QUALITY CONTROL IN SOUR CHERRY PROCESSSING PLANTS

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By

Donald G. Gillette

A THESIS

Submitted to the College of Agriculture
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The responsibility for any errors that remain in the final manuscript is assumed by the author.

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AN ABSTRACT

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ABSTRACT

The objectives of this study were (1) to analyze and evaluate the present techniques of quality control in sour cherry processing plants, (2) to examine those factors that influence quality, and, (3) to develop application of currently existing statistical techniques of quality control to the cherry processing industry.

Thirty-eight sour cherry processing plants in Michigan were surveyed during the 1955 cherry pack operations. Questionnaires and plant observations provided information in which to evaluate those factors which might influence quality. Raw product and processed product inspection records were obtained from governmental agencies to analyze the quality received and processed at different plants.

The study revealed that there were considerable differences between processors in relation to their attitudes toward quality control and maintenance programs. Many processors attempt to improve the quality that is received by conducting grower meetings, using quality payment plans and employing fieldmen. An attempt to evaluate the effect of these factors on the quality received was unsuccessful. In the processing plants considerable differences exist between the number of sorters placed on inspection belts, receiving, handling, process equipment and inspection methods. Sorting labor varied from 1.3 to 6.7 sorters per thousand pounds of fruit going over belts in an hour. Time studies also indicate that there is considerable difference in pickout among sorters.

Medium sized growers usually delivered higher quality fruit to the processor than did the larger or smaller sized growers. Those growers who did deliver high quality reduced their defects by having less defects over which they had some control.

The raw product quality received by plants varied considerably from one day to another. Windwhip, scars and undercolor were the more important defects influencing the raw product quality.

The grade of the raw product appeared to be a poor index of the finished product grade because of the different quality characteristics used in grading the two products.

The probability of a sample reflecting the actual grade or quality of a lot can be determined by an operating characteristic curve. The increase in reliability that can be obtained by increasing the size of the sample may be revealed with this statistical tool.

Quality control charts are decision making tools for management to use in adjusting and allocating resources. The control charts described herein are somewhat unique to the general concept of control charts. Moving average control limits provide the necessary flexibility needed by food processing industries that must allow for seasonal quality changes for those factors over which the plant has little control.

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CHAPTER I

INTRODUCTION

Quality Standards and Differences

The emphasis placed on quality control and improvement varies widely among plants processing amd marketing Michigan red sour cherries. Many packers concentrate on quantity production at the lowest possible cost. This often means packing a lower quality and selling at a lower price. Other packers attempt to build a high quality reputation for their business in an effort to increase sales and maintain steady outlets for their product.

Improving the quality of the finished product starts before the raw product reaches the plant. Grower education through fieldmen, grower meetings, mail contacts and other services are used to help the grower produce better quality than he would otherwise produce. Payment plans that offer premiums or discounts are used to provide the grower with an incentive to improve quality. New methods of transporting the cherries from the orchard or receiving stations to the plants are being attempted by many plants or growers in order to maintain incoming quality.

From the time sour cherries are received at the plant, many steps occur in which the quality of the product can be either improved or lowered. Improper receiving and handling methods may cause bruising, extremely long soaking periods may cause water scald, and improper mechanical equipment may cause unnecessary quality deterioration. Poor working conditions, too few sorters on the belts, lack of supervision and poor inspection procedures all may result in inadequate quality maintenance.

Wide differences exist between plants in relation to the means by which they attempt to improve and maintain quality. Many of the larger plants hire specialized personnel for quality control work. Smaller plants are usually much more limited in quality control programs because of the lack of specialized personnel.

Extreme differences in methods of quality maintenance and control exist in plants of equal size. Lack of management ingenuity and unwillingness or inability to acquire capital or belief that their plant is already operating very economically and efficiently may be a few of many factors that delay possible plant improvements. Some managers appear to be aggressive in developing and using new techniques to improve quality. Other managers are slow in adjusting to the changing times and the new technologies that become available. New equipment that will improve quality control or maintenance is often disregarded by the processor because of price uncertainty for his products or because a shortage of capital prevents making the investment required. Other managers are unwilling to admit that their plant operations can be improved.

Economics of Quality Control

Business firms often can increase sales without lowering price, either by altering the buyers attitude toward the product, or by modifying the product so that it conforms more closely to what the buyer wants. Sales promotion and advertising are the common means for changing the buyers attitude toward a product. Product modification generally involves making changes in some observable characteristic of either the product or the container, or a change in the service associated with the product. Sales based on maintained quality calls for brands as a means of identification to guide the consumers. In the processing industry quality-brand buyers will be attracted to those plants which have gained a reputation for packing a quality product.

The word quality can be defined in very broad terms or in more specific terms. Abbott defines quality as "any or all of the various qualitative characteristics of a physical product or service or combination of the two offered for sale."[1] In this context quality means any characteristic of a product that might affect the price that a buyer is willing to pay or the quantity he will take at a given price. Frank Knight writes:

> "If people are willing to pay for "Sunny Jim" poetry and "It floats" when they buy cereal and soap, then these wares are economic goods. If a name on a fountain pen or safety razor enables it to sell at a fifty percent higher price than the same article would ordinarily fetch, then the name represents one third of the economic utility in the article, and is economically no different from its color or design or the quality of the point or the cutting edge or any other quality which makes it useful or appealing."[2]

Quality as used in this thesis is restricted to those characteristics of the raw and processed contents in the container that influence the demand curve facing the firm. Quality will refer to the color and appearance, size and shape, uniformity and flaws in the raw and the processed cherries. Drained weight and fill weights are also

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[1] L. Abbott, Quality and Competition, Columbia University Press, New York, 1955, p. 4.

[2] F. H. Knight, Risk Uncertainty and Profit, Houghton Mifflin Company, New York, 1921, p. 262.

to be considered as quality factors.

Many producers desire to improve their positions in the markets and do so by taking independent action to modify the quality of their respective products. Quality may be improved or lowered, depending upon the kind and amount of resources used in processing and handling. The grower may employ pickers who "strip" trees rather than picking the cherries selectively. One processor may have only two sorters for every thousand pounds of cherries passing over the inspection belts in an hour while another processor receiving identical quality fruit may have six sorters per thousand pounds.

Quality improvement usually involves a greater utilization of resources and this usually means a greater cost. The additional resources used in improving quality must be paid for and therefore the processor believes he should have a higher price for his product. Several packers stated that they were not attempting to pack A grade because the price differential between A and C grades is not ordinarily great enough to warrant these additional costs.

Quality competition may prove to be more effective than price competition in increasing the sales of a firm. Ability to sell the cherry pack the same year it is produced is often very important to small processors. The need for money to meet current operating expenses may involve costly loans and storage unless the processed product is sold immediately. By maintaining quality product standards a processor helps assure an outlet for his product even in years when part of the total pack is carried over.

The benefits of quality control are often hard to measure in monetary terms. Decisions involving quality are often made on an intuitive basis without attempting to measure the result in dollars and cents. In making economic studies to guide decisions as related to quality, Grant divides the influencing costs into production, acceptance, and unsatisfactory product costs.[3] Production costs refer to those costs involved in the production of the product under consideration. The different amounts of labor requirements etc., to bring the raw product up to a given quality. Acceptance costs refer to the testing and inspection costs and the costs for administering the acceptance program. Raw product and finished product inspection costs are included in this classification. Unsatisfactory product costs refers to the costs incurred for accepting a product that turns out to be unsatisfactory for the intended purpose. These costs can be incurred by obtaining raw product quality that is below acceptable quality standards and by lossing sales because of selling products that are not of acceptable quality to the purchaser.

Many of the costs of quality control are incurred either to correct mistakes or to police them. High costs of increased inspection, processing losses, and unsatisfactory product may be substantially reduced by an effective program of statistical quality control. In the cherry processing industry, for example, plant or government regulations may require that all or some specified percentage of the processed product contain a stipulated weight. Most of the processors interviewed indicated that they overfilled containers to avoid trouble with regulatory agencies and to guard against unsatisfactory buyer acceptances.

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[3] E. L. Grant, Statistical Quality Control, McGraw-Hill Book Company Inc., New York, 1952, pp. 442-443.

The resulting average overfill may often prove to be an expensive insurance cost to the processor. For an example, assume that a plant is packing #10 cans and the buyer specifies 108 net ounces per can and the packer attempts to maintain a 2% overfill. Quality control techniques may show that little variation exists in can fill and the 2% overfill is excessive. At 10¢ per pound for fresh cherries, the reduction of 2% on the fill weight of a thousand cases of #10 cans will result in a savings of about $60.00.[4]

Quality control techniques and procedures may be extremely useful in making decisions on the quality levels to be maintained. The primary purpose of the control chart is to improve decision making. Control charts not only show where quality improvements can be made, but also show where reduction in quality levels may be desirable. If quality is extremely high it may not pay to allocate as large a quantity of resources to quality maintenance. If the quality level is extremely low, more resources may be needed to improve quality. Statistical quality control is a tool to aid the packer in making these economic decisions.

Quality control and maintenance is a subject of increasing importance in the food processing industry. State and regional conferences and clinics and trade journals are emphasizing quality as a means of increasing sales.[5]

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[4]Assuming that 120 cherries = 1 lb and a #10 can weighing 108 oz. contains 700 cherries by count.

[5]W. A. Gould, Quality Emphasized at State Meeting, Food Packers, March 1955, pp. 44-46.

In Michigan the cherry processing industry has become increasingly concerned with quality maintenance and improvement. Increased cherry production has brought the need for increased sales and many packers are looking toward quality improvement and the development of new cherry products to absorb the expected additional output.

Objectives of this Study

Because of the importance of the cherry processing industry in Michigan and the interest in quality control, the objectives of this thesis are as follows:

1. Determination of the change in product quality during the processing operation: Raw product quality received by plants will be compared with the quality of the resulting processed product.

2. Determination of the accuracy of current quality measurement techniques: Analysis of the current inspection procedures used by different plants and development of operating characteristic curves for different sampling plans.

3. Evaluation of in-plant operating practices which effect product quality: Receiving and handling methods, inspection and sorting rates, machinery and equipment, quality/quantity flow adjustments, and actions of supervisory personnel, etc.

4. Evaluation of factors influencing the quality of raw product received: Inspection procedures, locational influences, payment programs, educational programs and size of grower.

5. Evaluation of between plant quality variations: Size of grower, seasonal and daily quality variations, importance of specific defects, and transportation and handling methods.

6. <u>Application of control charts to quality maintenance</u>: Evaluation of the quality control technique. Application of this technique to a typical cherry product. Usefulness of this tool in the processing operation.

CHAPTER II

SCOPE AND SOURCE OF DATA

Scope

Data for this study were obtained through a survey of 38 sour cherry processing plants in Michigan. Most of these plants were visited twice; first for an interview with the plant manager, and second, for a visual inspection of the plant while processing the cherry pack. The reason for two visits were: (1) for a more complete interview with the manager before he became too involved in the processing operation, and (2) to hasten the visits when the processing season once got underway. Regardless of this precaution, several plants were not seen in operation because of the short processing season that occurred in many areas in 1955.

The processing plants included in this survey are located in twelve western Michigan counties (Figure I). Of the 38 plants, 26 were inspected while in operation. The output from these plants represented over 95% of the total tonnage of sour cherries canned or frozen in Michigan.

Data Gathered

Different types of questionnaires were used depending on whether the plant used government inspection services or maintained its own inspection service. The questionnaire for plants without continuous inspection contained more detailed questions referring to inspection procedures. The survey included eleven plants with continuous-in plant

Location of Cherry Processing Plants Included in Survey

FIGURE I

government inspection and twenty-seven plants without this service.

The purpose of the visual inspection was to observe the processing operations of each plant in order to make between plant comparisons. Time studies were made on the rate of pick out from the sorting belts and the volume passing over these belts. Information was gathered as to the types of equipment used and the labor used in maintaining quality.

Raw product inspection records were obtained on all sour cherries that went into processing plants in Michigan during the 1955 cherry season. Michigan law requires that all cherries to be processed must be inspected by the federal-state inspection service. The records obtained from the inspection service included: (1) name of the grower, (2) name of the inspector, (3) processing plant, (4) location of inspection, (5) date of delivery, (6) size of load, (7) size of sample taken, (8) specific defects, and (9) the grade and score of the lot.

Permission was obtained from several plants, which maintained government inspection service to obtain data from finished product inspection records which are on file in the Detroit office of the Processed Fruit and Vegetable Division of the USDA. Information contained on these records included grades on lots and individual samples, net and drained weights, vacuum and head space, the name of the inspector and the date and time the samples were drawn. The points system as used in determining grades of the processed product was also contained on these records. The importance of color character and defects in determining the processed product grade was noted by the relative weighing of these points.

Sampling Procedure

Raw product records were analyzed by taking 100 samples from all inspectors at each inspection point. These samples were used to determine the average quality raw product going into each of the plants and regional and local differences. All of the raw product records from three plants were analyzed to determine the extent of variation between growers and to provide data for determining the correlation between the quality of raw product received and the finished product which was produced. These records also provided information on the day to day variations in quality of the raw product received.

Final inspection records were obtained on three plants. All of the records available from these three plants for the 1955 pack were used to determine quality improvement. Probable grades were also obtained on most of the processed product from the three plants. Probable grades are taken immediately after packing while the final grade is taken after the product has been in storage for a period of time.

Limitations of Study

The material contained in this thesis provides the researcher with a good background for further study of quality maintenance in the sour cherry processing industry. General comparisons are made of the individual plants in the cherry processing industry. More detailed comparisons were made of three of these plants. The information contained in this paper does not provide a detailed comparison study of all factors that would affect quality maintenance. More detailed study of in-plant and producer oriented quality maintenance is needed of plants in the industry.

Much of the information obtained in the questionnaire and in the plant observation is subjective. It is highly probable that many managers over-emphasized their quality maintenance operations while other managers may have underestimated theirs. Opinions formed by the author were affected by not only the interview with the manager but also by the observation of the plant operations. Most plants were observed for about two hours. This provided information only as to major differences in operational methods that might affect quality. The time studies taken of sorters on the sorting belt to determine the rate of pick out was affected by the volume and quality passing over the sorting tables at the time the observations were made. The way the plant was operating during the short period of observation in some cases may not represent an accurate picture of its usual operations. A more detailed study of these plants would provide this information.

Quality improvement as measured by the change from the raw to the finished product is difficult to measure because of the dissimilarity of the factors determining the raw product score and the factors determining the processed product score. The probability of error that is inherent in sampling provides the basis for further questioning as to the reliability of this measurement of quality improvement. Records were not obtainable on all of the finished product inspections for those plants in which quality improvement was measured. This often resulted in only a small proportion of the finished product being compared to the raw product scores.

Quality control techniques that are presented in this thesis can be used by all processing plants. Sampling is as much a part of this technique as the actual control technique. These tools tell management when adjustments are needed to improve or maintain quality. Quality control technique is merely a guide to be used in operations. The adjustment must be made by management.

CHAPTER III

THE CHERRY INDUSTRY

The purpose of this chapter is to develop an understanding of the industry in which the quality problem will be discussed. A knowledge of the characteristics of the processing industry is essential to the understanding of the quality problem. The types of cherry products produced and their outlets are additional background information that will prove to be useful.

Inspection and Quality Standards are contained in the latter part of this chapter. This material is necessary in developing the quality control problem in later chapters. The attitudes and opinions of the processors toward the present inspection and quality standards of both raw and processed cherries are discussed briefly.

Importance of the Industry

From 1950 to 1955, 60% of the total red cherry crop of the United States has been produced in Michigan. The Michigan Department of Agriculture predicts that from 1955 to 1961 this state will increase the number of red cherry trees planted by 28%.[1] Based on normal expected yields per tree, the state crop is expected to total approximately 100,000 tons by 1961. Any substantial change in production technology can by expected to boost this production still higher.

The red cherry industry has become localized and specialized

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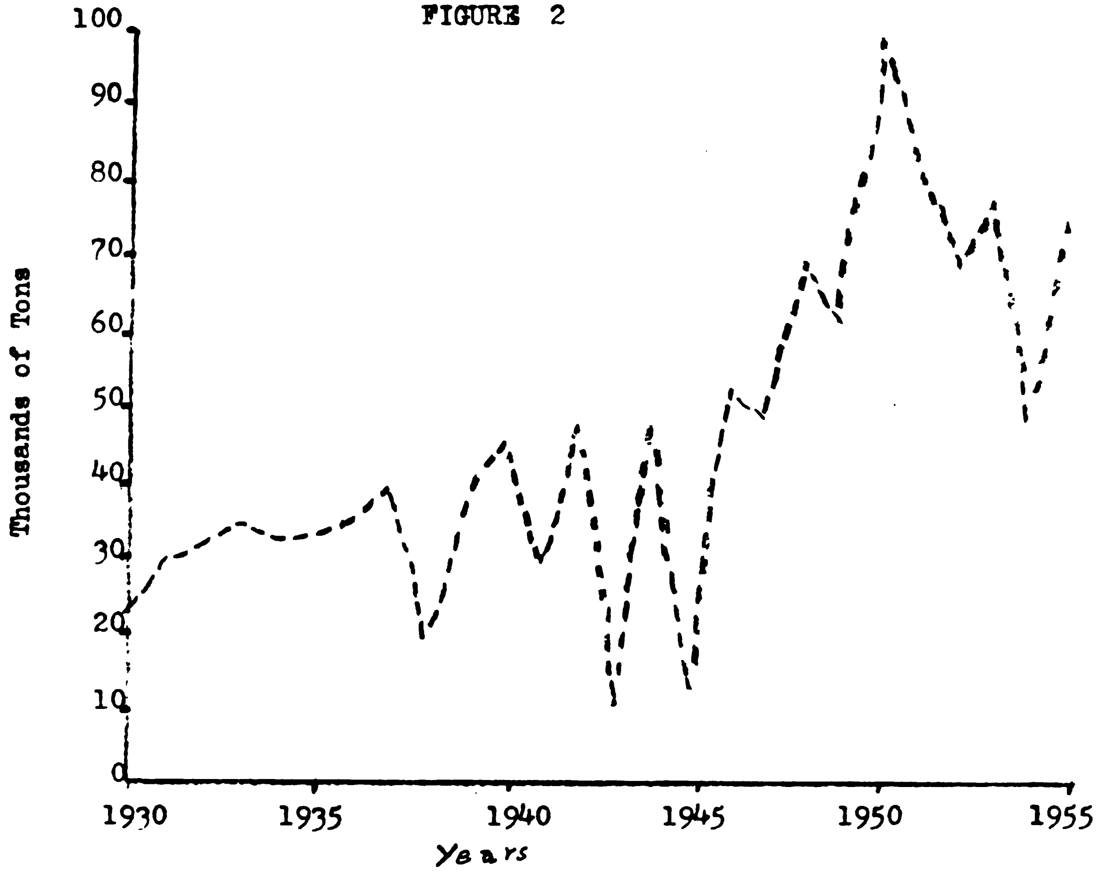
[1]This estimate was based on a cherry tree planting survey made by the Michigan Federal State Crop Reporting Service in 1955.

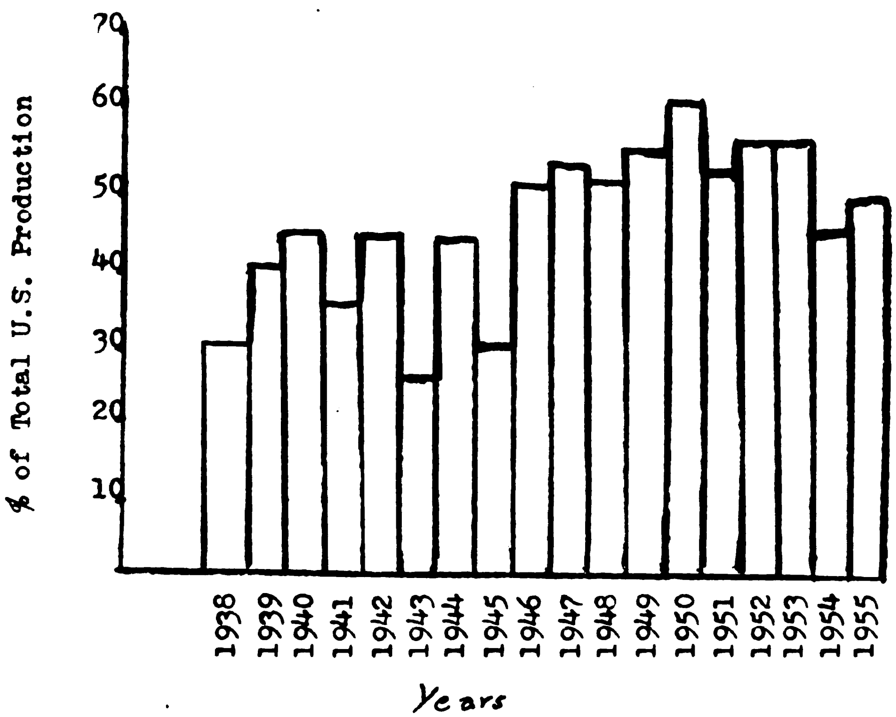
Red Cherry Production in Michigan
1930 - 1955

FIGURE 2



Red Cherries - Michigan's Share of U.S. Production
1938 - 1955

FIGURE 3



through time. In Michigan the major producing areas are concentrated along the shores of Lake Michigan. The economic activity of many communities are heavily dependent upon this industry.

The 1949 cherry survey estimated that there are about 4,000 commercial cherry growers in Michigan.[2] The large commercial cherry growers are concentrated in the northwest and central west districts in the state. The average orchard size in the northwest district is 1,150 trees as compared with an average of 350 trees per orchard in the southwest district of the state. The southwest district has much more diversified fruit and vegetable farming than the central and northwest districts and is therefore, not as dependent upon the cherry market.

The Processing Industry

In 1955 there were 41 firms or 44 plants engaged in the canning and freezing of red sour cherries in Michigan. Seven of these firms processed over half of the quantity produced in the state. The smaller plants are concentrated in the southern part of the state.. Twelve plants are located in the northern district, twelve in the central district and twenty in the southern district. (See figure I.)

Those plants surveyed varied in the number of years that they had been processing from 2 to 78 years. Of the thirty-eight firms surveyed, thirty-two are corporations, three are cooperatives, two are single owners and one is a partnership. Management in the processing industry appeared to have little turnover. Twenty-two of the managers contacted have served in this capacity since the origination of their

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[2]Michigan Federal-State Crop Reporting Survey, 1949.

processing plants.

Along with the increase in production of red sour cherries there has been a small amount of expansion in the size of processing plants. Boger points out that there has been a tendency for the range in the relative size of individual firms to become smaller.[3] Because of erratic crop conditions due to frost, hail, windwhip, etc., many processors have not expanded their plant size. One year a processor may lack adequate facilities to handle the crop and is forced to operate 24-hours a day. The next year this same processor may need only a skeleton crew to handle the cherries that are brought to his plant from the surrounding area. In 1955, two plants that ordinarily process red cherries did not operate because of the poor cherry crop in their area. Other plants reduced their red cherry processing time from the normal four week period to less than two weeks because of the poor quality that was to be had.

Over 90 per cent of the sour cherries produced in Michigan are processed. This emphasizes the importance of the cherry processing industry as a market for the growers product. To help insure an adequate supply some plants in the state receive and deliver the raw cherries to their plant from receiving stations over 100 miles away. In years of extremely good yields these processing plants help to relieve the surplus problem in areas where the local processing plants cannot take care of the crop. During 1955, some plants that were in the midst of a large crop area contracted with other plants to take some of

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[3] L. L. Boger, Michigan Red Cherry Prices, Special Bulletin 371, Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, 1951, p. 14.

their growers cherries.

The southern plants generally haul from distant receiving stations or plants because of the desire to extend their processing season once they have the labor available and the plant organized for cherry processing. The desire to extend the processing season may also depend on what other crops the particular plant may plan to process. In most cases it can be said that the red sour cherry is the main processing crop for the plant though it is much more important to northern plants than to southern plants.

Cherry Products Produced

The cherry processing plants in Michigan can be classified according to the kind of pack produced. Of the 38 plants surveyed twenty plants produced both hot and cold packs, eleven produced hot pack only and seven produced cold pack only.[4] Many of the newer plants in the industry tend to specialize in coldpack operations. In 1935 the percentage of the total pack frozen in Michigan was less than 10 percent. In 1955 30 percent of the total cherry pack was frozen. Even though the expectations of some individuals have not been realized, the coldpack has increased in importance as a method of marketing and processing the cherry crop.

