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2 could Price, Relationship of qualities

THE RELATION OF QUALITY TO THE PRICE OF FARM PRODUCTS

FREDERICK V. WAUGH

NEW ENGLAND RESEARCH COUNCIL ON MARKETING AND FOOD
SUPPLY, BOSTON, MASSACHUSETTS

I T IS often said that there can in a truly competitive market be only one price for a commodity at a given time and place. Price as a function of time varies with changes in the volume of the supply on the market and with changes in the aggregate demand curve of the consumers in the various markets, and other causes.

The price research which has developed rapidly during the past few years has naturally followed closely in the footsteps of the economic theory of value. Thus, the most important theories of value are primarily concerned with the relationship of price changes through a period of time to changes in the volume of the supply and in the elevation and slope of the supply-price curve. The price studies of Moore, Working, Ezekiel, Warren and Pearson, Schultz, Leontief and many other statistical economists have been primarily concerned with measuring these relationships.

Differences in price from place to place have received less attention both from the theorist and from the statistician. One of the few studies of this question with which the writer is acquainted is an analysis of intermarket differentials in the prices of watermelons, cantaloupes, and peaches in three eastern United States cities.[1] While little research has yet been done in this field, such studies are likely to provide interesting and useful conclusions.

PRICE VARIATIONS AT THE SAME TIME AND PLACE

Until recently, quantitative price research as well as price theory has been rather closely limited to these two phases: The variation of price from time to time, and from place to place. Does this give an adequate explanation of commodity prices? The answer depends upon the truth or falsity of the original assumption that there is only one possible price for a given commodity at the same

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[1] A. S. McLeod, Intermarket Distribution of Perishable Fruits and Vegetables, N.Y. Food Marketing Research Council Report Vol. 1, June 30, 1926.

time and place.   If the assumption is strictly true, an explanation of price changes from time to time and from place to place will be an adequate and complete explanation of price behavior.   If the assumption is not true, further analysis is needed to explain the variation in prices occurring at the same time and place.   A few facts might not be out of place at this point.   Recent studies of the prices of certain fruits and vegetables in Boston, Massachusetts, have indicated that the following ranges in price between different lots of a commodity at the same time in the Boston wholesale market are not unusual: Potatoes from $1.75 to $3.25 per hundred pounds; McIntosh apples from $1.00 to $3.00 per bushel; asparagus from $3.00 to $12.00 per crate; and tomatoes from 50¢ to $2.50 per bushel.   If we consider potatoes, McIntosh apples, asparagus and tomatoes as commodities, it is evident that there is a wide variation in prices in the same market at the same time. In many cases, this variation in prices is greater than the usual variation in average prices of the same commodities from month to month or from year to year.   The theorist sidetracks this fact by defining the word "commodity" in such a way that all units must be of identical quality.   Such a definition is valid enough for the purposes of analysis.   Yet, it rules out of consideration an element of prices which is important.   It should also be noted here that no two carloads of apples or potatoes are, in fact, identical in quality.

What causes this type of price variation?   The causes fall into two groups.   The first group of causes includes all factors determining the bargaining ability of different buyers and sellers, such as the size and regularity of the buyer's purchases, credit terms and many other complex factors.   The second group of causes includes all differences in the characteristics of the goods themselves.   This complex group of factors is usually called "quality" although the word quality is also often used in more limited senses.   As used in this paper the word "quality" refers to any characteristics, such as size, shape, color, firmness and amounts of damage by various insects and diseases, which vary from one lot of a commodity to another.

STUDIES OF QUALITY-PRICE RELATIONSHIPS

We are here concerned with the relation of quality to the prices of agricultural products. A number of studies of such relationships have recently been made. Benner and Gabriel and also Yount have studied the relation of retail egg prices to quality.[2, 3] Kuhrt has determined the relation of wheat prices to protein content, test weight, dockage and other quality factors.[4] Studies of prices and quality of about ten fruits and vegetables have either been completed or are being completed by the writer and by Kroeck.[5] Studies of cotton quality and prices are being made by Campbell of North Carolina and work on this subject has also been done by Youngblood and others of the Bureau of Agricultural Economics. Cornell University is planning a series of quality-price studies covering the most important agricultural products of New York State.

