QUALITY CHARACTERISTICS OF CANNED FOODS: A COMPARISON OF COMMERCIALLY AND EXPERIMENTALLY PACKED PEACHES, PEARS, GREEN BEANS, AND WHOLE KERNEL CORN

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LITERATURE REVIEW

The term "quality" is generally associated with the degree of excellence of a product or material. Webster has defined quality as a "characteristic" or "attribute". Kramer and Twigg (1970) define quality in its application to food as "the composite of those characteristics that differentiate individual units of a product and have significance in determining the degree of acceptability of that unit by the buyer". Food quality characteristics may be categorized according to three groups: 1) sensory, 2) quantitative, and 3) hidden. Sensory characteristics are those that affect flavor, appearance, or texture. Quantitative characteristics include such things as soluble solids, proportion of ingredients, net weight, and drained weight. Hidden characteristics are those that are normally undetected by the senses such as nutrients, harmless adulterants, and toxic substances. The current study is directed mainly towards the sensory and quantitative factors.

In general, food products are evaluated on the basis of a composite of characteristics such as size, shape, density, maturity, moisture content, oil content, flavor, firmness, texture, tenderness, color, and defects. Most of these factors are directly related to or are synonymous with the sensory characteristics as detected by the consumer. Those aspects of quality affecting the senses have been described and illustrated by Kramer and Twigg (1970) in the form of a circular diagram. In their model the sensory characteristics of flavor, appearance, and kinesthetics (muscle sense) each represent a portion of a circle. Each of these main categories is further divided into more specific characteristics or subgroups. Some of these include color, size, shape, consistency, texture, smell, and defects. Although sensory characteristics are often regarded as distinct and separate, some properties overlap and can be perceived in such a manner as to affect more than one sense. A good example of such a characteristic is mouth-feel which can be categorized both as a flavor and a kinesthetic quality.

Each fruit or vegetable, whether raw or processed, has its own unique combination of important quality attributes. Once these have been adequately defined and are objectively measureable, it is then possible to evaluate that product. Objective measurements are normally carried out by means of physical or chemical tests that have been shown to correlate well with sensory evaluations. The accuracy of such a correlation along with the precision or reproducibility combine to make an effective test. A great deal of research has been conducted by both private and government agencies in an effort to define those attributes that relate to both product acceptability and safety. The Federal Food, Drug, and Cosmetic Act of 1938, is the basic statute of the United States Food and Drug Law. The primary purpose of the act was to prohibit movement in interstate commerce of adulterated and misbranded food, drugs, devices, and cosmetics. A summary of the current United States food law is contained in the Code of Federal Regulations (CFR), Title 21, parts 100 through 199 (CFR, 1977). Examples of some of the major areas that are found in the code are Food Labeling (part 101), Nutritional Quality Guidelines for Foods (part 104), Standards of Identity, Quality, and Fill for Canned Fruits and Vegetables (part 145), Food Additives (part 170), and Tolerances for Pesticides in Food (part 193). The Food and Drug Administration has the responsibility of monitoring the law as it pertains to food and insuring that this aspect of the law is observed.

The "Standards of Identity, Quality, and Fill for Canned Fruits and Vegetables" includes testing procedures and specifications for the evaluation of many different canned fruits and vegetables. The standard of identity guarantees to the consumer that the information on the label of a container properly identifies the product. Foods produced under the standards of quality give consumers a guarantee that the product not only meets the legal description, but also meets a certain minimum standard of acceptability. The minimum standards of quality are generally equivalent to a USDA grade C. In the event that the quality falls below the minimum standards, a special substandard designation must be included on the label, including specified categories of the deficiencies. The standards of fill include guidelines related to the amount of product that is expected for a given size container. Some of the generally used standards of fill include headspace, net weight, fill weight, and drained weight.

The United States Department of Agriculture (USDA), in conformance to the basic food law, and in cooperation with FDA, has also established quality guidelines for the grading and quality evaluation of fruits and vegetables, both fresh and canned. These guidelines are not mandatory, but are offered as an additional means of quality assessment for processors on a strictly voluntary basis. Standards for the grading of canned fruits and vegetables are found in the Code of Federal Regulations, Title 7, part 52. In addition, detailed guidelines have been published by USDA in pamphlet form for many of the canned fruits and vegetables. Included among these are those items specifically involved in the present study: clingstone peaches (USDA, 1973), freestone peaches (USDA, 1969), pears (USDA, 1976), green beans (USDA, 1961), and corn (USDA, 1952). Under these guidelines, federal and state inspectors may inspect and certify products as to quality, condition and grade. The USDA has an official program under which trained agents are invited by private industry to evaluate and grade agricultural products, both processed and unprocessed. The agency is called the Food Safety and Quality Service, formerly the Agricultural Marketing Service (Judge, 1977).

Quality control and inspection are essential elements in any food processing operation. Herschdoerfer (1967) has divided quality control into three areas of emphasis: namely 1) raw material control, 2) process control, and 3) finished product inspection. As a general rule, a high quality processed product cannot be made from a poor quality raw product. Raw products for canning must be at the proper state of maturity as well as to meet other certain minimum standards with respect to blemishes and defects. The control of such quality must begin long before the time of harvest. Factors such as pruning, fertilizing, irrigating, use of insecticides and herbicides, time of harvest, and many other things have a certain amount of influence upon the quality of raw fruit. Also after harvest, no fruit or vegetable remains static, but each in its own way continues to change with time. By controlling the temperature and the environment during storage prior to processing, it is possible to prolong the natural characteristics in a fruit or vegetable, or under certain circumstances, to obtain more desirable characteristics. Much information exists in the literature concerning the proper storage of fruits and vegetables including optimum temperatures, length of storage, humidity, and modified atmosphere where applicable (USDA, 1977).

A perfectly sound raw fruit or vegetable may be converted into an inferior canned product as a result of poor techniques during the processing operation. Stier (1953) discusses production control in terms of three major areas, referred to as the "three M's", namely men, machinery, and materials. If any one of these areas is not properly controlled, the end product will likely fall short of its potential. Beem (1966) emphasizes the need for every food processing employee to become involved in quality control, since a sizeable portion of quality control problems involves human error. Thus, production personnel should be motivated toward producing quality products as an integral part of their job, and not leaving the responsibility to the quality-control department. Kramer (1970) discusses in considerable depth the use of manpower and machines in a processing plant, showing how each can feasably be used in maximizing product quality.

Once a product has been processed, there is little that can be done to improve its quality. Thus, the examination of finished products only permits acceptance of material reaching the desired standard or rejection of material which fails to reach this standard. Such a process is therefore one of inspection and not one of control. The inspection procedure has value only in identifying weaknesses in the control of quality during and prior to the processing (Herschdoerfer, 1967). The use of statistical analysis throughout the various phases of quality control and inspection presently has wide application. A scheme for sampling may be devised which depends on the product being inspected and the degree of reliability required. Many such schemes are presented in the literature including sampling procedures for either destructive or nondestructive testing (Anon., 1952; Anon., 1963; Anon., 1964; Bartlett and Wegener, 1957; Dodge and Romig, 1944). Inspection standards and procedures are outlined in the Code of Federal Regulations and other separately published material by both FDA and USDA as previously referenced. Sampling plans for canned fruits and vegetables have been devised by both FDA and USDA (21 CFR 145.3; 7 CFR 52).

Extensive research has gone into identifying those quality parameters in peaches, pears, green beans, and whole kernel corn that are accurately and objectively determined through physical and chemical testing, and which closely correlate to human acceptability and therefore quality. Many of those tests which have proven to be reliable in the quality assessment of canned products have been adopted as standard procedures by the Food and Drug Administration. Similarly standard methods for the grading of both fresh and canned fruits and vegetables have been adopted by the USDA. The Association of Official Analytical Chemists publishes a book entitled Official Methods of Analysis which outlines methods for the analysis of foods and other agricultural products. Many of the methods found in this publication are directly applicable to the quality assessment of canned food items.

Many of the general quality factors pertaining to peaches, pears, green beans, and corn have been researched. These are discussed in connection with the sensory quality factors such as texture, flavor, and appearance. Kinesthetic or textural qualities deal with the sense of feel or kinesthesis. The goal of food analysts has been to find an instrument that has the capability of closely simulating the sensations experienced by the consumer through his sense of feel, particularly in the mouth. According to

Brennan and Jowitt (1977) there are three different types of instrumental methods of textural measurement: empirical, imitative, and fundamental. Empirical methods usually involve measurement of the resistance of a food sample to deformation. An example of this type is the Kramer shear-press cell. This apparatus compresses and shears the sample to measure firmness, fibrousness, tenderness and other textural qualities. Imitative instruments attempt to simulate to some extent the action of the jaws and/or teeth when masticating food in the mouth. An example is the denture strain gauge. Fundamental methods involve measurement of one or more well-defined physical properties of the sample and relate these to the textural properties of the food. An example of this is the puncture tester which was used on peaches and pears. This is described later in methods.

Some of the instruments that have been used for the evaluation of textural properties in foods includes tenderometers, texturemeters, puncturemeters, succulometers, fibrometers, and pressure testers (Kramer and Twigg, 1970). Some of the physical properties having a relationship to texture includes fiber content, soluble and insoluble solids tests, liquid expression, pectic materials, etc. Finney (1971) conducted tests using an instrument which measures the vibrating frequency of a fruit. This technique involves excitation of the fruit with a spectrum of single wavelength vibration of the surface of the fruit to find resonant frequencies. Such a technique is capable of almost instantly measuring relative fruit ripeness or maturity based on texture. Because of the speed of this method, it could be effectively used in sorting and quality control of the raw product.

Addoms, et al.(1930), conducted tests involving amounts of protopectin in peaches in relationship to peach firmness. They discovered that ripe clingstone peaches contained twice as much insoluble protopectin as did ripe freestones, thus accounting for the softer texture in the freestones. Sterling and Kalb (1959) found that the methyl ester content of pectic substances of the Elberta peach continually decreased as it ripened. This was accompanied by an increase in water-soluble pectin, a decrease in acid soluble pectin, and a decrease in total pectin, indicating a loss of pectin and depolymerization of pectin. Road (1957) in testing fresh peaches, showed that of six physical properties tested: pressure test, skin ground color, flesh color, chlorophyl content of the flesh, titratable acidity of the juice, and percentage of soluble solids in the juice, the Magness Taylor Pressure Testor using a 5/16 inch diameter probe was the best index of maturity. The Magness Taylor Pressure Testor has been recommended by the National Food Processors Association as an effective means for judging the ripeness in peaches. Various stages of maturity in peaches have been correlated with pressure readings of the instrument (Leonard, 1959). This instrument is used extensively by USDA grading inspectors.

In whole kernel corn the texture is influenced by several factors, including maturity, size of the kernel, pericarp development, soluble and insoluble carbohydrates, and moisture content. One of the tests used to determine maturity in whole kernel corn is the alcohol-insoluble solids (AIS) test which consists of the extraction of a sample with 70 to 80 percent alcohol. The filtered, washed, and dried residue is a measure of the alcohol-insoluble starches, celluloses, fiber, pectins, and proteins which account for the chewiness and mealiness of the product. This method is particularly suitable for vegetables such as peas, sweet corn, and lima beans. Details of this test for corn as prescribed by the Food and Drug Administration are found in the federal regulations (21 CFR 155.130).

Kramer and Smith (1946), conducting research at the University of Maryland, developed an instrument called a succulometer for measuring the extractable liquid from either fresh or canned whole kernel corn. It makes use of the principle of compression in that the volume of extractable juice under controlled conditions of time and pressure is the measure of quality. A close correlation was shown between AIS and succulometer values.

Huelson (1954) indicated a relationship between overall tenderness in corn and tenderness in the pericarp and stage of development in the endosperm. Both are closely related to maturity. As the corn matures, the pericarp becomes tougher. Texture within the endosperm of the kernel is very milky in young corn, creamy in prime corn, and dough-like in older corn. It is possible for the pericarp and the endosperm to mature at different rates. For instance, Englett (1970) showed that in abnormally cool weather, the insoluble polysaccharides develop very slowly, but the pericarp continues to develop and toughen even at these low temperatures. In addition, the moisture content remains quite high indicating an immature product, even though it may be very tough.

In vegetables such as asparagus and green beans, the fibrousness of the product is the dominating factor in texture. Instruments such as the fibrometer (Wilder, 1948) and the fiber-pressure tester (Kramer, et al., 1949) were developed to measure this. The AOAC method for fiber determination involves the isolation of that fraction of the food product which is not digested by boiling in a weak acid or alkali (AOAC, 1975). A rapid modification of this procedure was developed by the Food and Drug Administration, which consists of boiling the sample in water and 50% sodium hydroxide (NaOH), stirring, filtering through a 30-mesh monel metal screen, and drying. Details of this procedure for green beans are found in the Code of Federal Regulations (21 CFR 155.120).

Several studies have shown the importance of both varietal characteristics and environmental effects on the fiber content of green beans. Fiber development, which occurs in the inner mesocarp, is genetically determined, but can fluctuate tremendously depending upon environmental factors. For example, Kaldy (1966) showed that cool temperatures and high rainfall have a depressing effect on the increased cell thickness of the inner mesocarp layer. He also showed that beans of the same variety grown under different conditions of moisture and temperature yielded different fiber contents. He found that the fiber content of beans grown under warmer conditions and lower humidity was more than tenfold that of the same variety grown under cool conditions. This confirmed the work done by Stark (1942) who found that two crops of the same variety maturing at different times of the season had different fiber contents. For instance, those beans harvested during the warmer months of the summer had a greater amount of fiber than those harvested in the cooler weather of the fall.

as a general rule, most fruits that are green are considered undesirable because greenness is associated with insufficiently ripened fruit. Conversely, greenness may be desirable in many vegetables since it is an indication of a very young and tender product, one that is not too mature. In addition to its usefulness in evaluating product maturity, color can also serve as an indicator of the treatment given a fruit or vegetable from the time it is harvested until it reaches the consumer. Discoloration characteristics give clues as to specific problem areas in handling and processing.

There are basically two general categories for browning reactions that are found in fruits and vegetables, enzymatic and nonenzymatic. Much research has been conducted on each of these types of browning reactions and much has been published in the literature. Enzymatic browning is particularly a problem in fruits prior to canning. For example, when the flesh of peaches or pears is exposed to oxygen in the air, an enzymatically catalyzed oxidation of the naturally occurring phenolic compounds takes place, resulting in a browning or darkening of the fruit. Bruising or subsurface damage to the fruit also brings about this type of browning reaction (Ponting, 1960; Guadagni, et al., 1949; Joslyn, 1951; Luh, et al., 1967; Tate, et al., 1964). Several types of nonenzymatic browning reactions occur in processed fruits and vegetables. Of these the Maillard reaction and caramelization are possibly the most well known. Huelson (1954) noted several causes for discoloration in whole kernel corn. For instance, immature corn has a relatively high sugar content, which caramelizes during processing to give a dull coloration. Overprocessing or improper cooling during post-process may accentuate the problem. An indirect type of discoloration associated with canned corn is known to canneries as "first-run black". This type of discoloration is brought about by contamination of copper or iron from the machinery. The copper or iron reacts with the volatile sulfur compounds from the corn to form finely divided iron or copper sulfide. Perceptable darkening occurs when the concentration of copper exceeds 1 part per million, or in the case of iron, 6 parts per million. Before the introduction of the "C" enamel can, iron from the "plain" cans caused extensive darkening. In the case of "first-run black" discoloration, usually after the machinery had been used a short time, contamination with iron or copper fell to an insignificant level.

Environmental factors and farm cultural practices are known to have an effect on the color characteristics of some fruits and vegetables. For instance, Carter, et al. (1958) reported that in one investigation, nitrogen fertilization was found to produce a deep orange color in canned peaches. This increase in nitrogen was also correlated with an increase in Hunter a/b color ratios. Boggess and Heaton (1972) investigated the relationships of sensory ratings with tannin components of canned peaches. They found that the total phenols were significantly correlated with both color and flavor. The leucoanthocyanin content closely correlated with peach visual color ratings. Undesirable purplish or red pigments in canned peaches are the result of the red anthocyanin pigment leaching from the pit cavity into the syrup in some yellow fleshed varieties of freestone peaches, of which the J. H. Hale variety is the most prominent. The resultant purplish colored syrup is generally attributed to the combining of the anthocyanin pigments with soluble tin or iron from either equipment or cans (Anon., 1948).

Canned pears are subject to a pinking discoloration problem that appears unique to this fruit. Although the other quality aspects of the pears are not adversely affected, commercially it is undesirable because of its effect on the appearance. The pink color comes about as a result of high concentrations of leucoanthocyanins associated with low pH, high titratable acidity, and high soluble solids in the fresh fruit. The high amounts of leucoanthocyanins come about as a result of a complex of environmental factors. Excessive cooking and delayed cooling are considered to be two processing factors that bring about the pink discoloration.

Flavor attributes are largely associated with the senses of taste and smell, although the sense of feel in the form of product texture and temperature also has a considerable influence. The psychological effects of experience and surroundings also influence the flavor response, making it a very complex phenomenon. Because of these many interrelated factors, it is often difficult to assess flavor based on a single objective test. When substances with different taste qualities are mixed, the intensities of their tastes change even if no chemical reactions occur. These interactions play an important role in the use of condiments or flavoring ingredients in foods. For example, the addition of salt to a food not only adds a salty taste, but also changes the perceived intensities of other tastes in the food. Thus, accurate flavor evaluation is still largely based on the human response. Nevertheless there exist some objective tests using instrumentation or chemical means that are useful in generally evaluating flavor quality. For instance, sweetness of syrups, or water extractions of foods containing sugars, can be closely estimated by the use of a refractometer. Refractive index readings can be readily converted to soluble solids values using standard tables. Results are normally expressed in terms of percent sucrose.

Acidity, one of the flavor factors, can be designated both in terms of quantity and strength. The quantity or concentration of an acid may be readily determined by titration with a known amount of sodium hydroxide or other base. Results are expressed as the number of grams of a specific acid per 100 grams of the product. Acid strength, on the other hand, is expressed in terms of hydrogen ion concentration and is measured by means of a pH meter. Flavor is affected by both the strength and concentration of an acid. Flavor balance in some products, for instance orange juice, is often determined objectively by comparing the concentration of soluble solids or sweetness with the acid concentration as a brix acid ratio.