Canned cherries are generally packed in No. 10, No. 2, and No. 303 containers. The No. 10 can is a larger container that is used in the institutional trade. The No. 2 and No. 303 cans are consumer sized for

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[4]Hotpacking is commonly referred to as canning. It is a heat treatment process in which the contents in a container are cooked. Coldpacking refers to the process of freezing the contents in the container.

distribution in the retail channels. Michigan processors have canned about 69 per cent of the actual cases of red sour cherries since 1945.[5]

Coldpack cherries have been directed primarily toward the institutional trade. The large 30 lb. tins is the most common size used. Fifteen pound tins and two pound cans are also used as containers for cold packing by some plants. The lack of cold storage facilities and the cost of acquiring these facilities has definitely been an inhibiting factor on the expansion of the cold pack market.

New red cherry products are being introduced by the industry in order to further stimulate demand. Syrup packs are being put out by several plants in both hot and cold packs. In addition to taking advantage of lower drained weight requirements for syrup packs, the processors hope that the consumers will find the pack more useful for purposes other than baked pies. Cherry products are being developed and promoted by the National Red Cherry Institute for desserts, toppings, jams, jellies and sauces. With the expanding production, there comes the need for expanding demand.

Market Outlets

Processing plants sell their finished product either through brokers or direct to buyers. In analyzing the sales of twenty-seven plants, it was found that two-thirds of the sales are made through brokers and one-third of the sales are made direct. A greater percentage of the cold pack sales were made direct than were the hot pack sales.

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5 ________________________, Canned Food Pack Statistics, 1955, National Canner's Association, Washington, D. C., June 1956.

No consistancy was found in the type of sales made by the various plants. Some plants sold their entire pack direct while others sold their entire pack through brokers.

Cherry buyers in order of importance are wholesale houses, food processors, chain stores, institutions, and the government. Regardless of whether these sales are made direct or through brokers their relative importance as sale outlets remained the same except for the government and institutional sales.

TABLE I

Analysis of Cherry Pack Sales[6] (1954) 27 Plants

Hot & Cold Pack	% of Sales	%Chain	%Whole sale	%Govt.	%Inst.	%Food Proc.
Direct	32	20	42	6	5	27
Broker	68	15	43	2	7	33
All Sales	100	16.6	42.7	3.3	6.3	31.1
Cold Pack						
Direct	40	5	31.0		7	57
Broker	60	1	9.0	2	8.8	69.6
Cold Pack Sales	100	2.6	17.8	1.2	8.8	69.6
Hot Pack						
Direct	29	34	47	11	2	6
Broker	71	24	67		9	3
Hot Pack Sales	100	26.9	61.2	3.2	4.8	3.0

Cold pack sales are mainly to food processors while most hot pack sales are to the retail trade either through wholesale houses or chain stores. A considerable volume of the cold pack tins are sold directly to consumers by many of the smaller processing plants. The smaller sized containers of either the hot pack or the cold pack are sold to wholesale houses or chain stores. The larger sized containers are sold to government agencies, institutions or food processors.

[6] These percentages represent average percents of the sales of 27 plants and not the percent of total pack sales for the packs.

The average sour cherry processing plant sells 84 percent of its cherry products to the same buyer year after year. At the extremes one plant sold only 50% of its products to the same buyers and two plants sold their entire output to the same buyer year after year. No relationship was apparent either between the percentage of steady customers or the type of outlets for an individual processor and the quality maintenance program used.

Inspection and Quality Standards

Raw product cherries that are to be processed must be inspected by the Federal-State Inspection Service.[7] Under a cooperative arrangement the inspectors are hired by the state and work under the supervision of the United States Department of Agriculture. The inspector's report shows the percentage U.S. No. 1 grade cherries, percentage No. 1 Michigan Revised grade standards and the specific defects found in the sample.[8] Samples are supposed to be drawn randomly so that the quality of the sample will be as closely representative of the quality of the growers load as possible. Usually a 500 gram or 1 lb. sample is drawn and the score is determined by weighing the defects.

The Michigan revised standard is used to determine the acceptability of a given lot for processing. In Michigan no plant is allowed to process

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[7] In 1955 the Federal-State Inspection Service maintained 108 inspection points and 100 inspectors in Michigan for the inspection of sour cherries.

[8] Standards for Red Sour Cherries for Manufacturers. U.S.D.A. P.M.A. (Effective April 20, 1941.)

Michigan revised standards are identical to U.S. Standards except for the exclusion of the specific defects of lugscald, stems, undersize and under color.

sour cherries that grade below 88 score.[9] Most cherries that grade below this score are used for juice. The U. S. Standards are used by many processors as a basis of payment for quality.

Many plant managers reported that they were dissatisfied with the sampling done on the growers loads to determine its grade. Some felt that it is economically impossible to arrive at an accurate grade on these loads. Other packers voiced much concern over the growers practice of taking cherries that were turned down for processing at one plant to another plant where they were accepted.

About half of the processors said that the Michigan revised standards are too low. The processors stated that the omission of color, under-size, lugscald and stems from this standard encouraged poor harvesting and handling practices on the part of the grower. Processors argued that the standards used on finished products did not exclude those factors which are excluded in the raw product, and thus, the special concessions given to the raw product standards are not justified.

The registration of complaints by plant managers against the omission of quality factors in the revised standards are as follows: Color 21, size 12, lugscald 14, stems 14, sugar content 2, and other 2. Undercolor and sugar content are in most cases the results of immature fruit. Many growers picked their fruit as early as possible to reduce the danger of windstorms or hail damage and as a result packing began with under ripe fruit. This resulted in lower drained weights, smaller cherries and poorer color in the processed product.

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[9] Special permission was given to process sour cherries in 1955 that graded below 88 providing they brought this grade up to 88 on the sorting belts.

The finished product is inspected either by government inspectors or plant inspectors. The U.S.D.A. furnishes the food processing industry with inspectors who are allowed to certify the quality of the product according to U.S. Standards.[10] This service is open to all plants who apply and meet the requirements that are set.[11] Plant inspectors do not certify the quality of the finished product but in most cases furnish the plant with reliable records as to the quality of certain lots.

The U.S.D.A. provides inspection procedures which inspectors must follow in performing their duties. Many plant inspectors remove samples from the processing line at certain time intervals rather than basing their sampling on quantity rates. The minimum sampling rates of the Agricultural Marketing Service, however, provides a fairly close approximation of the sampling done by most plants.[12]

In the grading of the finished product on cherries the scoring system shown on the following page is used. This system helps in determing the grade by giving respective ratings of the factors color, defects and character in addition to the other requirements (such as size) as defined in the grades. These factors and their relative importance in determining the grade expressed numerically in the chart on the following page.

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[10] U.S. Standards for Grades of Frozen and Canned Red Sour (tart) Pitted Cherries (CFR Section 52. 242). (CFR Section 52. 241.)

[11] U.S.D.A. P.M.A. Questions and answers on Government Inspection of Inspection of Processed Fruits and Vegetables.

[12] Agricultural Marketing Service Standards Inspection Marketing Practices. Department of Agriculture Public Law 156, 83rd Congress. Approximately July 28, 1953, p. 5.

TABLE II

Score Chart for Canned or Frozen Sour Pitted Cherries

Factors	Max. Pts.	Gd. A Fancy	Gd. C. Stand.	Gd. D Substand.
Color	20	17-20	14-16	0-13
Defects	40	34-40	28-33	0-27
Character	40	34-40	28-33	0-27
Minimum Score		85	70	

The total number of points that can be scored for any lot is 100. If any of the three factors fall into a lower grade based on the above points system then the grade for that product will be the lower grade regardless of the total score.

In addition to grade specifications, the standards for the canned product contain recommended brix measurements for syrup packs and drained weights. Neither one of these factors are incorporated in the grades of the finished product and are not considered as being factors of quality for the purpose of these grades. Most packers, however, follow the recommendations for drained weight, fill weight and syrup content provided in the Canning Trade Almanac.[13]

All sour cherry processing plants use the U.S. Standards for inspecting and grading their finished products. These standards provide the cherry packing industry with a yardstick with which they can compare and measure the quality of their product. Grade certification of the finished product by governmental inspectors has been of great assistance in the financing, storing and marketing of the cherry pack.

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[13] Canning Trade Almanac is compiled and published each year by the Canning Trade, a weekly business journal of the canning and allied industries.

Wholesale, institutional, chainstores and other buyers frequently demand products that have been graded according to the U. S. Standards to enable them to purchase the quality of pack desired.

In Michigan, eleven sour cherry processing firms acquired government inspection service for continuous or in-plant inspection in 1955.[14] Fifty per cent of the firms which did not have continuous or in-plant inspection indicated a desire to have such service either now or in the near future. These firms gave the following reasons for not having this service at the present time:

1. Cost
2. Size of Operation
3. Viewpoint Differences
4. Type of Outlet
5. Unavailable at Time of Application

Cost and size of operation were the most common reasons given by processors for not having government inspection. Viewpoint differences were mainly related to the lack of appreciation by government inspectors, for the costs and value of volume in gaining a favorable cost of production. Many plant managers felt that they could better manage the quality of their products by maintaining their own quality control personnel. Some plants did not use government inspectors because their customers did not request government certification.

Some managers in the packing industry are discontented with the present standards used in grading the processed pack. The majority of the comments received indicated that they thought that the present standards were too low. The most common comments were those relating to the need for drained weight requirements on the cold pack, need for

[14] Continuous - Inspection covering every phase of processing operations.
In-plant - Inspection on only the finished product.

a grade B in the standards and the allowance of too many defects in A grade. Many canners believe that government grades do not conform to the trade practice and are too stiff in the top grade. At a meeting of the Michigan Canners Association one cherry packer commented that "There is no such thing as a fancy grade cherry pack under the standards as set up. It is impossible to segregate sufficient unblemished fruit to meet the restrictions. Since there is no intermediate grade, the result is that practically all cherries become Grade C."[15]

Many of the processors who complained about the grades did not suggest ways in which they could be improved. Some canners were concerned with the variations in human judgment of such things as color and character.[16] Several people suggested the use of color charts. Drained weights on cold packs are extremely hard to obtain because of the need for a uniform temperature and time period for thawing before the check can be taken.

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[15] "Are U.S. Canned Food Grades Commercially Suitable ?" The Food Packer, December 1943, p. 719.

[16] The research branch of the U.S.D.A. has undertaken research on the measurement and specification of color as a factor of quality with the use of photoelectric instruments. See The Measurement and Specification of Color by B. A. Brice. Eastern Utilization Research Branch, U.S.D.A.

CHAPTER IV

FACTORS INFLUENCING RAW PRODUCT QUALITY

Raw product quality varies considerably between growers, between plants and between days. Many factors contribute to these variations. Many processors attempt to influence grower harvesting and production practices through educational programs and payment plans. Transportation and handling practices affect quality levels. Grower size and attitudes influence raw product quality. Such non-controllable factors as weather conditions or locational influences are also important. This chapter is an attempt to evaluate these factors.

The first part of the chapter is concerned with general comparisons between plants. Transportation and handling methods, raw product inspection methods, locational influences, payment plans and educational programs are considered in this section.

The second part of the chapter consists of a three plant analysis in which seasonal and daily quality variations, grower differences and specific defect differences are computed. Seasonal and daily quality variations are figured and compared for three different plants in ~~different plants in~~ different areas. Controllable and non-controllable defects are related to high, low, and medium quality growers at each of the three plants. Grower size is related to quality at five different plants. The importance of specific defects in determining raw product quality is correlated between three plants.

GENERAL ANALYSIS

Transportation and Handling Methods

Proper transportation methods and careful handling practices are important factors in preserving the quality of the raw product. The red cherry is a delicate fruit and bruises easily. Unnecessary handling and poor transportation methods should if possible be eliminated and better handling and transportation practices adopted.

Some plants in the state receive most of their raw product from local growers within a 10 mile radius. Other plants receive their raw product from growers over 100 miles away. The distance that must be traveled in order to deliver cherries to a plant has a great influence on the quality that will be delivered. Over 60 per cent of the processing plants interviewed maintained distant receiving stations for cherries. About 75 per cent of these processors stated that they received poorer quality from this source.

Cherries are usually transported from the orchard to the receiving station or processing plant in lugs. Since 1952, several plants have adopted the use of water carriers in order to preserve the quality of the raw product during transportation. Lugscald and sunscald are two important defects that have been reduced considerably by this type of transportation. Gaston and Levin stated that processors records showed that the average grade of water transported cherries were significantly higher than that received in lugs and that scald and collapsed cherries were eliminated almost entirely.[1] On the other hand, water in these

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[1]Gaston and Levin. "Transporting Red Cherries in Water from Orchard to Processing Plant," Quarterly Bulletin, Michigan Agricultural Experiment Station, MSU, East Lansing, Michigan, Vol. 37, No. 3, p. 44.

tanks must be kept fresh in order to prevent water scald. Without doubt this method of transportation is an improvement over hauling cherries in lugs. This is especially true when the distances hauled increases.

The time period from picking of the cherry until it is dumped into a soaking tank is another important quality factor. The average time period for most growers and plants is from four to six hours. The actual range of time estimated by different processors was from one to twenty hours. Those processors that received cherries from indirect sources (receiving stations) had larger time intervals between picking and tanking. Some growers delivered their cherries to the processor six times a day while others delivered only once a day.

Method of Inspection

Raw product inspection determines the acceptability of a given load for processing and provides the processor with a basis for making payments to growers. The true quality of the load will be determined from the inspection sample only if this sample is representative of the load. The way in which the inspection and sampling is done, therefore, has an important influence on the quality determination of the load. Proper inspection and sampling procedures are important to processors and growers. Processors do not want to accept low quality fruit that will require extensive sorting to produce a standard grade finished product. Inadequate sampling and inspection may discourage quality incentive programs by awarding low quality growers premiums and high quality growers discounts.

The accuracy of sampling the raw product may depend a great deal upon where the inspectors platform is located. Some inspection stations are located at the tanks and others are located at the scale houses. When the samples are taken from the loads at the scale house, these samples are generally gathered from the top two layers of the load. In many cases this may have encouraged stacking of the boxes and facing the load with better quality cherries. Research conducted by the U.S.D.A. revealed that the percentage of the U.S. NO. 1 quality reported by the official inspector was 5 per cent to 9 per cent higher than that found by the investigators who obtained samples from all parts of the loads as they were being dumped into the soak tanks.[2] The inspection of the cherries as they were being dumped enabled the inspector to get a more random and representative sample from the entire load.

The size of the sample taken from a load is constant despite the varying size of the loads, for example, inspection records indicated that whether the size of the load is 500 boxes or 5 boxes the sample size remained the same.[3] The size of the load will have very little influence on the reliability of a constant size sample if the sample is drawn randomly and the variance of the quality of the different size loads are identical.[4] By increasing the size of the sample greater reliability is attained.

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[2] Edward R. Thompson and Raymond L. Spangler. Some Observations on the Relationship of Quality of Fresh Sour Cherries to Their Processed Products and Effects of Processing of Various Types of Defects. USDA, PMA, Washington, D. C., June 1949.

[3] In those cases that appear to be marginal in respect to their acceptance for processing two samples are usually drawn.

[4] Because even very small lots contain several thousand cherries the correctional factor due to the finite size of the universe being sampled is of no practical consequence.

Even though all inspectors may be receiving sour cherries from the same local area, there is often a considerable difference in the average quality graded by each inspector.[5] The method of gathering samples and the subjectivity necessary in judging defects was questioned by many processors and growers. The large volume that is delivered to processors during the peak of the season necessitates quick and fast inspection service. This often results in carelessness in obtaining random samples of growers loads and poor judgement of the quality of the sample drawn.

Locational Influences

Raw product quality received by plants varied considerably between and within areas. The average quality received by all cherry processing plants in Michigan during the 1955 processing season was 92.8 per cent U.S. No. 1 grade. The average quality received by the plants in the northern, central and southern areas were 91, 94, and 93 per cent respectively. The average quality received by 27 plants are listed on the table on the following page.

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[5] Sampling of raw product records for inspector differences indicated that the average quality of raw product sampled by 10 inspectors located at Traverse City ranged from 5.7% defects to 16.5% defects.

TABLE III

Average Raw Product Quality (per cent U.S. No. 1) Received by 27 Processing Plants in Michigan in 1955 - by area.

	Northern	Central	Southern
1	90.0	93.7	94.1
2	90.8	93.5	95.2
3	83.5	93.8	93.3
4	92.2	95.0	92.9
5	93.1	94.3	94.9
6	91.4	94.9	92.0
7	92.7	94.1	94.6
8	91.7	93.8	94.4
9	88.8	93.4	91.2
10	93.1	94.2	95.7
11	93.4		93.9
12			92.7
13			93.8
14			91.7
15			91.7
16			91.7
Average	90.91%	94.07%	93.36%
Range	9.9%	1.6%	4.5%

Northern area plants received the poorest quality cherries. Variation in the average quality received by different plants in this area was large. Weather conditions had important implications of the raw product quality. A considerable amount of hail and frost damage occurred in some parts of the area. Dry weather conditions in other sections of this area reduced the size of the fruit.

The central area plants received the best quality cherries in 1955. Little variation existed between plants in relation to the quality received. Weather conditions were very good in this area with the exception of the northern part.

Southern area plants received fairly good cherries. Those plants that did have poorer quality were concentrated in areas subjected to

considerable frost damage and sunscald. Many plants in the southern area received cherries from the central and northern areas. It is, therefore, doubtful whether the average quality received by these plants are representative of the local raw product quality.

Payment Programs

Processors in Michigan base their payment programs for red cherries on Michigan Revised or U.S. Standard Grades. Over two-thirds of the processing firms offered the growers incentives for good quality by means of discounts or premiums. Processors recognized the need for receiving good quality cherries to reduce sorting labor and waste and to maintain quality packs.

Ten different types of payment programs are used in the red cherry processing industry. Twelve firms offered no premiums or discounts. Twelve firms offered both premiums and discounts. Eleven firms offered discounts only and three firms offered premiums only. The type of payment method used and the number of firms using each are as follows:

TABLE IV

Payment Plans for Raw Product Cherries

Plan No.	No. firms using	Description of Payment Plan
1	10	88 score - 100 score = 100% pay
2	9	95 score - 100 score - 100% pay, 1% dock for each score below 95.
3	6	1% for each score above 95, 1% dock for each score below 95.
4	3	1½% for each score above 95, 1% dock for each score below 95.
5	3	1% for each score above 95, 90-95 score - 100% 1% dock for each score below 90.
6	2	90 - 100 score = 100%, 88-90 score dock 3%.
7	2	Standard price plus % of profits above certain level.
8	1	1/8 cent for cherries 96 or above 1/4 cent for cherries 98 - 100 score.
9	1	1¢ per pound above standard price.
10	1	1% for each score above 95, 88-95 score - 100% pay/

Premiums and discounts are usually dependent upon the score that the grower received from the raw product inspector. These discounts and premiums are usually stated as a percentage of the standard price for a pound of cherries. If we assumed that a grower delivered 100 lugs of 98 score cherries each weighing 30 pounds and the processing plant uses payment plan 4 (Table IV) then the grower should receive $309 if the standard price for cherries is 10¢ per pound.

The type of payment plans used by different firms appear to be somewhat related to the competitive conditions existing in the areas in which they are located. Similar payment plans are used by plants competing for raw product within certain regions. Seven out of eleven plants in the northern area used a dockage payment plan. Six out of eleven plants in the central area offered no premiums or discounts. Twelve out of nineteen plants located in the southern area offered the growers premiums and discounts or premiums only. The plants in the southern area offered the greatest variety of payment programs to growers.

Educational Programs

All processors recognized the need for encouraging and helping the grower to deliver a better quality cherry to its plants. Fieldmen, grower meetings, mail contacts, and other activities are sponsored by plants to help fill this need. The larger plants carried on many types of educational programs from fieldmen to radio programs. Smaller plants are often quite limited in their educational activities.

Twenty-six out of thirty-seven cherry processing plants interviewed had one or more regular fieldmen during the growing season. In other plants the managers work as fieldmen on a part-time basis when not busy

with packing operations. Large plants employ fieldmen on a year around basis while those plants with a smaller scale of operations employ fieldmen only during the growing season. Grower contacts made by fieldmen varied from two to six times per grower during the season.

Only twelve of 38 processing firms held grower meetings. One firm had about twelve meetings yearly and another firm held meetings every other year. The district horticultural meetings played important roles in educating the grower in the use of spray materials, fertilizers and grade standards. These meetings are generally held twice a year and are considered by plant managers to be of great importance in grower education.

Mail contacts are the third most popular type of educational activity engaged in by processing plants. Twenty-two out of 38 processing firms had one or more mail contacts with growers during the year. Some firms published monthly newsletters while other firms sent one or two newsletters prior to the harvesting season.

Importance of Factors in Determining the Grade of Raw Product

Average grower size, educational programs, payment plants, and plant location of thirty-seven different plants were used as independent variables to measure their influence on the average raw product delivered to the plants. The effort to measure the effect of these factors was unsuccessful. Lack of adequate information for classifying the data and the effect of the necessary aggregation for classification reduced the accuracy of the independent variables. The correlations obtained were very low but it is expected that they would be higher provided more accurate data were available.

THREE PLANT ANALYSIS

Seasonal and Daily Quality Variations.

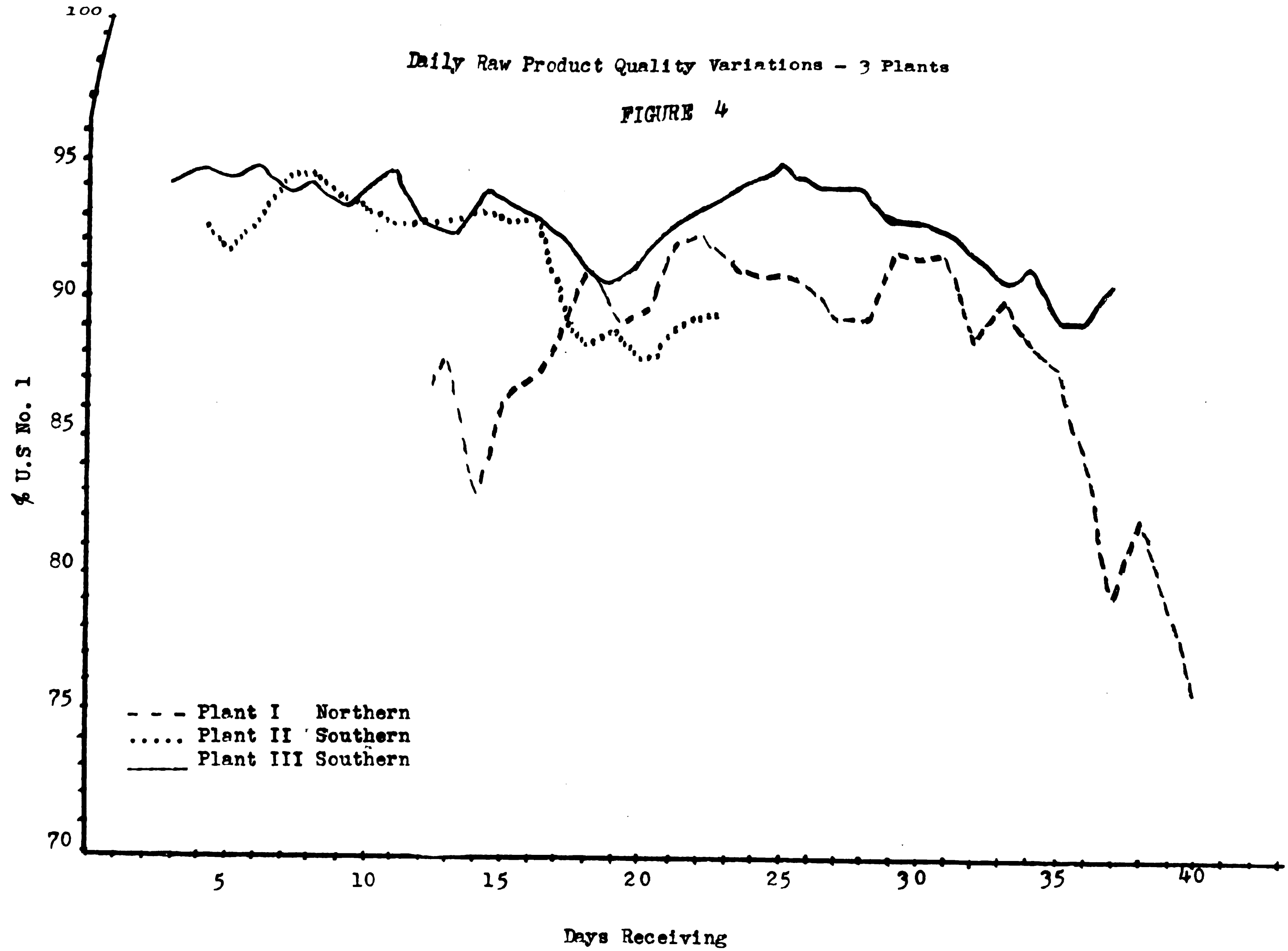
Seasonal movements in raw product quality appeared to be inconsistent from one plant to another. It is normally expected that the seasonal quality movement will be lower in the beginning and at the end of the harvesting season. Plants in the northern area had a greater tendency to follow this typical pattern than did the plants in the south. The seasonal movement of quality delivered to southern area plants was much less pronounced.

