Agricultural Economic Report No. 48

SWEETENERS USED BY FOOD PROCESSING INDUSTRIES

heir Competitive Position
n the UNITED STATES

nomic Research Service U.S. DEPARTMENT OF AGRICULTURE

PREFACE

This is the last of a group of publications dealing with the use of sweeteners and competition among sweeteners in the various food industries. In it, an attempt is made to summarize the principal findings of the earlier publications:

1. Sweeteners Used by Food Processing Industries in the United States: Their Competitive Position in the Canning Industry. AER No. 20, November 1962.

2. Sweeteners Used by the Dairy Industry: Their Competitive Position in the United States. AER No. 30, April 1963.

3. Sweeteners Used in the Beverage Industry: Their Competitive Position in the United States. AER No. 31, May 1963.

4. Sweeteners Used in the Baking Industry: Their Competitive Position in the United States. AER No. 32, May 1963.

5. Sweeteners Used in the Confectionery Industry: Their Competitive Position in the United States. AER No. 37, June 1963.

Research analyzing and evaluating trends in the production and consumption of various sweeteners and in competition among sweeteners has been recommended by the Sugar Research and Marketing Advisory Committee. This group of reports deals with these problems.

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Washington, D. C. January 1964

SUMMARY

Industrial food processors are the largest users of sweeteners in the United States. The principal sweeteners used are sugar, corn sirup, dextrose, and the noncaloric sweeteners, saccharin and sucaryl. In addition, food processors are important users of such other sweeteners as honey, maple sirup, and edible molasses.

Sugar is still the primary sweetener used by food processors, but its position in the manufacture of a number of products, such as canned fruits, ice cream and other frozen desserts, and soft drinks, has been slowly weakening and that of other sweeteners, particularly corn sirup and noncaloric sweeteners, improving. The rising price of sugar, relative to other sweeteners, is an important factor inducing industrial food processors to substitute other sweeteners for sugar. Other factors working in the same direction include: (1) The introduction of new noncaloric sweeteners following World War II, and (2) improvements in the quality of corn sirup and an increase in the variety of types available to purchasers.

In spite of some substitution of other sweeteners for sugar by food processors, both the total quantity and the proportion of the total quantity of sugar consumed in the United States which is delivered to food processors has been increasing, at least since 1929, the earliest year for which data are available. This increase in proportion is a reflection of the trend in the United States toward more purchases of prepared food and less home cooking. The increase in per capita deliveries of sugar to industrial users has not caused total per capita sugar consumption to increase.

The total quantity of the principal caloric sweeteners (sugar, corn sirup, and dextrose) delivered to industrial food processors in the United States increased at an average rate of 190,000 tons, or 4.0 percent per year, from 1952 through 1961. Deliveries of corn sirup increased most rapidly, 5.3 percent per year, and those of dextrose the least, 1.8 percent per year.

The most rapid increase in the use of sugar was in the beverage industry, primarily in the manufacture of soft drinks. Indications are that the use of noncaloric sweeteners in soft drinks also increased even more rapidly than that of sugar. The increased use of sugar by the soft drink industry, under these circumstances, is a reflection of the rapid growth in sales of the industry.

The per capita use of corn sirup by industrial food processors increased at an average rate of 3.6 percent per year from 1952-61, as compared with 2.2 percent for sugar and a slight decrease, 0.1 percent, for dextrose.

The most rapid increase in the use of sugar by industrial users since 1952 was in the North Central States, followed by the Southern and Western States. The slowest rates were in New England and the Middle Altantic States. These variations correspond generally to the variation in the rates of growth in industrial food processing in different parts of the United States. The rate of growth in the use of dextrose was greatest in the Middle Atlantic States. However, the ratio of dextrose to sugar usage in these States in 1961 was still below that for the rest of the United States.

Except in the canning industry, Government regulations of the use of sweeteners have had comparatively little effect on the quantities or mixtures of sweeteners used by food processors. A considerable proportion of fruit canners interviewed are using the maximum proportion of dextrose or corn sirup permitted by regulations of the Food and Drug Administration, and several indicated that they would use more if permitted.

There has been a distinct trend among industrial users toward the use of more sugar in liquid and dry bulk forms and toward the use of purchased blends of sweeteners. The most important of these blends is a mixture of liquid sugar and corn sirup, the proportions of each sweetener depending upon the needs of the purchaser. The most common proportion, however, is 75 percent sugar and 25 percent corn sirup.

Although the prices of sugar and other sweeteners were comparatively stable through 1961, price fluctuations and differences in price trends for different sweeteners have been of sufficient importance to require careful attention by food processors. This has been particularly true where sweetener costs are a substantial part of total raw material costs and where the processor has some choice as to the proportions of each type of sweetener used.

Widening price differentials between sugar and other sweeteners since 1952 have been a major cause of the substitution of other sweeteners for sugar. This has been of more importance in the canning, dairy, and beverage industries than in baking or confectionery, although some substitution has occurred in all major fields of food processing. Improvements in the quality of corn sirup and the introduction of new noncaloric sweeteners also have encouraged the increased use of sweeteners other than sugar.

The demand for sweeteners in the United States, especially for household use, is quite inelastic (changes in quantities purchased, as a result of price fluctuations, are small). The demand by industrial food processors is slightly more elastic (increases or decreases in response to price changes) because of the greater importance of costs to industrial users. Also, industrial users are able to substitute one sweetener for another to a much greater extent than household consumers.

SWEETENERS USED BY FOOD PROCESSING INDUSTRIES

Their competitive position in the United States

By

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INTRODUCTION

Food industries are the largest users of sugar in the United States. 1/ Also, the proportion of the total quantity of sugar consumed in the United States, used in these industries, has been increasing at least since 1929, the earliest year for which data are available. In addition to sugar, food industries are the principal users of dextrose and corn sirup which compete with, or in some cases supplement, sugar as a sweetening agent. These industries also are using increasing quantities of noncaloric sweeteners, mostly saccharin and sucaryl, although complete data showing the quantities so used are not available. Other caloric sweeteners, such as honey, maple sirup, sorgo sirup, and edible molasses are used in small quantities in various food products. They are used mostly for their special flavor qualities and their sweetening effect is only incidental.

Sweeteners are an essential ingredient of many manufactured food products: Most frozen, canned, or preserved fruits; dairy products, such as ice cream, other frozen desserts, and condensed milk; beverages, especially soft drinks; many bakery products; and practically all candies and confections. 2/ In many food products, sweeteners act both as a preservative and a means of providing desirable flavor and body. In some products made with yeast, such as bread and beer, the sweetener serves primarily as food for the yeast or other fermenting agent.

Changing conditions in the food industries, particularly changing competitive relationships among sugar, corn sirup, and other sweeteners, have created a need for adjustments in marketing policies and operating practices among both producers and users of sweeteners. Although sugar is still the primary sweetener used by food industry processors in the United States, its relative position among sweeteners in some industries has been weakening slowly since World War II. Basic information on the nature of this trend and its causes is needed to assist producers and users of sweeteners in effecting necessary adjustments, not only for their own benefit

1/ The canning, dairy, beverage, baking, and confectionery industries are the principal food industries using sugar and other sweeteners. The canning industry includes the production of frozen foods, jams, jellies, pickles, and preserves; the dairy industry, frozen desserts, some of which contain no dairy product; the beverage industry, flavorings; the baking industry, cereal and ready-to-mix desserts; and the confectionery industry, chewing gum and chocolate products in addition to products more clearly indicated by the name of the industry.

2/ More details are given in the previous publications of this group referred to in the preface.

but also in the public interest. A previous publication of the U.S. Department of Agriculture contains information of a related nature for an earlier period. 3/

The specific purposes of this report are: (1) to determine and project trends in the quantity of each type of sweetener used; (2) to provide information concerning the problems and practices of industrial users in their purchase and use of sweeteners; and (3) to analyze the competition among producers of different sweeteners in selling their product to industrial food processors.

The information on which this report is based was obtained from a sample of firms in food processing industries (canning, dairy, beverage, baking, and confectionery) and from various secondary sources. The survey covered about 200 firms in 17 States and included representative producers in each major industry.