Considerable work has been done in recent years in the area of flavor research. Much of this has been made possible as a result of advancements in instrumentation, e.g. sophistication in such areas as gas and high pressure liquid chromatography, mass spectrometry, etc. Flavor compound profiles have been established on many fruits and vegetables. With this has come the capability to evaluate products, both fresh and canned, objectively through instrumentation. Advantages of using instrumentation in quality control work include precision and accuracy as well as speed. Even today, however, there is still no substitute for a well trained person in evaluating overall flavor quality.

Although can vacuum in itself is not a factor of quality in canned items, it may have an indirect influence. Boyd and Bock (1952) discuss the importance of can vacuum in considerable detail. They list three reasons for maintaining measureable vacuum in the can: 1) maintenance of can ends in a concave position during normal storage, 2) reduction of oxygen, 3) the prevention of permanent distortion of can ends during thermal processing. To this list might also be added consumer acceptance. The maintenance of can ends in a concave position not only helps maintain the integrity of the can but also serves as an indicator of the condition of can contents. Bacterial spoilage usually, but not always, results in gas formation which causes the ends of the can to bulge. Thus bulging in a can becomes a good indicator of microbial spoilage. A reduced oxygen content in canned foods is desirable to minimize adverse chemical changes in the product such as oxidation of fats, vitamins, color compounds, etc. Residual oxygen may also cause the interior of the can to corrode, often resulting in hydrogen gas production, and a swelled can.

The quality of food is vital for its intended purpose. Commercially canned foods meet a certain quality level to meet the consumer demand. Some experimental packs of foods processed in different localities and under a variety of quality assurance awareness were prepared. These experimental packs and certain selected commercial packs were then evaluated for quality.

MATERIALS AND METHODS

Commercial brands of canned corn, green beans, peaches, and pears were obtained from local retail grocery stores. The non-commercially processed items were obtained from stocks of experimental packs.

Sampling procedures

Regulations governing inspection and certification (7 CFR 52) provide detailed sampling plans for canned fruits and vegetables. They indicate the number of sample units to be drawn from lots of specific size for the various size containers. The suggested sample size is three cans for both the smaller (303 x 406) and the larger (401 x 411) containers, based on a lot size of less than 3,000 cans. Inasmuch as all of the experimental packs fell within this range, a sample size of the stated amount was chosen. For each processor of a particular product, five different lots containing three cans each were tested, totaling 15 cans per processor. In the experimental packs, however, five lots were not available in some instances. Consequently, only those lots available were selected for testing. Care was taken to avoid selecting adjacent cans from a lot. Insofar as possible, cans of the same batch were taken from different boxes or places on the grocery shelf. From such a selection it was hoped that a more representative sampling would result.

Coding and Identification

After the sample cans were selected, they were grouped according to product, processor, and can code. Numbers were marked on the cans, starting with number one, to give each can a simple identification. After recording each number and corresponding processor and can code into a log book, the labels were removed from the cans in order to eliminate as much bias as possible during testing. Before the cans were tested, they were thoroughly randomized. Products of the same batch were, therefore, presumably tested separately. As a result, the potential drift involved in subjective testing was hopefully evenly spread throughout the various lots and processors.

In an effort to keep the identities of processors anonymous, letter codes were assigned to each processor. Letters A through G represented commercial processors and letters H through O were experimental packs. In addition, each of the experimental packs had a number assigned, indicating the year in which the product was processed. In the experimental packs, a letter without a number represented the combined years.

Product Testing

Each of the products was tested according to procedures outlined in the "Standards of Identity, Quality, and Fill" of the federal regulations: "Canned Corn" (21 CFR 155.130), "Canned Green Beans and Wax Beans" (21 CFR 155.120), "Canned Peaches" (21 CFR 155.170), and "Canned Pears" (21 CFR 145.170). Additional testing not directly related to product quality was also included in the study such as can vacuum, head space, and drained weight. Individual tests for the four different products are briefly described below. It should be noted that some tests pertain to all four items while other tests pertain only to a single product.

Can vacuum (all products): Can vacuum was the very first test to be run on any can. All tests were made with a product temperature the same as that of the laboratory or 71 degrees F., and were completed using a Marshalltown (Bourdon type) Vacuum gauge which gives a reading in inches of mercury (Hg).

Head space (all products): A "gross head space" was measured in every can tested, which is the distance from the surface of the liquid (solids submerged) to the top of the double seam of the can. The actual head-space, the distance from the surface of the product to the lid, was not determined inasmuch as this value is seldom used in industry. All measurements were recorded in 32nds of an inch.

Drained weight (all products): Every can was drained for two minutes on a No. 8 sieve. The drained weight of the product was then determined using an Ohaus Heavy Duty Solution Balance.

Color (all products): Color measurements were made with a Hunterlab Color and Color Difference Meter model D25. Values of lightness ("L" value), greenness versus redness ("a" value), and blueness versus yellowness ("b" value) were made. Green beans and corn were measured by placing the sample into the bottom of a cylindrical glass receptacle having a diameter of four inches, the same diameter as the specimen port in the instrument. Once the instrument was calibrated, the receptacle was placed over the specimen port and the color determinations were made. Procedures were different for the peaches and pears since each unit in the can was tested separately. In order to measure the individual peaches and pears, the size of the specimen port had to be modified. This was done by covering the port with a black piece of non-reflective paper having a center opening of 1.4" diameter. Each peach or pear half was placed over the hole in such a manner that the color of the outer surface was measured. Units were modified in such a way that the sample lay flat against the surface of the hole. Clean water was added to the receptacle and air bubbles removed from the surface being measured.

pH measurements (peaches and pears): All pH measurements were made using a Corning Model 5 pH Meter. The instrument was calibrated before each period of use, using a standard pH 4 buffer solution.

Soluble solids (peaches and pears): A Bausch & Lomb table model refractometer was used to obtain refractive indexes of the syrups. Soluble solids values were then obtained from the respective refractive indexes from conversion tables found in the Handbook of Physics and Chemistry, 55th Edition. Values were reported as percent sucrose.

Peel area (peaches and pears): Peel areas were determined by carefully collecting loose and attached peel material and placing the combined peel on a flat surface. The areas in square inches were then calculated.

Pit volume (peaches): Peach pit volumes were obtained by placing pieces of pit into a partially filled 10 milliliter (ml) graduated cylinder and measuring displaced water. Results were recorded as cubic centimeters (cc^3).

Blemished units (peaches, pears, and beans): Blemished units in peaches are those units (halves) having scab, hail injury, discoloration, or other abnormality which materially affects the appearance or edibility. In pears two categories of imperfections were considered - "blemished units" and "minor blemished units". Blemished units include those having scab, hail injury, abnormal discoloration, or other defects. They include those units with an aggregate surface area of a circle greater than 1/4 inch in diameter and otherwise materially affecting the appearance or eating quality of the pears. Minor blemished units are those having light brown areas aggregating the area of a circle 1/4 inch or less in diameter, which significantly (but not materially) affect the appearance or eating quality. Where corky or hard spots of less than 1/2 inch in diameter are found on the outer surfaces, and where the appearance is not significantly impaired, the unit would be considered a minor blemished unit. In the case of green beans a unit (a cut pod piece) is considered blemished when the aggregate blemished area exceeds the area of a circle 1/8 inch in diameter.

Unit weights (peaches and pears): Immediately following the two-minute drained weight determination, each peach and pear unit was placed into a separate, numbered, small plastic weighing boat. Each unit was then weighed and the amount recorded in grams. These units were subsequently tested for color and hardness.

Unit hardness (peaches and pears): Each separate unit was tested for hardness using a procedure as outlined in the Code of Federal Regulations. The apparatus consisted basically of a modified "Precision Penetrometer" in which the weight in grams when added at a rate of 12 grams per second and transmitted through a rod 5/32 inch in diameter penetrated a peach or pear section to a depth of at least 1/4 inch. The weight was added as water at the rate of 12 ml per second to a container situated above the rod.

Internal stems (pears): The internal stem is that portion of the pear interior extending from the stem end to the core or seed cavity. Any section with a fibrous or tough interior stem was counted as one interior stem.

Loose seed (pears and beans): A loose pear seed refers to any seed or equivalent thereof which is not attached to the core material. A loose seed in green beans includes any seed not attached to a pod, or its equivalent in pieces of seed.

Units 27/64 inches diameter or greater (beans): A green bean with a diameter greater than or equal to 27/64 inches was considered one unit. This test is used to measure the relative maturity.

Strings supporting 1/2 pound weight (beans): Green beans having a diameter of 27/64 inches or greater were tested for tough strings. A tough string is defined as any string 1/2 inch or greater in length that will support a 1/2 pound weight for five seconds. The amount was recorded as the number of strings per can.

Unstemmed units (beans): Those units having attached stems or portions thereof were counted as unstemmed units. The number recorded was the total number of unstemmed units per can.

Percent seed of whole bean (beans): This is a test of relative maturity in green beans. Immediately following the two minute drained weight determination, five ounces (141.8 grams) of beans were weighed out. They were then deseeded and the seeds weighed to the nearest one tenth of a gram. From this weight the proportion of seed to whole bean was determined and expressed as a percentage.

Percent fiber (beans): The pods from the previous test were used to determine the percent fiber (21 CFR 155.120). The procedure basically involves the digestion of bean pod tissue using a sodium hydroxide solution, thoroughly washing the remaining fiber, and drying in order to determine the percentage of fiber in the pod. A slight modification of the procedure was implemented in order to insure a more complete digestion of the pod tissue. Preliminary tests had shown that by first freezing the bean pods and then mashing with a mortar and pestle, the digestable tissue was more completely broken down. Thus, the pods were first frozen. In addition, the fiber was not dried on the original monel screen as specified, but was transferred to pre-dried and pre-weighed paper filters. These were then dried for 12 hours at 180 F and cooled in a dessicator before weighing.

Silk length (corn): Silk segments from canned corn were separated, measured, and the total length determined. Values were recorded as inches per can.

Husk area (corn): Husk areas were determined by collecting any pieces of husk in the can and laying them out on a flat surface. The total husk area was then determined and recorded as square inches of husk per can.

Cob volume (corn): The volume of cob material in whole kernel corn was determined by placing pieces of cob into a partially-filled 10 or 25 milliliter graduated cylinder. The amount of cob material was then recorded as the value of the displaced water as cubic centimeters.

Discolored kernels (corn): Those kernels of corn showing insect damage or discoloration and having a significant effect on the overall quality, i.e. materially affecting its appearance or eating quality, were counted as discolored kernels and recorded on a per can basis.

Alcohol insoluble solids (corn): Basically the alcohol insoluble solids (AIS) test involves extracting the alcohol soluble materials from a given weight of two-minute drained whole kernel corn and then determining the percentage of the remaining solids. This was done by boiling the comminuted sample of corn in an 80 percent solution of ethanol for 30 minutes and running the material through a previously-dried and weighed filter paper. The filter was then dried in an oven for approximately 12 hours at 180 F and cooled in a dessicator before weighing. The percent AIS was then computed.

Succulometer test (corn): The succulometer was used as a means of evaluating the maturity of corn. It measures the amount of liquid that can be expressed from a 100 gram (3.5 ounce) sample of corn within three minutes under a pressure of 500 pounds per square inch. The corn was allowed to drain for two minutes before the sample was weighed.

Cut of the corn: The cut refers to the smoothness, depth, and uniformity, as well as the degree of freedom from adhering cob tissues. Four descriptions of the cut are given with numerical designations: 4 = well cut; 3 = reasonably well cut; 2 = fairly well cut; 1 = poorly cut. Each of these descriptions is defined in the government guidelines for corn as earlier referenced.

Flavor (corn): Flavor was evaluated on a six point system as follows: 6 = very good (like fresh); 5 = good to very good (slightly better than most canned corn); 4 = good (typical of most canned corn); 3 = fairly good to good (slight sweet corn flavor); 2 = fairly good (lacking in sweet corn flavor, but no off flavors); 1 = poor (contains atypical off-flavors such as those occurring in overprocessed corn).

Data Computations

Data from the testing were consolidated and transferred onto computer cards. Between two and three cards were required for the data of each sample. The cards were then given a preliminary screening test on the computer to identify any errors in the data or mispunched cards - errors were corrected at that time. Computer programming was done by BYU Computer Services, and final data runs were made on a DEC-10 computer. Statistical data obtained included mean, mode, minimum, maximum, range, variance, standard deviation, kurtosis, skewness, and standard error. In addition, programs were set up to identify the number of samples exceeding recommended minimum drained weights.

Assignment of Grade

Individualized can samples of each of the four products were assigned a U. S. Grade according to guidelines established by federal regulations governing inspection and certification of processed fruits and vegetables (7 CFR 52.1f). Based on the sampling plans established by the same regulations, each lot was then assigned an overall grade. According to the sampling plan, using three cans per lot, no deviants were allowed. A deviant is a sample unit that falls into the next grade below the grade indicated by the average score of the total samples in a lot. Thus, the overall lot grade could be no better than the lowest grade of the three cans.

The procedures for grading canned fruits and vegetables as outlined in the Code of Federal Regulations are also available in booklet form as published by the United States Department of Agriculture. Individual booklets for each of the four products evaluated in this study were used as references for assigning grades. References are listed with each of the tests below.

Peaches. Separate standards exist for the grading of canned clingstone (USDA, 1973) and freestone (USDA, 1969) peaches, although the differences are relatively minor. The factors of grade quality for peaches, both freestone and clingstone includes the following:

color - 20 points, size and symmetry - 20 points, defects - 30 points, and character - 30 points. The assigned grade basically depends upon the combined score of individual factors. For instance, a combined score of 90 to 100 is Grade "A" or "Fancy", 80 to 89 is Grade "B" or "Choice", 70 to 79 is Grade "C" or "Standard", 60 to 69 is Grade "D", and below 60 is "Substandard". However, canned peaches which score lower in certain of the basic categories may be limited to a lower grade regardless of the accumulated score. This is known as the limiting rule.

The size and symmetry factor was not scored in the evaluation of peaches because of the great variation of size in the experimental packs. In scoring for grades, this factor was given the maximum number of points in all packs tested, thus making comparisons in other categories more meaningful.

Pears. Pears were evaluated on the basis of criteria established by federal regulation (USDA, 1976). The factors used to establish grades for pears include the following: color - 20 points, defects - 30 points, size and symmetry - 20 points, and character - 30 points. The assigned grade then basically depends upon the combined score of individual factors. A combined score of 90 to 100 is Grade "A" or "Fancy", 80 to 89 is Grade "B" or "Choice", 70 to 79 is Grade "C" or "Standard", and below 70 is "Substandard". However, as with the peaches, canned pears which score lower in certain of the basic categories may be limited to a lower grade regardless of the accumulated score. This is the limiting rule.

The size and symmetry factor was not scored in the pears because of the great variation in size among experimental packs. Most of the packs would have been severely downgraded had this category been used. In the scoring this factor was given the maximum number of points, thus making comparisons of other categories more meaningful.

Green beans. The evaluation of green beans for grading was conducted according to procedures as outlined in federal regulations (USDA, 1961). The scoring factors used to establish grades for green beans are as follows: clearness of liquor - 10 points, color-15 points, absence of defects - 35 points, and character - 40 points. The assigned grade basically depends upon the combined score of individual factors. A combined score of 90 to 100 is Grade "A" or "Fancy", 80 to 89 is Grade "B" or "Extra Standard", 70 to 79 is Grade "C" or "Standard", and below 70 is "Substandard". Canned green beans which score lower in certain of the basic categories may be limited to a lower grade regardless of the total score, thus the limiting factor.

Whole kernel corn. The grading of whole kernel corn was completed according to guidelines established by the United States Department of Agriculture (USDA, 1952). The following criteria were taken from the score sheet used by USDA in grading whole kernel corn: color - 10 points, defects - 20 points, tenderness and maturity - 40 points, and flavor - 20 points. The assigned grade is basically dependent on the combined score of individual factors. A combined score of 90 to 100 is Grade "A" or "Fancy", 80 to 89 is Grade "B" or "Extra Standard", 70 to 79 is Grade "C" or "Standard", and below 70 is "Substandard". Canned whole kernel corn which scores lower in certain basic categories may be limited to a lower grade regardless of the total score. This again is the basis for the limiting factor rule.

RESULTS AND DISCUSSION

The data collected from individual tests for peaches, pears, green beans, and whole kernel corn are summarized in Tables 1 through 73 which includes evaluations for can vacuum, headspace, drained weight, color, texture, defects, and other product-specific tests. Tables 74 through 78 contain the results of grading evaluations which also serve as summaries of other tests. The main objective of this study was to ascertain any significant differences in quality between commercial and experimental packs and determine reasons for such differences. Since the scope of the study was quite broad, it was impossible to determine reasons for each variation that was demonstrated. Nevertheless, reasons for obvious differences were determined. Another objective of the research was to expose trends in product quality that may have been closely related to quality control strengths and weaknesses.

Fourteen separate tests were conducted on each of the two peach categories (clingstone and freestone), sixteen tests on pears, fifteen on green beans, and fourteen on whole kernel corn. Test results are discussed individually by product, and results and discussion of the grading are also presented. Throughout this section reference is made to individual processors. These have been designated as either commercial packs (CP) or experimental packs (EP) followed by a letter or a letter and number. The number represents the year in which the product was processed and applies only to experimental packs.

Peaches

The two types of peaches, clingstone and freestone, were tested separately because of slight variations in the quality factors existing between them. For example, freestone is a distinct type of peach fruit in which the pit separates readily from the flesh. Clingstone, on the other hand, is a different peach type in which the pit adheres to the flesh. Another difference is the stronger peach flavor and softer texture in the freestones. Some freestone varieties are so soft that they cannot be successfully canned (Anon., 1959). Results of tests on both clingstone and freestone types are discussed below.

Can vacuum (Tables 1 and 2). The degree of can vacuum, measured in inches of mercury (inches Hg), is influenced by several factors at the time of processing including sealing temperature, steam flow closure adjustment, can vacuum pump adjustment, or can seam integrity. Post-process reduction of can vacuum may result from microbially produced gases, gases which are generated as a result of purely chemical reactions, or the leakage of air into the can through tiny pinholes or defective seams. As a general rule, the vacuum decreases along with the age of the canned product. Although no definite standards have been established for can vacuum, normal values range from 5 to 10 inches Hg.

Among the clingstone peaches one can (CP "B") had a zero vacuum. The remaining two cans from the same lot had normal values which indicates that the problem likely came about as a result of a temporary malfunction of the steam-flow closure device. Product quality in the can having zero vacuum was normal.