Many growers start picking their cherries early to reduce the threat of weather uncertainty and to relieve the late season harvesting rush. This practice results in a large amount of undercolored, immature and stemmed cherries being delivered to a plant. Late harvesting often results in many cherries that are over-ripe and subjected to additional weather hazards. Pulled pits, scald, decay and bruising defects usually increase late in the season.

The comparison of the daily quality received by three plants in 1955 (Figure 4) indicated that plant I, located in northern area, had much more day to day quality variation than plant II and III in the southern area. The average quality variation between days in the northern plant was 14 percent as compared to 10 per cent in the southern plants. The daily quality change exceeded 20 per cent 8 times in the northern plant as compared to only 5 times in the two southern plants. The composition of the specific defects determing the total defects varied during the season. Frost damage, hail, sunscald and other defects related directly to weather conditions played an important part in

Daily Raw Product Quality Variations - 3 Plants

FIGURE 4



daily quality change at some plants.

Quality Differences Among Growers

Some specific defects can be controlled by growers through the use of better production, handling and harvesting practices. Color may be improved by proper pruning. Decayed and wormy cherries can be reduced by proper spray treatments. Pulled pits and stemmed cherries are related to picking practices. Lugscald can be reduced by moving the cherries from the orchards to soak tanks as rapidly as possible.

Other defects that are considered to be partially controllable are related directly to the weather. Windwhip, frost damage, hail damage, sunscald and undersize almost always reflect weather conditions. Limb-rub, scars and miscellaneous defects may be partially controlled by certain harvesting and production methods but are considered as non-controllable in this analysis.

The following charts present a break-down of growers into three different groups according to the average percentage of defective fruit delivered to three plants. There are approximately 200 growers at plant I. 50 growers at plant II and 100 growers at plant III. The high 1/3 group represents the one-third of the growers who delivered to the plant the highest quality fruit or the lowest percentage defective fruit. The low one-third represents those growers who delivered poorer quality which contained a higher percentage of defects.

TABLE V A

Grower Differences - Per cent Controllable and Noncontrollable Defects

Plant I

Defects	High 1/3		Medium 1/3		Low 1/3		All Growers	
	Absol. % defects	% of total defects	Absol. % defects	% of total defects	Absol. % defects	% of total defects	Absol % defects	% of total defects
Color	.42	7.22	.92	10.10	3.39	22.45	1.54	15.43
Decay	.03	.52	.14	1.54	.68	4.50	.28	2.81
Worm damage	.00	.00	.00	.00	.01	.07	.00	.00
Lug-scald	.51	8.76	.64	7.03	.95	6.29	.70	7.02
Stems	.55	9.45	.65	7.14	2.14	14.17	1.09	10.92
Pulled pits	.17	2.92	.27	2.96	.22	1.46	.22	2.20
Partially Controll-able	1.68	28.87	2.62	28.77	7.36	48.94	3.83	38.38
Wind-whip	1.92	32.81	2.13	23.38	1.87	12.38	1.98	19.84
Scars	1.16	19.93	2.14	23.49	2.51	16.62	1.95	19.54
Limb-rub	.12	2.06	.26	2.85	.07	.46	.16	1.60
Frost damage	.03	.52	.02	.22	.02	.14	.02	.20
Hail	.12	1.89	.10	1.10	.11	.72	.11	1.10
Sun-scald	.45	7.73	.79	8.67	1.12	7.42	.79	7.92
Under size	.25	4.30	.84	9.22	1.77	11.72	.95	9.52
Bird peck	.02	.34	.04	.44	.07	.46	.04	.40
Misc.	.09	1.55	.17	1.86	.17	1.14	.15	1.50
Non-Con-trollable	4.16	71.13	6.49	71.23	7.71	51.06	6.15	61.62
Total defects	5.84	100.00	9.11	100.00	15.10	100.00	9.98	100.00

TABLE V B

Grower Differences--Per Cent Controllable and Noncontrollable Defects

Plant II

	High 1/3		Medium 1/3		Low 1/3		All Growers	
Defects	Absol. % defects	% of total defects	Absol. % defects	% of total defects	Absol. % defects	% of total defects	Absol. % defects	% of total defects
Color	.33	6.18	.33	4.42	.46	4.67	.38	4.85
Decay	.01	.19						
Worm damage	.01	.19			.02	.20	.01	.13
Lug-scald	.33	6.18	.72	9.65	1.05	10.65	.74	9.45
Stems	.12	2.25	.17	2.28	.26	2.64	.19	2.43
Pulled pits	.02	.37	.02	.27	.12	1.22	.06	.77
Partially Controllable	.82	15.36	1.24	16.62	1.91	19.38	1.38	17.63
Wind whip	1.66	31.09	.28	37.53	3.76	38.13	2.87	36.65
Scars	2.36	44.19	2.92	39.74	3.85	39.05	3.13	39.97
Limb-rub	.03	.56	.05	.67	.06	.61	.05	.64
Frost damage	.25	4.68	.32	4.29	.17	1.72	.25	3.19
Hail	.01	.19						
Sun-scald	.01	.19						
Under-size	.19	3.56	.11	1.47	.10	1.01	.13	1.66
Bird peck	.01	.19	.02	.27			.01	.13
Misc.					.01	.10	.01	.13
Non-Controllable	4.52	84.65	6.22	83.38	7.95	80.62	6.45	82.37
Ave. Total Def.	5.34	100.00	7.46	100.00	9.86	100.00	7.83	100.00

TABLE V C

Grower Differences—Per Cent Controllable and Noncontrollable Defects

Plant III

Defects	High 1/3 Absol. % defects	High 1/3 % of total defects	Medium 1/3 Absol. % defects	Medium 1/3 % of total defects	Low 1/3 Absol. % defects	Low 1/3 % of total defects	All Growers Absol. % defects	All Growers % of total defects
Color	.17	3.31	.36	5.25	.76	7.20	.39	5.45
Decay	.03	.58	.30	4.37	.38	3.60	.22	3.07
Worm damage	.18	3.52	.09	1.31	.24	2.27	,16	2.23
Lug-scald	.08	1.56	.27	3.94	.50	4.74	.26	3.63
Stems	.27	5.26	.30	4.37	.60	5.59	.36	5.03
Pulled pits	.28	5.46	.28	4.08	.50	4.74	.34	4.75
Partially Controllable	1.01	19.69	1.60	23.32	2.98	28.14	1.73	24.16
Wind-whip	1.57	30.60	1.94	28.28	3.14	29.76	2.11	29.47
Scars	1.00	19.49	1.52	22.01	.98	18.77	1.44	20.11
Limb-rub	.92	17.93	.73	10.64	.60	5.59	.76	10.61
Frost damage	.23	4.48	.25	3.64	.33	3.13	.27	3.77
Hail	.32	6.24	.21	3.06	.67	6.35	.36	5.03
Sun-scald	.03	.59	.42	6.12	.83	7.88	.38	5.31
Under-size	.02	.39	.07	1.02	.02	.19	.04	.56
Bird peck	.03	.59	.10	1.46			.02	.28
Misc.			.03	.45	.02	.19	.05	.70
Non-Controllable	4.12	80.31	5.27	76.68	6.59	71.86	5.43	75.84
Ave. Total Def.	5.13	100.00	6.87	100.00	9.57	100.00	7.16	100.00

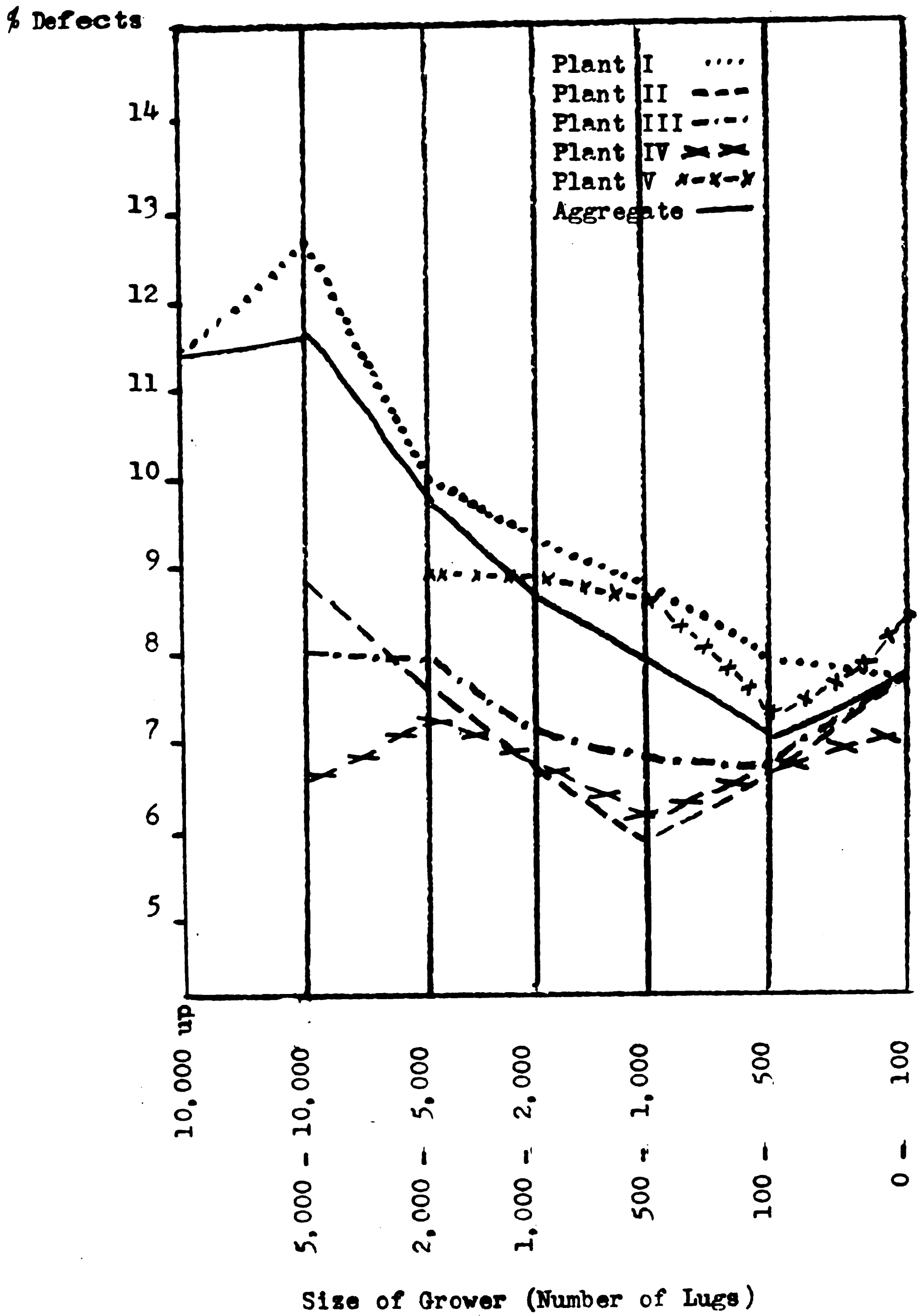
The previous tables proved invaluable in making comparisons between growers at a plant. At plant I about a 10 per cent difference exists in the amount of controllable defects from the high quality to the low quality groups. At plant II this difference amounted to 2 per cent. At plant III the difference was 8.5 per cent. These figures infer that growers who deliver high quality attempt to remove those defects that are considered to be partially controllable.

Size of Grower

The quantity delivered by the individual grower appeares to have an important influence on the quality of the raw product that is delivered by the growers to the plant. Extremely large quantity producers are unable to directly oversee the picking operations and are probably unable to get their cherry crop harvested at the best time. Average size growers are better able to see that the picking operations are done properly and that the crop is harvested at the right time. Smaller growers probably lacked the proper equipment to take care of the production and harvesting of the crop. These probable assumptions are borne out by the following graph:

Average Percent Defects - by Grower Size - By Plant

FIGURE 5



Two hundred growers from plant I in the northern area were compared with two hundred growers from plant II and III in the southern area. This comparison revealed that the range of grower size and quality delivered by the growers was much wider at the northern plant. The size of the growers as determined by the number of boxes delivered to the plant ranged from less than 1000 to over 15,000 at the northern plant and from less than 1000 to only 9,000 boxes at the southern plants. The average per cent defects delivered by these growers ranged from 2 to 26 at the northern plant and from 2 to 15 at the southern plants.

Importance of Specific Defects in Determining Raw Product Quality

The raw product inspection records of three plants were analyzed to determine the difference in the relative importance of specific defects at different plants. Plant I is located in the northern area and plants II and III are located in the southern area. The results of this analysis are recorded in the following table.

TABLE VI

Relative Importance of Specific Defects - 3 plants[6]

Defects	Plant I	Plant II	Plant III
Windwhip	1	1	2
Scars	2	2	1
Color	3	4	4
Stems	4	6	6
Undersize	5	14	7
Sunscald	6	5	13
Lugscald	7	10	3
Decay	8	11	14
Pulled pits	9	8	8
Limbrub	10	3	9
Miscellaneous	11	13	15
Hail damage	12	7	10
Bird peck	13	15	12
Frost damage	14	9	5
Worm damage	15	12	11

The rank order correlations between plants I, II, and III shows that significant dependence in ranking exists. The rank order correlation of incoming defects between two plants indicate that there is a closer agreement in the ranking of the northern plant to each of the southern plants than there is between the two southern plants. Birdpeck, miscellaneous and worm damage are of minor importance while windwhip, scars, and color are very important. There is considerable difference in the ranking of the defects which are of minor importance.

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[6] R I, II, III = .582 = (Significant at 5% level)
R I, II = .603 = (Significant at 1% level)
R I, III = .585 = (Significant at 5% level)
R II, III = .557 = (Significant at 5% level)

CHAPTER V

INPLANT QUALITY FACTORS AND QUALITY RELATIONSHIPS

In the last chapter the factors influencing raw product quality were discussed. Though satisfactory measurement of differences between plants is not feasible it is probable that weather conditions, payment plans, educational programs, and grower characteristics will all influence quality to some extent. The analysis of three plants indicated that a highly variable daily quality pattern existed. Quality differences between groups of growers revealed that good quality growers had a lower amount of controllable defects in their cherries. Large size and small size growers usually had poorer quality fruit. Windwhip, scars, and lack of color were important defects affecting raw product quality.

Raw product quality is but one of many other factors influencing the finished product quality. After the fruit has been delivered to the plant, quality of the fruit may be lowered, maintained, or improved by processing operations. This chapter will discuss these in-plant operations and quality factors. Handling methods, inspection methods, sorting methods and other processing operations can influence quality. Quality relationships are discussed in the second part of this chapter. An understanding of these relationships will be useful as aids for the evaluation of sampling for quality control.

IN-PLANT QUALITY FACTORS

Handling Methods in Receiving

Cherries should be transferred from lug boxes or water tank trucks with the mimimum amount of bruising. Consideration should be made by the processor as to which method of receiving cherries will cause a minimum amount of damage. At the present time many plants dump cherries directly into the soak tanks while others dump cherries into booted water conveyors or into hoppers which are carried by belt conveyors above the soak tanks where they are emptied. Bruised cherries have important consequences in determining the yield and quality of the finished product. Research conducted by Hills and Whittenberger revealed that unbruised red cherries soaked in water increased in weight and firmness and decreased in soluble-solids content and acidity while bruised cherries did not gain significantly in weight and lost appreciable quantities of soluble solids and acids.[1]

The soak tanks not only wash the cherries and provide a medium for storage but they also provide a means by which the cherries can be firmed for processing operations. A reduction in the temperature at which the cherries are stored either in air or in water, increases the firmness of both bruised and unbruised cherries.[2] Dr. W. F. Robertson of Michigan State University stated that when the temperature in the center of the cherry is the same as the temperature of the medium in which it is stored additional periods of storage will not increase the firmness of the cherry.[3]

A positive relationship exists between the length of soaking time and the temperature of the water in the soak tanks amongst the 37 plants sampled on this study.

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[1] Claude H. Hills and R. T. Whittenberger, Studies on the Processing of Red Cherries, Food Technology, 1953, Vol. VII, No. 1, p. 31.

[2] Ibid.

[3] Personal interview with Dr. W. F. Robertson of the Horticulture Department at Michigan State University.

Very few processors keep cherries in soaking tanks over 24 hours. Extremely long firming periods may cause cherries to split while short firming periods may not allow sufficient firming for good processing. Results obtained from soaking cherries from zero to 48 hours in water supplied continuously at 45° F. and 37° F. indicated that water at lower temperatures is more desirable and that the firming period should be limited to twelve hours or less to reduce the loss of soluble solid, and color and to minimize the amount of cullage.[4] Northern plants have a valuable asset in being able to obtain a cheap and abundant supply of water below 50°F. The average temperatures in the firming tanks are 52, 48, and 45° F. in the southern, central and northern area plants respectively.

Sorting Process

Cherries are flumed from the soaking tanks into conveyors that carry the fruit over eliminators. As the fruit passes over the eliminators, undersized and cull cherries drop between the horizontal bars while the larger cherries continue toward the inspection tables. About 1% of the total volume of cherries received by the plants are removed from the processing line in this operation. For a plant processing about 10,000 pounds of cherries in an hour this piece of equipment is worth approximately 5 sorters who can each remove 20 pounds of undersized cherries in an hour.

Eliminators are not only used for removing undersized cull cherries but they are also used as grade sizers for good cherries. The factor of

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[4] Roy E. Marshall. Cherries and Cherry Products, Interscience Publishers, Inc., New York, 1954, p. 196.

uniform size is important in the determination of pack quality. By the use of size graders this uniformity can be obtained in a very cheap and economical manner. Undersized cherries normally are processed for special purposes or used for cherry juice.

Processors should maintain two or more eliminators in the processing lines to remove undersized cherries and foreign materials. Eliminators are efficient equipment for reducing sorting labor requirements. As grade sizers they assure the processor of getting a more uniform size in his pack. Pie-making concerns buy much of the undersized fruit. Those cherries that pass over the eliminators usually will pass Grade A requirements for size and uniformity.

Cherries are guided from the distributing belts on to inspection or sorting tables. The average sorting table is twelve to fourteen feet in length. Most processors have one sorter for every two linear feet of belt. Some plants have the sorters working close together while others have the sorters spread along the table as much as possible. Many plants have sorters stationed along the distributing belt and between the pitters. This is frequently the case in plants which do not have an adequate number or large enough sorting tables.

Wide differences existed in the number of sorters that processors maintained on their line. One processor stated that he employed only enough sorters for the purpose of keeping the government officials happy. Other processors employed large numbers of sorters with the objective of improving quality. The number of sorters per thousand pounds of cherries going through the processing lines in an hour ranged from 1.30 to 6.67 among thirty-seven different plants.

Adjustments in the rate of flow per sorter are often made by reducing the volume or by reducing the speed of the belts. Most plants made adjustments by changing the volume going over the belts while maintaining a belt speed of around twenty feet per minute. The number of sorters maintained by the plants varied little from day to day regardless of the quality. Unexpected weather hazards may reduce the incoming quality rapidly and most processors saw the need for holding a constant crew for such conditions.

Time studies in the processing plants revealed that considerable differences exist between sorters in the quantity of cherries that are sorted out in an hour.[5] Studies conducted in twenty-six processing plants on 155 sorters showed a variation of from 5.5 to 42.4 pounds of cherries in the hourly rate of pick.[6] Plants receiving poorer quality generally had the higher pick out. The efficiency of the sorter seemed to be reduced in those plants that were visited in the afternoon. This can probably be explained by the increased fatigue among the workers.

The range of the percentage pick out among plants is large, varying from 9.6% to 2%. Most managers stated that sorters on belts could not sort out more than 5%. The average for all plants as determined by the time studies is 4.6%. The differences in the percentage pick outs may by attributed mainly to different quality received and different quality standards set by the plant management, though both the time of the observation, and the size of the cherries may influence the performance of the workers.

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[5] These time studies were conducted on each sorter for 5 minutes. The count was then multiplied by 11 to arrive at an hourly figure that allowed for a 5 minute break per hour.

[6] This pick out was figured by calculating the average number of cherries sorted out per hour divided by 120.

TABLE VII

Sorting Performance - 37 Processing Plants

Plant	Volume per hr. (1000 lbs)	Number of Sorters Employed	Number of Sorters Timed	Range of Pick out per Sorter[a] timed. Low	High	Ave.	Sorters Employed per 1000 lbs.	Total Pounds Picked Out[b]	Per cent P.O.
1.	12.00	39	4	6.87	15.58	11.04	3.25	446	3.7
2.	3.54	20	3	10.08	24.75	16.96	5.65	339	9.6
3.	24.00	54	10	9.90	38.40	28.96	2.25	1564	6.4
4.	9.00	34	5	13.02	32.54	21.91	3.77	745	8.3
5.	16.00	36	4	21.27	42.44	33.37	2.25	1201	7.5
6.	9.00	12	4	9.17	21.82	15.40	1.30	185	2.0
7.	15.00	45							
8.	28.00	64	3	5.50	21.91	12.56	2.28	804	2.9
9.	20.00	30	4	13.75	17.61	16.32	1.50	490	2.4
10.	9.50	25					2.63		
11.	6.00	12					2.00		
12.	8.00	23					2.88		
13.	8.00	14	3	19.25	22.91	21.08	1.75	295	3.7
14.	10.00	20	4	18.33	27.50	22.92	2.00	458	4.6
15.	3.50	13					3.71		
16.	3.70	8					2.16		
17.	11.34	28	4	7.33	20.17	19.84	2.47	387	3.4
18.	20.00	57	7	8.25	13.75	10.45	2.85	596	3.0
19.	6.00	12	4	20.17	22.92	21.27	2.00	255	4.2
20.	9.00	20					2.22		
21.	17.00	35	6	11.46	36.65	26.12	2.05	914	5.4
22.	12.00	48					4.00		
23.	10.365	20	5	19.25	36.29	25.02	1.93	500	4.8
24.	4.50	30					6.67		
25.	7.40	26	6	11.92	25.21	19.43	3.51	505	6.8

TABLE VII (cont.)

Plant	Volume per hr. (1000 lbs)	Number of Sorters Employed	Number of Sorters Timed	Range of Pick out per Sorter Timed. Low	High	Ave.	Sorters Employed per 1000 lbs.	Total Pounds Picked Out	Per cent P.C.
26.	12.00	39	6	7.79	22.92	14.48	3.25	565	4.7
27.	12.00	41	4	7.79	16.04	12.38	3.42	506	4.2
28.	9.00	20	6	17.42	30.25	23.74	2.22	475	5.3
29.	25.00	60							
30.	15.00	29	6	16.04	22.92	19.43	1.93	563	3.7
31.	50.00	91	8	13.75	34.38	19.82	1.82	1803	3.6
32.	24.00	60	12	6.87	20.62	14.30	2.50	600	2.5
33.	17.00	50	6	11.92	19.70	16.23	2.94	811	4.8
34.	27.00	42	6	9.17	27.50	18.70	1.55	1122	4.1
35.	18.50	46	4	14.67	25.21	19.98	2.49	919	5.0
36.	16.00	72					4.50		
37.	9.50	22	3	9.17	18.70	14.30	2.32	315	3.3

(a) Range of pickout in pounds with 120 cherries = 1 lb. Range determined from sorters timed only.

(b) Assuming that the average timed is the average for all sorters.

