TECHNOLOGY IN FOOD MARKETING

A Survey of Developments and Trends in
the Processing and Distribution of
Farm-Produced Foods,
1930-1950

Agriculture Monograph 14

UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON, D. C.
October 1952

TECHNOLOGY IN FOOD MARKETING

A Survey of Developments and Trends in the Processing and Distribution of Farm-Produced Foods, 1930-50

A Special Report Prepared under the Direction of an Inter-Bureau Committee of the United States Department of Agriculture

Agriculture Monograph No. 14
UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.
1952

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. Price 55 cents

Preface

The complicated process of marketing food in this country is as closely connected with the daily life of the Nation as eating is with the life of the individual, and it is just as commonly taken for granted. Thus it is sometimes difficult to realize how complicated the marketing system is and how great the technological developments in food marketing that have taken place during the life span of one generation. Some of the changes such as new methods of selling for most commercial farmers, new products, and new methods of buying for housewives who shop for families, are obvious to the most casual observer. Yet between the two extremes of the long process—in this report the term "marketing" covers assembling, processing, transportation, wholesaling, retailing, in fact everything that happens to food from the time it leaves the farmer's gate until it reaches the family kitchen—are other developments which may not be so obvious. Taken together, these developments constitute a technological revolution comparable to that which has taken place in the production of food on farms.

The effects of this revolution are felt by everyone. Farmers no longer take their products by horse and wagon to the nearest town for sale. Instead, farm products are assembled by motortruck for shipment to markets for further processing, storage, and distribution. To a large extent, the modern marketing system has taken over several functions formerly performed by farmers, thus freeing them for further specialization in production. These changes, plus technological developments in sanitation and preservation of food, have made available to city dwellers a greater variety of foods than was available to their grandparents on farms. Further, much of the processing and some of the preparation of food that used to be done in the home is now done by industry; some foods, in fact, can now be bought in ready-to-eat form. To the extent that her work in the kitchen is reduced, the housewife is freed for gainful employment, recreation, or fuller attention to other activities of the home.

In short, technology has made possible greater specialization at both ends of the line, and has created a national rather than a local market for most kinds of food.

On balance, it seems clear that these changes have helped to raise levels of living and in general have benefited the national economy. But progress is seldom altogether painless. The march of technology in food marketing has created a number of new problems, and has raised questions that are as yet unanswered. For example:

1. Creation of a true national market has meant that products are shipped over thousands of miles. Products from a single shipping point may go to any one of a large number of receiving markets—large or small—all over the country, and each of these receiving markets may get shipments from a large number of shipping points. Making sure that all the consuming centers have adequate supplies but are not glutted with surpluses has created increasingly complex problems of organization and communication.

2. Grades and standards by means of which buyers and sellers can understand each other have become more important than ever. Further, because canned and frozen foods, and even many fresh foods in their modern packages, cannot be inspected or judged by retail shoppers, consumers have become increasingly dependent upon the reliability of manufacturers' brands and labels and upon the efficacy of Government inspection and grading.

3. Need has arisen for legal protection of producers and consumers against undesirable practices in marketing over which they have no direct control.

Producers whose products are sold in distant markets necessarily rely upon the operations of the marketing system to get their products to ultimate consumers in proper condition. Failure of the marketing system to handle their products properly, arising either through lack of organization or inadequate regulatory controls, inevitably affects the prices and returns producers receive.

The use of chemical and other methods of preserving color and taste has raised questions of health hazards as well as of possible misrepresentation of products to consumers.

4. Additional services in the marketing system, such as the offering of foods in ready-to-eat form, may raise costs to a point where many consumers would prefer to pay less and have fewer services performed for them. Competition might be expected to allow consumers to choose freely between items that do or do not include extra services, but all too often competition emphasizes

services or some point other than price, so that consumers are denied effective choice in regard to added services.

5. Much technological progress in marketing clearly results in reduced costs, but gains in efficiency may be offset by increasing inflexibility of the price structure and other losses in the effectiveness of market competition. Thus, problems may arise as to how the benefits of lowered costs are shared among producers, consumers, and middlemen at the various stages of the food-marketing system. In addition, the increasingly large investments in existing methods of operation and the increasing costs of establishing new enterprises may mean loss of willingness or ability to introduce rapid changes.

These problems, and many more, are already with us. And the end is not in sight. The full impact, even of methods now in commercial use, has not yet been felt. New methods of marketing keep crowding up from the pilot plant and the laboratory, and other developments throughout the economy will in their turn call forth still further ingenuity on the part of the technologists. Present world tensions, and the widespread defense program designed to enable the United States to meet the situation, have underlined the need for conserving manpower and materials in food marketing through further technological gains.

The report that follows brings together information on major technological developments in all phases of food marketing, with special emphasis on progress during the last 20 years. Attention has been given to the rate at which new methods have been adopted Insofar as data are available, an attempt has been made to appraise the present and the potential effects of major developments upon the marketing mechanism itself and upon producers and consumers of food. Thus this report is concerned with the impact of technology upon the whole complex of enterprises, from assembling to retailing, that go to make up food marketing.

What is technology? In a civilization like ours, in which the application of science is woven into the entire fabric of daily living, including our pattern of thought, there might be as many answers as there are readers of this report, and most of the answers would be broad. Technology on the farm, for instance, has freed from tilling the soil millions of workers needed elsewhere in industry, commerce, and the professions. Technology, in fact, has set the economic and social pattern of the whole country. A bare handful of random examples will suffice. The railroad, the automobile, the motorship, and the airplane; the telephone, the radio, and the power press; it is difficult even to imagine what daily life would be like without them.

Any general definition of technology would cover far too much territory for the purposes of a report such as this. Viewed broadly, the forces of technology are everywhere; so are its effects. Often it is impossible to distinguish clearly between cause and effect, for modern technology is a self-renewing force. Technical progress creates new situations which in turn call forth more technical progress. What is needed here is a working definition that will indicate which developments in modern food marketing should be identified as technological forces. Such a definition has been developed for the purposes of this report. It is relatively narrow and is restricted to devices and techniques closely associated with the physical sciences.

First are the direct applications of research in the natural sciences—chemistry, physics, biology, and the others—to one or more aspects of food marketing. Many of these techniques were developed specifically for use in the marketing of food—the refrigerated truck, for example—or a solvent extraction process for oils. Others have far wider application and may have been adapted for use in marketing only incidentally—the radio and the passenger car for example—but these must be included if their place in the food-marketing structure can be clearly recognized. "What hath God wrought," was the first intercity message flashed by telegraph, rather than, "No. 2 potatoes opened 80 cents Baltimore," but the telegraph nevertheless has become one of the leading contributions of technology to the communications network that is indispensable to modern marketing.

Second, the aspects of technology clearly stemming from engineering and design have been included, such as lay-out of processing plants and arrangement of counters in retail stores to facilitate self-service. Here again the criterion of technology is that there be a recognizable physical aspect.

Nonphysical techniques, such as those relating to finance or management, are not considered here as primary technological forces, even though many are of first importance. They are considered only to the extent that they are effects of technology, and they are discussed as such in the appraisal of recent developments.

The grading of food products offers an example of the distinction that has been drawn. Grading as such is a business practice, and when grades are imposed from outside the industry, the practice has social and political implications as well. Consequently, grading as a function has not been treated as a technological

development. But a number of devices and processes have been perfected to facilitate the establishment of grades and the judging of foods after the grades have been established. These are treated here as technological forces.

This over-all appraisal of technology in food marketing draws primarily upon material already available. Such material is extensive, but it is scattered and uneven. A few of the aspects of technological development have been studied in detail, some partially, and many others not at all. The selection of the examples and case studies used in this report sometimes reflects the unevenness of material, although it also should be pointed out that the report is in no way intended as a comprehensive compendium. Among its other purposes, the present report is intended as a guide to the direction of future research in the many areas of the field for which further facts and analyses are needed.

The report, however, does bring together for the first time information on all aspects of the impact of technology upon the marketing of foods. It is hoped that the resulting picture of the whole broad area, insofar as such a dynamic situation can be caught on paper, will in itself be of value. It is also hoped that appraisal of present and potential effects of technology will bring out major trends more clearly and will help to shed light on some of the problems that are likely to require decisions on the part of industry, Government, or the general public.

Finally, specific attention must be drawn to the fact that the subject of technology in food marketing, broad as it is, comprises only a part of the whole field of food marketing, which in turn is only a part of the far broader process that begins with farm production and ends with consumption. Improvements in the technology of food marketing hold great possibilities for benefiting farmers, middlemen, and consumers, but these are by no means the only possibilities.

How This Report Was Prepared

This study of the impact of technology on the processing and distribution of food was undertaken at the request of the Agricultural Research Policy Committee and carried out by the United States Department of Agriculture under authority of the Research and Marketing Act of 1946. In suggesting the project, the Committee emphasized the need for a summary of the principal developments in technology in food marketing and an appraisal of their current influence and probable future effects.

The scope and content of the report were determined in consultation with representatives of State Agricultural Experiment Stations, who attended a series of regional meetings, and who also contributed many of the facts and interpretations that went into the text and reviewed the manuscript before it assumed final form. The list of those who attended the meetings in the spring of 1950 appears in this section.

Valuable assistance also was given by State Commissioners, Secretaries, and Directors of Agriculture, many of whom provided information on technological developments and their effects in their respective States.

Participating agencies within the Department of Agriculture were the Bureau of Agricultural Economics; various Bureaus of the Agricultural Research Administration, particularly the Bureau of Agricultural and Industrial Chemistry, the Bureau of Dairy Industry, the Bureau of Human Nutrition and Home Economics, the Bureau of Plant Industry, Soils and Agricultural Engineering, and the Office of Experiment Stations; several agencies of the Production and Marketing Administration, particularly the Marketing and Facilities Research Branch. Primary leadership in the project was assigned to BAE. A small Steering Committee was set up to guide the study. Membership is listed in this section.

Herman L. Myers, with the assistance of Robert E. Frye, and Albro Martin, all of the Bureau of Agricultural Economics, coordinated the research and assembled the material for the report. Henry Jarrett organized the material and completed the report. Authors in the various subject-matter fields were Harry W. von Loesecke, Agricultural Research Administration, Bureau of Agricultural and Industrial Chemistry; Chester Wasson, Production and Marketing Administration; Day Monroe, Agricultural Research Administration, Bureau of Human Nutrition and Home Economics; R. Claude Wright, and Wilbur M. Hurst, both of Agricultural Research Administration, Bureau of Plant Industry, Soils, and Agricultural Engineering,

and Earl O. Whittier, Agricultural Research Administration, Bureau of Dairy Industry. Other staff members of the United States Department of Agriculture contributed to the report.

Unless identified as from other sources, statistics cited in this monograph are from published series of either the Bureau of Agricultural Economics or of the Bureau of the Census of the United States Department of Commerce.

Mention of a material or equipment in this publication does not imply that it is endorsed by the Department of Agriculture over others of a similar nature not mentioned.

Steering Committee

F. F. Elliott, Associate Chief, Bureau of Agricultural Economics, *Chairman*

Budd A. Holt, Deputy Director, Marketing and Facilities Research Branch, Production and Marketing Administration

Roy W. Lennartson, Assistant Administrator for Marketing, Production and Marketing Administration

John R. Matchett, Assistant Chief, Agricultural Research Administration, Bureau of Agricultural and Industrial Chemistry

Wilbur T. Pentzer, Chief, Division of Handling, Transportation and Storage of Horticultural Crops, Agricultural Research Administration, Bureau of Plant Industry, Soils, and Agricultural Engineering

Herman M. Southworth, Research Assistant, Bureau of Agricultural Economics

Whitney B. Stout, Experiment Station Administrator in Marketing Technology, Office of Experiment Stations

Harry C. Trelogan, Assistant Research Administrator, Agricultural Research Administration

Gertrude S. Weiss, Head, Family Economics Division, Agricultural Research Administration, Bureau of Human Nutrition and Home Economics

Bennett S. White, Jr., Head, Division of Marketing and Transportation Research, Bureau of Agricultural Economics.

State Agricultural Experiment Station Consultants

Washington, D. C., Meeting

Delaware: G. L. Baker and S. T. Rice
Kentucky: H. B. Price and E. J. Nesius
Maryland: G. M. Beal and Amihud Kramer
North Carolina: H. B. James and I. D. Jones
Tennessee: B. H. Luebke and G. A. Shuey
Virginia: M. C. Conner
West Virginia: H. C. Evans and A. D. Longhouse

New York, N. Y., Meeting

Connecticut: Stewart Johnson
Maine: C. H. Merchant and M. E. Highlands
Massachusetts: A. A. Brown and W. G. Colby
New Hampshire: J. R. Bowring and H. C. Woodworth
New Jersey: J. F. Hauck and W. A. Maclinn
New York: M. E. Brunk and D. B. Hand
Pennsylvania: Wayne Lee and M. A. Farrell
Rhode Island: J. L. Tennant and W. H. Wiley
Vermont: T. M. Adams

Chicago, Ill., Meeting

Illinois: L. B. Howard and L. J. Norton
Indiana: G. B. Wood and F. W. Quackenbush
Iowa: G. F. Stewart
Kansas: J. A. Shellenberger
Michigan: Roy Marshall and G. G. Quackenbush
Minnesota: Harold Macy and W. C. Waite
Missouri: O. R. Johnson
Ohio: J. I. Falconer and T. S. Sutton
Wisconsin: H. L. Cook and K. G. Weckel

Lincoln, Nebr., Meeting

Colorado: C. R. Creek and Gestur Johnson
Kansas: George Montgomery
Montana: H. E. Ward and G. C. Hughes
Nebraska: G. M. Severson and C. C. Mitchell
North Dakota: P. V. Hemphill
South Dakota: A. L. Moxon and Ernest Feder
Wyoming: A. F. Vass

Berkeley, Calif., Meeting

Arizona: G. W. Barr and Leland Burkhart
California: R. G. Bressler, Jr., and Roy Bainer
Nevada: Howard Mason
Oregon: G. E. Korzan and E. H. Wiegand
Utah: G. T. Blanch and D. A. Broadbent
Washington: C. M. Elkinton

New Orleans, La., Meeting

Alabama: B. T. Lanham and Ernestine Frazier
Arkansas: J. W. White
Florida: A. H. Spurlock and A. F. Camp
Georgia: N. M. Penny and J. G. Woodroof
Louisiana: M. D. Woodin
Mississippi: W. E. Christian and F. E. Edwards
New Mexico: P. W. Cockerill and J. V. Enzie
South Carolina: W. C. Barnes and C. R. Smith
Texas: W. E. Paulson and R. F. Cain

Contents

Technology in Food Marketing

CHAPTER 1

The Modern Marketing System: Developments, 1930-50

Technological progress often springs from nontechnological causes and leads to nontechnological results. It will, therefore, be helpful at the start of this monograph to take a brief look at the major changes in food marketing during the last two decades without regard to what brought them about. Against such a general background it will be possible to trace more intelligibly the purely technological developments of the period.

The processing and distributing industries that make up the Nation's food-marketing system expanded greatly between 1930 and 1950. They grew in numbers of employees and capital invested. They handled more food and performed more services. They grew in importance in relation to farm production of food, and they served more consumers, both at home and abroad. Along with this expansion came advances in ways of doing things; the quality of many products was improved while many operations became quicker and less costly. Significant shifts occurred within the food-marketing structure, some geographical, others concerning the relationship among the different segments of the industry.

Certain basic characteristics of food marketing, however, underwent little or no change. In general, foods are much more perishable than most industrial products so that processing, packaging, storage, and transportation all must be performed with a special eye to preservation of the product. Also, because foods are produced by large numbers of independent farmers and because foods lack the uniformity of most factory products, the functions of assembling, grading, and standardization, are more important and complicated than for most industrial products.

Finally, because annual production of food can vary sharply with weather, and because most farmers must plan production many months ahead, production of food cannot be adjusted quickly to changes in demand. This circumstance puts an added emphasis on the preservation and storage of food. All of these factors have left their mark on the over-all developments in food marketing during recent years and on the course of technological progress.

More Customers with More Money to Spend

For the country as a whole, the period from 1930 to 1950 was one of growth. The population of the United States increased 23 percent, from less than 124 million persons to more than 152 million. Also, the population became more evenly distributed over the continental area as the sharpest gains were made in the Pacific and Mountain regions and the center of population moved farther west. Consumers tended to become more concentrated in urban centers, while areas of food production also became more concentrated (fig. 1). Not only were there more people, but they had more money to spend. Despite the great depression of the early 1930's the period as a whole was one of intense economic growth. The total physical output of the national economy approximately doubled.

The food industry not only shared in these national gains, but its growth outran the average rise. As the total population rose, the farm population declined from 29.5 million in 1930 to 24.3 million in 1950. Also, of the families remaining on farms, fewer were on a subsistence basis, growing food primarily for their own use. Instead, they channeled more of it through the commercial marketing machinery. As a result, a larger proportion of the increased population was served by the food-marketing system. In addition, between 1930 and 1950 the volume of food exports, some of which pass through processing and distributing channels in this country, increased by 60 percent.

Domestic consumers spent more money for food. In addition to a rise in the national average real income, the distribution of income changed in such a way as greatly to reduce the number and proportion of persons whose family-budget limitations prevent them from buying the kinds and total amounts of food that they want. In 1948, 72 percent of individuals, as compared with only 36 percent in 1935–36, were in consumer-

FIGURE 1

unit groups having real incomes of $2,000 or more (table 1). This was reflected in the greater amount of food consumed, and in the shift to more expensive foods and to forms of food that include more services.

Total food expenditures of consumers, including out-of-home eating, ranged from an estimated $18 billion in 1930 to a low for the period of $11 billion in the depressed year of 1933, to a high of $53 billion in 1950 (table 2). Thus total expenditures nearly tripled over the 20-year period. Expenditure per capita, even allowing for the rise in price level, increased nearly 50 percent.

Underlying the entire structure, furthermore, in addition to the growth in population, is the gradual long-time shifting of demand by consumers to foods conventionally associated with diets of higher-income families (fig. 2).

TABLE 1.—*Approximate distribution of individuals by consumer-unit incomes in selected years*

Total disposable real income per consumer unit (adjusted to 33 percent above 1935–39 average)	Approximate proportion of individuals				
	1935–36	1941	1943	1946	1948
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Under $500	11	3	3	3	3
$500 – $999	17	10	7	6	6
$1,000 – $1,499	20	10	10	8	9
$1,500 – $1,999	16	13	14	11	10
$2,000 – $2,999	19	24	23	22	27
$3,000 – $4,999	12	27	27	32	28
$5,000 and over	5	13	16	18	17

BURK, MARGUERITE C. CHANGES IN THE DEMAND FOR FOOD FROM 1941 TO 1950 (*5*).

TABLE 2.—*Population and total and per capita food expenditures, United States, 1930–50*

Year	Population July 1 [1]	Food expenditures excluding alcoholic beverages			Retail food price index, 1935–39 = 100
		Total	Per capita		
			Actual	Actual divided by retail food price index	
	Million	*Billion dollars*	*Dollars*	*Dollars*	
1930	123.8	18.1	146	116	126.0
1931	124.8	14.8	118	114	103.9
1932	125.6	11.4	91	105	86.5
1933	126.3	10.9	86	102	84.1
1934	127.1	12.3	96	102	93.7
1935	128.0	13.7	107	107	100.4
1936	128.9	15.3	119	117	101.3
1937	129.6	16.5	127	121	105.3
1938	130.7	15.7	120	123	97.8
1939	131.7	15.8	120	126	95.2
1940	133.0	17.1	128	133	96.6
1941	134.2	20.1	150	142	105.5
1942	135.7	25.3	186	150	123.9
1943	137.6	29.3	213	154	138.0
1944	139.3	31.9	229	168	136.1
1945	140.8	35.2	250	180	139.1
1946	142.3	41.6	292	183	159.6
1947	145.0	47.7	329	170	193.8
1948	147.5	51.6	350	167	210.2
1949	150.0	50.7	338	167	201.9
1950	152.6	52.8	346	169	204.5

[1] Adjusted for underenumeration of children under 5 years of age.
Bureau of Agricultural Economics.

Changes Within the Marketing System

As the food-marketing system as a whole grew from 1930 to 1950, significant changes took place in the organization of the different branches of the industry and in their relationships with each other. Broadly speaking, the trend was toward consolidation, with fewer and larger individual concerns, toward greater integration of the various stages of marketing, and in many instances, toward a more direct flow of food products from farms to ultimate consumers. New techniques often held down costs. But more elaborate processing and other new services tended to increase the cost of marketing.

More People in Food Marketing

Food production increased by approximately 40 percent between 1930 and 1950. Reflecting the larger volume of food marketings as well as the added services provided by the marketing system, the number of workers engaged in marketing food—processing, transportation, wholesaling, and retailing—increased from around 3½ million in 1930 to about 4.8 million in 1948, an increase of 36 percent. Each of the marketing functions shared in the increase.

How Retail Expenditures Were Shared

In 1930, farmers received 39 percent of each dollar paid at retail for farm food products produced in the United States (fig. 3). Market agents, including processors, received 61 percent. In the period of rising prices after the depressed 1930's and especially the war and postwar period, farm food prices followed their normal pattern of rising faster than retail food prices. In addition, increased consumer income resulted in the purchase of a greater amount of food and a greater proportion of meat products which return a relatively high proportion of the consumer's dollar to the producer. In 1950 the consumer's dollar was shared almost equally by farmers and market agents—48.5 percent for farmers and 51.5 percent for processors and distributors (fig. 3).

Changes in Processing

Since 1930, the trend toward more processing and a greater variety of processing has been continued and accentuated. Higher consumer income has facilitated the transfer of many services, formerly performed on farms and in homes, to modern commercial processing plants. New and improved techniques have replaced outmoded methods, and faster, more continuous

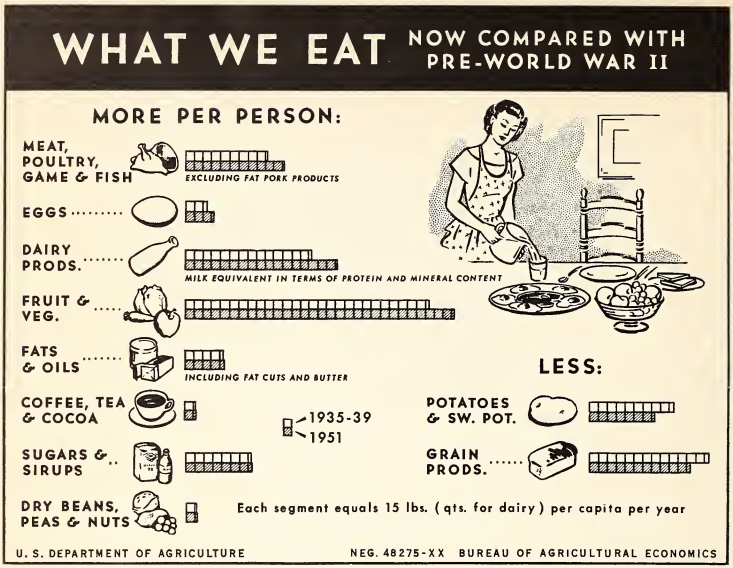


FIGURE 2

methods are now used for processing many foods previously prepared in individual batches.

For the period covered by the 1929 and 1947 censuses the total number of establishments engaged in the manufacture of food decreased by 33 percent; the total number of workers increased by 47 percent, with the average number of workers per plant more than doubling. The value added by food manufacture increased from $3 billion in 1929 to more than $8 billion in 1947. These data indicate a trend to production on a larger scale with the use of modern mechanical-technical methods of manufacturing.

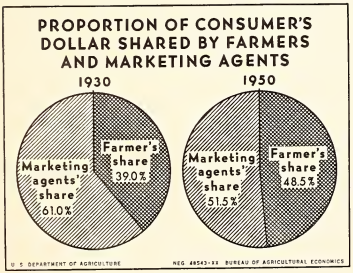


FIGURE 3

Changes in Wholesaling

Wholesalers of food products as reported by the census include merchants, manufacturers' branch houses, agents and brokers, and assemblers. Since 1930, sales by all these types of wholesalers, taken together, have quadrupled, with all classes sharing in the larger volume. Between 1929 and 1948 the total number of wholesale food establishments rose from 36,458 to 52,132. In some particular categories, such as assemblers and manufacturers' sales agents with stocks, the number of establishments decreased. In the latter two classes for which separate employment figures are available, total employment rose.

In most food lines, the big change in wholesaling has been the continued trend toward more direct marketing, the bypassing of the traditional rail-oriented central markets, the greater integration of production, wholesaling, and retailing functions as large-scale retail organizations buy foodstuffs directly from producers and producer-organizations. Other manifestations of the trend toward more direct marketing have appeared in the continued growth of auctions and interior packing of livestock.

Changes in Storage

The main developments in the storage of foodstuffs since 1930 are the expansion in total refrigerated storage capacity and the increased proportion of sharp-freezer space. By 1949 total refrigerated food-storage capacity, exclusive of meat packinghouse storage, had increased to 43 percent. The shift toward a greater proportion of storage capacity in the freezer (0° to 29° F.) and sharp freezer (0° and below) space paralleled the rise in output of frozen foods. From 1925 to 1945, sharp-freezer capacity practically doubled, and freezer space increased by half; in contrast, cooler space declined by 15 percent.

Warehouses were formerly concentrated almost entirely in rail-terminal and port areas. Ship and train facilities still have an important bearing on location of warehouses, but with the growth of the frozen-food industry and the emergence of the motortruck as a major carrier, refrigerated warehouses are more frequently built nearer areas of frozen-food production and at intermediate points from which further distribution can be made with the greatest flexibility. Since 1947, refrigerated storage capacity increased net 11 million cubic feet in the Western States, compared with only 5 million in the East (84).[1]

Transportation Developments

Motortrucks and surfaced roads were in general use by 1930, mainly for short hauls. Since 1930 both numbers of trucks and miles of hard roads have more than doubled, and a national system of highway truck transport has come into being. The figures for truck registrations and miles of hard-surfaced roads show this development (table 3).

Motortrucks were swiftly and extensively applied to both on-farm use and marketing. The importance of the motortruck to the marketing of livestock, for example, is demonstrated by the fact that in 1950 "drive-ins" (mainly trucks) accounted for more than three-fourths of the receipts of cattle, calves, and hogs, and almost half of the sheep and lambs at 64 public markets; in 1933 the former accounted for about half and the latter about one-fifth of the receipts.

TABLE 3.—*Number of truck registrations and miles of surfaced rural roads, selected years*

Year	Truck registrations	Year	Surfaced rural roads [1]
	Thousands		*1,000 miles*
1920	1,006	1921	387
1930	3,486	1930	694
1940	4,590	1940	1,340
1945	4,835	1944	1,430
1949	8,028	1948	1,574
1950	8,604	1949	1,617

[1] STATISTICAL ABSTRACT (77).

In terms of expenditures for intercity transport of all kinds of foods, trucks have come to equal railroads in importance. It is estimated that in 1950 slightly more than 2⅔ billion dollars were spent for movement by both truck and rail. Of this total, 52 percent was spent on truck transport and 48 percent on rail. This compares with one billion dollars spent for shipping by these carriers in 1930, with rail carriers obtaining 75 percent and trucks 25 percent of shipping payments (fig. 4). Comparing the change from 1930 to 1950, the total transport bill increased by 153 percent, payments to rail carriers by 62 percent, and payments to trucking concerns by 419 percent.

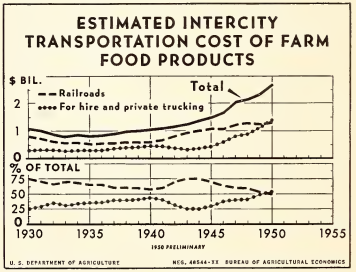


FIGURE 4

Better Communications

By 1950, producers, processors, distributors, and consumers of food were in better touch with each other and with market developments in general than they were two decades earlier. Sales by long-distance tele-

[1] References to figures in parentheses refer to Literature Cited, p. 112.

phone and teletype communication between major markets had come into daily use. The Federal-State Market News Service had grown in speed, flexibility, and breadth of coverage. Airmail had developed from a small-scale innovation to a fast, cheap, widely used service. The percentage of urban homes with radios rose from 50 in 1930 to more than 95 in 1950; of farm homes from less than 21 in 1930 to more than 93 in 1950. These and other advances in communications stimulated and enhanced the effectiveness of technological gains in processing and distribution of food.

Changes in Retailing

The most important change in retailing since 1930 has been the rise of the supermarket as the modern method of selling foods to the consumer. Prepackaging and self-service have displaced bulk products, delivery, and credit, and have resulted, together with modern mechanical refrigeration, in both homes and stores, in large-scale once-a-week shopping.

This trend to one-stop shopping is reflected in the figures which indicate that grocery stores without meats, and specialty stores such as meat markets, fruit, and confectionery stores have been largely displaced by stores that handle all products together (table 4). Outlets for milk and bakery products, however, are exceptions to the rule. The number of retail food outlets increased from 1929 to 1939 by 16.4 percent but a falling off since that date has left a net increase of only 4.9 percent.

TABLE 4.—*Number of retail food stores, by class of store, 1929, 1939, and 1948*

Retail food store	1929	1939	1948
	Number	*Number*	*Number*
Grocery:			
Without fresh meat	191,876	200,303	154,277
With fresh meat	115,549	187,034	223,662
Meat	43,788	35,630	24,242
Fruit and vegetable	22,904	27,666	15,763
Candy, nut, and confectionery	63,265	48,015	32,876
Dairy products and milk dealers	8,478	16,834	11,727
Bakery products	12,013	16,985	20,152
Egg and poultry	3,258	6,532	5,582
Other	14,683	14,820	10,935
Total [1]	475,814	553,819	499,216

[1] Excluding fish markets.

Not only did total sales vary during the period, but the concentration within, and organization of, the industry shifted significantly. The percentage of total grocery sales by chains was about the same in 1929 as in 1948, around 38 percent. But the number of chain stores as a percentage of total stores went down from 17 to 7 percent in the period. The total number of grocery stores increased from 307,000 to 378,000 while chain outlets decreased from 52,618 to 28,000 stores. For the largest chain enterprises, the number of stores was reduced to less than half, with A & P showing an even sharper drop. Total sales and sales per chain store, however, increased tremendously (table 5).

Milestones in Commodity Marketing

A great deal of food marketing is done on a commodity basis by specialists in the handling of a particular commodity. As a supplement to the general changes just mentioned, it may be helpful to review briefly some of the more important changes that occurred between 1930 and 1950 in the marketing of principal commodities.

Dairy Products

In the marketing of fluid milk, distributors introduced the square glass bottle and the paper carton. Carton-packaging machinery operates on a large scale. This, combined with larger loads per truck, has made possible an extension of the delivery area. Homogenized fluid milk has gained general acceptance. The paper carton and homogenization have tended to eliminate the cream line as a competitive selling device, and have increased sales through retail stores at the expense of home delivery by distributors. Every-other-day home delivery of milk, introduced as a wartime conservation measure, has been widely accepted as a continuing practice. New and larger mechanical home refrigerators enabled consumers to keep milk for longer periods and the square cartons and half-gallon size bottles cut down space requirements.

A recent innovation in fluid milk marketing is the introduction of concentrated milk designed to cut storage and transportation costs by two-thirds. The extent to which the new product is adopted apparently will depend largely on the retail price differential that is offered. Frozen concentrated fluid milk for home consumption has been introduced on an experimental basis.

Among manufactured dairy products, ice cream has become a year-round food; processed rindless cheese has accounted for an increasing proportion of the total consumption of cheese; the nonfat components of milk have become important raw materials for manufactured feeds, for other industries, or in the production of other types of foods. The volume of butter consumption and the pricing of all dairy products have

TABLE 5.—*Number of stores, total sales, and sales per store of selected chains, 1929 and 1949*

Company	1929			1949		
	Stores	Sales		Stores	Sales	
		Total	Per Store		Total	Per store
	Number	*Million dollars*	*Dollars*	*Number*	*Million dollars*	*Dollars*
A. & P.	15,418	1,054	68,362	4,600	2,837	616,739
Kroger	5,494	287	52,239	2,204	807	366,152
American	2,730	143	52,381	1,671	409	244,764
First National	2,002	76	37,962	1,083	354	326,870
Safeway	2,660	210	78,947	2,177	1,193	548,002
National Tea	1,073	57	53,122	655	274	418,321
Colonial	811	32	39,457	374	169	451,872
Total	30,188	1,859	382,470	12,764	6,043	2,972,720
Average	4,313	266	54,639	1,823	863	424,674

LEBHAR, G. M. THE STORY OF THE FOOD CHAINS (*30*).
Direct verification of these figures was not possible but they are assumed to be correct.

been affected by the rising competition from margarine and other substitute vegetable shortenings. Technological improvements in the manufacture of these substitutes have been one of the reasons for the shift. Since 1946 the upward trend in consumption of colored margarine has been accelerated.

Relatively high prices for butter in comparison with colored margarine in 1947–50 probably were important in bringing about the postwar increase. Also, since 1947, prohibitions against the sale of colored margarine have been repealed in many States. The repeal in 1950 of the Federal tax of 10 cents a pound on colored margarine was primarily responsible for the large increase in consumption of colored margarine in the second half of that year.

Livestock and Meat Products

Since 1930 the extension and growth of the auction method of selling has been an important development in livestock assembly—feeding in the West, feeding and breeding in the Midwest, and all types in the South. This tended to cut into the business previously done by local traders and dealers. The great reduction in sales of meat by manufacturers' branch houses is related to direct purchase by large chain retail organizations on the basis of Federal grades, which has enabled sales by description and has reduced the need for purchases by inspection. This has meant less handling and more direct movement from packinghouses to retail stores.

The introduction of prepackaged self-service meats was a revolutionary development in the retailing of meat products. Among its other effects is the reduction in the number of specialized meat outlets. Modern displays of prepackaged meats were first installed in 1940 but wartime restrictions prevented large-scale adoption until 1946 (*30*). This method of retailing meats is important inasmuch as, in groceries handling meat, the meat department accounts on the average, for 25 to 30 percent of total sales, and an even larger share of gross profit. Although they represent less than 2 percent of all food stores handling fresh meat, self-service stores accounted for more than 10 percent of sales of meat in such stores in April 1951.

Since 1946, when a survey showed only 28 complete self-service meat stores, their numbers increased continuously to almost 2,000 in 1950 and almost 4,000 in early 1951. In addition, more than 10,000 stores maintain partial self-service meat departments. The chains were not the first to adopt this new method; only 30 percent of the stores with self-service meats in 1947 were operated by chains, compared with 75 percent in 1951 (*40*, p. 10).

Poultry and Eggs

As in livestock, the growth of egg auctions became important as a method of first sale off the farm. With the increase in direct buying by large retail organizations and the allocation problem induced by the price ceilings of World War II, however, the auctions have lost ground. In retailing, the sale of cartoned eggs on a Federal-State graded basis provides more information for the consumer. More adequate refrigeration permits better control of quality at all levels in the market channel.

In the poultry-meat sector of the industry, broiler production has developed on a year-round basis. Large-scale slaughtering plants, which utilize modern mechanical equipment are typical of the industry, and

financial arrangements between producers and suppliers or processors have relieved many farmers of much of the risk of unfavorable short-term prices.

Commercial freezing has been extended to poultry meat, along with other products, and the market now makes available cut-up chickens and turkeys in consumer-size packages. Thus the consumer can choose those portions of the bird for which his preference is greatest. Freezing has encouraged turkey production in the Western States for supplying eastern markets. An important development has been the systematic breeding of meat-type chickens and broad-breasted turkeys, including the Beltsville Small White. In 1930, when the bulk of poultry meat came from egg-producing flocks, poultry was considered a Sunday treat; by 1950 prices of poultry meat were closely competitive with those of other meats.

Fruits and Vegetables

Auctions have become a relatively important method of sale of various fruits and vegetables. In addition, in several States, notably New Jersey, with large suburban populations and heavy passenger automobile traffic, roadside markets have become big business and major outlets for local products. Marketing agreements in western fruits and the Federal price-support program in potato production have been factors in determining the total supply of products going to market, the time of marketing, and the size of production.

In the retailing sector, there has been a revolutionary trend toward prepackaging of fruits and vegetables, which has reduced waste and spoilage and to some extent has cut down the cleaning operations in the home, but which may have cut down somewhat the retail shopper's ability to select. Only since the late 1920's has produce become a common item in general-line food stores. Today, produce departments account for about 15 percent of total sales of the average food chain stores and a higher portion of store profit (30, p. J 37). The improvement of refrigerated transport, the opening up of specialized areas of production, and growing recognition by consumers of the importance of fruits and vegetables in the diet are all important developments of this period.

The chief development in the citrus industry was the mass production of citrus juice in the early 1930's. The juice was of higher quality and flavor due to the introduction of flash pasteurization and mechanical extraction processes. More recently, a successful large-scale method for producing frozen concentrate citrus juice for home use has been developed.

Fats and Oils

Since 1930, soybeans have become an important domestic farm product. Soybean oil is used as a raw material in margarine, vegetable shortenings, and other edible fats and oils products, as well as in various industrial products. Improvement in processing of vegetable shortenings was originally responsible for the swing in demand from lard to vegetable products. More recently, improved methods of producing a bland animal shortening appear to point at least toward stabilization of the situation, and possibly to some reversal in the trend. The development and adoption of the solvent extraction method of oil production is displacing the older screw-press and hydraulic methods, particularly for soybeans, resulting in more efficient oil recovery.

During World War II and since 1949 the United States has been a net exporter rather than a net importer of fats and oils. Production has expanded rapidly in this country, whereas certain countries, such as India, which in the past had large exports, now consume more of their fats and oils at home.

Grains

Mechanical harvesting of grain resulted in a product of higher moisture content, which was more susceptible to deterioration in storage. This has been offset by improved drying methods both on farms and in commercial elevators. Improved storage facilities and handling methods, including the bulk handling of grain and flour, and insect and rodent preventive methods have helped to reduce the cost of maintaining the quality of the raw material and flour. In consumer products, enrichment of bread and many other cereal products, which began originally as a wartime measure, has become standard practice. The development and availability of prepared mixes and of frozen bakery products have enabled housewives to save time and take advantage of standard, uniform services supplied by the marketing system.

Changes in Ways of Living

The increase in our population, the continuing shift from farms to cities, and the growth in real incomes, especially among the poorer segments of the population, have already been mentioned. Accompanying these shifts have been marked changes in general patterns of living which have both encouraged and been facilitated by technological changes in the processing and distribution of foods. The following developments are particularly significant from this standpoint:

1. More homemakers had jobs. The proportion of married women who held positions outside the home rose from about one in eight in 1930 to about one in four in 1950. Employed housewives have far less time for the kitchen phases of their domestic work.

2. The spread of the 40-hour week increased and regularized the amount of waking time away from the job. Even though many more people were working, the shortening of work hours encouraged a wide variety of avocations, participation in civic activities, and sharing by men of household work.

3. A whole new system of urban housing arose, built around the private automobile and mass public transportation. As urban population increased, the people of the cities more and more moved to suburban communities of apartments or small houses. Distances to jobs, schools, and stores became greater.

4. Most young married women began housekeeping with less experience in selecting and preparing foods. Many had been working in offices or factories before marriage rather than helping their mothers at home. A smaller percentage of the new generation of homemakers had memories or close family connection with rural living.

5. Mechanical equipment for kitchen work and other housekeeping tasks were widely bought during these decades, and homemakers came to set a high value on household machinery. Thus the laborious and time-consuming tasks of home food processing and preservation were less important than formerly.

As a result of these and other developments, millions of families welcomed new forms of processed food that required fewer hours in the kitchen and less culinary skill. Fewer lunches were packed for taking to school or places of work, and greater distances prevented most school children and workers from coming home to lunch. Thus, school and industrial lunchrooms and commercial restaurants took over much of the job of noonday feeding.

But selecting the food the family wanted from the profusion of types, varieties, and brands displayed in supermarkets and other large retail stores became even more important. Men as well as women devoted some of their enlarged free time to weekly or semi-weekly shopping expeditions; food buying became more of a family affair. Much of the food brought back in the family car was ready, or nearly ready, for cooking; most of it had been packaged in some form or other when the shoppers themselves picked it from shelves or cabinets.

In 1930 a housewife was likely to telephone her daily order to a small neighborhood grocery or to send one of the children with a list; many items in her order would be weighed out of the store's bulk stocks. Today, although few families are able or willing to give more time than they must, either to shopping for food or to preparation of food, the tendency is to use the time for selecting the family food supply and to pass on to commercial processors and distributors as much as possible of the task of preparation.

As we have seen, extensive changes in processing, transportation, storage, and wholesaling, most of them outside the notice of the average food shopper, lay behind the changes in retailing. Technological progress in food marketing has been one of the major forces in setting the new pattern. Technology has, in fact, played a dual role, not only making it possible for food processing and distribution to respond to new wants of a changing society, but also generating some of the social changes. The chapters that follow attempt to separate technological developments from the other significant influences on food marketing in the last 20 years, examine some of the major manifestations of technology, and appraise their effects.

CHAPTER 2

Frozen Foods for the Mass Market

The play of the forces of technology upon the food-marketing system is essentially a dynamic process. The rise of the frozen-food industry is a clear-cut example of this dynamism. Within the last 20 years a whole new enterprise has been built through the integrated application of scientific principles. The principles themselves are old; but not until technologists learned to apply them to modern needs and wants was a real beginning made. And even after practical methods of commercial freezing were developed, the first step amounted to little until ways were found to transport frozen foods in large volume, store them, offer them for retail sale, and keep them in homes.

Now that these difficulties have been met, or partially so—for the search for improvement never ends—the frozen-food industry is a fast-growing branch of food marketing. It has wide repercussions as the rising demand for frozen products helps change the eating habits of the people and creates technical problems in farm production, processing, and handling. For these reasons this chapter departs from the structure of the remainder of the monograph. Cutting across the general headings under which the other developments are discussed, it considers the rise of frozen foods as a case study in interdependence.

Beginnings

Like nearly all innovations, the frozen-food industry is based on very old scientific principles and, as with most new developments, its sudden emergence as a major enterprise was preceded by a fairly long period of modest commercial application. Only after patient technological advance had broken down the greatest barriers to placing frozen foods in the homes of millions of consumers was the time ripe for the great rush of improvements and refinements that still continues.[2]

Freezing is primarily a method of preserving food so that it may be transported over long distances or kept from season to season. The knowledge that food keeps better in cool places than in warm, and in cold places than in merely cool, is older than history, and commercial freezing of foods in this country is by no means new. By the end of the Civil War, fish were preserved by use of ice and salt as a refrigerant. Commercial freezing of poultry is about as old. Before 1890, eggs were frozen on a fairly large scale. Before 1905, berries and other small fruits were preserved by freezing for further processing rather than for direct use by consumers. Freezing of fruit as a continuing industry began in the Pacific Northwest in 1909.

The technological milestone in the preservation of foods by freezing was the development of mechanical refrigeration, which first took on practicable importance around 1890. Subsequently many improvements in techniques of refrigeration and many new designs for special purposes have been made, but the greatest obstacle to large-scale freezing of many kinds of food was surmounted when men learned to create and maintain low temperatures under controlled conditions.

In 1930 the list of commercial frozen foods consisted mainly of fish, small fruits, poultry, meats, eggs, and a few vegetables. In comparison with total food production, the volume of those frozen products was negligible. The new industry had made almost no impression on the vast body of consumers; most of them were unaware that foods were being frozen. For fish, poultry, and meats, freezing meant no change in the products on the counters of retail stores; it was just another method of getting them there in good condition. Most frozen fruits and vegetables were used in preserve making or in further manufacture of some kind.

Technology had solved the central problem of preserving food through freezing, especially in arresting micro-organisms and in slowing the life processes of the foods themselves. But in many instances the taste and texture of the frozen product were inferior to those of the fresh. The keeping quality of many frozen foods

[2] Ice cream is not generally considered a frozen food and has not been so included in this study. Freezing of ice cream is not primarily for the purpose of preservation, but is rather an integral part of processing a product which is eaten in frozen form.

was uncertain, partly because of intrinsic defects in the freezing process and partly because of inadequate transport and storage facilities. Another deterrent was the fact that comparatively few consumers had mechanical refrigeration in their homes, so that frozen foods, even had they been widely available, could not have been kept many hours after purchase. An outside influence which slowed progress was the economic depression of the period.

But despite the depression, the rise of the frozen-food industry began in the 1930's. One by one the troublesome technological hurdles were overtopped and as each barrier was surmounted conquest of the others became easier. By 1951 the list of commercially frozen foods mentioned above had been augmented by shellfish, a large variety of vegetables, fruit juices, cream, baked goods, and many others. Furthermore, many of these products went into the homes of millions of people and began to affect tastes and eating habits. The newer frozen products felt, looked, and tasted more like the fresh ones.

As a percentage of total production, the volume of foods sold in their frozen form is still small, but the rate of growth since 1930 has been striking (table 6), and it is continuing.

Commercial manufacture of frozen orange concentrate began in 1945–46 (fig. 5, table 7), but during that and the succeeding season, the output went mostly to public eating places such as restaurants and soda fountains. Retail distribution to households, on a sizable scale, did not begin until 1947–48. Yet by the second quarter of 1950, the frozen concentrate accounted for 24 percent of total household purchases of oranges; canned juice for 25 percent; fresh fruit for 51 percent. Doubtless more frozen concentrate would have been used had it been readily available.

TABLE 6.—*Quantity of selected frozen foods and as a percentage of total production, 1930–50*

Year	Frozen Foods									
	Fruits [1]		Vegetables [2]		Eggs		Meat [3]		Poultry [3]	
	Quantity	Percentage of total production	Quantity	Percentage of total production	Quantity	Percentage of total production	Quantity	Percentage of total production	Quantity	Percentage of total production
	Million pounds	*Percent*	*Million pounds*	*Percent*	*Million pounds*	*Percent*	*Million pounds*	*Percent*	*Million pounds*	*Percent*
1930	85				185	4.7				
1931	69				152	3.9				
1932	60				138	3.7				
1933	50				171	4.7				
1934	65	0.3			198	5.6				
1935	77	.3			206	6.0				
1936	70	.3			208	5.9				
1937	111	.4	73	0.2	200	5.1				
1938	129	.5	90	.2	116	3.0	5	0.03	12	0.5
1939	141	.5	73	.2	177	4.4	10	.1	15	.5
1940	172	.6	83	.2	190	4.6	14	.1	50	1.7
1941	208	.7	107	.2	237	5.4	18	.1	75	2.3
1942	198	.7	163	.3	258	5.1	12	.1	70	1.9
1943	193	.7	223	.5	413	7.3	14	.1	90	2.0
1944	338	1.0	239	.5	512	8.4			90	2.0
1945	430	1.4	308	.6	398	6.8			120	2.5
1946	523	1.4	450	.8	392	6.8	12	.1	125	2.9
1947	347	1.0	346	.7	371	6.4	15	.1	130	3.2
1948	378	1.1	446	.9	345	6.0	20	.1	150	4.0
1949 [2]	360	1.1	566	1.1	318	5.4	50	.2	200	4.4
1950 (est.) [3]	400	1.3	700	1.4	354	5.7	75	.3	300	6.4

[1] Citrus fruits for previous year shown; apples not produced in commercial market areas excluded.

[2] Includes rough estimate of unreported commercial truck crops, market gardens for fresh sale, and farm gardens for home use; excludes production estimates of town and city gardens.

[3] 1951 DIRECTORY OF FROZEN FOOD PROCESSORS OF FRUITS, VEGETABLES, SEAFOODS, MEATS, POULTRY, JUICES, AND SPECIALTIES THROUGHOUT THE WORLD (*48*).

Bureau of Agricultural Economics except where otherwise noted.