TABLE 1

CLINGSTONE PEACHES - CAN VACUUM (inches Hg)

PROCESSOR	MEAN ± sd[a]	RANGE
A	5.4 ± 2.2	2.0 - 8.0
B	7.2 ± 2.7	0.0 - 10.5
C	4.6 ± 2.3	1.0 - 8.0
M	5.3 ± 1.9	2.0 - 9.0
M5	5.7 ± 2.1	2.0 - 8.5
M6	5.8 ± 1.8	2.0 - 9.0
COMMERCIAL	5.8 ± 2.6	0.0 - 10.5
EXPTL PACKS	5.8 ± 1.9	2.0 - 9.0

[a]sd = standard deviation

In the freestone peaches, CP "A" and EP "L5" each had one can with zero vacuum. Overfilling in CP "A" was the cause of the zero vacuum. However, in EP "L5" the remaining two cans of the lot also had low vacuums of 2 inches Hg, which indicated a low sealing temperature inasmuch as steam-flow closure was not used.

TABLE 2

FREESTONE PEACHES - CAN VACUUM (inches Hg)

PROCESSOR	MEAN ± sd[a]	RANGE
A	8.0 ± 3.3	0.0 - 12.5
H	11.7 ± 2.2	7.0 - 15.5
L	7.0 ± 3.3	0.0 - 13.5
N	8.4 ± 2.1	4.0 - 12.0
O	8.3 ± 2.5	3.5 - 14.5
H5	11.1 ± 2.2	7.0 - 15.5
H6	12.2 ± 2.2	8.0 - 15.5
L5	7.7 ± 4.4	0.0 - 13.5
L6	7.9 ± 1.8	4.0 - 11.0
N6	8.4 ± 2.1	4.0 - 12.0
O5	7.2 ± 1.6	3.5 - 10.0
O6	9.5 ± 2.8	5.0 - 14.5
COMMERCIAL	8.0 ± 3.3	0.0 - 12.5
EXPTL PACKS-75[b]	8.7 ± 3.4	0.0 - 15.5
EXPTL PACKS-76[b]	9.5 ± 2.8	4.0 - 15.5

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

<u>Headspace (Tables 3 and 4)</u>. The degree of headspace in a can is an indication of the fill of the container. In order to avoid "slack filling" or underfilling, the headspace is assigned an upper limit.

TABLE 3

CLINGSTONE PEACHES - HEAD SPACE (1/32 inch)

PROCESSOR	MEAN ± sd[a]	RANGE
A	13.9 ± 1.4	11.0 - 16.0
B	14.8 ± 1.6	13.0 - 19.0
C	14.8 ± 1.2	13.0 - 18.0
M	13.9 ± 1.4	11.0 - 16.0
M5	13.3 ± 1.3	11.0 - 15.0
M6	14.5 ± 1.2	11.0 - 16.0
COMMERCIAL	14.5 ± 1.5	11.0 - 19.0
EXPTL PACKS	13.9 ± 1.4	11.0 - 16.0

[a]sd = standard deviation

Federal guidelines have been established which allow a headspace of not greater than 20/32 inch for a 2½ size can in order to avoid this. The headspace used for this standard is called the "gross headspace" which is the distance from the top of the double seam to the surface of the product (Judge, 1977).

None of the cans of clingstone peaches fell into the "slack filled" category. However, in the freestone peaches, EP "H5" and EP "O5" each had cans with headspaces beyond the limit. For instance, fourteen out of fifteen cans in EP "O5" were "slack filled", with a mean value of 20.6/32 inch.

TABLE 4

FREESTONE PEACHES - HEAD SPACE (1/32 inch)

PROCESSOR	MEAN ± sd[a]	RANGE
A	14.9 ± 2.4	8.0 - 19.0
H	17.0 ± 3.1	12.0 - 23.0
L	14.7 ± 2.1	12.0 - 21.0
N	15.4 ± 1.0	13.0 - 17.0
O	19.1 ± 2.0	16.0 - 22.0
H5	17.9 ± 4.0	12.0 - 23.0
H6	16.1 ± 1.4	12.0 - 18.0
L5	15.4 ± 1.9	12.0 - 18.0
L6	14.0 ± 2.0	12.0 - 21.0
N6	15.4 ± 1.0	13.0 - 17.0
O5	20.6 ± 0.8	19.0 - 22.0
O6	17.6 ± 1.7	16.0 - 21.0
COMMERCIAL	14.9 ± 2.4	8.0 - 19.0
EXPTL PACK-75[b]	18.0 ± 3.3	12.0 - 23.0
EXPTL PACK-76[b]	15.8 ± 2.0	12.0 - 21.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

<u>Drained weights (Tables 5 and 6)</u>. There were some significant differences in drained weights among clingstone peach packs. Mean values for experimental packs "M5" and "M6" fell well below the minimum drained

weight limits (see Figure 1). Only one can from EP "M6" was above the minimum value. Such occurrences are often the result of large fruit. However, in this instance,

TABLE 5

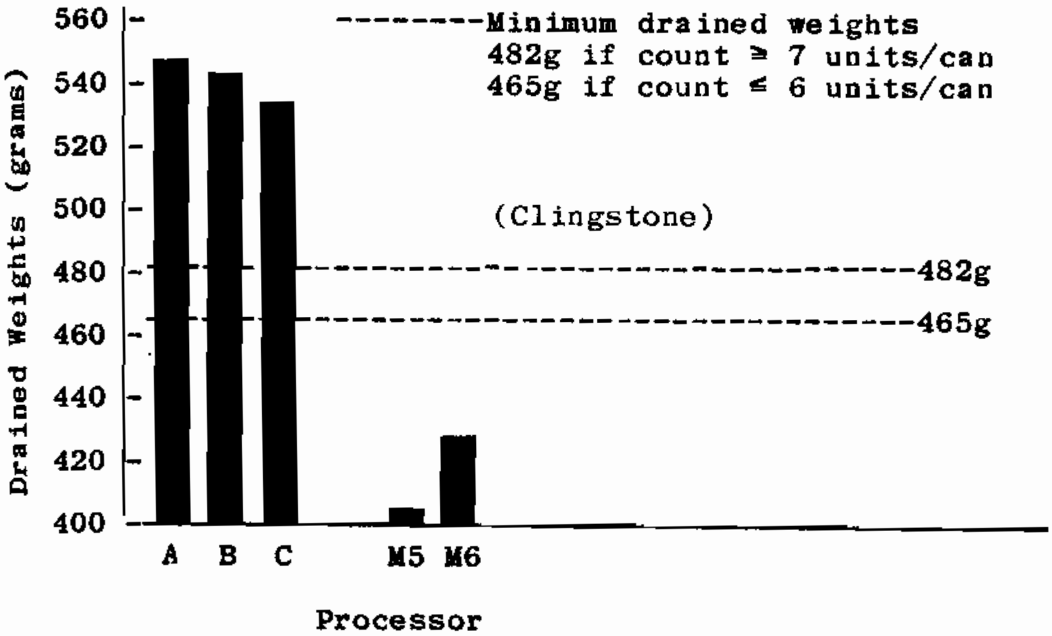
CLINGSTONE PEACHES - DRAINED WEIGHT (grams)

PROCESSOR	MEAN ± sd[a]	RANGE
A	546.5 ± 42.5	475.0 - 619.0
B	541.4 ± 33.1	486.0 - 589.0
C	535.2 ± 29.1	499.0 - 585.0
M	414.8 ± 37.5	350.0 - 504.0
M5	402.7 ± 32.9	352.0 - 450.0
M6	426.9 ± 39.0	350.0 - 504.0
COMMERCIAL	541.0 ± 34.9	475.0 - 619.0
EXPTL PACKS	414.8 ± 37.5	350.0 - 504.0

[a]sd = standard deviation

the fruit was not large, but was of comparable size to the commercial clingstone peaches that were tested. When canned peaches fall below the specified drained weight, which is based on can size, number of individual units per can, syrup density, and peach variety, the FDA standards of fill require the cans to be labeled "Below Standard in Fill" (21 CFR 130.14).

Most of the cans of freestone peaches, with the exception of EP "O5", were well within drained weight standards. One third of the cans in EP "O5" fell below the minimum drained weight standard (see Figure 1). These low drained weights were likely brought about by the large size of the peach halves (see Table 26). When minimum drained weights are difficult to achieve because of large fruit, the processor may be inclined to



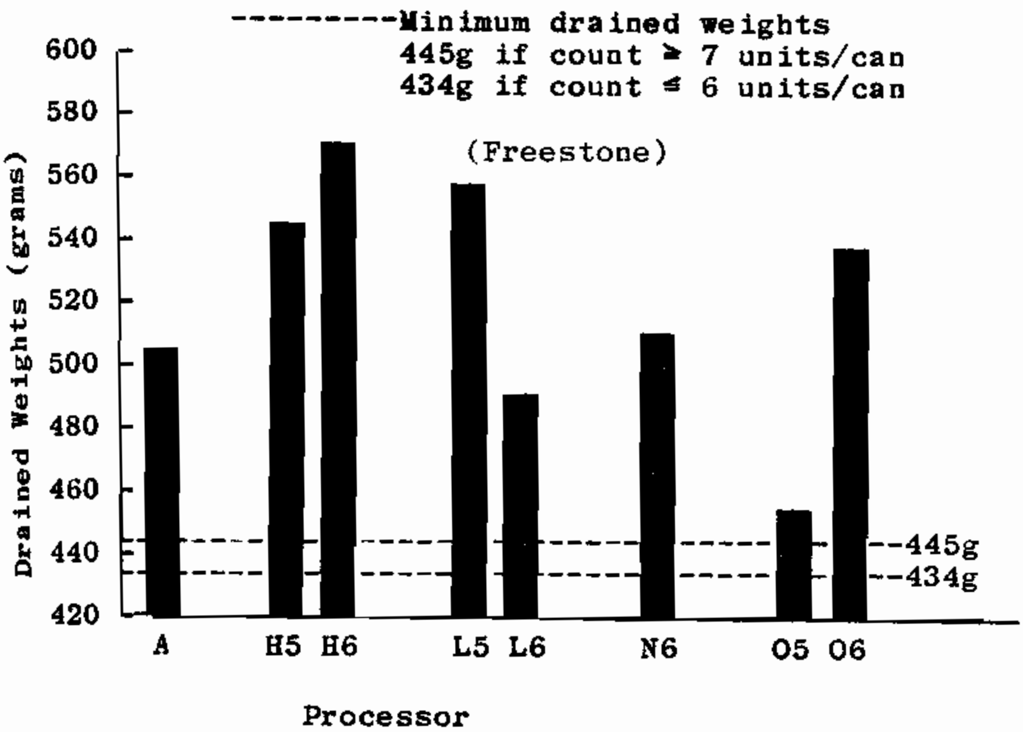


Figure 1. Mean drained weights for clingstone and freestone peaches.

have the fruit forced into the cans. When this occurs, the fruit quality often suffers. As a general rule, the extra large peaches are better utilized on the fresh market or as slices.

TABLE 6

FREESTONE PEACHES - DRAINED WEIGHTS (grams)

PROCESSOR	MEAN ± sd[a]	RANGE
A	505.0 ± 45.1	421.0 - 589.0
H	558.5 ± 53.0	446.0 - 681.0
L	522.3 ± 53.6	399.0 - 647.0
N	510.9 ± 36.1	459.0 - 602.0
O	495.8 ± 54.3	382.0 - 582.0
H5	545.9 ± 35.5	477.0 - 599.0
H6	571.9 ± 65.8	446.0 - 681.0
L5	556.6 ± 38.3	495.0 - 647.0
L6	490.3 ± 46.0	399.0 - 565.0
N6	510.9 ± 36.0	459.0 - 602.0
O5	453.7 ± 38.8	382.0 - 521.0
O6	537.9 ± 28.6	508.0 - 582.0
COMMERCIAL	505.0 ± 45.1	421.0 - 589.0
EXPTL PACK-75[b]	517.9 ± 59.5	382.0 - 647.0
EXPTL PACK-76[b]	527.0 ± 54.1	399.0 - 681.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Hunter color values (Tables 7 through 12). The Hunter color values "L" (lightness), "a" (redness versus greenness), and "b" (blueness versus yellowness), have

TABLE 7

CLINGSTONE PEACHES - COLOR "L" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	27.69 ± 0.57	26.90 - 28.60
B	27.05 ± 0.54	25.90 - 27.80
C	27.33 ± 0.48	26.90 - 28.80
M	27.59 ± 0.92	25.90 - 28.80
M5	28.34 ± 0.42	27.40 - 28.80
M6	26.83 ± 0.60	25.90 - 27.70
COMMERCIAL	27.52 ± 0.62	25.90 - 28.80
EXPTL PACKS	27.59 ± 0.92	25.90 - 28.80

[a]sd = Standard deviation

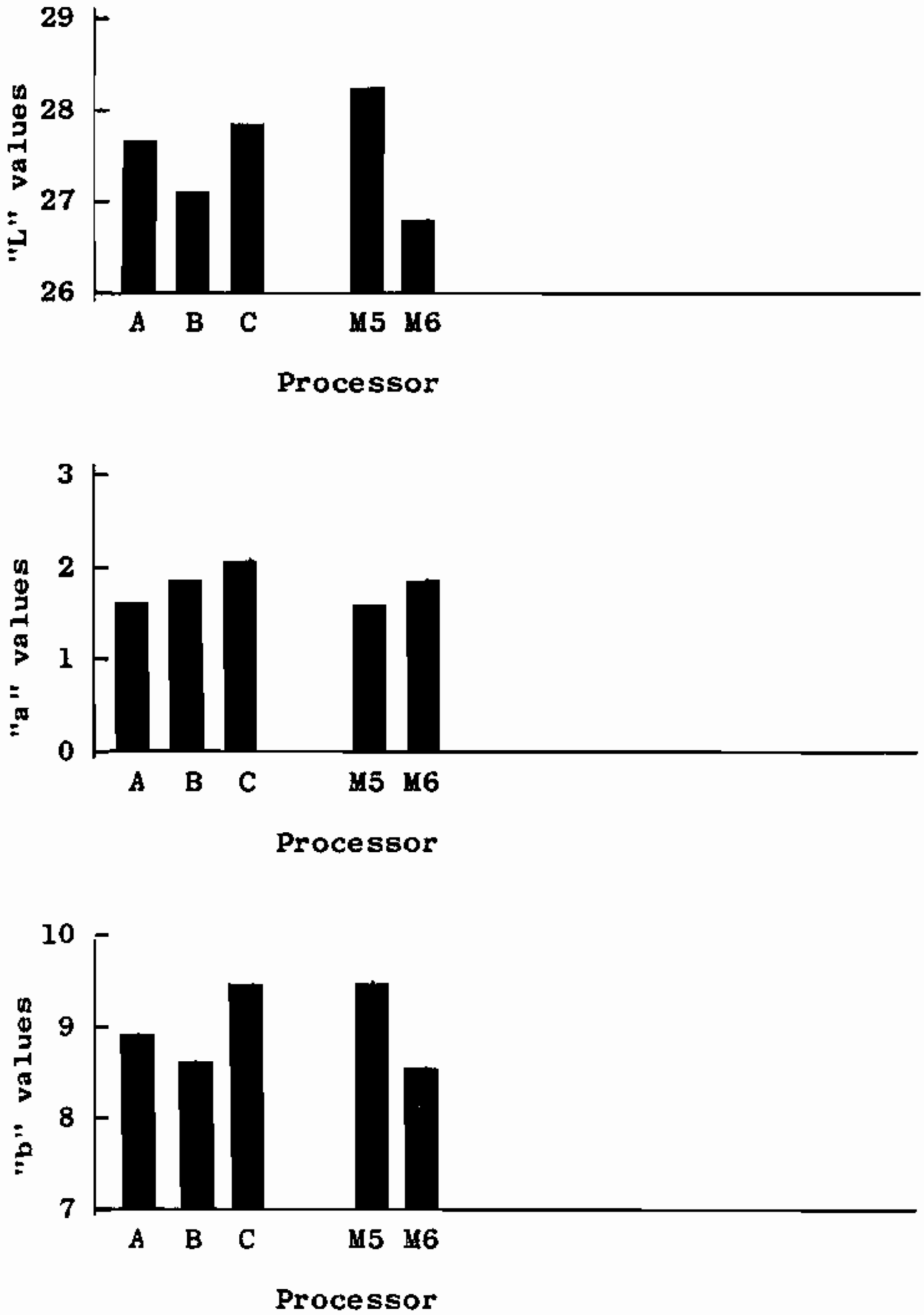


Figure 2. Mean Hunter color values for clingstone peaches.

been effective in objectively assessing quality in canned peaches. Results of tests show a few significant differences in mean color values among some of the processors. In addition, some interesting differences are noted in the color ranges. In clingstone peaches, color "L" values decreased between EP "M5" and EP "M6" (Table 7), showing an increase in the darkness of the fruit during the second season. Color "a" values were very diverse

TABLE 8

CLINGSTONE PEACHES - COLOR "a" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	1.65 ± 0.33	1.20 - 2.20
B	1.88 ± 0.47	1.30 - 2.80
C	2.05 ± 0.40	1.50 - 2.90
M	1.75 ± 0.53	0.90 - 3.10
M5	1.58 ± 0.57	0.90 - 3.10
M6	1.92 ± 0.44	1.10 - 2.80
COMMERCIAL	1.86 ± 0.43	1.20 - 2.90
EXPTL PACKS	1.75 ± 0.53	0.90 - 3.10

[a]sd = standard deviation

in EP "M5" with ranges from 0.9 to 3.1. The low "a" values indicate a more immature fruit. Inasmuch as

TABLE 9

CLINGSTONE PEACHES - COLOR "b" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	8.92 ± 0.64	8.10 - 10.20
B	8.88 ± 0.66	7.60 - 10.10
C	9.45 ± 0.74	8.70 - 11.00
M	9.14 ± 0.71	7.90 - 10.30
M5	9.64 ± 0.42	8.70 - 10.30
M6	8.63 ± 0.56	7.90 - 9.90
COMMERCIAL	9.02 ± 0.74	7.60 - 11.00
EXPTL PACKS	9.14 ± 0.71	7.90 - 10.30

[a]sd = standard deviation

immature peaches are generally more susceptible to browning, the low "L" values are in part explained. A parallel can be observed between color "L" and color "b" values. This is shown by the bar graph in Figure 2.