TABLE VIII

Cost of Sorting Labor per Thousand Pounds*/hours
at Different Volume Levels and Different Number of Sorters

Volume/hr. 1000 lbs.	100 Sorters	80 Sorters	60 Sorters	40 Sorters	20 Sorters	10 Sorters
50	$ 2.00	$ 1.60	$ 1.20	$ .80	$ .40	$ .20
45	2.22	1.78	1.33	.89	.44	.22
40	2.50	2.00	1.50	1.00	.50	.25
35	2.86	2.29	1.71	1.14	.57	.29
30	3.33	2.67	2.17	1.33	.67	.33
25	4.00	3.20	2.40	1.60	.80	.40
20	5.00	4.00	3.00	2.00	1.00	.50
18	5.55	4.44	3.33	2.22	1.11	.55
16	6.25	5.00	3.75	2.50	1.25	.62
14	7.14	5.71	4.29	2.86	1.43	.71
12	8.33	6.67	5.00	3.33	1.67	.83
10	10.00	8.00	6.00	4.00	2.00	1.00
9	11.11	8.89	6.67	4.44	2.22	1.11
8	12.50	10.00	7.50	5.00	2.50	1.25
7	14.29	11.43	8.57	5.71	2.86	1.43
6	16.66	13.33	10.00	6.67	3.33	1.66
5	20.00	16.00	12.00	8.00	4.00	2.00
4	25.00	20.00	15.00	10.00	5.00	2.50
3	33.33	26.67	20.00	13.33	6.67	3.33
2	50.00	40.00	30.00	20.00	10.00	5.00
1	100.00	80.00	60.00	40.00	20.00	10.00

*Based on wage rate of $1.00 per hour.

TABLE IX

Cost of Sorting Labor per Thousand Pounds*/hour
at Different Volume Levels and Different Number of Sorters

Volume/hr. 1000 lbs.	100 Sorters	80 Sorters	60 Sorters	40 Sorters	20 Sorters	10 Sorters
50	$ 1.70	$ 1.36	$ 1.02	$ .68	$ .34	$ .17
45	1.89	1.51	1.13	.76	.37	.19
40	2.13	1.70	1.28	.85	.42	.21
35	2.43	1.95	1.45	.97	.48	.25
30	2.83	2.27	1.84	1.13	.57	.28
25	3.40	2.72	2.04	1.36	.68	.34
20	4.25	3.40	2.55	1.70	.85	.42
18	4.72	3.77	2.83	1.89	.94	.47
16	5.31	4.25	3.19	2.12	1.06	.53
14	6.07	4.85	3.65	2.43	1.22	.60
12	7.08	5.67	4.25	2.83	1.42	.71
10	8.50	6.80	5.10	3.40	1.70	.85
9	9.44	7.56	5.67	3.77	1.89	.94
8	10.62	8.50	6.38	4.25	2.12	1.06
7	12.15	9.72	7.28	4.85	2.43	1.22
6	14.16	11.33	8.50	5.67	2.83	1.41
5	17.00	13.60	10.20	6.80	3.40	1.70
4	21.25	17.00	12.75	8.50	4.25	2.12
3	28.33	22.67	17.00	11.33	5.67	2.83
2	42.50	34.00	25.50	17.00	8.50	4.25
1	85.00	68.00	51.00	34.00	17.00	8.50

*Based on wage rate of 85¢ hour.

Sorting labor is an important part of the labor costs incurred in the processing business. Quality adjustments are made by reducing or increasing the volume going by a given number of sorters on the inspection tables in a given time period, or by increasing or decreasing the number of sorters on the inspection tables. Tables VIII and IX show the costs per thousand pounds of cherries for different volumes passing over inspection belts for different numbers of sorters. Table X indicates the number of sorters needed to upgrade fruit of varying quality and of different rates of volume.

TABLE X

Man Hours of Sorting Labor Required to Up Grade Fruit Using Average Pickout Rate*

lbs/hour over sorting belt	Percent Defective Fruit to be Removed											
	1	2	3	4	5	6	7	8	9	10	11	12
50,000	25	50	75	100	125	150	175	200	225	250	275	300
45,000	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270
40,000	20	40	60	80	100	120	140	160	180	200	220	240
35,000	17.5	35	52.5	70	87.5	105	122.5	140	157.5	175	192.5	210
30,000	15	30	45	60	75	90	105	120	135	150	165	180
25,000	12.5	25	37.5	50	62.5	75	87.5	100	112.5	125	137.5	150
20,000	10	20	30	40	50	60	70	80	90	100	110	120
18,000	9	18	27	36	45	54	63	72	81	90	99	108
16,000	8	16	24	32	40	48	56	64	72	80	88	96
14,000	7	14	21	28	35	42	49	56	63	70	77	84
12,000	6	12	18	24	30	36	42	48	54	60	66	72
10,000	5	10	15	20	25	30	35	40	45	50	55	60
9,000	4.5	9	13.5	18	22.5	27	31.5	36	40.5	45	49.5	54
8,000	4	8	12	16	20	24	28	32	36	40	44	48
7,000	3.5	7	10.5	14	17.5	21	24.5	28	31.5	35	38.5	42
6,000	3	6	9	12	15	18	21	24	27	30	33	36
5,000	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30
4,000	2	4	6	8	10	12	14	16	18	20	22	24
3,000	1.5	3	4.5	6	7.5	9	10.5	12	13.5	15	16.5	18
2,000	1	2	3	4	5	6	7	8	9	10	11	12
1,000	.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

* Assuming that the average sorter can remove 20#s of defective fruit in an hour.

Variations in rates of pick out of different sorters timed in different plants indicates that no one rule may be applied to sorting labor requirements. As the quality of the incoming fruit improves it becomes more difficult to detect the defective fruit. Quality of the incoming fruit and the efficiency of the sorting labor are variables that have important implications in determination of the sorting labor requirements. These variables must be considered in using Table X.

Many processors are selective in hiring sorters to work on the tables. One plant gave prospective employees a marble test. These marbles were colored and with blemished spots. Each participant had to sort out the undercolored and blemished marbles within a given time period. The manager said that this test proved to be very useful in preventing extremely slow sorters and colorblind people from working on their sorting tables.

Processors are not only faced with the problem of insufficient amounts of defective cherries being removed by the sorters on the sorting tables but they also have the problem of too many good cherries being removed. Inaccurate sorting frequently results in many good cherries being discarded in the pick-outs. One plant inspector has checked the pick outs of certain individuals on the sorting tables and has often found that these pick-outs included over 50% absolutely good cherries.

Florescent lighting is provided by all processors over the sorting tables. Two plants had colored lighting in order for their workers to better detect the small but major defects in the cherry. An experimentation on the use of colored lights revealed that blue florescent lights increased sorting efficiency 10 to 30% and that red florescent lights increased sorting efficiency about 64% over the ordinary white florescent light.[7]

Most cherries are rolled around by hand in order to detect defects on all sides of the cherry. The use of foam rubber fingers placed over an inspection belt proved 80% effective in turning the cherries over for a more complete inspection.[8] Much of the sorters time is utilized in rolling the cherries over instead of picking out the defects. The defects on a cherry are extremely hard to find because of the tendency for the defect to have a flattening effect on the side of the cherry. This usually results in having the defect face down on the belt with its mobility reduced.

All plants have some person supervising the inspection belts to co-ordinate the flow of the cherries with the quality and the rate of sorting. Larger plants have head floor-ladies in charge of all inspection belts and sub-floor ladies in charge of each line. Usually a line consists of one to four inspection tables. Sub-floor ladies generally work near the end of the sorting belts where they can judge the quality going through the lines.

Pitting Operation

After passing over the inspection tables the cherries are fed into an automatic pitting machine. The pitting operation has important quality

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[7] G. M. Peterson and W. M. Carleton. Possibilities of Using Colored Lights for Detection of Cull Cherries. Quarterly Bulletin, Michigan Agricultural Experiment Station, East Lansing, Michigan, Vol. 34, No. 2, Nov. 1951, pp. 177-178.

[8] Ibid., p. 180.

implications that are related to the firming process. Cherries that are not firmed properly will tear and lose more juice during pitting. Also many surface blemishes have a chance of being removed by the needle plunger.

The pitters generally used for sour cherries have the capacity of one ton of cherries per hour. Some processors attempt to operate pitters above this capacity during the peak of the season with the result that some cherries with pits get through the pitters. Some processors maintained sorters between pitters to prevent cherries with pits from flowing through.

Most processors operate pitters at 85% of the rated capacity. The number of pitters in use varied from 38 in the largest plant to 1 in the smallest plant. Most processors maintain four to six pitters per line.

The check maintained on pitter operation varied from one plant to another. The amount of pitter supervision varied from one man in charge of 18 pitters in one plant to one man in charge of 6 pitters in another plant. Close supervision is necessary when pitters are operating near capacity.

Hotpack Process

V troughs and circular semi-automatic hand pack fillers are commonly used for filling cherry containers. The circular filler is a revolving stainless steel table with circular holes around the edges under which the container is located. The V trough consists of a trough with a gate across the end. Containers are automatically positioned under this trough by means of a conveyor. The V trough is used mostly for No. 10's while No. 2 and No. 303 are usually filled by circular handpack.

After filling the containers it is customary to check the fill weights of the cans. Exact weight scales are generally situated near the line and cans are removed as they are filled. All No. 10 cans are usually checked on the fill weight. The spot check on the smaller containers varies between plants from that of every fifth can to that of every 10,000th can.

Water or syrup is added to the contents of the container before it goes into the exhaust box. The great majority of red cherries are packed as pie stock and are therefore canned in water. In recent years there has been an increase in the syrup packing of red cherries in an attempt to create new consumer uses for the product.

After the cans are filled they are conveyed into exhaust boxes to produce a vacuum in the can when it is closed. Open cans are fed onto a wide metal belt that conveys the cans through a shallow tank of hot water for a certain period of time. Gear type exhaust boxes are also used in which these cans are conveyed back and forth throughout the exhaust box in single file. Most processors attempt to obtain a 160 degree temperature in the center of the container.

From the exhaust box the cans are conveyed on a belt to a closing machine, that seals the cover on the can. Most processors run the No. 10 closing machine at about 160 cans per minute. The smaller cans are run through closing machines at about 200 cans per minute. These machines are located close to the exhaust boxes so that the vacuum created by the exhaust boxes will not be lost.

Red cherries are processed in retorts or in continuous cookers. Most continuous cookers and coolers are of the flat type constructed similar to the exhaust boxes. Four of the plants visited have reel type cookers and coolers that conserved considerable plant floor space. Twenty-four have continuous cookers and coolers and ten plants have retorts. Retorts enabled the processors to better adjust his cooking time for different products. The cans in the retorts are cooled by passing the cages through tanks of cool water. Most processors attempt to obtain a temperature of 200 degrees F. in the center of the cans during cooking and 100° F. in the center of the cans after cooking.

Cold Pack Process

After the pitting operations cherries to be coldpacked are generally put into 30, 15, or 10 lb. tins. Out of twenty-five plants that coldpack, eighteen plants use a trough or hopper type filler with a sliding gate and the seven plants have automatic fillers. Red cherries are usually cold-packed with sugar added to its contents. The most common type of mixture for 30 lb. tins are 25 lb. of cherries and 5 lb. of sugar. Sugar is usually added with a measured scoop for hand filling operations. The automatic filler usually adds the sugar automatically as the container is being filled.

All large cold pack cherry tins are weighed on exact weight scales. The automatic fillers not only add cherries and sugar but also weighs and stamps the contents as the container is being filled. The filling operation automatically stops when the scale is pressed down. The hand filling operations consist of adding cherries and sugar to the containers contents until the desired reading is obtained on the scales.

Inspection Methods

The thoroughness of the check on the quality being packed varies from one plant to another. Plants that have continuous government inspection service have rather complete and systematic checks on the quality flowing through the plant. Those plants which do not have this service vary widely in their checking methods. Checks are made by plant employees from randomly to every 15 minutes. The persons obtaining this check ranged all the way from specialized quality control personnel to floor ladies.

The inspection of the product before processing is done according to the standards for the raw product while the inspection on the finished product is done according to the U. S. Standards for processed cherries. Practically all plants check the drained weights, the fill weights and the net weights and the vacuum, similarly as it is done by government inspectors. About one-half of the plants without governmental inspection service maintain records of their inspection.

Government inspectors determine a probable grade and a final grade on the finished product. The probable grade is determined the day the product is processed and the final grade is determined after the product has been stored for a period of time. Changes in the product occur after processing and usually the final grade will be higher ~~then~~ than the probable grade due to the blending of color and other factors. The final grade on the coldpack is usually determined one or two days after processing but the hot pack is usually allowed to cure in storage for ten days before a final grade is determined.

QUALITY RELATIONSHIPS

Raw and Final Product Quality

An attempt was made to correlate the raw product grade to the final product score. The average proportion of fresh cherries that graded U. S. No. 1 for the current and the previous day was correlated with the average score of the finished product for the current day. This resulted in two significant correlations at two plants and no significant relationship at the third plant.

It is doubtful whether the grade designations on the fresh cherries prove to be a satisfactory index of the quality of the processed product. Spangler and Thompson noted that some of the defects which are scored in grading the fresh cherries are of little consequence in the grading of the canned or frozen product.[9] Their study indicated that if the fresh cherries are of such a nature that they do not seriously affect processing quality, they can easily obtain a much higher grade in the processed inspection. Cherries with attached stems are easily removed by sorters and undersize cherries are removed by eliminators. Scald and off-colored cherries usually blend with the other cherries and do not present much of a problem if the defects are not too serious.

The correlations indicate that quality is reduced as it is processed. At one of the plants the mean value of the raw product is 93.42% U. S. No. 1 grade cherries while the average total score on the processed product is 85.72%. This problem is not one of quality deteriation but simply one of dissimilarity of standards used in evaluating the raw and processed grades.

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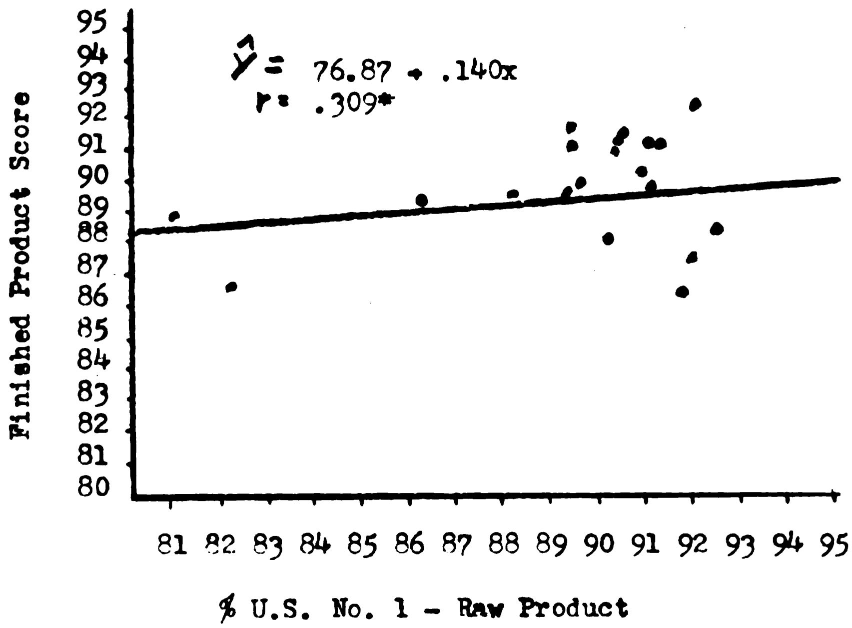
[9] Thompson and Spangler. "Some Observations on the Relationship of Quality of Fresh Sour Cherries to Their Processed Product."

Influence of Raw Product Quality on Finished Product Score

FIGURE 6A

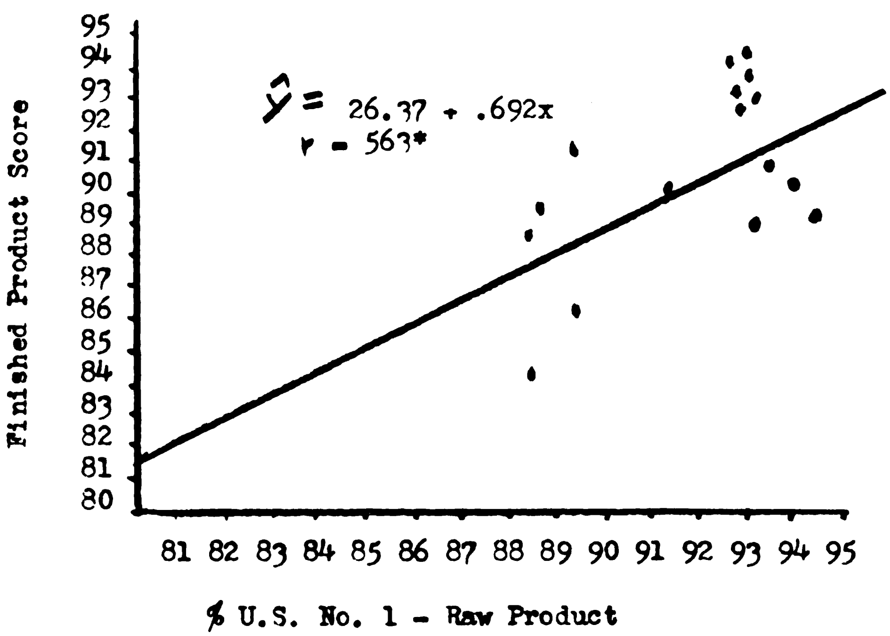
Plant I



*Non-significant at the 5% level

FIGURE 6B

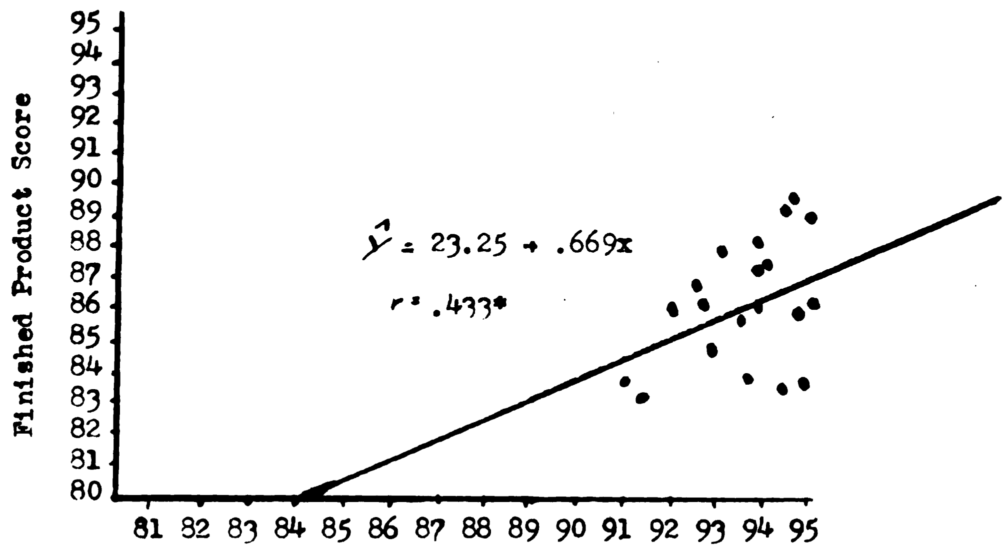
Plant II



* Significant at the 5% level

FIGURE 6C

Plant III



% U.S. No. 1 - Raw Product

*Significant at the 5% level

Influence of Raw Product Defects on Processed Product Quality

Certain defects in the raw product are very important in determining the quality of the processed product. Plant managers were asked to rank these defects in their order of importance in affecting the grade of the processed product. The following chart illustrates the points system used in evaluating the importance of these defects and their effect on the hot, cold and total pack.

TABLE XI

Importance of Raw Product Defects in Determining Processed Product Quality at 37 Plants

Scoring System			Total Pack		Hot Pack		Cold Pack	
			Points	Rel.	Points	Rel.	Points	Rel.
Rank order	Points	Defect						
1	7	Windwhip	318	35%	173	39%	145	30%
2	6	Lugscald	194	21%	68	15	126	26
3	5	Color	180	19	75	17	105	22
4	4	Undersize	106	11	59	13	47	10
5	3	Sunscald	63	7	39	9	24	5
6	2	Character	24	3	12	3	12	3
7	1	Hail	17	2	10	2	7	2
		Maturity	12	1	6	1	6	1
		Stems	10	1	4	1	6	1
			924	100	446	100	478	100

Windwhip, lugscald and color are the most important factors affecting the processed product quality. A rank order correlation of the defects affecting the hot and cold packs resulted in an R value of .985. This is very high because the only difference in the rankings of the defects is a switch in the relative importance of color and lugscalds. Lugscald is more evident in the cold pack because of the absence of a cooking process to blend the color throughout the contents. Maturity and character of the cherry are not listed as defects in the raw product as such, but usually are related to the sugar content and the firmness of the cherry.

There is some difference between the importance of raw product defects in affecting the processed product quality and the importance of specific defects in determining the raw product grade. Scars are not mentioned by the plant managers as defects affecting their processed product. It could probably be assumed that they considered windwhip and scars as synonomous terms even though there is a distinct difference between these defects. Lugscald is comparatively important in the processed product but is ranked fairly low as a factor determining the raw product grade in two of the plants. Those defects not ranked as factors affecting the processed product are low in the rank of importance of the specific defects in determining the raw product grade.

Importance of Factors Determining Final Product Score

Color, defects and character are the three quality factors that determine the final product scores. Four hundred inspection samples of the processed product scores were analyzed on one of the plants. The effects and importance of each factor on the total scores is included in the following charts. Defects accounted for 39.2 per cent of the differences and character and color accounted for 35.3 and 25.3 per cent of the differences respectively.

Two hundred samples of hotpack inspections showed that defects are the most important factor in determining the total score of the hotpack. Defects, character and color accounted for 43.9, 32.5, and 23.6 per cent of the differences respectively between the potential and the actual count on the scores. The coldpack inspection samples revealed that character is the most important factor affecting the total score. Defects, character and color accounted for 34, 38.5, and 27.5 per cent of the differences respectively between the possible and the actual scores on the coldpack.

TABLE XII

Relative Importance of Color, Defects and Character in Determining Finished Product Quality

(400 samples Hot and Cold Packs)

Factor	Potential		Actual Count		Difference	
	Points	Per cent	Points	Per cent	Absol.%	%Total
Color	8,000	20	6970	17.4	2.6	25.5
Defect	16,000	40	14397	36.0	4.0	29.2
Character	16,000	40	14552	36.4	3.6	35.3
Total Score	40,000	100%	35919	89.8%	10.2%	100.0%
Hotpack (200 samples)						
Color	4,000	20	3465	17.3	2.7	23.6
Defects	8,000	40	7006	35.0	5.0	43.9
Character	8,000	40	7258	36.3	3.7	32.5
Total Score	20,000	100%	17729	88.6%	11.4%	100.0%
Coldpack (200 samples)						
Color	4,000	20	3505	17.5	2.5	27.5
Defects	8,000	40	7391	36.9	3.1	34.0
Character	8,000	40	7294	36.5	3.5	38.5
Total Score	20,000	100%	18190	90.0%	9.1%	100.0%

Fifteen per cent of the 400 samples graded C or standard grade. Defects caused 44 samples to grade standard. Color caused 12 of the samples to grade standard and character was responsible for placing four samples in grade C. Color has much less influence on the total score but it can affect the grade more easily because it allows for the dockage of only three points before the sample falls into a lower grade. Defects and character are each allowed six points before the grade is dropped. Total score cannot affect the grade unless one of the three factors is below the minimum number of points.

A multiple correlation of the three factors that determine the total score for 200 samples grouped into fours indicated the possible influence that defects had on affecting the total score. The following R values were obtained in attempting to get the interaction of these four factors on each other.[10]

$Rx_1y = .335$	$Rx_1x_2 = .048$	$R = .999$
$Rx_2y = .933$	$Rx_1x_3 = .499$	
$Rx_3y = .523$	$Rx_2x_3 = .217$	

The above R values indicated that defects and character are more important as factors determining the processed score. The intercorrelation between color and character is much higher than that between color and defects or character and defects. These results were expected on basis of the preliminary exam of the records. Defects had greater variation than the other two factors and was therefore, expected to have greater influence on the total scores. Color and character were expected to be more highly correlated because of the relationship of immaturity and scald in affecting both character and color.

[10] These factors are X_1 = color, X_2 = defects, X_3 = character, and Y = total score.

Daily Changes in Finished Product Quality

Processed product quality changed throughout the season. At one large plant defect and character were important factors in decreasing product quality as the season progressed. Color improved the grade of the finished product as the season progressed.

Most plants have better quality in their coldpack than in their hotpack. This was either because the plant attempted to pack better quality in the coldpack or the defects contained in the coldpack are not as noticeable to inspectors. Defects and character in the coldpack are considerably lower than in the hotpack. Color improved daily in the coldpack while in the hotpack the color remained about constant.