These studies are concerned with the variation which exists in the prices of a commodity at the same time and in the same market. They attempt to measure the relationship of such price variation to differences in quality. It should, perhaps, be noted in passing that such an analysis does not deny the existence of price variation at the same time and place due to factors other than quality (such as differences in the size and terms of individual purchases). The existence of variation in prices due to such other causes need not in most cases hinder us greatly from determining the average relationship of prices to various qualities.

METHODS OF COLLECTING AND ANALYZING DATA

The methods used in all these studies are practically the same. A trained inspector works with a group of producers or dealers

[2] C. L. Benner and Harry S. Gabriel, Marketing of Delaware Eggs, Delaware Agricultural Experiment Station Bulletin No. 150, 1927.

[3] H. W. Yount, formerly of the Massachusetts Agricultural College. This study has not yet been published.

[4] W. S. Kuhrt. A Study of Farmer Elevator Operation in the Spring Wheat Area. U. S. Bureau of Agricultural Economics Preliminary Reports (mimeographed) 1926 and 1927.

[5] Frederick V. Waugh, Quality Factors Influencing Vegetable Prices. Journal of Farm Economics, April, 1928.

Frederick V. Waugh. Quality as a Determinant of Vegetable Prices. Columbia University Press, 1929.

Julius Kroeck. McIntosh Apple Study. Mass. Dep't of Agriculture Bull., 1929.

Frederick V. Waugh, C. M. White and M. R. Hersey, Market Preferences and Premiums for Maine Potatoes. Maine Development Commission Bulletin, 1930.

for a period of time—preferably for at least one marketing season. He makes careful and detailed inspections of a large number of samples of wheat, cotton, potatoes or asparagus. After each sample has been sold, the actual selling price is determined. When a sufficient number of records of quality and prices is available they are tabulated and analyzed to determine the average relationship between each quality and price. Such an analysis can be made by simple averages of prices received or paid for various qualities, or net relationships can be determined by multiple correlation methods.

The method can be illustrated from a study which is now being made of market preferences and premiums for Maine potatoes.[6] A potato inspector is visiting about thirty-five wholesalers and jobbers in Boston and New York. During the past season he inspected one thousand lots of potatoes (car lots in the wholesale markets and smaller lots in the jobbing markets). The inspection records go into considerable detail showing with respect to each lot of potatoes the percentages of various diameters, lengths, weights, shapes and amounts of various defects; also the color of skins, variety, origin and all other information which might indicate desirable or undesirable quality. About forty statements of quality are recorded for each car. To correlate with these qualities we have jobbing prices in lots of one to five 100-pound bags, wholesale prices in lots of over five bags, and prices to shippers. These data have been partially analyzed, using both simple averages and multiple correlation methods.

Before making the analysis of prices it was necessary in this case—as in most others—to make allowance for the seasonal variation in prices due to the supply situation. This was done by expressing each actual price as a deviation from the top of the quoted daily range of U. S. No. 1 potatoes according to the government market report. Such an adjustment rather effectively eliminates seasonal changes in the general level of potato prices in the market and limits the study to an analysis of factors carrying individual lots to sell above or below the quoted price.

The next step was to average the adjusted prices received for

[6] This study is being made by the Maine Development Commission cooperating with the U. S. Bureau of Agricultural Economics, the New England Research Council, the Maine Department of Agriculture and the University of Maine. It was started in October, 1929 and will be continued until about March, 1931.