In the freestone peaches CP "A" and EP "N6" had slightly lower mean "L" values, but not a significant difference. Color "a" values were smaller in CP "A"

TABLE 10

FREESTONE PEACHES - COLOR "L" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	27.09 ± 0.73	25.90 - 28.40
H	27.67 ± 0.58	26.30 - 28.30
L	27.87 ± 0.63	26.70 - 29.10
N	26.95 ± 0.59	26.00 - 28.00
O	27.76 ± 0.63	25.80 - 29.00
H5	27.89 ± 0.55	26.50 - 28.80
H6	27.45 ± 0.56	26.30 - 28.30
L5	27.83 ± 0.62	26.70 - 28.90
L6	27.92 ± 0.65	26.80 - 29.10
N6	26.95 ± 0.59	26.00 - 28.00
O5	27.95 ± 0.32	27.60 - 28.50
O6	27.57 ± 0.80	25.80 - 29.00
COMMERCIAL	27.09 ± 0.73	25.90 - 28.40
EXPTL PACK-75[b]	27.89 ± 0.50	26.50 - 28.90
EXPTL PACK-76[b]	27.47 ± 0.73	25.80 - 29.10

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

and EP "L6" indicating an increase in green and a decrease in red coloration. The mean hardness values of CP "A" are significantly higher than the others tested which would indicate possibly less mature peaches (see Table 28). Lower "b" values in CP "A" and EP "N6" correspond to the lower "L" values in the same packs. A common way of demonstrating color is by combining the "a" and "b" values in the form of the a/b ratio. By so doing it is then possible to reduce the two color

TABLE 11

FREESTONE PEACHES - COLOR "a" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.45 ± 0.31	-0.20 - 0.90
H	1.54 ± 0.67	0.50 - 2.90
L	1.10 ± 0.66	-1.20 - 2.30
N	1.81 ± 0.49	0.70 - 2.40
O	2.89 ± 0.41	2.20 - 3.80
H5	1.15 ± 0.52	0.50 - 1.90
H6	1.94 ± 0.58	1.30 - 2.90
L5	1.31 ± 0.62	0.50 - 2.30
L6	0.90 ± 0.65	-1.20 - 1.70
N6	1.81 ± 0.49	0.70 - 2.40
O5	3.00 ± 0.50	2.20 - 3.80
O6	2.76 ± 0.28	2.20 - 3.10
COMMERCIAL	0.45 ± 0.31	-0.20 - 0.90
EXPTL PACK-75[b]	1.82 ± 1.00	0.50 - 3.80
EXPTL PACK-76[b]	1.85 ± 0.84	-1.20 - 3.10

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

parameters to one. The a/b ratio then becomes a function of hue in the three dimensional Hunter color model. In the current study color and hardness were compared in freestone peaches. Figure 7 illustrates the relationship that was demonstrated. Generally, as the fruit

TABLE 12

FREESTONE PEACHES - COLOR "b" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	7.96 ± 0.62	7.20 - 9.40
H	8.60 ± 0.51	7.50 - 9.60
L	8.63 ± 0.56	7.20 - 9.70
N	8.01 ± 0.69	6.50 - 9.00
O	9.11 ± 0.62	7.50 - 10.00
H5	8.75 ± 0.53	7.50 - 9.60
H6	8.46 ± 0.46	7.50 - 9.20
L5	8.66 ± 0.62	7.50 - 9.70
L6	8.60 ± 0.52	7.20 - 9.30
N6	8.01 ± 0.69	6.50 - 9.00
O5	9.48 ± 0.35	9.00 - 10.00
O6	8.70 ± 0.61	7.50 - 9.80
COMMERCIAL	7.96 ± 0.62	7.20 - 9.40
EXPTL PACK-75[b]	8.96 ± 0.62	7.50 - 10.00
EXPTL PACK-76[b]	8.45 ± 0.63	6.50 - 9.60

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

became softer and more tender, there was a corresponding increase in the a/b values. Most of the change was shown in the "a" value, or a shift from greenness to redness.

Units per can (Tables 13 and 14). The mean number of units per can among clingstone peaches shows some variation. Commercial packs had an average of about one peach half more per can than did the experimental packs. Inasmuch as the mean unit sizes were very similar in both the experimental and commercial packs (Table 25), the lower drained weights in the experimental packs appear to have resulted from inadequate packing of the cans. There was considerable variation in mean units per can in the freestone packs. The numbers ranged from 4 to 18 units (halves) per can. Because of the small size of most of the units, there was little difficulty in maintaining an adequate drained weight. Only EP "O5" showed any difficulty in maintaining

TABLE 13

CLINGSTONE PEACHES - UNITS PER CAN

PROCESSOR	MEAN ± sd[a]	RANGE
A	8.3 ± 0.7	7.0 - 10.0
B	7.2 ± 1.2	5.0 - 9.0
C	8.2 ± 1.5	6.0 - 10.0
M	6.8 ± 1.5	4.0 - 10.0
M5	6.5 ± 1.4	4.0 - 10.0
M6	7.2 ± 1.6	5.0 - 10.0
COMMERCIAL	7.9 ± 1.3	5.0 - 10.0
EXPTL PACK	6.8 ± 1.5	4.0 - 10.0

[a]sd - standard deviation

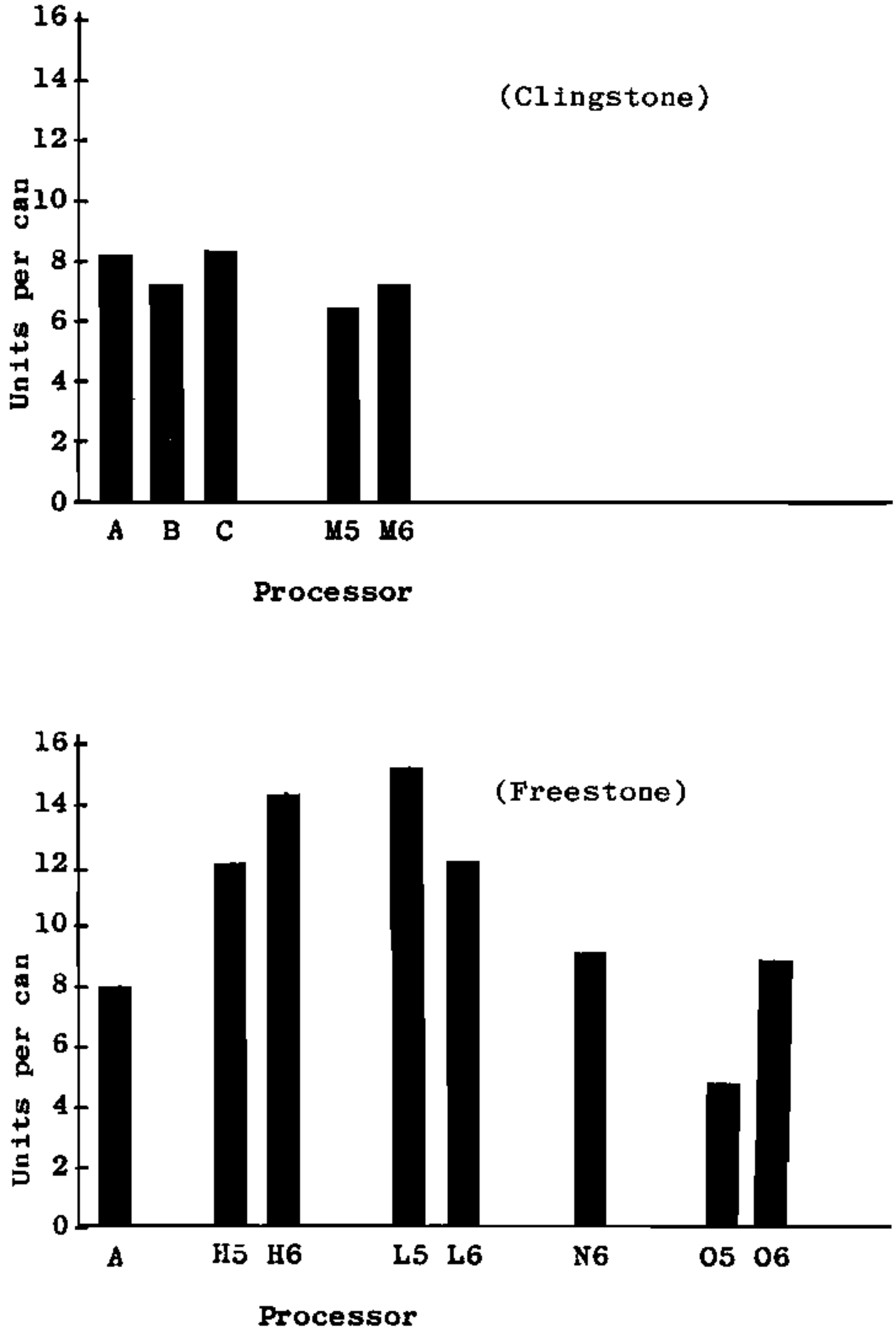


Figure 3. Mean number of units per can for clingstone and freestone peaches.

adequate drained weights as indicated in previous discussion. The reasons are related to the large size and low numbers of units. The Canners League of California has established limits on the number of units allowed for various size containers. These limits are pointed toward obtaining uniform sized peaches and eliminating small canned pieces (Anon., 1959).

The number of units per can in the commercial packs was noticeably consistent in both freestone and clingstone. On the other hand, the experimental packs were very irregular. This may have been due to lower initial quality of cull fruit which would have required extensive trimming. Also size sorting is often neglected in small packs. In fully packed cans, the number of units per can is closely correlated with drained weight.

TABLE 14

FREESTONE PEACHES - UNITS (HALVES) PER CAN

PROCESSOR	MEAN ± sd[a]	RANGE
A	8.0 ± 1.6	6.0 - 11.0
H	13.3 ± 2.5	9.0 - 18.0
L	13.7 ± 2.2	9.0 - 18.0
N	9.3 ± 2.0	6.0 - 12.0
O	7.0 ± 2.5	4.0 - 13.0
H5	12.2 ± 2.3	9.0 - 17.0
H6	14.3 ± 2.4	11.0 - 18.0
L5	15.1 ± 1.6	12.0 - 18.0
L6	12.4 ± 2.0	9.0 - 15.0
N6	9.3 ± 2.0	6.0 - 12.0
O5	4.9 ± 0.9	4.0 - 7.0
O6	9.1 ± 1.6	7.0 - 13.0
COMMERCIAL	8.0 ± 1.6	6.0 - 11.0
EXPTL PACK-75[b]	10.7 ± 4.6	4.0 - 18.0
EXPTL PACK-76[b]	11.3 ± 3.0	6.0 - 18.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

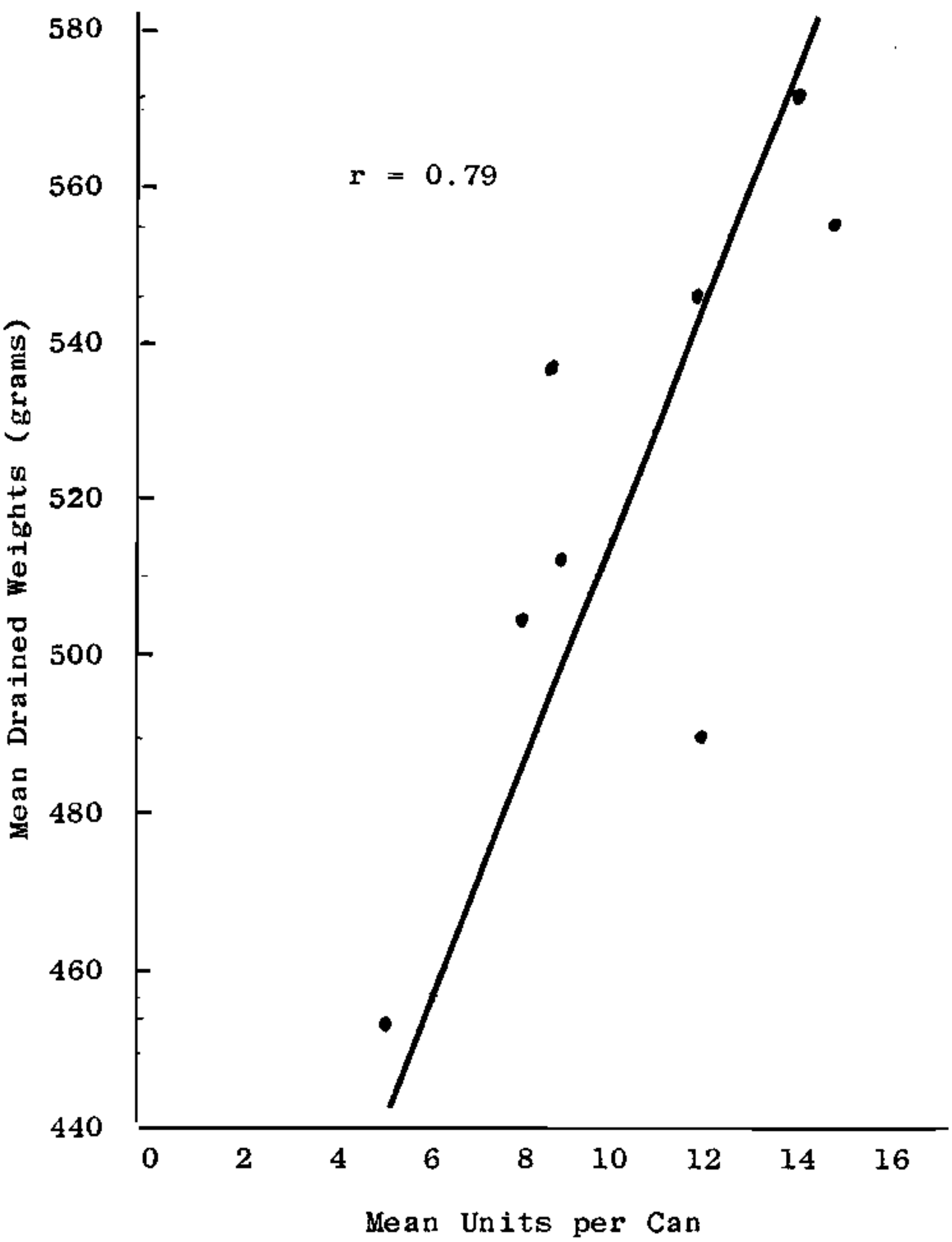


Figure 4. Mean drained weights versus mean units per can in freestone peaches.

A comparison of mean drained weights and mean units per can was made in the freestone packs. Although adequacy of packing was not considered at the time of testing, most of the experimental and commercial packs showed a fair degree of correlation (see Figure 4).

pH (Tables 15 and 16). Reasonable pH ranges were maintained in both commercial and experimental packs. These were well below the safety limit of 4.6 for acid foods (Anon., 1975). Among the clingstone peaches, the commercial packs had generally lower mean pH values than the experimental packs. Peaches from the experimental packs were softer than the ones in commercial packs. The higher pH values may have resulted from an increased maturity, i.e., the pH in fruit generally increases with increased maturity and the softness also increases. The hardness of clingstone peaches was shown to be greater in those packs having lower pH values (Table 27).

TABLE 15

CLINGSTONE PEACHES - pH

PROCESSOR	MEAN ± sd[a]	RANGE
A	3.8 ± 0.12	3.6 - 4.0
B	3.7 ± 0.10	3.5 - 3.8
C	3.8 ± 0.12	3.5 - 3.9
M	3.9 ± 0.06	3.8 - 4.1
M5	3.9 ± 0.07	3.8 - 4.1
M6	3.9 ± 0.05	3.8 - 4.0
COMMERCIAL	3.7 ± 0.12	3.5 - 4.0
EXPTL PACKS	3.9 ± 0.06	3.8 - 4.1

[a]sd - standard deviation

Freestone peaches also showed some significant pH differences. For instance, EP "O5" and EP "O6" had pH values of 4.2, which was considerably higher than the next lower value of 3.9. These higher pH values correlate with an increased softness of the fruit as demonstrated in the present study. Another potential reason for high pH values in canned peaches relates to the lye-peeling process. Failure to adequately rinse the fruit after the application of the caustic soda (NaOH), may result in higher pH values. Such a process is widely used by commercial canners. However, experimental packs in this study were not subjected to this process. Mold in fruit has also been implicated as a cause of reduced acidity and higher pH values. Once a fruit has been processed and sealed in an air-tight

TABLE 16

FREESTONE PEACHES - pH

PROCESSOR	MEAN ± sd[a]	RANGE
A	3.7 ± 0.08	3.5 - 3.9
H	3.9 ± 0.11	3.7 - 4.1
L	3.9 ± 0.06	3.7 - 4.0
N	3.9 ± 0.07	3.7 - 4.0
O	4.2 ± 0.09	4.0 - 4.4
H5	3.9 ± -	3.7 - 4.1
H6	3.9 ± 0.11	3.7 - 4.1
L5	3.9 ± 0.04	3.8 - 4.0
L6	3.9 ± 0.06	3.7 - 4.0
N6	3.9 ± 0.07	3.7 - 4.0
O5	4.2 ± 0.09	4.0 - 4.3
O6	4.2 ± 0.07	4.1 - 4.4
COMMERCIAL	3.7 ± 0.08	3.5 - 3.9
EXPTL PACK-75[b]	4.0 ± 0.16	3.7 - 4.3
EXPTL PACK-76[b]	4.0 ± 0.17	3.7 - 4.4

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

can, mold is not a problem. However, canned peaches may show a higher pH due to mold activity on the fresh fruit prior to canning.

Soluble solids (Tables 17 and 18). The percentage of sugar (soluble solids) can vary considerably, depending upon the purpose of the processor. Commercial processors in this study utilized two ranges for their syrups: a light syrup, 14 to 18 percent; and a heavy syrup, 18 to 22 percent (21 CFR 145.170). Results of tests showed that the commercial pack values corresponded with label values. Experimental packs should have all been within the light syrup range. However, as illustrated in Figure 5, the EP "M5" group fell well below the minimum values for light syrup. In the ensuing year, EP "M6" was over-compensated with a mean value in the heavy, 22 percent sugar range. Although mean values for the freestone packs were close to the desired range, fluctuations in

TABLE 17

CLINGSTONE PEACHES - SOLUBLE SOLIDS (percent)

PROCESSOR	MEAN ± sd[a]	RANGE
A	18.2 ± 0.9	16.3 - 19.8
B	20.0 ± 1.1	18.1 - 21.6
C	19.8 ± 2.3	13.6 - 23.0
M	17.3 ± 5.5	11.1 - 25.5
M5	12.0 ± 0.6	11.1 - 13.1
M6	22.3 ± 2.2	17.7 - 25.5
COMMERCIAL	19.3 ± 1.7	13.6 - 23.0
EXPTL PACKS	17.3 ± 5.5	11.1 - 25.5

[a]sd = standard deviation

percentages indicate inadequate quality control in the syruping procedure. For instance, EP "L5" had a range of from 11.0 to 17.9 percent. Commercially, syrups of the desired concentrations are made up in large quantities before being added to the cans. In the experimental packs, granulated sucrose is measured volumetrically for each individual can. As a result of this method, there is a great deal of fluctuation in sugar content.