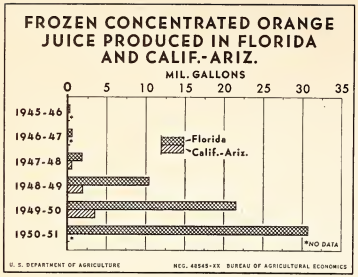


FIGURE 5

TABLE 7.—*Production of frozen concentrated orange juice, Florida and California-Arizona, 1945–50*

Season beginning	Florida	California-Arizona	Total
	Gallons	*Gallons*	*Gallons*
1945	225,684	0	225,684
1946	559,309	0	559,309
1947	1,935,868	437,376	2,373,244
1948	10,232,831	1,963,035	12,195,866
1949	21,647,000	3,490,000	25,137,000
1950	30,758,000	4,180,000	34,938,000

Bureau of Agricultural Economics.

Improvements in Processing

Since 1930 many improvements have been made in freezing equipment and techniques. Technological developments contributed to quality retention in frozen foods through the careful selection of kinds of food products, including varieties of fruits and vegetables, that are well preserved by freezing. Advances in technology were made in harvesting at the prime stage of maturity, in prompt handling and preparation, in blanching (scalding) of vegetables to inactivate destructive enzymes, in adequate packaging, and in quick transfer of food products to freezers and to warehouse storage temperatures maintained at 0° F. or below. Prompt chilling of products in freezers below temperatures favorable to micro-organisms is a contributing factor in quality retention.

Blanching

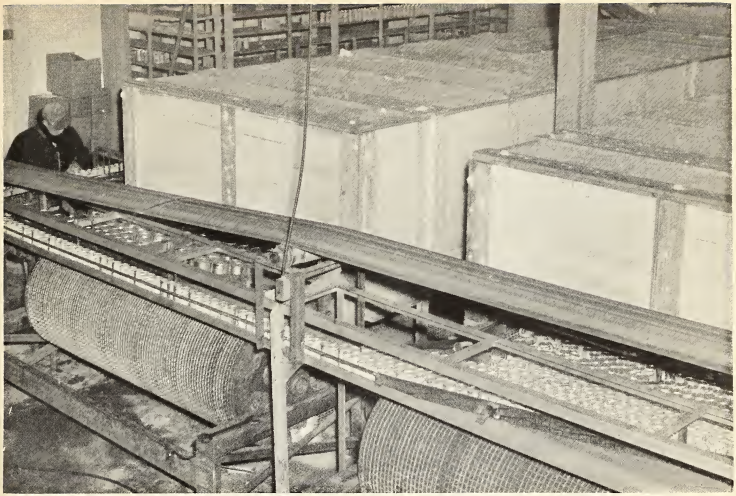
Until 1928, it was felt that vegetables could not be frozen successfully. As growers had observed, frost-damaged vegetables spoiled almost immediately after thawing and became unpalatable. In that year, however, the necessity of blanching before freezing was established. Blanching consists of a short period of scalding in steam or hot water which, to a large extent, inactivates the enzymes that hasten chemical reactions. When properly done, blanching helps to prevent off-flavors and off-colors caused by enzyme action, and aids in retention of carotene and vitamin C while in storage.

These findings gave impetus to engineering developments in the form of improved handling and processing machines, specialized refrigerating equipment, and organization of the flow of products. Improvements in refrigerating equipment included high-speed individually driven compressors, more efficient heat exchangers, better control instruments, and unit coolers. Also, much was learned about the selection and handling of foods destined for freezing.

Methods of Freezing (*59*)

Machines adapted to the freezing of different kinds of food are many and ingenious. Creating the cold, through the action of ammonia or other liquids, is only the first step. The cold must be brought to the product to be frozen. Or, more scientifically, heat must be drawn from the product. Air may be the medium; this method of freezing is known as the convection process. Or the food may be brought into direct contact with some other material cooled by the refrigerant —metal plates, liquids, fogs, sprays—this is known as the conduction process. Freezing apparatus based on conduction usually falls into one of two main types: (1) Direct contact, by which the product to be frozen is sprayed with or immersed in the cooling medium and (2) indirect contact, by which the product is cooled by metal plates or some other surface which in its turn has been cooled by the refrigerating medium. The tunnel air-blast freezer, in which cold air is blown at high speed over the product to be frozen, is the more widely used of the convection types of equipment.

Tunnel air-blast freezers apparently originated around 1930 in Canada. Wire mesh belts, however, were used in this country at an early date to move fish through the freezing zone in a tunnel. More recent developments in this type of freezer include successive stages of freezing in an effort to control evaporation of moisture from the product and an apparatus for shaking or vibrating the product to hasten the rate of freezing. These improvements can offset, to a considerable extent, the two major drawbacks of tunnel freezing: dehydration of the product and the need for frequent defrosting.



Air-blast freezing tunnel

The illustration shows the feed end of a tunnel for frozen concentrated orange juice. Before entering the tunnel, the concentrate in the cans is frozen to a slush; the cans then enter the tunnel where they are subjected to a blast of air at about —30° F., freezing the juice solid. (Photograph from *Food Engineering.*)

Direct-contact freezers date back to about 1923, when a spray freezer was used for fish. Whole fish were sprayed with water, then with brine, followed by water to remove the brine and to cover the product with a glaze of ice. A "fog freezer" which operated in a somewhat similar fashion was patented around 1933.

An immersion freezer was developed around 1939 for vegetables and small fruits. The product is submerged and moved through liquid on a wire mesh conveyor and the excess liquid adhering to the product is removed by a centrifuge. Another direct-contact freezer which appeared a few years later used an edible refrigerant for fruits and vegetables and brine for fish.

Indirect contact freezers have a long history; the old-fashioned ice cream freezer with ice and salt outside the metal container is a familiar example. Adaptation of this method to the quick freezing of foods can be traced back at least as far as 1924, when metal containers submerged in brine were used in this country for fish. By 1926, or thereabouts, endless metallic belts which moved the product through the freezer and carried the heat away as it moved, were in commercial use. In the original form of this process, the top side of the belt above the product and the bottom side of the one that supported the product were sprayed with brine. A freezer using movable refrigerated plates similar to shelves in a closet was developed around 1930. Packages of produce to be frozen rested between the plates, in contact with both top and bottom.

Although the type of freezer used depends to some extent upon the physical characteristics of the product to be frozen and upon whether freezing is done before or after packaging, the different systems are remarkably flexible. The three major systems of freezing are to be found in establishments of the same size or plants which freeze the same products. As a general rule, the air-blast type can be used on a wider variety of products and permits a greater choice of package sizes and packaging materials than the surface-contact or liquid-immersion types. However, the latter types are generally more economical as to power cost.

In the case of the blast freezer, air movement increases the rate of freezing but it also increases evaporation of moisture from the product and aggravates defrosting problems. Liquids are better conductors of heat than gases, but when liquids are used. either in spraying or immersion, metal or glass containers may be required. Moisture from the product may dilute the liquid used or some of it may adhere to the product.

Freezing Plant

The modern freezing plant need not be complex from an engineering standpoint or particularly large. Nevertheless, a commercially feasible plant cannot be constructed overnight or financed on a shoestring. Modern engineering developments include machines that are faster, more nearly automatic, better adapted to avoiding contamination, and more compact. Some are portable. Many are more versatile, and are able to handle products of different shapes with no difficulty.

In general, however, some observations as to desirable capacity in freezing plants, based on a 1945 study, are still valuable guides. These studies indicate that the minimum economical production in a commercial freezing plant would be in the neighborhood of 3,000,000 pounds a year (49). Such a plant would have a capacity of 1,500 to 2,000 pounds an hour, cover an area of 15,000 to 20,000 square feet, and represent an investment of at least $200,000. A comparable plant constructed under 1951 conditions would cost at least $300,000 and probably more.

Large-scale commercial freezing as a process of preservation has grown during the last 20 years until in 1948 approximately 1,000 plants were estimated to be engaged in the freezing of foods.[3] Nearly half of the plants—448—were wholly or partially engaged in freezing fruit, 325 had facilities for freezing eggs, 230 for vegetables, 203 for cooked products, 102 for poultry, and 60 for meats. These plants are most heavily concentrated along the Pacific Coast and around the New York area (fig. 6). In many cases, freezing plants are located so as to provide market outlets to areas suited to the production of perishable crops that would otherwise not be able to compete successfully in distant consuming markets.

Freezing plants, like other manufacturing establishments, are especially designed and constructed to incorporate developments as they occur; and older plants are redesigned or reorganized from time to time as competition dictates. Plant investment and cost-volume relationships vary in accordance with the kind and number of products frozen, the number of units frozen per day, the degree of mechanization, construction costs, storage facilities required, and labor unit costs.

Economies in labor and a reduction in desiccation of the product have been reported in handling lima beans through the substitution of hydroconveyors for mechanical conveyors (22). One advantage of the hydroconveyor system is its economy in combining two necessary operations; the water chills the product as it moves it. However, the water may also leach valuable vitamins and other nutrients from some types of product. Methods of fog chilling now are being devised to avoid such losses; if these are found practicable another method of conveyance will have to be found. This situation is only one of many in which technological advances bring new technological problems.

Frozen Food Packaging

Most frozen foods reach consumers in the home- or institutional-sized packages in which they leave the freezing plant. However, in some instances, particularly in the Pacific Northwest, vegetables such as peas may be frozen in bulk and then repackaged. Thus, from the start, packaging has challenged the ingenuity of the food-freezing industry. The package for any food must meet not only the physical and chemical requirements of the freezing process itself, but also those of storage, transportation, retailing, and holding in the home until the consumer is ready to use it. In addition, packages that are to be sold through retail stores—and they make up a majority—must also meet the commercial requirement of attractiveness to buyers.

Each packer has his own ideas on packaging. Certain problems, however, are common to all branches of the industry. Manufacturing costs, strength, suitability for use with automatic handling, sales appeal, resistance to moisture and vapor, and ability to minimize desiccation, are some of the factors that must be considered in suitable packaging.

The conventional package has been a sealed inner lining, placed in a treated cardboard container, with a sealed overwrap. There is a trend toward a one-piece laminated box which will greatly simplify filling. Other packaging materials in use are the window-type box, which uses the newer transparent films, and the very

[3] Exclusive of locker plants which are discussed later in this chapter. Out of an estimated 981 freezing plants, 253, located in Massachusetts and in Coastal and Great Lakes areas, were engaged in the freezing of fish.

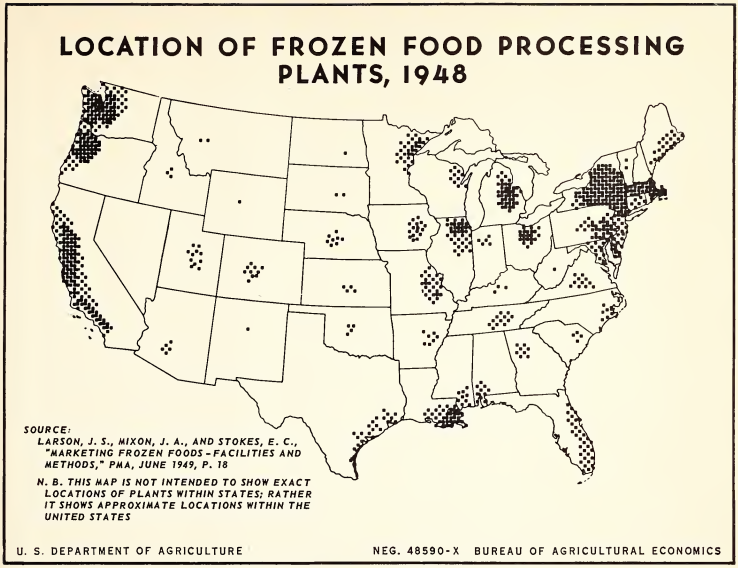


FIGURE 6

successful rigid cardboard container with metal ends. Concentrated frozen juices are packed in cans, and glass jars with metal lids are used for coffee concentrates. Institutional and industrial packs, which range from 7 to 50 pounds in size, utilize lacquer-lined tin cans with friction top lids and fiber containers for some vegetables. Another new material is aluminum foil, which is leak- and moisture-proof and which has been adapted to manufacturing lines. Other packaging materials include treated paper, wax coatings, latex rubber, and polyethylene bags or laminates.

Storage and Transportation of Frozen Foods

In the frozen-foods industry initial freezing is only the first step. Technological developments in the freezing process which lead to better preservation or lower cost can be rendered ineffective by failure to maintain proper temperatures after the product leaves the freezing plant. Figure 7 shows the likely agents through which frozen foods may be distributed. These include the functions of transporting, storing, and selling. Problems in these fields had to be surmounted before frozen food for the mass market became a reality.

Technical improvements have made it possible to transport and store frozen foods more efficiently or economically than previously. Even without some of these improvements, most frozen foods can be stored and transported more cheaply than their fresh equivalents (table 8). This is true because in processing for freezing a greater proportion of the inedible parts of the product are left at the point of production or of processing.

Technological advances made thus far in the storage and transportation of frozen foods have led to better maintenance of quality than was hitherto possible, reduction in those costs which reflect bulk or weight of a product, lower cost refrigerants, and greater ease in handling.

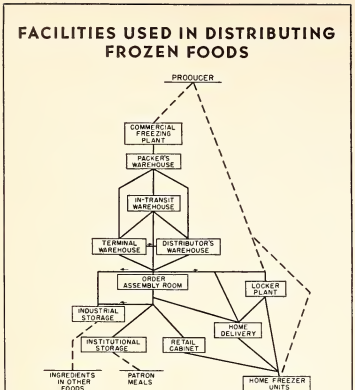


FIGURE 7

Storage

In general, the lower the temperature at which frozen foods are stored, the less the deterioration, provided they are adequately packaged. However, it is not economically feasible to store at temperatures much below 0° F. This temperature is low enough to retain quality in most products.[4]

Freezing plants normally require 0° F. storage at the plant or in nearby public warehouses for a sizable portion of their annual production. Recent warehouse construction has been designed to permit use of modern handling equipment and is generally better adapted to the requirements of frozen foods. In many of the older buildings, delays in waiting for elevators often cause undesirable warming of frozen products. In-transit warehouses are now located at points more suitable to the transportation network for frozen foods, rather than at points dictated solely by requirements for perishable commodities that do not need subfreezing temperatures. With the experience gained in operating storage warehouses for frozen foods, progress has been made in insulation applications.

As more food moved into storage at subfreezing temperatures, the problem of fluctuations in temperature became more acute. Some of these fluctuations resulted from improper functioning of temperature-control devices; others from temporary break-down of the equipment itself. Excessive loading of the freezing room was an additional cause, as was the frequent opening of doors for loading and unloading. Improvements in design of machinery and storage rooms, and experience in establishing maximum capacities have already removed a number of the difficulties.

The problem of what temperature, if any, marks a point below which fluctuations are unimportant is an open question. Agreement is fairly general that comparatively rapid changes in quality occur in some foods stored at 10° F. Some authorities believe that certain products deteriorate more rapidly at temperatures that fluctuate between 0° and 10° F. than at a constant temperature of 10° (*25*). Others believe that constant temperature is unimportant if the maximum does not rise above 5°. The problem of fluctuation is still under investigation.

The effect of humidity in the storage room offered another difficult problem to the technologists. At low temperatures, the coils of the refrigerating system act as a condenser for the moisture in the air of the storage space and the moisture forms frost on the coils. If the air in the freezing room is relatively dry it attempts to pick up moisture from the stored products. Improperly protected materials, particularly meat and poultry, are then subject to a drying out of the tissues known as freezer burn. The advantages of high humidity during freezing storage are now well recognized, although during the early years of the industry this question received little attention. For a time much of the problem was masked by the common practices of freezing meat in bulk and of glazing hams and fish with a coating of ice. These methods prevented drying out. Then public demand for packaged fish fillets stimulated the development of new packaging materials and led to a demand for small portions of meat and other products in frozen form. Glazing of fish and bulk freezing of meat became less common and a familiar pattern was repeated: progress in packaging and retailing created a new technical problem.

Thus far, the new problem has been met principally through development of even higher-quality packaging

[4] One of the most important exceptions is frozen milk, for which a maximum storage temperature of —10° F. is required. Even lower temperatures, down to —20°, are considered preferable. The difficulty of commercially maintaining such low temperatures is one of the chief reasons why the freezing of milk has as yet been of small commercial importance.

TABLE 8.—*Comparative cost, based on railroad charges for shipping certain fruits, vegetables, poultry, and meats in both fresh and frozen form* [1]

Commodity [2]	Amount to ship to get one car of edible merchandise [3]	Refrigerated cars required [4]	Freight rate per cwt.	Estimated refrigeration cost per car	Total cost per car	Transportation cost per 1,000 pounds of edible merchandise
	Pounds	*Number*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Fruits:						
Frozen	53,000	1	1.61	157.30	1,010.60	19.07
Fresh (deciduous)	68,000	2	1.83	125.64	747.84	28.22
Vegetables:						
Frozen	46,000	1	1.61	157.30	1,010.60	19.07
Fresh	106,000	5	[5] 2.17	105.20	565.24	61.00
Poultry:						
Frozen (eviscerated)	20,000	1	1.31	90.00	352.00	17.60
Frozen (New York dressed)	28,000	1	1.31	90.00	456.80	22.84
Live	32,000	0	1.48		236.80	23.68
Beef:						
Frozen (boneless)	21,000	1	1.30	90.00	363.00	17.29
Frozen (carcass)	29,000	1	1.30	90.00	467.00	22.24
Fresh (carcass)	29,000	1	1.30	34.36	411.36	19.59

[1] Rates for fruits and vegetables are from California, Oregon, and Washington to New York City as of January 10, 1949. Rates for poultry and beef are from Chicago to New York as of January 10, 1949.
[2] Based on products that are commonly frozen.
[3] Ratios based on CONVERSION FACTORS AND WEIGHTS AND MEASURES FOR AGRICULTURAL COMMODITIES AND THEIR PRODUCTS (*81*).
[4] Shipping weights equal to or above the minimum per car are used. Nonrefrigerated cars used for live poultry.
[5] Average for several vegetables.

materials that resist desiccation. Meanwhile, devices for maintaining high humidity throughout the storage room have been developed and some have been brought on the market, but these devices appear to need further refinement before they can come into general use.

Transportation

In the early days of the frozen-food industry, it was obvious that mass distribution over any considerable distances would not be practicable without large-scale improvements in transportation facilities. In transit, as in static storage, frozen products must remain frozen —and at temperatures well below the freezing point. Much technological ingenuity has gone into the solution of this problem. Great progress has been made; mass distribution is an established fact. New gains are being made, but even further progress is needed.

The results of a considerable body of research have led to the conclusion that long-term storage of frozen foods should be at 0° F. or lower if quality is to be fully preserved. Less is known of the effects of somewhat higher temperatures for shorter periods, as when a frozen product is in transit; that question is now being investigated. The frozen-foods industry in general takes the view that its products should be held at or below 0° F. in transit as well as in longer-term storage. By the end of 1950 some refrigerated trucks and railway cars were capable of maintaining the desired low temperatures uniformly but the majority were not. The long effort to build and operate an adequate number of satisfactorily refrigerated units has characterized the relationship of both railroads and truckers to the frozen-food industry.

Rail Transportation

In the 1930's, with a Nation-wide rail network already in existence and refrigerator cars in wide use, it was natural that many persons in the frozen-food business should think in terms of shipping by rail. Certain obstacles stood in the way. On long hauls, shipping schedules tended to be inflexible and average miles per hour for complete runs fairly low, principally as a result of making up long trains. At many rail terminals, refrigerated storage space was either inadequate or nonexistent. But the chief difficulty in transport was the fact that conventional refrigerator cars were not capable of maintaining during all seasons of the year the sustained low temperatures required for frozen foods.

A number of steps have been taken to overcome the difficulty. Regular refrigerator cars, which were found to be inadequate for the task of transporting frozen foods, have 3½ inches of insulation and are equipped with end bunkers in which ice is carried. The first

move toward improvement was the use of salt with the ice. Then, in an effort to get still lower temperatures, cars with 3½-inch insulation were equipped with air-circulation fans powered by a car's own wheels when it was in motion. At the same time, experiments were made with 6-inch insulation for cars, some of which were fitted with end bunkers and some with overhead brine tanks. Some of these cars were equipped with inner linings to create a flue for the passage of air in order to remove heat before it entered the lading.

Both lines of endeavor resulted in lower cargo temperatures, although they were not as low as the industry desired. Under optimum conditions of loading and unloading and of quick transit from shipping point to destination, the performance of the more lightly insulated cars with fans was comparable to that of the heavily insulated cars, but tests showed that under adverse conditions the latter were more dependable. The Frozen Food Traffic Committee of the National Association of Frozen Food Packers recommends the use of cars with at least 6 inches of insulation.

Meanwhile, new types of refrigerator cars were built and put to experimental use. A few used dry ice as the primary refrigerant, with a secondary refrigerant circulated through coils along the walls. A larger number had complete mechanical refrigeration units. Tests were made also with end-bunker fan cars in which dry ice was placed on top of the cargo. Experiments conducted in the summer of 1950 by the United States Department of Agriculture, in cooperation with the frozen foods industry and the railroads, indicated that the performance of all these new types was better than past averages and that the mechanically refrigerated cars seemed best adapted to maintaining temperatures of 0° F. or below (*51*).

About 165 mechanically refrigerated cars, capable of maintaining temperatures of 0° F. were expected to be in service by the end of 1951, with more in prospect later. Some of the refrigeration units are powered by gasoline motors, some by small diesel engines.

Meanwhile, because of poor rail connections of many cities and inadequacy of refrigerated warehouse space —two circumstances which have been greatly improved in recent years—many wholesalers turned to motor-trucks for the delivery of frozen foods.

Refrigerated Trucks

The rise of the highway truck as a major factor in medium- and long-haul freight transportation has in large measure paralleled the development of the frozen-food industry. Because of this, the scope for adapting truck design to the technological requirements of hauling frozen foods has been broad.

Refrigerated highway trucks are now widely used for transporting frozen foods. Most of them have 6 inches of insulation. Fiber glass is the most common truck insulation used today.

The specially adapted models are owned and operated both by frozen food distributors and truck-transport lines. Many other refrigerated trucks are constructed for cool temperatures only and are not suitable for transporting frozen commodities.

While many of the city delivery trucks use dry ice as a refrigerant, the mechanically refrigerated trucks usually have a compressor driven by a gasoline engine. Although the low temperature in some truck bodies is acquired by means of a refrigerant circulating through coils, most highway trucks use the air-blast system, with space around the walls and floor for air circulation. The importance of providing adequate circulating space is still not generally recognized by truckers and manufacturers.

The biggest difficulty with the mechanically refrigerated system is that the moving parts are subject to break-down, so that facilities for quick repairs and properly trained drivers are necessary if satisfactory service is to be maintained.

In the last 10 years, builders of truck equipment have made striking improvements in the mechanically refrigerated truck, which now comes closer to the goal of positive control of cargo temperature. Air circulation, one of the most stubborn problems, is being improved. During the course of tests, conducted cooperatively by the United States Department of Agriculture and the industry for several months in 1950, a new type of duct to draw return air from the floor instead of the top of the load was developed, resulting in improved efficiency.

Some trucks now in use are capable of maintaining cargo temperatures of 0° F. or below, but improvements in equipment and methods are needed to raise the general level of service. The chief advantage of refrigerated highway transport is its flexibility and the opportunity to tailor design to the specific needs of any important class of shipper. A truck can pick up its load at the door of the freezing plant and deliver it with a minimum of delay to the distributor's warehouse or even to a large retail store.

Refrigeration of Small Shipments

Special containers have been developed for shipping small quantities of perishable foods. Some of these

belong to wholesalers who ship some frozen foods along with products not requiring refrigeration. Others are controlled and rented by the Railway Express Agency. The typical container of this kind is a large insulated metal box equipped with dry-ice bunkers. The bunkers fit into the cargo space and hold up to 100 pounds of dry ice. These containers provide 10 to 12 cubic feet of storage space for shipments weighing from 300 to 400 pounds. If frozen foods are to be shipped long distances, storage space can be sacrificed for larger dry-ice bunkers. Insulated shipping containers also are used for storing frozen foods when refrigerated facilities are not available. Some consignees are willing to pay an additional fee for holding the container as a refrigerated storage unit until the frozen foods are used.

Wholesaling and Retailing

Most of the technological problems in the sale of frozen foods through wholesale and retail channels relate to keeping the products at sufficiently low temperature while they are moved out of long-term storage warehouses and into short-term storage at the distributor's plant, assembled, delivered to retail stores or institutions, and displayed in retail stores until the time of purchase. Many of the conventional methods and equipment used in performing these functions for nonfrozen foods are not well adapted to the maintenance of near-zero temperatures.

Wholesaling

Although many of the firms engaged, either wholly or in part, in wholesale distribution of frozen foods also undertake long-term frozen storage, they usually regard it as a separate function of the type already discussed. The wholesaler's job, as considered here, begins with receiving frozen foods into short-term storage preliminary to further distribution.

The burden on wholesalers is considerably greater in the frozen-food industry than in other food-distribution systems. Wholesalers of nonfrozen foods deliver to retailers and institutions almost entirely in case lots. With frozen food, however, this job is considerably more complicated. A wholesaler delivers many of his orders in less than case lots because retailers generally have no freezer storage space other than the retail frozen-food cabinets. Usually these retail cabinets contain a wide assortment of items and are shared by several wholesalers of frozen food. So, deliveries must be made more frequently than deliveries by conventional grocery suppliers.

During the early 1930's, when the frozen-food industry was beginning to grow as a mass enterprise, accidental circumstance temporarily took care of some of the physical problems of wholesalers. Public refrigerated warehouse space during that period was seriously underutilized. Thus, wholesale distributors could easily get ready-made facilities for setting up their order-assembling activities and, in most instances, the need for separate short-term freezing storage space was obviated.

Eventually, demands upon public refrigerated storage space became heavier and distributors were thrown back upon their own resources at the very time their operations were expanding and thus were creating a greater need for refrigerated storage. Their facilities did, and still do, vary widely in suitability.

Some distributors have quarters that are too cramped for efficient order assembly, a poor location, or unsatisfactory facilities for loading trucks. For example, a recent study by the Production and Marketing Administration revealed that, of those wholesalers visited who operate independently of refrigerated warehouses, 40 percent have no platforms at truck-bed level; and three-fourths of the wholesale distributors who depend primarily on rail shipments of frozen foods into the city have no direct rail connections to their plants. (28)

Some distributors have met their difficulties by building new plants of modern design. Others have relied mainly on the application of up-to-date handling equipment. But it is the relationship of methods and equipment to physical plant arrangement that is the chief key to efficient operation. The noticeable trend toward selling in full cases is making wholesalers hesitate to undertake extensive remodeling to facilitate handling of less than case lots.

The problem of short-term storage in itself has been attacked by use of previously discussed methods of refrigeration and guarding against desiccation. But in wholesale distribution the relationship of the storage room to the assembly room also is important. Deliveries to retailers still are usually made in less than case lots. Individual orders must be assembled and at times this can be a complex operation. Yet during this process thawing of the frozen food must be prevented.

Some wholesalers have met the problem by adopting plant designs whereby the assembly room, although partitioned from the storage room, is cooled by the same refrigerating apparatus and held at the same or only a slightly higher temperature. This system works well except for its effects upon those who do the assembling in a room where the thermometer reads well below freezing.

An alternative system is to take advantage of every

possible device for mechanized, speedy handling of frozen food, and to assemble orders in warmer temperatures, sometimes as high as 70° F., so quickly that they can be put back into 0° storage before the food has time to deteriorate seriously. Gravity and power-driven conveyor belts have been especially designed for this purpose, and fork-lift trucks and pallets are used by some distributors.

Actual distribution of the food is the next danger point. Again, in modern plants, special design and equipment have been utilized to hold the orders in frozen storage until the last possible minute before loading on delivery trucks.

The trucks themselves vary greatly in design. A survey by the Production and Marketing Administration shows that at the end of 1949 nearly half of the trucks used to deliver frozen foods were refrigerated and that another 31 percent were insulated. But the remaining 22 percent were not protected in any way; some, in fact, were open-stake models (28, p. 62).

Methods of refrigerating delivery trucks range from distributing dry ice loosely around the order boxes to portable motor-driven condensing units. The latter systems, however, are comparatively rare. One of the more usual methods is the installation of specially designed holding plates which can hold the temperature at a low point after refrigeration. In some instances, the plates are refrigerated by a compressor unit that runs only when plugged into an external source of electric power. In others, no compressor is required; the refrigerant is pumped from an outside source through the holding plates.

Much care has gone into the design of truck bodies. Many have only a single door, to cut down the opportunity for warm air to come in. Other models, which are especially adapted to congested and uncertain traffic conditions, have a side as well as a back door, so that orders can be taken out quickly when deliveries cannot be made in the order planned when the boxes were placed in the truck. Models have been developed with several separate compartments, each with its own small door. This type of design localizes the effects of warm air when the driver reaches in for any particular product; it is especially well-adapted to the needs of wholesalers who sell direct from trucks.

Retailing

Although some retail distribution of frozen foods began as early as 1930, during the first years these products were bought almost entirely by institutions, public eating establishments, and manufacturers of finished products such as bakery goods and ice cream.

The quantity of frozen fruits and vegetables packed in consumer sizes varies from year to year, but the trend clearly is upward. From 1942-43, when marketing to the consumer began to receive attention, to 1949, the percentage of total pack going into consumer or retail sizes increased. In fruits, the increase was from less than 10 percent to about one-fifth; in vegetables it was from one-third to two-thirds of the total pack. Around 80 percent of frozen orange concentrate is packed in retail sizes (38).

Although some commercially frozen foods are sold by locker plants and special firms that cater to owners of home freezers, by far the greater volume moves through retail stores. The two principal types of store are the supermarket and the neighborhood grocery.

Naturally, specific situations vary widely among the types of stores and even within each of the types, yet certain broad problems are common to all of them. Chief of these problems is how to preserve frozen food and at the same time to display it in such a way that customers will be influenced to buy it. The answer, as it has been developed thus far, is the specially designed retail storage and display cabinet for frozen food. If preservation were the only object, customers might not be able to see the products at all; if display alone were the goal, the products might thaw and become unfit to eat.

Although a leading processor of frozen food became interested in construction of specially adapted display cases as early as 1930, the first frozen foods sold at retail were generally dispensed from the refrigerated cabinets that had been developed for ice cream and for meats. These were difficult of access and otherwise not adapted to self-service. Soon designers were at work upon special models adapted to self-service, which from the start were closely associated with the retailing of frozen foods. By 1934, at least one practicable, fairly low-priced model had been developed commercially and made available to retailers on a rental basis. By 1940, several manufacturers were selling a variety of models adapted to various special situations.

Most of the cabinets in use at the end of 1950 were of the chest type, built low to the floor. Basically this design has drawbacks as a display medium, but many of the difficulties have been overcome by the use of glass which the customer can see through and by the placing of mirrors at effective angles. Self-service is facilitated by easily opened glass panels at the side or top. Engineers have found ways to prevent glass from being clouded by condensation due to temperature contrasts. Many of the chest cabinets have no doors or panels, but

are open at the top, on the principle that cold air stays close to the floor and thus, for the most part, remains in the refrigerated cabinet.

Vertical cabinets, built up high from the floor like sectional bookcases, have come into use in recent years. Usually they are placed against walls. Elaborate models have been developed with numerous compartments with separate doors, so that a minimum of cold air will be lost when a customer reaches in to get a package. Some of these cabinets are equipped with automatic lights which warn attendants when each compartment is empty. The most intricate refinement introduced thus far is the coin-operated door for each compartment. These vertical cabinet models are generally considered more expensive to operate, chiefly because of the tendency of the heavy cold air to spill out whenever a door is opened, and because they have less storage capacity per unit of refrigerated space. Engineers, however, already have developed several ways of reducing the losses of cold air.

Much technological work remains to be done in maintaining sufficiently low temperatures in retail cabinets of all types. One of many indications of this continuing need is a sampling in 4 different years (1948–51) of 55 cabinets in West Coast markets that handle frozen fruits and vegetables; [5] this study showed wide differences in the temperature levels of the display cabinets. Closed-top cabinets ranged from 14° F. to −12°, open-top from 21° to −7°, and one upright, closed cabinet was held at −10°. The sample was too small to be broadly representative.

The location of refrigerated cabinets in the store also has presented problems that concern installation costs and efficiency of operation as well as relation to counters for other kinds of food and to general traffic of customers through the store. One usual question, the solution of which varies with different types of store, is whether to maintain a wholly separate department for all frozen foods or to locate the cabinets for each different kind of food near the counters for fresh or canned varieties.

The technical aspects of many questions are deeply interwoven with commercial questions that concern retailing practice in general. For example, judging by the varying opinions of the trade, the question of whether a frozen food cabinet, with its initial cost and operating expense, brings better returns than the display it replaces, is as debatable as it is important. Undoubtedly, the required investment in a display cabinet has retarded expansion of sales of frozen foods, as has uncertainty concerning consumer attitudes and the necessity of stocking a small quantity of a large variety of products. More than anything else, the spectacular success of frozen citrus juices is resolving these uncertainties for the retailer by providing him with a frozen food which is a sure seller and a volume item.

[5] Supplied by D. G. Sorber, U. S. Dept. Agr., Western Regional Research Laboratory.

Locker Plants

The locker plant has developed as a specialized storage, processing, and selling agency that utilizes freezing for storing. The modern locker plant generally combines all of the operations incidental to the marketing of frozen foods. The first locker plants provided frozen storage space only. But in 1949, a survey of 100 cooperative locker plants showed that revenue from processing operations averaged 33 percent more than from rentals of refrigerated locker space. As processing and handling service increased, the number of locker plants multiplied and facilities were expanded still further to include provisions for slaughtering livestock, curing, grinding, and wrapping of meat, and manufacture of edible and inedible byproducts. From 1940–41 to 1947–48, the number of plants as a percentage of the total number reporting increases in services were as follows: Slaughter, 5 to 33 percent; poultry-dressing facilities, 0 to 22 percent; and curing and smoking facilities, 40 to 65 percent (35).

The number of locker plants has grown about ninefold since 1938 and in 1950 plants were located in every State (figs. 8–9).

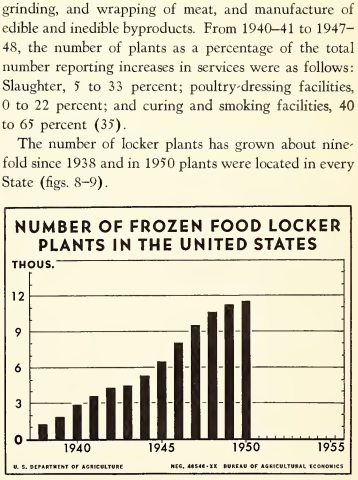


FIGURE 8

Locker plants are primarily engaged in the processing and storing of meat, meat products (beef and pork), and poultry. They are found mainly in rural areas

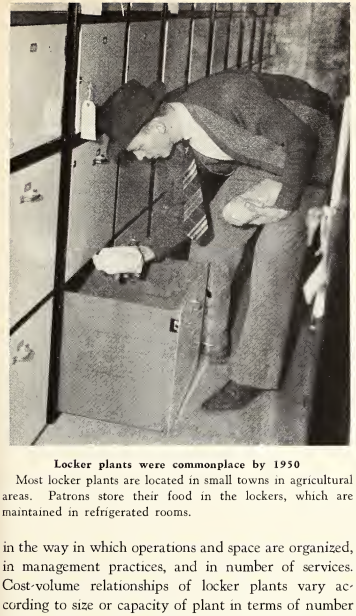
FIGURE 9

and serve producers who grow their own products. City home-freezer owners use locker-plant facilities to a lesser extent. It is estimated that, in 1950, 93 percent of the processing in locker plants consisted of meat and poultry products and the remaining 7 percent of fruits and vegetables (35).

In recent years, as the number of home freezers has increased, locker plants near large towns have tended to buy carcasses of meat and sell it by the quarter, half, or whole to owners of home freezers or to locker renters. The locker operator cuts and wraps the different cuts for his patrons. Although plant operators usually charge a small handling fee, most of the income from this type of operation comes from charges for cutting, wrapping, and freezing. Locker plants also tend to buy poultry and commercially frozen foods and sell them at some discount to owners of home freezers. Many plants now derive a large part of their income from this type of business. Some plants engage wholly in this operation and do not rent locker space.

Specialized facilities for locker-plant storage were provided as early as 1917, but not until the 1930's were plants constructed which were actually designed to offer modern services (59, p. 42). Reasons for changes in design and scale include increased consumer recognition of higher-quality products which have resulted from advances in freezing methods. Also important were the legal requirements for more sanitary processing and freezing and improvements in refrigeration, especially adaptation to small-scale units. Important, in this connection, were advances in automatic controls and development of relatively small-scale compressors. Recently a pea and bean sheller and corn cutter, not before available, were placed on the market; they are designed primarily for locker plants and community canners. Scalding equipment also is available, as well as hand tools and mechanical aids such as slicers and pitters.

The technology of freezing is the same for different sizes and types of locker plants. Plants differ, however,



Locker plants were commonplace by 1950

Most locker plants are located in small towns in agricultural areas. Patrons store their food in the lockers, which are maintained in refrigerated rooms.

in the way in which operations and space are organized, in management practices, and in number of services. Cost-volume relationships of locker plants vary according to size or capacity of plant in terms of number of lockers, degree to which capacity is utilized, ratio of locker space to gross space, time period, number of years the plant has been in operation, and number and variety of services offered. As future studies take all of these factors into account together, the results will provide operators of locker plants with a basis for comparing their operations with those of other plants.

From a national viewpoint, local locker plants apparently have not affected commercial marketing of meat products to any significant extent. A recent study by Bjorka and Fritts covers about half the lockers in the United States and sums up the over-all effect as follows:

> Meat obtained from slaughter for storage in frozen food lockers is estimated to be equivalent to about 6 percent of all meat produced by commercial slaughter. The bulk of this amount represents meat that in the absence of locker plants would not have been produced by commercial slaughter, but would have been obtained from farm slaughter for home use by farmers. Locker plants have made it possible to shift storage of meat on the farm (as fresh, cured, canned, and smoked meats) to central freezer storages and have likewise enabled farmers around numerous plants to dispense with farm slaughter in favor of slaughter at the locker plant. Such operations in themselves have not lessened to any significant extent the normal volume of livestock flowing into commercial livestock and meat distribution channels. There is some diversion to the extent that larger numbers of animals are locally killed and processed than before locker plants provided such service and that urban locker renters procure their meat from this source. Such diversion, however, has been very small (43, p. 8).

Consumption of Frozen Foods

From 1930 to 1950, equipping of home kitchens with mechanical refrigeration made tremendous strides. This development has had important effects on the tasks of shopping for food, and preparing and serving it at home. More significant for this discussion is the fact that without adequate refrigeration, storage of frozen foods is limited. Thus, the widespread use of the mechanical household refrigerator, itself a product of technology, has been a necessary factor in expansion of the retail market for frozen foods.

Mechanical refrigerators for home use were developed before 1930, but only 1 household in 10 had such equipment in that year. By 1950, 8 in 10 households had mechanical refrigerators. Although only a small proportion of these machines had special compartments that maintained low temperatures, some frozen food could be kept in the space designed for ice cubes. As ice-cube compartments do not maintain temperatures much below 15° F., frozen foods can be kept in them only a few days without deterioration. Home freezers have played a comparatively small part in final storage until recently; but there is a marked upward trend in their use. Early in 1949 most of the families with home freezers lived in rural areas and probably used their equipment as much for freezing and holding home-produced foods as for storing the products they bought. Since then, monthly sales of home freezers have almost doubled, with many of the purchases made by city families. Estimates of the National Electrical Manufacturer's Association indicate that at the close of 1950 about 3½ million families had home freezers. Further expansion in home storage for frozen foods is possible as the remaining families now without mechanical refrigerators acquire them, and as more refrigerators with special compartments for storing frozen foods and more home freezers are sold.

Quick transportation from store to home, like adequate refrigeration, is needed for full satisfaction from frozen foods. Hence, the family automobile, like the home refrigerator, is a technological development that

has contributed to increased home consumption of frozen foods.

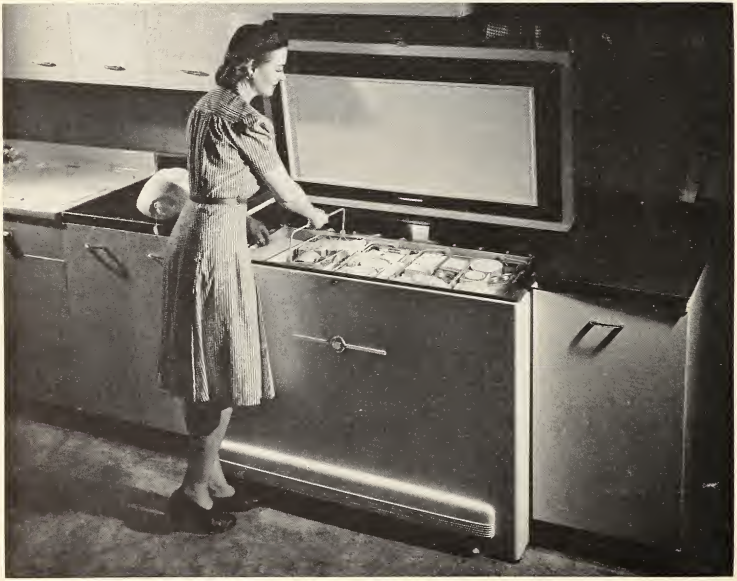
Despite the popularity of frozen foods, their consumption in homes is still much smaller than that of their canned and fresh counterparts. Comparisons for fruits and vegetables consumed by city families in 1948 are shown in table 9. Despite further increases in frozen food consumption since that date, the comparison today would not be markedly different.

The popularity of frozen foods is attested by response to consumer surveys (*53*, pp. 8–18; *18*). Moreover, the larger amount used by higher-income families also suggests that when choice is less limited by the food budget frozen foods are more popular.

On a cost basis, frozen fruits and vegetables seldom compete favorably with canned (*31*). Price competition with fresh products varies with season. Changes in these relationships at different seasons and the price effects of an increased volume of frozen foods are illustrated for orange juice (fig. 10).

There is agreement, however, that the frozen vegetables save labor for the housewife; peas do not have to be shelled; spinach does not have to be washed. Frozen fruits and vegetables take less space in the refrigerator than fresh and they can be held several days in most refrigerators. Furthermore, the buyer of a frozen vegetable such as peas knows the quantity of edible food she has purchased; she has no such certainty when she buys the fresh product, as the waste from a pound varies greatly. The higher prices, therefore, in part represent added services for which many housewives are willing and able to pay.

In assessing the possibilities for expanded consumption, a system of distribution that would make frozen



A type of home freezer

It is obvious that no single type of home freezer will answer all purposes. Medium-sized or small freezing cabinets, with capacities of 4 to 12 cubic feet, similar to the one shown above, are in more general use than larger freezers. (*Photograph from Electrical Merchandising.*)

TABLE 9.—*Consumption of fresh, canned, and frozen fruits and vegetables by urban families, United States, April-June 1948* [1]

Income class (1947 income after Federal income tax)	Families	Fruits and fruit juices				Vegetables			
		Total	Frozen	Canned	Fresh	Total	Frozen	Canned	Fresh
	Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
All incomes [2]	1,558	4.49	0.024	1.03	3.44	3.82	0.065	1.05	2.70
Under $2,000	257	3.26	.013	.73	2.52	3.24	.023	.85	2.37
$2,000 – $3,999	761	4.19	.019	1.01	3.16	3.60	.045	1.06	2.49
$4,000 and over	393	5.53	.036	1.22	4.27	4.37	.120	1.06	3.19

[1] Average purchased quantities used at home per person in a week, by income class, housekeeping families of 2 or more persons.

[2] Includes some families for whom no income data were obtained. Calculated from FOOD CONSUMPTION OF URBAN FAMILIES IN THE UNITED STATES (*67*).

foods available at lower cost appears to be the main problem that technology and economic organization of the food industry have yet to solve. Adequate home refrigeration, formerly a limiting factor, has been made increasingly available. Tremendous advances have

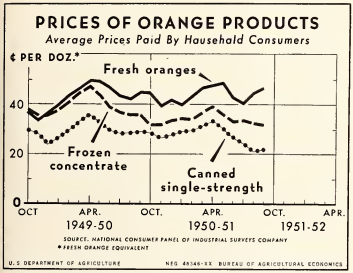


FIGURE 10

been made, also, in equipping retail outlets with frozen-food cabinets, so that frozen foods now are available to most shoppers. Continued increase in household consumption is likely, especially if frozen foods can be offered that compete more favorably as to cost with canned foods and with fresh fruits and vegetables in season.

One current problem concerns the changes in a frozen product that may take place from the time it leaves the freezing plant until the consumer buys it. At present levels of technology the length of time that various products may be expected to retain their quality under good storage and transportation conditions is fairly well established. Dating of packages at the time they leave the freezing plant might be helpful to wholesalers, retailers, and consumers. But other factors in quality would remain unaccounted for, particularly the question of whether a product had been permitted to thaw during the distribution process. Recent experiments indicate the possibilities of including in each package a substance that turns color upon thawing. Such a device, in itself, might prove of small practicable value, as technologists generally agree that in most instances the length of time a product has been allowed to thaw, rather than the fact that it may have thawed briefly or partially, is the measure of possible deterioration.

Thus, the advance of marketing technology continually generates further problems for the technologist.

In the long run, consumer preferences, or the hope of creating them, set the problems for the technologists, from processing to retailing. Each broadening of the mass market puts an added premium on new equipment and methods that will reduce costs and improve quality.

The story of the rise of the frozen food industry is an example of the place of technology in modern marketing and of the constant interplay among technical, economic, and social forces. The end product is what counts. Without marketing technology we would have no frozen foods. Yet, despite a number of individually brilliant achievements in developing new machines and methods, if the foods developed had not been tasty and easy to prepare, and if their prices had been out of reach of moderate-income families, there would not be today a mass frozen-foods industry.

CHAPTER 3

Technology in Commercial Processing

Almost all food products are processed to some extent before reaching the retail store. More and more, this is becoming a commercial operation, taking place on a large scale in modern food factories. Technological gains during the last 20 years have done much to make possible these large-scale operations, with their attendant increases in efficiency and economy.

Food processing is a broad field, made up of a number of industries that in themselves are large—canning and preserving, freezing, dehydration, extracting and refining, meat and poultry packing, baking, dairying, and miscellaneous food industries.

The number of operations performed in modern food processing is bewilderingly large. Among the most important are separation of edible or more valuable materials from inedible or less valuable materials by means of crushing or pressing (fruits, oils, sugar); filtration of juices or liquids from pulp or solids (fruit); flotation of sound from damaged oranges or peas; concentration by removal of water, for juices, sirups, and preserves; distillation of volatile compounds such as oils from fruits or herbs; centrifugal separation of oils from fruit juice and fats from milk, and clarification of juices; emulsification and homogenization as in milk, margarine and salad dressing; crystallization of sugars and organic acids; and mechanical sifting of coarse from fine materials (cereals). Many of these operations are done by machines similar to those used in other branches of industry.

Among the important unit operations which are carried on in food plants, handling of the product, packaging, and sanitation requirements are common to all. Also, a decided shift from traditional vat or batch methods to continuous operations has taken place in all of the various industries that process food. These common developments are presented separately for special consideration. Other important developments are covered in the discussion of each of the leading industries in the food-processing field.

A Word About Automatic Instruments

Along with development of improved processing equipment mentioned in this chapter have come accurate and efficient control devices, such as proportioning pumps, pH indicators, flow meters and level indicators, and instruments to control and record a wide range of temperatures and relative humidities. These increase the usefulness of nearly all kinds of processing equipment, reducing labor costs, eliminating human errors, and making for higher and more uniform production.

Many of these automatic devices are electric, others are pneumatic or hydraulic, and still others use a combination of these systems. The condition or environment for control are usually temperature, humidity, pressure, and volume or flow.

The most recent developments in automatic controls used directly or indirectly in the marketing and utilization of foods involve centralized control panels and electronic applications. In early attempts to control certain environments, locally mounted instruments such as thermometers were used merely as indicators and the operator manipulated devices for obtaining the desired conditions. The new instruments not only provide the desired condition automatically but indicate and record it as well. Thus, a glance at the instrument panel not only indicates to the management existing operating conditions throughout the plant at the moment but provides a continuous record for future use.