CHARACTERISTICS OF VARIOUS SWEETENERS

Refined sugar, the most important sweetener, is a pure substance, the chemical name of which is sucrose. Nearly all the world's commercial supply of sugar is obtained from sugarcane and sugarbeets. The sugar in these plants is contained in solution in the juice, from which it is extracted and purified. Sucrose is a disaccharide, each molecule of which can be divided into a molecule of dextrose and a molecule of levulose. This process is known as inversion, and the resulting mixture is invert sugar. Invert sugar and mixtures of invert and sucrose are available commercially only in liquid form. Sucrose is sold commercially in both dry and liquid forms.

Sugar is the primary product obtained from both sugarbeets and sugarcane. Neither sugarcane nor sugarbeets have any important commercial use, in most of the world, except to produce sugar. Consequently, the value of sugarcane or sugarbeets at any time and place is very largely a reflection of the market price of sugar, less the costs of processing the raw material and marketing the sugar.

Dextrose, except that which forms half of invert sugar, and corn sirup or glucose sirup are products derived from starch. The starch molecule is a polymer which can easily be broken down chemically into simpler substances. If this process is carried out completely, the end product of the ordinary conversion of starch is dextrose.

When corn starch is partially converted to simpler carbohydrate compounds, the result is a mixture of saccharides other than sucrose. Processors can control, to a considerable extent, the proportions of the various saccharides in the mixture. As a result, they are able to offer sirups of various specifications to meet the needs of their customers.

Starch suitable for the manufacture of dextrose and sirup may be obtained from any of numerous plant sources, although corn is the most important source in the United States. The number and commercial importance of the joint products obtained from corn is greater than in the case of sugarbeets or sugarcane. In addition to starch and its derivatives, these include livestock feed, steep water, zein and other individual proteins, various amino acids, and xanthophyll oil. It is possible for a processor to vary the proportions of the various starch derivatives which are produced

3/ Jones, P. E., and Thomason, F. G. Competitive Relationships Between Sugar and Corn Sweeteners. Agr. Inform. Bul. No. 48, 245 p. 1951.

in response to changes in market demand or other factors. This flexibility is not possessed by processors of sugarbeets or sugarcane.

Producers of dextrose and corn sirup in the United States use only a small proportion of the corn grown in this country. They obtain this corn by purchases in the open market, in contrast to processors of sugarbeets who contract annually with individual growers for their supply of beets and processors of sugarcane who grow the cane they grind, or they purchase it on a seasonal basis from independent growers.

The corn wet milling industry, because of the circumstances under which it obtains its raw materials and the ability of producers to vary the proportions of corn sirup, dextrose, and nonsweetener products obtained from corn starch, has a considerable degree of flexibility in making changes in response to varying market requirements. This flexibility is not possessed by the processors of sugarbeets and sugarcane. On the other hand, because of the small proportion of the total supply used by the industry, the price of corn is not related closely to the price of dextrose and corn sirup, as are the prices of sugarcane and sugarbeets to the price of sugar. Consequently, in periods of high corn prices, which were not important from 1952-61, producers of corn sirup may have more difficulty in competing with sugar than they have experienced in recent years.

Neither dextrose nor corn sirup is as sweet as sugar. This limits their suitability for use in certain products. However, in some uses sweeteners are not important, and in a few products their lower sweetening power is regarded as an asset by users.

The noncaloric sweeteners are products of the chemical industry. They are manufactured in comparatively small volume. However, their sweetening power per unit of weight is many times that of sugar, and their economic significance, in comparison with other sweeteners, is much greater than the volume of production alone suggests.

The minor sweeteners used in small quantities in the manufacture of certain food products are either byproducts of the sugar industry -- cane sirup and edible molasses -- or are produced by separate industries -- honey, maple sirup, and sorgo sirup. They are used primarily for the special flavors they impart to products in which they are used, and they compete with other sweeteners only incidently.

TOTAL UNITED STATES CONSUMPTION OF MAJOR SWEETENERS

Total distribution of sugar (household, industrial, institutional, etc.) in the United States increased from 7,309,000 tons of refined sugar in 1952 to 8,775,000 tons in 1961. This is approximately the same rate of growth as that of the United States population and gives rise to the common observation that the people of the United States, in contrast to those of many other countries, have reached a plateau in their use of sweeteners per person, although a larger proportion of the total was being channeled through industrial food processors (table 1).

The observation about the static character of per capita demand, particularly since 1957, is correct only if confined to sugar and dextrose. The per capita consumption of corn sirup increased by 1.5 pounds between 1952 and 1961, a rise of 19 percent. By 1961, about 8.4 percent of the caloric sweeteners used in the United States was corn sirup, a rise from 7.1 percent in 1952. Plans reported by industrial

Table 1.--Total and per capita distribution of sweeteners in the United States, 1952-61 1/

Year	Sugar		Dextrose		Corn sirup		Total	
	Total	Per capita	Total	Per capita	Total	Per capita	Total	Per capita
	1,000 tons	Pounds	1,000 tons	Pounds	1,000 tons	Pounds	1,000 tons	Pounds
1952..	7,309	95.3	338	4.3	587	7.5	8,234	107.1
1953..	7,607	97.5	351	4.4	604	7.6	8,562	109.5
1954..	7,437	93.5	333	4.1	610	7.5	8,380	105.1
1955..	7,680	94.6	324	3.9	635	7.7	8,639	106.2
1956..	8,066	97.6	336	4.0	651	7.7	9,053	109.3
1957..	7,950	94.4	328	3.8	656	7.7	8,934	105.9
1958..	8,210	95.8	370	4.2	711	8.2	9,291	108.2
1959..	8,336	95.4	387	4.4	753	8.5	9,476	108.3
1960..	8,423	94.6	381	4.2	790	8.8	9,594	107.6
1961..	8,775	96.7	391	4.2	842	9.2	10,008	110.1

1/ Dry basis. Sugar, refined weight as produced; dextrose, 92.0 percent; and corn sirup, 80.3 percent of weight as produced.

The Sugar Situation, March 1962. Economic Research Service, U. S. Dept. Agr.

food processors and recent trends in output strongly indicate that the proportion will continue to rise. If recent trends continue, corn sirup would account for about 9.1 percent of the total by 1966 and 10 percent by 1972.

If noncaloric sweeteners could be included in table 1, the increase in per capita consumption of sweeteners would be greater than that shown. The use of such sweeteners in various canned and frozen products and in soft drinks is known to have increased in recent years, but data adequate to measure the increase are not available. Again, indications are that the consumption of these sweeteners will continue to increase.

QUANTITY OF SWEETENERS USED IN FOOD INDUSTRIES

The quantities of each of the principal sweeteners delivered to the major food industries by primary distributors (continental cane sugar refiners, domestic beet processors, importers of direct consumption sugar, and producers of dextrose, and corn sirup) were larger in 1961 than in 1952 (table 2). The aggregate increase amounted to about 45 percent. In addition to deliveries to the canning, dairy, beverage, baking, and confectionery industries, the figures in table 2 include deliveries to industrial users for use in other food products. They also include deliveries to users who manufactured products classified under two or more of the industrial groups listed.

In addition to deliveries shown in table 2, some food processors, particularly those with small plants, purchased part or all of their sweeteners through wholesalers. Also, some purchases were made in the form of blends of sugar and corn sirup or sugar and dextrose. Complete information about the quantities of blends

Table 2.--Sugar, dextrose (corn sugar), and corn sirup delivered to industrial food processors in the United States, 1952-61 1/

Year	Sugar	Dextrose	Corn sirup	Total	Sugar	Dextrose	Corn sirup	Total
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	Percent	Percent	Percent	Percent
1952...	3,182	279	423	3,884	81.9	7.2	10.9	100.0
1953...	3,488	279	459	4,226	82.5	6.6	10.9	100.0
1954...	3,402	269	467	4,138	82.2	6.5	11.3	100.0
1955...	3,647	263	498	4,408	82.7	6.0	11.3	100.0
1956...	3,933	266	520	4,719	83.4	5.6	11.0	100.0
1957...	4,006	256	522	4,784	83.7	5.4	10.9	100.0
1958...	4,031	298	566	4,895	82.3	6.1	11.6	100.0
1959...	4,295	315	610	5,220	82.3	6.0	11.7	100.0
1960...	4,453	308	653	5,414	82.2	5.7	12.1	100.0
1961...	4,643	308	705	5,656	82.1	5.4	12.5	100.0

1/ Dry basis. Sugar, 100.0 percent; dextrose, 92.0 percent; and corn sirup, 80.3 percent, as produced.