TABLE 18

FREESTONE PEACHES - SOLUBLE SOLIDS (percent)

PROCESSOR	MEAN ± sd[a]	RANGE
A	20.6 ± 1.7	15.8 - 22.4
H	17.8 ± 1.9	13.9 - 21.2
L	15.9 ± 2.5	11.0 - 20.1
N	16.4 ± 1.3	14.4 - 19.0
O	15.3 ± 1.2	13.2 - 17.8
H5	18.9 ± 1.5	16.1 - 21.2
H6	16.8 ± 1.8	13.9 - 18.9
L5	14.4 ± 1.9	11.0 - 17.9
L6	17.4 ± 2.0	12.7 - 20.1
N6	16.4 ± 1.3	14.4 - 19.0
O5	15.7 ± 1.4	13.2 - 17.8
O6	14.8 ± 0.9	13.2 - 15.9
COMMERCIAL	20.6 ± 1.7	15.8 - 22.4
EXPTL PACK-75[b]	16.2 ± 2.5	11.0 - 21.2
EXPTL PACK-76[b]	16.4 ± 1.8	12.7 - 20.1

[a] sd = standard deviation
[b] Experimental packs for 1975 and 1976

Peel area (Tables 19 and 20). In evaluating peel area, consideration must be given to the fact that standards for canned freestone peaches have a greater tolerance for peel than do the clingstone peaches of grade A. Whereas 1/2 square inch is allowed in freestone grade A peaches, only 1/4 square inch is allowed in the clingstone for the same grade. A maximum of one square inch is allowed before either clingstone or freestone

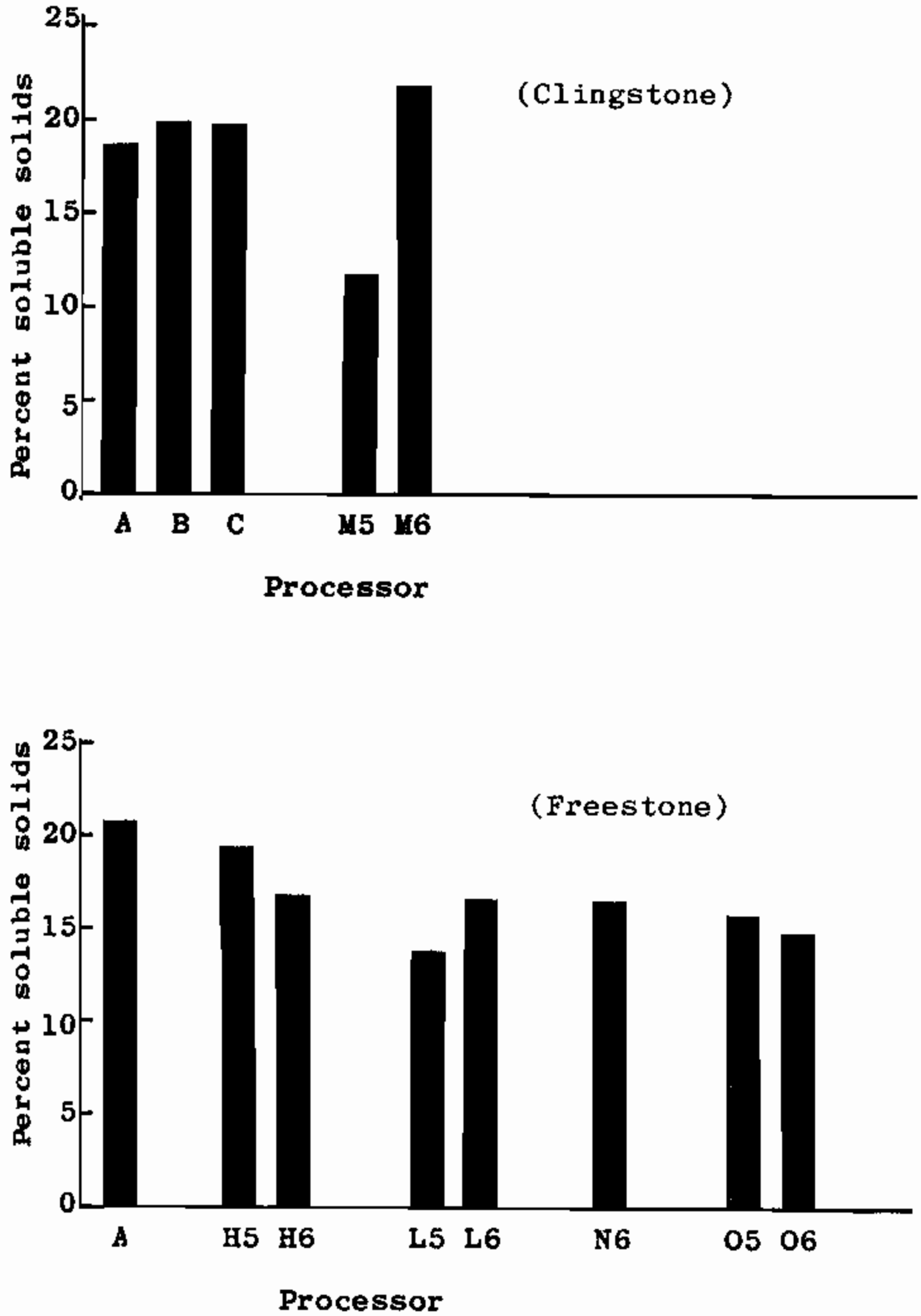


Figure 5. Percent soluble solids (sugar) in clingstone and freestone peaches.

TABLE 19

CLINGSTONE PEACHES - PEEL AREA (IN^2)

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.01 ± 0.05	0.0 - 0.20
B	0.04 ± 0.11	0.0 - 0.30
C	0.00 ± 0.00	0.0 - 0.00
M	0.08 ± 0.42	0.0 - 2.30
M5	0.00 ± 0.00	0.0 - 0.00
M6	0.16 ± 0.59	0.0 - 2.30
COMMERCIAL	0.02 ± 0.06	0.0 - 0.30
EXPTL PACKS	0.08 ± 0.42	0.0 - 2.30

[a]sd = standard deviation

must be designated as substandard in quality (USDA, 1969 and USDA, 1973). Test results showed EP "M5" and EP "M6" in clingstone peaches to have significantly more peel than the commercial packs. The commercial packs were all low in peel.

In the freestone peaches, EP "O6" had a mean value for peel area of 1.59 square inches, one can having a total of 14.4 square inches. Nine cans in

TABLE 20

FREESTONE PEACHES - PEEL AREA (IN^2)

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.01 ± 0.03	0.00 - 0.10
H	0.04 ± 0.09	0.00 - 0.30
L	0.23 ± 0.47	0.00 - 1.70
N	0.16 ± 0.29	0.00 - 1.00
O	0.81 ± 2.68	0.00 - 14.40
H5	0.05 ± 0.09	0.00 - 0.30
H6	0.03 ± 0.09	0.00 - 0.30
L5	0.39 ± 0.51	0.00 - 1.70
L6	0.28 ± 0.44	0.00 - 1.40
N6	0.16 ± 0.29	0.00 - 1.00
O5	0.03 ± 0.06	0.00 - 0.20
O6	1.59 ± 3.68	0.00 - 14.40
COMMERCIAL	0.01 ± 0.03	0.00 - 0.10
EXPTL PACKS-75[b]	0.15 ± 0.34	0.00 - 1.70
EXPTL PACKS-76[b]	- ± 1.92	0.00 - 14.40

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

EP "06" fell in the substandard category because of excessive peel. The other packs had relatively little peel as is shown by the mean values and standard deviations. The practice of lye-peeling has almost eliminated the problem of peel in peaches. However, a few instances were found in the commercial packs in which only the surface layer of the peel was removed. That which remained was counted as peel in the evaluation.

Pit volume (Tables 21 and 22). Neither clingstone nor freestone had significant amounts of pit material in either the commercial or experimental packs.

TABLE 21

CLINGSTONE PEACHES - PIT VOLUME (CM^3)

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.01 ± 0.05	0.0 - 0.20
B	0.02 ± 0.06	0.0 - 0.20
C	0.02 ± 0.04	0.0 - 0.10
M	0.00 ± 0.00	0.0 - 0.00
M5	0.00 ± 0.00	0.0 - 0.00
M6	0.00 ± 0.00	0.0 - 0.00
COMMERCIAL	0.02 ± 0.05	0.0 - 0.20
EXPTL PACKS	0.00 ± 0.00	0.0 - 0.00

[a]sd = standard deviation

The existence of pit material in peaches is an important consideration because of its potential hazards to the consumer. Federal standards allow not more than one complete peach pit per 227 grams (8 ounces) of finished canned peaches. No complete pits were found in any of the samples tested.

TABLE 22

FREESTONE PEACHES - PIT VOLUME (CM^3)

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.01 ± 0.04	0.00 - 0.10
H	0.02 ± 0.07	0.00 - 0.30
L	0.00 ± 0.00	0.00 - 0.00
N	0.00 ± 0.00	0.00 - 0.00
O	0.01 ± 0.03	0.00 - 0.10
H5	0.00 ± 0.00	0.00 - 0.00
H6	0.03 ± 0.09	0.00 - 0.30
L5	0.00 ± 0.00	0.00 - 0.00
L6	0.00 ± 0.00	0.00 - 0.00
N6	0.00 ± 0.00	0.00 - 0.00
O5	0.01 ± 0.04	0.00 - 0.10
O6	0.00 ± 0.00	0.00 - 0.00
COMMERCIAL	0.01 ± 0.04	0.00 - 0.10
EXPTL PACKS-75[b]	0.00 ± 0.02	0.00 - 0.10
EXPTL PACKS-76[b]	0.00 ± 0.05	0.00 - 0.30

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Blemished units (Tables 23 and 24). No significant numbers of blemished units were found in the clingstone peaches. Only EP "O6" of the freestone

TABLE 23

CLINGSTONE PEACHES - BLEMISHED UNITS

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.5 ± 0.7	0.0 - 2.0
B	0.7 ± 0.6	0.0 - 2.0
C	0.5 ± 0.6	0.0 - 2.0
M	0.2 ± 0.5	0.0 - 2.0
M5	0.2 ± 0.4	0.0 - 1.0
M6	0.3 ± 0.6	0.0 - 2.0
COMMERCIAL	0.6 ± 0.7	0.0 - 2.0
EXPTL PACKS	0.2 ± 0.5	0.0 - 2.0

[a]sd = standard deviation

peaches showed excessive numbers of blemished units. Most of the blemishes were the result of bruising, although some scab and insect damage was also observed. Bruising usually occurs as a result of mishandling overripe fruit. Excessive sorting and handling increase the chances of bruising. If a fruit is allowed to remain on the tree until it is completely ripe, considerable bruising due to handling may occur prior to canning.

TABLE 24

FREESTONE PEACHES - BLEMISHED UNITS

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.4 ± 0.8	0.0 - 3.0
H	0.4 ± 0.8	0.0 - 3.0
L	0.1 ± 0.3	0.0 - 1.0
N	0.7 ± 1.2	0.0 - 4.0
O	0.7 ± 1.0	0.0 - 3.0
H5	0.5 ± 0.7	0.0 - 2.0
H6	0.3 ± 0.9	0.0 - 3.0
L5	0.1 ± 0.3	0.0 - 1.0
L6	0.1 ± 0.3	0.0 - 1.0
N6	0.7 ± 1.2	0.0 - 4.0
O5	0.5 ± 0.8	0.0 - 3.0
O6	1.0 ± 1.1	0.0 - 3.0
COMMERCIAL	0.4 ± 0.8	0.0 - 3.0
EXPTL PACKS-75[b]	0.3 ± 0.7	0.0 - 3.0
EXPTL PACKS-76[b]	0.5 ± 1.0	0.0 - 4.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Thus, for freestone peaches it is recommended that the harvest take place 6 to 7 days before full-ripe maturity (Anon., 1959).

Unit weights (Tables 25 and 26). The mean unit weights of commercial freestone and clingstone peach

TABLE 25

CLINGSTONE PEACHES - UNIT WEIGHTS (HALVES)[b]

PROCESSOR	MEAN ± sd[a]	RANGE
A	65.0 ± 10.4	43.0 - 92.0
B	72.9 ± 12.8	33.0 - 103.0
C	62.6 ± 13.5	38.0 - 93.0
M	61.2 ± 42.2	20.0 - 157.0
M5	66.0 ± 57.9	20.0 - 104.0
M6	57.2 ± 20.5	23.0 - 157.0
COMMERCIAL	66.4 ± 12.9	33.0 - 103.0
EXPTL PACKS	61.2 ± 42.2	20.0 - 157.0

[a]sd = standard deviation
[b]unit weights are given in grams

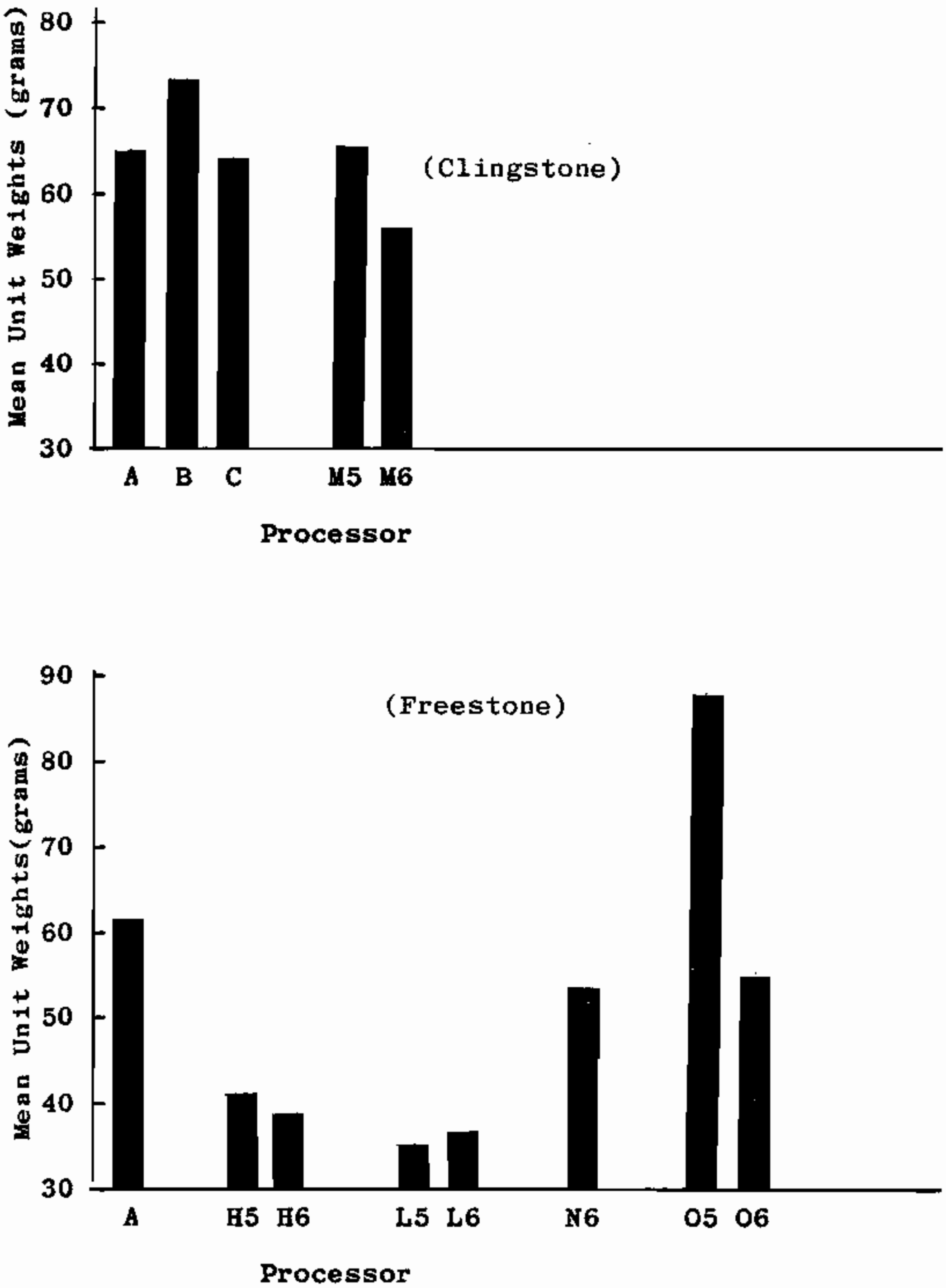


Figure 6. Mean weights of individual halves of clingstone and freestone peaches.

halves were very similar. Freestone experimental packs varied considerably in weight, with the units of the experimental packs being generally smaller (see Figure 6). However, in the case of EP "05", the mean unit size was considerably greater than those of any of the experimental packs. This resulted in some insufficiently filled cans with drained weights well below minimum values.

TABLE 26

FREESTONE PEACHES - UNIT WEIGHTS (HALVES)

PROCESSOR	MEAN $\pm$ sd[a]	RANGE
A	60.6 $\pm$ 16.4	25.0 - 115.0
H	39.5 $\pm$ 12.3	20.0 - 90.0
L	36.2 $\pm$ 9.5	20.0 - 71.0
N	52.6 $\pm$ 19.0	22.0 - 117.0
O	67.4 $\pm$ 25.0	20.0 - 141.0
H5	40.8 $\pm$ 15.0	21.0 - 90.0
H6	38.6 $\pm$ 10.0	20.0 - 82.0
L5	35.7 $\pm$ 8.8	20.0 - 71.0
L6	36.7 $\pm$ 10.2	20.0 - 70.0
N6	52.6 $\pm$ 19.0	22.0 - 117.0
O5	88.1 $\pm$ 25.7	20.0 - 141.0
O6	56.3 $\pm$ 16.1	21.0 - 92.0
COMMERCIAL	60.6 $\pm$ 16.4	25.0 - 115.0
EXPTL PACKS-75[b]	46.7 $\pm$ 24.5	20.0 - 141.0
EXPTL PACKS-76[b]	44.6 $\pm$ 16.0	20.0 - 117.0

[a] sd = standard deviation
[b] Experimental packs for 1975 and 1976

Unit hardness (Tables 27 and 28). The test as described in 21 CFR 145.170 was used to evaluate the hardness or tenderness of the peach halves. In using this test, peaches that are pierced by a weight of 300 grams (10.6 ounces) or more are considered to be "not tender" and must receive a substandard rating according to United States grade standards. Although no hardness standards other than the 300 gram limit are expressed in the standards, based on the writer's personal experience and preference, the ideal peach hardness range lies somewhere between 75 and 150 grams (2.6 and 5.3 ounces).