The usefulness of electric control systems has been enlarged by the introduction of electronic controllers. These new instruments are in general more sensitive, more accurate and cost little, if any, more than their predecessors.

Materials Handling: The Trend Toward Bulk Handling

Technological developments in handling of products in processing plants have been numerous. Despite the great increase in mechanization during recent years, an estimated 30 percent of the labor costs in food processing still goes for the handling of materials. The search for better methods, therefore, is still of great importance.

Emphasis on handling of materials is fairly recent in food-processing plants. Most of the methods and

devices have been borrowed from other industries. The trend toward continuous operations has been largely responsible for innovations in methods of handling materials; processing operations cannot be completely automatic and straight-line unless handling is mechanized and geared into over-all operations.

Within the last 20 years there have been so many developments in the handling of materials in the food-processing industry that it is possible here to mention only a few that illustrate major trends.

The more recent line of development has been the trend toward bulk handling. This has been especially important in the receiving of incoming raw materials or ingredients and the movement of these items to and through the processing operations. Bulk-handling techniques are most suitable to liquids and solid materials that can be made to flow from one place to another as though they were true liquids.

Hydroconveying

Materials that will flow, and that are not harmed by immersion in water, have for some time been conveyed in a moving stream of water through a canal, sluiceway, or pipeline. This type of conveying was originally utilized when movement from a high to a lower point could take advantage of the force of gravity. Its particular application was found in handling fruits and vegetables such as citrus fruits, tomatoes, and peas.

In recent years, the canning industry has begun to use hydroconveying as a means of moving such items as green peas, lima beans, cut corn, string beans, and almost any solid up to 3 inches in diameter along a horizontal plane and even from a lower to a higher point. The development of a suitable pump has been the strategic innovation. This type of handling is really a form of pumping, as the water stream is moved by pumps, and the solid material is carried by the force of the moving water. When the stream is forced uphill, the solids are able to pass through specially designed pumps. Advantages of this method are in the time saved in the actual processing operation, and in reduced desiccation and partial cooling of the product. Such items as lima beans, peas, and cut corn move with less bruising and deterioration than by other methods. Chlorine or other chemicals added to the water may help to combat bacterial growth. Although this method has many advantages, caution is still displayed by processors of products which are susceptible to leaching of nutrients.

Hydraulic pumps and pipelines are used extensively to move liquid products. Development of liquid sugar has broadened the usefulness of this method. The liquid sugar is delivered to the plant in tank car or truck, and drawn by pump or gravity to storage tanks in the processing plant. Plant sanitation is improved by liquid handling. Exact control of sugar input or other liquid ingredients made possible by automatic metering results in savings in cost as well as in products of a higher quality.

Another application of the bulk-handling principle is that of pumping milk from the tank car or truck into the processing plant. Combined with pumping milk from the milking station into the tank car or truck, this system greatly reduces the possibilities of contamination and insures a higher-quality milk at the processing plant. It also does away with much manual labor and eliminates the need for milk cans.

Extension of the Dump-Truck Principle

For bulk handling of grains such as wheat, corn, oats, peanuts, and soybeans, handling devices have been developed to take advantage of the force of gravity. An unloader has been devised which gives trailers and large trucks the labor-saving advantage ordinarily associated with dump trucks. In this operation a truck or tractor-trailer loaded with grain moves under its own power onto a ground-level unloading platform. After brakes are set and wheels immobilized the front of the platform is raised by hydraulic cylinders. Then the tail gate of the truck is opened, and the grain flows by means of gravity through gates into an underground bin. From there it is moved by screw conveyor or other means to the elevator for storage, or, if a flour mill, to the processing line. Simpler adaptations of this idea have been developed for mills whose operations do not justify large outlays.

The same principle is applied in the handling of grapes. Economies of bulk transport to and unloading at the processing plant appear to more than offset the disadvantages of greater crushing, molding, and souring of the grapes. Changes toward bulk handling took place in three steps: first, the elimination of 50-pound lug boxes and the use of open-bed trucks and hand shoveling at the winery. Next, greater economies were obtained from the use of gondola trucks and trailers and the use of cable hoists for tipping the truck at the crusher. The most efficient method, introduced about 1945, incorporates the use of a hydraulic dumping mechanism which tips the truck body to the side. These innovations, although they require some additional investment, cut man-hour requirements about 90 percent —a 20-ton load can be unloaded in 10 minutes using

one man. With manual methods it would take 2 men approximately 45 minutes to shovel out such a load.[6]

Pneumatic Conveying

During the last 20 years the use of pneumatic conveyors has been greatly extended for the bulk movement of food products in powdered, ground, or flake form. Perhaps the widest use of this method has been to move flour, but pneumatic conveyors also carry dried milk, beans, cocoa, coffee in whole bean and in ground or flaked form, peanuts, malt, rice, and other products.

In one plant it is reported that flour is delivered direct from a nearby mill by pneumatic conveyor to a storage bin and later moved by screw conveyors to be processed (33). It is estimated that for each 100 tons moved, this bulk mechanical method saves the services of 13 men. In addition to reducing manpower requirements, pneumatic handling is outstanding for its cleanliness. The pipes clean themselves, leaving no residues of material to deteriorate and become infested. The absence of moving parts, with the exception of the blower and motor, makes it easy and inexpensive to maintain except in plants where the product being moved is abrasive and must pass through elbows in the conveyor. Also, dust in the plant is minimized.

Large bakeries now lean toward bulk handling of flour, sugar, and other dry ingredients. Semi-bulk systems of handling flour and other dry ingredients are being tried by several baking concerns by the use of so-called tote containers. These are generally aluminum bins holding about 3,500 pounds of flour. The flour is placed in the bin at the mill, sealed, and shipped to the bakery. Here the bin is connected with a conveying and measuring mechanism so that the flour can be removed automatically from the bins and in controlled quantity. When the tote bins are emptied they are returned to the flour mill for reuse.

Sanitation

Adequate sanitation is an integral part of the efficient processing of food. From the time raw products are received until they leave the plant in finished form, precautions are needed to make sure that contaminated and otherwise unfit materials are removed and that no new sources of uncleanliness and spoilage are introduced. Sanitary measures affect both the quality of the end product and the cost of producing it.

The importance of sanitation to the protection of consumers and the maintenance of a manufacturer's reputation for quality are obvious. In addition, increased emphasis has recently been given to better sanitation by a number of processors, because of its direct connection with the reduction of waste and spoilage and the fewer number of man-hours required in the cleaning and maintenance of some of the newer machines and materials.

Sanitation in food-processing plants is becoming more and more a matter of public interest. In the days when most of the food prepared in the home was locally grown and purchased in fresh form, consumers were in fairly strong position to guard against dirty, unwholesome food. They could examine raw products for spoilage or contamination and could see to it that the food was well stored and handled. Personal vigilance of this kind became less effective as the cooking and preserving of food became more remote and commercialized. Today, the conditions under which food is processed are to a large extent public concern.

Enactment of the Federal Food, Drug, and Cosmetic Act of 1938 did much to encourage sanitary practices in food processing. The requirements of the act prohibit interstate commerce in adulterated foods, and broad definitions of adulteration are set up to deal with many different abuses. Under the act, criteria of adulteration include not only foods that can be shown by objective examination to contain filth, but also foods that are prepared, packed, or held under insanitary conditions whereby they may become contaminated with filth or rendered injurious to health.

Today, many food-processing companies require a guaranty of compliance with the act from their shippers. The act authorizes the Federal Security Administrator to exercise jurisdiction over sprayed fruits shipped in interstate commerce; requires manufacturers of foods that contain artificial flavorings and chemical preservatives to give information on labels; and requires makers of special dietary foods to specify their mineral and vitamin properties. The Federal Security Administrator enforces the provisions of the act requiring wholesome processing of foods and, after public hearing for consumers and industry, to set up standards of identity for foods.

With the increasing responsibility and public interest, processors as a group now give more thought to sanitation, not only in guarding the products themselves from spoilage and contamination, but also in considering the quality of the water used, the personal hygiene of large numbers of workers, and the effects upon the community of improper disposal of waste. To a large extent, improved sanitation in food process-

[6] From information obtained for this study by Neil Houston, University of California, from A SURVEY OF GRAPEHANDLERS, 1950.

ing has been made possible by recent gains in technology: better materials for building, better plant design, new types of equipment, and new techniques (*1*).

Plant and Equipment Design and Materials

Construction of modern processing plants is planned for proper lighting, sufficient floor space to avoid congestion of materials-flow, smooth floors properly sloped to the drainage system, rat-and-insect-proofing of the building, and proper ventilation.

Construction of food-processing plants has been improved by the development and adoption of glass brick; special windows that decrease transmission of infrared light, thereby reducing heat; fluorescent lighting; rubber-base and fungicidal paints; air conditioning; new synthetic resins and plastics; and many other materials that were in their infancy or were unknown two decades ago. Food products—raw or finished, liquid or solid—in most instances are moved from one operation to the next by mechanical methods involving pipes or moving belts.

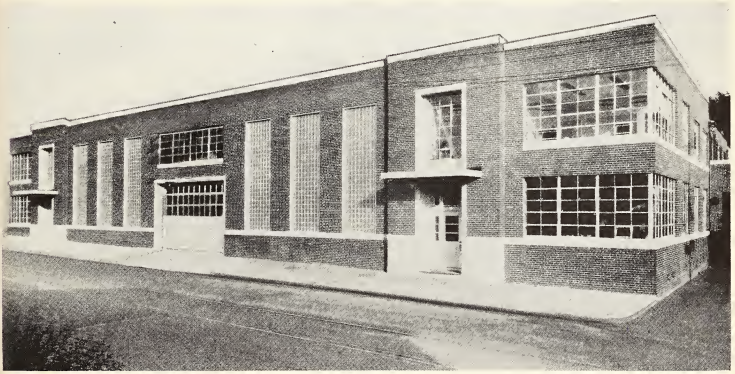
In a modern food plant, stainless-steel and metal-alloy tanks replace wooden tubs; tanks are mounted for easier washing; and glass and stainless piping replaces copper, which often was a source of oxidation and of off-flavors in milk and fruit juices and also reduced the vitamin C content.

In general, centralized operations under one roof are now considered best. Centralization means better sanitation, with less exposure to outside contamination and less wall space to keep clean. Except where gravity flows are utilized, as in cereal milling, single-story buildings avoid maintenance of elevators and stairways, require less exposed piping and fewer breeding places for insects and rodents, use roof ventilators for odor control, and make it easier to use bulk containers and to dispose of waste.

Water Supply and Specifications

Food-manufacturing plants use water in great quantities for plant cleaning and sanitation as well as for the preparation of the food itself. The quantity of water used per ton of commodity is enormous. In the early days of food processing, much of this water was not potable; now practically all of it is.

The desirability of a specific water supply depends largely upon its bacterial and chemical content and its odor and flavor. Each industry or use demands a water of certain characteristics to obtain products of the highest quality. Above all, water must be clean. The first concern of a processor is to find a natural source of satisfactory water, but if this proves impossible, he now has a broader alternative than in the past. Ways of purifying water and otherwise treating it have been improved. The most important development of recent years, in this respect, has been perfection



A present-day food processing plant

Modern plants have made use of the newer materials of construction to insure proper sanitation, light, ventilation, and ratproofing. In the plant illustrated above, the six vertical windows are made of glass brick for better outside light. (Photograph from *Food Engineering.*)

of equipment to purify water through the principle of ion exchange. These units consist of reactor tanks containing special synthetic resins through which the water is passed to remove metallic constituents, such as calcium, magnesium, iron and sodium; and such acidic constituents as sulfate, chloride, and nitrate. Purification of water by ion exchange on a commercial scale reached a high degree of perfection during World War II.

In-plant chlorination is now generally recognized as a distinct advance in sanitation procedures for canning plants, although it cannot be used to replace established clean-up procedures. The values of in-plant chlorination stem from the fact that it reduces bacterial population, reduces the time spent in clean-up operations, and makes it possible to carry on continuous processing operations for a longer period. Swells and bursters in canned goods are reduced because the small amount of cooling water drawn into cans through pin holes or soft compounds in the lid gutter are less likely to inoculate the contents with spoilage organisms. In 1950 about 200 food-processing plants were using in-plant chlorination.

Cleaning of Equipment

Steam blown onto the surface of a sorting or conveyor belt often spreads rather than destroys bacteria. In-plant chlorination—the application of chlorine to the water in regulated and closely controlled quantities—has been found more effective. The benefits of in-plant chlorination of water first became apparent during the early part of World War II when trouble was experienced with bacterial slime formation in potato-dehydration plants.

Proper cleaning of food-processing equipment, utensils, and surrounding premises presents a constant problem to every food processor. The modern frozen-orange-juice-concentrate plant will serve as an example of the problem in many kinds of food manufacturing. Most frozen-concentrate plants operate continuously for a 72-hour run, which is followed by thorough clean-up involving the whole plant. In order to keep a uniform product, samples are taken about every 30 minutes and if mold or bacteria counts are too high, the plant may be shut down at any time for a clean-up.

The cleaning of equipment not only removes food residues, which provide a source of bacterial growth, but also mechanically removes a great proportion of the bacteria remaining on the equipment. Before 1930, cleaning was accomplished chiefly by soap powders, mild alkalies, and scouring powders. Soap invariably leaves a film on the surface cleaned, and after a time this builds up to a hard grease which holds dirt. The development and manufacture of synthetic detergents in the last two decades marked an improvement over these former stand-bys.

The rapid and efficient wetting power of synthetic detergents makes them particularly suitable for degreasing. They are surface-active agents and for that reason have recently been named "surfactants." The first commercial production of synthetic detergents took place in Germany in 1930, production in the United States following somewhat later.

In recent years ultraviolet radiation also has been used to combat bacteria in food plants. Microorganisms are especially sensitive to certain wave lengths in the ultraviolet region. For some purposes, suitable application of ultraviolet rays has proved effective. A number of limitations, however, remain to be overcome. Ultraviolet radiation may in some instances accelerate the development of rancidity in foods containing a high percentage of fat. Ultraviolet rays have very little penetrating power, so that even a very thin film of dirt or moisture may shield the microorganisms from the damaging effect of the radiation. Furthermore, the shape and contour of the surface being radiated and the position of the source and direction of radiation must be such that no areas are shaded or shielded from the direct line of radiation from the ultraviolet source. Considerable work has been done in the use of ultraviolet radiation for the bacteriological purification of air. This type of radiation finds some use for control of mold growth in the bread-rising chambers in bakeries and for protecting the bread during slicing and wrapping operations.

Pest Control

Within the last 20 years, considerable progress has been made in the control of pests in food processing. The task of pest control has been made easier by the discovery of new pesticides and tests to detect contamination. Recently, attention also has been focused on the relation between the pest-killing effectiveness of the substance and its toxicity to humans. The finished food products, as well as batch and ingredient materials, are tested for both pest contamination and harmful residues of pesticides. In some cases contaminants can be seen with the unaided eye. In other instances physical aids are necessary.

A successful method has been developed for protecting flour-mill products against insect infestation by

use of a machine which utilizes centrifugal force to kill all forms of insect life by high-velocity impact against the casing of the machine. This method gives considerable protection against infestation from incoming materials; goods in process are protected against insect contamination during handling and blending operations; and the finished product is delivered into the shipping container with reasonable assurance of freedom from insects, larvae, and eggs.

Commercial adoption by cereal and dry-foods plants of a vacuum method of fumigation has found increasing favor in the last few years. A product is placed in large cylinders; a vacuum is created; and the fumigant, for example, methyl bromide, is introduced. When the vacuum is slightly reduced the fumigant heavily penetrates the product. Fumigation is accomplished in from 4 to 6 hours rather than in the usual 24 to 36 hours.

Another method developed in recent years consists of coating the outer surfaces of multiwall bags used for packaging flour with pyrethrum and an activator. This prevents infestation of the food after it is ready for storage or transit.

Cleaning and Purifying the Product

In cleaning the product itself the choice of methods is necessarily limited to those that will have little or no adverse effect upon it. Recent progress has been considerable in both new cleaning methods and tests to discover when purification measures have been effective. A few examples will serve to show the gains that have been made in diverse fields.

For many years pasteurization has been the accepted method of destroying harmful organisms in milk and other liquids. Until around 1933, there was no chemical test to indicate whether milk had been properly pasteurized. In that year a phosphatase test based on the inactivation of the enzyme phosphatase was reported. Further work by other investigators improved the technique and in 1947 Sanders and Sager were able to test not only milk, but also cheese to determine whether the milk from which it was made had been pasteurized. The test is now known as the Sanders and Sager phosphatase test and makes possible the detection of a decrease of as small as 1° F. in the pasteurizing temperature.

Millions of dollars are lost to the poultry industry each year because of dirty or improperly cleaned eggs. Losses are being reduced through the use of mechanical equipment in packing plants where large volumes of eggs have to be cleaned. There are several types of machines, but all are designed for cleaning the eggshell without causing bacterial penetration of the shell.

Pea canners were once unable to find any commercially feasible way of removing the berries of nightshade, a common weed in pea-fields. Mechanical shakers and screens sifted out fine weed seeds from coarse trash, but not the nightshade berries, because they were almost exactly the same size and color as peas. Worse yet, the berries had almost exactly the same specific gravity, so that running a mixture into a tank of salty water to allow one to float and the other to sink proved futile. But the berries had a waxy coating, the peas did not. Hence the peas were more wettable. So a method—froth flotation—was devised to treat the mixed peas and berries with an emulsion of air, oil, water, and a detergent. The treated peas sank but the berries were carried to the surface; there the berries were skimmed out with the foam. Froth flotation also took out most of the injured peas and bits of skin.

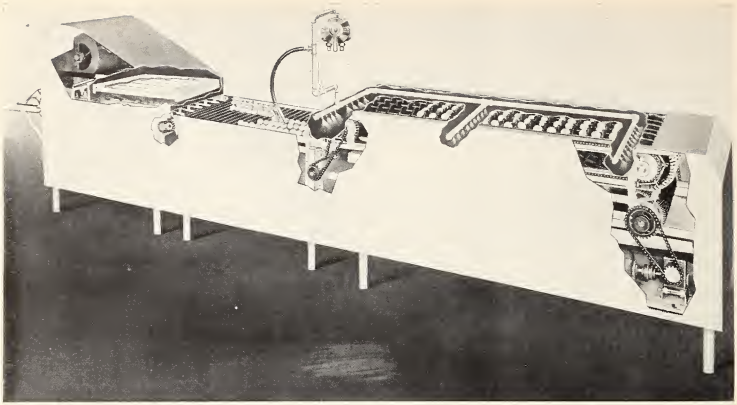
The economic importance of this method may be judged by the fact that in 1941, losses due to nightshade berries in peas grown in the Blue Mountain area of Oregon and Washington were estimated to be from 3 to 10 percent of the crop (*41, p. 238*). The froth-flotation method of removing trash has more recently been applied to lima beans and other vegetables, and is being adapted by canners of sweet corn.

Waste Disposal and Byproduct Utilization

A processing plant must not only manufacture food in a sanitary way, it must comply with the laws and social pressures of its community. With the increase in food processing over the last two decades, the disposal of waste has become of increasing concern. The extra load placed upon municipal sewage-treatment plants in many instances may equal or even surpass the waste from the homes. Measuring the load in terms of biochemical oxygen demand, it has been estimated that the liquid effluent from canning one case of peas is equivalent to the daily domestic sewage of three persons (*88*).

The wastes from food-processing plants are both solid and liquid. The former from fruit and vegetable processing plants alone probably amounts to more than 5 million tons annually (*88*). Liquid wastes consist chiefly of cooling tank water and factory waste water contaminated with organic matter.

In recent years considerable progress has been made in economic disposition of both solid and liquid wastes. Efforts have resulted in a profit to processors in some instances; in others, the operation has been merely one of disposal. Some waste peel and rag from citrus-juice



An egg-cleaning machine

Improperly cleaned or dirty eggs cause a loss of millions of dollars to the poultry industry every year. In cleaning an egg, it is necessary to remove the bacteria from the surface without driving them into the shell. (Photograph from *Food Engineering*.)

plants now are used for pectin manufacture; and tomato waste is used chiefly for feed for dogs and fur-bearing animals; citrus and apple wastes are used for cattle feed; pea vines and pods are dehydrated and ground for feed admixtures, or fed as dry hay; leafy vegetable wastes are dried and ground for feed or for the recovery of chlorophyl and carotene.

Brewers' yeast is dried for feed and food; whey for the production of lactic acid, for feed, or in the production of other foods. Corn-steep liquor is used as a constituent of the culture medium in the production of certain antibiotics. Beef blood is dried; sometimes the plasma and fibrin are separated and the serum and fibrin dried for food, medicinal, and industrial uses. Animal glands are salvaged for production of medicinals; and bones and certain connective tissues for fertilizers and glue.

In the majority of instances, disposition of liquid effluents is a problem of avoiding stream pollution. Proper treatment is an expensive procedure; it has not been entirely solved. Improvements in design and operation of trickling filters, by which the waste substances are oxidized during percolation of the waste water through a gravel bed, have done much to decrease operating costs and capital expenditures.

The processing of citrus offers a good illustration of progress in waste disposal. As canning developed it brought with it a supplementary problem due to the fact that more than half the weight of the fruit was left at the plant in the form of peel, rag, and seed. When the canning industry was in its infancy this material was spread out in groves for its fertilizer value or dumped in woodlands, but as the canning industry expanded this dumping of waste became a nuisance. The first step was the development of a method of drying the waste for cattle feed. The process involves a grinding of the waste peel, pulp, and seed with lime to help break down colloidal constituents. This is followed by removal of considerable liquid in presses.

Press liquor, however, contains sugar and other materials and quickly becomes a problem in itself. In the early days some processors put it into lakes, where it killed the fish by removing dissolved oxygen from the water. When run into groves it sometimes killed trees, especially where the land was flooded. When put in woodlands in pits it gave off a very bad odor. These evils have finally been avoided by development of citrus molasses, which is made by concentrating the press liquor under vacuum in much the same way that cane sirup is concentrated in making sugar and blackstrap molasses; the molasses finds a market in animal feeds.

More Objective Grading

Development of new equipment and new techniques for grading food products has done much to improve processing, both in maintenance of quality and control of costs. The entire field of standards and grading is broad. Many of its aspects, such as those concerning marketing practices and the social forces of Government regulation, are beyond the scope of this study of technology in marketing. But the technological gains that have been made in the establishment of standards and the grading of products have in themselves been considerable. These are treated here, in the belief that advances in grading methods have been of particular importance in the processing stage of marketing. The effects upon other aspects of marketing, particularly transportation, have been great. Also, the improvements that have contributed to increased accuracy and wider use of consumer grades have had a considerable effect upon the retailing stage of food marketing.

Among the important characteristics for which standards of quality have been established to meet consumer preferences or the requirements of the modern processing plant are: size and shape; color; stage of maturity, moisture, protein, fiber, oil, and kernel content; tenderness; and such technical quality characteristics as the proportion of solids or fat. For particular food products one or more of these characteristics is important to consumers or processors so far as they affect taste, storage life, color, and other factors that make for better eating. Grades have been established which recognize commercial distinction in degrees of quality of the particular product involved.

Recognized uniform grades and standards facilitate the more efficient and economical sale of food products. They are indispensable in the settlement of disputes between buyers and sellers and make easier the settlement of claims against transportation companies. They make possible Nation-wide market reporting, thus aiding orderly marketing and the equalization of prices between markets. Grade inspection certificates provide a basis for credit transactions.

Recognition of these advantages has brought the official grades and standards promulgated by Federal and State authorities into widespread use in the trade.[7] These grade standards establish absolute levels of quality to which products must conform to qualify for grade designation.

A similar function is fulfilled by many private brands whose reputation for quality has become widely established. Reliability differs from brand to brand, however, with some variations observed in many instances from year to year, reflecting the effect of weather on crops or the relative availability of certain types of fruits and vegetables in packs combining two or more kinds. In some commodities, quality designations are assigned according to the "top of the crop," a fixed percentage of each year's production being given the highest designation. Some brands have been found to vary in quality even within the same pack.

Consumer grades are generally used in processed products. Thus, the labeling of canned foods as "fancy pack," or "Grade A" indicates higher-quality food products. About 38 percent of the standards and about 33 percent of the grades promulgated by the United States Department of Agriculture can be used by consumers as well as by buyers and sellers of quantity lots (*82, p. 2*).

For some food products, such as tomatoes, it is not as yet possible to tell from the product in mature green form what its quality will be at the time of consumption. Deterioration of fresh produce in transit, although it is diminished over time because of modern methods of refrigeration and faster transit time, is still a problem of some magnitude.

Quality, so far as it relates to consumer acceptance of the finished product, may be tested by smell, sight, taste, and—to a lesser extent in foods—touch; or by more objective methods which rely on impersonal instruments or physical processes and eliminate to a great extent the human element in testing and grading.

The big change in grading and standardizing food products during the last 20 years is the greater use of objective methods. This is true despite the fact that for some important foods, such as butter and other dairy products, no objective tests are as yet available to measure the qualities desired by consumers or the trade. New objective processes take the form of improved mechanical, chemical, and electronic tests.

The objective tests are not perfect indicators of preference; in most cases the devices used are designed to measure one factor alone. Sometimes the relation-

[7] While the regulations of the Federal Food and Drug Administration are primarily designed for consumer protection, they likewise contribute to marketing efficiency. Food and Drug Administration Definitions and Standards of Food provide uniform language for the description of many processed products. These standards eliminate the movement in interstate commerce of foods not in conformity with the minimum requirements. No United States Department of Agriculture grades for processed foods are assigned unless the requirements of the Federal Food, Drug, and Cosmetic Act are met.

ship between factors is inversely associated; a high score on color may reflect a poorer score on tenderness. There is a chance, also, that the tests may be imperfectly administered.

Although some States allow the results of tests using an objective method alone, official U. S. grades are seldom met unless the grading method also takes into account the results of taste and other subjective tests.

Innovations in the last two decades have taken the form of more accurate machines or tests, adapting existing tests to new foods, and more mobile equipment. A still serious limitation of the methods available is that they have greater application to sample-testing and less to lot-testing.

A recent development that contributes to more objective and uniform grades is the visual aids supplied to Federal inspectors and to handlers of fruits and vegetables for processing. These take the form of drawn or photographic reproductions of particular products in color representing different stages of maturity or other quality characteristics. Still another medium is found in the wax reproductions which indicate stated percentages of trimming or core defects. These visual aids permit inspectors more accurately to determine such characteristics as texture, body, and finish of various products which as yet cannot be measured readily by objective tests.

Color of food products varies according to the variety of the product, the stage of maturity, season harvested, and processing method used. Among the methods now available to plants for processing fruits and vegetables, soybean oil, and macaroni for measuring color is the disk colorimeter, which allows a comparison of the product color with a standard color test to give a numerical color value. A second method is the spectrophotometer which involves either a solvent method for extracting the product color and measurement in terms of light wave transmission or direct measurement of the surface reflectance at various wave lengths. An electronic grader has recently been introduced for grading both size and color of lemons.

In 1949, plexiglass slides carrying painted tomato slices indicating minimum color requirements for the various grades were substituted for color photographs and painted models, neither of which were sufficiently reliable. Replacing the caramel-glycerin solutions, which in practice were not highly stable in respect to color, a simple color comparator fitted with permanent standards of colored glass has been developed by the United States Department of Agriculture for measuring the color of maple sirup and honey.

The combined butterfat content and bacteria count are weighted to determine the grade of milk in many States. The resazurin test is gradually being substituted for the time-consuming methylene blue test for measuring bacterial contamination without loss of accuracy of results. Both are chemical tests. For a number of years the common method of indirectly measuring the bacterial content of milk has been the methylene blue test, in which methylene blue added to the milk is reduced to colorless form by the action of bacteria. This method took several hours, and was especially long for milk with a relatively low bacteria count. A new method, the resazurin test, is being substituted. It works on the same principle, but makes use of a chemical combination that works much more rapidly. It can be completed in 2½ to 3 hours without loss of accuracy.

Uniformity of size and shape are criteria of quality in many fresh fruits and vegetables, and of grains used in processed foods; they are important to attractiveness of the packaged product, to utilization, particularly in institutional trade, and in packaging given weights in given containers. Further, in products that are to be processed, uniformity of size and shape often are essential to quality, because size of a unit frequently determines the time and temperature of processing. Mechanical grading equipment designed to accommodate various shapes of food products has been designed, such as screen, roller, rope, and weight graders. Development of these mechanical graders has reduced the labor necessary for grading purposes. Automatic scales have been developed which allow speedy evaluation of weight of products, such as eggs, poultry, sweetpotatoes, and peanuts, for which this characteristic is important.

The fibrousness or toughness of many foods, especially asparagus and snap beans, may now be measured by a fiber-tester, an instrument which registers the force necessary to cut the stalk. This device is adapted from the fruit pressure tester, which has been in use for many years, by the simple expedient of replacing the plunger with a stainless steel blade.

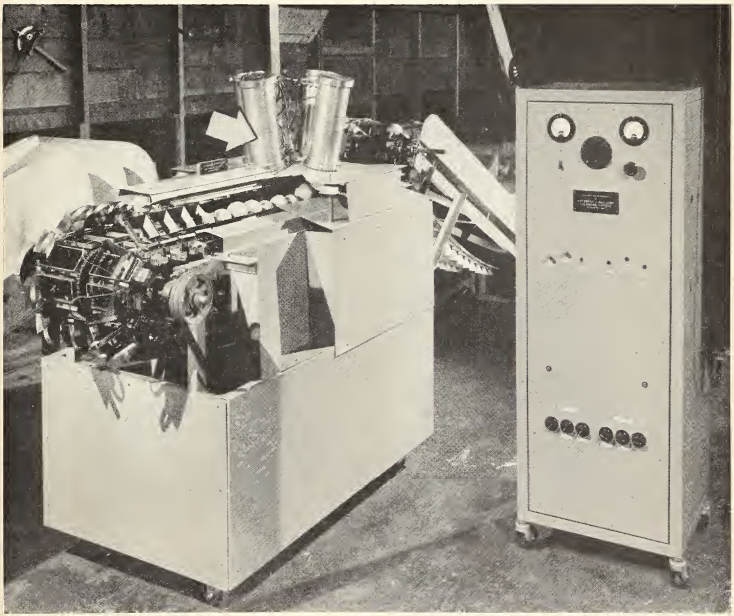
Internal damage, such as frost damage in citrus, is commonly detected by separation of the lighter weight frozen oranges from the sound oranges by floating the fruit through a tank of swiftly moving water. Rejected fruit is skimmed from the surface by one conveyor while another, under water, carries the sound fruit to the processing room or packing shed. A recently displayed X-ray fruit grader is said to be more accurate and to allow packers and processors to salvage

from 30 to 50 percent of the culls for use in canned or frozen juice. The essential principle used is to measure the amount of rays stopped by good as compared with damaged fruit. The new, fully automatic machine replaces a manually operated machine developed in 1937, and is said to require only one rather than five or six men to operate (*26*).

The maturity of peas has been measured by mechanical devices for many years as a basis of payment to the grower and as a guide to separation of lots in processing. Recently a miniature tenderometer has been developed to replace the more expensive standard tenderometer. In addition, through the use of interchangeable sample boxes, blades, and plungers, the innovation becomes a multipurpose tester that can also be used as a succulometer to test the proportion of juice in corn, or to test asparagus or beans.

Development of Continuous Processes

During the last two decades many forces have combined to raise the level of productivity in food processing. Some of these, such as better selection and training of employees and improved labor policies, have had little direct connection with technology. But new machines, new processing techniques, and better organization of plant operations have played a dominant part. Foremost among the purely technological developments are those that have made possible the shift from batch



New X-ray orange grader

This orange-grading machine not only detects frost-damaged oranges, but also separates the fruit into six quality classifications according to juice content. When the machine is in operation, the oranges pass X-ray units (arrow) and an impulse, varied by the X-ray's permeability on the fruit, sets a grading device on each orange, which rests in a cup on the conveyor belt. (Photograph from *Food Engineering.*)

operations to a continuous, assembly-line-type operation. Although the change-over is not yet complete it is already far-reaching and its effects are felt in nearly every branch of food processing.

The old-fashioned batch or vat method was by nature discontinuous. Whether the product was to be cooked, or otherwise treated, there were almost invariably waiting periods while the vat or other receptacle was being prepared for the new run, and while the product was being put into it or taken out. The flow of materials through the plant was slowed; sometimes it was stopped altogether. In addition, the older method generally required considerable hand labor, and often involved temporary storage of semifinished products.

Continuous processes, which are almost always faster as well, reduce or remove those difficulties. They tend to reduce costs through replacing hand labor or the less efficient machines. In most instances they improve the quality of the product through greater uniformity of operations and by reducing the time during which the products are exposed to contamination or the deteriorating effects of air or heat. Usually the shift to a continuous-process basis involves only a partial modernization or reorganization of a plant; often a great many of the operations can be carried on as before.

Continuous Sterilization of Canned Foods

Until 1930 almost all canned foods were sterilized in retorts in a batch process. The retort or pressure cooker was invented as long ago as 1874. Patents for continuous cookers were granted as early as 1902; only in the last 20 years have they come into general use. Under the older method, the cans were loaded into crates by hand, and the crates were then placed in the retort which was closed by hand. Loading and unloading the average retort are in themselves considerable enterprises. A common-sized model stands over 13 feet high, weighs more than a ton, and holds 1,600 No. 2 cans or the equivalent in other sizes. In the new continuous-process retorts, the canned product is conveyed in and out automatically and the operation goes forward without interruption. In the newer cookers, the cans are agitated continuously. This motion prevents overheating of that portion of the product in contact with the container, and shortens cooking time by permitting the use of higher temperatures.

Automatic control is becoming the rule rather than the exception in bringing cookers up to the required temperature, in maintaining this temperature for a specified time, in introducing the cooling water and air under definite pressure, in maintaining cooling for a definite period, in discharge of cooling water, and in cutting off air pressure. Cookers are usually equipped with a variety of partially manual controls, alternative to the automatic ones, to permit variations in processing. Automatic control eliminates uncertainty in the pack, obviates the need for stacking hot canned products awaiting their turn to be cooked, increases the output per machine, brings savings in steam consumption, and is easily adjusted to any can size or to any product.

Flash Pasteurization and Short-Time Sterilization

Before and during the early 1930's fruit juices were pasteurized either by batch methods in kettles or by heating in the final container for a predetermined period of time. This method had several disadvantages, chief of which was impairment of flavor and color. When open kettles were used, moreover, deterioration of food value also took place.

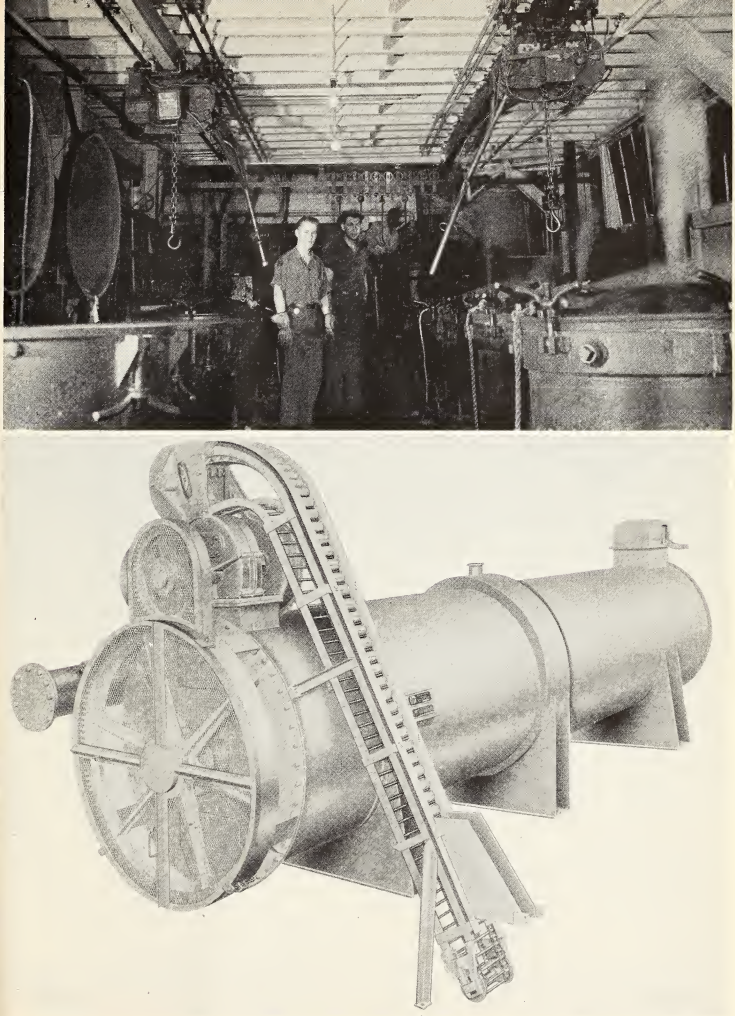
Around 1935 flash pasteurization came into use for fruit juices. In this method, the juice was pumped through stainless steel heat exchangers, in which the product was subjected to a high temperature for a short period of time. At first, temperatures of around 180° F. were used, but it was later learned that higher temperatures were preferable, with a corresponding decrease in the heating time. At present, temperatures as high as 300° F. followed by rapid cooling are used without harming the product.

A recent improvement (about 1948) in short-time sterilization at high temperatures consists of pumping a liquid product successively through the heat, holding, and cooling sections of a closed heat-exchange system, following which the cold, sterile product is filled and sealed aseptically in sterile containers. In the conventional high-temperature short-time method, the product is filled at 190° to 200° F. into containers that are clean but not sterile.

High-temperature short-time methods in which the product is filled cold into the containers generally produce finished products of better flavor and color than equivalent low-temperature processes; there is an economy in fuel and cooling water. Compactness of equipment and continuous operation result in saving of floor space with streamlining of factory lay-out; a high degree of mechanization and use of automatic instruments provide for close control of all operations while permitting savings in labor.

Continuous Butter-Making and Continuous Cheese-Packaging

Development of new processes for making butter, using continuous operations, has resulted in acceleration of the operation and economy of labor through the high degree of mechanization involved. A more



Old and new in pressure cooking

The old-style pressure cooker (top) had to be loaded and unloaded by hand. In a continuous-process retort (below) the canned product is conveyed in and out of the retort automatically. (Photographs from *Food Engineering*.)

uniform product results, although its characteristics differ slightly from those of butter made by churning cream in the past. Churning is eliminated as a means of phase reversal in the continuous processes. The new methods originated in Europe and are being adapted to large-scale use in this country.

In the past it has been customary to ripen cheeses of nearly all types in wheels, blocks, or other shapes of sizes up to several hundred pounds. A paraffin coating was applied and a thick inedible rind was permitted to form to protect the main portion of the cheese from the action of undesirable bacteria and molds during ripening and marketing. In addition to the rind, there was further loss to the grocer, as he cut portions from a big wheel of cheese over an extended time, because of molding and drying of the cut surfaces. In the late 1930's these losses were obviated for Cheddar cheese by several companies which packed the curd in consumer-sized, valve-vented cans, in which the cheese was ripened without formation of rind.

This method of merchandising had a limited popularity, mainly because the cheese could not be seen by the customer before buying. Because of the shortage of tin plate, this procedure was abandoned during World War II. Production of transparent wrapping materials, such as pliofilm and cellophane and the development of techniques for their use in packaging perishable foods has led to their use for packaging cheese curd in airtight, consumer-sized packages in which the cheese is ripened and delivered to the consumer. While some cheese is ripened in blocks in such wrappings and repackaged in small units before selling, large-scale packaging of rindless cheese in a continuous line has done away with the necessity of storage, turning, and multiple handling of cheese.

Continuous Ice Cream Manufacture

Use of continuous ice cream freezers has come about during the last two decades. Their use has resulted in some economies of manufacture, especially in large-scale manufacture, and it is an important factor in the increase of the proportion of ice cream marketed in prepackaged containers. The continuous freezer makes possible a more precise control of overrun than is possible in the batch freezer. The process of homogenization has helped make possible the use of the continuous freezer.

De-aeration

De-aeration, a procedure which removes a substantial part of the dissolved air in fruit juices and certain other liquid foods, has resulted in much better products than were previously obtainable. De-aeration is not a new process, but it was not until the early 1930's that it was applied to fruit juices. De-aeration has had much to do with the tremendous increase in the canning of single-strength orange juice, and has contributed to better retention of vitamin C in fruit juices generally. It has helped to eliminate "black-neck" in bottled tomato catsup, and has proved beneficial in the packing of pineapple and apple juices, honey, strained baby foods, fresh market milk, tomato juice, and carbonated beverages. De-aeration is also a part of the vacuum and nitrogen packing of such solid, fat-containing foods as coffee and dried whole milk.

Continuous Deodorizers

Odorless and tasteless oils first came into large demand as ingredients for margarine manufacture. If deodorization is properly carried out, oils from different commodities are difficult to distinguish from one another by odor or taste. Older methods of deodorizing were by batch operation in which the oil was heated in a tank under vacuum. The process usually took several hours; consumption of steam was relatively high, and efficiency low. It was found that savings of steam, as well as of time, were possible by bringing the oil and steam into contact in countercurrent streams, as part of a continuous deodorizing process. This method has been used in Europe for some time, but it was not until the late 1930's that it was introduced into the United States. Less steam is required to remove the volatile substances from the oil, and some saving of heat is effected by using the hot oil, leaving the deodorizer to heat the raw incoming oil.

It is necessary to operate a continuous deodorizer, however, on one type of oil for several days, which decreases the flexibility of operations in a refinery. For that reason, many processors, especially smaller ones, have been reluctant to install continuous deodorizers. In 1948 a semicontinuous deodorizer was introduced. This to a large extent combines the flexibility of the batch deodorizer and the economies of continuous countercurrent operations.

Sugar Beet Diffusion Processes

Beet sugar may now be obtained by a continuous automatic process, replacing the individual battery for diffusing the juice from the cut-up beet particles, known as cossettes. This new method gets around one of the more laborious parts of the conventional process—filling and emptying the tanks of the battery. In the continuous battery, the shredded beets are fed onto a

special carrier, which transports the cossettes through a series of narrow tanks against the reverse flow of warm water. The tanks are enclosed; they appear to be a single unit. About one-fifth of the beet-sugar factories had installed continuous diffusers by the end of 1950. Besides saving work, the continuous diffuser more completely extracts the sugar from the cossettes, the diffusion juice is more concentrated, and the pulp is better drained and ready for processing for stock feed.

Other improvements in sugar-beet processing are constantly being made. Liming and carbonation of juices, by which the lime gathers up suspended matter and excess lime is in turn precipitated by the addition of carbon dioxide, require attentive control of alkalinity through chemical testing, as well as equipment that gives almost instantaneous and uniform mixing. For many decades that was done on a batch basis, a tank of juice at a time. In most factories it is now performed continuously and is controlled by instruments that maintain the best conditions for removing impurities and color. The process notably reduces variations in processing conditions.

Multiple-effect evaporators, by which the vapor from the first heats the sirup in the second, and so on, have also been improved. Many are now equipped with control instruments so that the flow of juice and sirup from one evaporator to the next is regulated and stabilized. Sometimes an electric eye is used to give warning of excessive foaming in the evaporator.

Fresh-Pack Pickles

The common method of preparing pickles requires more than 9 months because it involves brining to obtain "salt stock." Around the middle 1930's a method was developed for preparing so-called "fresh-pack pickles." The fresh cucumbers are soaked in tanks, then run through a washer. The washed cucumbers are packed in glass containers, covered with cold dill brine, and pasteurized at 165° F. for about 15 minutes. The process is applicable to whole dills or to sliced sweet pickles. Although the product thus obtained is not exactly the same as the brined product, the taste is quite similar and it has been well accepted by consumers. Processors are finding that the new method does not require the large amounts of storage space for the same level of output, and that it is well adapted to an assembly-type, straight-line process. In addition to reducing storage requirements, the new method cuts the carrying charges required under the longer process.

Solvent Extraction

Solvent extraction of oil from soybeans, cottonseed, and other oil-bearing materials is, in practical application, a continuous process. The batch method is technically possible but relatively inefficient and is little used in processing oilseeds in this country.

In continuous-process solvent extraction, the oil-bearing solids move in one direction and are washed by a liquid solvent moving in the other. Only about 1 percent of the oil is left in the meal, compared with 4 to 7 percent when mechanical pressing is used. In addition to the higher rate of extraction, the solvent process can be operated, when desired, to produce a meal in which denaturation of the protein has been held to a minimum. Such a meal is better suited for industrial uses. When the meal is to be used for feeding livestock, it is usually heated in the presence of moisture to enhance the nutritive value. Increased returns of oil from the solvent process more than offset the additional installation and operating costs required, provided sufficient oilseeds are available to justify large-scale operations for all or most of the year.

During most of the 1940's attempts to extract cottonseed by the solvent process were not generally considered successful because of a number of technical difficulties. Late in the 1940's some mills were able to process cottonseed with moderate success directly by solvent extraction. But in 1952 a number of the mills were installing equipment to fore-press the cottonseed and follow such pressing with solvent extraction of the press cake.

Continuous Refining Innovations

After the oil has been extracted, it must be refined. The batch method of caustic-refining vegetable oils such as cottonseed and soybean oil, has been largely superseded in the United States by continuous methods. In caustic refining an amount of caustic soda determined in relation to the acid that must be removed is added to the oil. The soda and acid combine and are precipitated as a curd. The first continuous system of employing this method was developed about 1933, and the technique has been somewhat improved during recent years. The chief advantage of continuous refining is the higher recovery of oils.

Centrifuges, used commercially in the refining of oils and in the preparation of certain fruit juices, separate solid portions of the product by centrifugal sedimentation. Formerly, it was necessary to stop operations every so often to remove the solid material collected on the sides of the spinning cylinder. Improvement in the design of centrifuges now permits continuous removal of the separated solids while the machine is running at full speed. Continuous centrifugal

operations increase capacity of the plant and lower labor costs. In the dairy industry continuous centrifugation has a longer history.

Macaroni and Spaghetti Presses

In 1930 presses for making macaroni products were still of batch type and dryers were loaded and unloaded by hand. In 1934 continuous presses appeared in France, Switzerland, and Italy, and around 1940 in the United States. These new presses completely revolutionized the manufacture of macaroni products and made the mixer, kneader, and older style press obsolete. Operations that had previously been performed by individual machines are now handled by a single unit comprising a continuous feeding system for semolina and water, a continuous mixer, and continuous kneading and extruding devices. Also, large continuous dryers are replacing the small drying chambers and cabinet dryers that have been the standard for drying macaroni products during the last 40 years.

Manufacture of Potato Starch

In the early factories, starch-settling and purification operations were on a batch basis, although grinding the raw potatoes, screening, and starch drying were continuous. However, the speed of grinding and screening potatoes was limited by how quickly the settled starch could be emptied from the settling tanks and purified. Approximately 3 days were required to produce finished starch in the batch process.

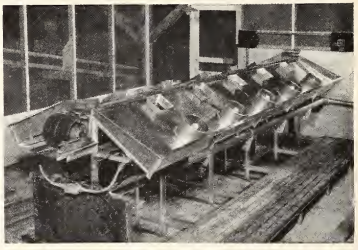
This compares with from 1 to 3 hours for the continuous process, which came into general use in the early 1930's. The old raspers were replaced by better rasps. In addition, brush and jig sieves, protein-water separators and fine regrind mills increased yields greatly. Batch processes were replaced by continuous methods eliminating waste of starch from "brown starch" in the former process. Flash drying of the finished starch gives considerable savings in reduced original investment, operating floor space, and processing costs.

Automatic Juice Extraction

Canned single-strength and frozen concentrated citrus juices would not be possible today without automatic juice extractors. As recently as 1933 practically all of the orange and grapefruit juice canned was extracted from fruit by hand. One man could extract about 10 gallons of orange juice or 25 gallons of grapefruit juice an hour. On this basis, it would require a force of approximately 2,500 people to extract sufficient juice to keep one of the large modern citrus-processing plants running for 1 day. Today, automatic juice extractors are used exclusively and one of these machines extracts as much orange juice in a minute as one man could extract by hand in an hour.