Sugar Reports, Agricultural Stabilization and Conservation Service, U. S. Dept. Agr.

purchased is not available. However, it is doubtful if the inclusion of such data would change materially the trends and relationships shown, except to make the tonnage and percentage figures somewhat larger.

The total quantity of sugar, dextrose, and corn sirup used by major food industries in the United States increased at an average annual rate of about 190,000 tons, or 4 percent, based on average deliveries for the period 1952 through 1961 (fig. 1 and table 3). This exceeds the rate of population growth in the United States.

The deliveries of sugar increased 156,000 tons per year, as compared with 29,000 for corn sirup and 5,000 for dextrose. However, the average percentage rate of increase was highest, 5.3 percent per year, for corn sirup. It was lowest, 1.8 percent, for dextrose.

If the deliveries of sweeteners continue to increase at the 1952-61 rate, the total distribution to industrial users of sugar, dextrose, and corn sirup for 1966 will be approximately 6,354,000 tons. About 82.5 percent of this total will be sugar, 5.1 percent dextrose, and 12.4 percent corn sirup.

The percentage distribution of total caloric sweeteners -- sugar, dextrose, and corn sirup -- delivered to all industrial users did not vary greatly from 1952-61. Sugar made up more than four-fifths of the total each year. The proportion gradually increased from 1952 to 1957, after which it declined. The dextrose share declined somewhat, while that for corn sirup increased.

Trends in deliveries of each of these caloric sweeteners varied widely among industries from 1952-61. The increase for sugar was the largest, both in tons and percentage rate, in the beverage industry (table 3). The increase also was relatively rapid for the baking industry.

Sweeteners - Sugar, Corn Sirup, and Dextrose, 1952-65

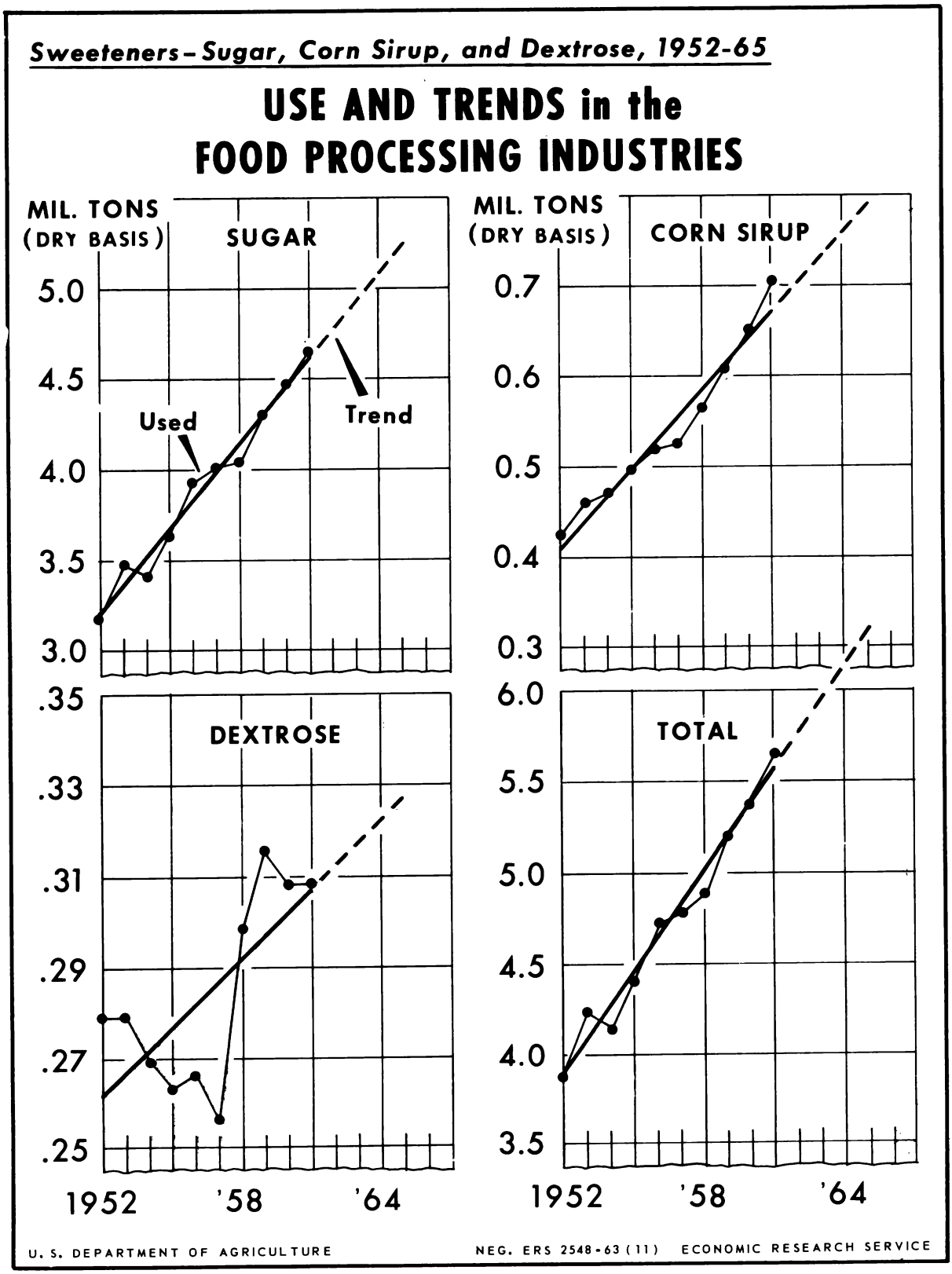

Figure 1

Table 3.--Average annual increases in the use of sweeteners by food processing industries, 1952-61 1/

Industry	Sugar	Dextrose	Corn sirup	Total
	1,000 tons	1,000 tons	1,000 tons	1,000 tons
Canning	31	2/	7	38
Dairy	14	-1	5	18
Beverage	49	2/	3	52
Baking	40	4	4	48
Confectionery	20	2/	5	25
Other	2	2	5	9
All food industries	156	5	29	190
	Percent	Percent	Percent	Percent
Canning	4.4	0.8	6.8	4.6
Dairy	4.0	-6.7	12.5	4.7
Beverage	5.1	-.4	12.2	5.2
Baking	4.4	2.1	7.1	4.2
Confectionery	2.8	1.9	1.5	2.4
Other	1.1	3.9	18.6	3.7
All food industries	4.0	1.8	5.3	4.0

1/ Least square trends.
2/ Less than 500 tons.

The beverage and baking industries used more sugar than any other industry groups from 1952-61, and there was no tendency for the proportion of sugar in the total caloric deliveries of sweeteners to these industries to decline from 1952-61. The weight of these factors, together with the comparatively rapid increase in deliveries of sugar to the beverage and baking industries, is sufficient to offset the effect of the decline from 1952-61 in the proportion sugar was of the total caloric sweeteners delivered to the canning, dairy, and "other" industries. Thus, the data in table 2 do not reflect details of the changes in the market position of the various caloric sweeteners in specified industries, 1952-61. Except for the "other" category, the increase was lowest in the confectionery industry. The largest tonnage increase in the use of dextrose was in the baking industry, although the percentage rise was highest in the "other" category. Deliveries of corn sirup to the canning industry increased at a rate of about 7,000 tons per year from 1952 through 1961, more than for any other industry. However, the percentage increase was lower than that for any industry except confectionery.

The percentage distribution of deliveries of sugar and dextrose among food industries did not change materially from 1952-61 (table 4). The largest quantities of industrial sugar deliveries throughout the period went to the beverage and baking industries.