TABLE 27

CLINGSTONE PEACHES - UNIT HARDNESS (HALVES)[b]

PROCESSOR	MEAN ± sd[a]	RANGE
A	125.7 ± 48.4	47.0 - 299.0
B	110.6 ± 48.9	36.0 - 286.0
C	76.4 ± 27.6	33.0 - 198.0
M	94.2 ± 38.1	38.0 - 270.0
M5	91.5 ± 31.5	38.0 - 175.0
M6	96.4 ± 43.0	40.0 - 270.0
COMMERCIAL	104.0 ± 47.3	33.0 - 299.0
EXPTL PACKS	94.2 ± 38.1	38.0 - 270.0

[a]sd = standard deviation
[b]Unit hardness is expressed as the weight in grams when added to a rod 5/32 inches in diameter brings about penetration of a sample to a depth of 0.3 inches.

None of the clingstone peaches exceeded the 300 gram limit in hardness; however, several units in both the experimental and commercial packs approached that limit. Hardness values for freestone peaches were

TABLE 28

FREESTONE PEACHES - UNIT HARDNESS (HALVES)[c]

PROCESSOR	MEAN ± sd[a]	RANGE
A	143.2 ± 50.0	64.0 - 317.0
H	88.4 ± 23.1	38.0 - 160.0
L	89.8 ± 25.0	45.0 - 249.0
N	115.1 ± 58.0	36.0 - 390.0
O	64.7 ± 20.0	30.0 - 126.0
H5	83.6 ± 22.7	38.0 - 160.0
H6	92.7 ± 22.7	46.0 - 158.0
L5	83.7 ± 18.3	45.0 - 150.0
L6	97.0 ± 29.6	46.0 - 249.0
N6	115.1 ± 58.0	36.0 - 390.0
O5	64.0 ± 19.6	35.0 - 124.0
O6	65.0 ± 20.3	30.0 - 126.0
COMMERCIAL	143.2 ± 50.0	64.0 - 317.0
EXPTL PACKS-75[b]	80.7 ± 21.5	35.0 - 160.0
EXPTL PACKS-76[b]	93.0 ± 37.9	30.0 - 390.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976
[c]Unit hardness is expressed as the weight in grams when added to a rod 5/32 inches in diameter brings about penetration of a sample to a depth of 0.3 inches

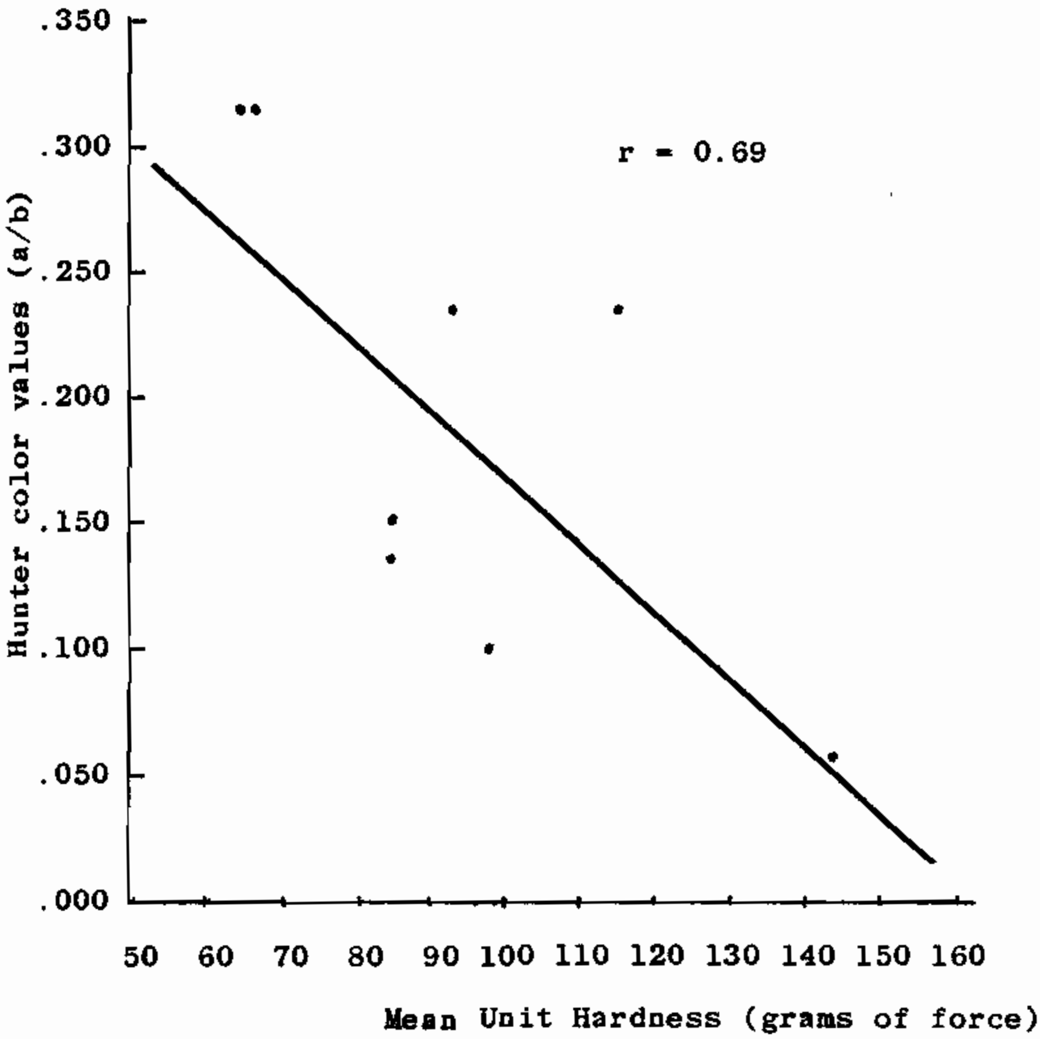


Figure 7. Hunter color values (a/b) versus unit hardness in freestone peaches.

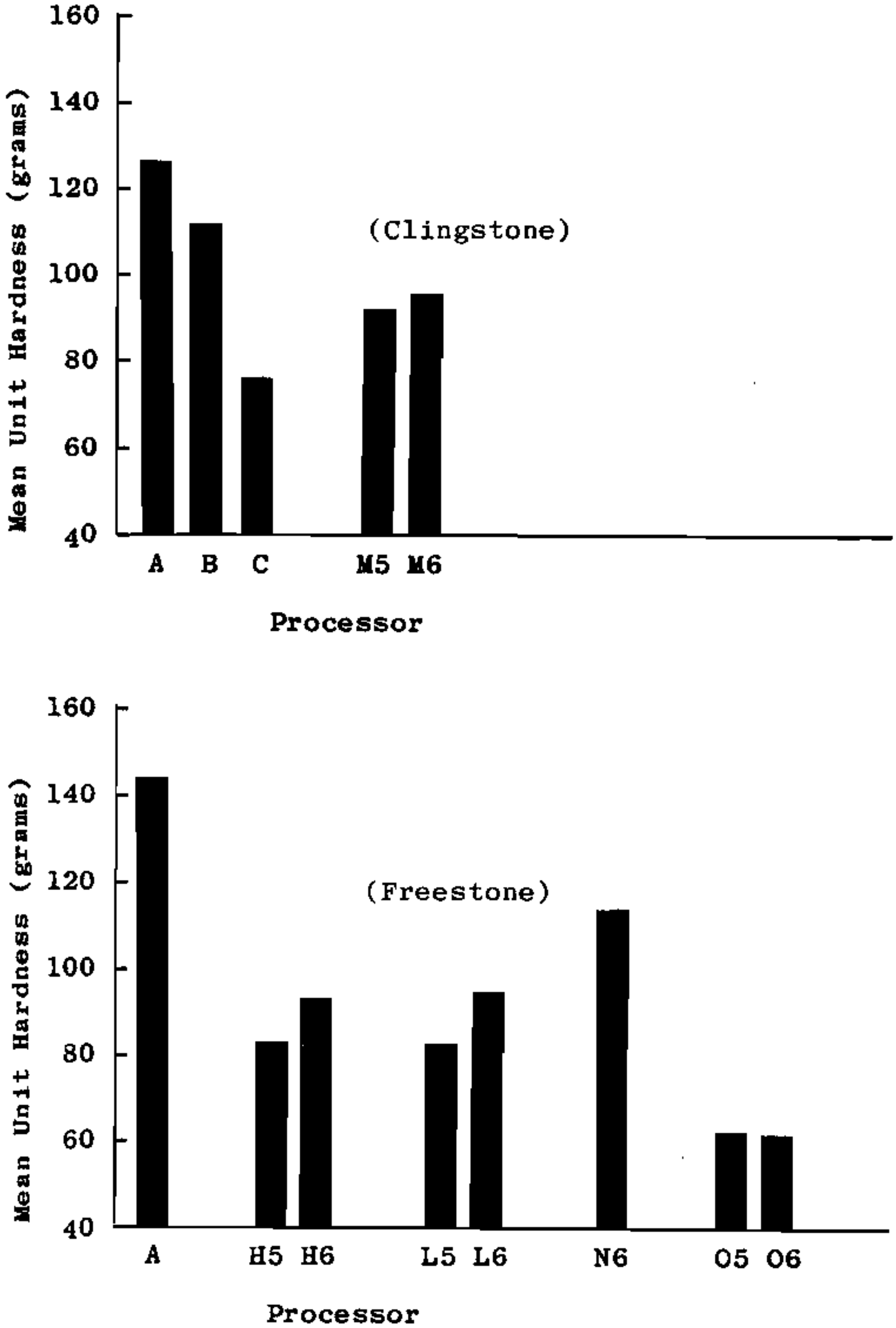


Figure 8. Mean unit hardness for clingstone and freestone peaches.

generally well within desirable limits. However, two cans from each EP "N6" and CP "A" fell into the sub-standard category as a result of hard peaches. Figure 7 shows the correlation between color and hardness. Color ratios appear to change slightly with a change in hardness as the correlation plot indicates. Mean hardness values for both freestone and clingstone peaches are illustrated in the bar graphs in Figure 8.

Pears

The pears tested in this study were of the Bartlett variety, the main variety used for canning. Results and discussion of tests are presented in the paragraphs which follow.

Can vacuum (Table 29). Most of the cans that were tested had acceptable vacuums. However, in several

TABLE 29

PEARS - CAN VACUUM (inches Hg)

PROCESSOR	MEAN ± sd[a]	RANGE
A	7.8 ± 1.7	5.0 - 11.0
B	8.6 ± 2.4	6.0 - 13.5
C	3.6 ± 3.0	0.0 - 8.5
D	12.5 ± 2.1	8.0 - 15.0
L	7.2 ± 2.7	0.0 - 13.0
M	4.5 ± 3.2	0.0 - 10.0
O	9.5 ± 3.3	1.0 - 16.0
L5	7.2 ± 2.7	3.0 - 13.0
L6	7.3 ± 2.8	0.0 - 10.0
M5	7.7 ± 0.6	7.0 - 8.0
M6	3.9 ± 3.1	0.0 - 10.0
O5	7.5 ± 3.0	1.0 - 11.0
O6	11.6 ± 2.2	8.0 - 16.0
COMMERCIAL	8.1 ± 3.9	0.0 - 15.0
EXPTL PACKS-75[a]	7.4 ± 2.7	1.0 - 13.0
EXPTL PACKS-76[b]	7.4 ± 4.2	0.0 - 16.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

instances zero vacuums were encountered. CP "C" contained one lot wherein all three cans from that lot had zero vacuums. The condition of the container and pears were normal, indicating that the problem most likely occurred at the time of processing and resulted from a poorly adjusted steam flow closure or low sealing temperature. In EP "L6" one can registered a zero vacuum which appears to have resulted from container overfill. EP "M6" had two cans from the same lot with zero vacuums. The remaining can from that lot had a vacuum of 2.0 inches Hg. Inasmuch as the condition of the cans and pears were normal, the problem was likely a result of low sealing temperature.

Headspace (Table 30). Headspaces in both commercial and experimental packs were within reasonable

TABLE 30

PEARS - HEAD SPACE (1/32 inches)

PROCESSOR	MEAN ± sd[a]	RANGE
A	12.8 ± 1.2	10.0 - 14.0
B	13.1 ± 2.7	5.0 - 16.0
C	13.7 ± 1.9	11.0 - 16.0
D	13.7 ± 1.0	12.0 - 15.0
L	12.9 ± 1.3	10.0 - 15.0
M	13.2 ± 1.5	10.0 - 16.0
O	14.7 ± 1.6	12.0 - 18.0
L5	13.5 ± 1.3	11.0 - 15.0
L6	12.2 ± 0.9	10.0 - 14.0
M5	12.7 ± 0.6	12.0 - 13.0
M6	13.3 ± 1.6	10.0 - 16.0
O5	14.0 ± 1.6	12.0 - 16.0
O6	15.5 ± 1.3	14.0 - 18.0
COMMERCIAL	13.3 ± 1.8	5.0 - 16.0
EXPTL PACKS-75[b]	13.7 ± 1.4	11.0 - 16.0
EXPTL PACKS-76[b]	13.7 ± 1.9	10.0 - 18.0

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

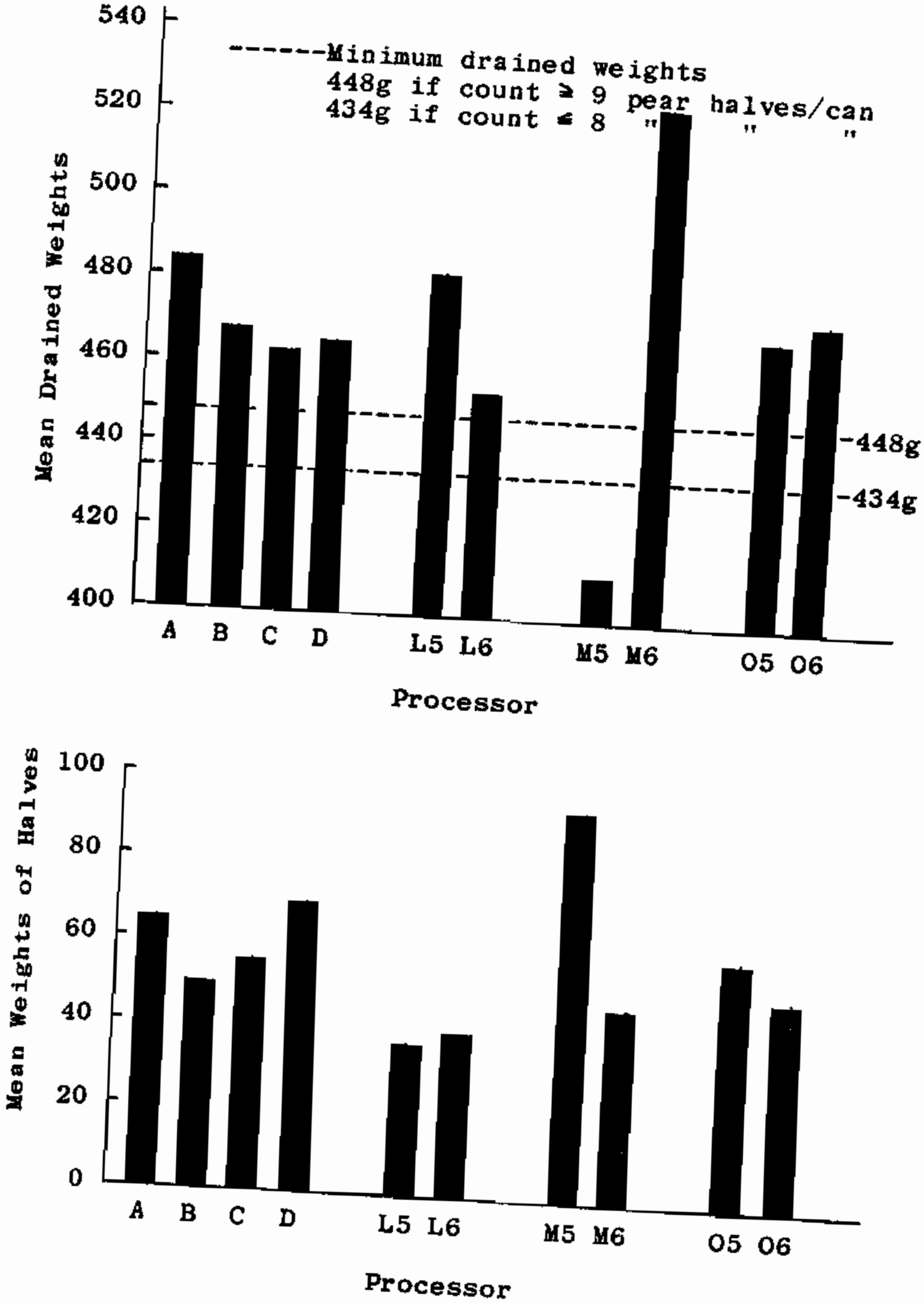


Figure 9. Mean drained weights and mean weights of individual halves for pears.

ranges. In no instance did individual cans fall into the "slack filled" category, those with headspaces greater than 20/32 inch.

Drained weight (Table 31). Drained weights were found to be of acceptable values in most cases. However, EP "M5" had a mean drained weight well below the minimum recommended federal limit of 16.3 ounces or 434 grams (see Figure 9). At least part of the problem is related to the larger sized units (see Table 43 and Figure 9). EP "M6" of the following season contained smaller pears. Consequently, the mean drained weight increased considerably.