potatoes of different sizes, colors, and so forth, in order to find the simple relationship of each of these factors to prices in the jobbing market, prices in the wholesale market, and prices returned to shippers in Maine. After studying these simple averages, certain correlation problems were analyzed to determine the net relation of certain qualities to prices.
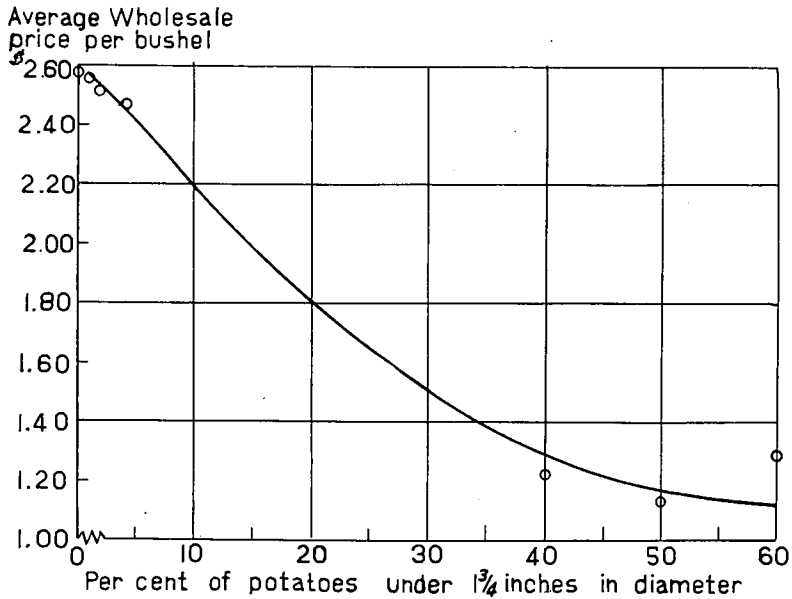

FIGURE 1. RELATION OF THE PERCENTAGE OF POTATOES UNDER 1¾ INCHES IN DIAMETER AND THE CARLOT WHOLESALE PRICE PER BUSHEL IN THE BOSTON MARKET

PRELIMINARY RESULTS OF THE MAINE POTATO QUALITY STUDY

The simple average prices paid last season in the Boston wholesale market for potatoes with varying size, color and amounts of bruises are shown in figures 1 to 3.

Average wholesale prices for cars of potatoes with 0 per cent, 1 per cent, 2 per cent, and so forth, under 1¾ inches in diameter are shown in figure 1. Cars with no undersized potatoes sold at an average (adjusted) price of $2.59 per hundred pounds; cars with 1 per cent under 1¾ inches sold at an average of $2.57; 2 per cent undersize at $2.52; 4 per cent undersize at $2.47; 40

per cent undersize at $1.22; 50 per cent undersize at $1.17; and 60 per cent undersize at $1.29. It is quite apparent that potatoes under 1¾ inches in diameter are undesirable in the Boston wholesale market. Even a small percentage of this size evidently has a depressing effect on prices. Cars of "seconds" with 40 per cent to 60 per cent under 1¾ inches in diameter sold at only about one-half the price of cars with from none to 4 per cent of this size.

Potatoes from 1¾ inches to 2¼ inches in diameter appear to be sold readily in the Boston wholesale market without any de-

JOBBING   PRICES, FANEUIL HALL, BOSTON

BRIGHT($2.99)			
DULL ($2.66)			
0	$1.00	$2.00	$3.00

WHOLESALE   PRICES, CHARLESTOWN, MASS.

BRIGHT($2.65)			
DULL ($2.31)			
0	$1.00	$2.00	$3.00

PRICE TO SHIPPERS

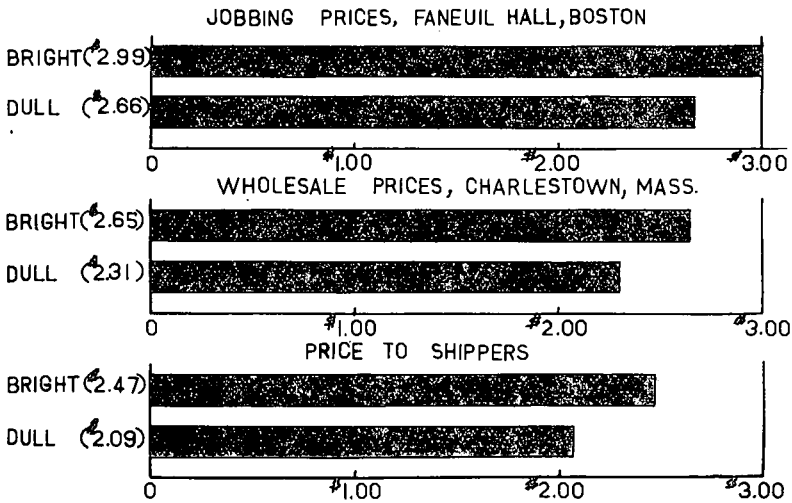|			
BRIGHT ($2.47)			
DULL ($2.09)			
0	$1.00	$2.00	$3.00

FIGURE 2.   PRICES RECEIVED IN THE BOSTON MARKET BY JOBBERS, WHOLESALERS, AND SHIPPERS FOR BRIGHT-COLORED AND FOR DULL-COLORED POTATOES

cided reduction in price except in case 40 per cent or more of the potatoes are of this small size.