The baking industry used more than 60 percent of the dextrose delivered to food industries each year from 1952 through 1961. There was a slight upward trend

Table 4.--Distribution of sweeteners delivered by primary distributors to industrial users in major industries, 1952-61

Year	Canning	Dairy	Beverage	Baking	Confectionery	Other	Total
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Sugar							
1952	17.2	8.7	24.2	21.4	20.3	8.2	100.0
1953	17.7	8.1	23.3	22.4	20.0	8.5	100.0
1954	18.3	8.6	24.0	23.3	18.0	7.8	100.0
1955	17.9	8.2	24.2	24.1	18.0	7.6	100.0
1956	18.8	8.2	23.6	22.9	18.8	7.7	100.0
1957	18.4	8.2	23.6	23.3	19.1	7.4	100.0
1958	18.6	8.5	23.7	23.6	18.0	7.6	100.0
1959	18.6	8.6	25.9	22.4	17.1	7.4	100.0
1960	17.7	8.2	25.8	23.5	18.1	6.7	100.0
1961	18.4	8.5	26.1	23.2	18.1	5.7	100.0
Dextrose							
1952	9.3	5.0	9.7	62.7	6.5	6.8	100.0
1953	9.0	4.3	9.0	63.0	6.8	7.9	100.0
1954	8.9	4.5	8.6	61.7	7.0	9.3	100.0
1955	9.5	4.2	8.0	62.4	6.4	9.5	100.0
1956	10.5	4.1	7.9	63.2	6.4	7.9	100.0
1957	10.2	3.5	7.8	62.9	7.4	8.2	100.0
1958	9.7	2.7	6.7	65.5	6.7	8.7	100.0
1959	8.6	2.5	6.0	65.1	6.4	11.4	100.0
1960	8.7	2.8	8.7	64.1	6.4	9.3	100.0
1961	8.4	2.6	9.1	64.6	7.2	8.1	100.0
Corn sirup							
1952	13.2	4.3	3.1	11.3	66.9	1.2	100.0
1953	12.9	5.4	3.7	10.9	63.8	3.3	100.0
1954	14.6	6.4	3.6	10.7	61.0	3.7	100.0
1955	16.5	7.4	4.0	10.2	58.7	3.2	100.0
1956	15.8	6.9	5.0	11.0	57.3	4.0	100.0
1957	15.0	8.0	5.0	11.3	56.3	4.4	100.0
1958	14.8	8.3	4.9	10.8	55.5	5.7	100.0
1959	16.4	9.0	5.4	11.6	50.7	6.9	100.0
1960	16.5	9.5	5.8	12.3	49.3	6.6	100.0
1961	16.9	9.9	6.2	12.8	46.3	7.9	100.0

in this proportion. The share of dextrose going to the dairy industry was not only the smallest going to any industrial group, but it also declined by nearly one-half during the period.

Deliveries of corn sirup to the confectionery industry were about two-thirds of total deliveries of the product in 1952, but dropped to less than one-half in 1961. In spite of this decline in share of total deliveries, the tonnage of corn sirup delivered to the confectionery industry increased at an annual rate of about 5,000 tons per year. The average annual increase in the use of corn sirup for all industries was 29,000 tons per year. The proportions of total industrial deliveries of corn sirup going to the canning, dairy, beverage, baking, and "other" industries increased

from 1952-61, although the increase for the baking industry was small. It decreased for the confectionery industry. The dairy and beverage industries are the smallest users of corn sirup, but the percentage of the total supply going to these industries increased steadily during 1952-61.

The delivery of sweeteners to food processing industries in the United States increased considerably faster than population from 1952 through 1961 and the per capita use of sugar and corn sirup manufactured products increased steadily (table 5). The aggregate increase of sugar, dextrose, and corn sirup used in food industries averaged about 1.2 pounds per year, or 2.2 percent of the average quantity delivered from 1952-61 (fig. 2). The per capita use of corn sirup increased at an average rate of 3.6 percent per year, as compared with 2.2 percent for sugar and a decline of 0.1 percent for dextrose. If the 1952-61 trends continue until 1966, the per capita use of these sweeteners will approximate 66.4 pounds, about 5 pounds more than in 1961. The increase for corn sirup will be 0.9 pound and that for sugar, 4.1 pounds.

Table 5.--Per capita deliveries of sugar, dextrose (corn sugar), and corn sirup to major food processing industries in the United States, 1952-61 1/

Year	Sugar	Dextrose	Corn sirup	Total
	Pounds	Pounds	Pounds	Pounds
1952	40.9	3.6	5.4	49.9
1953	44.1	3.5	5.8	53.4
1954	42.2	3.3	5.8	51.3
1955	44.4	3.2	6.1	53.7
1956	47.0	3.2	6.2	56.4
1957	47.1	3.0	6.1	56.2
1958	46.6	3.4	6.5	56.5
1959	49.0	3.6	6.9	59.5
1960	49.4	3.5	7.3	60.2
1961	50.7	3.4	7.7	61.8

1/ Dry basis. Sugar, 100 percent; dextrose, 92.0 percent; corn sirup, 80.3 percent, as produced.

Sugar Reports, Sugar Div., Agricultural Stabilization and Conservation Service, U. S. Dept. of Agr.

GEOGRAPHIC DISTRIBUTION OF THE USE OF SWEETENERS

The quantity of sugar delivered to industrial food processors in the North Central States in 1961 was 31 percent of total deliveries of sugar to food processors in the United States, and was larger than deliveries to such processors in any other section of the country that year (table 6). Also, deliveries of sugar to food processors in the North Central States increased more rapidly, an average of 5.9 percent per year, than in any other region (fig. 3). Sugar deliveries to food processors in the Middle Atlantic States were larger than those in the North Central States from 1952 through 1957 and second in size during the remaining 4 years of the period. However, the increase in the Middle Atlantic States was the slowest, 2.2 percent annually, in any census region.

Sweeteners–Sugar, Corn Sirup, and Dextrose, 1952-65

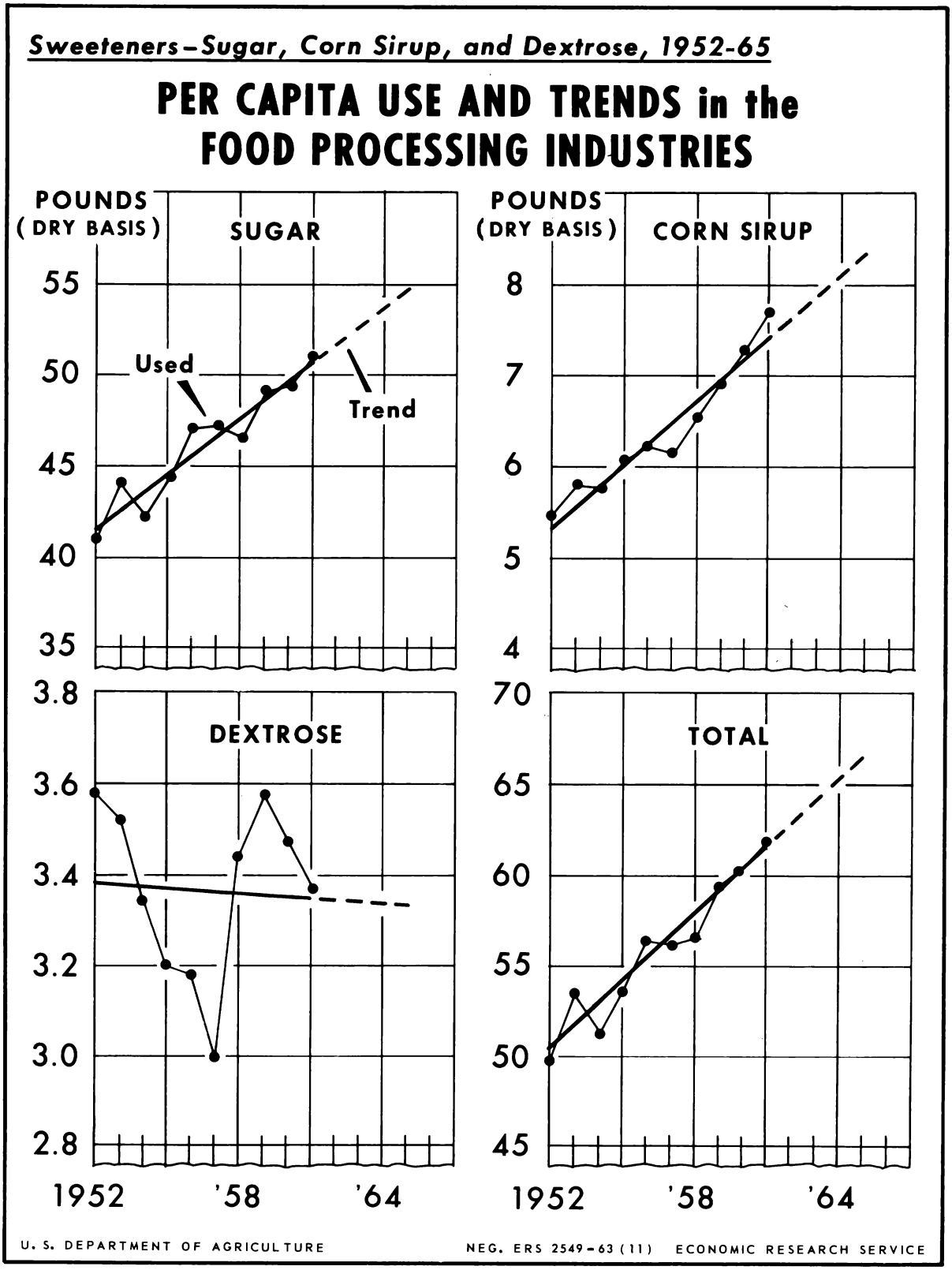

Figure 2

Table 6.--Deliveries of sugar and dextrose to major food processing industries, by years and geographic areas, 1952-61 1/