Drained Weights

"Drained weights are not affected either by soluble solids content or by time and temperature of soak, but varied with relation to areas and years and with weather conditions. Small amounts of sugar, dry or syrup, gave higher drained weights and better quality without increasing costs."[11]

The above statement condenses the results of a five-year study by Bedford and Robertson on the factors affecting drained weights on sour cherries. The tissue structure of the cherry that was formed three or four weeks before harvest appeared to be the significant factor influencing drained weights. Bedford stated that drained weights on cherries were probably influenced by three things: (1) weather conditions, (2) nitrogenious fertilizer, and (3) harvest maturity.[12]

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[11]Bedford and Robertson. "The Effect of Various Factors on the Drained Weight of Canned Red Cherries." Food Tech., 1955, Vol. IX, No. 7, p. 321.

[12]Ibid., p. 321

Probable and Final Scores

Plants that maintain continuous and inplant inspection often have the processed cherries inspected twice. The first inspections are made immediately after processing. The product's probable grade is determined at this time on the basis of the score and the size of the cherries in the containers. On the hotpack, the net weight, vacuum, and drained weights are usually measured even though they do not affect the grade. It is on this grade that the processor must evaluate the quality level of his product in order to make immediate adjustments.

The final inspection is often eliminated unless the product is being sold to the government or another buyer who demands certification of the grade. The final inspection is done by drawing representative samples out of a given lot in storage as contrasted to the probable inspection that is done as the lot is being processed. Final inspection on the canned pack is made after the product has been in storage for at least ten days. The coldpack final inspections are often made the day after the cherries are processed.

The curing period allowed between the probable and final inspections enable quality changes to take place in the processed product. Probable and final grades were taken from samples representing the same lots on both hot and cold packs in order to measure this change. Thirty-five hotpack samples of probable and final scores are used in this comparison. More samples would have been desirable but difficulty was met in obtaining lots that had both probable and final inspection made on them.

TABLE XIII

Change in Scores - Probable to Final

	Character			Color		
	Ave. Prob. Score	Ave. Final Score	% Change	Ave. Prob. Score	Ave. Final Score	Change
Hotpack	36.09	37.14	2.9	17.43	18.40	5.6
Coldpack	36.91	37.09	.5	17.43	18.03	3.4
Total Pack	36.50	37.12	1.7	17.43	18.21	4.5
	Defects			Total Score		
Hotpack	36.26	36.66	1.1	89.78	92.20	2.7
Coldpack	36.74	36.74	0.0	91.08	91.86	.9
Total Pack	36.50	36.70	.5	90.43	92.03	1.8

Quality change in the hotpack appeared to be much more noticeable. The hotpack total score increased 2.7% as compared to only a .9% increase in the total score of the coldpack. The average final total score on the hotpack is greater than that of the coldpack even though the coldpack had a greater average total score on the probable inspection. The greatest percentage change in scores for both hot and cold packs occurred in the color factor. The blending that occurs during the storage period is responsible for this improvement. Defects appeared to change very little from the probable to final inspection periods. The coldpack might show greater improvement if it were allowed to set as long as the hotpack before the final inspection.

CHAPTER VI

SAMPLING AND STATISTICAL QUALITY CONTROL

Raw and processed cherries are accepted or rejected and bought or sold according to quality on the basis of sampling inspections. Growers, processors, wholesale buyers and others who are involved in transactions of the particular products are all directly concerned with the accuracy with which a particular sample reflects the actual quality of a given load or lot. The first part of this chapter evaluates sampling plans and indicates how the reliability of a sample may be increased.

The latter part of this chapter shows how quality control charts may be used in a typical cherry processing plant. Although the application of these control charts are in the cherry processing industry, they are likewise applicable to other processing industries. Quality control charts are tools for management to use in making economic decisions concerning resource allocation and utilization. Those factors reducing or improving quality often may be easily detected by management through the aid of this tool and substantial savings may occur because of their discovery and adjustment.

Evaluation of Raw Product Sampling

The acceptability of a load is determined by the percentage of No. 1 grade cherries (Michigan revised Standards) that is found in a sample. A 500 gram or 1 pound sample is usually taken from a load by the federal-state inspectors regardless of the size of the load. If 88 per cent or more of the sample is No. 1 grade the load can be accepted for processing. When the quality of the raw product, as determined by the sample, is questionable as to its acceptance for processing, the inspector might take another sample to verify the quality of the load. The past reputation of the grower may cause the inspector to be more or less cautious in gathering a random sample.

Whenever a load's quality is based on a sample of that load, there exists a probability that this sample will not reflect the actual quality of the load. This sampling error can be reduced by increasing the size of the sample until the entire load is included in the sample. In acceptance inspection this sample is drawn randomly from the load and permits the measurement of the sampling error for different sample sizes. The probability of accepting a load of red cherries that contain a certain percentage No. 2 or unclassified grade cherries for samples of different sizes is given in figure 7. The relationship between the percent defectives in the lots being submitted for inspection and the probability of acceptance is called the operating characteristic of that particular sampling plan.

The operating characteristic curves for raw product sampling indicates the probability of accepting or rejecting loads on the basis of the sample taken, if the actual quality of the loads are at different levels. The larger the size of the sample, the greater the ability of the sample plan to discriminate between lots of different qualities. In figure 7 a 16 per cent defective lot has a 14 per cent chance of acceptance if the size of the sample is 120 cherries and 12 per cent defectives or 14 defects are allowable for acceptance.[1] If the size of this sample is

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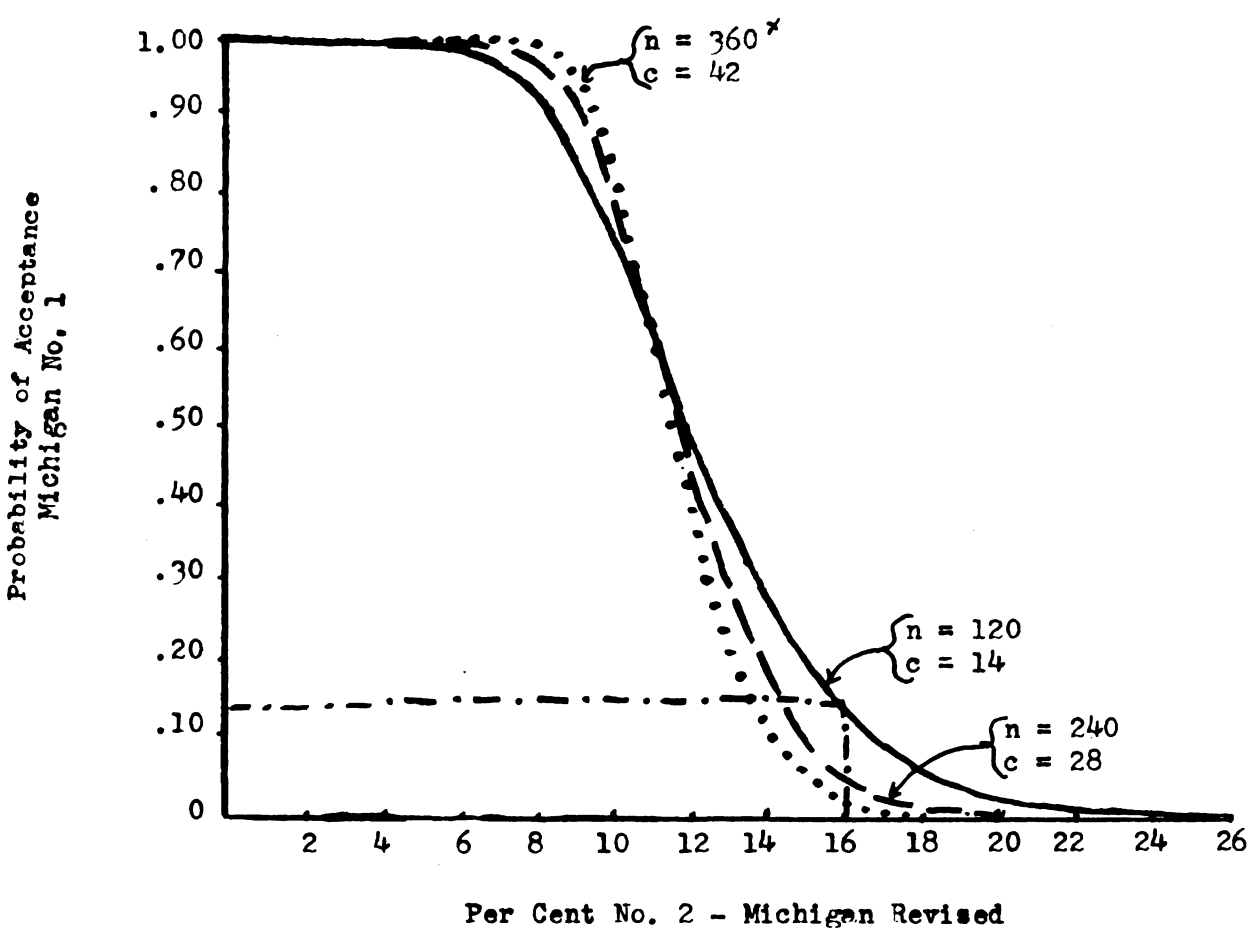
[1]120 cherries assumed equal to 1# or 500 grams
240 cherries assumed equal to 2# or 1000 grams
360 cherries assumed equal to 3# or 1500 grams

Accuracy of Different Sampling Plans in
Determining Raw Product Acceptability

FIGURE 7



x n = Size of Sample
c = Actual Number of Defects in Sample

tripled (sample size 360 - allowable defects 42) then this same lot has only a 2 per cent probability of acceptance.

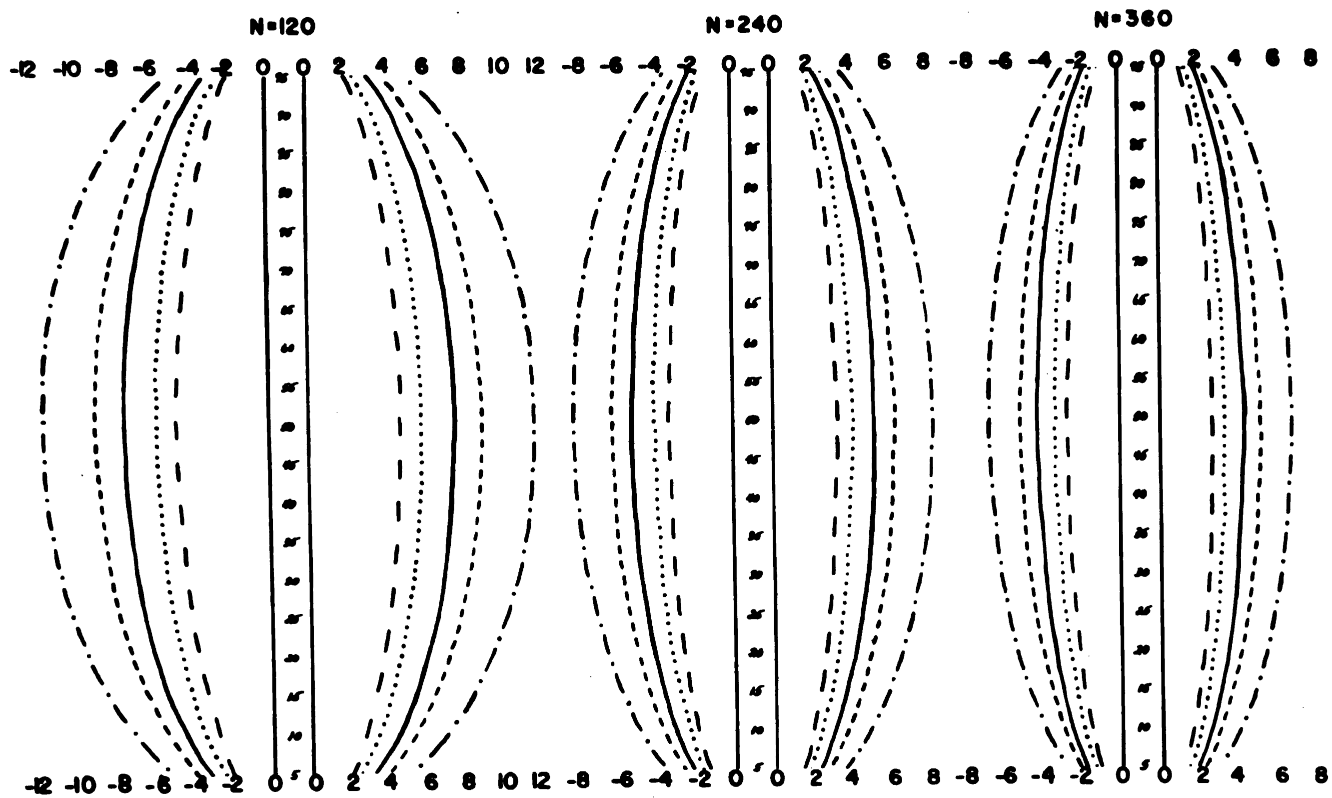
The increased accuracy resulting from the doubling or tripling of the sample size is very important when payment is based on quality or a load is questionable as to its quality for acceptance. When time permits the inspector should increase the size of the sample taken from a grower's load. This is especially important when the loads are large and unsatisfactory acceptance costs and quality payments are detrimental to the grower and the processor. As the sample size is increased the accuracy of the sampling plans increase at a decreasing rate. If the quality of the load contains 16 per cent No. 2 grade cherries then the probability of acceptance with different sample sizes are:

Sample size	=	Chance of acceptance when shouldn't.[2]
120	=	14 per cent
240	=	5 per cent
360	=	2 per cent

Probability is used in reasoning from a known population to a random sample while confidence is used in reasoning from an observed sample to its unknown population. Sampling plans may be evaluated by determining the interval estimates of the quality of the load for different levels of confidence. In figure 8 the confidence interval for different sample sizes and for several confidence coefficients are determined. The confidence coefficients define the confidence that one might have that the quality of the load will fall between the confidence limits for that particular sample. If one makes the interval wider, he can have greater

[2]The discrimination ability of the samples increased 9 per cent from sample sizes 120 to 240 and only 3 per cent from sample sizes 240 to 360.

CONFIDENCE RANGES FOR RAW PRODUCT SAMPLING



CONFIDENCE RANGES

-·-·- 99%
--- 95%
— 90%
····· 80%
-- 70%

FIGURE 8

confidence that his statement will be correct. An estimate that the quality of the load is between 97 and 83 score when the quality of the sample is 90 and the size of the sample is 120 is made with a .99 confidence coefficient. He can be confident that 99 times out of 100 that the quality of the load will be between these scores. If a lower confidence coefficient is chosen for the above sample then then interval will be much narrower. The ranges in figure 8 are only estimates of the confidence range. The true confidence range must be computed by the use of the binomial distribution. As the scores move away from the 50 score the accuracy of the confidence ranges in figure 8 become more inaccurate. For this reason the confidence ranges of scores from 0-5 and from 95-100 are omitted because of the increase in the error at the extremities.

The influence of sample size can be noted on width of the confidence intervals for similar levels of confidence by comparing A, B, and C in figure 8. When the sample is 90 score with a desired confidence coefficient of .90, the interval range decreases from 9.012 to 6.372 when the sample size is doubled and from 9.012 to 5.204 when the sample size is tripled. This again illustrates the importance of increasing the sample size to reduce sampling error.

Evaluation of Processed Product Sampling

The processed product is inspected immediately after it is packed. The procedure usually used is to take a certain number of cans from each line at certain time intervals. The cans are then taken to the quality control laboratory, where the vacuum, drained weights, and net weights are checked and the contents are scored and graded. On the small sized cans the most common sampling procedure consists of checking two cans every half hour. The No. 10 cans are usually checked by removing and testing one can every half hour. The 30 pound coldpack tins are scored and graded by removing a one pound sample from a tin every half hour. The processed product is scored and graded on a count basis as compared to a weight basis on the raw product.

The sample on which a lot is graded is removed from what may be considered as an infinitely large population. We may assume, for practical purposes that one No. 303 can is withdrawn and inspected out of every thousand cans. The question may now be asked: if the lot has a certain per cent defective in one of the factors determining grade, what is the chance of accepting this lot as an A grade when it is a C or D grade lot? These questions are answered in the operating characteristic curves in figure 9 which gives the probability of acceptance as A, C, or D grade when the actual quality of the particular quality characteristic in the lot is set at different levels.

The grades of the processed products are determined by a point system in which any of the three factors of color, character, and defects can place the sample into a lower grade. If the quality is scored down more than 15 per cent on any of these factors, the product will fall into a grade C classification. If the quality is scored down more than 30 per cent on any of these factors, the product will fall into a grade D classification. Because of this condition we may take each factor seperately and determine the probability of accepting it as a certain grade when the lot actual per cent factor defective is at different levels. If any of the factors fall into a lower grade, then the whole lot from which that sample is taken is considered to be in the lower grade.

Assume, for example, that the entire lot of cherries has been inspected and the average scores for the lot on color, character, and defects are 17, 36, and 30 respectively. Table XIV illustrates these scores and defines the grade into which the factors fall. $\frac{17}{20}$ or 85 per cent of the color is good, $\frac{36}{40}$ or 90 per cent of the character is good and $\frac{30}{40}$ or 75 per cent of the lot is free from defects. We can therefore say that the per cent defectives for color, character, and defects are 15, 10 and 25 respectively. Now the question arises as to what the chance is of accepting this lot as an A grade when in reality it is a C grade lot. We will assume that the size of the sample taken is 100 cherries.

TABLE XIV

Scoring System for Finished Product.

	A Grade	C Grade	D Grade
Color	20------17	16------14	13-------0
Character	40--36--34	33------28	27-------0
Defects	40------34	33--30--28	27-------0
Total Score	100-----85	85--83--70	69-------0

In figure 9 color would have a 55 per cent chance of being accepted as an A grade and a 45 per cent chance of being accepted as a C grade. Character has a 95 per cent chance of being accepted as an A grade and 5 per cent chance of being accepted as a C grade. Defects have a 2.5 per cent chance of being accepted as an A grade, 82.5 per cent chance of being accepted as a C grade and a 15 per cent chance of being accepted as a D grade. In the above lot, defects would be most likely to be the limiting factor in the quality determination of the lot.

GRADING PROBABILITIES ON FINISHED PRODUCT

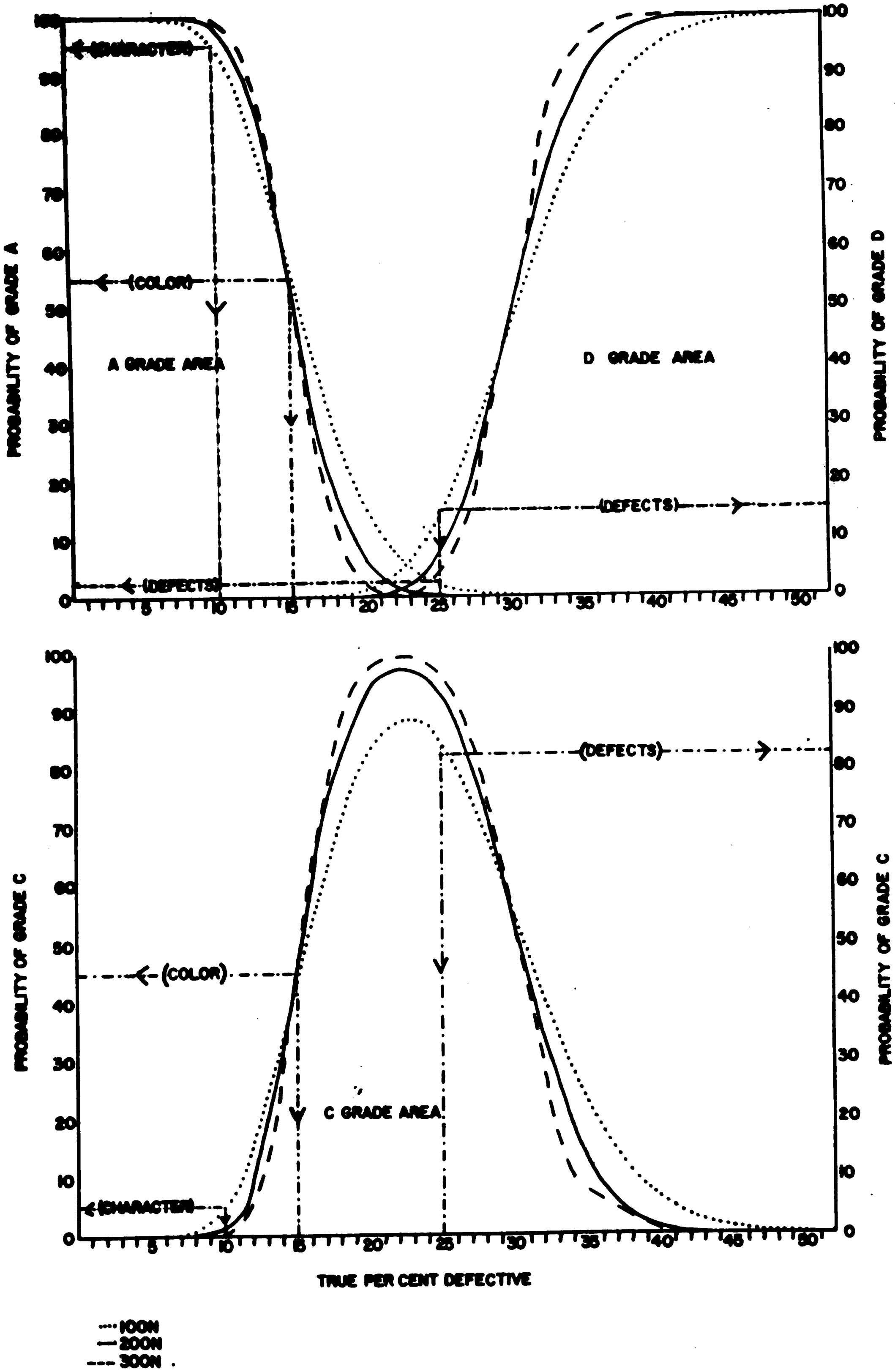


FIGURE 9

By increasing the size of the sample from 100 to 200 or 300 cherries, the probability of this sample predicting the actual grade of the lot is increased. This fact is well illustrated in figure 9. The operating characteristic curves for larger sized samples become steeper and show less dispersion at the extremes. The absolute size of the sample is much more important from the standpoint of quality determination than its relative size.[3] The accuracy of the sampling plans increase at a decreasing rate as the sample size is increased.

The selection of a quality acceptance plan depends on the risk and cost that the processor is willing to accept. This decision is usually based on the objectives of minimizing the sum of production costs, acceptance costs, and unsatisfactory product costs. The amount of inspection can be reduced, held constant or increased, depending upon the processor's estimate of the types and amounts of costs involved. The accuracy of any sampling plan can be described in the formation of an operating characteristic curve. This curve is therefore merely another tool which the processor can use in making economic decisions on sampling plans and procedures.[4]

Theory and Application of Control Charts

Control charts are tools that may be used by processors to detect unusual variations in processing operations. They provide management with guides for making economic decisions concerning the allocation, replacement, and adjustment of the resources or inputs going into

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[3]This fact is well illustrated in Grants' book, Statistical Quality Control pp. 316-317.

[4]For further reference in computing and understanding the formation of this curve see E. L. Grant, Stat. Qual. Control or A. V. Feigenbaum, Quality Control.

processing operations. This tool for guiding management may be defined as "a chronological graphical comparison of actual product quality characteristics with limits reflecting the ability to produce as shown by past experience on the product characteristics."[5]

The inspections preformed on the processed cherry products provide the necessary data for the construction of control charts for different quality characteristics. The variation in quality of different characteristics in the past are used to predict what the variation should be in the future. If new technologies or practices, which reduce or increase quality variation, are adopted by a plant, then the expected variation in the future should also be reduced or increased. In the cherry processing industry defects, character, and color are quality factors which determine the grade of the finished product and are readily applicable to quality control charts. Other quality factors such as net weights, drained weights and vacuum are also measurable observations that can be easily analyzed graphically in control charts.