Other Improvements in Processing

Continuous and faster processes have reduced costs and improved quality. Many other new machines and methods, which are not continuous, made significant contributions to processing and handling in a number of food industries.



Citrus fruit juice extractors

Automatic citrus-juice extractors have made possible the huge output of canned single-strength and frozen concentrated citrus juices now on the market. Operating a reaming table of the type used around 1930 (upper), one man could turn out 10 gallons of orange juice an hour. Each extractor in a battery of the present-day automatic extractors (lower) will turn out about 480 gallons of orange juice an hour.

Canning

The preference of consumers for specific colors, textures, and flavors of canned fruits and vegetables has spurred processors into constant search for methods of preserving and improving these qualities.

In the processing of apple juice, it has been found that the addition of small amounts of ascorbic acid (vitamin C) either to the ground apples before pressing, or to the juice after processing, will result in a lighter-colored juice and will retard darkening during storage. In 1944, it was found that addition of ascorbic acid to frozen peaches would prevent discoloration upon defrosting. This removed the major barrier to commercial packing of frozen peaches. Somewhat earlier, it had been found that pureed bananas could be frozen without undue discoloration if ascorbic acid was added. This made possible the use of bananas in ice cream preparations.

One problem in canning of peas is the gradual change in color of the peas to a duller shade of green. This change of color is caused by a break-down of the chlorophyl which is brought about chiefly by high processing temperatures. Around 1940 it was found that chlorophyl could be protected and the green color of peas retained by the addition of certain sodium and magnesium salts.

The texture of processed foods is affected by the type of water used. Excessively hard water may cause a degree of hardening of such vegetables as peas, lima beans, and all types of dry beans that will cause the canned product to be down-graded. In recent years, sodium hexametaphosphate has been used increasingly to treat hard water intended for soaking and blanching of peas, lima beans, and dry beans. Salt-water blanching has also been used to prevent absorption by peas and beans of calcium and magnesium.

Unless they are handled carefully, tomatoes break down into pulp or sauce when canned, resulting in down-grading and, in some cases, rejection by consumers. Around 1939 it was found that the addition of small amounts of calcium salts to whole tomatoes in canning increases their firmness so that they retain their shape. Certain varieties of apples can also be firmed in canning by this method.

The necessity of obtaining a proper vacuum in cans of food has long been recognized as necessary to prevent swelling of the can which is often caused by changes in altitude during transit, and to aid in preserving the quality of the food. Early methods consisted of preheating foods before closure, or use of mechanical methods. In the early 1930's it was found that if live steam is properly injected into the head-space volume of a container, it replaces essentially all of the air with steam. If the cover of the container is immediately applied and sealed, a vacuum is formed when the steam condenses. This method was first applied to glass containers, and it was not until around 1939 that it was applied commercially to cans. Steam-injection units have been installed on regular closing machines, replacing many exhaust boxes, and in some instances, vacuum-closing equipment.

The exact temperatures required to process adequately low-acid foods in cans have been known for some time. Not until around 1948 was similar information available on packing those foods in glass containers.

Although fruit concentrates are an improvement over single-strength juices, the natural bouquet—the particular flavor quality of the natural fruit—was found to be volatile and almost completely destroyed during normal processing. Attempts to recover the "essence" or flavor of the fruit have been numerous during the last 20 years, but it was not until 1944 that improved designs in stills and stripping columns made possible the commercial separation and concentration of natural flavoring materials in apples and grapes. In addition to being restored to the concentrates themselves, these materials are now used to flavor confections and beverages, in place of the synthetic flavors formerly used.

Improvement in design of vacuum evaporators during the last 20 years has made possible concentrated fruit juices of high quality and has meant greater economy in production as well. Two decades ago pans and circulating evaporators were used. Both employed steam at relatively high pressures. Around 1940 several new types of evaporators were developed. An innovation involved using the heat of compression of ammonia gas. After some of the heat of the compressed ammonia was used for heating, the ammonia was allowed to expand and the cold ammonia was used to condense the vapors that boiled off from the juice under vacuum. Not only was this method more efficient than the old steam tube method, but a much better product was obtained. Whereas, in the old evaporations comparatively large bulks of liquid had to be heated, in the newer design the material is heated when in a thin film.

The use of two or more evaporators hitched together in series already has been mentioned in connection with sugar processing. This method, with its economies of using the vapors from one evaporator

to heat the liquid in the succeeding one, has been adopted by the fruit-juice-concentrate industry, along with the practice of recompressing vapors from heating.

A decade ago peaches were mostly pitted by hand. Today, mechanical pitters for clingstone peaches are coming into use. Cherries, plums, and prunes also are pitted by machines. Machine pitting increases speed of production, reduces labor cost, and results in a more uniform product.

Dehydration

In many of its aspects, the dehydration industry thrives on emergencies. In the last 20 years the greatest peak in the dehydration of food was reached during World War II. Another major stimulus came later with the need for effective handling of the large quantities of eggs and milk purchased in the course of price-support operations of the Federal Government. During the war, the facts that dehydrated products required fewer transportation and storage facilities and did not have to be packaged in containers requiring scarce tin, heightened interest in dehydration.

As a consequence, the record of technological improvement in dehydration must be viewed against a different background from the pattern of steadily increasing production and consumption that prevails for most other forms of processed food. After World War II, as after World War I, there was a decided decline in production and use of dehydrated products. After the second war, however, the drop was not nearly so sharp as it was after the first, partly because of price-support operations and partly because technological improvements allowed some dehydrated products to compete on a peacetime footing with other forms of food for institutional or home use. Production of dehydrated eggs, milk, and vegetables fluctuated from 1930 to 1950 (fig. 11, table 10).

Of the production of 68.6 million pounds of dehydrated vegetables shown for 1949, 50 million pounds were potatoes (pieces, flour, and meal), 16.6 million pounds were onions, peppers, and garlic, and the remainder was made up of beets, carrots, cabbage, tomatoes, and greens.

In the last two decades a number of significant forward steps have been taken in the techniques of dehydration. One of these was the development of active dry yeast. Yeast dried with cereals as a carrier had been known for some time. During World War II military demands for yeast in bread making, and the fact that refrigeration facilities were unavailable in advanced combat areas brought out the need for an active dry yeast without bulky cereals as a carrier. In

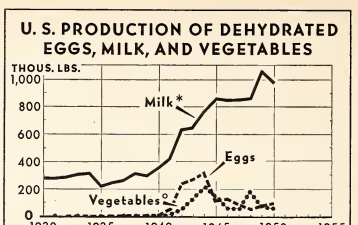


FIGURE 11

1941, more than 2 million pounds of active dry yeast were produced and by 1944, production had increased to more than 11 million pounds. The dry yeast needed no refrigeration, and if properly packaged and stored its viability remained essentially unimpaired for nearly a year. For general consumer use, active dry yeast has made possible certain types of frozen biscuit mixes.

TABLE 10.—*Production of dehydrated eggs, milk, and vegetables, United States, 1930–50*

Year	Eggs	Milk [1]	Vegetables [2]
	1,000 pounds	*1,000 pounds*	*1,000 pounds*
1930	489	276,115	----
1931	553	274,565	2,500
1932	2,286	282,177	----
1933	3,796	301,140	3,700
1934	4,300	310,804	----
1935	3,000	216,873	1,600
1936	1,486	242,007	----
1937	2,391	258,187	1,500
1938	6,002	310,617	----
1939	10,039	292,332	5,600
1940	7,487	351,252	5,400
1941	45,280	412,082	13,200
1942	235,649	627,581	53,800
1943	261,972	647,386	125,500
1944	320,742	760,666	208,700
1945	105,862	859,822	130,300
1946	125,444	841,871	54,200
1947	85,561	842,829	51,000
1948	44,275	851,632	179,500
1949	75,962	1,059,203	68,600
1950	93,418	973,635	60,000

[1] Includes dry whole milk, and nonfat dry milk solids for human consumption 1935–50 only. Figures prior to 1935 reflect production for animal and human use.
[2] WESTERN CANNER AND PACKER (*90*).

Residual yeast as a byproduct of beer production is another new product. During the making of beer,

yeast reproduces itself at the rate of 4 to 1. Around 25 percent of this amount is used again for pitching subsequent brews. As recently as 19 years ago most of the surplus yeast was run into the sewer. During the war, shortages of protein feeds and foods directed attention to recovery of this yeast by drying. Satisfactory techniques were developed. Current production is believed to be between 15 and 20 million pounds annually. Brewers' dry yeast is used in poultry and livestock feeds and in pharmaceuticals, specialty foods, baked goods, candy, soups, breakfast foods, alimentary pastes, sauces, gravies, and spreads.

Equipment for freeze drying was devised in 1935 and 1938 and since that time improvements have been made, capacities increased, and refinements added. Freeze drying is simply a practical adaptation of the old-fashioned housewife's observation that washing hung out on a cold, windy day would freeze and dry quickly without the ice melting. Today freeze drying is applied principally to substances particularly liable to chemical or structural changes. These are first frozen and then "bled" of their water content under a high vacuum. Present application is confined chiefly to medicinal products, such as antibiotics, blood plasma, serums, antitoxins, bacteria, vaccines, hormones, human milk, and certain other products that command a high price.

During the last 20 years the quality of dried milk has steadily improved. Rancid flavors have been overcome by using high temperatures for very short periods of time to inactivate the fat-splitting enzymes in the fluid milk. Tallowy flavors and odors in whole dry milk have been combated by using stainless steel equipment, packaging in containers from which nearly all the oxygen has been removed, and storing the dry milk at as low a temperature as practicable.

The present trend in the manufacture of nonfat dry-milk solids is toward tailoring the product specifically for its end use. The bakery trade, for example, requires a nonfat dry-milk product that has been made from skim milk which has been subjected to a high heat treatment before concentrating and before drying. A high heat treatment improves the water-holding capacity of the powder. A dry-milk product for use in the making of cottage cheese and starter cultures is being made from low-heat treated skim milk. Low-heat treatment makes a powder which is easier to reconstitute and makes a better curd in the case of cottage cheese.

The dried egg-albumen industry in the United States began in the early 1930's. At that time, pan drying was used almost exclusively. Recently, a successful method of spray drying was developed through design of a spray nozzle that does not subject the product to a shearing force. Spray drying, through its rapidity, minimizes bacterial change or spoilage, and lessens the effects of heat on the physico-chemical properties of the product.

During World War II it was found that slightly acidifying liquid whole eggs before spray drying gave the product a materially longer storage life.

During the last 10 years, it has been established that for certain vegetables (potatoes and cabbage, for instance) treatment with sulfur dioxide, in addition to blanching, is advantageous. Dehydrated blanched carrots that have been lightly coated with starch are more stable than uncoated carrots. The steam blanching of apricots, peaches, and pears before sulfuring has not only shortened the drying time but has produced fruits similar in color and appearance to the sun-dried product. However, the technique is not used commercially.

Instant dehydrated mashed potatoes of better consistency have been produced by techniques that cause very little rupturing of the cells. This is accomplished by more exact control of moisture content prior to granulating.

Molecular Distillation of Delicate Products

Molecular distillation has come into commercial use in the production of vitamin A concentrates from fish liver oils that are particularly sensitive to heat. The molecular still is particularly well-adapted to handling such materials, as heat is used during a very short period only, and the temperatures required are much lower than for conventional distillation.

Molecular distillation is not a new process, but its translation from the laboratory to the commercial plant is comparatively recent; suitably designed equipment has become available since 1935. Conventional methods of distillation, whether or not under a vacuum, often cause serious disintegration of the structure of the more delicately balanced constituents that are turned from liquid to vapor by boiling. In molecular distillation the material is distilled from a very thin heated layer to a condenser placed very close by. The operation is conducted under a very high vacuum, so that the molecules being distilled can make the short jump intact to the condenser.

Baking

The baking industry has made significant advances in design and manufacture of machinery and equipment during the last 10 years. Equipment and methods have been modified to take advantage of new techniques of

bulk handling of flour and sugar. Design of dump and blending bins has been improved for better cleaning and more compact storage. Brush-type sifters, which frequently left brush bristles in baked goods, are becoming obsolete. Efficient vibrating sifters are coming more into use, and some of these sifters reduce floor space necessary for sifting.

Improvements in methods of weighing flour have resulted in dustless, ventilated types of weigh hoppers, the vent part being accessible for cleaning. Some bakeries are getting away from pan greasing, a tedious and objectionable task. Silicone coatings for pans are coming into use; they overcome the physical objections to pan greasing and, more important, remove the cause of objectionable flavors and odors from improperly cleaned greased pans. A single application of the coating is sufficient for from 100 to 200 bakings; such coating must be done carefully. For bakers who still prefer to grease their pans, there are now machines that grease pans automatically. Tunnel and tray ovens are being equipped with automatic loading devices to assure a complete and uniform load.

Automatic bread depanning, although not widely used at present, has become a practical reality. This step is the link in bread-shop operations that will permit the nearest approach to complete mechanization in bread baking. Newly designed band slicers will cut 50 to 60 loaves a minute with a minimum of crumbs. Other improvements in the baking industry during the last 20 years include automatic pan washers, improved rack washers, electronic control devices, and more sanitary conveyors.

Dairy Products

Development of the airtight separator has resulted in a machine that gives the best present-day method of centrifugal cream separation. The separator is a hermetically sealed machine in which the whole milk, skim milk, and cream are under controlled pressure at all times. This machine does an efficient job of skimming—much better than the open type—thereby cutting down butterfat losses in the skim milk. The fat globules are protected from mutilation, and are preserved in better state for churning. In this separator there is no danger of incorporating air into the product. The presence of air hinders separation and causes foaming. With the airtight separator it is possible to adjust the fat content of the cream at any time during the operation. This type of separator has been widely adopted by the dairy industry.

The use of counter freezers for freezing and dispensing frozen custard and soft ice cream has simplified merchandising of frozen products, especially at park concessions, amusement areas, and summer resorts. Prepared mix is purchased and is flavored and frozen only as required.

Use of pasteurized milk for cheese making has greatly increased the proportion of high-grade cheese in factories where it has been used. So far, Cheddar cheese is the only type made on a large scale from pasteurized milk, but other varieties are expected to be made from pasteurized milk as soon as the necessary accompanying changes in techniques are developed for each.

An improvement in the manufacture of stirred curd, or granular cheese, improperly called a continuous process, has lately been introduced into a number of cheese plants. Its advantages are in economy of labor and in accelerating the process. The milk is allowed to stand after the addition of rennet as in the past. But, instead of the cutting, piling, and draining of the curd being done by hand labor, the curdled milk flows, or is pumped, to a second vat and is there stirred with mechanically driven paddles and, after the whey has been drained off through a screen, forkers replace the paddles. The procedure is essentially a mechanical adaptation of the stirred-curd process.

Improvement in the degree of vacuum obtainable with commercial vacuum pumps has made possible the production of a concentrated milk which has comparatively little cooked flavor. The 3 to 1 milk now distributed directly to stores and homes by dairies in a few States is concentrated by means of higher vacuum and, consequently, at lower temperatures than were used in the past. These high-vacuum pumps have also made it more practicable to remove oxygen to the required extent from cans of dried whole milk.

Poultry Slaughtering and Dressing

Most of the improvements in poultry killing and dressing reflect improved and more specialized machines of the types in use before 1930. New since then, however, is the use of an electric killing knife which stuns and relaxes the bird and thus makes killing and picking easier. This method is used almost entirely for killing turkeys and is said to have reduced bruising previously caused by thrashing. Specialized machines, such as the gizzard-cleaner, now are available to speed up cleaning and eviscerating.

Although mechanical picking was practiced in the early 1920's, new-model pickers with longer and more flexible fingers have been developed. Modern, fully equipped plants supply operators with five different machines, one each for the major parts of a bird's body. The use of a mechanical washer (actually a picker)

finishes picking under a water spray, and when used at the end of the eviscerating line has been found to reduce bacterial contamination up to 85 percent.[8]

Scalding and wax coating are common methods of dressing. In 1929, when Rosenberger patented his wax coating method to aid in defeathering, it was common practice to hard-scald, that is, to use boiling water. Recent methods call for slack or semiscalding, at 128° to 130° F. and subscalding at about 138° to 140° F. In the new technique, immersion has been supplanted by spraying, the pressure of which separates the feathers and gets at the quills. Use of these new methods results in a clean white-colored, thin-skinned finished bird as compared with the scaly yellow product.

These practices are especially suited to the packaging of cut-up poultry in waterproofed materials, as high scalding results in hardening and browning of the skin if it is exposed to the air and allowed to dry out. Use of wax is less popular now than when it was introduced, partly because mechanical picking machines have been improved and have found greater favor and partly because only a very large plant can afford to install the necessary wax recovery machinery which will allow economical wax recomposition. This is true despite improvements in the waxes available since 1930.

Improved Retention of Nutrients

The greater retention of nutrients, mainly vitamins, in the finished processed product has become possible through the introduction of new processes and new machines.

The most telling instance is in the modernized parboiling method of processing rice which "fixes-in" the vitamins into the kernel. The so-called rice conversion process has been in commercial use in the United States since 1943. Before removal of the husk, the rice is steeped, steamed, and dried under vacuum. The finished rice is found to retain a higher thiamine, riboflavin, and niacin content than unconverted rice; correspondingly less is retained in the bran and hulls. In addition, the process results in less broken rice which is said to offset any added costs of the process.

Several of the other new methods mentioned elsewhere in this chapter have resulted in greater retention of vitamins and other nutrients in processed food. These practices include de-aeration of certain fruit juices, which reduces losses of vitamin C; continuous sterilization in canning; more rapid filling, closing, and cooling of containers, which reduces losses through exposure to air; packaging under vacuum; and the introduction of inert gases such as nitrogen or carbon dioxide, in packages.

Adding Nutrients to Processed Food

In general, the main stream of technological development during the last two decades has flowed in the direction of higher nutritive value as well as improved taste and texture of finished food products. For a few foods, however, chiefly grains, the long-term trend until quite recently was in the other direction. This trend has been reversed, not by modifying primary processing methods but by adding another step to processing, through which vitamins and other nutrients are added as a separate operation, usually in amounts that more than compensate for losses from milling.

The whole story of fortification or simple restoration is too long and complex to be told here. Many of its aspects that relate to Government regulation, social pressures, business practice, and efforts toward nutritional reform are beyond the scope of this study. But other important aspects are of direct concern to the technology of food processing. For the most part these relate to the enrichment of flour and bread, although fortification or restoration of a few other foods is also significant.

Technological progress of an earlier age brought about the problem of loss of nutrients in grain when roller-mill equipment supplanted the old method of grinding grain between two stones. The newer process, which was in wide use by 1870, separated much more completely the outer coating of each grain from the starchy endosperm inside. Under the older process much of the outer layer had remained in the flour. The new white flour represented about 72 percent of the weight of the wheat; the older flour had represented about 85 percent. The more refined flour resulting from milling had much less of minerals and vitamins than the older type of flour. In general, the situation was the same for rice and corn.

Thus the average national intake of certain important nutrients was significantly lowered. More and more, scientists came to realize that the increased refinement of grain in milling was having serious effects, but methods of accurately measuring the losses had not then been devised. Meanwhile the food industry and the general public seemed better satisfied with the new white flour, and there is little reason to believe that under any circumstances they would willingly have gone back to the kind of coarse gray flour that had been

[8] U. S. Prod. and Mktg. Admin. Poultry Branch; and Goresline and others (*21*).

ground between stones. The refined flour was better adapted to storage, and consumers liked its texture and white color, especially for bread making.

From the standpoint of the nutritionist, these advantages were heavily outweighed by losses of nutrients, especially thiamine, niacin, and iron. Technological developments of recent years have made it possible to redress the balance through the manufacture of synthetic vitamins on a large scale. Restoration of nutrients lost in processing, or fortification with larger proportions than occur in the original product, has become a regular step in several lines of food processing.

Enrichment of Flour and Bread

Dietary improvements by adding nutrients are not new, for as early as 1923 a white bread was produced to which vitamins and minerals were added. The product had a brief career; apparently consumers were not prepared to pay for such service.

By 1930, food technologists were becoming increasingly aware of the consequences to consumers of loss of nutrients through refinements in processing. During the last 20 years, and especially during World War II when average food intake and productivity of workers were of critical importance, the necessity for replacing at least some of the nutrients in highly refined foods was recognized.

In 1939, the Committee on Foods of the American Medical Association, later supported by the American Institute of Nutrition and the National Research Council recommended that consideration be given to restoring to the refined flour and white bread, the nutrients lost in flour milling. In 1940, many bakers started to add thiamine (vitamin B_1) to their white bread. More formal action was instituted in 1940 when the Food and Drug Administration held public hearings on proposed flour standards. Standards of identity for enriched flour were published in 1941 and revised in 1943. These standards specified the minimum and maximum quantities of thiamine, riboflavin, niacin, and iron that must be present in a pound of flour in order to qualify the product to be described as enriched, and provided for optional inclusion of calcium and vitamin D at specified levels.

Official publication of the standards gave a precise legal meaning to the term "enriched." Although further research is going forward on some aspects of the question, it is the opinion of many nutritionists that the specified ranges for thiamine, niacin, and iron are in the lower end of the ranges reported for whole-wheat flour, while the minimum levels specified for riboflavin exceed those found in whole-wheat flour.

Development of the synthetic vitamin industry during the late 1930's and early 1940's made it possible to develop and foster the restoration and fortification of foods. The steady decrease in the cost of commercial vitamin products appears closely related to their use on a relatively large scale. For example, initial efforts toward enrichment of flour were retarded somewhat by the limited supply of riboflavin. In 1941, production of this vitamin amounted to about 5,000 pounds for all purposes, but by 1950 production had increased to 199,000 pounds (87).

Plain flour is generally enriched by combining a stream of enrichment mixture with the millstream at controlled rates. Enrichment wafers may be suspended in water through the use of a yeast emulsifier and added by the baker to the bread dough in liquid form. A few bakers use proprietary mixes, which enable them to produce enriched bread. Such mixes may contain wheat germ or milk as the basic ingredients, and are generally added in dry form on top of the flour and incorporated in the dough during the mixing process. Most bakery bread contains around 3 or 4 parts of nonfat milk solids for every 100 parts of flour. These milk solids have been used by the industry primarily because of their functional value and as aid in the production of uniform-quality bread, not as a method of meeting the enrichment requirements. Milk solids, however, when used in conjunction with synthetic sources of vitamins, have become significant as an ingredient in the production of enriched bread.

Processing techniques are being steadily improved. A recent advance came from the discovery that the use of thiamine mononitrate as the source of thiamine in the enrichment mixture for flour permits better retention of this vitamin in storage than the previous use of thiamine hydrochloride.

After the enrichment of wheat flour had been shown to be of value, enrichment of farina, corn meal, corn grits, and macaroni products followed. Restoration of certain vitamins to cereal breakfast foods was in common practice by 1943. Recently some packs of grape, apple, and tomato juices have been fortified with ascorbic acid (vitamin C). Since 1943 some of the rice sold to the customer has had certain vitamins of the B complex added, and in some instances, iron.

Fluid milk fortified with vitamin D first appeared in 1931, produced by feeding proper amounts of irradiated yeast to the cows. In 1932, vitamin-D fluid milks were produced by irradiation of the milk itself, and by the addition of vitamin-D concentrates. In 1934, canned evaporated milk fortified with vitamin D

appeared on the market, and somewhat later certain brands were fortified with vitamin D_3, the principal form of vitamin D in fish oils.

In the early 1930's margarine was fortified by the addition of vitamin A, but the practice did not have widespread application for several years. It is estimated that by 1938, 65 percent of the margarine was fortified to a level of 9,000 International Units of vitamin A per pound.[9] The amount fortified at this level continued to increase until by 1944 virtually all margarine was fortified with at least 9,000 International Units of vitamin A per pound. In the late 1940's some manufacturers began to raise the amount of vitamin A added to margarine to 15,000 International Units. It is estimated that after 1948, 95 percent of the margarine sold was fortified at this higher level and the present standards of identity call for 15,000 Units of vitamin A per pound.

Enrichment of appreciable amounts of white flour has been accomplished mostly since 1940. In 1941 approximately 20 percent of the white flour was enriched with iron, thiamine, and niacin to minimum levels promulgated by the United States Food and Drug Administration (80).[10] In 1942, approximately 50 percent of the flour was enriched to these levels. Estimates for the years since 1943 indicate that 65 percent of all white flour—excluding macaroni and other pastes—has been enriched. In the last quarter of 1943 the Food and Drug Administration raised the minimum levels for enrichment of flour and called for the addition of riboflavin (80). Since then all of the white flour (except macaroni and other pastes) that has been enriched (estimated at 65 percent) has been at the increased minimum levels established by the Food and Drug Administration in July 1943.

Packaging

Packaging—particularly in containers that reach the ultimate consumer—has undergone many changes since 1930. In many instances it has become more of an integral part of processing than it used to be. Many of the new forms of food have called for new packaging methods. Much has been learned about how packaging can contribute to the preservation of a product's quality through storage, transportation, and retail stages and to its general usefulness and attractiveness to consumers. A number of the new developments have made it possible to reduce or to hold down packaging costs.

Improved Materials

Tin cans and glass jars and bottles are the traditional containers for canned foods; in the last 20 years each type has undergone improvements that make it more satisfactory. Perhaps the major improvement in the tin can has been the recent development of two kinds of enamel, one sulfur-resisting and the other acid-resisting.

The electrolytic process for tin plating also is a significant development. Electrolytic plate production rose from 3 percent of the total production of tin plate in 1942 to approximately 60 percent of the total in 1950 (9). This type of tin plating, which was developed around 1938, uses only about a third as much tin as the conventional hot-dipped process. The possibility of savings in tin offered by the electrolytic process may permit tin cans to meet the competition of other materials such as glass and fiberboard.

A "Bonderite" can, requiring no tin at all, was developed early in 1941. The primary function of the "Bonderizing" treatment is to provide more suitable surfaces than regular steel plate. Enamel applied to "Bonderized" plate showed less loss of adhesion in processing than when applied to untreated steel.

Glass allows the customer to see what he is buying; it can often be reused for refrigerator storage or home canning. The major draw-backs to glass containers have been their weight and fragility. New methods of manufacturing make glass containers tougher. Glass jars of little more than half the weight of conventional jars have been produced also. Colored glass is used for some vitamin products packaged in glass.

In recent years, new plastic and transparent flexible materials have solved a number of problems in food packaging. The most widely known plastic films probably are pliofilm, cellophane, and polyethylene. Although some of the films vary in trade name only, several have certain distinct physical characteristics such as resistance to moisture and permeability to gases that make each type particularly suitable for packaging certain food products. Until recently the emphasis in use of films in packaging food has been on appearance, particularly transparency. Many of the newer materials were developed during or immediately after World War II, with little regard to cost, so that some are too expensive for commercial use in food packaging.

New ingredients in wax have improved the physical properties of waxed papers. Wet-strength paper also has been improved by recent developments. Paper to

[9] Clark, F., Friend, B., and Burk, M. C. Nutritive value of the per capita food supply, 1909–1945. (*12*, pp. 14–15); consumption of food in the United States, 1909–1948 (*63*); and unpublished data for later years.

[10] See footnote 9.

which small amounts of urea formaldehyde or melamine formaldehyde resins have been added may be soaked for weeks at room temperature and still remain strong. One of the wet-strength papers is used in frozen food packaging. Wet-strength greaseproof papers are also used for butter, cheese, and ice cream.

Sixty-seven percent more milk can be transported in the same space in square paper containers than in the space-saving square glass bottles. As most of the paper containers are purchased as flats, relatively little space is required for storage. They do not have to be collected or washed. Containers made of waterproof paper now are extensively used in packaging milk and cream. Paper containers are thinner and lighter than glass bottles and, as they are square in cross section, they require less space than round bottles or even the recently adopted four-sided glass bottles, of the same capacity.

More extensive use of multiwall paper bags began during World War II, when cotton and burlap bags were scarce. Their use has continued to increase since World War II, largely as a result of improvements in the bag itself. The bags are now made of stronger paper, which reduces their weight as much as 25 percent. Some have plastic-coated inner linings resistant to greases, acids, and moisture. A number of flour mills and sugar refineries have found that use of paper bags materially reduces costs of packaging.

Aluminum foil is another notable development in the packaging field. Collapsible aluminum tubes are finding limited use in the food field. Aluminum closures or caps are finding wider use.

Vacuum packing in flexible film is now possible for a number of products, for example, sliced bacon. Foods that readily take on moisture can be stored longer and protected better when packaged in a water-vapor resistant flexible package or rigid container. Conversely, foods that give off moisture may be protected by a water-vapor resistant package.

Nitrogen packaging to prevent deterioration of perishable food products through oxidation was formerly limited to rigid containers. Recently developed machines and techniques now can turn out flexible film for packaging with nitrogen. Packaging in inert gas has made it possible to transport dried whole milk for greater distances than before and to store it for longer periods without spoilage. This development is a principal cause for increased production of dried whole milk in recent years.

New Designs for Consumers' Convenience

Many of the recent trends in packaging aim at the convenience of the user. As an example, butter may be bought in a package containing individual butter pats. Similarly, baking powder may be bought in individual film-packed teaspoon-portions for convenient use in home baking. In sugar packaging, individual wrapped cubes have been available for a long time but the trend toward smaller packages in the granular form has become most pronounced.

In some instances, added protection may be provided with the more convenient package. Uncooked breakfast cereals are packaged extensively in individual consumer-sized packages. These packages are convenient for home and restaurant serving, and also insure a fresher and crisper cereal than that from a larger package that is opened but not used immediately. The innovation of wrapping a divided loaf of bread in two separately sealed wraps before putting it together again in one outer wrap is a pre-World War II development which has been reintroduced in the baking industry. Packaging in this way not only makes for fresher bread, but also allows the possible combination of two kinds of bread.

The trend toward smaller sizes is common throughout the food industry. A review of the volume of packs over the last decade shows a significant increase in the use of 6 oz., 8 oz., No. 300, and No. 303 [11] for canned products, particularly juices. Increased use of No. 303's and other smaller sizes instead of No. 2's for peas, corn, and lima beans also is apparent. Canned fruits are apparently being shifted to some extent from wartime standard 2½'s to prewar smaller sizes—8 oz. No. 1 tall, and 303.

Multiple-Purpose Packaging

The primary function of packaging still is to protect the product. In addition, modern designers of packages for food have worked toward a more appealing and convenient package.

Appeal in packaging may be realized in a number of ways such as use of color, descriptive labeling, and different sized and shaped containers. The most recent development has been the use of transparent packaging materials. This type of packaging gains its appeal not wholly from the package itself but also from the fact that the product may be seen.

Many of the new containers or packaging materials are suitable for reuse in the home. Containers for many products have been designed for reuse as drink-

[11] A No. 300 can would be 3 inches in diameter by 4 7/16 inches high. A No. 303 can would be 3 3/16 inches in diameter and 4 9/16 inches high.

ing glasses, refrigerator dishes, flower vases and pots, cooking utensils, and as other household implements. Flour may be bought in colored or printed cloth bags suitable for reuse as clothing or household decoration. Plastic and other films used in food packaging are formed into bags that can be used for shopping, laundry, protective covers, and refrigerator bags for fruits and vegetables.

Food processors with a national market have found that protective packaging requirements may vary according to geographical location. For instance, bakery products going into humid areas must be carefully moisture-proofed, whereas in less humid areas the same care is not necessary.

Packaging Equipment

Developments in food-packaging equipment have brought increased speed and greater flexibility for handling different sized packages at variable operating speeds. Automatic or semiautomatic machines have been designed to wrap or package a wide variety of food products, ranging from doughnuts to chickens.

For irregularly shaped meats a new and rapid wrapping method has been devised. One such process utilizes two simple semiautomatic machines—a wrapper and a twister.

In the bakery industry numerous automatic packaging devices are used. One machine, for example, cartons small pies. This unit automatically picks up flat blanks from a magazine, sets them up into cartons, feeds pies into the cartons, and closes the cartons.

Another kind of machine fills the cartons with free-flowing materials such as salt, rice, or cracker crumbs through adjustable measuring cups, and then seals the top of the carton. This machine is entirely automatic. For packaging operations that involve weighing, new machines combine weighing and filling operations in one unit. These are only a few examples of higher speed and automatically controlled packaging operations in the food field.

At the beginning of World War II, most of the equipment for handling films in food packaging was adapted to handling and sealing only the stiffer films with low elongation qualities, such as cellophane. Although further improvements are needed, equipment has been devised for handling the new softer and more extensible films like the vinyls and polyethylenes.

As compared with 20 years ago when closing machines sealed about 150 cans a minute, present-day machines seal from 300 to 400 cans a minute. Faster fillers for food products are another important development.

Conflicting Trends in Cost

There are many economic factors to be considered in connection with the trend toward smaller and more appealing packages. The cost of the package and the amount of processing and handling per unit of food packaged tend to increase with the trend toward smaller sizes. Added packaging beyond that necessary to contain and protect the food also results in increased cost that may be reflected in higher prices.

There are, then, two opposite trends in food packaging that significantly affect costs. Cost reduction may result from faster, more automatic packaging machinery, more efficient techniques, cheaper packaging materials, and resultant saving of retail handling costs. Cost increases may result, however, from smaller packages which require more material per volume packaged than larger sizes, and more time and labor, and from features designed primarily for their reuse value.

CHAPTER 4

Technology in Transportation, Storage, and Communications

Processing is only one of several steps in the complex operation of bringing food from the farm to the kitchen. Foods must at times be transported over great distances. They must be stored for short or long periods, often under carefully controlled conditions. Full advantage must be taken of the Nation-wide system of rapid communications if transportation and storage are to be so scheduled that the desired amounts of foods will be in the right places at the right times and that sellers and buyers hundreds of miles apart can reach informed decisions swiftly.

In the two decades since 1930 technological progress has wrought far-reaching changes in methods of transporting and storing foods and in the many aspects of the general system of communications that have been incorporated into modern food marketing. Many of the changes have affected the quality of the foods reaching the consumer as well as the costs of getting them to him.

This chapter examines the outstanding developments in the technology of food marketing that have affected:

(1) Transportation
(2) Storage
(3) Methods of handling materials that apply to both transportation and storage
(4) The adaptation of general communication methods to food marketing

Transportation

Of all the changes that have taken place in the transportation of food in the last two decades, the dominant development is the rise of the motortruck as a long-distance carrier. A number of striking changes also have affected the methods and equipment used in rail transportation. With a few exceptions, air transport has not yet assumed commercial importance for foods.

Highway Transportation

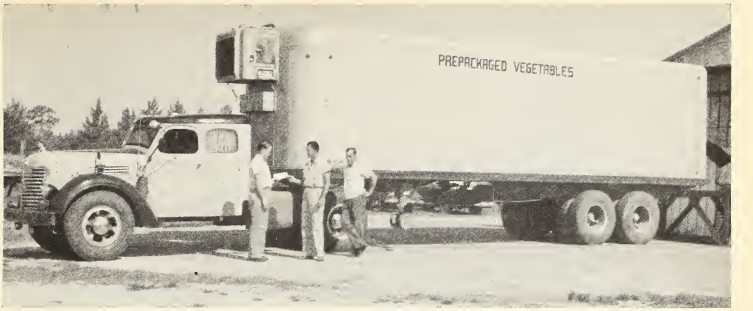
Although the years since 1930 have seen no radical change in the design of truck engines, many noteworthy improvements have been made. Even more significant have been changes in the size and construction of truck bodies, improvements in brakes and tires, and vast improvements in the network of roads over which the trucks run.

Conventional gasoline engines for trucks have been made more rugged and powerful, and capable of achieving higher speeds upgrade under heavy loads. Diesel engines were in use in trucks before 1930, but since then their design has been greatly improved and they have come into much more general use, especially as power units for big tractor-trailer combinations. Improvements in tire construction have more than kept pace with the tendency toward larger trucks and heavier loads.

Within the limitations of State regulations and the capacity of roads to accommodate their size and bear their weight, the more recently built trucks tend to be wider and longer. Manufacturers' designers have learned to improve distribution of weight per axle, thus allowing heavier net loads. Practicable semitrailer and tandem trailer units have been developed. The 2½-ton truck, which was a giant on the roads in 1930 now is a comparative pigmy. The trend has been toward larger trucks, and the increasing share of tonnage has been carried by the large combinations (table 11).

A variety of truck bodies has been designed for special requirements, including those of food transportation. Tank trucks have been developed for hauling milk as well as liquid forms of lard, sugar, and other foods. There are special models of dump trucks for transporting grain and grapes. Automatic heating or refrigerating systems have been devised to provide the temperatures required by fresh or frozen food products while in transit on the highways.

Improvements in highways have been as striking and significant as in the trucks themselves. As with so many technological gains, the two developments have taken place side by side. It is clear that in the first instance the invention of the automobile more than



Modern food truck transportation

Since 1930 significant changes have occurred in size and construction of food-truck bodies. Improvements in brakes and tires and more rugged and powerful engine design have been developed for the purpose of achieving higher speeds upgrade under loads.

half a century ago gave the impetus for development of the modern highway system. After that, cause and effect became hopelessly intermingled. During the last 20 years the existence of an extensive and constantly improving network of roads across the country was as much a stimulus to the manufacture of more and better trucks as the existence of the trucks was a cause of further improvement in roads. At any rate, it is apparent that the motortruck could not become a major factor in transportation of foods on a national scale until there was an adequate mileage of well-built roads, open in all kinds of weather, coordinated into a national system, and plainly marked.

From 1930 to 1950 was a great road-building period. During the two decades, the total mileage of rural roads remained almost constant at slightly over 3 million. In 1929 not much more than a fifth of this mileage was surfaced, but by 1948 more than half was sur-

TABLE 11.—*Trend in automobile and truck transportation and equipment, selected years*

Item	Unit	1929	1936	1940	1949
Motor vehicles registered:					
Automobiles and taxis	Thousand	23,060	24,108	27,372	36,293
Trucks	do	3,408	4,001	4,590	8,028
Size of truck—average load carried:					
Single unit	Ton		1.9	2.1	2.3
Combinations	do		6.9	7.4	10.2
All types	do		2.9	3.3	5.1
Truck travel — loaded and empty:					
Single unit	Billion vehicle-mile		12.6	16.7	24.3
Combinations	do		2.8	4.4	9.5
Total	do		15.4	21.1	33.8
Distance carried:					
Single unit	Billion ton-mile		14.3	22.9	25.6
Combinations	do		13.7	23.3	63.5
Total	do		28.0	46.2	89.1

HIGHWAY STATISTICS (*85*).

Food tank trucks

Tank trucks, similar to the milk truck shown above, are now used also for hauling such commodities as liquid sugar, vegetable oils, and wines. (Photograph from *Food Engineering.*)

faced. During the same period the mileage of the larger truck routes of the State rural highway systems more than doubled, going from 208,000 to 475,000 miles. The trend toward extra-lane superhighways began. In 1939, there were 300 miles of roads of 45 feet or more in width; in 1949, there were more than 2,000 miles (85). Highway engineers learned more about grades and curves and about surfaces to withstand the wear of heavy fast trucks. As the road system was extended, roads were rebuilt and relocated to accommodate high-speed traffic, and thousands of miles of light surfaces were replaced with heavier types. Much of the re-surfacing was inevitable, as the older surfaces broke down under the wheels of the big trucks and the increased volume of motor traffic.

As a result of improvements in trucks and roads a comparatively fast, highly flexible system of highway transport for foods has been developed within the last 20 years. In 1931, the longest regular route of any trucking line was 530 miles and very few routes were more than 250 miles (86, p. 18). By 1949, hauls halfway or all the way across the continent were commonplace.

The flexibility of truck shipment is unquestionably one of the major reasons for the growth of highway transport. A truck can move in any direction and to almost any place where a market exists, by a relatively direct route and at the time it is needed; often a train cannot do this. A trucker can offer his best service to a shipper with a single truckload. The railroad can serve best the shipper with a trainload, a relatively rare phenomenon in the movement of food products. Train shipments to distant points requiring less than a train-load tend to go by way of central terminals which serve as break-up or reclassification points; trucks tend to move directly to any point taking a truckload, or even a large fraction of a load. Even a split shipment can get fast truck service. The only time lost is that incurred directly in unloading. No switching or train make-up time is lost. The flexibility of highway shipment has appreciably shortened the marketing route between the producer and the smaller town, which generally could not absorb a carload of a particular commodity all at one time, or even a mixed carload shipment of several food products.

The absolute speed of truck shipments also has increased. In 1935 the average speed at which cargoes were moved by truck, including all delays from consignor to consignee, was about 15 miles an hour. In 1950, the average speed on long hauls was about 25

miles an hour. With a few exceptions, railroads do not match this 25-miles-an-hour over-all speed, even on direct transcontinental shipments of agricultural perishables. In many instances, the fact that trucks can take fairly direct routes between almost any two points, plus their greater facility for handling small shipments and for timing in general, has meant greater speed as well as a more closely tailored service.

Consequently, trucks have become the principal carriers for many agricultural products, especially for those which must be moved fast and assembled from many production points (fig. 12). However, sharp differences often occur among the various markets. The chief cause of these differences appears to be distance from supply areas. The closer a market is to its sources of supply, the more likely it is to receive a higher proportion of its shipments by truck. The farther it is from sources of supply the greater the likelihood of a high proportion of rail shipments. Many other factors enter into the relationship, so that there are exceptions to the general rule.

Comparable figures as to the proportion of truck shipments in 1930 are not available, but the statistics that can be obtained for that year, or for other years near the beginning of the 20-year period, indicate that the truck's share of food transportation was then much smaller than for 1939–45. A few examples follow: In 1929, only 22 percent of the livestock receipts of public stockyards in 16 markets came by truck. In 1930, less than 30 percent of the estimated total production of fruits and vegetables moved by truck, and 20 percent of the New York and Chicago receipts of live poultry moved by truck.

Rail Transport

Railroads still carry the larger part of the bulkier and less perishable agricultural commodities, and even a considerable volume of the perishables, despite the heavy and continuous inroads of trucking. The basic structure of the Nation's marketing system in 1930 was built around rail transport, and this structure has been modified, though not completely changed, in the last two decades. The basic price-making markets are still the sites of the large rail terminals. In the last 20 years, railroad transportation has undergone a series of technological changes.

The most spectacular advance in railroad technology in the last 20 years was the introduction of the diesel-electric locomotive. The first diesel-electric went into operation in 1926. In 1929, there were only 25 in the country and, even in 1940, less than 1,000 of the 44,000 locomotives then in use were diesels; but by 1950 approximately half the freight was pulled by diesels. The diesel has proved to be more efficient and cheaper to operate and maintain. It can keep faster schedules and does so on passenger runs. It can haul longer trains, and on freight runs it is so used. A longer train usually means slower transit time, whatever the actual train speed; more time is spent on sidings and in classifying yards. In many instances, therefore, the time from shipper to receiver has not been reduced. But there are exceptions. One large railroad now operates a run from Salt Lake City to San Francisco, utilizing diesels and the recently developed roller-bearing freight cars. The current run takes 27 hours, compared with a minimum of 57 hours under previous schedules. There are other such examples, although not many as yet.

Improvements in the design of refrigerator cars using ice, and the recent introduction of mechanically refrigerated railway cars have been mentioned in connection with the frozen-food industry (ch. 2). Several of these developments were designed primarily to serve other purposes. The reverse-flow fans, powered by the turning of the car wheels, are equally effective in circulating cool air for fresh perishables and warm air for products that must be guarded against cold. On a long haul under changing weather conditions, both heating and cooling may be needed to preserve a constant temperature for the same cargo.

Also, a method of half-stage icing has been developed, so that shippers of perishables that require only mildly cool temperatures are saved the expense of fully loaded ice bunkers.

Solid carbon dioxide (dry ice) is now used to some extent in checking decay in sweet cherries while in transit from the Pacific Coast. This has been found particularly useful when the fruit is shipped during warm humid weather. This treatment also preserves the bright fresh color.

A major problem of transportation of foods by rail has been damage in shipment. Much of this is believed to come from shocks and jars suffered in switching. Three main attacks have been made on this problem. Manufacturers of rail equipment have designed couplings and undercarriages which soften the impact of sudden stops and starts. Some work has been done in finding new loading patterns and shipping containers that will minimize load-shifting under such impacts. Finally, the roller-bearing truck for freight cars has been perfected to reduce the friction that so often results in a jerking start. However, the latter has not been widely adopted as yet.

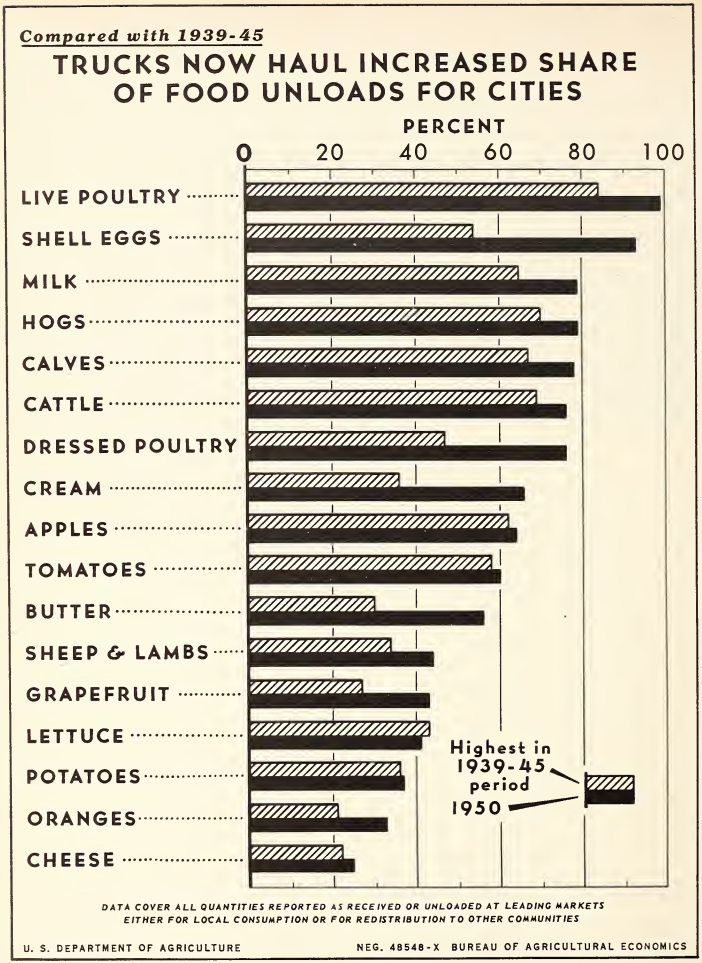

Compared with 1939-45
TRUCKS NOW HAUL INCREASED SHARE OF FOOD UNLOADS FOR CITIES
PERCENT
0
20
40
60
80
100
LIVE POULTRY
SHELL EGGS
MILK
HOGS
CALVES
CATTLE
DRESSED POULTRY
CREAM
APPLES
TOMATOES
BUTTER
SHEEP & LAMBS
GRAPEFRUIT
LETTUCE
POTATOES
ORANGES
CHEESE
Highest in 1939-45 period
1950
DATA COVER ALL QUANTITIES REPORTED AS RECEIVED OR UNLOADED AT LEADING MARKETS EITHER FOR LOCAL CONSUMPTION OR FOR REDISTRIBUTION TO OTHER COMMUNITIES
U. S. DEPARTMENT OF AGRICULTURE
NEG. 48548-X BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 12

Air Transport

Growth of air transport for all types of freight and express has been phenomenal. Ton-miles flown grew from 100,666 in 1930, to 3,476,224 in 1940 to 123,001,652 in 1949. However, for most agricultural food products, air carriers are still unimportant. Part of the early Louisiana strawberry crop goes north by air, and air transport of baby chicks, hatchery eggs, and a few high-priced specialties has assumed some significance. The advantage of air shipment of foods has not proved as great as many people had expected in the latter days of World War II. Precooling in production areas has proved to give as great an advantage in delivering produce of good quality, when coupled with fast surface shipment, as air shipment. In addition, air cargo costs, with current equipment, are still too high for most farm-produced foods. Not many foods have the combination of relatively high density and high value required to make them what the airlines call good candidates for air transport. Any sweeping effects air transport may have on food marketing are in the future.