Sweetener and year	New England	Middle Atlantic	North Central	South	West	United States
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
Sugar (refined)						
1952	183	1,021	810	667	501	3,182
1953	182	1,097	940	703	566	3,488
1954	177	1,063	907	726	529	3,402
1955	182	1,134	1,004	765	562	3,647
1956	188	1,179	1,117	809	640	3,933
1957	194	1,204	1,150	822	636	4,006
1958	197	1,174	1,178	838	644	4,031
1959	209	1,204	1,269	906	707	4,295
1960	214	1,244	1,349	962	684	4,453
1961	219	1,274	1,444	967	739	4,643
Dextrose (dry basis)						
1952	12.0	60.9	105.2	61.3	39.2	278.6
1953	10.0	58.4	110.0	61.5	39.5	279.4
1954	10.1	59.7	106.3	57.7	35.1	268.9
1955	10.2	62.1	97.7	55.5	37.2	262.7
1956	9.6	58.8	101.4	59.1	37.6	266.5
1957	9.1	57.8	97.4	56.9	34.5	255.7
1958	11.0	68.0	111.4	64.0	44.0	298.4
1959	12.2	74.4	121.7	63.5	42.7	314.5
1960	11.8	72.4	119.6	61.3	42.7	307.8
1961	10.6	78.3	115.1	62.1	42.3	308.4

1/ Area boundaries are shown in figure 3.

Sugar Reports, Agricultural Stabilization and Conservation Service, U. S. Dept. Agr.

The more rapid increase in the use of sugar by industrial food users in the North Central States appears to be related to the faster growth of the principal sugar using, food processing industries in that region than in the Middle Atlantic States. The value added by manufacturers of such products in the North Central States increased about 35 percent from 1954 to 1958, as compared with 23 percent in the Middle Atlantic region and 27 percent for the entire United States.

Food processors in the North Central region received about 38 percent of the dextrose delivered to food industries in the United States during the period 1952-61, an even larger proportion than for sugar, but the rate of increase in dextrose deliveries, 1.5 percent per year, was only about one-fourth that for sugar. The most rapid increase in dextrose deliveries, 3.2 percent per year, was in the Middle Atlantic States. However, in spite of the slow rate of increase in the use of dextrose in the North Central States, the ratio of dextrose use to sugar use in this region in 1961 was still the highest for any part of the United States, although substantially below that in 1952.

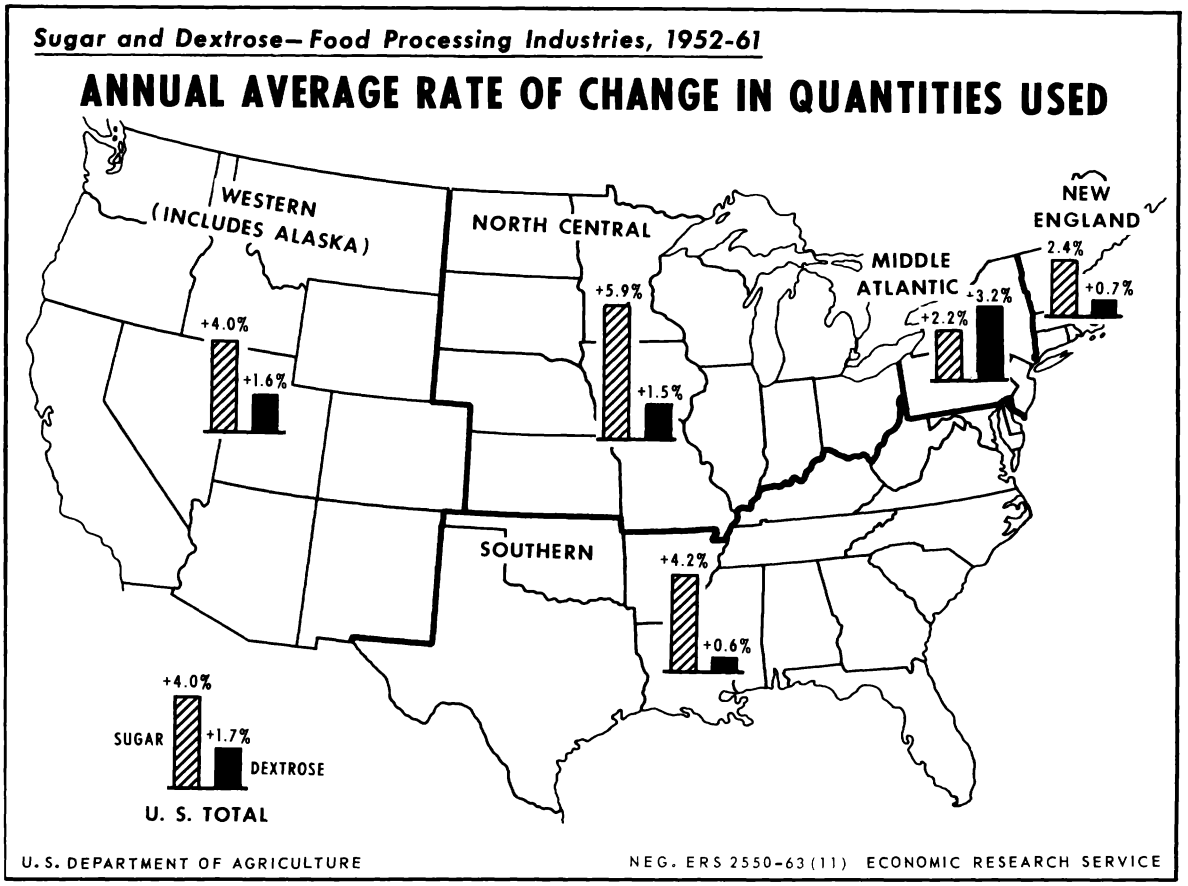

Figure 3

Dextrose is produced in plants in the North Central States, and sales to nearby users possess certain advantages of convenience and low transportation costs. While these advantages continue to exist, producers of these products have in effect widened their market since 1952, particularly with reference to industrial users in the Middle Atlantic States.

About half the dextrose used by industrial food processors in the United States is delivered to the baking industry for the production of bread and other items manufactured with yeast. The relatively slow increase in the consumption of bread in the United States, as compared with most other food products in which sweeteners are important, has been an important factor accounting for the slower rate of increase in the deliveries of dextrose to food processors than in deliveries of sugar.

Data for corn sirup, similar to those shown in table 6 for sugar and dextrose, are not available.

GOVERNMENT REGULATION OF THE USE OF SWEETENERS

Both the Federal and most State governments have issued regulations on the use of sweeteners in various commercial food products. In most cases, the principal exception being ice cream, the regulations of the Food and Drug Administration have had more influence on industrial practices in the use of sweeteners than the

regulations of the States. Even so, these regulations have not been highly important to processors in certain industries, particularly baking, confectionery, and beverage industries.

The most important effects of Food and Drug regulations on the use of sweeteners in commercially processed foods have been in certain products of the canning industry. Most States regulate the use of sweeteners in ice cream. 4/

ELASTICITY OF DEMAND FOR SWEETENERS BY INDUSTRIAL USERS

As a result of the administration of the sugar quota system, sugar prices in the United States were unusually stable from 1952 through 1961, and it is not possible to measure numerically the response of consumption to changes in price. It is also impossible to measure the consumption response to changes in the price of corn sirup. This is true both because of the stability of prices and of the gradual substitution of corn sirup for sugar which occurred during the period.