Standard deviations are measurements of dispersion from the average of a number of observations. By the use of this measurement, predictions can be made as to where the observations of a given quality characteristic should fall. A large number of observations generally will form a normal distribution that is commonly described as a bell-shaped curve. If the population is normally distributed, probabilities can be determined as to the relative frequency that an observation will fall at given distances from the mean. Control limits are points on each side of the mean which discriminate between those observations that fall within a

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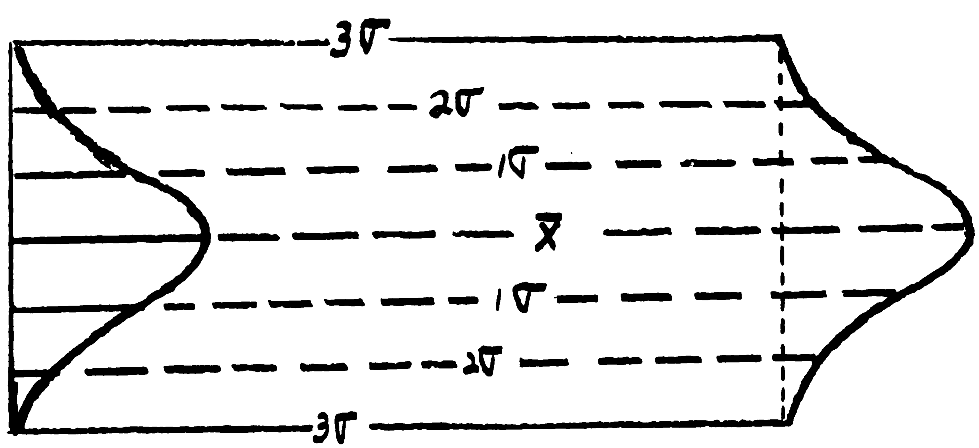
[5] A. V. Feigenbaum, Quality Control, Mc Graw-Hill, New York, 1951, 1st ed., p. 121.

given distance and outside a given distance from the means. If the process is operating normally then the number of observations falling within these limits will approximate the probability that defines this range. If the process is not operating normally then this number of observations will not approximate the probability that is defined by the control limits.

Figure 10 more adequately describes the theory behind control charts. If a large number of observations are drawn from a population, the curve represents the distribution that should be obtained. Standard diviations of 1, 2, and 3 on each side of the mean represent 68, 95, and 99.7 per cent of the area under the curve and defines the probability of a observation falling within this area. Three standard diviations are most commonly used to define the contol limits on a control chart. If control limits are set at three standard diviations on each side of the mean, then three observations out of a thousand should fall outside these limits when the operation is normal.

Control Chart - Based on 3σ

FIGURE 10



Observations do not necessarily have to fall outside the control limits before plant operations should be investigated. Trends in quality characteristics or a concentration of these observations near the control limits may provide evidence of non-random elements occurring in the operations. Observations falling near or below the lower control limits or above or near the upper control limits tell management when to investigate processing operations for possible causes of high or low defective quality character. If the quality character is extremely good as indicated on the control chart then the process should be investigated in order to find and adopt any element into the operation that may improve quality.

If the quality characteristic is extremely poor as indicated by the control chart then the process should be investigated in order to find the cause of the poor quality and make the possible changes in plant operations that would correct this situation. The changes in quality should be examined critically until the factors causing these changes are discovered. The factors causing the poor quality should be eliminated and the factors causing quality improvement should be adapted whenever it is possible and economically feasible. The control limits of the control charts must be adjusted when any permanent change is made in the plant processing operations that will have an important bearing on the quality levels of the various products.

Control charts may be maintained for every product quality characteristic that is measurable. The inspection service or plant quality control personnel can provide the necessary information for the calculation of these charts. Quality factors such as color, character, defects, and total score may be obtained from all processed product inspection samples.

Color, character, defects and total scores are measured in standard units for all processed cherry products and therefore only four control charts, one for each quality factor may be used for the entire plant output. Separate control charts may be maintained of different groups of products or for each processing line in order to have more direct control over each of these quality factors.

Drained weights, net weights and vacuum vary between the different types of products and cannot be aggregated together, therefore, each product must have a separate set of control charts for each of these factors. Additional work may be involved in keeping a separate set of control charts for each product or line but this does help management to discover and find the cause of non-random quality variation by restricting the area of needed investigation.

Some quality characteristics of the processed cherries are affected by weather and other seasonal conditions. In analyzing the records of several plants, seasonal trends were noted in the quality level of the different quality characteristics affecting the processed product. The weather factor is not controllable by man and therefore adjustments are needed in order to obtain control limits that reflect quality variation during any particular day of the season. In order to obtain reasonable control limits, trend lines must be obtained for seasonal changes and a standard error of estimate must be calculated from this trend line.

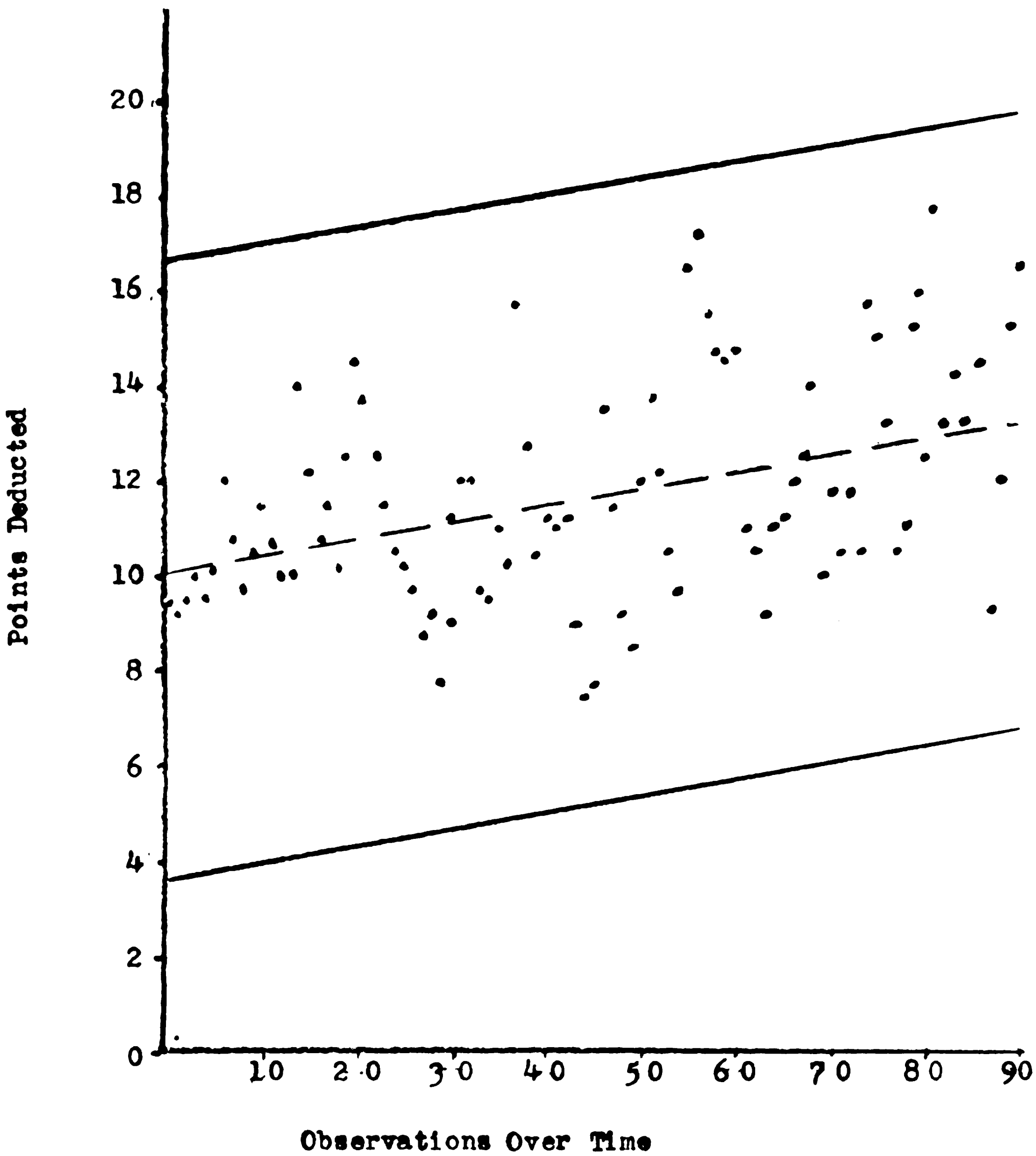
Control charts are presented on the following pages for the various qualitative characteristic that may be found in processed cherries. The control limits are computed as standard error of estimates on those factors that are affected by weather or seasonal conditions. The points plotted on the control charts for color, character, defects and total score represent the points deducted from their possible scores. A score of 17 for color would be plotted as a 3 and a score of 88 for total score would be plotted as a 12. This reduces the size of the numbers needed in calculating control limits and provides the same amount of accuracy.

The observations plotted on the following control charts are taken from actual data of a processing plant during the 1955 season. In order to narrow the control limits on the plotted observations, the observations plotted are averages of four actual observations. The control limits for the individual observations can be obtained by multiplying the 3σ for the grouped averages by the square root of the number in each group. In the case of these control charts, the control limits for actual observations may be obtained by multiplying the 3σ control limits for the averages by $\sqrt{4}$ or 2. Three hundred sixty-four actual observations were grouped into 91 groups for the purpose of the following charts.

Figure 11 is a control chart for total scores for a processed product. The control limits are computed on the basis of a standard error of estimate calculated from the trend line which in this case indicates the quality becomes poorer as the season progresses. This standard error of estimate, as a measure of dispersion, is then used to determine the control limits in figure 12 in which the trend is removed from these limits by the use of a moving average. This moving average can be computed as a certain number of days or as a certain number of observations. In figure 12 an average of 30 observations are used to obtain the adjustments. Ten observations are dropped and ten observations are added every time the adjustments are made. The moving average allows for seasonal changes and yet helps to keep these changes in check because of the residual effect of earlier quality levels.

Control Chart - Total Scores - With Trend [6]

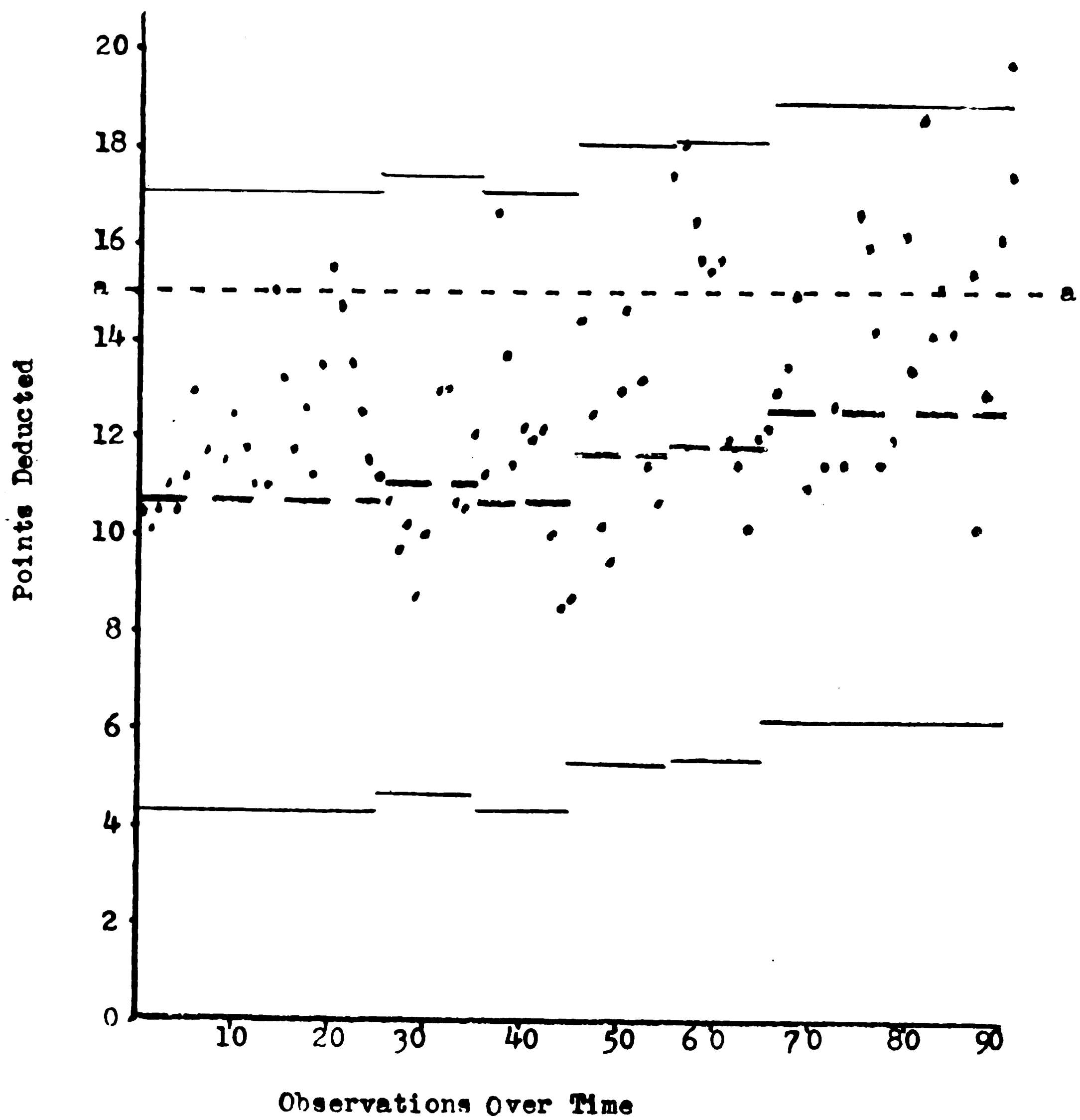
FIGURE 11



[6] In figure 11 the trend line is 10.02 + .037X and the standard error of estimate is 2.149 and the control limits are set at 3σ or $\pm$ 6.45 from the trend line.

Control Chart - Total Score - Moving Average

FIGURE 12



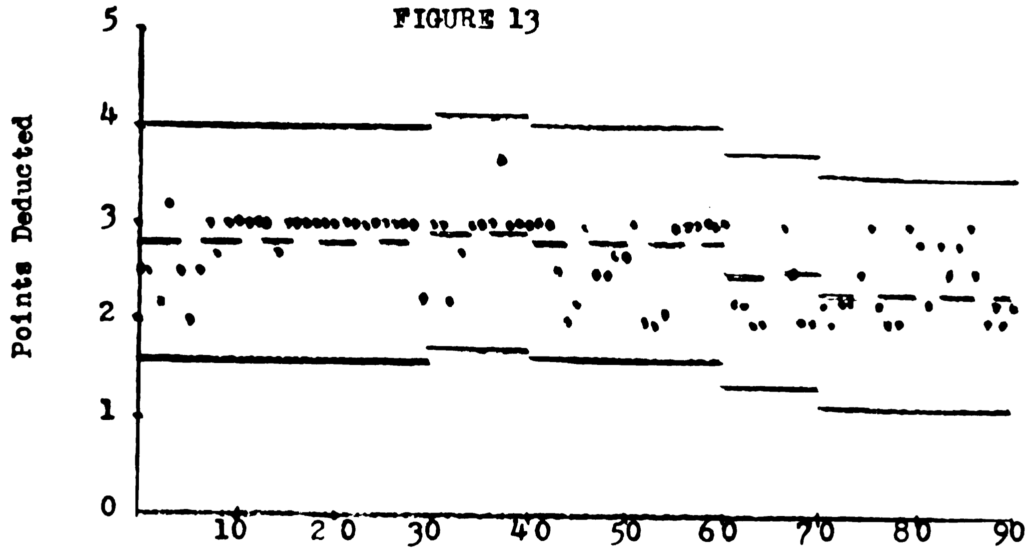
Grade specifications can be incorporated into the control charts to provide information as to the probable grade that is being produced. These specifications may be represented as straight lines drawn across a control chart to distinguish between those observations that fall in A grade classification and those that fall in the C or D grade classification. A 15 point deduction is allowable on total scores before the observation will fall into a C grade. This is indicated by line a - a in figure 12. Another grade line can be drawn at 30 to distinguish between C and D grades.

Total score is composed of the scores of color, character, and defects. Therefore, the control chart for total scores provides management with an indication of when all three of these quality constituents should be investigated. Separate control charts for each of these three quality factors provide management with more direct guides in finding the cause of the non-random variations.

Color is a quality factor that is affected by seasonal changes and therefore must be computed on a moving average control chart. In figure 13 the observations appear to be in control with little variation. A grade classification line can be drawn through 3 on the vertical axis of this chart to distinguish this quality factor as falling in A grade or C grade. Such factors as improper soaking periods or improper cooking may cause color to fall outside the control limits. The influence of seasonal conditions on the color characteristic should be partially removed by the effect of control limit adjustments during the processing season.

Control Chart - Color - Moving Average [7]

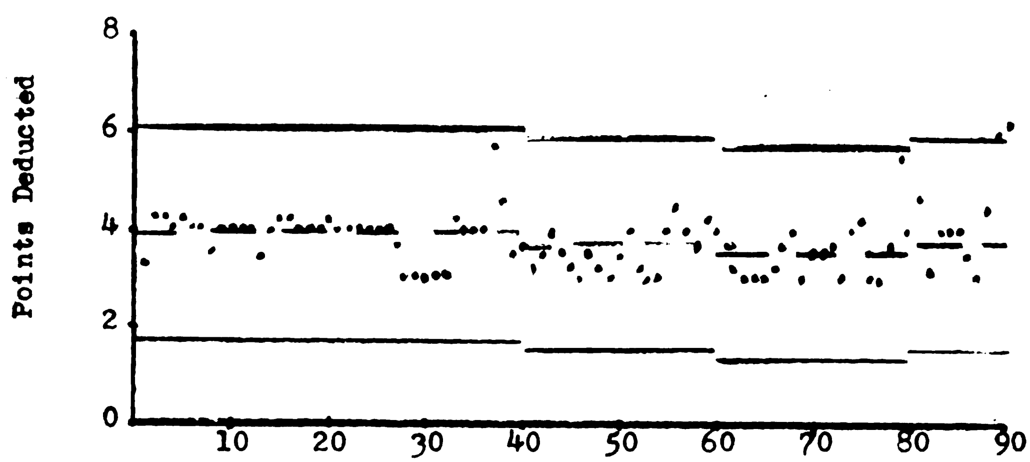
FIGURE 13



Observations Over Time

Control Chart - Character - Moving Average [8]

FIGURE 14



Observations Over Time

7 Control limits are $\bar{\bar{X}} \pm 1.20$

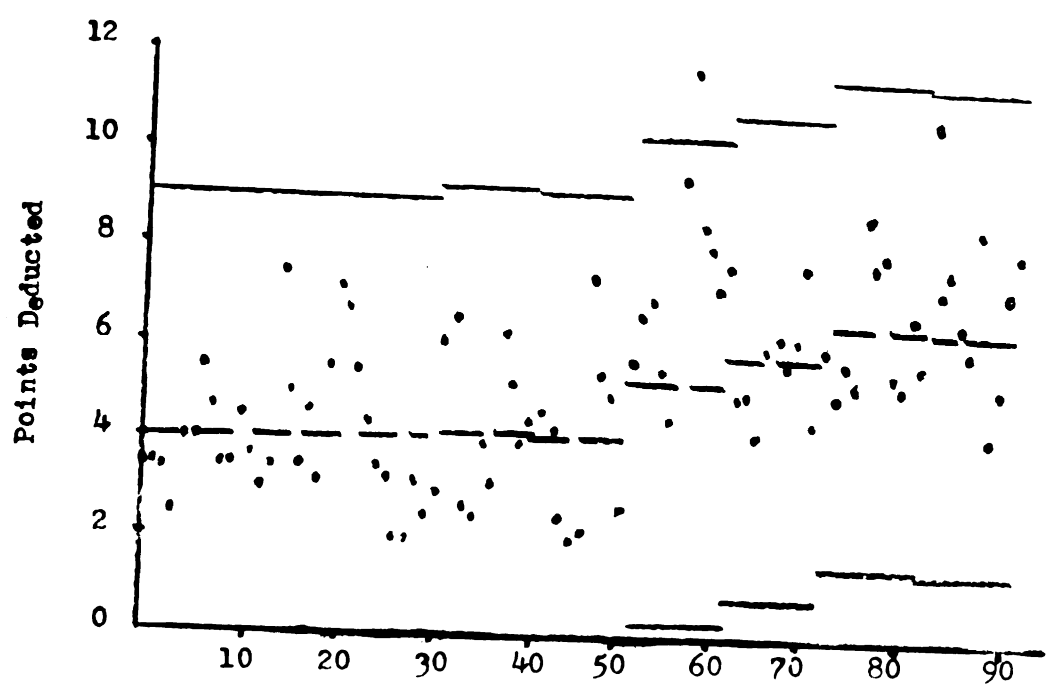
8 Control limits are $\bar{\bar{X}} \pm 2.30$

Figure 14 is a control chart for the quality factor "character." In this chart grade discrimination lines can be drawn horizontally from 6 and 12 to distinguish between A grade and C grade, and between C grade and D grade. In figure 14 the variation of the observations are much greater than those for color. The last observation on the control chart is above the upper control limit and indicates that this process may not be in control. Investigation of the cause of poor character may reveal that the cherries are soaked too long or not long enough in the tanks before processing or that the processing equipment is not operating properly. Proper length of soak is important in getting good character and better performance. Continued investigation may relate the cause back to the grower who may have delivered a load of cherries containing a high per cent of scald or other character defects. A character observation falling below the lower control limit indicates that exceptionally good character is being maintained and investigations may reveal something about the process which can be adopted to improve the process in the future.

Figure 15 is a control chart for defects. Grade lines may be drawn horizontally from 6 and 12 to indicate how the observations fall in relation to government specifications. In the above control chart one observation is extremely high and investigation may indicate that an excessive number of pits or pit fragments are present or that extremely poor quality is being processed. The control chart may show that sorters should be placed between pitters or that more sorters should be put on the inspection belts. Good pitting performance or good raw product quality are two factors that may cause the observations to fall below the lower limits for defects. Mechanical difficulties and inadequate sorting labor are important quality factors. The speed of the processing operation can also be determined by the amount of defects passing over the belts as reflected in the score of the processed product.

Control Chart - Defects - Moving Average

FIGURE 15



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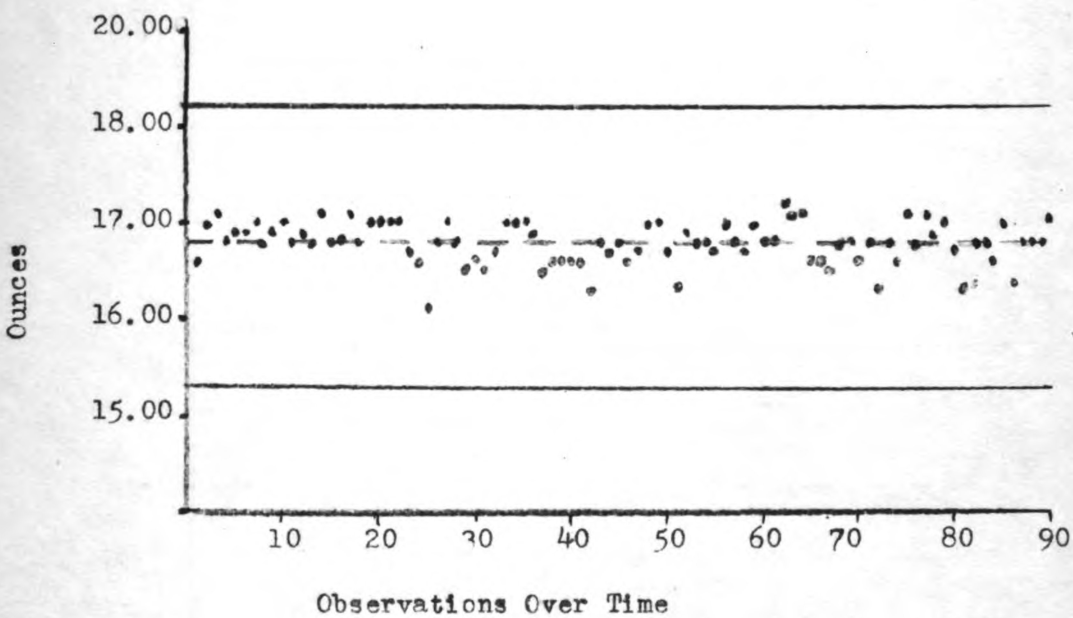
[9]Control limits $\bar{\bar{x}} = 5.03$.