Precooling

The last two decades have brought great strides in both the theory and practice of precooling foods, mainly fruits and vegetables, before transportation and storage. The effect of these developments has been considerable on rail and truck transport and upon the general problems of storage.

Relatively low temperatures, even though they are above freezing, tend to check the action of microorganisms and to slow the life processes of fruits and vegetables. Thus, unless higher temperatures are required to facilitate further ripening, many foods can be shipped with less deterioration and held longer in storage if their temperature has been brought down sharply as soon as possible after harvest. In many instances, precooling makes possible the use of simpler and therefore less expensive refrigeration methods during transit.

During recent years much progress has been made in determining the temperatures to which different fruits and vegetables should be precooled and in the methods for bringing them to those temperatures. Ice and cold water were the two principal media used. Within the last 5 years an entirely new method of precooling has been developed, utilizing the cooling effects of the evaporation of moisture under vacuum. In less than an hour—sometimes in less than half an hour—the temperature of the product can be brought down to about 35° F. with a negligible loss of moisture.

A good example is a new process used to chill lettuce. The lettuce is packed ready for shipment with no ice in the crates and is subjected to a very high vacuum. The vacuum-cooled load travels with bunker ice only, no top ice being used, making possible a minimum carload of 30,000 instead of 24,000 pounds. This should mean a substantial savings in freight.

Tailored Storage for Fresh and Processed Foods

The active contribution that good storage can make to the marketing of foods has been widely recognized since 1930. Much has been learned as to the different conditions that are best for different foods and as to methods of bringing about the conditions required for each.

Two decades ago the storage of many foods was quite generally regarded as a relatively static phase of marketing. Except for the obviously different requirements of foods in cold storage, relatively little attention was paid to individual types of handling, tailored especially to the needs of other foods. Much thought and care, however, had been given to methods of handling products for which storage was part of an aging or curing process that improved quality.

The chief problem in storage is maintaining the quality of the product, or at least inhibiting deterioration to the greatest degree possible. Within recent years there has been a growing realization on the part of farmers, market agents, and warehousemen of how proper storage can maintain quality, and a better understanding of the factors that enter into good storage. Among these factors, greater stress is now laid on (1) the condition, maturity, and strain or variety of produce from the farm, (2) temperature and humidity control in storage, and (3) modified atmosphere for control of volatile gases and for stimulating or inhibiting processes of growth. Closely allied to the latter are new chemical treatments for inhibiting growth.

Influence of Farm Practices on Storage

For many products good storage begins on the farm. Investigations have shown that some varieties of fruits and vegetables naturally have longer storage lives than others. When farmers know in advance that products are going into storage they can plant varieties that keep longer and are more resistant to bruising in transit. Unfortunately, these tougher members of the fruit and

vegetable families often lack the perfection of flavor of varieties usually grown for home consumption.

Use of insecticides and fungicides on fruits or vegetables protects crops from insect injury and the rotting that follows injury, and thus reduces losses in storage. But use of this modern farming practice necessitates certain precautions when crops are put into storage. Poisonous residues which may affect the consumer's health if the insecticide is applied too near harvest time must be removed after harvest; and in the case of one material (benzene hexachloride) a distinctly "off" flavor may be absorbed.

Hormone sprays have been found useful in preventing the premature dropping of sound fruit before it can be picked. If this practice results in prolonging the normal picking season, however, it may lead to storage of overmature fruit which will have a shorter storage life.

A number of other inquiries into what constitutes good storage have led back to the farm. Unnecessarily rough handling leads to faster deterioration of products in storage. Even small scratches provide openings for decay organisms. Much modern harvesting and handling machinery has been altered to reduce sharp edges and dropping distances. Many parts are covered with rubber to avoid bruising.

Time of picking is important to the keeping quality of many products in transit and storage. Modern marketing practice is based on the knowledge that pears have the best quality if removed from the tree at a definite hardripe stage of maturity, determined by an instrument known as a pressure tester, and are then ripened at temperatures between 65° and 70° F.

Tomatoes cannot be satisfactorily shipped and handled for any great distance after they have ripened. But they can be picked in the mature-green stage, shipped to distant markets under proper conditions, then ripened at from 55° to 70° F. This enables growers in the South to ship to Northern markets during the winter and spring seasons when tomatoes are scarce and bring a good price. Tomatoes are ripened in special rooms at the market. The ripening temperature depends largely upon the market demand. At 55° tomatoes can be ripened very slowly and are not in danger of cold injury as could happen at lower temperatures. At the other extreme they can be ripened quickly at 70° when demand is active.

Temperature and Humidity Control

By far the greater part of the technological advance in the control of temperatures and humidity for foods in storage has consisted of discovering the best conditions for individual products. The problem of bringing about those temperatures and humidities was for the most part relatively simple and in general has not required revolutionary innovations in equipment.

Deterioration of fresh produce in storage is usually due to rots caused by fungi and bacteria or physiological deterioration brought on by improper temperatures. Decay-causing organisms are always present in quantity in field soil and are therefore brought in on the products of the soil.

Most products are stored to best advantage at a temperature just above their freezing point (31° to 32° F. in most instances). When exposed to temperatures below this, freezing ruptures the tissues and the product can no longer be handled as fresh. Products of tropical or subtropical origin cannot be stored at temperatures near their freezing point without soon showing physiological deterioration. In commercial practice, the storage temperatures selected depend upon the use to be made of the product as well as the particular diseases to which it is subject. For example, potatoes stored at close to 50° F. retain their best table quality and their vitamin C content is retained longer than at lower temperatures. At 50° potatoes sprout in from 2 to 4 months. When they are to be kept longer, lower temperatures are used, but at these temperatures, the sugar content increases. Methods have been developed by which potatoes held at as low as 40° can usually be desugared by raising the temperature to 70° for from 1 to 3 weeks.

Although temperatures of 30° to 32° F. are usually recommended for apples, certain varieties are better stored at 35° to 38° to prevent development of brown core; Grimes Golden apples stored at 34° to 36° do not develop as much soggy breakdown as those held at 32° or below.

Similarly, oranges are ordinarily stored at about 38°, but a storage temperature of 32° to 33° is usually best for oranges from the humid Gulf Coast regions.

Next in importance to uniform and correct temperatures in the storage of fresh food products is the control of humidity to maintain freshness, flavor, and other characteristics of quality. For most fresh products a relative humidity of from 80 to 90 percent should be maintained. Exceptions are onions and nuts, which have been shown to require a relative humidity of about 70 percent. Control of humidity is especially important in storage of dehydrated products. For these, the lower the humidity, the better.

Both humidity and temperature are of greater importance in the storage of canned foods than was

earlier supposed. Realization that canning did not automatically insure preservation for indefinite periods was widespread, especially in relation to canned vegetables, well before 1930. It is now known that high humidity in low-temperature storage results in rusting of the cans through condensation of moisture on the outside, and that taking cans suddenly from low temperatures in storage to high-temperature, high-humidity atmosphere outside has the same effect. An intermediate stage to avoid sudden and extreme changes in temperature has been found useful. During the early years of production of canned citrus juice, little attention was paid to storage even in periods of extreme heat. Now, canned juice is generally kept in well-built warehouses, and extreme heat is avoided through a cool-storage system by which the warehouses are tightly closed in the daytime and ventilated at night when the air is relatively cool.

Principal developments in storage of grains have aimed at overcoming the problems of excessively moist grain and of lack of storage space in commercial facilities. Taken individually, the technological advances have not been spectacular; together they add up to a far-reaching change in methods.

With the coming of the combine, farmers harvested their grain earlier in the season than previously. They soon found that the wet grain deteriorated unless brought to the elevator for quick drying. Harvesting of grain during drier periods alleviated this problem somewhat, but the growing practice of custom combining has seen gradual return to harvesting of grain which contains excessive amounts of moisture. Also, both the shift toward varieties of grain sorghum more suitable to combining and the mechanical picking of ear corn have resulted in higher-moisture products.

To prevent deterioration in the grain, commercial elevators have installed and adopted permanent-type dryers, and small drying units have been developed, many of them portable, for use in farm storage. An important innovation in such drying equipment has been the shift from coal to oil and gas as sources of heat.

Twenty years ago, the idea of storing grain in one-story bins received slight consideration because of the danger of germination and moisture during the hot season. Department of Agriculture scientists, however, have developed designs for use by the Commodity Credit Corporation in storing its grain at bin sites rather than in central commercial elevators. These facilities have proved adequate for successful storage. Engineers surmounted another possible handicap by the use of a steel foundation which prevents the bins from being blown over and of prefabricated weather-proofed material designed to take advantage of ventilation. In addition, the grain is dried carefully before it is stored.

Other noteworthy developments of recent years include improvements in storage of rice and shelled corn, and a change from sacked to bulk storage of grains on the west coast. In the case of shelled corn, ventilation of storage structures and drying of the product are the chief elements added. The use of combines for rice, which was begun only during World War II, resulted in wet rice coming to the elevator. It was found that drying at low temperatures was necessary to prevent cracking of the hull which results in down-grading of the product. The shift toward bulk storage of grains in the West reflected the lack of bags during the war; bulk packaging was especially suited for shipping to the Orient. Economies in bulk storage and handling are so evident that there have been few instances of return to the previous method of storing.

Controlling Growth in Storage Through Chemistry and Modified Atmospheres

Fruits, vegetables, and other products are still "alive" in storage and continue to undergo changes. Proper temperatures and humidity can retard undesirable changes but in many instances modified atmosphere and applications of chemicals also are helpful.

An example of the chemical approach is a potato-sprout inhibitor, which came into limited commercial use after the middle 1940's. The active chemical (methyl ester of naphthaleneacetic acid) is usually incorporated in a dust which is applied to the potatoes as they go into storage and removed when they are taken out. When this treatment is applied before the potatoes go through the natural rest period they usually remain dormant or free from sprout growth for several months even when stored at 70° F.

Atmospheric control in storage has drawn considerable attention and comments in the last 5 or 6 years. Modified atmospheres offer a method of lengthening the storage life of those apples that must be held at the relatively high temperatures of 35° to 38° F. Modified atmospheres are obtained by holding fruit in gas-tight rooms and regulating the proportion of carbon dioxide and oxygen in the atmosphere. England has several "gas storages" and in this country storage of McIntosh apples in modified atmosphere is practiced to a limited extent in New York State. The difficulty and expense of suitable construction and maintenance of the proper atmospheric concentration, up to the present time, have stood in the way of wide use of

controlled atmosphere in large commercial cold storage in this country.

Prepackaging of fruits and vegetables has brought its own problems of atmosphere control. Film wrappers used in prepackaging are made from a number of different materials and vary in gas and moisture permeability. With most products when confined in a film impermeable to CO_2, there generally occurs a build-up of this gas while oxygen is depleted. This abnormal concentration is likely to impair flavor and, in repacked tomatoes, for instance, it prevents normal ripening. In most films it has been found that venting perforations are necessary in preventing this CO_2 concentration. The vents do not interfere with optimum moisture retention.

Activated carbon as an agent for the removal of volatile gases given off from ripening fruit, especially apples, during storage has received considerable attention. Among the volatiles given off from ripening apples is ethylene which, in concentration, is responsible for hastening the ripening process in more immature fruit when the storage room contains both mature and immature apples. Other gases in the apple storage room are apparently responsible for scald, a diffused brown discoloration of the skin, which is best controlled by use of oil-impregnated wraps or shredded paper distributed throughout the containers. Recent experimental evidence shows that odorous elements are removed by activated carbon, but that those causing ripening and scald are not always reduced in important amounts. Commercial applications have given variable results in controlling ripening and scald. Operators believe that their use has value in removing odorous volatiles.

Degreening of oranges through the use of ethylene gas in storage has developed to extensive commercial application since 1930. The Valencia variety tends to regreen on the tree if not removed when it has attained full color. In California, this is a late-crop orange and to extend the market during the summer it is desirable to leave the crop on the tree and harvest as needed. The regreened fruit is subjected to a very low concentration of the gas in special rooms in packinghouses.

Other treatments supplementary to refrigeration are the use of sulfur dioxide for the control of decay in grapes, copper-impregnated wraps on pears for control of grey mold rot, and diphenyl-impregnated wraps or separators on oranges and grapefuit to control blue mold, green mold, and stem end rot.

Ultraviolet light has been tried as a method of controlling rots in fruit and vegetables, but serious difficulty has been met in killing molds which are responsible for the destruction of most products. The principal drawback is the nearness to the lights required to effect a kill.

Use of ozone as a fungicide in storage has been advocated, but experimental evidence has disproved its value in controlling storage rots when used in concentrations commercially feasible. Ozone has proved useful, however, as a deodorant and is used commercially in egg storage.

Improvement in Storage Facilities

Knowledge of how better to control the physiological changes of stored products would, in itself, make only a limited contribution to the efficient marketing of foods. Storage facilities must be properly located and efficiently arranged and constructed.

Since the early 1930's, storage facilities have been improved and many new ones built, but this trend is still far short of its potential. Many wholesale establishments do not yet have temperature-controlled rooms. Many retailers of fruits and vegetables do not have adequately refrigerated holding rooms or display cases. Public warehouses have overabundant space in some areas; in other areas there is far too little.

As warehousing, especially the refrigerated type, is expensive, multicommodity storage is increasing. This allows fuller use of space by scheduling storage of commodities to conform to complementary seasonal in-and-out movement patterns.

The last two decades have brought many advances in the design of storage facilities. Insulation and ventilation have been improved. Vapor barriers that keep moisture from entering or leaving storage space and that keep insulation dry, have been considerably refined.

Warehouses have been built that are suitable either for general storage with controlled temperature, for refrigerated cooler storage, or for refrigerated freezer storage. Space thus constructed is called convertible space and permits warehousemen to store almost any commodity.

Refrigerated rooms are available to wholesalers and retailers in prefabricated sections, so that small rooms can be constructed or expanded hurriedly. These storage units can be "knocked-down" and moved from one place to another. Several large warehouses have been built quite economically from sections prefabricated at manufacturing plants.

Automatic control of storage-house temperature with minimum and differential thermostats to control ventilation fans and intake dampers is proving effective,

especially in milder climates, through the use of cooler outside air, particularly at night.

Shell cooling is a new type of storage construction in which air is circulated between inside walls and a tight liner, and under the floor to a center duct. Its chief practicable use thus far has been in storing potatoes. The shell construction prevents condensation of moisture within the building and thereby protects the structure from deterioration, protects the stored products from cold walls, prevents loss of moisture from the product through air circulation in the bins, and insures more uniform temperatures throughout the structure.

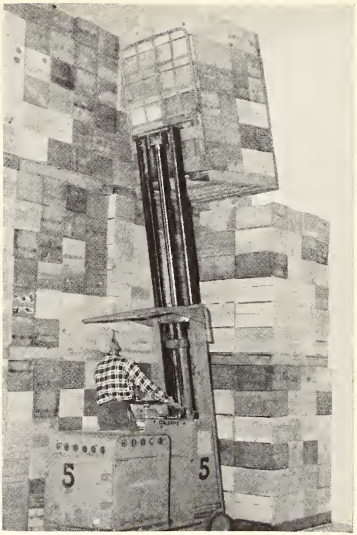
Increased Mechanization in Storage and Handling

Application of engineering principles to the handling of food is relatively new. Nearly all of the considerable advance that has been made has taken place in the last two decades. The chief aim has been to reorganize handling techniques so as to reduce costs, principally through replacing manpower with machines or reducing the need for manpower through improved methods.

In the early 1920's industrial trucks or tractors and platform-lift trucks came into use. Around a decade later one of the most revolutionary tools—the fork-lift truck, powered either by electricity or gasoline—began to be used commercially. All of these devices proved well-adapted to the handling of food products in transit or storage. Use of the fork-lift truck was preceded by a simpler method—handling of shipments on skids by means of a hand-lift truck. This method became important in handling canned goods as early as 1930.

Unit Loads

A development in handling that is supplemental to mechanization is the pallet. A pallet is a load-carrying platform made of wood or metal with the bottom surface raised 3 or 4 inches from the floor or ground. This construction makes it possible for the forks of an industrial truck to be placed under the pallet and its load. Then, by means of electric or gasoline power, the pallet can be raised or lowered vertically at will, and, as the truck is self-propelled, the load can be moved anywhere on a level floor. The dimensions of the pallet depend upon the material to be handled and the nature of the space to and from which it is to be moved. The approximate size is usually 40″ x 48″ or 48″ x 48″; and the pallets accommodate loads up to one ton. Some products, for example, field boxes of apples and potatoes, are loaded on pallets in the orchard or field at harvest, picked up by tractors with fork-type attachments, set on highway trucks, and removed from them by fork-lift trucks at the storehouses where they are stacked, often several pallets high, for storage. Potatoes also are loaded direct from the digger onto large bin-like pallets which hold about a ton each. These are loaded two on a truck and hauled to storage, where they are stacked.



Handling palletized field boxes with fork-lift truck

By means of electric or gasoline power, the load-carrying platform, called the pallet, can be raised or lowered at will for convenient stacking. As the truck carrying the pallet is self-propelled, the load can be moved anywhere on a level floor.

The complex supply problem of World War II stimulated the Armed Forces into active encouragement of the unit load and use of the fork-lift truck. With this push, supplying industries widely adopted "unitized shipment" and storage.

Palletized storage allows free air circulation beneath each pallet and between the bottom pallet and the floor, although the problem of ventilating the interior of large pallet loads remains. Furthermore, use of pallets facilitates inventory-taking; each warehouse

usually develops a standard pattern of loading pallets for each different commodity, so that the total number of stored boxes or cartons can be calculated by counting the loaded pallets. A possible disadvantage is the amount of cubic storage space occupied by the pallet. Under some circumstances the additional space requirement becomes a serious consideration.

With palletized loads and fork-lift truck, more volume per unit of labor can be handled. A large chain organization thus increased the volume of groceries handled at its main warehouse and processing plant 40 to 50 percent, with a 15-percent increase in labor (*37*).

Design and Structure of Facilities

The Armed Forces also exploited a principle that was becoming evident to a few warehousemen at the beginning of the war, that is, that mechanization is more than the introduction of handling machines. Proper mechanization also means proper building design for utilization of the machine's full capacity. It means proper lay-out that will afford maximum storage capacity without sacrifice of ease of access to stored material or of quick movement. These operations have led to construction of modern one-story warehouses. These one-story houses eliminate delays in waiting for elevators; several highway trucks or railway cars can be loaded or unloaded at once; no space is taken up by stairways and elevator shafts, and less space by supporting columns.

The most efficient warehouse for most purposes is a single-story warehouse, with ceilings at least twice the height of the old-type buildings. Men can stack goods to a height of 7 feet by hand and to a height of 20 feet or more, depending on the stability of the product, by pallets and lift truck.

By the middle 1940's the tendency toward construction of one-story warehouses was clearly an industry-wide trend. A survey of supermarket chains in 1947 showed that the trend was particularly strong in the food-wholesaling industry. Replies as to the kinds of warehouses they maintained at that time were received from 47 companies operating 1,743 stores. They divided as follows:

47 percent operated single-story warehouses only.
43 percent operated multi-story warehouses.
6 percent operated both single- and multi-story warehouses.
4 percent maintained no warehouses.

Future building intentions, as reported by 30 of the companies, underline the strength of the trend toward one-story warehouses. Less than 5 percent of those companies which in 1947 were planning to build warehouses favored multi-story construction (*7*).

On equipment to be purchased, approximately 40 percent of those replying in 1947 were already using fork lifts and pallets, but more than 60 percent were planning to buy them. Two-thirds were still using 2-wheeled hand trucks, but only 4 percent were planning to buy more.

Operators are finding it economical to redesign the lay-out of their multi-story warehouses, and to put in conveyor systems and other labor-saving devices. A company in Cleveland, Ohio, redesigned the lay-out of its old multi-story warehouse and put in a conveyor system. The conditions before and after the change are reported in table 12 (*36*).

TABLE 12.—*Conditions before and after an old multi-story warehouse was redesigned and a conveyor system installed, Cleveland, Ohio*

Item	Unit	Before	After
Supplies handled per month	Cases	40,000	50,000
Maximum trucks loaded per day	Number	5	10
Work force:			
Pickers	do	9	4
Receivers and shippers	do	5	3
Required to handle 600–800 cases:			
Men	do	2	1
Hours	do	2	1

Warehousing has long been recognized as an integral part of wholesaling and retailing. Only recently, however, has recognition been given to the fact that the function of a warehouse is as much the movement of goods as that of storage, and that warehousing costs are in considerable part costs of handling materials.

New Equipment, Improved Methods

Considerable reduction in man-hour requirements can still be made in the better-managed warehouses as well as in those where extremes of physical handling are necessary. Recently developed equipment and methods give promise of holding down costs and speeding operations.

An example of improved methods is the use of voice-recording and play-back equipment in the loading of delivery trucks. The conventional method used by service wholesalers requires a checker to call off items from the invoices during the loading of a truck while other workers pick up the items as called. Under the new method, an office clerk makes a voice recording of items in each truckload in the course of his regular work of handling the invoices. When a truck is to be loaded,

the recording is played over a loud speaker at the loading point in the warehouse, thus eliminating the need for a checker. The player can be stopped or turned back at will. The Production and Marketing Administration has estimated that the new method reduces loading labor requirements by one-third and that the cost of the equipment can be paid for out of savings made in 6 months in warehouses which employ only one loading crew, and paid for in a shorter time by companies that use two or more crews (*27*).

In a number of large warehouses, self-propelled hand trucks and other small equipment increase the efficiency of operations. In some instances, a string of tractors and trailers go through one-story warehouses speedily assembling orders for delivery. In this, as in simple operations, it is the integration of equipment and of construction and lay-out, rather than any one new or costly device, that produces the best results in efficiency and economy.

Other important labor-saving devices are automatic dumping equipment for emptying crates of fruit or vegetables before washing or packing, automatic stacking equipment as used in storage of lemons and apples, and automatic weighing devices for packaged foods.

The Production and Marketing Administration of the United States Department of Agriculture has estimated that in 1950 fewer than 25 percent of the stores and warehouses used by wholesale produce receivers had direct rail connections. The semi-live skid and jack are proving great labor savers in the transfer of goods from railway cars to trucks.

The semi-live skid is a platform with two steel legs, like the conventional dead skid, but with two wheels in place of legs at the other end. Its two legs make this skid an immobile piece of equipment until a jack is run under its dead end. The jack is a handle with two wheels at its base of the same type as the wheels of the skid. Thus when a jack has been coupled the semi-live skid becomes a four-wheel truck.

In the team-track operation, the highway truck backs up to the door of the freight car and if the car is not too fully loaded (or as soon as there is sufficient space near the door) the skids are rolled into it with the aid of jacks and loaded there. They are wheeled back into the truck and again immobilized until they reach the warehouse, where they are wheeled to the place they and their loads are to be stored. Thus only one stage of this process instead of three requires handling of individual boxes or cartons.

The use of the skid and jack may mean that somewhat smaller loads are moved by the truck. Under certain conditions this factor may result in increased cost of truck operation, partially offsetting reduced cost of labor (*24*).

Communications

Technological advances that have made it possible to transport foods for thousands of miles would be of little practicable use without corresponding gains in facilities for communication which enable shippers all over the country to know without delay the demand, supply, and price conditions in markets throughout the country.

None of the many forms of communication, from the postal service to television, was developed solely with an eye to the better marketing of food. Nor are many of the present means of communication new. Printing is an ancient craft; the United States Post Office is nearly as old as the Constitution. The telegraph and the camera both were in use before the Civil War. In fact, only television, facsimile reproduction, and color photography were not in wide commercial use by 1930. With the exceptions named, the last two decades have been marked not so much by invention of new equipment as by the weaving of existing devices into national or international networks.

Table 13 shows at a glance the progress that has been made since 1930 in building comprehensive Nation-wide networks of communications.

Most significant from the standpoint of food technology are the harnessing of modern communications to facilitate the marketing of foods and the extent to which such adaptations have been pushed within the last 20 years.

In the 1920's a long-distance call of 1,000 miles or more was something of an adventure; often it took a long time to put a call through; when contact was established, there was no certainty that both parties, or even one of them, would be able to hear clearly what the other said. There were no automatic teletype systems to flash private messages back and forth, and leased wire services for transmitting messages in code were sometimes difficult to arrange. Air mail was new and relatively expensive, and service between many points was by no means rapid. Today, buyers and sellers separated by the breadth of the continent can communicate as quickly and easily as next-door neighbors could a generation ago.

Ease of long-distance negotiations among the persons directly interested in a particular transaction is only one part of a much broader picture. The national market that today exists for foods depends, to a large

TABLE 13.—*Developments in communication systems: Selected years*

Communications media	Unit	1930	1940	1950
Air mail:				
Length of routes	Mile	14,907	37,943	[1] 130,093
Distance traveled	1,000 mile	14,939	59,236	[1] 321,662
Mail carried	Million pound-mile		18,671	[1] 67,717
Cost per mile of service	Dollar	0.98	0.33	[2] 0.11
Telephones	Thousand	20,201	21,928	[2] 40,665
Percentage of homes with radio:				
Urban	Percent	50.0	91.9	96.9
Rural nonfarm	do	33.7	79.0	93.2
Rural farm [3]	do	20.8	60.2	93.1
United States	do	40.3	82.8	95.6

[1] 1948 data.
[2] 1949 data.
[3] U. S. CENSUS for 1930, 1940, and 1950 (*72*, *76*, *74*); CENSUS OF AGRICULTURE, 1945 (*78*).
STATISTICAL ABSTRACT, 1950 (*77*), and CENSUS OF AGRICULTURE, 1945 (*78*).

extent, on the free and speedy exchange throughout the country of a wide variety of background information. What are the current farm prices and margins in the principal trading centers for each commodity? What are crop prospects; how are harvests progressing? What supplies are moving in and out of storage? From the standpoint of consumers, what products are available or about to become so?

These are only some of the questions for which prompt answers must be available if foods are to be marketed on a truly national basis. In general, although several bare spots still remain to be covered, the answers are available. The climate for a national marketing system exists, thanks to progress in organizing and putting to use the technological gains that have been made in communications. Among developments that have brought about this situation are the organizing of radio broadcasting facilities into regional and national networks; the beginnings of similar progress in television; the special-interest information of big press associations and private market news services, both built to a large extent around improvements in teletype facilities; automatic typewriters, photo-offset printing, and other refinements for quickly and cheaply duplicating the printed word; and advances in photography, including sound movies and color-photography.

Perhaps the best examples of how modern media of communication are being used in food marketing can be given by briefly sketching the progress in the market news service supplied in the public interest by the Federal and State Governments. This undertaking is cooperative in the fullest sense of the word. The line between public and private information sources of these types often is paper-thin. The information made available by public agencies is designed to meet the real needs of those who produce, market, and consume food.

Thus, by its very nature, it is news, and to a considerable extent the same kind of news sought after by press associations, general and women's news editors of papers, program directors of radio networks or stations, and editors of general-interest magazines and special trade papers. Much of the information gathered and issued by public agencies reaches the ultimate reader or listener through privately operated publications or broadcasts. If the information were not supplied by Government, the privately operated media would try to collect much of it themselves. Many do have their own sources of similar or supplementary information. Cooperation between public and private agencies is close, and serves as an example of how completely the marketing of food is meshed into the whole fabric of the national life.

Public Market News and Information

Market news began in a small way. The first Federal market-news reports were issued in 1915, with work on prices and shipments or receipts of fresh fruits and vegetables in six consuming centers and seven producing areas. Reports between offices went over leased commercial telegraph lines in Morse code and mails carried the burden of releases. Since then the market-news services have grown to more than 100 year-round and 44 seasonal offices. The offices are operated on a commodity basis with some reporting on fruits and vegetables, others on livestock, on dairy and poultry products, on grain, tobacco or other products. The Morse telegraph system has been replaced by leased teletype circuits which continue to provide fast, accurate exchange of information between offices. Also, the services go to a number of State offices, making possible a wider dissemination of the information than could be done solely by the Federal Department.

The market-news services have developed as a result

of insistent demands from those interested in specific commodities in certain markets or areas. Recently, at the request of Congress, a long-range plan was developed for future market-news work. This plan recognizes the changes in marketing practices, the increased use of trucks, the greater volume moving to market in processed form, the need for services on additional commodities and at additional points with fully effective dissemination of the market information. It also recognizes that the long-established practice of conducting these services on a cooperative basis with State agencies should be continued.

Use of the radio began in 1921. For the next decade and a half most of the broadcasts were over stations in the same localities where the market news offices were located. At best, they provided only regional coverage. In 1937, U. S. Department of Agriculture started the preparation of daily and weekly summaries specifically designed for press and radio use and arranged for their release over press association lines.

By 1951, radio provided the widest and fastest public distribution of market news, and the over 1,300 cooperating stations served an audience which never could have been reached by mailed reports. A sample study made in Iowa in 1949 revealed that 90 percent of the farmers interviewed used their radio daily for market reports.

Newspapers provided the second most important channel for market-news dissemination. U. S. Department of Agriculture reports are carried in nearly 1,100 daily papers with a circulation of more than 37 million. Newspapers get considerable information from U. S. Department of Agriculture local market-news offices if they are in the same city, but most papers get their Federal and Federal-State reports through the facilities of the press associations. According to a study of newspapers published in May 1951, the Department's Chicago livestock market report is carried in 510 daily papers published in 44 States and the District of Columbia. No other report is carried in more than 325 papers.

The mail is still important, however, and about 35 million copies go out annually to some 200,000 recipients. Although these reports are mailed free upon request, it is obvious that radio and press more adequately serve the needs of the producers, dealers, and others interested in the information.

In addition, the Western Union Telegraph Company transmits detailed reports of specified commodities from particular markets over CND (Commercial News Dispatch) whenever enough users subscribe to warrant transmission of such a report. Bulletin boards accessible to farmers and tradespeople carry reports of local interest in such places as stockyards, cotton gins, shipping sheds, tobacco warehouses, post offices, country stores, and banks.

So far as types of commodities are concerned, market-news coverage of farm products was nearly completed with the start of the tobacco news service in 1932. Market-news services for naval stores and molasses were started in 1951. But coverage of some important kinds of market information is even yet far from complete. The estimate of degree of satisfactory coverage of market news attained by late 1949 indicates considerable lack of balance in current service (fig. 13).

FIGURE 13

Reporting on wholesale trading in terminal markets is reasonably complete. But this terminal-market price is not the farmer's price for many commodities. There is considerable room for improvement and expansion in reporting prices in local marketing areas, and on fruits and vegetables sold for processing. The absence of such information may often mean that farmers do not get the full reflection of terminal-market prices, especially the quality premiums that would otherwise stimulate production of better-quality products. For instance, a pilot study on the f.o.b. creamery price of butter in Iowa indicates that very little of the quality premiums quoted in central markets were showing up in the average prices received by creameries that produce the better qualities.

At the other end of the distribution chain, retail stocks and prices are almost completely unreported. At all levels, the rapidly growing motortruck movement has bypassed market-news channels except for a few products in some markets.

Consumer Market News and Information

Aside from information in advertisements, consumers get their news of foods from two principal sources: from public news sources, principally "women's interest" magazines, newspapers, and the radio, or direct from State and Federal Government agencies via publications and home-demonstration agents. By far the chief source of consumer-product news has been the regular news agencies, and improvements in the field have been so great in the last 20 years as to constitute virtually a new development.

Women's interest magazines have undergone the smallest change. Leaders in this field have had professionally competent food editors for many years. Newspapers have had women's sections for a long time, and have always paid some attention to food, but only in recent years have many had well-qualified food editors. The food news in most papers now ties in its menus and recipes with nutrition news and marketing information. As a result of this definite news responsibility, newspapers have become a channel for spread of new scientific information as to availability of plentiful foods, latest developments in nutrition, best methods of buying, storing, and preparing foods, and, in general, the best current knowledge for carrying out the housewife's responsibilities as to food.

Radio has been an important medium for communication of new food and nutrition knowledge since the earliest days of broadcasting. In 1926, the Department of Agriculture started regular network broadcasts designed to reach consumers with the best current knowledge on food, nutrition, and other home-economics programs. Regular broadcasts have been going on ever since and at least three of the networks carry regular features of their own today, cooperating with Department scientists and other specialists. Shortly after the establishment of U. S. Department of Agriculture area marketing information offices in the late 1930's, broadcasters began to request information on supplies, especially those in abundance. Starting about 1938, this service expanded rapidly, with direct broadcasts from some of the market-news offices. Today, many television stations cooperate in the dissemination of information concerning food.

CHAPTER 5

Technology in Retail Distribution

Buying food at retail is now a very different procedure from what it was in 1930. Then, as a general rule, stores were smaller and carried a narrower range of products from which to choose. The shopper usually told the grocery clerk what she wanted; if any choices among brands or grades were involved, the clerk often recommended which to buy. Often the housewife did not visit the store at all, but telephoned her order and awaited its delivery. Shopping, whether in person or by telephone, often involved several stores —one for staple dry groceries, one for meats, one for fruits and vegetables, and so on. Food buying was a frequent choice—every weekday for many families. Perishables did not keep long in the average home icebox of the period.

Today the average housewife shops for food less frequently, often making major buying expeditions twice a week, and sometimes only once. She is more likely to go in person than to telephone, and less likely to visit more than one store. Stores are larger and have a wider range of foods, particularly of perishables. The shopper usually selects all the items herself, as she fills her cart from shelves or cabinets. Although there is a good possibility that she will deal with store employees at one or more specialty counters, often her only contact with a clerk is at a check-out counter where she pays her bill and has her purchases put in a bag. In most instances she will have come in the family car because of the distance from home and the size of her purchases.

Some of the changes of the last 20 years have only a remote connection with the advance of technology; others have a very direct connection. Among the latter are improvements in refrigeration that enable both stores and customers to keep perishables much longer; gains in processing that have changed many perishables into nonperishables; advances in prepackaging and in the design of store lay-outs, both of which are indispensable to the technique of modern self-service; and improvements in roads and parking facilities that enable consumers to go relatively long distances to food stores and to bring home large packages without inconvenience.

The swift emergence of the supermarket is the dominant development in food retailing during recent years.

The Supermarket

What is a supermarket? Opinions vary as to some details, but shoppers are now fairly familiar with the elements that make up the modern supermarket.

It is a large [12] departmentalized one-stop food center with relatively complete lines of at least dry groceries, fresh produce, fresh meats, and dairy products. It carries a variety of brands and foods in each line. It is in a central location with respect to automobile traffic flow, and is usually associated with a reasonably adequate parking area. The groceries, at least, are dispensed by self-service, with all other departments tending in the same direction.

In 1930, of more than 300,000 grocery and combination food stores in the United States, only around 500 were supermarkets.[13] Many of these were new.

During the depression the number of supermarkets increased; lean years often spelled opportunity for new-type enterprises. In the depression years, the food market was flooded with large distress stocks; the real estate market was glutted with vacant warehouses and automobile showrooms. These vacancies were not in the traditional "high-foot-traffic" business centers. The big chains and other old-line retailers in general saw little value in such locations, but the new enterprisers

[12] The Supermarket Institute, Inc., early in 1951 adopted the following definition of a supermarket: "A complete, departmentalized food store with at least the grocery department fully self-service and with a minimum sales volume of $500,000 a year." The Institute reported in August 1951 that the average 1950 sales volume of its members that qualified under the new definition was $893,000, or slightly more than $17,000 per week per store.

[13] After adjusting for changes in the price level, 1929–48, stores doing $300,000 in 1929 are comparable to today's supermarket (1935–39 = 100).

saw their worth. There is little reason to suppose that even those who started the new stores saw at once that their "out-of-the-way" locations were actually "high-traffic" in terms of automobiles, or that the very extent of their floor space introduced a distinctly new technique into food retailing. Adoption of self-service, however, was deliberate. Low price was the chief appeal of the new stores, and self-service helped keep prices low. Whatever their foresight, these new operators had hit on a new method of retailing.

By 1935, supermarkets were so obviously established that one huge food chain decided to start converting to supermarkets, gradually closing its clerk-type stores. Some local and regional chains had already made the same decision. In 1949, the number of supermarkets —stores with annual sales of $500,000 or more—was over 7,000.

One-stop Shopping

Probably the most important single feature of the supermarket is the one-stop shopping principle—a principle uniquely fitted to automobile transport. The automobile, for all of its widening of the trading area and enabling people to carry home more at one time, is an awkward method of getting from one store to another in the same neighborhood. The one-stop principle, modified to suit the size of operation, is the dominant trend in food merchandising today, spelling at least partial eclipse of most forms of specialty distribution, especially meat and fruit and vegetables. (See table 5, p. 7).

One aspect of the decline of specialty selling is the decrease in wagon-route selling of many products. Statistical tracing of these trends is difficult because of the inclusion of such operations with "stores" in census figures, but it is evident that fruit and vegetable huckstering has declined in the large cities. In addition, milk is sold increasingly over the retail counter rather than through home delivery (table 14). On the other hand, the "rolling store," handling groceries, vegetables, meats and frozen foods, seems to be growing in importance in some parts of the country, especially when legal barriers are not thrown in the way. Thus, even this branch of retailing is being adapted to the supermarket one-stop pattern.

Self-service

The principle of self-service antedates the supermarket, but the method did not become Nation-wide or dominant until the rise of the supermarket. Once established there, self-service spread to other types of food stores and beyond the dry-grocery department. By 1949, an estimated half of the total dollar-volume of larger independents was self-service, and only 20 percent of the dollar volume in full-counter-service stores. By that year, also, 86 percent of the dollar volume of the corporate food chains came through self-service stores (*47*, p. 6).

TABLE 14.—*Sales of fluid milk in stores as a percentage of total, for selected cities and years*

City	1925	1929	1934	1940	1948
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
New York City	34	35	39	56	72
Chicago	.....	20	23	52	.....
Los Angeles	8	18	38	58	.....
Philadelphia	.....	.....	13	27	.....
San Francisco	15	20	55	70	.....
St. Louis	.....	20	44	41	.....
Boston	.....	30	43	[1] 32	.....
Baltimore	.....	14	28	46	.....
Pittsburgh	.....	.....	52	[2] 35	.....
Portland, Oreg.	.....	.....	59	[2] 47	.....

[1] Store price differentials decreased from 2 cents per quart to 1 cent by State price control board.

[2] Store differentials in price (previously existing) prohibited by State price control board after 1934.

BARTLETT, R. W., THE MILK INDUSTRY, p. 172 (*3*); INCREASING MILK CONSUMPTION BY QUANTITY DISCOUNTS (*2*); and ANNUAL REPORT OF THE NEW YORK STATE TEMPORARY COMMISSION ON AGRICULTURE (*42*).

All over the country counters were ripped out, or in newly built stores, never put in. Shelf space in the middle of the floor was added to that along walls. There food was displayed in consumer-sized boxes, bags, cans, or jars. The price of each item was clearly indicated, either on the package itself or by a sign on the shelf. Frozen foods were displayed in accessible cabinets, and in other cabinets, equally easy to get into, were milk, butter, and other products that required milder refrigeration. In the larger stores, wheeled pushcarts were available, many of them double-decker models with two wire baskets that could accommodate a week's food for a family.

Nevertheless, at the start a number of departments, even in the best-equipped stores, tended to remain on a counter-service basis. Survivals of this kind were in some instances largely the result of habit. The grinding of coffee in many stores was easily changed from a counter to a self-service function by the introduction of an automatic grinder that could be operated by the least mechanically minded shopper. Other counter services proved harder to get away from, particularly those that involved the subdivision of larger units (such

as cutting off consumer-sized pieces of meat) or the assembling and weighing of loose units (such as fresh fruits and vegetables.) Prepackaging has proved to be the answer to a number of these difficulties, although in some instances the relative merit of counter-service and self-service remains a moot point.

Prepackaging [14]

The swing toward self-service could not have occurred without corresponding developments in prepackaging which made it possible for the food shopper to select from shelves or cabinets items that clerks formerly located and put together for her. Most of the processed foods have for a number of years been available in easily handled, labeled containers of various sizes. These foods already were adapted to the requirements of self-service. Meats and fish, fresh fruits, vegetables, and other produce were not so adapted. It is for these items that the great advances in prepackaging have been made and for which experimental work is continuing. Although a small percentage of stores are completely on a self-service basis, service counters for the display and sale of meats and fresh produce remain in most establishments, including supermarkets.

This uneven situation has been a spur to efforts to improve prepackaging. Service counters, in stores that are largely on a self-service basis, create bottlenecks that slow down the flow of customers. In addition to filling the requirements of self-service, many forms of prepackaging are in themselves more efficient and economical than the older methods. Prepackaging also makes it possible to extend brand identification to kinds of food that formerly lost their identity upon being unpacked for retail display. It has not been established that prepackaging is practicable or desirable for all kinds of foods, but the trend of recent years toward more prepackaging continues undiminished.

Prepackaging of vegetables and other produce is

[14] In the terminology of marketing, prepackaging means packaging, previous to sale, items that in the past had not been packaged before the actual time of sale to the consumer. The term thus connotes innovation; if the prepackaging of an item were fully accepted and became standard practice over a number of years, the operation would in time tend to be called simply packaging. Prepackaging is not in itself a processing operation, but in many instances a prepackaged product, because it has been carefully trimmed and washed, requires less preparation in the kitchen.

Modern self-service of prepackaged foods

Since 1930 prepackaging of meats, fish, fresh fruits, and vegetables, as a means of making retail units of items that used to be displayed in bulk, has come into wide use. Prepackaging also reduces waste and spoilage, and generally preserves quality. (Photograph from *Food Engineering*.)

primarily a method of making retail units out of items that were formerly displayed in bulk. For a number of items, prepackaging also reduces waste and spoilage and generally preserves quality. Although retail display of a few items, notably mushrooms and strawberries, in small measured boxes has been commonplace since the 1920's, the practice of prepackaging many kinds of fruits and vegetables, as well as eggs, did not come into wide use until the 1930's.

Fresh fruits and vegetables are living organisms and, in their respiration require oxygen and give off carbon dioxide, water vapor, and other gases. This necessity of breathing must be considered in selecting a packaging material. Some uncertainty remains as to the gas permeability of the various films. To avoid possible development of harmful atmosphere in the package, some type of ventilation is frequently used.

During the 1950 season, between 3½ and 4 billion pounds of fresh fruits and vegetables were prepackaged by wholesale dealers who used 12 million pounds of flexible film, 50 million pounds of paperboard, 201 million mesh bags, and 17 million paper-mesh-window bags (*46*, p. 11). This estimate does not include the large volume of prepackaging performed by retailers.

New techniques in meat prepackaging are being tried, proved, or discarded from day to day. For the most part they aim at preventing the absorption of off-odors. Transparent moisture-vapor resistance films are conducive to the development of off-odors and discoloration, while films permeable to moisture-vapor permit too much drying-out.

Early in the 1940's in an effort to get a more satisfactory film for fresh meat, a modified cellophane was developed. It is a semi-moisture-proof film with one side wettable. With the application of the wettable side to the fresh meat, the color of the meat is retained for a sufficient time to make prepackaging practicable. A survey published in 1949 indicated that prepackaged fresh meats would remain in salable condition from 48 to 72 hours after being put in the display cabinet (*15*).

Certain intensities of light contribute to discoloration of meat. Opaque film would prevent this, but its use is not practicable because the customer cannot see the product. "Soft-white" fluorescent light is now used in some display cases along with low holding temperatures in an effort to lessen this discoloration.

Special techniques and machines have been devised for handling poultry, using pliofilm as the packaging material. Packers and distributors are providing the retailer with consumer-sized packages of cured, prepared, and ready-to-eat meats. Some prepared meats, except frozen meats and poultry and practically all fresh meats, continue to be prepackaged in retail stores.

The materials and labor costs of prepackaging foods in consumer sizes are higher than those of bulk packaging. Research thus far, however, indicates that in many instances the additional costs are not necessarily large, and that frequently savings in transportation and other handling costs offset the higher initial outlay.

For instance, a recent Department of Agriculture study indicates that prepackaging cranberries in a case of 24 one-pound cellophane bags cost only 5.8 cents more than packaging an equivalent amount in a quarter-barrel box (*29*). Another investigation indicates that prepackaging apples at the point of production is more costly than the conventional method of packing in boxes, but that the higher costs of prepackaging are nearly offset by savings in labor and transportation expenses and by reduction of waste at all market levels (*10*).

Other Aspects of Packaging

Many of the improvements in materials and design that made possible the spread of prepackaging have also contributed to advances in the more conventional packaging of processed foods.

In the 1920's packaging was just beginning to emerge from its first phase as a convenient method of handling and brand identification. By 1930, industry began to realize that the package could not only attract the consumer's attention, but could tell much about the product, and that it should also be a convenient storage unit for use in the home. Packages were redesigned and attention to proper use of materials increased.

From then on, development of packaging was accelerated. As more was learned of storage requirements for specific commodities, materials multiplied, and combinations of materials and treatments worked out. Cellophane film was soon joined by acetate film, by other plastics, and by rubber and its compounds.

Better Equipment: Faster Service

Unlike the neighborhood grocery of a generation ago, with its bins and barrels and mixed aromatic smells, the modern food store is marked by ample space and light and a great deal of elaborate equipment. Much engineering skill has gone into the design of the new equipment and into the lay-out of the store as a whole. Refrigerated cabinets are tailored to the requirements of the various products. They are well lighted and accessible, are either open or with glass doors or panels that slide or lift easily. Shelves for packaged articles

Typical retail food stores—1930 and 1950

Considerable effort has gone into the new stores for better lighting, convenience, and cleanliness, so that shopping is less of an ordeal for the housewife. (Photographs from *Food Engineering* and *Chain Store Age.*)

that do not require special atmospheres have been especially designed so that shoppers can get at them easily. Location of the various departments in relation to each other has been carefully considered with an eye to the speedy and smooth flow of customers through the store.

The spread of self-service, has, in fact, uprooted many old concepts because of its emphasis on display selling. When the majority of orders were telephoned or given to a clerk behind the counter, where goods were placed and how they were displayed had less effect on what shoppers bought. In a self-service store a package of food often must catch the attention of the shopper before she considers buying it. Thus the arrangement of goods on shelves, tables, or in cabinets has become a part of the complex operation of display selling, which also embraces such diverse points as store lay-out, package design, and advertising.

Recent developments indicate no slackening of the trend toward large buildings and elaborate equipment in supermarkets. Air conditioning of the entire establishment is becoming more common, not only for the comfort of customers but for the protection of frozen foods, and of meats and other prepackaged products kept under milder refrigeration. During hot weather, the whole refrigeration problem is simplified if the air admitted when shoppers take things out of cabinets is itself fairly cool. One large chain is building its new stores with no window displays visible from the street, and is converting some of its older stores to eliminate windows. The change is designed to make temperature control easier and to afford more inside floor space and is being undertaken in the belief that shoppers nowadays are little influenced by window displays (6). The modern supermarket building is expensive. During January 1951, two chains each began construction of a new store in Washington, D. C. The prospective cost of each was in the neighborhood of half a million dollars (89).

A number of floor lay-outs, beginning with that first used by the Piggly Wiggly stores at the time of World War I, have been copyrighted, but as the general principle of self-service cannot be copyrighted, improvements and variations have been continuous. An elaborate recent copyrighted system was "Keedoozle," which was abandoned in 1949 after an extensive trial in Memphis. Under this system, each item on display had a slot beside it into which a customer wishing to buy the article would insert a special key she had obtained on entering the store. Each turning of the key was recorded in a tape in the handle of the key. When the customer had turned the key in enough slots to buy everything she wanted she turned in the key to the cashier, who in turn ran the tape through a machine that automatically set off an automatic conveying process for all of the articles recorded on the tape and at the same time totaled the bill.

The check-out counter is a strategic point and potential bottleneck in any store even with partial self-service. The recently designed cash registers are fast, easy to operate, and relatively mistake-proof, although as yet none of the machines give the housewife a sufficiently itemized receipt. Much thought has gone into better procedures and physical equipment for the check-out. Tests of a new type of check-out counter developed by the United States Department of Agriculture have indicated that its use can increase the number of orders handled per hour by 38 percent and can decrease the cost of handling the average order by 26 percent (23). This is only one example of the ways in which the larger retail food store is making possible the introduction of engineering techniques.