In general, the consumption response to price changes appears to be slight, that is, the total demand for sweeteners seems highly inelastic.

This inelasticity is greater for sugar sold for household use than for sugar and other sweeteners delivered to industrial food processors. Sugar is a minor item in household expenditures, and there is little competition between sugar and other sweeteners for household use. Also, sugar is considered a highly essential ingredient in home cooking. Under the circumstances, household purchases of sugar in the United States hardly can be expected to vary materially with ordinary price changes.

However, the proportion of sugar delivered to household consumers has been decreasing at least since 1929, the earliest date for which statistics are available. Deliveries to wholesalers and retailers declined from about 53 percent of total sugar deliveries in 1952 to 43 percent in 1961. This decline was offset mostly by the increase in the proportion of total sugar deliveries going directly to industrial food processors, although quantities going to public eating places also increased.

The elasticity of demand for sugar by industrial users is greater than that of households, for a number of reasons. The most important of these is the ability of most food processors to use substitutes for all or part of their sweetener requirements. The extent of this cross elasticity varies widely among food industries and even among segments of the same industry. For instance, the substitution of corn sirup for sugar has been greater in the canning and ice cream industries than for other industries. The substitution of noncaloric sweeteners for sugar has been especially important in soft drinks. Also, the substitution of one sweetener for another by food processors generally takes place only gradually over a period of time and is reversed only with great difficulty, if at all.

Another reason for the greater elasticity of demand for sweeteners by food processors, as compared with household consumers, is the greater significance of the cost of sweeteners to industrial users. This importance varies widely among products. For some, it is slight; for others, it constitutes a major cost of doing business. In the latter cases changes in the relative cost of sweeteners encourage the use of the cheaper ones. General increases in sweetener prices may cause

4/ More details are given in the previous publications of this group referred to in the preface.

producers to make changes in the prices of the products they manufacture. This, in turn, may affect their volume of sales and thus the quantities of sweeteners purchased.

There are no signs of a slowing in the trend toward greater industrial use of sugar. The extent to which it continues in future years will have an important effect on the extent to which other sweeteners will be substituted for sugar.

Factors which may influence the decline in the proportion of sugar delivered directly to households include:

1. The declining proportion of United States population living on farms. A study of food consumption in farm and nonfarm households shows that in 1955 the average direct consumption of sugar per person in farm households was about 64 percent larger than in nonfarm households. 5/ Bureau of the Census reports show that the number of farm households decreased by 2,199,000 from 1950 to 1962, while the number of nonfarm households increased 11,255,000.

2. Rising incomes. The same study shows that direct purchases of sugar per capita are smaller for families of higher income than for low income families. The difference between high and low income families in 1955 amounted to about 19 percent for nonfarm families and 8 percent for farm families.

3. Changes in food habits. The decline in home baking, canning, and similar activities and the rise in the use of prepared or convenience foods obviously has transferred part of the market for sugar from households to industrial food processors.

Data necessary to measure the importance of these factors are not available. Rising incomes and increasing purchases of convenience foods appear to be closely related and, considered together, may be of greater importance than migration off farms.

The rise of sugar prices in the United States to high levels in the first half of 1963 has given further encouragement to the substitution of other sweeteners for sugar.

The demand for sweeteners as a group is, of course, even more inelastic than that for individual sweeteners. Substituting one sweetener for another has no effect on the total quantity used. Recent changes in the per capita consumption of sweeteners as a group appear to constitute an upward trend, and to have little relationship to price fluctuations.

INDUSTRIAL DEVELOPMENTS IN THE USE OF SWEETENERS

Information obtained from about 200 food processing firms with plants located throughout the United States shows numerous points of similarity and others of diversity among the principal groups of industrial food processors in their use of sweeteners and in the changes in usage which have been made in recent years. The substitution of other sweeteners, particularly corn sirup and noncaloric sweeteners, for sugar has occurred in varying rates in most industries, and the relative importance of corn sirup and noncaloric sweeteners has remained quite different for different

5/ Rockwell, George R. Income and Household Size: Their Effects on Food Consumption. Mkt. Res. Rpt. No. 340, U.S. Dept. Agr. June 1959.

industries. Noncaloric sweeteners have become increasingly important in the beverage industry, where corn sirup usage is small. In the canning and the dairy industries, corn sirup and, for some processors, dextrose is of much more importance than noncaloric sweeteners as substitutes for sugar.

Several reasons account for the increasing substitution of other sweeteners for sugar in various food products. Certainly a major reason for the increased use of corn sirup was the widening differences in prices between sugar and corn sirup from 1952 through 1961. Probably few, if any, food processors ever paid exactly the wholesale prices shown in table 7, but the trends shown in the table indicate that the price advantage of using either corn sirup or dextrose in place of sugar increased substantially between 1952 and 1961. Also, the price of corn, the raw material from which dextrose and corn sirup are manufactured, declined about 29 percent, while sugar prices rose.

Table 7.--Trends in the prices of sugar, dextrose (corn sugar), corn sirup and corn, 1952-61

Year	Refined sugar, wholesale, New York	Dextrose in bags, New York	Corn sirup in drums, New York	Differential -- sugar minus		Corn, season average price received by farmers
				Dextrose	Corn sirup	
	Dol. per 100 lb.	Dol. per 100 lb.	Dol. per 100 lb.	Dol. per 100 lb.	Dol. per 100 lb.	Dol. per 100 lb.
1952...	8.45	7.29	7.37	1.16	1.08	1.52
1953...	8.45	7.35	7.32	1.20	1.23	1.48
1954...	8.55	7.32	7.32	1.23	1.23	1.43
1955...	8.42	7.22	7.25	1.20	1.17	1.35
1956...	8.59	7.28	7.15	1.31	1.44	1.21
1957...	8.97	7.65	7.36	1.32	1.61	1.12
1958...	9.10	7.66	7.37	1.44	1.73	1.12
1959...	9.14	7.48	7.31	1.66	1.83	1.04
1960...	9.25	7.48	7.32	1.77	1.93	1.00
1961...	9.21	7.45	7.33	1.76	1.88	1.08

The Sugar Situation, Econ. Res. Serv., and Stat. Rptg. Serv., U. S. Dept. Agr.

The substitution of dextrose for sugar during the period 1952-61 was much less than that for corn sirup. In fact, the increase in the use of dextrose was at a slower rate than that for sugar. This might be taken as evidence that no substitution of dextrose for sugar occurred. However, the overall trends in use of dextrose were influenced by the relative decline in the importance of bread and other products manufactured with yeast, for which dextrose is the primary fermentation agent. Also, dextrose prices rose somewhat relative to prices for corn sirup between 1952 and 1961. This encouraged food processors to substitute corn sirup for dextrose whenever this was technically feasible.

Improvements in the quality of corn sirup, which have been made in recent years, are an important factor which has encouraged food processors to substitute corn sirup for at least a part of the sugar formerly used. This is true even in cases

where the improved types of corn sirup have sold at a somewhat higher price than the older types, thus reducing the price advantage of the corn sirup over sugar. These improvements have included the production of a wider variety of sirups, enabling producers to meet more exactly the demands of their customers. In other words, corn sirup is no longer a simple product, but a group of related products.

Trade reports suggest the possibility of further developments in the production of corn sirup which may widen its appeal to industrial food processors. One possibility of great potential importance concerns the development of a commercially feasible method of producing a corn sirup containing sufficient levulose to make the sirup much sweeter than the types now being marketed. Present corn sirups have only a fraction of the sweetening power of sucrose; that is, ordinary sugar. This has been an important factor limiting the amount of corn sirup which could be feasibly substituted for sugar in many food products.

Levulose, which is considerably sweeter than sucrose, is one of a large number of products classified by chemists as "sugars." It is not formed during the ordinary commercial conversion of starch into sirup. However, methods by which a portion of the corn starch is converted to levulose during the manufacture of sirup have been developed on a laboratory basis. The commercial feasibility of these laboratory methods is not yet established.

At existing price relationships, particularly if accompanied by changes in regulations of the Food and Drug Administration to permit more extensive use of sirup in various canned products, a corn sirup with sweetening power more or less equivalent to that of sugar, when and if produced commercially, might easily displace several times as much sugar as present types now do.