The prices received in the Boston market by jobbers, wholesalers and shippers for bright potatoes as compared with prices received for dull potatoes, are shown in figure 2. The premiums paid for bright potatoes average 33 cents per hundred pounds in prices to jobbers, 34 cents in prices to wholesalers and 36 cents in prices to shippers.

Average Boston wholesale prices for cars of potatoes with varying amounts of bruises, or mechanical injury, are shown in figure 3. Cars with 1 per cent bruises sold for an average price of $2.66

per 100 pounds; 2 per cent bruises for $2.62; 3 per cent and 5 per cent bruises for $2.55; and 6 per cent to 10 per cent bruises for $2.42. Additional bruises (more than 10 per cent) caused a sharp drop in prices: 11 per cent to 20 per cent of bruises averaged only $1.81. Beyond 20 per cent of bruises causes a further moderate decline in prices; cars with 31 per cent to 60 per cent of bruises averaged $1.57.

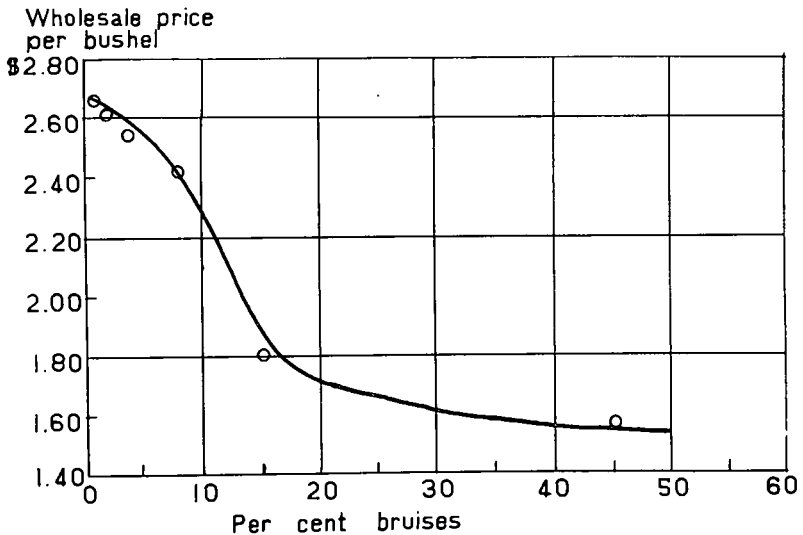It might be noted in passing that the relationship of bruises

FIGURE 3. RELATION OF THE PERCENTAGE OF POTATOES SHOWING BRUISES OR MECHANICAL INJURY AND THE CARLOT WHOLESALE PRICE PER BUSHEL IN THE BOSTON MARKET

to price is typical of relationships between most defects and prices of agricultural products. The curve is relatively flat at each end and steep in the middle indicating that the market will take a small percentage of defects at practically no reduction in price; beyond a certain point prices fall sharply with any increase in defects until a low level is reached; beyond this point further defects have little influence on prices. The shape of this curve has a decided bearing on grading policies.

The average prices received by shippers in six different producing regions in Maine and New Brunswick, Canada, compared with

the average color and the average percentage of bruises on the potatoes inspected from these regions, are shown in figure 4. Dull color and a high percentage of bruises brought low average prices in west central Aroostook and in central (or southern) Maine. High color and few bruises account for the fact that New Brunswick potatoes brought a substantial premium in the market. In general, it will be seen that the average prices received for potatoes from these six producing sections were closley related to the average color and the average per cent of bruises on the potatoes shipped from these sections. The coefficient of correlation is $R_{1.23}$ = 0.927.
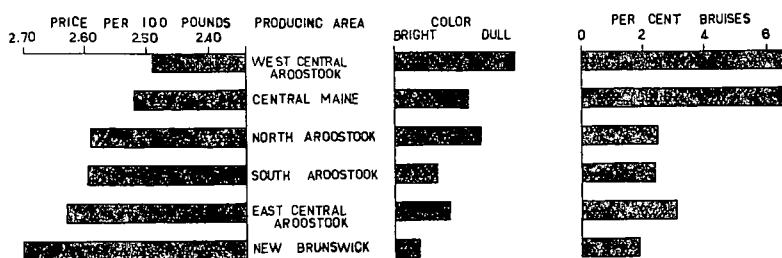