In one field, however, technological progress, in the opinion of a number of observers, has lagged behind progress in other phases of food marketing. This is the handling of materials after their delivery to the retail store. With a few outstanding exceptions, recent years have brought little change in the way car-

---

New check-out counter saves time and money ⋙→

This system of grocery check-out counters permits speedier and less costly handling of grocery orders. It has two variations, the Simplex and the Redi-Chek. Both are designed to combine, eliminate, or simplify the time-consuming details of checking out a retail order.

(1) On the "Simplex" check-out counter, the cashier removes the items from the bascart, places them in the recessed bag, and rings up the sale simultaneously.

(2) On the "Redi-Chek" check-out counter, the cashier can ring up and bag the items while the customer unloads the order on the counter.

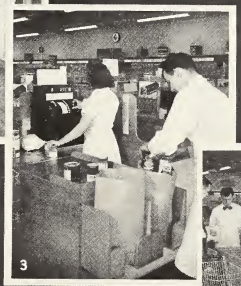
(3) A bagger is added to the "Redi-Chek" to increase production during rush hours.

(4) An expediter is added to the "Redi-Chek," making a three-man crew, to speed up customer service.

The system was developed by the Production and Marketing Administration of the United States Department of Agriculture and a national grocery chain under the Agricultural Marketing Act of 1946 (RMA, Title II). The development is part of the Department's search for more efficient and less costly ways of marketing farm products.

"SIMPLEX" SYSTEM

"REDI-CHEK" SYSTEM



tons, bags, and boxes are moved from the retailer's unloading platform or door to his storeroom, price-marked and placed on shelves or in cabinets. Both new equipment and improved techniques are involved. In large measure, the problem is one of more effective use of the store's labor force, particularly in supermarkets and other retail establishments with comparatively large staffs. In the small, family-operated type of neighborhood store, the problem of mobility and full use of the labor force is not so pressing.

Changing Types of Food Store

Technological developments that make for self-service and larger-scale operation have found their freest play in supermarkets, but their influence has been felt in all types of retail food stores. Even in the smaller establishments, lighting and refrigeration are better. Some degree of self-service has been introduced into many stores, and shelf design and lay-out have been changed accordingly. In both the corporate and voluntary chains a large degree of uniformity in equipment and lay-outs has proved useful.

The forces that have resulted in the big, self-service supermarket have also indirectly affected smaller stores. Although many of the older-type neighborhood and specialty stores survive, those that are being reorganized or newly established are designed to complement the supermarket rather than to compete with it. That is, each is designed to perform a special function that the supermarket cannot attempt. For instance, some stores are especially geared to home deliveries. Others are essentially delicatessens, specializing in the sale of a considerable range of products in off-hours. Still others specialize in luxury products, particularly bakery goods.

The growth of voluntary chains, that is, groups of independently owned retail stores that team up with their wholesalers and pool many functions of management as well as of buying, has been a striking development in food retailing since the middle 1940's. For the most part this trend lies outside the scope of this study, but it may be said that the larger scale of operations has made it easier for members of voluntary chains to take advantage of technological advances.

Automatic Merchandising

The ultimate in self-service in the retailing of food would be completely automatic merchandising, that is, a customer would see something she wanted to buy, insert some money, perhaps pull a lever, and out would come her purchase. To date, such a sweeping innovation has not been attempted or even seriously suggested, though the "Keedoozle," referred to elsewhere in this chapter, and the automat represent steps in this direction. The average grocery shopping list represents a range of possible combinations that would stall any machine yet thought of. But the sale of food products through machines has increased. Automatic merchandising, sometimes in food stores, sometimes outside them, already has become significant as a supplement to the more conventional retailing methods, and the trend is continuing.

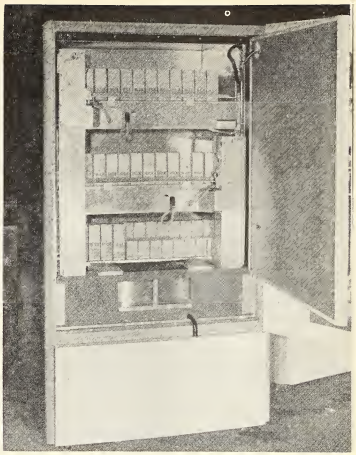
Vending through coin-operated machines is an old story in this country, and older still in Europe. By the end of the last century penny machines for selling chewing gum and nuts were commonplace. Use of the machines has gradually expanded to include candy bars, bottled soft drinks, and cigarettes. In the middle 1940's, the industry began a sudden expansion with the development of electronic equipment that made it possible to operate change-making devices and to control the temperature of products in the machines. By the end of 1950, foods sold through machines included hot tea and coffee, French fried potatoes, frankfurters, hamburgers and other hot sandwiches, citrus juices, milk, and ice cream. In a number of food stores, packages of frozen foods were sold automatically.

A recently developed milk-vending machine offers an example of how the automatic machines work and of some of their economic possibilities. The machine holds 150 quart containers of milk which are kept cool by a refrigerating unit in the base of the machine. The milk is stored on endless belts, which are set in motion when money is put in the machine and which stop as soon as one container has been propelled in the chute which delivers it to the customer. Built into the machine is a device for handling coins up to quarters, and for returning correct change (20). Separate coin changers have been developed for use with machines which operate only with the exact coin or combination of coins required.

Automatic merchandising of this kind is regarded as a supplement to sales that require some measure of personal attention. By making appropriate products available in places, and at times, when otherwise they would be inaccessible to potential purchasers, machine vending is expected to increase total sales rather than to substitute one method of purchase for another.

House-to-house retailing

Although the general tendency in recent years has been toward a decline in home distribution, usually referred to in the past as wagon jobbing or huckstering, such deliveries of milk, eggs, fruits, and vegetables still



A milk-vending machine

Sales of food products through machines are increasing yearly. The illustrations show the exterior and interior of a milk-vending machine. Foods sold through similar machines include hot tea and coffee, citrus juices, certain types of hot sandwiches, ice cream, and a few frozen foods. (Photographs from the Dairy Industries Supply Association, Inc.)

are common. Their survival has been due in large measure to advantages growing out of technological developments.

Every-other-day delivery of milk, for example, with its savings of fuel, tires, and labor, became more acceptable with the advent of larger and better mechanical home refrigerators. Larger and better designed trucks for a variety of products, and better insulation for trucks that distribute milk and eggs also have helped keep home delivery alive. An extreme example of improvements in trucks is the produce trailer, which is, in effect, a store on wheels, even to modern vegetable bins and control of temperature and humidity.

Out-of-Home Eating

The amount of food bought in restaurants and other places that serve ready-prepared meals, rather than in retail stores for further preparation in kitchens, has increased tremendously during the last two decades. In 1939, sales of restaurants and other public eating places in the United States totaled about $3 billion. In 1948, out-of-home eating, excluding alcoholic beverages and institutional feeding, is estimated at about $9.5 billion. In addition, food served by hospitals, by other institutions, by transportation agencies, by industrial firms to employees, and by private eating places is valued at about $2 billion, bringing the total value of out-of-home eating to about $11.5 billion in 1948. On an equivalent basis, this represented about 16 percent of the total civilian food supply in that year.[15]

Technological developments have had considerable impact on out-of-home eating, in terms of costs as well as quality of food and service. Mechanical fruit-juice dispensers that cool and agitate the liquid are widely used in snack bars and similar establishments. Large-scale automatic dishwashing units have been greatly improved and make use of recently developed detergents. Electronic cooking is coming into use on railroad cars. Planes carry compact special equipment for heating precooked meals.

Despite these and many other gains, the most important relationship of out-of-home eating to modern

[15] Computed by Marguerite C. Burk, U. S. Bureau of Agricultural Economics from data in the U. S. Dept. of Commerce, SURVEY OF CURRENT BUSINESS, NATIONAL INCOME SUPPLEMENT, July 1951 (*66*, table 30, p. 192), and, THE CENSUS OF BUSINESS, 1939 AND 1948 (*73*).

technology has been the way in which eating establishments have served as an outlet and proving ground for new food products. Few business establishments or institutions are troubled by the prejudices and dislikes of innovation that are deeply ingrained in many persons who buy food for families. If an institutional buyer can be convinced that a new food is better and cheaper, he will most likely try it. The first sale of many frozen foods, dry milk solids, and other dehydrated products on a commercial scale was to institutional users. Patrons of such establishments rarely knew they were testing new products.

CHAPTER 6

Some Effects of Technology on the Marketing System

Some immediate effects of advances in the technology of food marketing have been noted in this report. These include changed forms of food, improvements in quality, reduced operating costs, and greater ease in handling. This chapter deals with the broader effects of changes in food technology upon the structure of the food-marketing system itself.

During the 20-year period under discussion many forces besides the influence of technological progress were at work. The national population grew; levels of income and employment rose; price-support programs strengthened the bargaining position of food producers; and during World War II, and again more recently, emergency restrictions were imposed upon the use of scarce resources. Sometimes these nontechnological forces have exerted pressures in the same direction as those of technology, sometimes in a different direction.

Important developments in which the influence of technology can be seen most clearly are (1) changes in type and amount of marketing services, (2) changes in capacity of processing plants and optimum size of distributing enterprises, (3) increased integration and diversification, (4) new patterns of investment and risk, (5) changes in forms of competition, and, (6) as a culmination of these and other forces, the emergence of a national decentralized market for food.

Type and Amount of Services

Since 1930 the production and distribution of food products have substantially increased (fig. 14). The increase has been in both unprocessed and manufactured food products, although the rate of increase in manufactured foods has been greater than the growth of farm food production. This suggests that expansion took place by shifting many existing services away from home and farm to commercial factories, and by an increase in services that had not previously existed. A student of food marketing has estimated that between 1929 and 1947 the percentage of the country's baking done in factories rose from 41 to 58 percent and the percentage of canning of fruits and vegetables from 59 to 73 percent (*44*, p. 50).

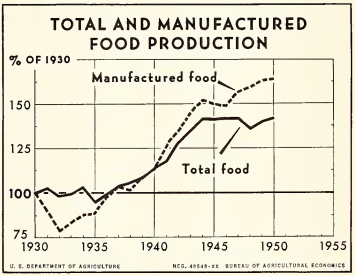


FIGURE 14

Services supplied by the marketing system have multiplied in both variety and quantity. Services in the form of greater fabrication such as frozen foods, citrus juice, baby food, and other new foods were available to a much lesser extent in 1930 than in 1950. Slightly different, but more fundamental are services which change the traditional market for particular products. Thus, there is a strong trend away from the marketing of live to dressed poultry, to take advantage of the economies of assembly-line slaughter and improved refrigeration. The ultimate effect of this change is the marketing of more birds through general retail outlets at the expense of specialized butcher shops. In general, the marketing services that have been added have been at the processing stage rather than in distribution.

In 1929, the share of the consumer's food dollar that went to marketing was divided roughly on a basis of one-third to processing and two-thirds to distribution. In the intervening years, the processor's share climbed steadily until by 1947 it was about equal to that of the

distributor (45).[16] Although many of the new services are possible only at costs which add to the price at some stage in the market channel, such costs are often offset or more than offset by reduced handling costs or reduced amounts of waste in later stages. Improvements in grading techniques have reduced the amount of spoiled produce in the market channel.

Despite the general increase in services, certain kinds of services traditional to the marketing system have decreased. Of particular importance in retailing has been the change to self service and elimination by many stores of deliveries and credit; and the institution of every-other-day delivery of milk.

Plant Capacity and Changing Optimum Size

Commercial application of new technological developments has resulted in economies of scale in food-processing plants and in distribution units. The increased size of plants has combined larger and more specialized machines with a greater quantity of labor per plant.

During the last 20 years the number of factories that process food products has declined continuously, from approximately 50,000 in 1929 to around 33,000 in 1947, the year of the last comparable census. Even these figures do not fully reflect the trend toward fewer plants, as those for 1947 include alcoholic-beverage plants, few of which were in operation in 1929. As the number of plants dropped, their average size grew. The total number of production workers in the food industry rose from 685,000 in 1929 to 1,009,000 in 1947. The more striking aspect of this development was the shift in employment away from plants employing fewer than 50 workers toward plants hiring 500 or more.

These changes represent, in great part, changing technology—new, more highly mechanized methods of manufacture. Two aspects are of special importance; the over-all production of food and the efficiency or unit cost as measured by labor, plant, and other resources of production.

This shift to larger facilities has resulted in more efficient production. Average value added per establishment, perhaps the best measure of output, has quadrupled since 1929 in terms of current dollars. When adjusted to eliminate the effect of the change in price level, output was more than 2½ times that of 1929 and twice that of 1931 (table 15).

Although these figures on total production, employment, and efficiency in the food-processing industries indicate a definite shift to a larger scale, some of the individual food industries showed contrary tendencies (table 16). The continued growth of interior plants in meat packing is at least partly responsible for the small reduction in the average size of meat-packing plants. Another reason is the relatively small degree of mechanization required in slaughtering.

Although tendencies toward larger scale are indicated by the data relating to the food industries taken as a whole, there is no way of isolating technology from the other forces that may be responsible for this shift. Insight is gained, however, from the case study of the effects of changing methods of oil extraction.

[16] Detailed data showing the break-down of marketing margins for various commodities by functions or types of enterprises would provide valuable clues regarding the effects of technological developments, not only upon the marketing system itself, but also upon returns to producers and costs to consumers. Unfortunately, very little such data, susceptible of comparison, is available except for very recent years.

TABLE 15.—*Number of establishments, workers and value added in the manufactured food industries, selected census years* [1]

Year	Establishments	Production workers	Value added		Wholesale price deflator [2]	Average workers per establishment	Average value added per establishment	
			Current dollars	1926 dollars			Current dollars	1926 dollars
	Number	*Number*	*Thousands*	*Thousands*		*Number*	*Thousands*	*Thousands*
1929	50,117	684,918	3,066,262	3,217,484	95.3	13.7	61.2	64.2
1931	43,518	604,702	2,527,273	3,462,018	73.0	13.9	58.1	79.6
1939	37,981	753,192	3,251,223	4,216,891	77.1	19.8	85.6	111.0
1947	33,431	1,009,092	8,297,337	5,455,185	152.1	30.2	248.2	163.2

[1] Food and kindred-products group of the CENSUS OF MANUFACTURES, excluding the following industries: Manufactured ice, prepared animal feeds, canned sea food, and cured fish. (Alcoholic-beverage industries are included in 1939 and 1947 only.) Because of changes in classification and coverage, data for all census years may not be strictly comparable.

[2] B.L.S. INDEX OF WHOLESALE PRICES OF ALL COMMODITIES, 1926 = 100 (71).

TABLE 16.—*Percentage change in average size of establishment, number of establishments, and production and related workers in selected food-processing industries, 1939 to 1947* [1]

Industry group	Average size of establishment [2]	Number of establishments	Number of production and related workers
	Percent	*Percent*	*Percent*
Natural cheese	229.4	—36.2	110.3
Ice cream	166.1	—43.6	50.2
Flour and meal	113.8	—42.0	24.0
Frozen foods	—.8	377.0	373.0
Shortening and cooking oils	—1.0	22.0	20.7
Corn products	—4.4	57.1	50.2
Meat packing	—6.1	54.7	45.2

[1] Insofar as possible, data were made comparable for the two census years. In some industries changes in coverage have introduced slight errors in magnitude of change.

[2] As measured by number of production and related workers per establishment.

Computed from data of 1947 CENSUS OF MANUFACTURES (*75*, v. 2, table 2).

The hydraulic press method has been used since the eighteenth century to process cottonseed and still is the principal method used in areas east of the Delta where production of cotton is declining. The type of equipment employed is rugged, has a long life, and allows the use of semi- or unskilled labor (*19*). The screw-press method has been perfected since World War I and is used to process a variety of oilseeds. The outturn of oil is considerably higher than by the hydraulic process. Screw presses predominate in the cotton areas of Oklahoma and Texas which were developed after World War I. Since 1947, the solvent method has been perfected to extract oil primarily from cottonseed and soybeans. Higher yields of oil are obtained by this process, but the plant is considerably more expensive to install, requires a relatively large volume for efficient operation, and requires more highly skilled labor. In the case of soybeans, about 20 percent more oil is obtained by the solvent method than by the screw-press method (*34*).

The solvent method is gradually replacing the older methods in the newer cotton-producing areas of Texas and the far West. These areas have sufficient supplies, and adequate rural highways to permit easy transport of the raw material to keep the large plants operating more than 300 days a year. It is estimated that around 7 to 8 percent of the 1950-51 cottonseed crop was processed by solvent methods in 5 plants; and around 20 to 30 percent by the screw process. In the 1951-52 season, 12 plants using the prepress solvent methods are expected to process 15 to 20 percent and screw press 25 to 35 percent of the crop.

The extraction of oil from soybeans has shown an even greater shift to solvent extraction. In 1949, approximately 56 percent of the crop was processed by the solvent extraction as compared with 13 percent in the 1936-37 crop-year.

Similar shifts from small to larger-scale manufacturing have taken place in the natural cheese industry where the small "crossroads" creameries have given way to larger centralized manufacturing plants. Economies of scale result from use of modern labor-saving devices, especially automatic packaging machines; production of rindless rather than rind cheese; and production of specialized cheese foods which utilize directly the by-products and returned merchandise under highly specialized technical supervision. Larger-scale processing makes possible savings in transportation by substitution of carlot for less-than-carlot deliveries of supplies and the finished product.

Economies of Scale in Distribution

Gains in efficiency of retailing, similar to those shown for processing, are found in the operation of larger retail stores—the modern supermarket. Savings are most important in regard to working capital and spreading of overhead costs.

Today's larger stores can and do operate efficiently on a smaller ratio of inventory to sales and thus require less working capital to carry inventory. Supermarket chains tend to operate on a 50-times-a-year turn-over. Goods are often sold before payment is due. Finally, a larger volume of goods can be handled per unit of land and building investment. The possible extent of these savings is illustrated by ratios worked out by one regional chain. This chain has three sizes of stores, with the largest having approximately three times the floor area of the smallest (table 17).

TABLE 17.—*Items carried, number of customers, and dollar sales, by size of store*

[Smallest size store = 100]

Size of store [1]	Floor area	Number of items carried	Number of customers	Dollar sales
Smallest	100	100	100	100
Middle	200	150	212	350
Largest	300	200	316	800

[1] SIZE MEANS SALES. Business Week, June 18, 1948 (*8*).

Changing Marketing Functions and Relationships

The advance of technology in the last 20 years has been one of the chief reasons for sweeping changes in the functioning of the various parts of the food-marketing mechanism, and in their relationship to each other.

Diversification and Flexibility Within Establishments

The invention and commercial application of new machines and processes have permitted and, in many cases, made necessary the diversification of many of the plants in the food industries. An example of diversification, that is, the production of more than one product by a given plant, may be seen in the citrus industry where the development of mechanical juice extractors has brought about the canning of grapefruit juice in addition to the canned segments. Diversification in this industry was made possible by improved flash pasteurization and mechanical extraction methods, and took the form of a greater degree of plant and labor utilization by stressing another product line. Compared with the pattern in 1930 when a negligible portion of Florida grapefruit—about 1 to 2 percent—went into juice, in 1946–49 about two-thirds went into this use (57).

Another form of diversification is the development of machinery, materials, and organization capable of application to more than one raw material or product. This provides an opportunity for a plant to utilize more of its capacity during the year, and to substitute other products when the primary product is scarce.

In citrus plants, for example, although there are still some slack periods during the year, greater use of mechanical facilities is provided in the importation of Cuban pineapples and Mexican limes. Another case in point is the ripening equipment which can be used for both tomatoes and bananas.

Increased flexibility is also obtained by the blending of two or more commodities, as in the case of canned fruit mixtures, which allows processors to take advantage of surpluses by changing proportions of the blend.

Producers and distributors have gained considerable mastery over the timing of sales with the increased knowledge of the control of ripening of food products. Maturity of products is now determined much more than in 1930 by market opportunities rather than physiological or biological processes, and the seasonality of production is offset to a great extent by storage. This permits the plant to even out its production schedule over a longer period.

Although the trend is toward greater flexibility and diversification, it is still negligible for some foods; only 1 percent of the manufactured dairy products plants in 1944 were generally diversified (*13*).[17]

For years many established industries such as hog packing have employed the resources of technology to develop salable byproducts. A few examples of by-products that more recently have become important are cold-pressed citrus-peel oil, industrial alcohol, feathers, adhesives and glues, and pharmaceuticals. Economically, these byproducts are important to businessmen insofar as they turn potential costs into profits—as is the case where the costs of turning citrus peel into feed or oil are more than offset by returns from the sale of the final product. In other cases, there has been a shift in revenue obtained from joint products so that the byproduct returns more and more of the total revenue.

Technological developments make diversification necessary if costs of large capital investment in machines, research facilities, and specialized production technicians are to be spread sufficiently. The same raw materials are used for the production of shortening and soaps, and the same sales forces are used in their marketing. Similarly, common machinery is used for canned and frozen fruits and vegetables.

Integration in the Food Industry

Within the last two decades, partly as a result of technological progress, there has been a significant tendency toward greater integration in the marketing of food.

In many food lines, marketing operations which are sequentially related, that is, in which the output of one operation becomes the raw material of the next, are carried on by one or a few large corporate-type enterprises.

Integration forward is illustrated by the organization of a sales force by large producer cooperatives to sell directly to retail outlets. Integration backward is seen in the operation of processing facilities by retailers such as chain bakeries and warehouses, or the purchase of fresh fruit directly from producers.

Integration, both forward and backward, is characteristic of the frozen-citrus industry; the dominant firms operate their own sales organizations, in connection with brand names already established in the frozen-foods business, and several have even bought their own

[17] Although production records indicated that 360 plants (3.7 percent of the number surveyed) were equipped to utilize both fat and nonfat solids in alternative products to some extent, only 100 of them (1 percent) produced such alternative products in quantities that required more than 20 percent of the raw materials.

groves to guarantee steady supply and stable prices of raw materials.

On the Delmarva Peninsula, known for its specialized broiler production, a large retail chain operates its own dressing plant, a large packer has entered the hatching business, and poultry processors are financing broiler production.

Integration in distribution has meant more than a combination of wholesaling and retailing under one management. The method of handling both retail and wholesale functions has changed. Whereas the old-line wholesaler gave advisory service on inventory planning and merchandising methods, the head office of a corporate chain exercises *supervisory* control over both. The voluntary chain sponsor tends in the same direction. With chain organization and control of inventory, the function of personal selling of commodities to stores has atrophied. In addition, the chain head office, even in voluntary chains, takes a more direct hand in store architectural and locational planning, and extends its advertising and selling promotion to cover retail advertising. Determining prices and grades and deciding times of purchase and sale are now largely centralized. This has made possible the purchase of products at greater distances from point of sale and has enabled retailers to make better buys, sometimes directly from the producing organization.

The trend to larger-scale, more diversified, integrated organization of the food industries permits these industries to offset, at least partially, the uncertainties of the business cycle. This is done in part through greater market control and reduced costs of distribution. In those industries in which tax and legislative proposals have implications for many concerns, greater diversification and flexibility—as is found in a firm that produces several products from the same raw materials—reduce the potential effects of uncertainties in demand for the final products. Although reduction in demand for the final product of a small specialized firm could spell ruin, it would do relatively little harm to giant diversified food concerns.

Other Effects on Distribution

The trend has been toward greater turn-over and less storage at the old-line wholesaler level. Fast, convenient truck transportation has made this possible, while the necessity of competing with chain stores, whose inventory policy is to reduce the storage function to a bare minimum, has provided the incentive.

The cause of orderly marketing of food products has benefited greatly in the last 20 years from developments in warehousing and storage, especially in the case of perishable products. Today, many commodities move more smoothly into and out of storage, providing an adequate supply, both seasonally and geographically. The amount of frozen storage space available is an important consideration in the growth of the frozen-food industry, which promises eventually to change markedly the areas in which fruits and vegetables are grown.

As progress is made in improving frozen-food marketing (for example, better packaging, and more effective retailing methods), the wholesaling of agricultural commodities in this form may be expected to grow in importance.

Adoption of technological developments has reduced the numbers of distributors in some cases and increased them in others.

Continuing a trend started before 1930, the increased knowledge of the benefits of pasteurization of milk has induced many local communities to make pasteurization a mandatory requirement. This has reduced the number of distributors in many of these markets, in some cases by as much as two-thirds. A high percentage of producer-dealers have not been willing to invest in the necessary equipment and have instead turned their efforts to more specialized production. This has permitted a smaller number of dealers to share a larger supply and a greater number of customers.

In the marketing of fresh fruits and vegetables, livestock, eggs, and some grains, there has been a considerable shift toward movement by truck, by merchant truckers. These merchants buy from producers and sell to larger concentrators in the central or terminal market. In the sale of fruits and vegetables these agents often buy direct from the field.

Changing Patterns of Investment and Risk

Technological development has a direct effect on investment in both processing and distribution. The relationship is especially important in connection with the ease of entry into the business and the rate at which innovations are adopted. In most instances, though not all, a higher level of technology calls for more expensive equipment.

General economic conditions, more than any other factor, appear to govern expenditures for such purposes as change of products, new processes, etc., even though such advances may well be justified on technological grounds at any time. The large volume of investment during the late 1920's was due mainly to a great increase in the proportion of food packaged for sale, for

example, sugar, cereals, and bakery products. New processes were introduced, and the industry was further mechanized and centralized into larger, more efficient plants (*11*).

Larger, elaborately equipped plants require more capital than their simpler predecessors. The investment in a modern citrus-freezing enterprise, for example, is much greater than that required for a single-strength juice-canning plant.

By mid-1949 the plant and equipment of one of the four largest concentrate companies was valued at approximately 3½ million dollars. During the 1948–49 season, that firm and three others of comparable size accounted for about 90 percent of all the frozen citrus concentrate sold in this country (*50*).

Investment of such a magnitude is out of reach of most individuals, indeed, of all but the larger corporations. Data as to the number of new businesses in manufacturing and distribution of food do not suggest any great falling off from year to year. This implies that the larger firms may be taking advantage of the newer high-capital requirements while other small-scale operators are trying to compete under levels of technology which do not require high initial investment.

Frequently the situation involved in a reorganization resulting from changes in technology or demand, however, is not a greater total need for capital, but a lower need in new and different form. A doubling in plant size may require less total investment per unit of product—one large plant may entail less initial investment than two small ones.

Also important, and usually expensive, is the spread of research departments operated as an integral part in many firms on a par with existing operations. A glance at any of the annual reports of the larger companies in meat packing, dairying, baking, etc., suffices to show the trend. National Dairies has some 78 laboratories (39); in 1930 General Mills employed 5 cereal chemists, in 1950 it employed 30 (*4*, p. 107).

Not all business organizations can afford elaborate research establishments of their own. Small companies, as well as large have had the benefit of research in food utilization carried on by the U. S. Department of Agriculture, State experiment stations, and trade-association laboratories. These laboratories are constantly engaged in seeking new ways to utilize farm products as well as improvements in the storage and transport qualities of the raw or processed product. As the practical results of this research are made widely available under public patent, they are likely to increase the competitive aspects of manufacturing and distribution.

The existence of large enterprises in many stages of food processing and distribution has frequently meant the rapid spread of innovations by firms able to carry out large-scale research and to finance speedy adoption of new practices. On the other hand, patent control and increased capital requirements have hindered entry of smaller firms in many branches of the industry and sometimes have delayed or prevented wide use of technological discoveries.

Uncertainty and Obsolescence in Marketing

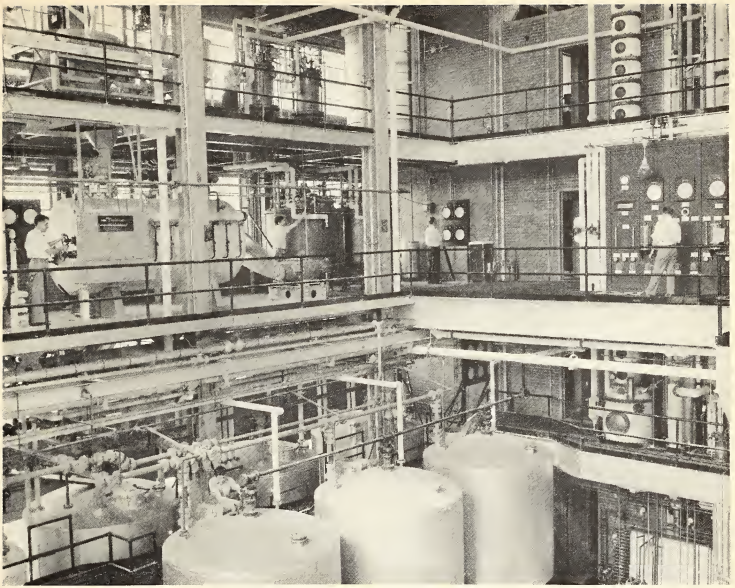
The very steadiness of progress in the technology of processing and handling of foodstuffs has introduced an element of uncertainty into the business operations of the firms engaged in these activities. In considering adoption of new methods and machines, businessmen are faced with the possibility that technology will develop still greater improvements even before innovations have been completely geared into plant operations; or that changing pattern of demand will reduce the revenue assumed during the repayment period.

Obsolescence in food processing is a very real problem. Failure to modernize may mean ruinous competitive disadvantage in unit costs, but short-lived improvements can be equally ruinous.

Failures in technological developments are seldom remembered, but there are many examples of promising developments quickly displaced or proved to be of limited application. The valve-vented can for cheese was used for only a short time because wartime scarcity of tin prevented its use; then pliofilm, which did the same job more economically, was introduced.

Some innovations have presented problems even more complex than the risk of being quickly superseded by something better. For example, development of methods of making concentrated milk involves difficult manufacturing problems. As in most market areas the price of the concentrate is tied to the farm price of class I milk, it involves also problems of price policy and of distributors' initiative. As concentrate would be distributed chiefly through retail stores, the effect on employment of delivery-route employees is also a problem.

Equipping and opening a modern retail outlet is so costly that every precaution must be taken against the possibility of failure. The risk of failure has been greatly reduced by the larger chain supermarkets which make preliminary investigation of population concentration and movement, lines of traffic, competition, and similar considerations. To guard further against risk, at least one large chain designs its stores so that the buildings can be used for other purposes, although at the same time they are well-adapted to retailing foods.



Research in utilization of farm products

The illustration shows part of a pilot plant in one of the four Regional Research Laboratories of the Bureau of Agricultural and Industrial Chemistry, which were authorized by Congress in 1938 to work on new scientific, chemical, and technical uses for agricultural raw materials. Many large industrial firms also conduct research, the results of which have led to innovations and the adoption of new practices.

Each new building is sold to an investor who leases the building back to the food retailer. The retailer recovers his investment in fixed assets which can better be used for working capital. A similar plan is followed with regard to certain types of fixed equipment and fixtures (52).

An individual firm's profits from innovations are uncertain and usually short-lived. They sometimes turn into losses as competition forces all the firms into line. A case in point may be seen in the fruit and vegetable packing industry. Frequently the pattern of development is for one or a few firms with a new idea to secure premium prices for a short time, but when they are imitated by other firms all are restored to their former competitive position with none receiving premiums, and often with all of them saddled with higher costs. An example of this occurred in the 1930's with melons. One firm conceived the idea of packing melons in a nest of shredded cellophane. As a result, it obtained a price premium of some 50 cents a crate. The next season all shippers packed in this way with none getting higher prices than before and all incurring an additional cost of about 12 cents a crate. The use of individual paper wraps on melons had similar results. Once introduced, each shipper feared to stop using it lest he lose his market to those who made the fancy pack. Both of these practices died out when materials were short during World War II, and no serious attempt has been made to revive them.

Similar results followed the introduction of services which were provided in the 1930's by milk distributors who originally obtained marginal customers by intro-

ducing the "extra-order" system. As soon as firms were prepared to send one quart of milk several miles to a customer, all firms bore costs with no gains to any in number of customers.

Changing Forms of Competition

The pattern of food marketing has moved in the direction of monopolistic competition. Competition is becoming more of a contest among a smaller number of bigger organizations than among a large number of small units.

This does not necessarily mean less intense competition. The fact that only a few large suppliers are in a particular field does not make each less desirous of getting as large a share as possible of the market. Monopoly power is also limited by the possibility of existing firms adding a new line as well as entry of new firms. With existing facilities, many of the giant firms that produce soaps and shortenings could easily add margarine to their line at little additional expense.

Another set of circumstances, also stemming partly from gains in technology, has increased the importance of nonprice competition. In retailing, a large number of small independent stores survive principally by virtue of their location or by offering some specialty, such as credit, delivery service, remaining open in off hours, or stocking all types and grades of some special kind of food, as their principal drawing card rather than prices as low or lower than those of their competitors. Of greater significance is the promotion of brands by large organizations. With the acceptance of uniform grades and broadened opportunity to advertise through radio, newspapers, and other media, the trend in the food industry has been toward the use of brand discrimination, advertising to create demand, and methods other than price to influence the consumer to want one brand rather than another.

Use of brands can be a method of inducing as well as restricting competition. Insofar as small processors combine high quality with their particular brand, they may assure a clientele who associate the two. But in general, there appears to be a rough correlation between use of brands and average size of firm in each industry—the larger the firm the greater the attempt to insure the market for its product (*56*).

Wholesale distribution of foods is tending toward fewer and larger sales organizations partly as a result of the growth of retail buying in recognized uniform packs. The trend is most obvious in the field of processed foods where advertised brands increasingly tend to dominate. Brand promotion, of necessity, requires a large organization and considerable volume to be successful. The tendency also reaches beyond the processed foods into the fields of unprocessed fruits and vegetables. Consumer recognition of a standard uniform pack requires both volume distribution and careful policing of the standard. Thus, State or grower brands or designations, such as Maine or Idaho potatoes, Texas grapefruit, Washington apples, and Diamond walnuts do not differ in this regard from brands of large private concerns. All require some over-all supervision of quality of pack and a considerable amount of advertising to establish consumer recognition, even though it may be through a State agency, as in apples and potatoes, or a cooperative sales agency, as in the case of walnuts.

Brands have been used extensively for certain types of food for many years (table 18).

TABLE 18.—*Percentage distribution of manufacturers' and distributors' brands in selected food industries, 1939*

Brand	Biscuits, crackers	Canned fruits and vegetables	Flour	Packaged cereals
	Percent	*Percent*	*Percent*	*Percent*
Manufacturers' or processors' brand	99.5	63.6	80.5	91.6
Distributors	.5	32.2	16.5	8.0
Combination	----	2.1	.5	(1)
No brand	----	2.1	2.5	(1)

[1] Negligible.

TEELE, S. F., and BURSK, E. C., MARKETING PRACTICES OF FOOD MANUFACTURERS (*56*).

A type of competition that is substituted for freely moving prices, is that of consignment selling, that is, processors stand ready to take back unsold goods. For example, to obtain the greatest share of the market, "insured freshness" has been attained by large-scale bakeries by selling on consignment and making multiple daily deliveries. With the coming of the supermarket and the greater emphasis on buying from displays, the overstocking of shelves by competing bakeries became even more pronounced. The effect of consignment selling, aside from the waste incurred, was to give financially strong enterprises an advantage over the small bakeries, which, lacking capital, fell by the wayside. In addition, the returned bread was sold for nonfood purposes, reaching about 250 million pounds a year (*79*).

On the positive side, monopolistic competition can make for more efficient marketing and faster progress

in development of new products. On the negative side it can mean, however, that the mistakes of a few individuals can affect the whole market. It can mean that innovations may be blocked or retarded by the limits of the imagination of a few groups or by the fear of the large organization of the costs of misjudgment of the scale on which it operates.

Whatever the net balance of the effect of the monopolistic competition which is a corollary of advertising promotion, the trend appears to be here to stay, for it is reinforced by practically every development in marketing. Much of food processing is of a type that requires heavy capital investment and invites dominance of a few firms. Self-service, the supermarket, and chain buying tend to require sources of supply that can sell large quantities of standardized products.

Growth of the National Market

The flexibility and speed of truck transportation, the network of national communication, and more objective grading have blurred the lines of traditional trade areas, have brought centers into closer competition for supplies and outlets, and have brought numerous small distribution centers into effective competition with each other and with the older and larger rail centers. The tendency is toward a single national market.

This is an extension of a tendency which, starting more than a century ago with the building of canals and railroads, gradually freed the farmer from dependence on the purely local market, the consumer from dependence on purely local food supplies, and both buyer and seller from the necessity of meeting physically at the same spot to bargain over farm produce by inspection. The rise of trucking, in addition to its direct effect of inducing the railroads in many instances to lower their rates and increase service, has strengthened the trend toward direct marketing, the bypassing of the central market, the development of auctions, the beginning of new geographic areas of specialization in farm production, and the reduction of gluts and shortages. These interrelated changes are the chief structural market effects brought about by the introduction and commercial adoption of technological innovations.

Shifts in Market Areas and Plant Location

Before truck transportation of foodstuffs became so important, the egg-producing industry of the Midwest depended upon local demand and outlets such as dehydration and freezing plants at relatively low prices. This reflected the extremely fragile and perishable nature of the product and the losses in quality and breakage when shipped by rail. Truck transport and direct sales to large chains have opened the premium-price markets of the East and the egg industry in the Midwest is becoming more commercialized and stabilized at a higher level of returns to the industry.

With the greater size and investment required to package milk in paper cartons, combined with the reduced weight in transporting to retail outlets, the market area for fluid milk has expanded considerably. In the East, trucking milk up to 150 miles is now common; in the Great Plains States from 300 to 400 miles is usual; and one plant in Texas is reported to ship its milk up to 600 miles.[18]

With the advance of technology, plants not only increased in size but were introduced in greater and greater numbers in areas formerly associated with other commodities. In several areas of the South cheese plants have been established. Refrigerating and humidity-control developments which guarantee a uniform final product were factors, although the development of special heat-resistant grasses for pastures was also important. Since 1930, cottonseed and soybean oil have replaced coconut oil as raw material for margarine, partially because of improved hydrogenation processes and partially because of the tax disadvantage suffered by coconut oil and wartime transport restrictions. This, plus the increase in consumption of margarine in the South has stimulated a shift of national production to the cotton States.

Many shifts in location also have occurred in the storage of foods associated with the development of large-scale processing, including drying and cleaning prior to storing, per unit cost of which is substantially less at central points than at farm centers.

Widening of the radius of profitable operations of wholesale firms, and the consequent decline in the number of wholesale trading areas, have come about through general use of the automobile and truck.

Changing Patterns of Concentration

Motortrucks have diminished the importance of large cities as carlot concentration or receiving markets. The truck put truck-lot shippers and receivers on virtually an equal footing with carlot shippers and receivers. As major consuming centers, the large cities remained important markets. In fact, they grew more important as their metropolitan and satellite areas included more

[18] WILLIAMS, S. W. MARKETING DAIRY PRODUCTS. Southern Agricultural Workers Conference. Memphis, Tenn. February 5, 1951. [Unpublished.]

of the country's population. But they began to receive less of the food not destined for sale in their immediate area, and interior markets became important.

The tendency toward decentralization of the market process has permitted more direct connection between producers and the small and medium-sized consuming areas which formerly were supplied from the central market. This has eliminated much unnecessary transportation from producer to central market back to consumers near the producer.

Comparative figures for livestock offer an example of changes in the volume of foods shipped through central markets for concentration purposes. Similar information on manufactured foods is not available for census years before 1947.

Since 1930, the percentages of all classes of livestock, except hogs, sold "direct" through the decentralized marketing system, have more than doubled (fig. 15). The percentage of hogs moving direct already was high, and it, too, has increased. Similar changes appear to have taken place in grains, fruits and vegetables, butter, and some poultry products.

Improved grades and standards have made it possible for products to follow the changed geographical routes. As Professor Shepherd has put it:

> The advent of the truck and the paved highway after 1920 introduced a transportation agency that filled the gap between the short-haul wagon and the long-haul railroad. The radio similarly filled the gap between the localized word-of-mouth means of communication and the long-distance telegraph or telephone. Standardization, spreading to more commodities, reduced the need for concentrating goods merely for inspection. The breakdown of the previous clear separation between local and central markets, and the rise of a new intermediate type of market, was a natural resultant of these changes. Not only did the physical goods short-cut the central markets to a greater and greater extent; the market news and the process of price determination short-cut them too. The new intermediate markets, instead of being articulated vertically, as it were, with the central markets (both in the flow of goods and the determination of prices) are articulated horizontally with each other. Prices in these "direct" markets are as likely to lead those in the central markets now as to follow them. The "concentration, equalization, and dispersion" of the physical goods that used to take place at the central markets is now spread all over the country, and the price-determining and title-transferring process is spread along with it. The *market place* or *market point* has given way to the modern *decentralized market* covering the country as a whole (*54*).

Offsetting to some degree the advantages of decentralized marketing, is the increased difficulty, at least in the transitional stage, of collecting and setting prices. In most instances, central market prices represent a smaller proportion of the supply than formerly. It is not as easy to collect data relating to price and supply when products are trucked in from many points as when rail freight invoices are available from a limited number of local collection points.

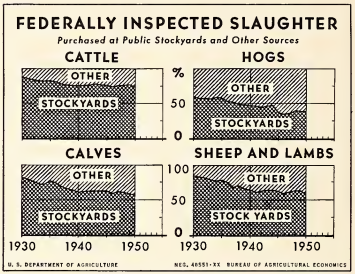


FIGURE 15

Trucking tends to give better distribution of foods as between sizes of markets, but its very fluidity can cause a condition of gluts and surpluses in the absence of adequate market information. In general, however, the out-of-season deficits in rural areas and points far from the central markets appear to be lessened. The centralized character of rail movement control permits rather accurate forecasting of receipts. The individualistic and nonchannelized character of trucking, as well as its speed, makes gathering of "en route" information difficult. In the early 1930's, the effect of trucked-in supplies was considerable demoralization of the market because of the sudden appearance of unexpected supplies. Unscheduled truck arrivals are still a problem and will remain so until an adequate market news on truck shipments can be devised. But communications and retail-trade developments have permitted offsetting adjustments in market structure. Extensive use of telephone and teletype, combined with the growth of direct buying by chains and supermarkets, has enabled a shift to f.o.b. pricing in major specialized areas. The speed of these communications systems has greatly enhanced the value of diversionary shipment privileges on the rails and similar devices on truck shipments. The growth of truck transfer-point markets has lessened the pressure on the larger central consignment markets.

When centralization was due, as in fruits and vegetables, primarily to transportation requirements, decentralization of the market seems to have proceeded rather far. But when centralization was mainly a

result of processing requirements, as in flour milling, little evidence of decentralization is found. Where markets had remained purely local, as in milk, the trend was toward greater centralization, also due in part to trucks.

Centralized organization is limited by the perishable nature of certain food products. In baking, around 100 miles is the maximum feasible distance from the point of manufacture—even with trucks. Unlike the baking industry, the manufacture of crackers, which are relatively nonperishable, is centralized in the hands of a few large concerns operating large-scale plants.

Effects of Better Grading

Objective and uniform grades have resulted in a shift from consignment to cash purchase. The equity in the product more frequently changes hands at the point of production than at the terminal market.

Establishment and adoption of official Federal-State grades have contributed to the direct marketing of poultry, fruits and vegetables, and eggs. The larger retail organizations have set up official grading and inspection stations in their warehouses and pay premiums directly to the producer or producer-cooperative. This has done away in part with the services previously performed by commission merchants.

Direct-to-retailer marketing of poultry from the Delmarva Peninsula, especially to the larger chain stores, has increased considerably. The central market for dressed poultry in New York City is becoming less important as a distribution center, although it still helps to set poultry prices for the country. Considerable evidence exists that the best grades of poultry bypass the central market in New York City and are sold at a premium above the New York price.

Technology in Food Marketing

CHAPTER 7

Some Effects of Technology Upon Producers

The changes wrought by technology in food marketing have a direct meaning for food producers. Subsistence farming is on the wane. By far the greater part of the Nation's food production comes from farms whose operators are commercial producers, dependent for a livelihood upon the relationship of their investment and production expenses to their cash returns from the market place.

Some of the more important effects of marketing technology on farmers as operators of producing units are discussed in this chapter. The effects upon farm households are discussed in chapter 8, which deals with all consumers, rural as well as urban.

During the last two decades the national system for marketing food has kept pace with the country's capacity to produce food. Production of food increased 40 percent from 1930 to 1950, yet food marketing was in most instances a smoother operation at the end of the period than at the beginning. Specific problems growing out of improved production techniques, such as excessive moisture in grain as a result of mechanical harvesting, were met by corresponding advances in processing and storage.

The changes in food marketing that result wholly or substantially from technological advances have affected the way in which farmers sell their products, frequently broadening their markets or lengthening the marketing season, and often influencing production practices. These changes also have affected returns to farmers, although exact measurement of their influence in this area is impossible because of other and stronger forces bearing upon farm prices and incomes during the last 20 years.

Production of food is more closely integrated with its marketing than formerly. Improvements in marketing technology are among the chief reasons for this, along with better farm-management and production technology, improved types of credit, and further development of cooperative marketing. Today the farmer is more likely than he was 20 years ago to produce one or more commodities especially designed in variety and grade, and time of readiness for sale, for the requirements of a particular market. Technological gains in processing, storage, transportation, wholesaling, and retailing have led to greater recognition of the physical characteristics in food products as they leave the farm that make them especially desirable for certain uses. In many areas, canning, freezing, and dehydration have become primary rather than distress outlets for farm production. Standards for foods to be used in processing frequently are as high as or higher than for foods to be sold fresh, and often the requirements for the two uses are quite different.

Many farmers have tended to become specialists in producing certain kinds of raw materials for the food industry. In such circumstances, the principal advantage has gone to those farmers best able to adapt their production patterns to the new situation. In many instances, however, increasing specialization and integration have meant some loss of producers' flexibility, as more of their resources are invested in capital equipment that may not be readily adapted to other types of production.

Changes in Production Practices

Gains in technology of food marketing have in many instances directly affected production practices as well as methods of processing and distribution. Some of these effects have meant increased use of completely new varieties. Others have meant changes in methods, such as harvesting at stages of maturity especially adapted to modern transportation or processing requirements. Another instance of changing methods is the special care required to avoid spray residues on fruits and vegetables that are to be processed into baby foods. Still other effects of the new technology have meant the transfer from many farms of processing functions which formerly were performed there, such as pickling and poultry killing.

Perhaps the outstanding example has occurred in dairying; it represents a combination of the three kinds of effects just named. First, improved large-scale equipment helped to accelerate the shift of cream separation from farms to commercial creameries. Second,

as uses for the nonfat solids expanded, dairy plants gave more attention to the drying processes, to make the product more acceptable for human consumption. This advance encouraged further transfer of cream separation and butter-making from farms to commercial plants, and also curtailed the feeding of home-produced skim milk. Between 1930 and 1950 the quantity of skimmed milk available from farm-separated cream declined from about 29 billion pounds a year to about 17 billion pounds. Farmers who continued to raise hogs, poultry, or other livestock as a supplement to dairying turned to packinghouse byproducts and soybean and other meals to replace the skim milk as a source of certain types of proteins.

Expanded uses for nonfat solids tended to increase the per unit value of these ingredients in relation to fat. At the same time, popularity of margarine and vegetable shortenings tended to reduce the demand for butter. As a final result, emphasis is shifting from the fat content to the nonfat components of milk.

Agricultural specialization has been accentuated by technological developments in food marketing. Instead of diversifying, many farmers have turned to production of a single crop. A small diversified producer often does not have sufficient volume of any one product to make grading and packaging feasible. Nor do small-volume producers attract large-volume buyers such as chain stores or processors. As a result they find themselves in a less favorable competitive position than the larger producers. Often the only way open to an individual producer is to increase his volume by producing only one crop. As a result there now are more specialists such as lettuce, tomato, and bean farmers and fewer general vegetable farmers. Cooperative marketing organizations have been formed in some instances to meet this problem.