Improvements also have been made in the quality of refined sugar since 1952, particularly for sugar intended for special uses where certain quality requirements are unusually high. However, the improvements in sugar quality appear to have had less effect on its use than is true of corn sirup, perhaps because opportunities to improve the quality of sugar were not as great as they were for corn sirup.

The increase in the consumption of corn sirup also has been helped by the expansion of facilities for marketing blends of sugar and corn sirup throughout the United States. Many food processors, who did not find it more convenient or economical to prepare their own blends, do find it advantageous to purchase such blends.

The increased use of noncaloric sweeteners has been the result of several factors including (1) the introduction of noncaloric sweeteners since World War II, (2) increasing awareness of the value of such sweeteners in dietetic products, (3) the appeal of products so sweetened to persons concerned with weight problems, and (4) rising prices of sugar which increase the cost advantage, or decrease the disadvantage, of replacing sugar with noncaloric sweeteners. The lack of complete statistical data on the quantities of noncaloric sweeteners used by the food processing industries makes a detailed analysis of these factors impossible.

In some cases, noncaloric sweeteners are used to manufacture products having markets largely, although never entirely, separate from those in which otherwise similar products are sold. In such a case questions of comparative prices of sweeteners, convenience, and quality have little influence on the processor's decision with reference to their use.

In other cases, most notably soft drinks, the markets for products manufactured with noncaloric sweeteners overlap, in considerable part, that for products sweetened

with sugar, dextrose, or corn sirup, and questions of price and quality are of greater importance. The recent introduction of several new brands of noncaloric soft drinks and the announced plans of manufacturers to expand their manufacturing capacity strongly suggest, that for soft drinks, the noncaloric sweeteners are, in large part, replacing sugar. While the decisions, for the most part, to proceed at this time with the marketing of new brands of soft drinks manufactured with noncaloric sweeteners, apparently were made before the unusually higher prices of 1963 developed, these higher prices may have encouraged the rapid promotion and development of such soft drinks.

Concern over weight control, to be achieved primarily by limiting the number of calories consumed, appears to have become of increasing importance to many people in the United States, even when no immediate problem of health is involved. One way of reducing the daily caloric intake, without appearing to eat less, is to consume products manufactured with noncaloric sweeteners. This appears to be an important factor in the sale of soft drinks. Much of the consumption of soft drinks occurs between meals, and many consumers wish to avoid making it a between-meals snack.

The Canning Industry

About half the canners interviewed stated that they were using the maximum proportions of dextrose, or corn sirup, or a combination of the two permitted by Food and Drug regulations. A number of canners reported that they would like to use a larger proportion of corn sirup in their products but were prevented from doing so by existing regulations. Price was the factor most frequently mentioned as the reason for wishing to use more corn sirup. This was usually coupled with the statement that using a larger proportion of corn sirup in their sweetener formula would not change the quality in such a way as to reduce the demand for their product.

The Dairy Industry

The use of corn sirup in the manufacture of ice cream increased at more than 3 times the rate for sugar -- 12.5 percent per year as compared with 4 percent. The use of dextrose, never important, declined. The increase in the use of corn sirup by the ice cream industry was considerably greater than the increase in output of ice cream, a further indication that considerable substitution of corn sirup for sugar occurred.

The 2 major reasons for this substitution are (1) the increasingly higher price of sugar, as compared with corn sirup, and (2) improvement in product quality which many ice cream manufacturers report obtaining by the use of a certain proportion of corn sirup in their sweetener formula. Improvements in the quality of corn sirup and increasing knowledge by producers of the effect of corn sirup on the flavor, texture, and appearance of ice cream have been important in connection with this improvement in quality of product.

The Beverage Industry

The largest use of sweeteners in the beverage industry is in soft drinks. Producers of soft drinks use little dextrose or corn sirup, although there was some increase in the use of a blend of sugar and corn sirup in certain types of soft drinks late in the period 1952-61.

The most significant trend in the use of sweeteners in soft drinks has been the rapid rise in the use of noncaloric sweeteners. Trade sources indicate an increase of about 25 percent from 1959 to 1961 in the production of noncaloric sweetened soft drinks, and predict a continued rapid increase in their use. This prediction is consistent with the plans reported by a number of the soft drink bottlers who were interviewed.

The Baking Industry

The baking industry is the principal consumer of dextrose in the United States. Bakers use dextrose primarily as a fermentation agent in the production of items manufactured with yeast. The production of bread and other products made with yeast has been increasing much more slowly than that of other bakery products. As a result, deliveries of dextrose to the baking industry during the period 1952-61 increased at a slower rate than occurred for either sugar or corn sirup. Interviews with bakers indicated no tendency to substitute other sweeteners for dextrose in products made with yeast.

There was some trend toward the use of an increased proportion of corn sirup in the sweetener formulas for bakery products manufactured without yeast. Although this substitution had not gone far enough to be important, interest in the use of more corn sirup appeared to be increasing.

The Confectionery Industry

The confectionery industry is the largest user of corn sirup among food processing industries in the United States. Corn sirup is especially important in the production of hard candies, where it makes up two-thirds or more of the total raw material used. The production of hard candies increased at a slower rate than that of most other confections and this was largely responsible for the slower rate of increase in deliveries of corn sirup to confectioners from 1952 to 1961 than prevailed for sugar or dextrose.

The production of chocolate and cocoa products has been increasing more rapidly than any other major category of confections. Sugar is the major sweetener used in these products, although a few producers reported using a blend of approximately 10 percent corn sirup and 90 percent sugar in recent years. The use of such blends appears to be increasing in importance.

TREND TOWARD BULK DELIVERY

A decided trend has developed in recent years towards the delivery of sugar to food processors in either liquid or dry bulk form, rather than in sacks. Recently, some dextrose deliveries also have been made in dry bulk. Corn sirup, ordinarily a liquid, is sometimes reduced to solid form and sold as corn sirup solids. Such deliveries are always made in moistureproof bags because of the hygroscopic nature of the product. Also, bulk deliveries of blends of sugar, dextrose, and corn sirup to food processors have become much more important since 1952.

Deliveries of sugar in liquid form in the United States, nearly all of which were made to food processors, increased from 691,000 tons, sugar solids content, in 1952 to 1,532,000 tons in 1961, a gain of about 122 percent. Total deliveries of sugar to

food processors increased only 46 percent during this period. The increase in deliveries in dry bulk form since 1957, the earliest date for which data are available, has been even more rapid than that for liquid sugar. The increase for dry bulk deliveries from 1957-61 was 116 percent, as compared with 52 percent for liquid sugar and 16 percent for total deliveries of sugar to food processors. While the available data include some deliveries of liquid and bulk sugar to users who were not industrial food processors, available information indicates that about 60 percent of all sugar deliveries to food processors in 1961 were in either liquid or dry bulk form.

The most important sweetener blends marketed in the United States are those of sugar and corn sirup. Complete data showing the quanties of corn sirup and sugar used in such blends are not available. However, in 1961 a total of about 156,000 tons of corn sirup, dry basis, were used in mixed sirups by corn sirup producers, delivered to sirup mixers or used in bulk blends. This was about 17 percent of total corn sirup deliveries. In 1958, the earliest year for which data are available, deliveries of these types were about 15 percent of the total. In addition, certain quantities of corn sirup were delivered to cane sugar refiners and beet sugar processors for blending, although data showing the quantity are not available. There are no data showing the quantities of blended sweeteners delivered to individual food processing industries.

Convenience, sanitation, and ease of handling are the most commonly cited reasons for the growing use of sugar in liquid or dry bulk form, and for the increasing importance of liquid sweetener blends. Less manual handling is required than when the product is bagged. Also, liquid products are kept in closed containers where they are less subject to certain types of contamination. However, liquid sweeteners ordinarily will not keep in storage as long as dry sugar, and more frequent deliveries to users are necessary.

IMPORTANCE OF SWEETENER COSTS TO FOOD PROCESSORS

Sugar and other sweeteners are part of the raw materials purchased by food processors. The proportion, by weight, which sweeteners are of the total raw material used varies from an insignificant amount to nearly 100 percent, depending on the product. When noncaloric sweeteners are used, the proportion is much smaller than for sugar and corn sweeteners because of their greater sweetening power.