The control charts for net weights, drained weights, and vacuum on No. 303 canned R S P cherries are given in figures 16, 17, and 18. These quality factors do not have seasonal trend and therefore no moving adjustments are necessary and the control limits are computed as the standard diviation from the means. Net weights and drained weights may indicate that the fill weights may be reduced or increased or that something is wrong with the filling operation. Drained weights are influenced by weather conditions from one year to another but do not have seasonal trends. Vacuum in figure 18 exhibits a large amount of variation and probably could be brought under closer control by reducing the lag between the vacuum tank and the closing machine.

Control Chart - Net Weight (303 cans)[10]

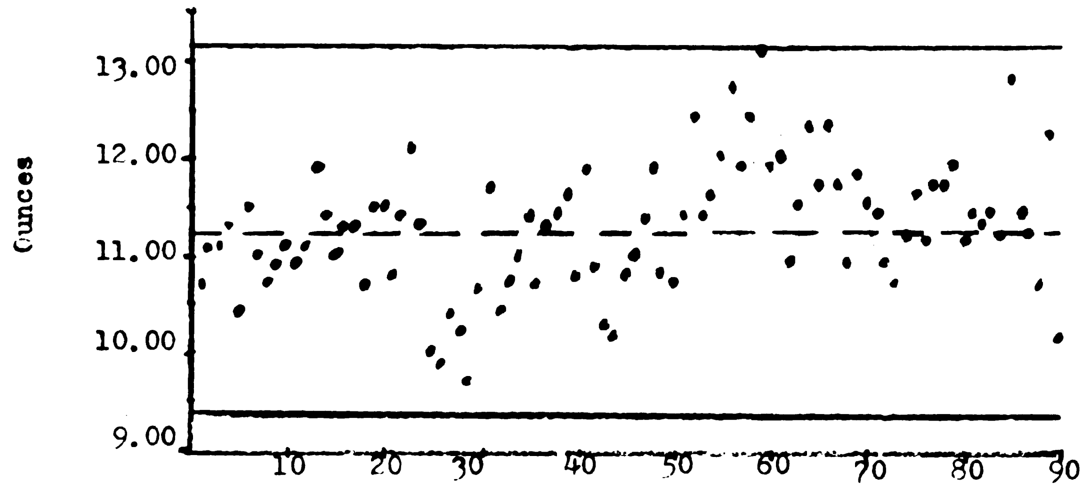
FIGURE 16



[10]Control limits for net weight 16.75 ± 1.45.

Control Chart - Drained Weight (303 cans)[11]

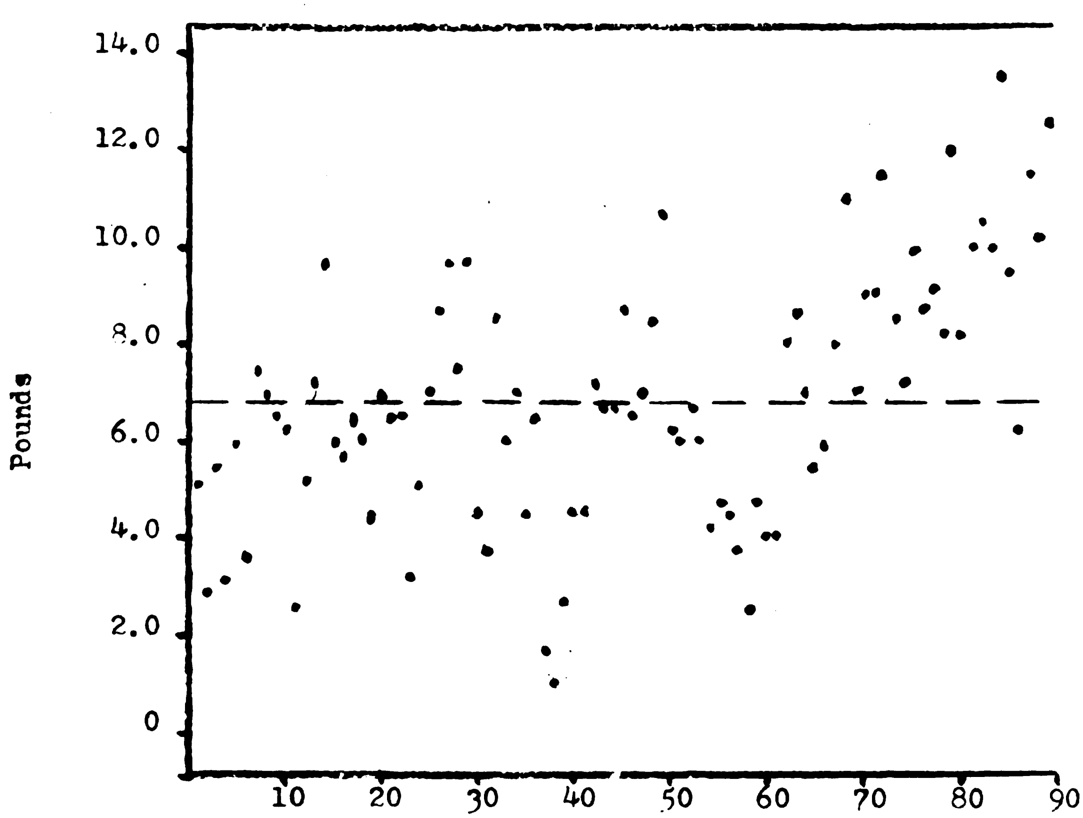
FIGURE 17



Observations Over Time

Control Chart - Vacuum (303 cans)[12]

FIGURE 18



Observations Over Time

[11]Control limits for drained weight 11.25 ± 2.00

[12]Control limits for vacuum 7.50 ± 6.50

The control limits used for any particular product must be calculated from emprical data of past operations. Those quality factors such as color, character, defects and total score which may exhibit seasonal trend should have their control limits based on the standard error of estimate while those which do not exhibit seasonal trend may have their control limits based on the standard deviation from the mean. It is a good practice to use the entire seasons output of one product to determine the control limits to be used for that product the following year. The control limits for products in the third year may be calculated from the second years emperical data or from the average of the first and the second years data. It is necessary to use the previous year's observations in the calculation of the control limits because of the improvements that might have occurred in that year's operations as compared to the first year's operation. By weighing in the effect of previous standard deviations, the control charts from one year to another may become more standardized and vary less from one year to another. The standard deviations for the same quality factors vary considerably for different plants and products. It is, therefore, necessary to have the standard deviations for that particular quality factor and product calculated from several processing seasons before the desired standard deviations may be found on which to base the control limits.

Operating characteristic curves are not only adaptable to sampling inspection, but they are also helpful in analyzing the probability of an observation falling within the control chart if the lot from which the observation is taken has a given percent defective. The computation for obtaining the operating characteristic curve of a control chart that has both a lower and an upper control limit is well described by Freeman, Friedman, Mosteller, and Wallis.[13] The poisson distribution tables by Molina are very helpful in the computation work.[14]

Figure 19 is an example of the results that one might get in calculating an operating characteristic curve for a control chart that has upper and lower control limits. The chart is read by saying that if the actual lot contains a certain per cent defectives, what is the chance that the sample of cherries drawn from this lot will fall within the control limits. In the following example the control limits for a sample of 100 cherries is set at 5 and 18 defectives. This means that if the number of defective cherries is between 5 and 18 then this quality factor is in control. For a sample of 200 and 300 cherries the control limits are set at 10 and 36 defectives and 15 and 54 defectives. An increase in the sample size again results in increasing the discriminating ability of the sample.

The statistical quality control charts discussed in this chapter are somewhat unique to the general concept of control charts. The manufacturing industry usually has a much greater degree of control over the quality of its products and therefore can set a standard for its quality control chart which need only be changed when plant technology or quality specifications change. The food processing industry usually has a lesser degree of control over the quality of its product because of the seasonal or weather conditions that influence quality before being received at

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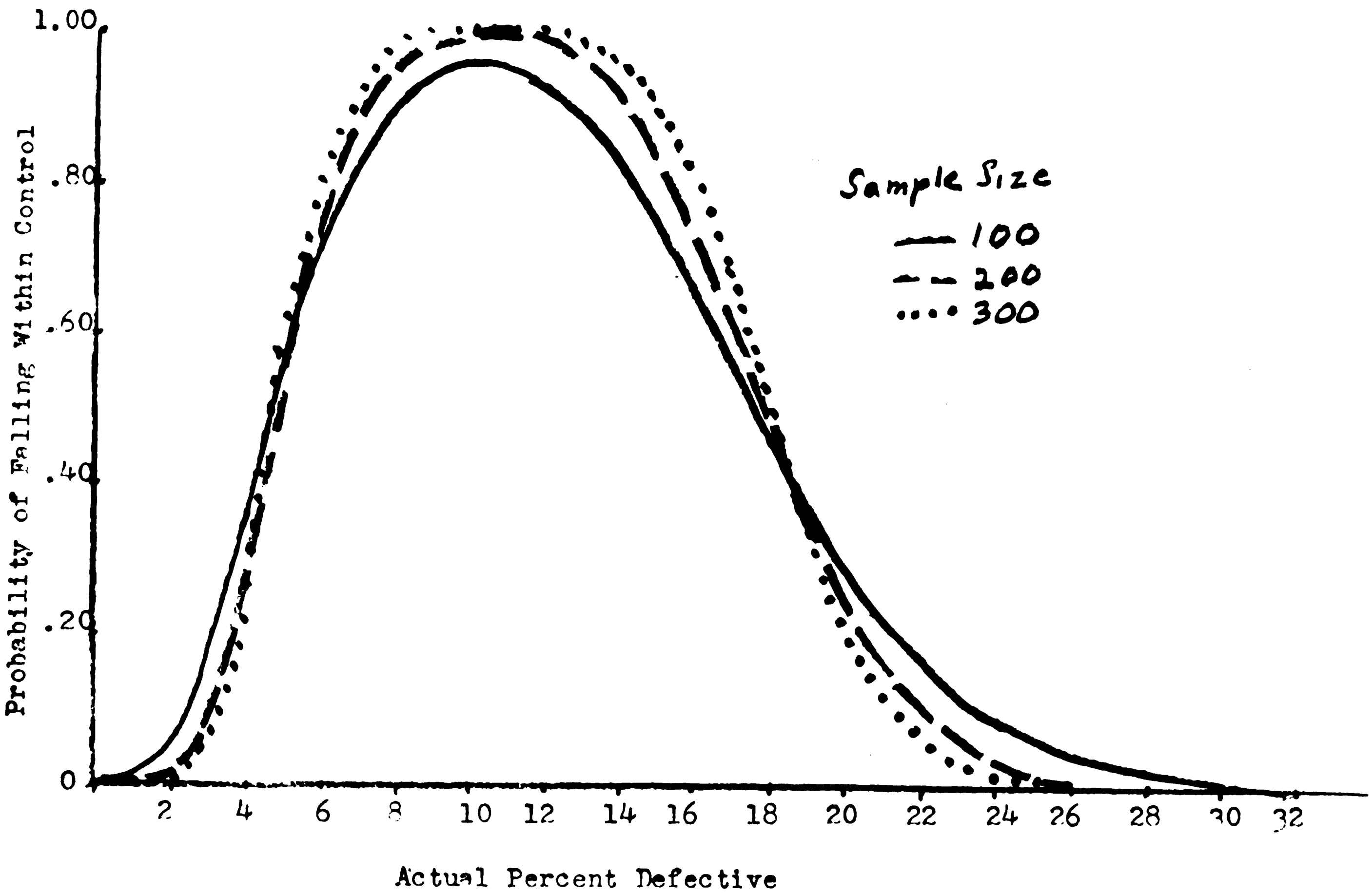
[13] Freeman, Friedman, Mosteller, and Wallis, Sampling Inspection, McGraw Hill Book Co., New York and London, 1st Ed., 1949, pp. 63-66.

[14] Molina, E. C., Poisson's Exponential Binomial Limit, Table II, Van Nostrand Co., Inc., New York, 1942.

Operating Characteristic Curve for a Control Chart
(with Upper and Lower Control Limits)

FIGURE 19



the plant. The control charts in this chapter are illustrated with the hope that more food processors will see that the quality control charts used by manufacturing industries are applicable to the food processing industries by making adjustments by the use of moving averages to account for seasonal changes in quality due to weather and other conditions over which they have no control.

CHAPTER VII

SUMMARY AND CONCLUSIONS

(1) Considerable differences exist between processors in relation to their attitudes toward quality control and maintenance programs. Some processors provided the growers with more incentives and aid for producing quality cherries than others. Several plant managers stated that the quality that went into their plants was the quality that came out. In many plants the quantity of output was emphasized rather than the quality of output.

(2) Processors have attempted to improve the quality of the raw product delivered to their plants by conducting grower meetings, using quality payment programs, employing fieldmen and promoting and engaging in other activities that may help the grower. Smaller plants were quite limited in their educational activities. Many different grower payment plans existed in the red cherry processing industry. The type of payment plans used by a plant was closely related to locational groupings. Payment plans, or educational programs or services, appeared to have very little influence on the quality of the raw product delivered to the plants.

(3) The size of the operation of the individual growers seemed to have an effect on the quality delivered to the plant. Growers who delivered from 100 to 1000 lugs to a plant usually had higher quality than smaller or larger growers. The average size grower is probably better able to supervise harvesting and production operations than large growers.

(4) An analysis of the growers' inspection records at three

processing plants revealed that growers who delivered high quality reduced their defects by reducing those that are controllable. Only 21.31 percent of the total defects shown in lots delivered by better quality growers were controllable as compared with 32.15 percent for the lower quality growers. This seems to indicate that the better quality growers had improved their quality by reducing those defects over which they had some control.

(5) Raw product quality varied considerably from one day to another. The average daily quality change at a northern plant was larger than those daily quality changes in other locations. No consistent quality trends were noticeable at any plant. The locational factor has a higher relationship to a plant's average raw product grade than did the average size of the grower or the type of educational and payment plans.

(6) The most important defects affecting the raw product quality were windwhip, scars and color. There was a closer correlation in the relative importance of these factors between a northern and southern plant than between two southern plants. Processors listed windwhip, scars, lugscald and color as the more important factors affecting the quality of the processed product.

(7) Attempts at in-plant quality improvement varied from one plant to another. The average processing plant had two and three-fourths sorters for every thousand pounds of raw product going over the sorting belts in an hour. An one plant, only 1.3 sorters were used on the belts for every thousand pounds of cherries, while at another plant 6.67 sorters were maintained for every thousand pounds. Attitudes of management toward quality improvement and the quality of the raw product passing over the lines were responsible for this difference between plants.

When raw product quality was poor, the volume passing over the belts was reduced.

(8) Sorters on belts varied in the amount of cherries they removed from the belts. It was not unusual to find one sorter removing three times as many cherries as other sorters in the same plant. The amount of pick-out varied between 2 and 9.6 percent of the volume passing over belts in 26 different plants. The average sorter picked out about 19.25 pounds of cherries in an hour. The average percentage pick-out for the 26 plants was 4.6%.

(9) Receiving, storing, size grading, pitting, weighing and other processing operations were important in quality improvement. Considerable differences existed between plants in receiving methods, handling practices and soaking periods. Several plants used two or more eliminators in their processing lines. Many plants overloaded their pitters during the peak of the season. Some plants weighed every 500th small can while others weighed every 5,000th small can. The check for quality of the contents also varied extensively between plants.

(10) Several plants maintained continuous government inspection service on their processed products and other plants had their own specialized quality control personnel. The usual procedure in checking the product quality consisted of removing cans from the lines at certain time intervals. There appeared to be some correlation between the raw and finished product grades. The grade of the raw product appeared to be a poor index of the finished product grade because of the different quality characteristics used in grading the two products. There was an increase in the quality of the processed product between the time the probable and final inspections were made. This improvement was the

result of improved character and the blending of the color in the contents.

(11) The need for quality improvement and quality control in the food processing industry has increased with the growth of competition. Increased cherry production has caused the cherry processors to enlarge their packs. This has resulted in more competition in pack sales among the packers. Government has bought cherries from packers to reduce the quantity-price squeeze, but the remainder of the pack must be put on a market where both price and quality will affect the sales. Quality maintenance may assure a processor of having a good outlet for this product. Several plants in the cherry processing industry have built such reputations.

(12) The use of quality control techniques enables the processor to know what qualities are coming through his plant. Signs of possible plant improvements may be detected and adopted into the plant's regular operations. Difficulties in the process may also be detected and corrected. Economic decisions concerning the allocation and disposition of in-plant resources may be aided by the use of such tools. Quality control techniques are receiving increased interest by the food processing industry, yet up to this time few cherry processors in Michigan have used these tools.

(13) More intensive study should be made of the actual quality improvement being made by a number of plants. The study that has just been conducted was too general to make detailed in-plant and between-plant comparisons in quality and efficiency operations. Many differences exist between plants and additional study in this field is undoubtedly needed.

(14) Information gathered in this study indicates that there may

be considerable differences between inspectors in the grading of the raw product. Wide differences existed in the quality of the cherries graded by different inspectors at the same receiving stations. Raw product inspection records are available which could be used to further evaluate the importance of these differences.

(15) Grading procedures for processed cherries presents a problem in statistical sampling. The grade of a lot is determined by multivariate factors. A model should be developed to determine the probability of acceptance or rejection of a lot on the basis of these factors. This should prove to be a very intriguing problem for a statistics major.

BIBLIOGRAPHY

Abbott, Lawrence, Quality and Competition, Columbia University Press, New York, 1955.

Anonymous, Agricultural Marketing Service Standards - Inspection Marketing Practices, United States Department of Agriculture, Public Law 156, 83rd Congress, Washington, D.C., Effective Date July 1, 1954.

Anonymous, "Are U. S. Canned Food Grades Commercially Suitable?" The Food Packer, December, 1943.

Anonymous, Canned Food Pack Statistics, 1955, National Canner's Association, Washington, D.C., June 1956.

Anonymous, Canning Trade Almanac, Published Yearly by the Canning Trade Journal, Baltimore 2, Maryland.

Anonymous, Michigan Cherry Survey, Michigan Cooperative Crop Reporting Service, Lansing, Michigan, 1949 and 1955.

Anonymous, Questions and Answers on Government Inspection of Processed Fruits and Vegetables, Misc. Publication No. 598, United States Department of Agriculture, Production and Marketing Administration, Washington D.C., April 1946.

Anonymous, Standards for Red Sour Cherries for Manufacture, United States Department of Agriculture, Production and Marketing Administration, Washington, D.C., Effective April 20, 1941.

Anonymous, U.S. Standards for Grades of Canned Red Sour (tart) Pitted Cherries, CFR Sec. 52:241, United States Department of Agriculture, Washington, D.C., Effective June 18, 1949.

Anonymous, U.S. Standards for Grades of Frozen Red Sour (tart) Pitted Cherries, CFR Sec. 52:242, United States Department of Agriculture, Washington D.C., Effective June 18, 1949.

Bedford and Robertson, "The Effect of Various Factors on the Drained Weight of Canned Red Cherries," Food Technology, Vol. IX No. 7, 1955.

Boger, L. L., Michigan Red Cherry Prices, Special Bulletin 371, Michigan Agricultural Experiment Station, East Lansing, Michigan. 1951.

Brice, B. A., The Measurement and Specification of Color, Eastern Utilization Research Branch, United States Department of Agriculture, Washington, D.C.

Feigenbaum, A.V., Quality Control, McGraw Hill Book Co., Inc., New York 1951.

Freeman, Friedman, Mosteller, and Wallis, Sampling Inspection, McGraw Hill Book Co., Inc., New York, 1st Ed., 1949.

Gaston and Levin., "Transporting Red Cherries in Water from Orchard to Processing Plant," Quarterly Bulletin, Michigan Agricultural Experiment Station, Vol. 37, No. 3, East Lansing, Michigan.

Gould, W. A., "Quality Emphasized at State Meeting," Food Packers, March, 1955.

Grant, E. L., Statistical Quality Control, McGraw Hill Book Co., Inc., New York, 1952.

Hills, C. H. and Whittenberger, R. T., "Studies on the Processing of Red Cherries," Food Technology, Vol. VII, No. 1, 1953.

Knight, F. H., Risk Uncertainty and Profit, Houghton Mifflin Co., New York, 1921.

Marshall, R. E., Cherries and Cherry Products, Interscience Publishers, Inc., New York, 1954.

Molina, E. C., Poisson's Exponential Binomial Limit, Van Nostrand, Inc. New York, 1942.

Peterson, G. M. and Carleton, W. M., "Possibilities of Using Colored Lights for Detection of Cull Cherries," Quarterly Bulletin, Michigan Agricultural Experiment Station, Vol. 34, No. 4, East Lansing, Michigan, November, 1951.

Thompson and Spangler, Some Observations on the Relationship of Quality of Fresh Sour Cherries to Their Processed Products and Effects of Processing of Various Types of Defects, United States Department of Agriculture, Production and Marketing Administration, Washington, D. C., June, 1949.

APPENDIX A

QUESTIONNAIRE AND
INSPECTION SHEETS USED
FOR COLLECTION OF INFORMATION

CONFIDENTIAL CONFIDENTIAL

Department of Agricultural Economics
Michigan State College

The information asked for in this study is for research purposes only. Your name will not be made public and none of the information will be divulged in such a way that your answers can be individually recognized.

(1) Name of business_______________ (2) Type of ownership_______

(3) Address ____

(4) Number of years in operation ____________________

(5) Manager's name __________________(6) Years at present job____

THE NEXT FEW QUESTIONS PERTAIN TO FINISHED PRODUCT
AND NOT TO CHERRIES RECEIVED FROM THE FARMER

(7) Throughout the last couple of years what factors have most often prevented you from putting up as good a pack as you would like to? Please list in order of importance.

Item	Hot Pack	Cold Pack
Excessive pits	______	______
Undersize	______	______
Lug scald	______	______
Limb rub.	______	______
Color	______	______
Defects	______	______
Variation in can weight	______	______
Other:__________	______	______
______________	______	______
______________	______	______
______________	______	______

(8) Have any of these affected the price you receive for cherries?
Yes____ No____ How much _______________________?

(9) Do you try to put up a pack that exceeds the minimum requirement specified in government grade standards? Yes____ No____. What score do you attempt to obtain when packing "A" grade_________? "C" grade __________?

(10) What is your opinion on the following items with respect to present government inspection procedures?

-2-

Item	Hot Pack	Cold Pack
Are grade standards too high, not high enough, about right?		
Are samples taken often enough?	Yes___ No___	Yes___ No___
Are samples taken large enough to be accurate?	Yes___ No___	Yes___ No___
Are there any important quality characteristics not now covered in the grade standards? If so specify.		

(11) What percent of your pack do you sell to customers who buy from you year after year? ________________

(12) Do you put up a different kind of pack early or late in the season in order to differentiate between the quality of cherries going into certain kinds of packs? If yes, explain________________

____

____

THE NEXT FEW QUESTIONS PERTAIN TO
CHERRIES RECEIVED FROM THE FARMER

(13) Do you pay a premium or bonus for high quality cherries?
Explain____

____

____

____

(14) What minimum quality will you accept for processing? If this varies with use, variety or season please give details.__________

____

____

____

____

(15) What is your opinion on the following items with respect to present government inspection procedures?

Are grade standards too high______not high enough______about right_____throughout the load to be accurate? Yes_____No_____.
If no explain:____

____

____

Are there any important quality characteristics not covered in the grade standards? Yes_____No_____. If yes, specify________

____

____

PATRONAGE DATA

(16) How many growers do you buy from in a normal year_______________?

(17) What proportion of your farmers do not expect to consistently deliver high quality cherries?_______________%

(18) What proportion of the cherries you receive are delivered directly to your plant by farmers__________, and what proportion comes from receiving stations______________?

(19) Is there a noticeable difference in the quality or condition of cherries received from each source? Explain________________

____

____

(20) Are cherries transported from receiving stations in water?________

(21) About how many hours pass from picking until these cherries are tanked?

____

(22) Do you use ice in your tank? Yes__________ No__________.

(23) How many hours pass from tanking till cherries are finished processed?__________________

(24) Do you work with farmers in any of the following ways in order to get them to improve quality?

Kind of Activity	Extent of activity, number of contacts or approximate cost
Fieldman	
Growers Meetings	
Mail contacts	
Other	

(25) Do you plan on any of the above in the future__________________

(26) How much storage capacity do you have cold____________, common____________?

SALES DATA

(27) In a normal crop year (1953 for example) what percent of your sales are made direct and what percent are made through brokers?