Specialization often increases the risk of farming. Even before 1930, risks associated with the market frequently were reduced by contractual agreement between processor and producers. During the last two decades such agreements have become more numerous, and their terms, in general, have grown broader. Although these contracts take many forms, they usually provide that the processor will take the production from a certain acreage of fruits or vegetables at the existing market price or at an agreed price on a grade basis. These contracts may also provide that the crop will be harvested by the processor and on a date determined by him. By doing the harvesting the processor can control the volume of incoming raw material and, because of the large volume contracted for, can use more efficient harvesting, grading, and handling methods than most individual producers. Also, these agreements usually name the specific variety to be grown; often the processor furnishes the seed.

Developments in the poultry industry have led not only to a transfer of some operations from the farm but also to a drastic change in the risk assumed by some farmers. Technological improvements have been among the chief reasons why the processing of broilers has become in many areas a straight-line, mass-production operation. Large-scale concerns have taken over some of the aspects of processing that were formerly performed on the farm, and in an effort to assure steady supplies throughout the year many of them have entered into arrangements that take much of the risk from the farmer's shoulders and put him somewhat in the position of the manager of a chicken boardinghouse. Because the processor finds it advantageous to have a year-round supply of birds to spread his overhead, he not only furnishes the chicks but also supplies feeds and other requisites at times of the year when they would be very costly to small individual producers. Agreements of this kind also make for less seasonal variation in production. Many feed-mill operators have offered similar contracts.

From the viewpoint of control of the quality, supply, and price of raw materials, the ultimate in integration is for the processor himself to get into the farming operation, or, at the other end of the scale, for growers cooperatively to undertake large-scale processing and marketing operations. Cooperative enterprises of this kind have increased markedly since 1930. So, on a much more limited scale, has entrance of processors into farming. Perhaps the most clear-cut instance of the latter development is the increase in ownership of citrus groves by processors.

In general, developments in techniques of processing and distribution have made it more necessary than ever that farmers use better methods and equipment and plan their operations more precisely. Because more machinery is used in processing, grading, transportation, and storage, and because more has been learned of the exact conditions in which the various farm products are best processed or otherwise handled, the specifications of the different raw products have become more narrow. Thus the trend toward a more specialized agriculture has been strengthened; it has become increasingly important that farmers exploit natural advantages to the fullest extent and avoid natural disadvantages as much as possible. Producers who are unable to keep in step with changing market-

ing requirements often find that the demand for their products has declined.

Effects on Farmers' Marketing Practices

Many of the marketing developments described earlier—new processing methods, better highway and rail transportation, improvements in refrigeration, and other aspects of storage, advances in grading, packaging, and communications—have directly affected the way farmers sell their products. On balance, these developments have helped give farmers a more organized and dependable but also a more competitive market. Because the quality of most products now can be maintained until they reach distant points, more farm products now have a Nation-wide rather than a regional or a local market outlet. Expansion of the area means less risk of price fluctuations caused by local or regional shortages or surpluses. But as each producer gains access to a broader market he loses some of his favored position in his own area, for the same forces that open other territories to him open his local territory to others. Thus the situation has become more competitive for nearly all producers.

The combined effects of better transportation and storage and of better grading, inspection, and communications have encouraged f.o.b. sales and immediate payment rather than consignment selling, so that in many instances farmers need not wait so long for their returns as they did formerly.

The great increase in the volume of processing has meant that frequently processors now offer farmers outlets of importance equal to, and sometimes greater than, those offered by the market agent who handled unprocessed products. Although this trend began well before 1930, it has been greatly intensified since that time, because of improvements in canning and dehydration and the recent growth of freezing.

In 1930 the part-time or marginal canner who operated only during periods of local surplus and bought unsold residues at distress prices was a more familiar figure than he is today. The trend has been toward longer-time processing operations on a larger scale, with standards and prices more comparable to those offered for products to be retailed fresh.

Difficulties of marketing their products have been eased for many farmers. In some areas tank trucks now go from farm to farm picking up milk by pumping it direct from the cooler. Improvements in mobile equipment have made it possible for the middleman or assembler often to take a farmer's product direct from the field. Improved commercial storage facilities at country points make it easier for farmers to store products successfully while waiting for market gluts to be absorbed.

Developments that made it easier for farmers to sell their products and brought them into contact with a national rather than local market might have done them more harm than good had it not been for the corresponding developments in communications. When farmers sold the bulk of their production through one or more local buyers whom they knew, at least some of the handicaps of distance from great commodity markets and being out of touch with trends in demand and price were compensated for by the personal relationship with the dealer and by the fact that practically all farmers were in the same boat. In recent years, the swift broadening of the potential market area for the individual farmer has taken place partly as a result of the greatly improved networks of communications. Many of those improvements, especially the Market News Service, were designed primarily for the benefit of producers, even though their most direct use is often by agents of the marketing system itself. Without them there might have been more chaos than progress.

Developments in communications have brought up-to-date market information within reach of nearly all farmers. Although producer and market organizations often have their own private sources of market information, the average individual producer has access to the market information furnished as a public service by the Market News Service through radio, newspapers, and other channels. By using this information the farmer has a better chance of marketing his crops in an orderly way. He can often avoid placing his produce on a market that is over-supplied. Flexible transportation makes it possible for the farmer to use market information to advantage by directing his supply to the most favorable market. But not all farmers have received unmixed, immediate benefits as communication developments brought areas of supply into closer competition. Efficient producers, frequently those operating on a large scale, in the areas of greatest natural advantage have become better able to compete in areas where once the position of local producers was rarely challenged.

Recently there have been indications that improvements in packaging and grading may be encouraging some agricultural producers to sell under individual brands, and thus to enter a field of competition in which nonprice considerations, as well as price alone, are significant. Fresh fruits and vegetables, which

bulk large in the total food-marketing picture, may come into a competitive situation similar to that which prevails now for many canned goods and dairy products. This development could in many cases reach down to the individual shipper, or producer. In such situations, the advantage usually would lie with the farmer, or association of farmers, operating on a scale large enough to permit efficient grading and packaging and to maintain uniform quality in each branded product.

Geographical Shifts in Production

During the last 20 years advances in processing, storage, transportation, and communications have done much to overcome problems of time and distance. The period since 1930, therefore, has seen many geographical changes in production which are traceable completely or partially to technological advances in marketing.

Developments that make it possible to ship perishable foods over long distances and to change a greater proportion of perishables into relatively imperishable form through canning, dehydration, and freezing made nearness to large consuming centers less of an advantage to farmers and made it possible for many areas of the country to specialize in production for a Nation-wide market of foods for both processing and fresh use.

Developments, such as the rail tank car, tank truck, better refrigeration, large-scale processing, and use of the paper carton have permitted expansion of many milkshed areas. But restrictions on entry of fluid milk in many markets have tended to offset this tendency to some extent.

Developments in truck transportation have been especially significant in changing the competitive nature of food production in areas surrounding large markets. With modern refrigerated trucks great distances can be covered with perishable commodities and some areas of production have developed completely apart from railroad connections. This development has extended the radius of the supply area around large city markets for fresh vegetables and poultry products. Many producers in high-rent areas just outside cities have found themselves increasingly in competition with distant areas, as well as with those lying only slightly farther out. The relative advantages enjoyed by traditional producers of "early" produce have shown a tendency to decline, as these areas compete more directly with low-cost producing areas. In addition, improved storage methods permit fresh products to be held over from one crop-year to the next; and high-quality, convenient-to-use food products are better substitutes for their fresh counterparts. The combined effect has been an evening out of the supplies coming to market.

Better packaging and more flexible, faster transport have been among the principal reasons why eggs from midwestern producing areas can compete in distant premium markets, although better care of eggs on the farm and up to the point of first assembly also has been important. Production statistics indicate that as total production of food crops has increased in response to increased demand, more and more of the supply comes from specialized production areas.

Gains in marketing technology have affected area production in other ways. Improvements in processing of vegetable oils have led to a greater increase in consumption of vegetable shortening than in consumption of animal products such as lard. As a result, production of soybeans has been stimulated.

Effects on Returns to Farmers

Improved technology in food marketing has been one of the reasons why commercial farming has become in so many respects a different enterprise from what it was 20 years ago. The general long-run effect of increased efficiency in food marketing, as in any other segment of the economy, is to spread the benefits over the entire society, including the farmers who produce the food. Technological gains in marketing have affected farm prices and farm incomes in indirect as well as direct ways.

The effect on returns to farmers of changes in processing and distribution techniques cannot be measured statistically on any broad basis. If a sufficient number of pertinent case studies were available, they might provide the basis for useful estimates. As yet, few studies of this kind have been made. Comparison of over-all figures for the beginning and end of the 20-year period tells little as to how marketing technology has affected farmers' returns. The increases in consumer purchasing power and in the level of prices in general have been so great since 1930, and the effects of production technology, crop loans, and other agricultural price-support actions so important, that the influences of other forces are submerged and cannot be separately measured. Also, the forms of many processed foods and the pattern of consumers' preferences for food in general have changed enough to make comparisons deceptive. Attempts to get at the answer from the other side, by comparing the farm prices and incomes of 1950 with what they might

have been had marketing technology stood still, are even more difficult. The whole national pattern of living has changed, including farm-production methods on the one hand, and consumers' needs and habits on the other. Food marketing has moved along with them.

Nevertheless, a number of the impacts of marketing technology upon farmers' returns can be identified. Not only are they part of the history of the last two decades and of the present situation, but they will also influence future developments. Most of the discernible trends can be expected to work in the general direction of higher farm returns; under some circumstances others might have the opposite effect.

Two fundamental trends have been noted frequently throughout this survey: (1) Technologically based increases in efficiency that improve quality and reduce processing and distribution costs, and (2) the introduction of new and often costly marketing services.

Efficiencies in Food Marketing

In a few instances the effects of marketing technology upon returns to certain groups of farmers can be clearly seen. Perhaps the most notable example is the way in which introduction of successful canning and freezing techniques prevented a ruinous situation for citrus growers. In the early 1930's with more trees coming into bearing, production already was outrunning demand and growers' prices and incomes were falling. Practically all of the fruit was sold as fresh. Canning operations were negligible and commercial freezing was nonexistent. Between 1930 and 1948 production of both oranges and grapefruit more than doubled, yet by reason of improvements in processing and distribution, demand was greatly stimulated during the same period. By far the greater part of the increase in consumption represented the processed product. In 1948, half the total grapefruit production and nearly half the total orange production went into processed form (fig. 16). Since that time production of frozen citrus concentrate has greatly increased. Without the new developments in processing, the market for citrus fruit never would have been broadened as it has.

But advantage to a particular group of farmers does not necessarily bring a corresponding net advantage for agriculture as a whole. Competition among different products and different areas usually means that gains in one sector are offset partly or altogether by losses in others. The most easily traced benefits of marketing technology to farmers' incomes have usually been of this competitive nature.

Nevertheless, the broad, long-run effect of the many efficiencies and economies introduced into food marketing by improved technology should be to increase returns to farmers as well as other groups. For shorter periods, in instances in which a money-saving innovation in processing requires large capital expenditures and cannot be adopted quickly by the rest of the industry, it is unlikely that much or any of the savings will be passed on to farmers in the form of higher prices by the concern using it. But when a technological improvement can be widely adopted, competition for larger shares of the business will tend to increase prices to farmers.

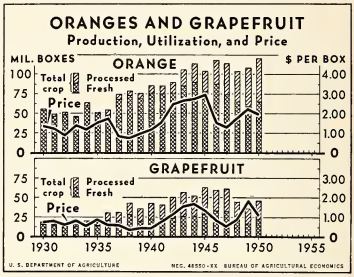


FIGURE 16

Added Marketing Services

The increasing proportion of food retailed in processed form, the growing elaborateness of many phases of processing, and the addition of new services and refinements in distribution all mean that farmers tend to sell more raw materials for further industrial processing rather than the finished products for consumption. In the absence of other influences, this trend could be expected to reduce the farmer's share of the retail dollar spent for food and, consequently, farm income. But in recent years contrary influences have more than balanced this tendency. Self-service in retail stores has in itself done much to offset the cost of new marketing services. Above all, consumers have more money to spend for food. It is probable that the new marketing services, insofar as they have made foods more attractive and convenient to use, have contributed to the willingness of the average family to spend a larger proportion of its income for food. So long as the great majority of consumers will pay the premiums that cover the cost of added services, the

extra marketing charges will not in themselves lower returns to farmers. But if consumers should become unwilling to pay the premium price—as would happen in a depression—and if the older, simpler forms of food no longer were available, existence of the more elaborate marketing services would tend to make returns to farmers lower than they would be otherwise.

Per Capita Consumption of Food

Effects of marketing technology upon the Nation's total demand for food are hard to isolate. Dominant influences have been the growth of population and the greater and more widely distributed buying power of consumers. Changes in buying power have enabled families that formerly had very low incomes to increase somewhat their consumption per person and have accelerated the shift by consumers of all income levels from such low-cost foods as cereals and potatoes to higher-cost, protective foods such as meats, milk and eggs, and fruits and vegetables. In 1950, the average consumer bought more food in terms of agricultural resources, if not in sheer bulk, than in 1930. Food marketing technology has reinforced this trend. Prepackaging of meats, poultry, and fruits and vegetables and the many other advances in getting fresh foods from farms to retail stores more promptly and in better condition have encouraged purchases of the so-called protective foods. In general, these are the foods for which the farmer traditionally receives a larger share of the consumer's dollar.

A few other straws in the wind may be worth noting. Stimulation of extra food purchases through automatic vending machines, and increased consumption of new forms of dried skim milk by low-income families suggest that technology has tended to broaden farmers' markets. On the other hand, the tendency to standardize retail forms of some foods at higher cost levels of quality or packaging would tend to work in the other direction by limiting purchases, particularly among low-income families.

Increased Specialization in Farming

Farmers in general have relinquished to industry a number of processing and marketing functions they used to perform themselves, and on some farms the diversity of production itself has been narrowed. In most instances, specialization enables farmers to take advantage of the economies of larger-scale production and to put all of their land and other resources to uses for which they are best fitted.

As such functions as pickling, curing, cream-separating, and butter-churning have been transferred from farmers to marketing agencies, farmers as individuals have lost sources of income from combined farming-marketing operations. Door-to-door selling also has declined. At the same time, however, this has enabled them to give more attention to farming itself. A skilled operator on good land usually can get much higher returns on his labor and other resources from crop and livestock enterprises than he can from small-scale, usually out-dated, processing and distribution activities. The question thus is one of alternative opportunity. With the strong demand for farm products that has prevailed in the last decade, most farmers have benefited from the tendency of the marketing system to take over tasks once done on farms. No doubt some farmers have been unable to shift their resources successfully and have lost rather than gained. If the demand for farm products should weaken materially, and if job opportunities off the farm should contract, some farmers would be disadvantaged by the loss of their former processing and distribution functions and might find it very difficult to get them back again from the marketing system.

The Fundamental Relationship

Marketing technology has not been the most important factor influencing returns to farmers, yet without it production efficiency of farmers and buying power of consumers could not have behaved as they have done. If marketing technology had stood still during the last two decades while farm output increased, farm prices and incomes would have been considerably lower than they are today. The actual course of farm prices has been influenced by increasing efficiencies both in marketing and in farm production; and the longer-run trend of incomes per farm, or per worker on farms, has been influenced by the trend of incomes in alternative pursuits. The extent to which the gains from technological advances in food marketing have been passed back to farmers is difficult to measure. But this is a separate question, subsidiary to the basic fact that there have been gains to share.

CHAPTER 8

Some Effects of Technology upon Consumers

The last 20 years have brought many changes in the ways in which people are fed. The nutritional value of the Nation's food supply has improved. A greater variety is available on a year-round basis. Foods are offered in different forms, many of which require less time or effort in preparation in the home. Shopping habits have been greatly altered by changes in store organization, by the use of the automobile, and by wider ownership of mechanical home refrigerators and introduction of home-size freezers.

This chapter summarizes the effect of technological developments in the processing and distribution of food on the end product—the food served on family tables. Although gains in technology helped bring about nearly all of the changes to some extent, they were not the only influence at work, and in many instances not even the major influence. Merely to mention the other broad economic and social forces that are important in shaping the total pattern of food use shows that no precise determination of the impact of technology can be made. For the increase in real income of the population from 1930 to 1950, with accompanying increased employment, especially of women, and shift to city ways of living, also have influenced the kinds, amounts, and forms in which food is consumed. Tastes change for other reasons, too. Wider knowledge and concern with nutrition have stimulated some shifts in food habits and have provided good reception for technological innovations that improved the nutritive quality of food. And at the base of the improvements of diets has been the greater volume and higher quality of farm foods mainly as a result of advances in the technology of agricultural production.

Far-Reaching Effects of Higher Purchasing Power

The greatest single reason for the changes in food consumption in the United States between 1930 and 1950 is the fact that the average family had more money to spend for food. Consumers' income (after payment of taxes) was nearly three times as large in 1950 as in 1930—$204.3 billion as compared with $73.7 billion. Prices rose sharply during the 20 years, but the gains in income were even greater. In terms of 1950 dollars, the national average income per person was $857 in 1930 and $1,339 in 1950. Also, income was more evenly distributed among families in 1950 than in 1930,[19] so that the proportion of low-income families was far smaller.

Food prices have risen somewhat more than the average of other retail prices, but not so much as consumers' incomes. The average family, therefore, bought more food, or more costly kinds of food, in 1950 than it did 20 years earlier. Average annual per capita expenditures for food (both expressed in 1950 food dollars to compensate for the change in the buying power of the dollar for food) were $235 in 1930 and $346 in 1950.

This increase in power to buy food has had double-barreled consequences. In itself it has been the principal reason for the large increase in consumption of such foods as milk, meat, and many fruits and vegetables. At the same time, higher purchasing power has stimulated the advance in food technology. With more money to spend, many families were in the mood to expand their food purchases, a circumstance which heightened their interest in new products and helped overcome resistance to the comparatively high prices that often prevail when a new product is first offered commercially.

Increased income has been, in part, the product of increased employment. Not only was there less unemployment in 1950 than during the 1930's, but women and other family members were more likely to have paid employment outside the home. Employees in domestic service, although never numerous, are less frequent than before. Thus a shifting of food processing from home to processor matched the loss of workers in the home. Shifts of population from farms to cities took place. Fixed habits of home processing of foods were thus more easily broken. No attempt can be made here to describe all of these influences in detail, although they have probably done more to change food

[19] See ch. 1, table 2.

habits than the technological advances with which this report is concerned. These general changes must be kept in mind in assessing the impact of technological innovations on consumption because they have provided a favorable climate for consumer acceptance of new foods, foods in new forms, and foods with added services.

The increase in food sold through restaurants and other institutions illustrates the interaction of several forces in changing the way in which foods are used. Higher incomes, a larger share of the population employed, population shifts, and a nutrition-conscious public aware of the values of the school lunch and in-plant feeding in industry, explain the increase in food eaten away from home.

Improvements in Diet Quality

Many of the recent advances in food-marketing technology have contributed in large or small degree to improvement in the nutritional value of average diets and to greater variety and attractiveness of meals.

Changes Contributing to Better Nutrition

The national food supply provides more of the elements essential to good nutrition than it did two decades ago. Although greater, more widely distributed purchasing power is the chief reason for this, improved food technology has been an important factor in the gain. In 1950, our food provided about 15 percent more vitamin A value, about 20 percent more calcium, iron, and ascorbic acid; and about 25 percent more thiamine, riboflavin, and niacin per person than in 1930 (table 19).

These improvements have brought substantial progress toward the national goal of adequate diets for everyone. In 1948, almost three-fourths of the urban families had diets that met recommended levels of the National Research Council for content of calcium—one of the essential minerals; in 1936, only about one family in three met this level. Diets of about 80 percent of the families met recommended levels of ascorbic acid (vitamin C) in the later year compared with only 40 percent earlier. Great improvement was shown also with respect to the content of the three B-vitamins (thiamine, riboflavin, and niacin), or vitamin A, iron, and protein (*55*).

Technology increased the availability of vitamin C through citrus fruit and tomato juice. Improvements in processing not only increased retention of vitamins, particularly vitamin C, but also lessened changes in the flavor of the product and this promoted its acceptance. Almost twice as much citrus fruit in various forms was consumed in 1950 as in 1930. This was due in large part to availability of canned and frozen citrus juices, which were little used 20 years ago. By 1950, the yearly consumption of citrus juices approximated 14 pounds a person. The canned juices are more generally available throughout the year than is the fresh fruit. Furthermore, they tend to be a cheaper source of vitamin C on a year-round basis, and therefore more within the reach of lower-income groups.

Canned tomato juice, little used in 1930, had, by 1950, become so popular that consumption for the year averaged about 4.9 pounds a person (including tomato-juice cocktails and vegetable-juice mixtures that contained 70 percent or more tomato juice) (*63, p. 81; 64, p. 24*).

TABLE 19.—*Average quantity of nutrients per person per day in the national food supply, 1930 to 1950*

Nutrients	Unit	Quantity		Percentage change from 1930 to 1950
		1930	1950	
Calories	Number	3,470	3,280	−5
Protein	Grams	92	95	3
Calcium	do	.90	1.06	18
Iron	Milligrams	13.6	16.5	21
Vitamin A	International Units	7,500	8,700	16
Thiamine	Milligrams	1.53	1.92	25
Riboflavin	do	1.85	2.34	26
Niacin	do	15.4	19.0	23
Ascorbic acid	do	100	120	20

Supplement for 1949 to the CONSUMPTION OF FOOD IN THE UNITED STATES, 1909–48 (*65, table 39, p. 18*) and NATIONAL FOOD SITUATION (*64, p. 6*), January-March, 1952.

Diets also have been improved by greater use of green, leafy, and yellow vegetables. In 1950, average consumption of these foods was 117 pounds a person compared with 88 in 1930. Better ways of storing and shipping the fresh vegetables and freezing provide an assortment from which to choose in winter as well as summer. Better arrangements for the sale of fresh produce in retail stores have helped to keep them fresh and crisp. The increase in average consumption per person is especially striking in view of the increase in total population.

The greater quantities of calcium and riboflavin in the national diet come in large part from greater consumption of milk and milk products (other than but-

ter). In 1930, average consumption was the equivalent of 206 quarts per person per year; in 1950, it had increased by one-fourth, or 255 quarts. Of equal, if not greater significance, was increased use of milk by groups whose diets needed the most improvement. Increased purchasing power probably was the chief reason for this change, as well as for the general rise in milk consumption. However, improved technology has been a large factor in the greater availability of dried skim milk, especially for institutional use, which has helped many low-income families to obtain diets more adequate in calcium. Consumption of the less expensive evaporated and dried milks has increased. Other gains in technology have helped the marketing system keep pace with the rising volume of consumption.

Consumers ate almost twice as much ice cream in 1950 as in 1930, 16.1 pounds a person compared with 9.1 pounds. Improved refrigeration made ice cream more widely available in retail food stores. More widespread ownership of mechanical refrigerators enabled more households to keep it on hand, ready to serve.

Most people in this country prefer foods in refined forms, even though the refined product may be less nutritious. While it could be said that technological innovations are, in part, responsible because they have provided increasingly for refined foods, there are some that have helped to meet popular demand without sacrificing nutritional values. Converted rice is an example. Made by a process of steeping rice in water so that water-soluble vitamins penetrate the grain, it has three times as much thiamine and more than twice as much niacin as white milled rice.

Effects of Enrichment and Fortification

Many families still cannot afford an adequate diet. Still other families, who can apparently afford to eat well, do not have good diets because of ignorance of nutritional needs or a tendency to cling to faulty eating habits. Enrichment of bread and fortification of some other foods have done much to improve the diets of both groups. Scientific research in nutrition showed deficiencies in diets and the possibility of remedying some of them by enrichment and fortification practices; processing technology provided a method of putting such practices into effect; and popular interest in nutrition provided a basis for their wide acceptance.

Enrichment of white bread and flour has meant increases in the iron, thiamine, riboflavin, and niacin in the national food supply, with little or no added cost to consumers. Bread is an important item in the meals of practically all consumers, but low-income families rely upon it more than do the well-to-do because it is one of the less expensive foods. The enrichment program, therefore, has done more to raise the dietary levels of the low-income families than of other families. Diets of urban families in the lower-income class in 1948 had 14 percent more iron because of enrichment of flour and bread than they would have had without it; in the higher-income class the increase in iron was 10 percent, because of the smaller bread consumption and the larger initial iron content from more eggs, meat, fruits, and vegetables than were included in low-income diets. Similarly, increases in the B vitamins were greater for the lower-income group (table 20).

TABLE 20.—*Percentage increase in diets of urban families, because of enrichment of bread and flour, by nutrients and income levels, 1948*

Nutrient	Income-dollars		
	All families	1,000–1,999	5,000–7,499
	Percent	*Percent*	*Percent*
Iron	12	14	10
Thiamine	16	20	13
Riboflavin	3	5	2
Niacin	13	15	9

United States Bureau of Human Nutrition and Home Economics. RURAL FAMILY LIVING CHARTS (*70, p. 37*).

Many breakfast cereals also are fortified by manufacturers. Practically all margarine is fortified by the addition of vitamin A. As margarine is commonly sold at a price below that of butter, its fortification has tended to increase the vitamin A content of lower-cost diets.

New Forms of Food: More Varied Diets

American meals are more varied and interesting than they were 20 years ago. The variety comes principally from new forms and combinations of old stand-bys; soybeans and their products are among the few real newcomers since 1930. Winter meals now resemble those of summer. Improvements in technology have lengthened the season for fresh vegetables; some are to be had the year around. Many fresh fruits also are in the markets for more of the year. When fresh fruits and vegetables are out of season, more of them can be bought in frozen form. A low-income family can vary its winter breakfast fruit by adding canned citrus juices—less expensive than fresh—to the dried fruits and apples that were once its mainstays. Through advances in freezing technology, fish now can be had

every day in the year, even in inland areas. Shortenings and salad oil from soybeans, cottonseed, peanuts, and other sources have been deodorized and otherwise improved.

Other great increases in the variety of family meals have come through the added convenience of many of the new forms of food. Dishes that used to be prepared infrequently because of the time and trouble they took, now can be served as frequently as the family taste dictates. Satisfactory premixes for cakes and pies have been widely available since technologists found ways to prevent rancidity of fats in them so that they could be packaged and distributed without refrigeration. Families who like variety in fresh baked goods can buy dough for biscuits and rolls, kept under refrigeration and ready for baking. Special ready-to-heat canned foods for babies that were just coming on the market in 1930 have become widely available. Annual consumption of baby foods went from an average in 1935 of 2.1 pounds per child under 3 years old to an average of 48.1 pounds in 1950 (*63, p. 169*).

Some Adverse Effects and Missed Opportunities

The net effect of technology in the processing and distribution of food has been to improve the quality of the national supply. There have been reverses along with the gains. Methods that are effective in enhancing one quality may lower other desirable qualities. In some instances the over-all results are not serious. For example, sulfur dioxide, while effective in preserving the color and flavor of dried fruit and in promoting retention of vitamins A and C, also causes considerable destruction of thiamine (*60*). As fruits are not usually an important source of thiamine in the diet, this particular circumstance is of small significance. But a few of the other new techniques designed to improve the texture or appearance of a product may at the same time seriously impair nutritional values. Some technological developments may even be prejudicial to human health. A few years ago, for instance, nitrogen trichloride (Agene) was among the agents used in bleaching flour. Its use was discontinued when tests disclosed that flour treated with nitrogen trichloride was toxic to dogs and some other animals. Even though limited experiments had disclosed no adverse effect on human beings, nitrogen trichloride in 1949 was omitted from the optional ingredients of flour prescribed by the Food and Drug Administration (*80*). In the search for an alternative to sulfur dioxide as a fruit preservative, a process using thiourea was developed. This method seemed satisfactory until it was discovered that the substance had adverse effects on the functioning of the human thyroid.

The number of such cases, together with those in which the consumer is likely to be misled rather than actively injured, is small compared with the number of clear-cut improvements in food quality brought about by technology, but the consequences could be disproportionately great. The increased complexity and larger scale of food processing and distribution have reduced the housewife's ability to judge for herself when she buys in the retail store and have consequently placed an added responsibility on the food-marketing system, as well as on the Federal Food and Drug Administration and the State regulatory agencies concerned with food.

There may have been times when possibilities of technological benefits to food consumers were not exploited fully, or perhaps were missed entirely. Results of the bread and flour enrichment program suggest that more could be done toward improving the nutritive value of processed foods on a commercial scale. Use of increased amounts of dried milk solids in making bread is technically feasible and nutritionally desirable.

Such situations are generally caused either by unwillingness of business concerns to risk the marketing of a new product or by consumers' apathy to those improved but unfamiliar products that are put on the market. Often both these factors operate together to prevent further gains from technology. All of the significant improvements that have come into wide use represent a three-way combination: The technologist devises the new method, the businessman decides it has a good chance of returning a profit, and the consumer buys it because she feels it is more nutritious, tastes better, or is more convenient.

Less Kitchen Work for Homemakers

Many of the technological developments in food marketing have had the effect of transferring tasks to the processor or distributor that used to be performed in the kitchen. Twenty years ago preparation of the foods brought into the home required more time, effort, and skill on the part of the housewife. The making of cakes and pies called for patient care, soup was more often made at home, preparation of food for babies called for much extra cooking, straining, and mashing. Even the least complicated dishes were not necessarily easy to prepare; a number of them required long soaking and long cooking, fresh vegetables had to be washed and trimmed, oranges for juice had to be squeezed.

Moreover, unless the homemaker was something of a culinary artist, or could afford the services of a cook who was, the results of all the time and labor often were far from perfect.

By 1950 the picture had changed considerably. Some of the preparation was already done when the shopper brought the food home from the store. A number of frozen and canned products were precooked and required only warming; others were ready to put on the stove and required only brief cooking. The canning, baking, and preserving that still are done in many homes are performed there largely because the family prefers the home-made product or because the housewife finds it advantageous to spend her time in those ways. Commercial processors have by no means taken over the whole job of food preparation, but it is clear that advances in technology have greatly reduced the amount of kitchen work that homemakers must do.

Modern food parcels often include dividends of skill as well as time. Many young married women are not the experienced cooks their mothers were. Some of them chose to work in factories or offices rather than to learn to cook by helping their elders. In many communities the prestige of being a good cook is smaller than it used to be. Thus the fact that a number of traditional kitchen operations have been transferred to processors could, in some homes, mean better meals than if they were prepared from the beginning.

One measure of the extent to which preparation of food has been shifted from the home to the commercial marketing system is the nature of consumers' purchases. In 1948 more than a fourth (26.5 percent) of the food expenditures of urban housekeeping families (two or more persons) were going for bread and other baked goods and ready-to-serve breakfast cereals, for cooked and canned meats, poultry, and fish, for canned and frozen vegetables, fruits and juices, for jams and marmalades, soups, and other partially prepared foods. This percentage differed little from one income level to another (table 21).

A study of purchases of bakery goods by households in Birmingham, Ala., offers a time comparison to illustrate this "out-of-the-kitchen" trend (68). There, in 1935, purchases of white bread by wage-earner families averaged 0.82 pound a person a week; in 1948, they were about half again as great. These increased purchases of bread were accompanied by decreased

TABLE 21.—*Percentage of total food budget used for specified purchased partially prepared foods, housekeeping families of 2 or more persons in urban United States, spring 1948 and four cities, winter 1948*

Item	Total [1]	Bread, baked goods, mixes, cereals	Meat, poultry, fish	Vegetables, fruits, juices—canned and frozen	Sugar and sweets	Soups, prepared or partially prepared dishes	All others
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Urban, spring 1948 income:							
Under $1,000	22.9	8.3	5.8	4.0	1.3	1.1	2.4
$1,000 – $1,999	25.2	8.8	5.9	4.4	1.7	1.3	3.1
$2,000 – $2,999	27.8	8.7	7.4	5.0	1.9	1.5	3.3
$3,000 – $3,999	28.5	8.5	7.3	4.9	2.4	1.6	3.8
$4,000 – $4,999	26.4	8.0	6.0	5.3	2.3	1.3	3.5
$5,000 – $7,499	25.3	7.4	6.2	5.0	1.9	1.3	3.5
$7,500 and over	22.4	6.7	4.9	4.8	1.8	.9	3.3
Not classified	26.4	7.6	6.4	5.2	2.3	1.4	3.5
All	26.5	8.2	6.6	4.9	2.0	1.4	3.4
Four cities, winter 1948, all incomes:							
Birmingham	26.6	6.9	3.9	9.5	1.7	1.7	2.9
Buffalo	30.9	9.3	8.2	5.6	2.9	1.7	3.2
Minneapolis, St. Paul	28.2	8.4	6.3	6.2	2.2	1.8	3.3
San Francisco	24.1	7.4	4.6	5.4	2.0	1.7	3.0

[1] Includes prepared flour mix, ready-to-eat cereals, ready-cooked pastes, bread, other baked goods; meat, poultry, fish—cooked, canned, bologna, other; frozen fruits and vegetables, canned fruits, vegetables, and juices; jellies, jams, preserves, candy, prepared desserts; soups, prepared or partially prepared dishes; pickles, olives, catsup, chili sauce, mayonnaise, French dressing, salad dressing, ice cream.

FOOD CONSUMPTION OF URBAN FAMILIES IN THE UNITED STATES (*67*), *and* FAMILY FOOD CONSUMPTION IN BIRMINGHAM, ALABAMA—MINNEAPOLIS, ST. PAUL, MINNESOTA—SAN FRANCISCO, CALIFORNIA—BUFFALO, NEW YORK (*69*).

purchases of flour—a fall from 2.05 pounds a person a week to 1.32 pounds—indicating less home baking. Quantities of cake, pie, and cookies bought rose more than threefold. Soup-making also seemed to be on its way out of the home in Birmingham. Purchases of canned soup were more than three times as great in 1948 as in 1935.

This tendency to buy increased amounts of partially processed, time-saving food is found among rural as well as urban households. Nearly all of a group of Kansas farm families studied were found to be using store bread in 1949, whereas the proportion found in 1936 was only two-thirds (table 22). The average quantity used per person had increased nearly one-third.

TABLE 22.—*Percentage of farm families purchasing and average quantity used per person per week, specified products, Kansas, 1936 and 1949*

Product	Percentage of families using		Average quantity used per person	
	1936	1949	1936	1949
	Percent	*Percent*	*Pounds*	*Pounds*
Bread	67	94	1.11	1.45
Packaged desserts	4	53	.01	.08
Ice cream	14	43	.10	.26
Canned fruit juice	2	39	.01	.45

Selected family types in four counties. Unpublished data of U. S. Bureau of Human Nutrition and Home Economics.

Technological developments in food marketing have had a profound effect on American family life. Feeding the family, in all its phases from caring for and preparing food to washing the dishes amounts to roughly one-third of the homemaking job in cities and even more on farms. Thus any reduction in the time required for kitchen work means in most instances an appreciable lightening of the total task of housekeeping. Also improved technology has, in general, tended to reduce the work involved in other phases of homemaking. Most women with families to take care of have more time for other things than they had in 1930. One aspect of this change can be seen in the fact that between 1930 and 1949, even though the number of domestic workers fell from 65 to 40 per thousand households, the proportion of married women in the labor force rose from 12 to 24 percent.

As with most aspects of the impact of technology on modern society, it is difficult to disentangle cause and effect. At least part of the increase in the percentage of married women with outside jobs can be attributed directly to the extent to which improved food technology has lightened their homemaking tasks. It is equally clear that the general expansion in business activity created many of the extra jobs that drew women from their homes, and that some families whose incomes have not kept pace with rising prices found it imperative to have another wage earner. These latter circumstances in turn have increased the demand for the products of technology that bring additional shortcuts in homemaking.

Probably the greater proportion of the housewife's time rescued from kitchen chores has gone into activities other than wage earning. Women, by and large, have more hours to devote to civic or cultural activities, recreation, and to the kinds of homemaking tasks that they enjoy. They have more time to take part in the pursuits and diversions of the family as a whole. These changes, which are more difficult to measure statistically than time shifted to gainful employment, in the long run may prove the more important in terms of national health and happiness.

Changes in Food Shopping Habits

Developments in food technology during the last 20 years have brought many changes in the way consumers shop for food. These changes are as contradictory as they are striking. The spread of self-service and the decline of retail deliveries mean that consumers are getting less service, but the fact that the processor or distributor has brought so many products nearer to readiness for eating means that consumers are getting more service of another kind.

The wide range of foods carried by many modern retail stores, and the accessible arrangement of foods in retail stores enable shoppers to read labels and compare similar items; this, plus the variety carried in many modern stores, makes for a wider range of choice by consumers. The fact that so many items, including some fresh fruits and vegetables, are displayed tightly wrapped and packaged gives the shopper less opportunity to sort, examine, and choose. To enable the consumer to buy intelligently in this new type of retail food market, characterized by self-service and packaging of food, more informative labeling is needed.

An informative label for a food should enable the consumer to select from the many packaged products confronting her the one best suited to her specific purpose, and representing the best value for the money she spends. It should, therefore, tell not only what is

inside the package—the information about ingredients required by law—but also, for most products, should indicate level of goodness. Without knowing the quality inside the package, the consumer has no basis for judging value for a price. Official grades provide a standardized method of describing quality and enable producers, retailers, and consumers to speak a common language.

Grade identification of food sold at retail has increased somewhat since 1930, but in 1952 it was still on a narrow basis. Only a small proportion of the products for which official grades are available are offered at retail under grade labels. Sale by grade probably is more general for eggs than for any other food; in some States their grading for retail sale has been made mandatory. Better informative labeling of foodstuffs, especially of canned goods, makes it easier for housewives to buy proper amounts of food and to plan meals. More than ever before, labels now include such facts as additional measure of quantity, the number of halves of peaches in a can; the size of the product, as the size of peas or olives, sometimes shown by a picture and/or official size class; the approximate measure of drained product in cups, in addition to the weight which is required.

On balance, the average family can buy its food with more convenience than formerly, although some groups may find themselves less well-served. The reduction in credit, delivery, and clerking services offered by most stores seems in the main a popular development, accompanied as it is by the feeling that the curtailment of these retailing services represents either savings through lower prices or additions in quality or in kitchen services.

Except for delivery of orders, which in most communities still can be had from stores specializing in that service, the emerging pattern of food retailing saves shoppers' time. Under nearly all circumstances self-service is faster than counter service.

Technology and Retail Food Costs

The capacity of family budgets to cover family food requirements has increased in the last two decades. The Nation's total food supply provides greater nutritional values than formerly; the average family can buy more nutrition for a given percentage of its income than in 1930. Advances in the technology of processing and distributing food have contributed to this improvement, but their effects upon all consumers cannot be measured in terms of dollars and cents. The effects of increased purchasing power and of the increased productivity of agriculture have overshadowed all other influences. Also the national pattern of living has changed greatly. Nevertheless, as with the impact of marketing technology upon farmers' returns, there is a basis for some broad judgments as to how food technology has affected the retail cost of food.

Where the marketing system has changed the form of the product or added related services, statistical comparison of the gains to consumers over time is not possible. In attempting even a judgment as to the general effect the addition of services may have on the consumer's pocketbook, it is necessary to make certain which of the newly instituted services are net additions. Transfer to the marketing system of functions formerly performed on farms does not affect the consumer unless the cost of the services themselves has changed. Other services have merely been shifted from one stage of the marketing process to another; many of these changes have tended to reduce total costs rather than increase them. For instance, flour and sugar usually can be weighed and put into consumer-size packages more cheaply and with less waste by the processor than by the retailer at the time of sale; for some other foods part or all of the extra cost of prepackaging is offset by economies in shipping and reduction of losses from deterioration.

It is the marketing services that were formerly performed by the consumer, or that never were performed by anyone, that tend to add to retail prices. There are many new services of this kind—premixing of special flours, baking and packaging of cakes and cookies, preparation by the processor of baby foods, soups, stews, and other mixed foods, wrapping of butter in quarter-pound sticks or smaller units, packaging vegetables partially prepared, and slicing of bread are only a few. In accepting and paying for these services, consumers are trading some additional money for time or skill. The popularity of the new foods that embody the extra services indicates that many families welcome such an exchange and find it advantageous. In times of national emergency, when a maximum labor force is needed, developments that free homemakers for work in industry can contribute significantly to maintaining high production. But there are some drawbacks that may be especially serious for certain groups. Many low-income families have more time than money; if they do not get the maximum in nutrients from each dollar spent for food, the tendency to turn kitchen work over to industry will hinder rather than promote higher dietary levels. The nub of this problem is whether the retail food shopper has a free choice of paying more

for extra services or paying less for products that represent a minimum of services and of luxury qualities over and above nutritional values.

The spread of packaging in consumer sizes has made it possible for an increasing number of foods to preserve their brand identity all the way to the retail grocer's shelf. Through advertising and maintenance of fine points of high quality, the manufacturer can hope to some extent to remove his product from price competition. A producer of packaged prunes, for instance, may package only fruit of large or medium size. If a retail store carries only packaged prunes there is a chance it will not stock any of the smaller cheaper sizes that help stretch food budgets. At present, most communities include retail food stores that stress cheapness of all or certain items as well as stores that emphasize added quality or services. The very prevalence of self-service gives consumers more opportunity than they had 20 years ago to choose between buying or not buying certain services.

But exercising a choice frequently means that a food shopper must visit more than one store; often this is difficult because of the growing distance between homes and stores and the spreading pattern of one-stop shopping. Also, some recently added services have become so nearly universal that it is difficult to avoid buying them. Although such widely adopted services have added little to total costs, the tendency toward narrowing the consumer's ability to accept or reject new services may be a significant trend.

Technology in Food Marketing

CHAPTER 9

Developments on the Horizon

The boundaries of technology are continually being pushed ahead. Every year methods of processing and distributing food, that may themselves have been new quite recently, are shunted aside for newer and better. methods. Sometimes the advance takes the form of entirely new products or of products so greatly improved that they seem new to consumers. Other changes are less apparent, although their effect on marketing costs or on the nutritional value of the product may be equally great. As yet there is no hint of any ultimate limit to the march of technology; indeed, continual progress along that line seems to be one of the characteristics of our modern Western civilization.

Technological developments mentioned thus far in this report are those which have had at least limited commercial acceptance. In this chapter some of the possible techniques and products of tomorrow are briefly reviewed. As only a few of the thousands of current research enterprises can even be listed in a report of this size, discussion is confined to research looking toward innovations that already have shown promise at the laboratory or pilot plant stage and that would have considerable economic significance if adopted on a commercial scale. This is a rigidly selective basis, which excludes at the outset the great volume of fundamental scientific research that will set in motion specific research projects of the future, and excludes also the constant scientific review of present methods that leads every day to improvements in quality and reductions in cost.

Even in presenting a small selected group of possibilities, further reservations should be clearly set forth. The road from the research laboratory to commercial adoption is long and hazardous. Many promising ideas never emerge from the laboratory; others die in the pilot plant. The percentage of survivals is small. Economic changes as well as physical difficulties take their toll. Often a sound new method is outdated before it is hatched. It is almost inevitable that a number of the ideas listed here will never be widely used commercially and that others, whose promise does not now appear so great, will prove of great commercial importance.

Research in food marketing undertaken by Federal and State agencies, privately endowed foundations, and the food industry, covers all areas of the field, from processing to retailing. In the main, however, it is the research on new processing methods that is most readily identifiable by separate projects. Many of the important developments in distribution technique are conceived and tested on a less formal basis. Often the changes grow out of developments in processing technology that change the form of a product. Further, although the potential gains from research and the promise of current research are large in the field of food distribution, it frequently happens that the cumulative effect, rather than the individual efforts, are the more significant.

Promising Research in Processing [20]

Although it may never be possible to make preserved foods taste exactly like the fresh product—in fact, this may not be always desirable—and to offer them at prices no higher than those of the fresh foods in season, progress toward these ends already has been great and further advances are in prospect.

Antibiotics

Laboratory investigations are being conducted on the use of antibiotics in food preservation, particularly in canning. Antibiotics are substances synthesized by some plants and micro-organisms, which in extremely dilute solutions are able to inhibit the growth of micro-organisms. The best-known antibiotic and the first used in medicine is penicillin. One of the antibiotics used experimentally in the canning of certain nonacid foods is subtilin, which is produced in cultures of a particular strain of *Bacillus subtilis*. In concentrations of only a few parts per million, subtilin has been found to inhibit the growth of some food-contaminating

[20] Nearly all of the examples of research in processing are based on work summarized in Research and Related Services in the United States Department of Agriculture (61). Much work along similar lines has, of course, been carried out by non-Government institutions and by private industry.

micro-organisms. In the presence of minute quantities of subtilin, along with a mild heat treatment of the canned food, it has been found possible to preserve laboratory-canned uninoculated vegetables such as corn, broccoli, cauliflower, and brussels sprouts. The canned product was superior in taste and appearance to the product processed by conventional canning methods. Some of the more delicate vegetables, in fact, are not often canned by ordinary processes because the extreme heat required makes them mushy.

The new method is not certain even in the laboratory. There have been failures, and considerable adverse opinion of late, but the results are promising enough to warrant further research. Should the method be successful, it would decrease processing and investment costs, and yield products more like the fresh commodity than present canned foods.

Sterilization by Electronics and Related Methods

Ways of preserving foods without the disadvantages of the conventional high-temperature cooking are the aim of research into the effects of electrical impulses upon biological materials.

In one line of investigation of the possibilities of cathode rays, foods of many kinds have been subjected to the penetration of high-energy electrons. Electrons can kill micro-organisms and insects by a quick, almost heatless process, yet even very energetic electrons can penetrate contaminated material only a short distance to do such killing. Several types of food, both cooked and uncooked, have been preserved on a limited laboratory scale for weeks or months. Much more research is needed, both from the economic standpoint and from the standpoint of quality of the product, possible harmful residues, change in constituents of foods that may affect their nutritional value, and public health implications of foods so treated.

Similar inquiries are being made into the possible usefulness in food processing of gamma rays emitted by radioactive byproducts of plutonium manufacture.

Considerable work is being done on the possibilities of dielectric heating in food processing. This method consists primarily of placing the material to be treated in a strong electric field and subjecting it to the effects of an alternating voltage that stresses the molecules, first in one direction, then in the other. With a homogeneous material this results in a rapid, even, and controllable spread of heat. This method already is in commercial use in some nonfood industries and for sterilizing feed bags. The food uses now being investigated are the drying and conditioning of rice, wheat, and corn, but the possibilities of inactivating micro-organisms and enzymes are also under investigation. The application of dielectric heating has also been used in a limited way for defrosting frozen foods.

Research into the food-processing possibilities of ultrasonics is under way. This branch of science, as its name implies, concerns sound radiation above the range that can be heard by the normal human ear. Strictly speaking, ultrasonics is a mechanical rather than an electronic method, as the electrical impulses are transformed into sound waves. It has been established on a laboratory scale that ultrasonic waves of certain frequencies will destroy rodents and insects and may be useful in controlling bacteria, sterilizing or pasteurizing milk and other foods, and homogenizing milk.

Dehydration and Dehydrofreezing

Dehydration offers many possibilities of reducing costs of packaging, transporting, and storing foods, yet for most foods the technique has not yet been brought to a point at which taste and other quality factors will satisfy consumers. On the other hand, most frozen foods, although acceptable as to taste, are comparatively expensive to transport and store. Much research has gone into a new method of preserving fruits and vegetables, called dehydrofreezing, which gives promise of reducing marketing costs while maintaining quality. By this process the product is partially dehydrated to a degree that materially reduces weight and volume, yet allows the product to be reconstituted without loss of quality. Good results have been obtained for apples, apricots, prunes, and peaches, and preliminary work has been done with red sour cherries. Among the vegetables, most progress has been made with peas, although it appears that the process is applicable to a number of other vegetables.

A possibility of improving the dehydration process proper is offered by experiments with infra-red heating under a high vacuum. This method, which is still in the early laboratory stage, is designed to dehydrate foods sensitive to heat with a minimum loss of flavor and nutrient value.

Successful dehydrated fig and prune powders have been made experimentally. These could be incorporated in baked goods and breakfast foods if commercially feasible; and fig powders would prove convenient for use in making soft fillings for fruit bars and other pastries of this nature.