FIGURE 4. RELATION OF THE AVERAGE COLOR AND THE AVERAGE PERCENTAGE OF BRUISES OF POTATOES INSPECTED IN SIX DIFFERENT PRODUCING REGIONS, AND THE AVERAGE PRICE PER BUSHEL RECEIVED BY SHIPPERS

RESULTS OF MULTIPLE CORRELATION ANALYSIS

The next step in the analysis was to find the net relationship of a few of the more important qualities to prices. This was done by multiple correlation methods. The correlation results in the Boston wholesale market will illustrate the conclusions. The quality factors selected for analysis were:

X_2 The percentage of potatoes under $1\frac{3}{4}$ inches in diameter.

X_3 The percentage from $1\frac{3}{4}$ to $2\frac{1}{4}$ inches in diameter.

X_4 The percentage of misshapen potatoes.

X_5 Color (coded as follows: bright = 1; fairly bright = 2; dull = 5).

X_6 The percentage of bruises.

The dependent variable, X_1, was the logarithm of the wholesale price in Charlestown. The correlation is based on 596 records covering potatoes from Maine and New Brunswick, Canada.

The correlation coefficient, $R_{1.23456} = 0.938$. When corrected by B. B. Smith's formula for the number of observations and independent variables this coefficient is unchanged in the third decimal place. In this type of price analysis there is practically no limit to the possible number of observations making the results much more reliable than the results of most time series. We can certainly conclude that wholesale potato prices in Boston are highly correlated with these five qualities.

Which are the most important? The determination coefficients are as follows:

Percentage under $1\frac{3}{4}$ inches, $d_{12.3456}$ 0.290
Percentage $1\frac{3}{4}$ to $2\frac{1}{4}$ inches, $d_{13.2456}$ 0.021
Percentage misshapen, $d_{14.2356}$ 0.025
Color, $d_{15.2346}$ 0.134
Percentage of bruises, $d_{16.2345}$ 0.410
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Total, $d_{1.23456}$ 0.880

It appears that variations in the amount of bruises accounted for 41 per cent of the squared variation in prices; variations in the per cent under $1\frac{3}{4}$ inches in diameter accounted for 29 per cent; and variations in color accounted for 13 per cent. The other two qualities were relatively unimportant.

The regression coefficients show the net increase or decrease in prices which accompanied increases of one unit in each of the quality factors. In non-technical language this means the "net influence" of one per cent of undersized potatoes, bruises, and so forth, on prices.[7] These regression coefficients show that in the Boston wholesale market each one per cent of potatoes under $1\frac{3}{4}$ inches in diameter tended to be accompanied by (or caused), a drop in price of 2.67 cents per 100 pounds. Each one per cent of potatoes from $1\frac{3}{4}$ to $2\frac{1}{4}$ inches reduced prices by 0.23 cents per 100 pounds; one per cent misshapen, reduced prices by 0.46 cents; one per cent of bruises reduced prices 2.23 cents; and dull color reduced prices 23.64 cents below the price for bright color.

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[7] Since price cannot be considered as influencing quality, we can for practical purposes consider that the relationships measure the influence of quality on price.

PRACTICAL APPLICATION OF RESULTS

These results can be used in a number of practical ways which cannot be fully discussed in this paper. The most important result is to focus the attention of the grower, the shipper and the technical production expert, on certain possible improvements in the processes of production and marketing. It has, of course, always been known that bruises, small potatoes, and dull colored skin were undesirable, but no reliable, definite estimates of their influence have been available. We now know that last season these three factors accounted for 83 per cent of the variation in prices in the Boston wholesale market. It is possible to control all these factors to some extent. Particularly is it possible to reduce the percentage of bruises or mechanical injury by better methods of handling potatoes. Bruises accounted for 41 per cent of the price variation in Boston and were the most important of the qualities studied. Each one per cent of bruises reduced prices about 2¼ cents per hundred pounds. What can be done about it?