	Hot Pack	Cold Pack
Direct	____	____
Brokers	____	____

(28) What percent of your direct sales are made in each of the following outlets in a normal crop year? (1953)

	Hot Pack	Cold Pack
a. Chain stores	______%	______%
b. Wholesale grocers	______%	______%
c. Government (military, etc.)	______%	______%
d. Institutional buyers (hotels, restaurants)	______%	______%
e. Food processors (ice cream plants, bakers, preservers, pie mixers, etc.)	______%	______%

(29) To the best of your knowledge that percent of your broker sales go to each of the following in a normal crop year (1953)

	Hot Pack	Cold Pack
a. Chain stores	____%	____%
b. Wholesale grocers	____%	____%
c. Government (military, etc.)	____%	____%
d. Institutional buyers (hotels, restaurants)	____%	____%
e. Food processors (ice cream plants, bakers, Preservers, pie mixers, etc.)	____%	____%

(30) How many pounds of sour cherries did you handle in 1953________, 1954________? How many do you expect this year?________________

(31) Approximately what proportion of your pack graded "A" and what proportion graded "C" in each of these years?

Year	Grade A	Grade C
1953		
1954		
Expected 1955		

(32) What may be the cause for the variations (if there are any) above?

____

(33) Can you supply the following information on sour cherry sales for last year?

Grade	Kind of Pack	Total Value of Sales

COST DATA

(34) Do you keep daily records on the volume of cherries processed, labor costs, and ingredient costs? Yes___ No___. If yes, would you be willing to make these records available at some later date?

____

PLANT INSPECTION

Receiving:

(35) Number of men employed in receiving?___________

(36) Equipment used? ____

____

____

(37) Describe method used in handling cherries up to point where they go onto belts; note particularly handling methods designed to help prevent damage or maintain quality.______________________

____

____

____

Picking:

Fill out the following table:

Line Number	Length	No. of Pickers on line	Normal rate cherries pass over line, #/hr.	Pick taken per hour

Pitting:

(39) Number of pitters in operation ______________________.

(40) Normal rate of use___________________________________.

(41) Describe what happens to cherries after they leave the picking belt. (Complete a separate sheet for each kind of pack.)

	Description of Equipment including Capacity	No. of Employees involved per shift
Hot Pack		
Pitting		
Filling		
Weighing		
Exhausting		
Closing		
Cooking & cooling		
Labeling & casing		
Warehousing		
Cold Pack		
Pitting		
Filling		
Weighing		
Adding sugar etc.		
Covers		
Stamping		
Warehousing		

UNITED STATES DEPARTMENT OF AGRICULTURE
Production and Marketing Administration

SCORE SHEET
for
CANNED RED SOUR (TART) PITTED CHERRIES
(Effective June 23, 1949)

Cont. No. __________
P. O. No. __________
Ref. No. __________
Cert. Form (_____)
Cert. No. __________
Date Inspected __________

Applicant ______________
____
Address ______________
____

													Average
Number, size, and kind of container													
Container makr or identification													
Label													
Net weight (ounces)													Oz.
Vacuum (inches)													
Drained weight (ounces)													Oz.
Designation (Ex Hvy, Hvy, Lt, etc)													
Sirup measurement (°Brix)													°
Size ** (% less than 9/16")													
F A C T O R S	Score Points												
I. COLOR	20	(A) 17-20 (C) 14-16* (D) 0-13*											
II. ABSENCE OF DEFECTS	40	(A) 34-40 (C) 28-33* (D) 0-27*											
III. CHARACTER	40	(A) 34-40 (C) 28-33* (D) 0-27*											
TOTAL SCORE	100												
NORMAL FLAVOR													
GRADE													

* - Indicates limiting rule within classification
** - See size limitation for U. S. GRADE A or U. S. FANCY only

Charge on Certificate
Fee __________
Expenses __________ : TOTAL __________

______________ Official Inspector

0320(1)

UNITED STATES DEPARTMENT OF AGRICULTURE
Production and Marketing Administration

SCORE SHEET
for
FROZEN RED SOUR (TART) PITTED CHERRIES
(Effective June 18, 1949)

Cont. No. __________
P. O. No. __________
Ref. No. __________
Cert. Form (______) __________
Cert. No. __________
Date inspected __________

Applicant __________
____
Address __________
____

Number, size, and kind of container															
Container mark or identification															Average
Label															
Net weight (ounces)															Oz.
Size **(% less than 9/16")															
FACTORS	Score Points														Average Score
I. COLOR	20	(A)17-20 (C)14-16* (D) 0-13*													
II. ABSENCE OF DEFECTS	40	(A)34-40 (C)28-33* (D) 0-27*													
III. CHARACTER OF FRUIT	40	(A)34-40 (C)28-33* (D) 0-27*													
TOTAL SCORE	100														
NORMAL FLAVOR															
GRADE															

* - Indicates limiting rule within classification
** - See Grade A only

Charge on Certificate
Fee __________
Expenses __________
Total __________

__________ Official Inspector

9986(1)

Form F&V—11 Revised 1-30-53

OFFICIAL INSPECTION REPORT

UNITED STATES and MICHIGAN DEPTS. OF AGRICULTURE

This report does not excuse failure to comply with any of the regulatory laws enforced by the State or Federal Departments indicated above.

Insp. Point:____________________ Date_______________

Grower:______________________________________

Canner:______________________________________

Product:____________________ No. of Packages:__________

Weight of sample:________________________________

Percentage of defects:____________________________

Number of worms in sample:_________________________

Grade:_______________________________________

____

____

Remarks:_____________________________________

____

____

I, the undersigned, on the above date specified, made personal inspection of samples selected from the accessible portion of the load and do hereby certify that the conditions on said date, as shown by said sample was as stated herein.

____________________ **A** 106688

Inspector

APPENDIX B

CONTROL CHART
DATA AND
SAMPLING EVALUATION

Control Chart Data
Points Deducted from;

Number of Observation	Color	Defects	Character	Total Score
1	2.50	3.50	3.50	9.50
2	2.50	3.50	3.25	9.25
3	2.25	3.00	4.25	9.50
4	3.25	2.50	4.25	10.00
5	2.50	4.00	4.00	9.50
6	2.00	4.00	4.25	10.25
7	2.50	5.50	4.00	12.00
8	3.00	4.75	4.00	10.75
9	2.75	3.50	3.50	9.75
10	3.00	3.50	4.00	10.50
11	3.00	4.50	4.00	11.50
12	3.00	3.75	4.00	10.75
13	3.00	3.00	4.00	10.00
14	3.00	3.50	3.50	10.00
15	3.75	7.25	4.00	14.00
16	3.00	5.00	4.25	12.25
17	3.00	3.50	4.25	10.75
18	3.00	4.75	4.00	11.75
19	3.00	3.25	4.00	10.25
20	3.00	5.50	4.00	12.50
21	3.00	7.25	4.25	14.50
22	3.00	6.75	4.00	13.75
23	3.00	5.50	4.00	12.50
24	3.00	4.50	4.00	11.50
25	3.00	3.50	4.00	10.50
26	3.00	3.25	4.00	10.25
27	3.00	2.00	4.00	9.75
28	3.00	2.00	3.75	8.75
29	3.00	3.25	3.00	9.25
30	2.25	2.50	3.00	7.75
31	3.00	3.00	3.00	9.00
32	3.00	6.00	3.00	12.00
33	2.25	6.75	3.00	12.00
34	2.75	2.75	4.25	9.75
35	3.00	2.50	4.00	9.50
36	3.00	4.00	4.00	11.00
37	3.00	3.25	4.00	10.25
38	3.75	6.25	5.75	15.75
39	3.00	5.25	4.50	12.75
40	3.00	4.00	3.50	10.50
41	3.00	4.50	3.75	11.25
42	3.00	4.75	3.25	11.00
43	3.00	4.25	3.50	11.25
44	2.50	2.50	4.00	9.00
45	3.00	2.00	3.50	7.50

Control Chart Data
Points Deducted From;

Number of Observation	Color	Defects	Character	Total Score
46	2.25	2.25	3.25	7.75
47	3.00	7.50	3.00	13.50
48	2.50	5.50	3.50	11.50
49	2.50	5.00	3.25	9.25
50	2.75	2.75	3.00	8.50
51	2.75	5.75	3.50	12.00
52	3.00	6.75	4.00	13.75
53	2.00	7.00	3.25	12.25
54	2.00	5.50	3.00	10.50
55	2.25	4.50	3.00	9.75
56	3.00	9.50	4.00	16.50
57	3.00	11.75	4.50	19.25
58	3.00	8.50	4.00	15.50
59	3.00	8.00	3.75	14.75
60	3.00	7.25	4.25	14.50
61	3.00	7.75	4.00	14.75
62	2.25	5.00	3.75	11.00
63	2.25	5.00	3.25	10.50
64	2.00	4.25	3.00	9.25
65	2.00	6.00	3.00	11.00
66	2.00	6.25	3.00	11.25
67	3.00	5.75	3.25	12.00
68	2.50	6.25	3.75	12.50
69	2.00	7.75	4.00	14.00
70	2.00	4.50	3.00	10.00
71	2.25	6.00	3.50	11.75
72	2.00	5.00	3.50	10.50
73	2.25	5.75	3.75	11.75
74	2.25	5.25	3.00	10.50
75	2.50	8.75	4.00	15.25
76	3.00	7.75	4.25	15.00
77	2.25	8.00	3.00	13.25
78	2.00	5.50	3.00	10.50
79	2.00	5.25	3.75	11.00
80	3.00	6.75	5.50	15.25
81	2.75	5.75	4.00	12.50
82	2.25	10.75	4.75	17.75
83	2.75	7.25	3.25	13.25
84	2.50	7.75	4.00	14.25
85	2.75	6.50	4.00	13.25
86	3.00	6.00	4.00	13.00
87	2.50	8.50	3.50	14.50
88	2.00	4.25	3.00	9.25
89	2.25	5.25	4.50	12.00
90	2.00	7.25	6.00	15.25

Control Chart Data
for 303 Cans

No. of Observation	Net Weight (ounces)	Drained Weight (ounces)	Vacuum (pounds)
46	16.88	10.94	8.75
47	16.63	11.13	6.50
48	16.75	11.50	7.00
49	17.06	12.00	8.50
50	17.00	10.81	10.75
51	16.75	10.75	6.25
52	16.38	11.56	6.00
53	16.94	12.50	6.75
54	16.88	11.50	6.00
55	16.88	11.75	4.25
56	16.75	12.19	4.75
57	17.00	12.81	4.50
58	16.88	12.06	3.75
59	16.75	12.50	2.50
60	17.00	13.25	4.75
61	16.81	12.00	4.00
62	16.88	12.19	4.00
63	17.25	11.00	8.00
64	17.19	11.63	8.75
65	17.13	12.44	7.00
66	16.63	11.88	5.50
67	16.69	12.44	6.00
68	16.50	11.81	8.00
69	16.81	11.00	11.00
70	16.88	11.94	7.00
71	16.69	11.19	9.00
72	16.88	11.06	9.00
73	16.31	10.88	11.50
74	16.81	11.38	8.50
75	16.69	11.75	7.25
76	17.13	11.25	10.00
77	16.88	11.88	8.75
78	17.13	11.81	9.25
79	16.94	12.06	8.25
80	17.06	11.25	12.00
81	16.75	11.50	8.25
82	16.38	11.44	10.00
83	16.88	11.50	10.50
84	16.88	10.88	10.00
85	16.69	12.19	13.50
86	16.06	11.50	9.50
87	16.44	11.38	6.25
88	16.81	10.88	11.50
89	16.88	12.31	10.25
90	16.88	10.25	12.50

Probabilities of Accepting Cherries for Processing with Different Sample Sizes and with Different Lot Qualities.*

Sample Size 120		Sample Size 240		Sample Size 360	
Percent Defective	Probability of Acceptance	Percent Defective	Probability of Acceptance	Percent Defective	Probability of Acceptance
02	1.000	02	1.000	02	1.000
04	1.000	04	1.000	04	1.000
06	.993	06	.999	06	1.000
08	.935	08	.977	08	.992
10	.772	10	.823	10	.860
12	.520	12	.490	12	.468
14	.298	14	.190	14	.132
16	.141	16	.050	16	.020
18	.060	18	.009	18	.000
20	.020	20	.001	20	.000
22	.010	22	.000	22	.000
24	.002	24	.000	24	.000
26	.001	26	.000	26	.000
28	.000	28	.000	28	.000
30	.000	30	.000	30	.000

*Allowable percent defective is 12.

CONFIDENCE RANGE FOR RAW PRODUCT SAMPLING

N = 120

Score of Sample	% level of confidence				
	70	80	90	95	99
95	± 2.062	±2.551	±3.274	± 3.900	± 5.126
94	2.246	2.779	3.566	4.249	5.585
93	2.413	2.986	3.831	4.565	6.000
92	2.566	3.176	4.075	4.855	6.381
91	2.706	3.349	2.397	5.120	6.729
90	2.838	3.511	4.506	5.368	7.056
89	2.959	3.661	4.698	5.598	7.357
88	3.073	3.802	4.879	5.813	6.640
87	3.181	3.936	5.050	6.017	7.908
86	3.282	4.061	5.211	6.209	8.161
85	3.377	4.179	5.363	6.390	8.398
84	3.468	4.291	5.506	6.560	8.622
83	3.552	4.396	5.641	6.721	8.833
82	3.633	4.496	5.769	6.874	9.034
81	3.710	4.591	5.891	7.019	9.225
80	3.782	4.681	6.006	7.156	9.405
79	3.852	4.767	6.116	7.287	9.578
78	3.918	4.849	6.221	7.413	9.742
77	3.980	4.925	6.320	7.530	9.897
76	4.039	4.999	6.414	7.642	10.044
75	4.095	5.068	6.503	7.748	10.183
74	4.148	5.133	6.587	7.848	10.314
73	4.100	5.196	6.667	7.944	10.441
72	4.247	5.255	6.743	8.034	10.559
71	4.291	5.310	6.814	8.118	10.670
70	4.334	5.363	6.881	8.199	10.775
65	4.511	5.582	7.162	8.534	11.216
60	4.633	5.733	7.356	8.765	11.520
55	4.704	5.822	7.470	8.900	11.698
50	4.728	5.851	7.508	8.945	11.757

Confidence Range for Row Product Sampling

N = 240

Score of Sample	% level of confidence				
	70	80	90	95	99
95	± 1.458	± 1.804	± 2.315	± 2.758	± 3.625
94	1.588	1.965	2.522	3.005	3.949
93	1.706	2.111	2.709	3.228	4.243
92	1.814	2.246	2.881	3.433	4.512
91	1.913	2.368	3.038	3.620	4.758
90	2.007	2.483	3.186	3.796	4.989
89	2.092	2.589	3.322	3.958	5.202
88	2.173	2.688	3.450	4.110	5.402
87	2.249	2.783	3.571	4.255	5.592
86	2.321	2.872	3.685	4.391	5.771
85	2.388	2.955	3.792	4.518	5.938
84	2.452	3.034	3.893	4.639	6.097
83	2.512	3.108	3.989	4.752	6.246
82	2.569	3.179	4.079	4.861	6.388
81	2.623	3.246	4.166	4.963	6.523
80	2.674	3.310	4.247	5.060	6.650
79	2.724	3.371	4.325	5.153	6.773
78	2.770	3.429	4.399	5.242	6.889
77	2.814	3.483	4.469	5.325	6.999
76	2.856	3.535	4.535	5.404	7.102
75	2.896	3.584	4.598	5.479	7.200
74	2.933	3.630	4.658	5.549	7.293
73	2.969	3.674	4.714	5.617	7.383
72	3.003	3.716	4.768	5.681	7.466
71	3.034	3.755	4.818	5.740	7.545
70	3.065	3.792	4.865	5.798	7.619
65	3.190	3.947	5.064	6.034	7.931
60	3.276	4.054	5.201	6.198	8.146
55	3.326	4.117	5.282	6.293	8.272
50	3.343	4.137	5.309	6.325	8.313

Confidence Range for Raw Product Sampling

N = 360

Score of Sample	% level of confidence				
	70	80	90	95	99
95	± 1.191	±1.473	±1.890	±2.252	± 2.960
94	1.297	1.605	2.059	2.453	3.225
93	1.393	1.724	2.212	2.636	3.464
92	1.482	1.834	2.353	2.803	3.684
91	1.562	1.934	2.481	2.956	3.885
90	1.639	2.027	2.602	3.099	4.074
89	1.708	2.114	2.712	3.232	4.248
88	1.774	2.195	2.817	3.356	4.411
87	1.837	2.273	2.916	3.474	4.566
86	1.895	2.345	3.009	3.585	4.712
85	1.950	2.413	3.096	3.689	4.849
84	2.002	2.477	3.179	3.787	4.978
83	2.051	2.538	3.257	3.880	5.100
82	2.098	2.596	3.311	3.969	5.216
81	2.142	2.651	3.401	4.052	5.326
80	2.184	2.703	3.468	4.132	5.430
79	2.24	2.752	3.531	4.207	5.530
78	2.262	2.800	3.592	4.280	5.625
77	2.298	2.844	3.649	4.347	5.714
76	2.332	2.886	3.703	4.412	5.799
75	2.364	2.926	3.755	4.473	5.880
74	2.395	2.964	3.803	4.531	5.955
73	2.424	3.000	3.849	4.586	6.028
71	2.477	3.066	3.934	4.687	6.160
70	2.502	3.097	3.973	4.734	6.221
65	2.604	3.223	4.135	4.927	6.476
60	2.675	3.310	4.247	5.060	6.651
55	2.716	3.361	4.313	5.138	6.754
50	2.730	3.378	4.335	5.164	6.788

Finished Product Grading Probabilities
For Different Sampling Plans

Percent Defectives	Sample size 100			Sample size 200			Sample size 300		
	Grade			Grade			Grade		
	A	B	C	A	B	C	A	B	C
00	1.000	.000	.000	1.000	.000	.000	1.000	.000	.000
00	1.000	.000	.000	1.000	.000	.000	1.000	.000	.000
04	1.000	.000	.000	1.000	.000	.000	1.000	.000	.000
06	.999	.001	.000	1.000	.000	.000	1.000	.000	.000
08	.992	.008	.000	.999	.001	.000	1.000	.000	.000
10	.951	.049	.000	.987	.013	.000	.996	.004	.000
12	.844	.156	.000	.904	.096	.000	.939	.061	.000
14	.669	.331	.000	.690	.310	000	.712	.288	.000
16	.467	.532	.001	.406	.594	.000	.367	.633	.000
20	.157	.830	.013	.062	.937	.001	.027	.973	.000
22	.077	.883	.040	.017	.974	.007	.004	.994	.002
24	.034	.870	.096	.004	.957	.039	.000	.983	.017
26	.014	.800	.186	.001	.878	.121	.000	.919	.081
28	.005	.685	.310	.000	.731	.269	.000	.764	.236
30	.002	.546	.452	.000	.534	.466	.000	.528	.472
32	.001	.405	.594	.000	.337	.663	.000	.291	.709
34	.000	.280	.720	.000	.182	.818	.000	.095	.905
36	.000	.181	.819	.000	.085	.915	.000	.030	.970
38	.000	.109	.891	.000	.034	.966	.000	.006	.994
40	.000	.062	.938	.000	.012	.988	.000	.001	.999
42	.000	.033	.967	.000	.004	.996	.000	.000	1.000
44	.000	.017	.983	.000	.001	.999	.000	.000	1.000
46	.000	.008	.992	.000	.000	1.000	.000	.000	1.000
48	.000	.004	.996	.000	.000	1.000	.000	.000	1.000
50	.000	.002	.998	.000	.000	1.000	.000	.000	1.000

APPENDIX C

PACK STATISTICS

Red Cherry Production

	MICHIGAN			UNITED STATES		
Year	Production (ton)	Price/Ton	Value of Production	Production (ton)	Price/Ton	Value of Production
1938	12,700	67.00	851,000	64,850	56.10	3,638,000
1939	34,270	42.00	1,439.000	96,770	43.20	4,180,000
1940	46,200	58.00	2,680,000	104,690	58.00	6,072,000
1941	27,700	92.00	2,548,000	81,400	96.56	7,855,000
1942	46,500	100.00	4,650,000	105,290	104.00	10,956,000
1943	10,800	172.00	1,858,000	40,840	177.00	7,229,000
1944	50,000	156.00	7,800,000	112,400	163.00	18,321,000
1945	14,000	294.00	4,116,000	45,760	260.00	11,898,000
1946	60,500	298.00	18,029,000	116,050	301.00	34,931,000
1947	49,500	192.00	9,504,000	90,970	199.00	18,103,000
1948	69,000	181.00	12,489,000	131,790	183.00	24,118,000
1949	60,500	182.00	11,011,000	108,690	188.00	20,434,000
1950	98,000	130.00	12,740,000	156,640	130.00	20,363,000
1951	84,700	138.00	10,488,000	158,240	138.00	21,837,000
1952	67,500	119.00	7,438,000	118,120	123.00	14,529,000
1953	77,000	176.00	13,464,000	134,130	177.00	23,741,000
1954	47,000	220.00	10,340,000	103,720	212.00	21,989,000
1955	73,000	130.00	9,490,000	150,350	125.00	18,794,000

Control Chart Data
for 303 Cans

No. of Observation	Net Weight (ounces)	Drained Weight (ounces)	Vacuum (pounds)
1	16.81	11.19	3.25
2	16.63	10.81	5.25
3	17.06	11.19	3.00
4	17.13	11.19	5.50
5	16.88	11.43	3.35
6	16.94	10.56	6.00
7	16.94	11.63	3.75
8	17.06	11.13	7.50
9	16.88	10.88	7.00
10	16.94	11.00	6.50
11	17.06	11.19	6.25
12	16.81	11.00	2.75
13	16.94	11.25	5.25
14	16.88	12.00	7.25
15	17.13	11.56	9.75
16	16.88	11.19	6.00
17	16.88	11.44	5.75
18	17.13	11.44	6.50
19	16.81	10.81	6.00
20	17.00	11.13	4.50
21	17.00	11.13	7.00
22	17.00	10.44	6.50
23	17.00	11.06	6.50
24	16.75	11.75	3.25
25	16.69	11.44	5.25
26	16.19	10.13	7.00
27	16.81	10.06	8.75
28	17.00	10.50	9.75
29	16.81	10.38	7.50
30	16.56	9.88	9.75
31	16.63	10.81	4.50
32	16.53	11.81	3.75
33	16.75	10.50	8.50
34	17.00	10.81	6.00
35	17.00	11.13	7.00
36	17.00	11.50	4.50
37	16.94	10.88	6.50
38	16.50	11.44	1.75
39	16.69	11.56	1.00
40	16.63	11.75	2.75
41	16.63	10.94	4.50
42	16.60	11.56	4.50
43	16.38	11.00	7.25
44	11.88	10.44	6.75
45	16.75	10.38	6.75

Production and Disposition of the Sour Cherry Crop
(Millions of Pounds)

Year	Lbs canned	Lbs Frozen	Lbs Brined	Total Lbs Proc.	% Canned	% Frozen	% Brined
1935	50.1	5.4	2.5	58.0	86.4	9.3	4.3
1936	41.3	6.0	8.8	56.1	73.6	10.7	15.7
1937	49.5	9.1	11.3	69.9	70.8	13.0	16.2
1938	25.7	2.4	2.8	30.9	83.2	7.8	9.0
1939	59.9	5.0	3.3	68.2	87.9	7.3	4.8
1940	65.4	12.5	5.9	83.8	78.0	14.9	7.1
1941	34.8	11.9	.9	47.6	73.1	25.0	1.9
1942	75.5	8.3	1.3	85.1	88.7	9.7	1.6
1943	9.4	4.1	.2	13.7	68.6	29.9	1.5
1944	71.9	18.7	1.0	91.6	78.5	20.4	1.1
1945	20.2	2.8	.2	23.2	87.1	12.1	.8
1946	78.9	34.3	.5	113.7	69.4	30.2	.4
1947	54.7	34.3	1.9	90.9	60.2	37.7	2.1
1948	89.0	38.0	2.9	129.9	68.5	29.2	2.3
1949	83.0	28.2	2.3	113.5	73.1	24.8	2.1
1950	133.7	51.4	1.9	187.0	71.5	27.5	1.0
1951	111.9	31.7	1.0	144.6	77.4	21.9	.7
1952	89.6	25.0	.2	114.8	78.0	21.8	.2
1953	88.2	58.2	.6	147.0	60.0	39.6	.4
1954	59.7	31.3	.6	91.6	65.2	34.2	.6
1955	97.0	39.3	2.3	138.6	70.0	28.3	1.7