TABLE 31

PEARS - DRAINED WEIGHT (grams)

PROCESSOR	MEAN ± sd[a]	RANGE
A	482.9 ± 33.4	419.0 - 532.0
B	468.8 ± 31.3	414.0 - 541.0
C	462.4 ± 46.1	367.0 - 550.0
D	464.5 ± 37.2	400.0 - 519.0
L	468.7 ± 48.1	386.0 - 592.0
M	507.7 ± 57.6	365.0 - 596.0
O	473.1 ± 41.8	370.0 - 562.0
L5	481.1 ± 54.7	387.0 - 592.0
L6	456.3 ± 38.3	386.0 - 522.0
M5	411.0 ± 40.0	365.0 - 438.0
M6	523.8 ± 42.3	457.0 - 596.0
O5	470.3 ± 48.5	370.0 - 562.0
O6	475.9 ± 35.3	412.0 - 536.0
COMMERCIAL	470.1 ± 37.3	367.0 - 550.0
EXPTL PACKS-75[b]	469.9 ± 53.2	365.0 - 592.0
EXPTL PACKS-76[b]	487.7 ± 48.1	386.0 - 596.0

[a] sd = standard deviation
[b] Experimental packs for 1975 and 1976

Hunter color values (Tables 32 through 34). EP "M5" had a significantly lower mean "L" value than the other packs tested. Some surface browning was also noted in these cans. Mean "L" values were slightly

TABLE 32

PEARS - COLOR "L" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	29.05 ± 0.35	28.20 - 29.60
B	29.08 ± 0.30	28.60 - 29.50
C	28.26 ± 0.24	28.00 - 29.00
D	29.86 ± 0.43	29.30 - 30.70
L	28.97 ± 0.41	28.00 - 29.80
M	28.08 ± 0.94	26.70 - 30.00
O	28.18 ± 0.80	25.90 - 28.90
L5	29.07 ± 0.34	28.20 - 29.80
L6	28.87 ± 0.46	28.00 - 29.70
M5	26.93 ± 0.25	26.70 - 27.20
M6	28.27 ± 0.87	26.90 - 30.00
O5	28.08 ± 1.08	25.90 - 28.90
O6	28.28 ± 0.30	27.50 - 28.90
COMMERCIAL	29.05 ± 0.65	28.00 - 30.70
EXPTL PACKS-75[b]	28.43 ± 1.01	25.90 - 29.60
EXPTL PACKS-76[b]	28.46 ± 0.68	26.90 - 30.00

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

higher in the commercial packs indicating a lighter color value. Generally, the "L" values in the experimental packs increased during the second season, showing reduced browning discoloration.

Color "a" values, degree of greenness versus redness, showed some significant variation within the experimental packs. It was observed that shifts from the negative (green) toward the positive (red) "a" values corresponded to decreases in "L" values. At least part of this shift appears to have resulted from the browning reaction compounds. However, part was also related to the pink discoloration frequently associated with pears. For instance, EP "O5" had a severe problem with this pink discoloration. This resulted in limiting one of the lots to "Substandard" grade. According to Czerkasky (1970), it is widely accepted that the pink

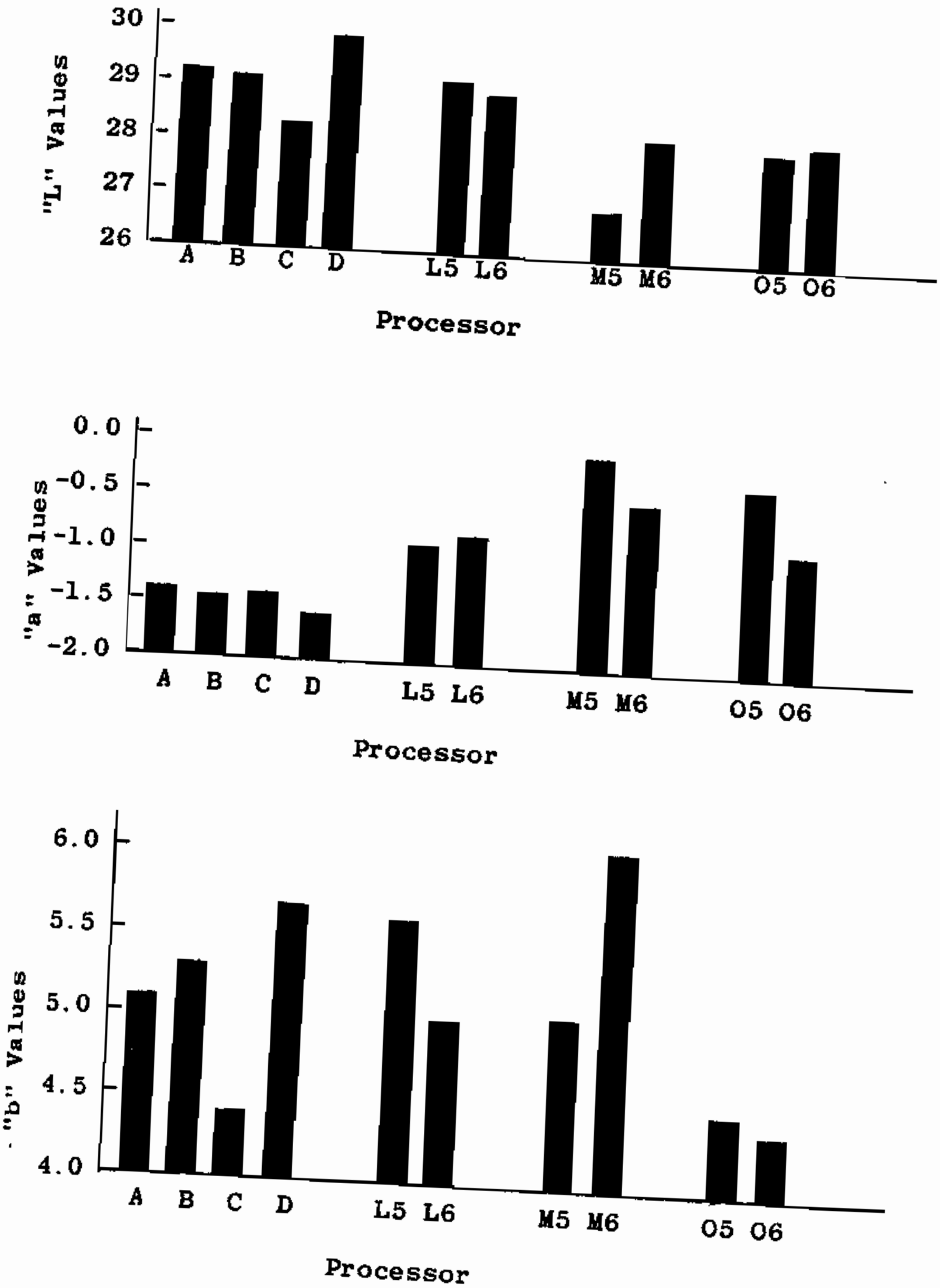


Figure 10. Mean Hunter color values for pears.

discoloration, although quite complex, can be considerably reduced at the processing plant by reducing the severity of the heat treatment where applicable, and by immediately cooling the cans following the process.

TABLE 33

PEARS - COLOR "a" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	-1.38 ± 0.13	-1.60 - -1.20
B	-1.45 ± 0.12	-1.60 - -1.20
C	-1.38 ± 0.08	-1.50 - -1.20
D	-1.61 ± 0.08	-1.70 - -1.50
L	-0.87 ± 0.33	-1.40 - 0.20
M	-0.48 ± 0.44	-1.30 - 0.90
O	-0.51 ± 1.14	-1.20 - 3.60
L5	-0.93 ± 0.38	-1.40 - 0.20
L6	-0.81 ± 0.28	-1.30 - -0.20
M5	-0.10 ± 0.20	-0.30 - 0.10
M6	-0.54 ± 0.44	-1.30 - 0.90
O5	-0.25 ± 1.51	-1.20 - 3.60
O6	-0.77 ± 0.53	-1.20 - 1.00
COMMERCIAL	-1.45 ± 0.14	-1.70 - -1.20
EXPTL PACKS-75[b]	-0.55 ± 1.09	-1.40 - 3.60
EXPTL PACKS-76[b]	-0.69 ± 0.45	-1.30 - 1.00

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

It should also be noted that all of the commercial cans that were tested fell within the negative color "a" values. Conversely, all but one experimental pack (EP "L6") had pears with positive color "a" values. EP "O5" contained pink pears with color "a" values as high as 3.60.

Color "b" values, degree blueness versus yellowness, varied significantly from one pack to another. However, the yellow coloration in pears may vary without affecting quality. The degree of yellowness changes with variety.

TABLE 34

PEARS - COLOR "b" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	5.15 ± 0.35	4.60 - 5.70
B	5.31 ± 0.31	4.80 - 5.80
C	4.35 ± 0.27	3.80 - 4.70
D	5.66 ± 0.30	5.20 - 6.20
L	5.31 ± 0.60	4.20 - 6.30
M	5.99 ± 9.34	4.70 - 7.70
O	4.42 ± 0.55	3.40 - 5.40
L5	5.63 ± 0.32	5.10 - 6.30
L6	4.98 ± 0.65	4.20 - 6.10
M5	5.07 ± 0.40	4.70 - 5.50
M6	6.14 ± 0.80	4.80 - 7.70
O5	4.49 ± 0.69	3.40 - 5.40
O6	4.35 ± 0.39	3.60 - 5.10
COMMERCIAL	5.11 ± 0.56	3.80 - 6.20
EXPTL PACKS-75[b]	5.06 ± 0.75	3.40 - 6.30
EXPTL PACKS-76[b]	5.22 ± 0.99	3.60 - 7.70

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Units (halves) per can (Table 35). As shown in Table 35, commercial packs had fewer units per can than did the experimental packs. One obvious reason stems from the generally larger size of the commercial pears (see Table 43). Uniformity of size in pears is more of

TABLE 35

PEARS - UNITS (HALVES) PER CAN

PROCESSOR	MEAN ± sd[a]	RANGE
A	7.6 ± 0.8	6.0 - 9.0
B	9.3 ± 1.2	7.0 - 11.0
C	8.3 ± 1.7	6.0 - 11.0
D	6.7 ± 2.6	5.0 - 14.0
L	11.8 ± 2.0	8.0 - 15.0
M	9.9 ± 2.5	5.0 - 14.0
O	8.0 ± 1.5	5.0 - 10.0
L5	12.7 ± 1.6	10.0 - 15.0
L6	10.9 ± 2.1	8.0 - 15.0
M5	5.7 ± 0.6	5.0 - 6.0
M6	10.6 ± 1.8	8.0 - 14.0
O5	7.5 ± 1.6	5.0 - 10.0
O6	8.4 ± 1.4	6.0 - 10.0
COMMERCIAL	8.0 ± 1.9	5.0 - 14.0
EXPTL PACKS-75[b]	9.7 ± 3.2	5.0 - 15.0
EXPTL PACKS-76[b]	10.0 ± 2.1	6.0 - 15.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

a factor in the grading than is the pear size itself. However, if the pear size is extremely small, as reflected by a large number of units per can, then downgrading occurs. When the number of units exceeds twenty-two, indications are that the minimum size of 3/5 ounce or 17 grams per unit (half) has been exceeded. The largest number of units encountered in any of the packs was fifteen.

pH values (Table 36). Mean pH values for commercial packs (3.92) were slightly lower than the experimental packs (4.13 and 4.05); however, the differences were not significant. Differences may be related to any one of a number of factors such as fruit maturity, climate, soil conditions, and farm cultural practices.

TABLE 36

PEARS - pH

PROCESSOR	MEAN ± sd[a]	RANGE
A	3.97 ± 0.08	3.80 - 4.10
B	3.97 ± 0.08	3.35 - 4.10
C	3.84 ± 0.07	3.70 - 4.00
D	3.89 ± 0.08	3.30 - 4.05
L	4.06 ± 0.10	3.85 - 4.25
M	4.08 ± 0.14	3.80 - 4.30
O	4.11 ± 0.13	3.90 - 4.40
L5	4.12 ± 0.10	3.85 - 4.25
L6	3.99 ± 0.06	3.90 - 4.10
M5	3.97 ± 0.18	3.80 - 4.15
M6	4.09 ± 0.12	3.80 - 4.30
O5	4.16 ± 0.10	3.95 - 4.30
O6	4.06 ± 0.13	3.90 - 4.40
COMMERCIAL	3.92 ± 0.09	3.70 - 4.10
EXPTL PACKS-75[b]	4.13 ± 0.12	3.80 - 4.30
EXPTL PACKS-76[b]	4.05 ± 0.12	3.30 - 4.40

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Percent soluble solids (Table 37). All of the experimental packs should have fallen within the "light syrup" range of between 14 and 18 percent. Commercial packs were labeled either "light syrup" or "heavy syrup". The percent sugar as sucrose in "heavy syrup" lies between 18 and 22 percent. Commercial packs consistently fell within the ranges indicated on the labels. On the other hand, experimental packs were not consistent. For instance, mean values in EP "L5" and "M5" were well below the range for "light syrup". Improvements were noted in EP "L6" and EP "M6" with mean values of 17.4 and 15.3 respectively. However, the range in each case was below and above the targeted light syrup range.

TABLE 37

PEARS - SOLUBLE SOLIDS (percent)

PROCESSOR	MEAN ± sd[a]	RANGE
A	18.2 ± 0.9	16.7 - 20.5
B	20.2 ± 1.6	17.7 - 23.6
C	18.7 ± 1.0	16.8 - 20.4
D	14.5 ± 0.9	13.4 - 17.2
L	14.5 ± 3.2	10.3 - 19.6
M	15.0 ± 2.7	10.9 - 20.0
O	16.2 ± 1.9	13.3 - 23.2
L5	11.7 ± 0.9	10.3 - 13.0
L6	17.4 ± 1.9	13.1 - 19.6
M5	13.4 ± 1.0	12.6 - 14.5
M6	15.3 ± 2.8	10.9 - 20.0
O5	16.0 ± 1.5	13.3 - 18.5
O6	16.4 ± 2.2	14.5 - 23.2
COMMERCIAL	17.9 ± 2.4	13.4 - 23.6
EXPTL PACKS-75[b]	13.8 ± 2.4	10.3 - 18.5
EXPTL PACKS-76[b]	16.3 ± 2.5	10.9 - 23.2

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Peel area (Table 38). Excessive peel became a factor in downgrading EP "L5" and EP "O5". Improvements were experienced in both of these experimental packs during the second year as demonstrated in EP "L6" and EP "O6", but were not then as low as mean commercial pack values. It would appear that local quality control has a major influence on the amounts of peel that occur. Differences in mean peel values are dramatically shown in Figure 11. At the present time, few commercial packers of Bartlett pears use the hand peeling method. The machine-peeled product is of improved quality over hand-peeled in terms of appearance and efficiency. Machines are designed to peel, stem, and core the pears (Anon., 1951). Very little peel was found in commercial pears. Experimental packs had a mean value of 0.43 square inches of peel the first year which decreased to 0.08 square inches in the 1976 packs.

TABLE 38

PEARS - PEEL AREA (in^2)

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.04 ± 0.13	0.00 - 0.50
B	0.07 ± 0.18	0.00 - 0.70
C	0.07 ± 0.10	0.00 - 0.30
D	0.04 ± 0.07	0.00 - 0.20
L	0.17 ± 0.37	0.00 - 1.50
M	0.11 ± 0.22	0.00 - 0.80
O	0.36 ± 0.78	0.00 - 3.90
L5	0.32 ± 0.48	0.00 - 1.50
L6	0.02 ± 0.06	0.00 - 0.20
M5	0.00 ± 0.00	0.00 - 0.00
M6	0.12 ± 0.23	0.00 - 0.80
O5	0.63 ± 1.03	0.00 - 3.90
O6	0.09 ± 0.17	0.00 - 0.60
COMMERCIAL	0.06 ± 0.13	0.00 - 0.70
EXPTL PACKS-75[b]	0.43 ± 0.78	0.00 - 3.90
EXPTL PACKS-76[b]	0.08 ± 0.17	0.00 - 0.80

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

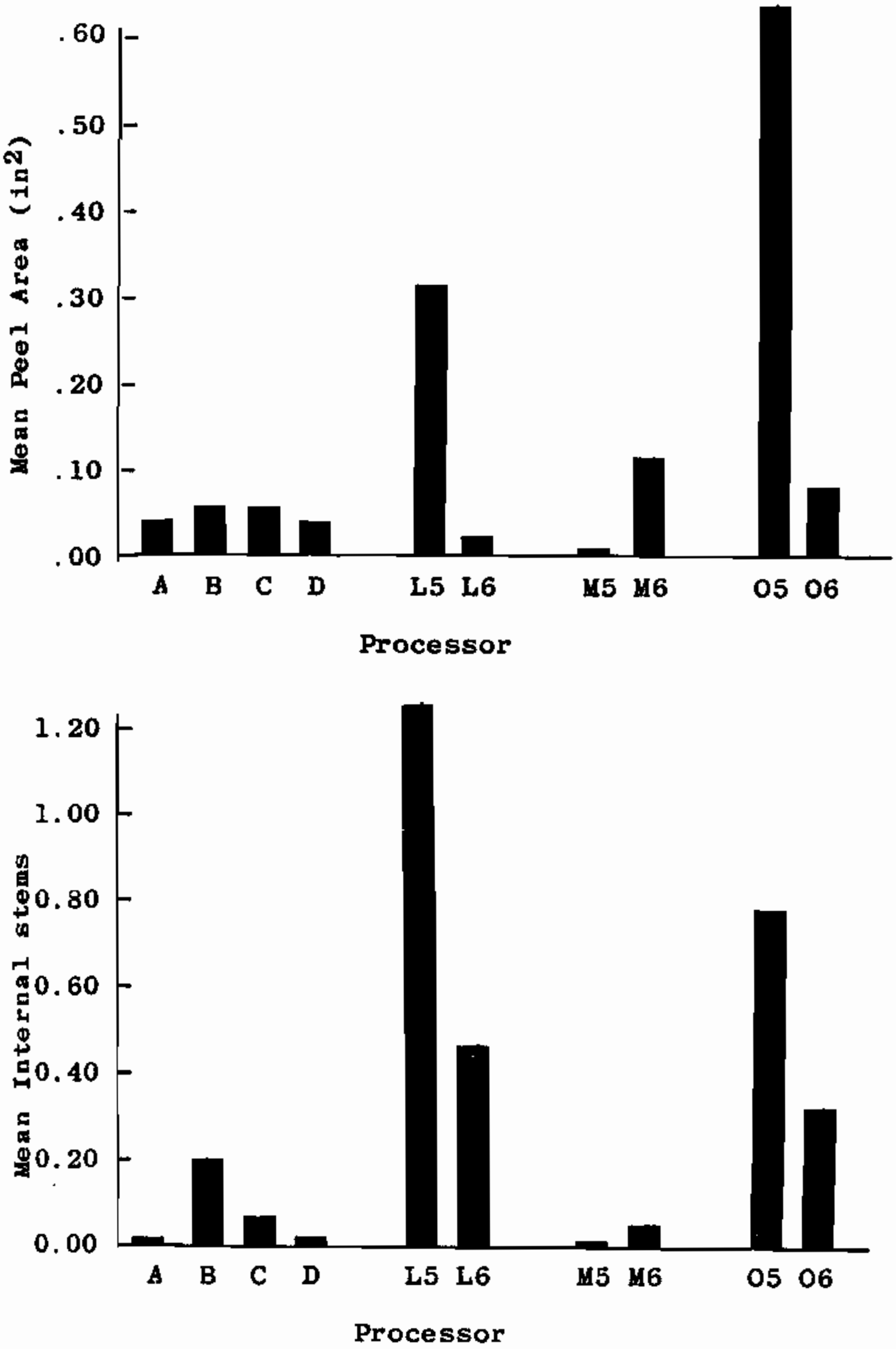


Figure 11. Mean peel areas and internal stems in pears.