First, we must note that there is a great deal of variation in the percentage of bruises from farm to farm, from storage house to storage house, and from one producing region to another. These variations are caused both by variations in natural conditions—such as the stoniness of fields, and so forth—and also by variations in methods of digging, picking up, storing, grading and loading potatoes. The next step, therefore, is to go into the producing region and study the technique involved in reducing bruises. How can the operations of digging, picking up, storing, grading and loading be done in such a way as to result in fewer bruises? Also, how much more will these methods cost than the methods now in use? Can growers and dealers get fewer bruises by practical, inexpensive methods? These questions are being studied this fall by a survey now under way in the fields and storage houses in Maine.

The grower controls size within certain limits, both by proper production practices and by grading. The study indicates that the present minimum size for U. S. No. 1 grade (1¾ inches in diameter) is satisfactory for the Boston market, but possibly rather low for the New York market. In both markets there might be some advantage in barring from the No. 1 grade, cars with more than 25 per cent or 30 per cent under 2¼ inches in diameter.

The premium of almost 24 cents a hundred pounds for bright colored potatoes suggests the need for methods of cleaning potatoes. If such methods can be devised they are likely to be profitable.

RESULTS OF OTHER QUALITY STUDIES

The potato quality study has been discussed at some length to give an idea of the purposes, methods, and results of this type of research. Results of a few other studies might be interesting.

A study in Boston a few years ago showed that the market paid an average premium of 38½ cents a dozen bunches for each inch of green color on asparagus. This was by far the most important quality factor influencing Boston prices. Since the study was made, production experts have demonstrated methods which local growers can use to produce "long green" asparagus without great additional expense.[8] Growers in Middlesex County, Massachusetts, have during the past two years changed their production methods to take advantage of the market premium for green color.

A study of prices of hot house cucumbers indicated that the Boston market paid a high premium for long, slender cucumbers. The premium was great enough to induce growers near Dighton, Massachusetts, to adopt a new variety of cucumber and certain new production practices in order to produce the proper length and shape. These growers are now getting a substantial premium.

A study of McIntosh apple prices in Boston showed that the market paid high premiums for well-packed fruit. Apples of average quality when "jumble-packed" brought $1.95 a bushel; layer-packed brought $2.29, and wrapped layer-packed, in the northwestern apple box, brought $2.58. Such information can and is readily used by growers.

RESULTS GIVE CHECK ON GRADE REQUIREMENTS

In addition to suggesting ways in which quality may profitably be changed by production methods, studies of quality can provide a useful check on grade requirements. A set of grades for a commodity should be based on qualities which cause differences in market prices. Fancy grade should bring higher prices than No. 1;

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[8] V. A. Tiedjens, W. O. Whitcomb and R. M. Koon; Asparagus and its Culture; Mass. Extension Leaflet, No. 29, 1929.

No. 1 should sell at higher prices than No. 2, and so forth. This subject cannot be at all adequately discussed here, but it should be noted that the United States grades on asparagus and cucumbers have been improved on by local growers' associations shipping to Boston.[9] These associations have a stricter requirement on green color of asparagus and length of cucumbers than is required by the United States grades.

NEED FOR STUDY COVERING A NUMBER OF MARKETS

If such studies are to be used to best advantage as a basis for grade requirements they should be made in a number of important markets rather than in one market. Market preferences vary from city to city and it would be absurd to base a United States grade on a measurement of demand in Boston. An example of this can be seen in the demand for green color on asparagus. Boston pays a large premium for green color; the premium is small in Worcester, Massachusetts, and practically no premium for green color is paid in Springfield, Massachusetts.

Such variation in demand suggests the desirability of detailed descriptive grades in the wholesale markets which would provide in code form the essential information about the quality of potatoes, asparagus, or wheat which was to be shipped. This could easily be done in the case of commodities which are inspected at the shipping point. For example, instead of quoting a car of U. S. No. 1 potatoes, the shipper might use a code to show the color, the percent under $2\frac{1}{4}$ inches in diameter, and the percent of grade defects. The term U. S. No. 1 might be followed by the statement, "1-10-4," to indicate that the potatoes were bright; had ten percent under $2\frac{1}{4}$ inches in diameter; and four percent of grade defects. Such a code is universally used in the fertilizer business to show the constituents. It might well be adapted to a description of the quality of fruits and vegetables, cotton, wheat, or other products.