Most jams, jellies, and preserves contain 50 percent or more of added sweeteners, and frozen fruits from 15 to 25 percent. For ice cream and other frozen desserts, the proportion varies from 13 to 26 percent. It averages 43 percent in sweetened condensed milk. In soft drinks, except those manufactured with noncaloric sweeteners, the caloric content, primarily sugar, varies from 7 to 20 percent of the volume of the drink and constitutes nearly all of the solids. Sweeteners added in the baking industry vary from 2 to 56 percent of the raw material used. Sweeteners added to products made with yeast are largely used up in the fermentation process. The weight of sweeteners in the confectionery industry vary from 20 percent to nearly 100 percent of the weight of the raw material used. In chocolate and cocoa products, the range is from 20 to 75 percent; in chewing gum, from 66 to 80 percent; in hard candy from 50 to nearly 100 percent; and in other candies, from 20 to 95 percent.

The cost of sweeteners, likewise, forms a highly variable proportion of the total cost of the raw material used. In some industries this proportion varies even more widely than the relative weights of sweeteners and other raw materials. This is likely

whenever the prices of the nonsweetener constituents have been more variable than the price of sweeteners. The wide variations in recent years in the price of cocoa beans, the source of chocolate, and the relative stability in the price of sugar and other sweeteners, is an example of how such variations occur.

Quality considerations greatly limit the extent of changes most food processors are able to make, especially during a short period of time, in the types and proportions of sweeteners used in a particular product. As a result, the quantity of the various sweeteners used is affected only slowly and over a considerable period of time by moderate changes in their price, such as occurred from 1952 through 1961. A number of purchasing agents for processors indicated more concern with purchasing sweeteners at prices no higher than those paid by their competitors than with changes in the general level of sweetener, which affect everyone.

Price changes which affect all producers more or less equally can be offset either by changes in the price of the final product or, in some cases, by changing the size of the unit in which the product is sold. Unless these changes are large enough to affect the processor's volume of sales, they have little effect on producers. Frequently, small changes in the price or size of package of the finished product, which may hardly be noticed by buyers, are sufficient to offset the change in sweetener cost.

If, however, a manufacturer pays a higher price for sweeteners than his competitors, he would not be in a positionto adjust the price of his product or to use other means to take care of the increased cost. Sweetener costs were less variable than those of many other agricultural commodities from 1952 through 1961. Changes were sufficiently large, however, and frequent enough to cause companies to give careful attention to their buying practices, particularly those companies for which sweetener costs are an important part of operating expenses.

Larger companies commonly have one or more specialists who devote most of their time to the market for sweeteners and who attempt to make purchases at the most favorable times and on the most favorable terms. Deliveries of sweeteners so purchased may be at intervals extending for several months after purchases are made. Other companies, usually of small or medium size, frequently rely on a single supplier of one or more of the sweeteners used, hoping that the prices they pay will be at least no higher than the average for the season in their location. The smallest companies merely make purchases as needed from local dealers.

IMPLICATIONS FOR SWEETENER PRODUCERS AND PUBLIC POLICY

The comparatively rapid increase in the use of corn sirup and of noncaloric sweeteners by food processors, particularly since 1957, and the slower rise for sugar represent trends of great significance to producers and consumers of sweeteners. These trends also involve questions of public policy since the sugar industry, in particular, is closely regulated by the Federal Government. The relative prices of sugar and other sweeteners are an important factor determining recent trends in the consumption of various sweeteners. Government programs also influence the price of corn -- the raw material for corn sirup and dextrose. The trend in corn prices, in recent years, has differed greatly from that for sugar.

The importance of the trend in certain food industries toward the replacement of sugar with substitute sweeteners is increased by the fact that in most products it appears to be reversible, if at all, only with great difficulty. It usually involves the

development of new techniques by food processors which enable them to produce goods of satisfactory -- sometimes superior -- quality. It also involves convincing consumers by advertising, demonstration, and other promotional techniques that products made in whole or part with substitute sweeteners are of such quality and cost that the food processor can produce them profitably. The process sometimes involves educating consumers to prefer products of slightly different characteristics than those in the items formerly purchased. These circumstances increase the difficulties and expenses to food processors of returning to the exclusive use of sugar as a sweetener.

Sugar remains the predominant sweetener in all major food industries, but its position has been weakening slowly in several major groups of food processors. The confectionery industry is an apparent exception, but this is largely the result of changes in the relative quantities of various types of candies marketed. A slower increase in output of hard candies than of other confections caused the increase in the use of corn sirup, mostly in hard candies, to be relatively slow. Some substitution of dextrose for sugar has occurred in certain types of confections, including chocolate products.

The increase in the use of noncaloric sweeteners was most marked in the soft drink industry, where, according to trade estimates, their use rose from almost none in 1950 to 25,000,000 cases in 1959. The estimated production of noncaloric sweetened soft drinks in 1961 was about 1.6 percent of the total output of these products in the United States. The increase continued into 1962 and 1963 as the advertising and promotion of noncaloric drinks increased markedly by soft drink manufacturers. As a result, increasing quantities of sugar are being replaced by the noncaloric sweeteners.

An important factor limiting the rate at which substitution of one sweetener for another occurs is the necessity for maintaining consumer acceptance of products. Consumer tastes change slowly. Food processors, however, can and do initiate and direct such changes. Advertising and sales promotion are important factors in inducing such changes. They are not confined to the efforts of the food processors, themselves. A considerable part of the effort along these lines has been made by the manufacturers of the substitute sweeteners. Their advertising has been directed both at consumers and at food processors. Also, promotional work with food processors has been important in demonstrating the best methods of using such sweeteners, the lower costs of using them, and the acceptability of the products obtained with their use. Changing price relationships between sweeteners, such as occurred from 1952-61, have been an important factor in making such advertising and promotional work effective.

Opportunities for making this substitution have been increased since World War II by the development of a new noncaloric sweetener, sucaryl, and by improvements in the quality and variety of types of corn sirup marketed in the United States.

The full economic impact of relative costs and changes in quality develop slowly, but once changes are made they have a way of lasting a long time and usually are more difficult to reverse than they were to induce in the first place. As customers become accustomed to the characteristics of various products made with a noncaloric sweetener or corn sirup, they sometimes come to prefer them and to purchase them in preference to products sweetened only with sugar. The result is likely to be a permanent shift in the market outlet for various sweeteners.

Available information is not sufficient to make possible a detailed estimate of the quantities of sugar which have been replaced by corn sirup and noncaloric sweeteners. Allowing for the effect of differing rates of growth in different segments of

several industries, a study of trends in sweetener use indicates that in 1961 corn sirup and noncaloric sweeteners were substituted for at least 100,000 tons of sugar, which would have been used if 1952 sweetener practices had remained unchanged.

This change is not apparent from the figures in table 2, where the substitution of noncaloric sweeteners for sugar is not included; and the rapid growth of the soft drink industry and its use of sugar, relative to other industries, offsets the losses in sugar deliveries in other industries, especially during the first half of the period 1952-61. This offsetting increase in the use of sugar was, of course, beneficial to the sugar industry in maintaining an increasing volume of business; but it does not alter the extent to which other sweeteners have been substituted for sugar in the beverage and other industries.

While the loss of 100,000 tons out of a total domestic market of 9,600,000 tons for sugar in 1961 may not appear very large, it represents a continuing and accelerating trend. For instance, the total industrial use of sugar increased at an average annual rate of about 160,000 tons from 1957 through 1961. This is 15 percent slower than the average increase from 1952 through 1956. In contrast, the aggregate average annual increase in the industrial use of dextrose and corn sirup from 1957-61 was 150 percent greater than from 1952-56.

Increased use of dextrose and corn sirup from 1952 through 1956 accounted for only about 10 percent of the total increase in deliveries of caloric sweeteners (sugars, dextrose, and corn sirup) to industrial food processors. From 1957-61 it was 27 percent. Should this rate of gain over sugar continue, dextrose and corn sirup will account for about half the increase in the use of these sweeteners by 1966, and 100 percent by 1981.

Also, the use of noncaloric sweeteners, particularly in soft drinks, has increased more rapidly since 1957 than prior to that time. Higher sugar prices in the first half of 1963 have further speeded up the substitution of both noncaloric and corn sweeteners for sugar. These factors further increase the impact of alternative sweeteners on the future growth of sugar use by industrial food processors in the United States.

One factor which could change these estimates of future trends in the use of sweeteners is a shift in price differentials between sugar and other sweeteners. Such shifts could occur either as a result of competitive forces, through changes in Government policy, or from shifts in consumer preferences.