Recent experiments of the Bureau of Agricultural and Industrial Chemistry and other research organizations have shown that addition of an inert desiccant to

packages of dehydrated food has been useful in further decreasing the moisture content of the packaged material.

Preservation of Milk for Fluid Consumption

Practicable commercial methods of preserving milk in its fluid form have been sought for many years. As noted earlier, commercial production and distribution of concentrated fluid milk already has begun. Meanwhile, recent gains in research indicate further progress toward acceptable forms of canned milk and frozen concentrated milk. Recent experiments with canned fluid milk appear to have gone further than any previous ones in eliminating the cooked flavor that has been associated with the experimental product. Toward the close of 1950, the Bureau of Dairy Industry of the United States Department of Agriculture reported that its investigations indicated the possibility of producing frozen concentrated milk that could be reconstituted into an acceptable beverage after several months in frozen storage. By the middle of 1951, production of such a frozen product on a commercial scale was reported (*16*).

Preservation of concentrated fluid milk on a commercial scale would be of particular importance to consumers situated far from areas of production and to the producing areas themselves in times of seasonal surplus production. There is a further possibility that if production costs could be held sufficiently low, the frozen concentrate might compete with dry skim milk as a product for cooking purposes. Of even more widespread implications, is the possibility that such a method may renew the comparative cost advantage of the traditional dairy areas, should freight rates not prove prohibitive. In fact, development of large-scale methods of concentrating or freezing milk would have a great impact on the whole marketing system for fluid milk. Frequency and methods of home deliveries might be affected. Sale through retail stores or vending machines might make further gains in relation to home delivery. The whole structure of fluid milk prices under present marketing agreements might come up for re-examination.

Preservation of Eggs

Considerable research has been conducted to find a sealing agent to preserve shell eggs stored at room temperatures. Experiments have been made with waxes and such plastics as polystyrene and chlorinated rubber along with a plasticizer. Preliminary tests on a small laboratory scale indicate that plastic-coated eggs show little structural or chemical deterioration after being held 10 days at low humidity and at a temperature of 99.5° F. Plastic coating of infertile eggs aims at making possible their transportation without refrigeration.

Thermostabilized eggs are being investigated on a pilot-plant scale. Thermostabilization consists of heating shell eggs in a bath of oil or water, preferably the former. This treatment retards thinning of the egg white and thereby increases the resistance of the eggs to normal storage deterioration. A successful commercial thermostabilization process would permit removal from storage of more high-quality eggs and there would be smaller losses.

Dried whole eggs already are a commercially important food product; their relatively poor keeping qualities have stood in the way of much wider use. Recent research has established the fact that one of the leading causes of deterioration is the chemical reaction between the sugars and proteins in the egg. The sugars, or glucose, represent only 0.3 percent of the entire contents of an egg, and a method of removing the sugars through fermentation without altering the other constituents has been found. Tests indicate that the shelf life of the glucose-free eggs is four to six times that of ordinary dried eggs. The practicability of the process has been tested on a commercial scale, with favorable results.

Attempts are being made to preserve shell eggs by freezing. In freezing shell eggs, the white of the egg freezes first and creates a solid wall around the yolk, so that when the latter freezes there is no room for expansion and the egg cracks. In the experimental process shell eggs are frozen under a vacuum, on the theory that the yolk then freezes first and pushes the white toward the shell so that all the room available in the air space is used during expansion of the white. This allows better utilization of the space available within the egg. The tendency of the yolk to become rubbery during freezing storage remains a problem.

Recovery of Volatile Flavors

Recovery of volatile flavoring constituents from fruit juices has been advanced significantly during the last 5 years, chiefly through gains in engineering techniques. Flavoring constituents from apples and grapes already have reached the market. Those from other fruits such as strawberries, raspberries, tomatoes, boysenberries, blackberries, and citrus are either in pilot-plant or laboratory investigation. The recovered essences are used for flavoring candy, ice cream, beverages, table sirups, or the concentrated juice from which the essences have been stripped. Successful recovery of volatile constituents from fruit juices and adding back

these constituents to the concentrated juice would permit cheaper production of full-flavored concentrated fruit juices. Also, the knowledge of how to change completely the natural flavor of raw material could lead to a whole range of new products and to new ways of marketing old ones.

Improvement of Soybean-Oil Flavor

In recent years soybean oil has come to share with cottonseed oil a position of dominance among all edible oils of domestic origin. Despite the many improvements in the flavor of soybean oil that have resulted from refinements in processing methods, the tendency of soybean oil and its products to develop "off" flavors and odors during storage has remained an obstacle to even wider acceptance than they enjoy at present. Recent research has established the fact that linolenic acid, one of the minor components of soybean oil, is the leading cause of the undesirable reverted flavors. Further research has identified four other components that contribute to off flavors.

Recovering Proteins from Whey

Practical methods of recovering the proteins from cheese whey have been developed; more recently, research workers of the U. S. Department of Agriculture have discovered a process for converting the grainy protein, by action of a proteolytic enzyme, to a product that has been used successfully as an ingredient of cheese spreads. The new method affords an economical means of conserving highly nutritious milk proteins for human consumption, instead of feeding the whey to animals or discarding it. From 4 to 5 pounds of the new product can be obtained from 100 pounds of whey, thus affording a potential maximum production of more than 400 million pounds annually at the 1950 level of cheese manufacture. Because the new product offers considerable promise as an economical and highly nutritious ingredient of cheese spreads and many other foods, it could become an important supplement to the cheese industry.

Synthetic Protein Foods

Synthetic protein foods and feeds are produced commercially by culturing yeast on waste material such as sulfite liquor from pulp mills. The abundance and rapid growth of algae as observed in nature and in fundamental studies on photosynthesis have led to the suggestion of possible large-scale algae culture to supplement the supply of protein and fat. The algae with which most work has been done are *Chlorella pyrenoidosa* and *C. vulgaris*. The chemical composition of *Chlorella* can be altered by changing the environmental conditions under which it is grown. Normal, rapidly growing cells have a protein content of more than 50 percent. By reducing the concentration of fixed nitrogen in the culture medium, cells with a fat content of more than 85 percent have been grown. Although this research is of great potential significance, especially to the food-deficit regions of the world, its immediate practical possibilities in the United States do not appear great. Also, a number of technical difficulties remain to be solved before the algae farm can become a reality. But the fact remains that synthetic protein foods can be produced. Remote as they may be in time, the implications are tremendous in terms of possible substitutions in diet and new patterns of food marketing.

Other Improvements

Hundreds of other new and better ways of processing food are under study in research laboratories or pilot plants. Some are far-reaching and complex, others comparatively simple. Some carry the possibilities of broad economic effects; others have a more limited potential. Among those that seem most worth watching are the following:

A new spray—maleic hydrazide—when applied before harvest apparently arrests the processes of plant decay as well as of growth in root crops, so that fresh vegetables such as onions, potatoes, carrots, beets, and turnips can be stored and shipped in good condition for months after they are harvested. Tests also have yielded good results for sugar beets. The practicability of the method and the possibilities of any harmful effects are being tested, and the experiments are being extended to nonroot crops such as peas and sweet corn (*58*).

A low-temperature, short-time rendering process that has been developed for lard is designed to reduce the chances of undesirable flavors. New information on the temperature at which stabilizers should be added to peanut butter is expected to reduce the separation of oil from meal that so often occurs after the product has been put in containers.

A method of converting refined cottonseed oil into a salad oil in 2 to 4 hours instead of the conventional 5 to 6 days has been tried on a semi-pilot-plant basis with encouraging results.

Research now under way looks toward development of a practicable commercial process of producing an edible pectin film that could be used for packaging certain food products, particularly meats.

New Ways to Cut Processing Costs

Many of the new possibilities already listed should bring about lower processing costs as well as new or better products. Others, however, aim primarily at

reducing costs either through short cuts or through finding profitable uses for byproducts.

Enormous quantities of vegetable wastes—in the neighborhood of 3.5 million tons a year—accumulate in fields and at packing centers. Extensive studies of the chemical composition of these wastes have been followed by using the meals prepared from them in feeding trials. Equipment and methods for making meals from the vegetable wastes have been developed. Procedures also have been developed for extraction, on a commercial scale, of carotene concentrates, a source of vitamin A. These research findings hold promise not only of producing additional income to offset costs of processing vegetables but also of helping to solve the difficult and costly problem of waste disposal.

Pilot-plant studies have been conducted on the recovery and purification of an edible juice from pear-cannery peels and cores. About 80 gallons of juice can be recovered from the peels and cores from 1 ton of pears. This is almost enough to supply the sirup needed to can the pears. Other studies, too, by California fruit canners aided by United States Department of Agriculture research have begun to convert cannery waste into dry meal and molasses used for cattle feed.

Promising Research in Distribution

To a large extent, changes in the distribution of foods come as a result of developments in processing. Thus the prospects for further advances in food processing themselves hold the key to many of the gains that will come about in storage, transportation, wholesaling, and retailing. Nevertheless, a number of forward-looking efforts in the field of distribution can be identified. Singly or in combination they give promise of quicker transit from producer to consumer, better preservation of quality, lower distributing costs, expansion of some markets, and increased services to consumers. Only a few of these lines of activity can be noted here.

Centralized Cutting and Prepackaging of Meat

Enough of a start has been made in the cutting and prepackaging of meat at a central point to indicate that the practice will be widely adopted by chain stores. Such a development would put small independent retailers at a competitive disadvantage except in instances in which an independent wholesaler would find it feasible to set up a central facility to serve independent stores. However, improvements in frozen storage and transportation of meat make it likely that centralized cutting and packaging eventually will move back to the packinghouse, where the meat would be put in consumer-sized packages and shipped in frozen form. If the trend should go that far, the competitive position of the small retailer would not be impaired. Opportunities for making maximum use of byproducts trimmed off in the course of packaging would be greatly enhanced.

Improvement in Wholesaling of Frozen Foods

At present the average wholesaler of frozen foods handles only two or three groups of products. As more foods are frozen and more retail stores sell frozen products, the handling of a wide range of frozen foods by one wholesaler should become more common. Such a development would stimulate the construction of large, well-equipped wholesale plants especially designed for storing and distributing large quantities of many varieties of frozen foods. Increased low-temperature holding and display space in retail stores will enable wholesalers to make larger and less frequent deliveries of frozen foods, thus making for more efficient distribution. Also it is probable that a number of locker plants would branch out into serving retailers and institutions to a much greater extent than they now do, while some locker plants might be converted into holding points for the distribution of foods frozen elsewhere. Wider use of home freezers will tend to stabilize wholesaling and locker-plant operations and to reduce costs of distribution.

Further Specialization in Bakery Products

Prepared mixes were intended originally to provide an easy method of preparing home-baked goods. But a substantial market at the commercial bakery level has developed in recent years. All signs point to this development becoming increasingly important. If it continues, the trend will affect marketing conditions for many products. Instead of selling and distributing such ingredients as flour, sugar, salt, shortening, eggs, spices, and leavening agents to individual bakeries, large blending plants may become the principal purchasers.

Storage

Storage losses of peanuts and rice in the South are believed to be of serious proportions. Extensive studies have been made of the levels at which the moisture content of rice attains equilibrium with air of varying temperature and relative humidity. The results obtained make it possible to pass on to commercial operators information that will enable them to reduce storage and milling losses by methods that take full advantage of prevailing temperatures and humidities. Similar

studies are in process for peanuts. Studies of this kind for onions have yielded data on humidities and temperatures at which the product can be stored for long periods without sprouting or drying out. At the same time, results of experiments in deodorizing the atmosphere point the way toward storage of onions with other products.

Several advances in the insect-proofing of packaging materials appear to be on the way. One of these is a method of treating with an insecticide the warp thread of cotton cloth used in flour bags; on a test basis, bags made of this material protected flour from infestation for many months. Tests with bags of closely woven burlap that had been given insecticidal treatment also gave encouraging results in the storage of grain. Although further improvements are needed before wide commercial use is practicable, the current approach appears to point the way toward large reductions in storage losses of a number of products.

Experience of retailers with meats and poultry has given rise to the idea that perhaps other foods can be allowed to thaw at the time they reach the retail store without suffering deterioration during the limited time before sale. High density, full (essence) flavor concentrated apple juice is among the products on which experiments along these lines have begun. The principle behind the experiments is that while frozen storage is required over long periods, simple refrigeration is sufficient during limited periods, the duration of which can be controlled by dating each can or other container. Products not sold by the expiration date would be removed from the shelves. Wide adoption of this practice would allow retailers to reduce capital and operating expenses by using more of the ordinary refrigeration facilities and less frozen display and storage space.

Transportation

The handful of examples noted below relate to specific improvements contemplated or undergoing test in truck, rail, or air transportation. Important as they are, the individual advances in shipping food are overshadowed by the possibilities of so integrating the transport system that the particular advantages of each medium can be fully utilized. Although such a development lies in the future, its possibilities are recognized by many persons both within and without the railroad and trucking industries. Current developments such as problems of crowded highways and plans for defense against possible aerial attack underline its importance. Long-distance rail routing still follows the pattern of the earlier era in which most of the tracks were laid. Food supplies for New England, for example, pass through the congested rail center of New York City. There is no longer any technical reason why the metropolitan area could not be largely bypassed, with trucks taking over the shipments from the South and West at points far from the present bottleneck.

Meanwhile, a number of more immediate prospects are to be noted in various aspects of transportation.

Some egg handlers have adopted what may prove to be a significant improvement in egg shipment. Eggs are packed at the point of origin in molded pulp, dozen-size cartons. These in turn are placed in larger paperboard cartons and are so designed that they may be packed honeycomb fashion, supporting each other without excessive pressure. The eggs then are shipped by truck to the final point of distribution, where they are placed in refrigerated rooms until they are moved by smaller trucks to retail stores. Breakage has been reported as so small that the usual second handling and candling operations are eliminated.

War-stimulated use of the pallet brought the term "unitized shipment" into prominence. For many products, however, the loaded pallet is still a very small unit. The ideal is a "package" of several tons, easily transferred from factory to truck to train, or even plane, to consignee, without packing and unpacking and without special installations. Two such units have shown value in pilot-stage operations.

One is a truck-train van body—the size of a standard truck-trailer body mounted on retractable wheels. It can be moved about the factory in loading—moved onto a flat-bed truck-trailer, transferred easily to flat-car, easily transferred to another truck, then moved into and out of a warehouse without intermediate unloading. It can be a refrigerated body, using a standard truck refrigerating unit, and can even serve as its own temporary warehouse. If widely adopted, such a unit might to some extent make unnecessary such specialized rail-car equipment as the refrigerator car, and also might facilitate coordination of rail and truck on long-haul shipments. It could cut both the direct costs of materials handling and the loss and damage sustained in multiple loading and unloading operations.

The other development is the "air-pod," a detachable air-cargo compartment which rides with a cargo plane as part of the fuselage, but is dropped and moved away on its own retractable wheels on landing. Although a military development, its possibilities for the future of civilian air transport, including fast movement of some foods, are obvious.

Meanwhile, attempts are being made to improve the present specialized types of railroad equipment. The start that has been made in introducing mechanically refrigerated cars is being followed up with experiments that look toward further improvements. Also, research on better types of boxcars and couplings promises less shock and jar in transit, and thus less loss and damage.

Wholesaling and Retailing

Retailing accounts for the largest single item in the costs of marketing most foods, so that savings through better methods can be of benefit to both consumers and producers. Wholesaling also offers opportunities for significant savings. It is possible here merely to mention two general lines of research that appear to hold special promise.

One of these is the large group of investigations, including comparative cost studies, of the handling operations performed in wholesaling and retailing. With a few outstanding exceptions on the part of firms that use modern methods and equipment, small progress has been made in the way foods are handled after the truck drops them at the warehouse or store platform. The new research holds promise of great improvements in economy and efficiency in the use of the labor force. The other line of research concerns the check-out procedure in self-service retail stores. Limited adoption of new equipment and methods designed to facilitate the check-out was mentioned in the chapter on retailing. Further basic research, and further tests of new methods already devised, are being carried out. Other current studies are concerned with store lay-out and utilization of selling space, displays, and services to shoppers.

Communications

Recent experimental work has shown the practicability of collecting and disseminating market news at the retail stage. Although retail sale is the goal at which the many-sided system of food marketing aims, no comprehensive efforts have been made to include retail food prices and sale in the Federal-State Market News Service. During the latter half of 1949 and throughout 1950, an experiment was conducted in Baltimore as part of the RMA program. Information on retail prices of 125 food items and sales-volume data on 40 items were collected from a representative sample of stores and published weekly.

The sampling technique worked out well in the collection of price information. Housewives who received the reports found them useful, and expanded their purchases of items listed as plentiful and relatively cheap. Most independent retailers reported that the service was helpful. Sampling did not prove so well-adapted to estimating the volume of sales of individual items for a single city, although there were indications that the technique might be used without too much error in making regional or national estimates. Data collected in the course of the experiment indicated that in periods of large supply, retail prices often tended to stay up well after producers' and wholesalers' prices had declined. Addition of retailing information to the Market News Service might, therefore, improve producers' markets during temporary peaks of supply, in addition to assisting housewives in the planning of food purchases and generally contributing to more flexible and realistic price relationships throughout the food-marketing system.

Limited use of television has shown the great possibilities of further breaking down the barriers of time and distance that stand in the way of a smoothly functioning, truly national market for food. Farmers with cattle or other livestock to sell, for instance, should be able to form a better opinion of what their own animals are worth from actually seeing the types and condition of other animals sold at auction than from reading or hearing the most detailed market reports. Consumers should get through television almost as good an idea of what products are available at retail stores and markets as though they visited the places themselves. The coming use of color will enable television to do such an information job even better.

Grading

Technological progress in other lines may enable buyers to make long-distance purchases by grade alone, without even seeing the products on a television screen.

Among many improvements in grading equipment that are being planned or tested is an electronic device for determining the redness of tomatoes. This machine is designed to test large lots brought in bulk to the cannery, to make fine distinctions between different color intensities, and to work with an absolute consistency beyond the capacity of human inspectors who rely on eye and judgment. It is being tested under pilot-plant conditions at three State agricultural experiment stations and experimentally in a few commercial processing plants.

Technology in Food Marketing

CHAPTER 10

Some Problems and Choices

The foregoing chapters have tried to bring out the breadth and force of technological progress in food marketing during the last 20 years. Nothing like a complete picture has been attempted. Although many examples of advances in technology have been given, they are only a fraction of the total number of innovations made possible by adapting the principles of chemistry, physics, biology, and engineering to all stages of the marketing operation, from processing to retailing. The evidence that has been presented, however, is more than enough to show that technology already has brought about a revolution in the marketing of food and that the forward drive is continuing.

Partly or wholly through the impetus of technology, the volume of processed foods greatly increased between 1930 and 1950. A whole new industry—the freezing of foods for mass consumption—was created. New efficiencies were introduced into practically all phases of processing and distribution. Marketing services became more numerous and often more elaborate. The various operations that together make up the marketing system tended toward larger scale and closer integration.

These sweeping changes have affected everyone in the United States, usually for the better. Over the years, farmers' markets have been broadened; the food supply available to the average family has been improved.

But not all of the people have been benefited all of the time; technology creates new problems as it solves old ones. Many of the truly important technological developments are attended by widespread temporary dislocations as one product or method displaces another. Sometimes certain groups, which include farmers or consumers as well as people in the food-marketing industries, are put at a disadvantage for longer periods. The more indirect effects of progress in food technology also can be significant. The marketing of food always has been meshed closely into the fabric of the national economy as a whole. The recent growth of the commercial food industries, and the extent to which they have taken over many functions previously performed by family labor on farms or in homes, have strengthened and extended these ties. Thus, an advance in food technology may have social and economic repercussions in what appear to be far distant quarters.

Although the net effects of the forward drive of technology are favorable, the record of the last two decades offers no grounds for the comfortable assumption that everything will automatically work out for the best. Unless the problems created by technology are met with intelligence and vigor, serious situations may result.

A few of the more urgent problems are noted briefly in this final chapter. Those that relate wholly to technology—invention, experiment, adoption, and obsolescence—are not considered. Although many of them are of first importance, they are the kind of problems that scientists and businessmen are best able to take in stride in the course of technology's self-propelled advance. We are concerned here, rather with questions of wider public interest. Some of them represent situations in which the efforts of laboratories and business concerns must be supplemented by more broadly based assistance; in other situations the effects of food technology have major impacts on large numbers of people.

Keeping Market News Abreast of the Times

Despite the great improvements in the gathering and dissemination of market news, serious shortcomings remain—shortcomings that are accentuated by the continuing increase in truck shipments and in general decentralization of many aspects of food marketing. Although more than half of the movement of perishable foods now is by truck, rail and water shipments remain the only source with complete coverage of day-to-day information on volume moving to market. Wholesale trading in major terminal markets and principal producing areas still are the chief sources of daily market news on prices and volume of sales. The proportion of the food supply distributed in processed form grows larger, yet there is no market news coverage of fruits and vegetables sold for processing. A system of market news fully keyed to modern conditions would

cover more fully such items as truck movement of foods, and food sold for processing and at the retail stage. Modern communication techniques are equal to the added tasks; the chief problem concerns careful determination of the exact items of current data that will best reflect the picture, and organization of public and private facilities required to collect and disseminate the information. Until market news can be so improved, and at reasonable cost, the full benefit of progress in transportation and storage of foods and in methods of rapid communication will not be reaped.

The Changing Role of the Central Market

As recently as 1930 the central market was a focus of food distribution not only for the large city in which it was located, but for considerable adjacent territory as well. Since then, the rapid growth in truck transportation has reduced the areas served by most of the big central markets; supplies are often shipped direct to smaller markets in the outlying territory. Also, less of the food supplies for the city proper go through the central market; corporate and voluntary chains and the larger independent supermarkets buy more of their supplies direct from producing areas. The central market remains, however, an important cog in the distribution system, serving as the principal source of supply for most of the independent retail stores and at least as source of marginal supplies for all the others. This is especially true where central markets, such as New York City, Chicago, and Boston are also terminal markets. Thus, the problem for the industry and the public is not the entire displacement of the central market, but its adaptation to changing functions. Most of the existing central markets are old; their equipment and facilities are to a large extent out of date; their size frequently is inadequate; and their locations, geared to the transport systems of an earlier day, are unsatisfactory for handling shipments by modern rail or truck and lead to general traffic congestions. The outmoded central markets are a prolific source of waste and spoilage.

The same difficulty is encountered in many smaller wholesale markets where foods are concentrated. Rebuilding central and wholesale sites is expensive in terms of land and materials. Such projects often require the financial cooperation of the municipality and of other agencies of State and local government. Experience gained recently in the rebuilding and relocation of a few central markets indicates that the general conclusions drawn from basic research are valuable, and that individual research and planning also are needed to adapt fundamental principles to the needs of each locality. It is important, therefore, not only that the obvious defects of many central markets be remedied, but that they be remedied in ways adapted to the new roles of these markets as well as to the special requirements of separate localities.

Seasonality of Processing

Between 1930 and 1950 the volume of foods commercially manufactured increased by 64 percent; by 1947 the number of production workers had passed the 1 million mark. Better methods of holding food while it is awaiting processing and greater diversification, by which some plants are able to perform different kinds of operations at different times of the year, have somewhat reduced the seasonal variations in employment in food processing, yet the fluctuations throughout the year still average higher than for industry as a whole. In New York State, for example, vegetable canners in 1947 employed three times as many workers in September as in May; average employment was twice as high in the busy months as it was in the slack season (*14, p. 18*). This problem has been intensified in many parts of the country with the growth of food processing in size and relative importance. Great seasonal swings in employment mean more migration and heavier relief loads. Thus, further technological gains in ability to hold food products before processing and to diversify the operations of individual plants would contribute to general industrial stability as well as to better utilization of the labor force and to the efficiency and economy of many individual processing establishments.

Disposal of Processing Wastes

The wastes that accumulate in processing animal and vegetable foods still are enormous despite the progress that has been made in utilization of byproducts. Disposal of plant wastes is a major problem. One of its aspects concerns the relationship of processing plants with their communities and with public authorities of larger areas. The public has become increasingly aware of health requirements, abatement of such nuisances as bad odors, and watershed conservation, including the preservation of marine life in streams and rivers. If good relations with the public are to be preserved and occasion for drastic regulatory measures minimized, the search for improvements in the disposal of processing wastes must continue until the accumulation of large piles of refuse and the dumping into streams or ponds of large quantities of water full of organic matter become things of the past.

The old and the new in central markets

Although their functions have been modified by changes in distribution that have taken place during the years, central markets continue to provide essential services in the distribution system. Most of these markets are old. The Faneuil Hall Market in Boston, shown above (top), dates from pre-Revolutionary times and once had Paul Revere as its manager. The more functional modern market, such as the one in San Antonio (bottom), is geared to modern handling methods and efficiency. Supplies arriving by both rail and truck are brought directly to the buildings in this market, where they are unloaded by efficient handling methods, stored, displayed, and offered for sale to buyers who can obtain a complete line of products in a short time.

Greater utilization of byproducts is another aspect of the problem. Mere disposal of wastes is sometimes costly in itself. During the last 20 years technologists have developed a number of ingenious ways of making marketable products from materials which once were destroyed or thrown away. Many research projects along these lines are in progress, including inquiries into large-scale methods of turning fruit and vegetable wastes into concentrated foods for animals and for recovery of chlorophyl and carotenoids. This is one of the phases of technological progress that can be expected to proceed briskly under its own steam. The question of more general interest is the temporary dislocation that might follow if the feed-from-vegetable-waste project or any similar enterprise of comparable scope should succeed to a point of colliding with more traditional sources of feed or other products that might be concerned. It is only one of the many aspects of the problem of substitution that keep coming up as new ways of doing things result in new products and changes in requirements for raw materials.

Problems of Long-Haul Trucking

As motortrucks have gained such an important place in the distribution of food, questions growing out of State regulation of commercial trucking in general have a bearing upon the present and future course of food marketing. As trucks have become heavier, bigger, and faster, the public has grown increasingly aware of the problems of highway safety and highway wear and tear. State governments have adopted regulations governing the size and design of trucks, maximum loads they may carry, speeds at which they may be driven, highways they may use, and taxes they must pay. In the absence of nationally agreed-upon criteria to serve as a starting point, there are wide differences and conflicts among the multiplicity of State regulations. More and more, trucks operate across State lines. The result has been confusion, widespread violations of existing rules, and costly delays.

There is need for cooperation among States toward a more uniform set of regulations based on objective studies of road maintenance and safety factors, and an informed decision as to where to strike a balance between the convenience and efficiency of truck transport and other aspects of the general public welfare. An associated problem is the extent to which rail and truck transport might be integrated into a comprehensive system to the benefit of both kinds of carriers and the food-marketing system as a whole. A solution that would combine the benefits of long-haul rail shipment with the flexibility of trucking might bring about faster, more economical transportation of food and at the same time might help to meet the difficulties of overburdened highways.

Grades and Standards

The effects of several technological advances have worked together to increase the responsibility of the marketing system for the quality of foods offered for retail sale.. A larger part of the foods displayed in grocery stores in 1950 was assembled from more distant production areas than in 1930, was held in storage for longer periods, and underwent more elaborate processing. Much of the cleaning, trimming, mixing, and sometimes cooking, was done in commercial plants instead of home kitchens. Nearly all of the processed foods and an increasing proportion of the fresh ones, were displayed in packages that could not be opened for the shopper's inspection. In most instances retail grocers could not add much first-hand information as to where the tightly wrapped food originally came from and just what it was like. The housewife had to rely more than before on her previous experience with a manufacturer's or distributor's brand or on sheer intuition.

Consequently the problems of establishing and maintaining uniform and adequate grades and standards, coupled with more informative labeling, in the interests of both consumers and the concerns engaged in the various stages of marketing, have become more pressing. Some aspects of the problem appear quite complex. One, for example, concerns the development of practical methods of carrying effective grading through to the retail stage. Another involves not only the devising of effective tests, but careful determination of the chief characteristics for which each product should be tested. Still another concerns the increased use of chemicals and other synthetic components of processed food. The problem is to protect the health of consumers without standing in the way of beneficial technological developments.

Avoiding Inflexibility

Technological progress has been one of the forces contributing to larger-scale operations and greater integration at all stages of food marketing. The many advantages of bigness are attended by certain potential disadvantages; prices may become less responsive and methods more frozen than when many relatively small business units are competing; some products may become overstandardized. The prices, quality, and services sold along with the food itself, in some instances,

have shown signs of becoming standardized at higher levels than formerly. Rigidity of this kind, especially during depressed times, can be detrimental when it reaches a point at which any significant number of consumers is denied a choice of buying less expensive forms of such foods, either of lower grade or without some of the added services. The tendency toward high-level standardization has especially serious implications for low-income families. Many nontechnological forces bear upon this problem, including the level and distribution of consumer incomes. Nevertheless, a major challenge to the technology of food processing and distribution is the need for improving the national average level of diet by increasing the nutritive content of low-cost foods and by reducing the cost of many of the traditionally higher-priced protective foods.

The Need for Better Guideposts

During the last two decades much more research effort has gone into finding new methods of processing and distributing food than into measuring the effects of the innovations that have been adopted or studying the desirability of further innovations in the light of consumers' needs and preferences, and the broad interests of producers, marketing agents, and the national economy as a whole.

However, in considering the efforts that have gone into improved methods of processing, it must not be forgotten that during World War II much of the research that would normally have been devoted to the accumulation of basic scientific facts was diverted to the more urgent problems that arose during the war. This has resulted in a reduction in our storehouse of facts. Thus, in the years ahead, basic research must be stressed, for without basic knowledge it will be impossible to solve practical problems in technology.

The lack of any large body of thorough case studies is particularly serious, for they offer the best method of charting the results of food-marketing technology and gaging the direction and strength of current trends. Comparisons of average price and income figures for different periods are of little use for this purpose; other factors, notably the great rise in national purchasing power, mask the effect of technological developments, important as they may have been. We need to know more about the whole complex of results that followed each of the major developments in technology. How efficient was it in terms of money costs, time, and manpower? What was the capital cost of adopting it? What happened to producers' markets and prices? What were the effects on retail prices, the quality of the products consumers bought, and the services they bought along with them? What happened in the various stages of marketing? What was the impact upon directly competing products? What was the net effect, if any, upon the entire national economy? Although concerns engaged in food marketing are vitally interested in such information, few are large enough to undertake social and economic research of so broad a nature. Furthermore, some of the studies needed can best be made from the standpoint of the economy as a whole, as, for example, how the benefits of increased efficiency have been shared among producers, consumers, and the various market agents. Without a considerable fund of such precise information most generalizations as to the broad effects of technology, both past and future, can be little better than guesses.

The Problems Can Be Solved

This report has described some of the ways in which the marketing process has been affected by technology, and has attempted to assess their importance to the marketing of foods. Continued benefits to producers and consumers alike will depend upon the further development of technology and upon the use made of these technological developments in marketing. Basic research, both in the physical and in the social sciences, is essential to full realization of the potential benefits of technology.

The examples just mentioned represent only a few of the many problems affecting the general welfare that will arise as technology continues its advance in the marketing of food as well as in other segments of the national economy. Many are difficult, but none is insoluble. Although the main stream of technology cannot be diverted or dammed up, it can be channeled to produce maximum benefits and to minimize the casualties of progress. The task of seeing to it that the forces of technology attain their greatest possible effectiveness requires the ingenuity, the judgment, and the cooperativeness of producers, consumers, and the industries engaged in food marketing.

Literature Cited

(1) Association of Food Industry Sanitarians, Inc., and National Canners Association.
1952. sanitation for the food-preservation industries. 284 pp. New York.

(2) Bartlett, Roland Willey.
1940. increasing milk consumption by quantity discounts. Milk Plant Monthly. 29 (4): 40.

(3) Bartlett, Roland Willey.
1946. the milk industry. 282 pp. New York.

(4) Bullis, Harry A.
1951. general mills' progress shows what teamwork means to food processor. Food Engineering. 23 (6): 105–109, 169.

(5) Burk, Marguerite C.
1951. changes in the demand for food from 1941 to 1950. Jour. Farm Econ. 33: 281–298.

(6) Business Week.
1951. chain boards up windows to sell more food. Business Week, June 30, 1951, p. 88.

(7) Business Week.
1947. industry-wide trend to one-story warehouses. Business Week, December 13, 1947, p. 24.

(8) Business Week.
1948. size means sales. Business Week, June 18, 1948, p. 70.

(9) The Canning Trade.
1951. tin plate and can making research. Report of a panel discussion at the 11th annual conference of the Institute of Food Technologists, New York, 1951. Canning Trade. 73 (50): 8.

(10) Carlsen, Earl W., and Stokes, Donald R.
1951. prepackaging apples at point of production. U. S. Dept Agr. Agr. Inform. Bul. 29, 52 pp., illus.

(11) Chawner, L. J.
1941. capital expenditures in selected manufacturing industries. U. S. Bur. Foreign & Dom. Com. Survey Current Business. 21 (12): 19–25.

(12) Clark, Faith, Friend, Berta, and Burk, Marguerite C.
1947. nutritive value of the per capita food supply, 1909–45. U. S. Dept. Agr. Misc. Pub. 616, 36 pp., illus.

(13) Cowden, Joseph M., and Trelogan, Harry C.
1948. flexibility of operation in dairy manufacturing plants. U. S. Dept. Agr. Cir. 799, 40 pp., illus.

(14) Dominick, Bennett A., Jr.
1949. the fruit and vegetable processing industry in new york state. New York (Cornell) Col. Agr. Dept. Agr. Econ. and Farm Mangt. A.E. 714, 25 pp., illus. [Processed.]

(15) Edinger, A. T., Mewis, B. H., Mumford, H. D., Bryan, James E., and Stokes, Donald R.
1949. retailing prepackaged meats. 27 pp., illus. Production & Mktg. Admin., Mktg. Res. Br. [Processed.]

(16) Food Engineering.
1951. it's here; frozen concentrated milk. Food Engineering 23 (7): 35, 121.

(17) Fulton, S. H.
1907. the cold storage of small fruits. U. S. Bur. Plant Indus. Bul. 108, 28 pp., illus.

(18) Garrison, E. E.
1948. consumer attitudes and habits regarding frozen foods. Univ. Tenn. Record V. 24, No. 1, 44 pp., illus.

(19) Gastrock, E. A.
1951. recent technological advances in cottonseed processing. Oil Mill Gazetteer. 56 (1): 35–37.

(20) Gemmill, A. V.
1950. milk at the drop of a coin. Food Industries 22 (3): 84.

(21) Goresline, Harry E., Howe, Milton A., Baush, Edward R., and Gunderson, Millard F.
1951. in-plant chlorination does a three-way job. U. S. Egg and Poultry Mag. 57 (4): 12, illus.

(22) Hart, William J.
1950. process line revamping pays off in plus-performance. Food Industries. 22 (12): 75–77.

(23) Harwell, E. M., and Shaffer, Paul F.
1951. the check-out operation in self-service retail food stores. U. S. Dept. Agr. Agr. Inform. Bul. 31, 72 pp., illus.

(24) Herrick, Joseph Francis.
1950. how fresh fruit and vegetable distributors can get more out of their materials-handling equipment. 100 pp. Production and Mktg. Admin. [Processed.]

(25) Hustrulid, Andrew, and Winter, J. D.
1943. the effect of fluctuating storage temperatures on frozen fruits and vegetables. Agr. Engin. 24 (12): 416.

(26) Joseph, James
1950. big saving with new x-ray fruit grader. Food Industries 22 (4): 56–57, illus.

(27) Kercho, Marvin Roy.
1951. use of recording and transcribing equipment in loading delivery trucks of produce wholesalers. U. S. Dept. Agr. Agr. Inform. Bul. 43, 20 pp., illus.

(28) Larson, J. Stanford, Mixon, James A., and Stokes, E. Clinton.

1949. MARKETING FROZEN FOODS—FACILITIES AND METHODS. 175 pp., illus. Production and Mktg. Admin. [Processed.]

(29) LE BEAU, OSCAR R.
1950. PREPACKAGING CRANBERRIES COOPERATIVELY. U. S. Farm Credit Admin. Misc. Rept. 138, 21 pp.

(30) LEBHAR, GODFREY M.
1950. THE STORY OF THE FOOD CHAINS, 1925–1950. Chain Store Age (Grocery Managers Ed.) 26 (6): J1–J12.

(31) LENOX, W. L., and SHERMAN, R. W.
1948. FROZEN FOOD QUALITY HIGH. PRICE NO INDICATOR OF GRADE IN FRUIT AND VEGETABLE. Ohio Farm and Home Research 33: 193–194.

(32) LIMMER, EZEKIEL.
1951. TRANSPORTATION OF SELECTED AGRICULTURAL COMMODITIES TO LEADING MARKETS BY RAIL AND MOTORTRUCK, 1939–50. 42 pp., illus. Bur. Agr. Econ. [Processed.]

(33) MCCARTHY, F. W.
1951. MODERN MATERIALS HANDLING GIVES NEW SPURT IN PROCESSING. Food Industries 23 (3): 107–109.

(34) MCINNES, C. C.
1951. PROGRESS IN SOLVENT EXTRACTION OF VEGETABLE OILS. Oil Mill Gazetteer. 56 (1): 34–35.

(35) MANN, L. B.
1949. TRENDS, PROBLEMS AND POTENTIAL OF THE LOCKER PLANT INDUSTRY. Quick Frozen Foods 12 (3): 96–97.

(36) MODERN MATERIALS HANDLING.
1949. GROCERY WAREHOUSING. CONVEYORIZING IN BOTH SINGLE AND MULTISTORY WAREHOUSES SPEEDS HANDLING WITHOUT THE NEED FOR HIGH COST CONSTRUCTION. Modern Materials Handling 4 (3) 13–14.

(37) MODERN MATERIALS HANDLING.
1948. SIMPLIFIED HANDLING WITH PALLETS. Modern Materials Handling 3 (12): 13–14, 62, illus.

(38) NATIONAL ASSOCIATION OF FROZEN FOOD PACKERS.
1945–1950. FROZEN FOOD PACK STATISTICS, 1944, 1949, PTS. 1 AND 2. Washington, D. C.

(39) NATIONAL DAIRY PRODUCTS CORPORATION.
1950. ANNUAL REPORT, 1949. New York.

(40) NATIONAL PROVISIONER.
1951. SELF-SERVICE MEAT BOOM CONTINUES, SURVEY SHOWS. Natl. Provisioner 124 (20): 10.

(41) NEUBERT, A. M.
1951. FLOATING PEAS TO CLEAN THEM. U. S. Dept. Agr. Yearbook Agr. (Crops in Peace and War) 1950–51: 237–241.

(42) NEW YORK (STATE) TEMPORARY COMMISSION OF AGRICULTURE.
1949. REPORT. 1948–49, PT. 1. Albany.

(43) NORTH CENTRAL LIVESTOCK MARKETING RESEARCH COMMITTEE.
1950. FROZEN FOOD LOCKERS & HOME FREEZERS IN MEAT DISTRIBUTION. Wis. Agr. Expt. Sta. Bul. 490, 63 pp., illus.

(44) PAUL, ALLEN B.
1950. FOOD PROCESSING MARKS 40 YEARS OF GROWTH. Food Industries 22 (11): 49–51, 179–180, illus.

(45) PAUL, ALLEN B.
1949. THE PROCESSOR'S SHARE OF THE FOOD DOLLAR. Ill. Farm Econ. Nos. 174–175, pp. 935–939, illus.

(46) PRE-PACK-AGE.
1951. ASSOCIATION SURVEY DISCLOSES FOOD, LABOR, AND TRANSPORTATION SAVINGS MADE BY PREPACKAGING INDUSTRY. Pre-pack-age 4 (6): 11–14.

(47) THE PROGRESSIVE GROCER.
1949. FACTS IN FOOD AND GROCERY DISTRIBUTION AS OF JANUARY 1949. New York.

(48) QUICK FROZEN FOODS.
1952. DIRECTORY OF FROZEN FOOD PROCESSORS OF FRUITS, VEGETABLES, SEAFOODS, MEATS, POULTRY, JUICES, AND SPECIALTIES THROUGHOUT THE WORLD, 1951. New York.

(49) QUICK FROZEN FOODS.
1945. PROBLEMS FORCED BY THE NEW FROZEN FOODS PACKER. Quick Frozen Foods 7 (9): 42–45, illus.

(50) RAWLINGS, BROWN R.
1950. FROZEN CONCENTRATES IN THE FLORIDA CITRUS INDUSTRY. Federal Reserve Bank. Monthly Rev. 35 (2): 13–17.

(51) REDIT, WALTER H., JOHNSON, HAROLD D., HALL, JAMES D., CUBBEDGE, RANDALL, and KAUFMAN, J.
1951. TRANSPORTATION OF FROZEN CITRUS CONCENTRATE BY RAILROAD AND MOTORTRUCK FROM FLORIDA TO NORTHERN MARKETS. U. S. Dept. Agr. Agr. Inform. Bul. 62, 77 pp., illus.

(52) SAFEWAY STORES.
1946–1950. ANNUAL REPORTS. 1945, 1947, 1949. Oakland, Calif.

(53) SCOTT, R. C.
1950. AN ANALYSIS OF FROZEN FOOD PURCHASES IN THREE NEW YORK AREAS. New York (Cornell) Agr. Expt. Sta. Bul. 861, 31 pp.

(54) SHEPHERD, G.
1942. DECENTRALIZATION IN AGRICULTURAL MARKETING: CAUSES AND CONSEQUENCES. Jour. Mktg. 6: 341–348.

(55) STIEBELING, HAZEL K.
1950. TRENDS IN FAMILY FOOD CONSUMPTION. Amer. Dietetic Assoc. Jour. 26: 596–598.

(56) TEELE, STANLEY F., and BURSK, EDWARD C.
1944. MARKETING PRACTICES OF FOOD MANUFACTURERS. Harvard Business Review 22: 358–376.

(57) Timmons, D. E.
1950. citrus canning in florida. Univ. Fla. A.E. 50 (4) p. 23.
(58) Treaster, W. Lowell.
1951. storage miracle for root crops. Country Gent. 121 (7): 20, 46.
(59) Tressler, Donald Kiteley, and Evers, Clifford F.
1947. the freezing preservation of foods. Ed. 2, rev. and enl., 932 pp., illus. New York.
(60) Tressler, Donald Kiteley.
1942. nutritive value of dried and dehydrated fruits and vegetables. New York (State) Agr. Expt. Sta. Tech. Bul. 262, 44 pp.
(61) United States Agricultural Research Administration.
1951. research and related services in the united states department of agriculture. Prepared for the Committee on Agriculture of the House of Representatives, Eighty-first Congress, 2d session, December 21, 1950. 3 v. Washington, D. C.
(62) United States Bureau of Agricultural Economics.
1950. agricultural outlook charts, 1951. 100 pp. Washington, D. C.
(63) United States Bureau of Agricultural Economics.
1950. consumption of food in the united states, 1909–48. U. S. Dept. Agr. Misc. Pub. 691, 196 pp., illus.
(64) United States Bureau of Agricultural Economics.
1951. the national food situation. No. 57, July-September, 1951, pp. 5, 24.
(65) United States Bureau of Agricultural Economics.
1950. supplement for 1949 to consumption of food in the united states, 1909–48. U. S. Dept. Agr. Misc. Pub. 691, 41 pp.
(66) United States Bureau of Foreign and Domestic Commerce.
1951. survey of current business. national income supplement, July 1951. Washington, D. C.
(67) United States Bureau of Human Nutrition and Home Economics.
1949. food consumption of urban families in the united states, spring 1948. U. S. Bur. Human Nutrition and Home Econ. 1948 Food Consumption Surveys. Prelim. Rept. 5, 32 pp. Washington, D. C. [Processed.]
(68) United States Bureau of Human Nutrition and Home Economics.
1950. food consumption trends in birmingham, ala., 1935, 1946 & 1948. U. S. Bur. Human Nutrition and Home Econ. 1948 Food Consumption Surveys. Spec. Rept. 1, 19 pp. [Processed.]
(69) United States Bureau of Human Nutrition and Home Economics.
1948–49. 1948 food consumption surveys. preliminary reports 1–4. Washington, D. C. [Processed.]
1. Family Food Consumption in Birmingham, Ala.
2. Family Food Consumption in Minneapolis-St. Paul.
3. Family Food Consumption in San Francisco, Calif.
4. Family Food Consumption in Buffalo, N. Y.
(70) United States Bureau of Human Nutrition and Home Economics.
1951. rural family living charts, October 1951. 76 pp. Washington, D. C. [Processed.]
(71) United States Bureau of Labor Statistics.
1929–47. monthly labor review. 1929–47.
(72) United States Bureau of the Census.
1933. abstract of the fifteenth census of the united states. Washington, U. S. Govt. Printing Off.
(73) United States Bureau of the Census.
1941–50. census of business. 1939, 1948. retail trade. Washington, D. C.
(74) United States Bureau of the Census.
1951. census of housing, 1950, preliminary reports, series hc–5, no. 2. Washington, U. S. Department of Commerce.
(75) United States Bureau of the Census.
1949. 1947 census of manufactures. V. 2, 948 pp.
(76) United States Bureau of the Census.
1943. sixteenth census of the united states, 1940. census of housing, vol. II, part 1. Washington, U. S. Govt. Printing Off.
(77) United States Bureau of the Census.
1946–50. statistical abstract of the united states. 1946: 321; 1950. Washington, D. C.
(78) United States Bureau of the Census.
1946–47. united states census of agriculture, 1945. 2 v. in 34. Washington, U. S. Govt. Print. Off.
(79) United States Federal Trade Commission.
1946. report . . . on wholesale baking industry. 2 v. Washington, D. C. (79th Cong., 2d. sess., House Doc. 535)
(80) United States National Archives.
1941–48. federal register. May 27, 1941; July 3, 1943; November 27, 1948.
(81) United States Production and Marketing Administration.
1947. conversion factors and weights and measures for agricultural commodities and their products. 83 pp. Washington, D. C. [Processed.]
(82) United States Production and Marketing Administration.

(1948) GRADE TERMINOLOGY USED IN U.S.D.A. STANDARDS. 3 pp., plus 6 pp. tables. Washington, D. C. [Processed.]

(83) UNITED STATES PRODUCTION AND MARKETING ADMINISTRATION.
1950. SUMMARY OF A PROPOSED PROGRAM FOR DEVELOPMENT OF THE MARKET NEWS SERVICE, U.S.D.A. 5 pp., illus. Washington, D. C. [Processed.]

(84) UNITED STATES PRODUCTION AND MARKETING ADMINISTRATION.
1950. A SURVEY OF THE CAPACITY OF REFRIGERATED STORAGE WAREHOUSES IN THE UNITED STATES AS OF OCTOBER 1, 1949. v. 15, 33 pp., illus. Washington, D. C.

(85) UNITED STATES PUBLIC ROADS ADMINISTRATION.
1947–51. HIGHWAY STATISTICS. SUMMARY TO 1945 AND 1949. Washington, D. C.

(86) UNITED STATES PUBLIC ROADS ADMINISTRATION AND UNITED STATES BUREAU OF FOREIGN AND DOMESTIC COMMERCE.
1932. MOTOR TRUCK TRANSPORTATION. CHARACTERISTICS AND COSTS OF MOTORTRUCK OPERATION BY COMMON CARRIERS AND CONTRACT HAULERS IN INTERCITY SERVICE. U. S. Bur. Foreign and Dom. Com. Dom. Com. ser. 66, 59 pp., illus.

(87) UNITED STATES TARIFF COMMISSION.
1941–50. SYNTHETIC ORGANIC CHEMICALS. UNITED STATES PRODUCTION AND SALES 1941, 1950. Annual. Washington, D. C., U. S. Govt. Print. Off.

(88) VON LOESECKE, HARRY W.
1949. STREAM POLLUTION. Food Technology. 3 (10): 323.

(89) WASHINGTON POST.
1951. WASHINGTON POST (real estate section). January 14, p. 2R.

(90) WESTERN CANNER AND PACKER.
1931–50. WESTERN CANNER AND PACKER. San Francisco. v. 22, no. 9 to date.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1952—208402