OTHER QUALITY QUESTIONS TO BE STUDIED

Many other questions concerning price differentials paid for quality deserve some study. It would be desirable to study the

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[9] Mr. Olsen in his talk on Monday evening clearly brought out the relationship of studies of market preferences to grade requirements.

variations in such premiums, not only geographically—from one market to another—but historically, *i.e.,* from week to week and from one season to another. These differentials change with the size and quality of the crop and also with the strength or weakness of the market. In general, dealers are more particular in their preferences when prices are falling than when prices are rising.

The premiums paid for quality also vary a great deal in some cases at different stages in the marketing process. The farmer who sells eggs to the country store, in many cases, gets the going price for eggs, regardless of the quality of his own product, in spite of the fact that when his eggs are sent to the terminal market in the city their price will depend a great deal on how they "candle out." Campbell and Youngblood, in the studies previously mentioned, find that in many cases the cotton grower gets only a small premium for quality in spite of substantial premiums in the central markets.

In the case of the potato quality study mentioned above, the quality of the potatoes has been correlated with the jobbing prices, wholesale prices and prices to the shipper. The results show that in this case the premiums paid in the city markets are reflected back almost fully in the prices returned to shippers. However, no information is available concerning the prices which the shipper pays to the farmer.

Studies of the variation in price differentials for quality at different stages of the marketing process are very important from the growers' point of view. It is not enough for us to demonstrate that the city market pays a premium for high quality food products. Unless the farmer himself gets a premium for producing and marketing products of high quality, he will not be particularly interested in trying to meet the demands of the market. Any system of marketing which pays the farmer a flat price for his commodities regardless of quality, is a poor system.

An aspect of quality which deserves the careful study of the home economist is the relation of market price differentials to "use value," or cooking value. To what extent do market premiums reflect superior qualities of economy in preparation, of taste, of consistency, or other factors representing basic differences in the adaptability of the commodity for consumption? The home

economic department of the University of Maine is making such a study of potatoes to determine the relation of size, shape, defects, and so forth, to both the waste in paring potatoes and the quality of the cooked product.[10]

Before concluding this discussion it might be well for us to note that the distinction between the words "qualitative" and "quantitative" have led many people to think of quality as an indefinite, unmeasurable factor. The fact is, I believe, that all qualities of commodities are tangible, measurable—and, if you please, quantitative factors. Size, shape, weight, color, percentages of defects and many other qualities are easily measured. Mr. Olsen has described measurements of moisture content, sugar content, firmness and other qualities harder to measure. It is possible now to describe almost all qualities in accurate terms. Among the few exceptions—so far as I know—are taste and smell. Even these seemingly intangible qualities must be determined by definite factors such as chemical composition and consistency.[11]

While it may be difficult to find methods of measuring some of these factors in ways simple enough to use in the field or in the market, methods for use in the laboratory should be possible. Meanwhile, before field methods are developed, it is comforting to know that inspectors can be trained to agree almost perfectly with one another in scoring commodities according to taste. Butter graders have standardized the description of taste to a remarkable degree.

CONCLUSIONS

In conclusion we can fairly state that careful studies of price premiums or price differentials paid for quality can give results which are practical and useful. When coordinated with studies of methods of production, harvesting, grading and marketing, they offer a necessary basis for adjusting the quality of production to market demand. In addition to answering such practical questions, I believe such studies can throw some much-needed light

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[10] While no results of this study have yet been published, a preliminary report is being prepared on the first phase. The title is "A Study of Factors Contributing to Culinary Waste of Maine Potatoes on the Boston Market" by Myrtle Walker Dow, University of Maine, 1930.

[11] Since writing this statement I find that classifications of both taste and odor have been proposed and the classification of odor has been used in quantitative measurements of perfumes.

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on price theory. The theory of value almost disregards quality by treating different qualities of potatoes, shoes or automobiles as separate and distinct commodities. In the case of many farm products, the variation in quality is so great as to be more important than variations in supply and demand conditions from time to time. Yet, we have a price theory largely in terms of changes in these supply and demand conditions and practically no knowledge of the relation of prices to quality. A more useful price theory would be one which accounted for the joint influence of time factors, geographical factors and quality factors. This would be, in effect, a four dimensional analysis with time, place and quality three independent variables at right angles with one another, jointly determining prices.