Blemishes, major and minor (Tables 39 and 40). Definitions for major and minor blemishes are found in the Materials and Methods section as specified in government regulations (USDA, 1967). Test results

TABLE 39

PEARS - MAJOR BLEMISHES

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.00 ± 0.00	0.00 - 0.00
B	0.00 ± 0.00	0.00 - 0.00
C	0.00 ± 0.00	0.00 - 0.00
D	0.07 ± 0.26	0.00 - 1.00
L	0.10 ± 0.40	0.00 - 2.00
M	0.10 ± 0.30	0.00 - 1.00
O	0.17 ± 0.38	0.00 - 1.00
L5	0.20 ± 0.56	0.00 - 2.00
L6	0.00 ± 0.00	0.00 - 0.00
M5	0.00 ± 0.00	0.00 - 0.00
M6	0.11 ± 0.32	0.00 - 1.00
O5	0.13 ± 0.35	0.00 - 1.00
O6	0.20 ± 0.41	0.00 - 1.00
COMMERCIAL	0.02 ± 0.13	0.00 - 1.00
EXPTL PACKS-75[b]	0.15 ± 0.44	0.00 - 2.00
EXPTL PACKS-76[b]	0.10 ± 0.31	0.00 - 1.00

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

indicate that commercial packs generally had fewer blemished units per can, both major and minor, than did the experimental packs. Inasmuch as most of the blemishes involved bruised and discolored areas of the fruit, several causes for these problems can be conjectured. Any excessive handling of pears, especially beyond certain ripe stages, can result in bruising. Where the ripening conditions of pears are not carefully controlled, uneven ripening will occur. Under such conditions, several sortings are required which increases the likelihood of bruising. The numbers of both major and minor blemished units decreased the second year.

TABLE 40

PEARS - MINOR BLEMISHES

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.12 ± 0.33	0.00 - 1.00
B	0.13 ± 0.35	0.00 - 1.00
C	0.27 ± 0.46	0.00 - 1.00
D	0.07 ± 0.26	0.00 - 1.00
L	0.10 ± 0.31	0.00 - 1.00
M	0.19 ± 0.40	0.00 - 1.00
O	0.27 ± 0.20	0.00 - 1.00
L5	0.20 ± 0.41	0.00 - 1.00
L6	0.00 ± 0.00	0.00 - 0.00
M5	0.33 ± 0.58	0.00 - 1.00
M6	0.17 ± 0.38	0.00 - 1.00
O5	0.33 ± 0.49	0.00 - 1.00
O6	0.20 ± 0.41	0.00 - 1.00
COMMERCIAL	0.15 ± 0.36	0.00 - 1.00
EXPTL PACKS-75[b]	0.27 ± 0.45	0.00 - 1.00
EXPTL PACKS-76[b]	0.13 ± 0.33	0.00 - 1.00

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Internal stems (Table 41). Presence of "internal" or "interior" stems became a limiting factor in downgrading otherwise high quality pears. This was particularly true with the experimental packs. Commercial packs had significantly fewer internal stems than

TABLE 41

PEARS - INTERNAL STEMS

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.00 ± 0.00	0.00 - 0.00
B	0.20 ± 0.56	0.00 - 2.00
C	0.07 ± 0.26	0.00 - 1.00
D	0.00 ± 0.00	0.00 - 0.00
L	0.87 ± 1.04	0.00 - 4.00
M	0.05 ± 0.22	0.00 - 1.00
O	0.57 ± 0.90	0.00 - 4.00
L5	1.27 ± 1.10	0.00 - 4.00
L6	0.47 ± 0.83	0.00 - 3.00
M5	0.00 ± 0.00	0.00 - 0.00
M6	0.06 ± 0.24	0.00 - 1.00
O5	0.80 ± 1.08	0.00 - 4.00
O6	0.33 ± 0.62	0.00 - 2.00
COMMERCIAL	0.07 ± 0.31	0.00 - 2.00
EXPTL PACKS-75[b]	0.94 ± 1.09	0.00 - 4.00
EXPTL PACKS-76[b]	0.27 ± 0.61	0.00 - 3.00

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

the experimental packs. These differences are explicitly shown in Figure 12. All of the commercially packed pears appeared to have been stemmed and cored by machine.

Loose seed (Table 42). Loose seed is defined as "any pear seed, or the equivalent in pieces of one seed, not included in core material" (USDA, 1976). Commercial packs had slightly higher mean values for seed (0.40) than did the experimental packs (0.30 and 0.13). A significant reduction in the amount of seed was noted between the 1975 and 1976 experimental packs. In a few instances, the grade assigned was "limited" due to loose seed (see Table 76).

TABLE 42

PEARS - LOOSE SEED

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.65 ± 0.70	0.00 - 2.00
B	0.27 ± 0.59	0.00 - 2.00
C	0.40 ± 0.91	0.00 - 3.00
D	0.27 ± 0.46	0.00 - 1.00
L	0.20 ± 0.41	0.00 - 1.00
M	0.10 ± 0.30	0.00 - 1.00
O	0.27 ± 0.58	0.00 - 2.00
L5	0.27 ± 0.46	0.00 - 1.00
L6	0.13 ± 0.35	0.00 - 1.00
M5	0.00 ± 0.00	0.00 - 0.00
M6	0.11 ± 0.32	0.00 - 1.00
O5	0.40 ± 0.74	0.00 - 2.00
O6	0.13 ± 0.35	0.00 - 1.00
COMMERCIAL	0.40 ± 0.69	0.00 - 3.00
EXPTL PACKS-75[b]	0.30 ± 0.59	0.00 - 2.00
EXPTL PACKS-76[b]	0.13 ± 0.33	0.00 - 1.00

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

Individual unit (halves) weights (Table 43). Pear size varied considerably within the experimental packs. Although size is not a critical factor in quality evaluation, uniformity of size within individual cans is important in the grading criteria. For instance, under the grading standards, the weight of the largest full-size unit cannot exceed the weight of the smallest fullsize unit by more than 50 percent for Grade A; 75 percent for Grade B; or 100 percent for Grade C. The smallest permissible size for Grades A, B, and C is 3/5 ounce or 17 grams (21 CFR 145.175). None of the pears in this study

TABLE 43

PEARS - INDIVIDUAL UNIT WEIGHTS

PROCESSOR	MEAN ± sd[a]	RANGE
A	62.9 ± 10.5	40.0 - 99.0
B	49.3 ± 10.1	28.0 - 84.0
C	54.2 ± 14.2	26.0 - 104.0
D	68.6 ± 24.7	24.0 - 134.0
L	38.4 ± 16.5	18.0 - 250.0
M	49.2 ± 19.2	20.0 - 131.0
O	55.8 ± 20.5	21.0 - 126.0
L5	36.8 ± 18.6	20.0 - 250.0
L6	40.4 ± 13.2	18.0 - 116.0
M5	93.8 ± 46.4	31.0 - 177.0
M6	46.9 ± 15.8	20.0 - 97.0
O5	59.9 ± 21.3	22.0 - 126.0
O6	52.0 ± 19.2	21.0 - 103.0
COMMERCIAL	58.0 ± 16.9	24.0 - 134.0
EXPTL PACKS-75[b]	46.9 ± 24.1	20.0 - 250.0
EXPTL PACKS-76[b]	46.0 ± 16.6	18.0 - 116.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

fell below 17 grams. However, there was considerable variation in size within individual cans of experimental packs which normally would have resulted in severe downgrading. Because processors of experimental packs originally placed very little emphasis on size and symmetry, this aspect of quality was not judged in the grading of either the commercial or experimental packs. The large sized units in EP "M5" were previously discussed as having contributed to the drained weight deficiency (see Figure 9). Otherwise, the mean weights were generally higher in commercial packs. In addition, the pears from commercial packs were consistently uniform in size.

Unit hardness (Table 44). Testing procedures as described in 21 CFR 145.175 were used in determining pear hardness. These procedures are identical to those used for peaches. For instance, pears that are pierced by a weight of 300 grams (10.6 ounces) or more are considered to be "not tender" and must receive a substandard rating according to United States grade standards. Although there are no hardness guidelines other than the 300 gram limit expressed in the federal standards, based on the writer's personal experience and preference, the ideal

TABLE 44

PEARS - UNIT HARDNESS (HALVES)[c]

PROCESSOR	MEAN ± sd[a]	RANGE
A	86.6 ± 28.2	42.0 - 219.0
B	89.9 ± 26.6	54.0 - 298.0
C	74.3 ± 34.3	36.0 - 242.0
D	76.4 ± 23.0	36.0 - 149.0
L	141.7 ± 81.8	49.0 - 822.0
M	179.0 ± 110.3	31.0 - 820.0
O	61.0 ± 36.9	17.0 - 372.0
L5	130.2 ± 82.2	49.0 - 822.0
L6	157.0 ± 78.9	51.0 - 505.0
M5	93.8 ± 46.4	31.0 - 177.0
M6	186.8 ± 111.2	53.0 - 820.0
O5	75.3 ± 39.8	20.0 - 372.0
O6	48.4 ± 29.1	17.0 - 248.0
COMMERCIAL	82.5 ± 29.4	36.0 - 298.0
EXPTL PACKS-75[b]	109.6 ± 73.5	20.0 - 822.0
EXPTL PACKS-76[b]	139.4 ± 102.5	17.0 - 820.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976
[c]Unit hardness is expressed as the weight in grams when added to a rod 5/32 inches in diameter brings about penetration of a sample to a depth of 0.3 inches.

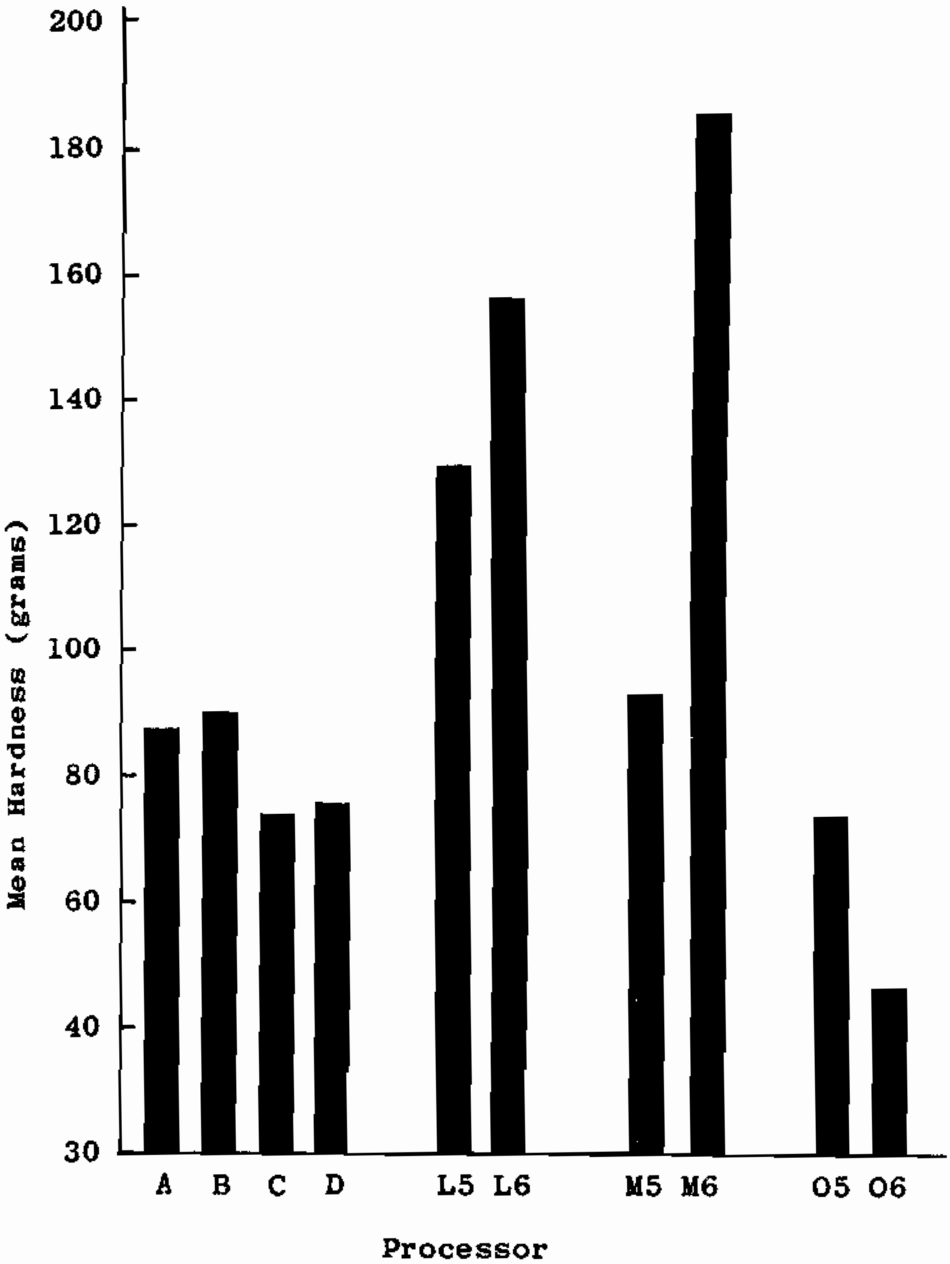


Figure 12. Mean <u>hardness</u> for individual pear units.

pear hardness range lies somewhere between 75 and 150 grams (2.6 and 5.3 ounces). All of the commercially canned pears had mean values within these limits.

None of the commercial pears exceeded the 300 gram limit. However, one can in CP "B" contained a pear with a hardness rating of 298 grams (10.5 ounces). Also, one can in CP "C" contained a moderately hard pear having a heardness rating of 242 grams (8.5 ounces). Both EP "L5" and EP "M6" contained pears with hardness values exceeding the instrument limit of 820 grams (28.9 ounces). Figure 12 helps to illustrate the comparison of mean hardness values between packs. Several lots were limited to "Substandard" grade even though the majority of the pears were within the ideal range for hardness. Table 76, a summary of grading results, indicates that all of the lots in EP "L6" and EP "M6" were limited to "Substandard" grade because of hard pears.

Green Beans

Test results for green beans are summarized in Tables 45 through 59, with grading scores found in Table 77. The quality of green beans in both commercial and experimental packs was good, with very few exceptions. Results of each of the tests along with discussion are given below.

Can vacuum (Table 45). Can vacuums were significantly greater in experimental packs than in commercial packs. The commercial mean vacuum as shown in Table 45 was 4.9 as compared to experimental mean values of 9.9 and 12.2 inches Hg. These differences may be related to the possible differences in geographical elevations at which these packs were processed. For instance,

TABLE 45

GREEN BEANS - CAN VACUUM (inches Hg)

PROCESSOR	MEAN ± sd[a]	RANGE
A	4.3 ± 1.7	1.0 - 8.0
B	5.7 ± 2.0	2.0 - 9.0
F	7.6 ± 1.8	4.0 - 10.5
G	1.8 ± 2.6	0.0 - 7.0
H	12.1 ± 2.6	8.0 - 16.5
J	11.8 ± 1.2	9.0 - 13.0
L	10.3 ± 1.8	7.0 - 14.0
H5	9.8 ± 1.2	8.0 - 12.0
H6	14.4 ± 1.0	13.0 - 16.5
J6	11.8 ± 1.2	9.0 - 13.0
L5	10.3 ± 1.8	7.0 - 12.0
L6	10.3 ± 1.9	8.0 - 14.0
COMMERCIAL	4.9 ± 2.9	0.0 - 10.5
EXPTL PACKS-75[b]	9.9 ± 1.5	7.0 - 12.0
EXPTL PACKS-76[b]	12.2 ± 2.1	8.0 - 16.5

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

a product that is packed at sea level, having a vacuum of 10.0 inches Hg, would indicate a vacuum of approximately 5.5 inches Hg at an elevation of 4,500 feet. This amounts to a decrease in vacuum of approximately 1.0 inch Hg for each 1,000 feet.

All of the test samples in two separate lots of CP "G" had zero vacuums. Product quality and can condition in each instance appeared to be normal. These low values are likely a consequence of low sealing temperatures or steam closure maladjustment.

Head space (Table 46). All of the gross head spaces were within acceptable limits. Federal guidelines have been established which allow a headspace of not greater than 19/32 inch for a 303 size can in order to avoid "slack filling".

TABLE 46

GREEN BEANS - CAN HEADSPACE (1/32 inch)

PROCESSOR	MEAN ± sd[a]	RANGE
A	10.5 ± 1.4	8.0 - 13.0
B	12.0 ± 1.5	10.0 - 14.0
F	11.2 ± 1.4	9.0 - 14.0
G	10.2 ± 1.6	8.0 - 13.0
H	12.6 ± 1.7	10.0 - 16.0
J	10.2 ± 0.6	9.0 - 12.0
L	10.7 ± 0.8	9.0 - 12.0
H5	13.9 ± 1.3	12.0 - 16.0
H6	11.3 ± 0.7	10.0 - 13.0
J6	10.1 ± 0.6	9.0 - 12.0
L5	10.6 ± 1.0	9.0 - 12.0
L6	10.7 ± 0.6	10.0 - 12.0
COMMERCIAL	10.9 ± 1.6	8.0 - 14.0
EXPTL PACKS-75[b]	12.2 ± 2.0	9.0 - 16.0
EXPTL PACKS-76[b]	10.7 ± 0.8	9.0 - 13.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Drained weight (Table 47). The majority of green bean packs had mean drained weights which conformed to federal minimum standards for a number 303 size can of 9.2 ounces or 261 grams (USDA, 1961). However, as shown in Table 47 and Figure 13, EP "L5" and CP "G" fell below the lower mean limit. Packs such as these are subject to seizure by the FDA when sold in the market place, unless the label indicates a low drained weight.

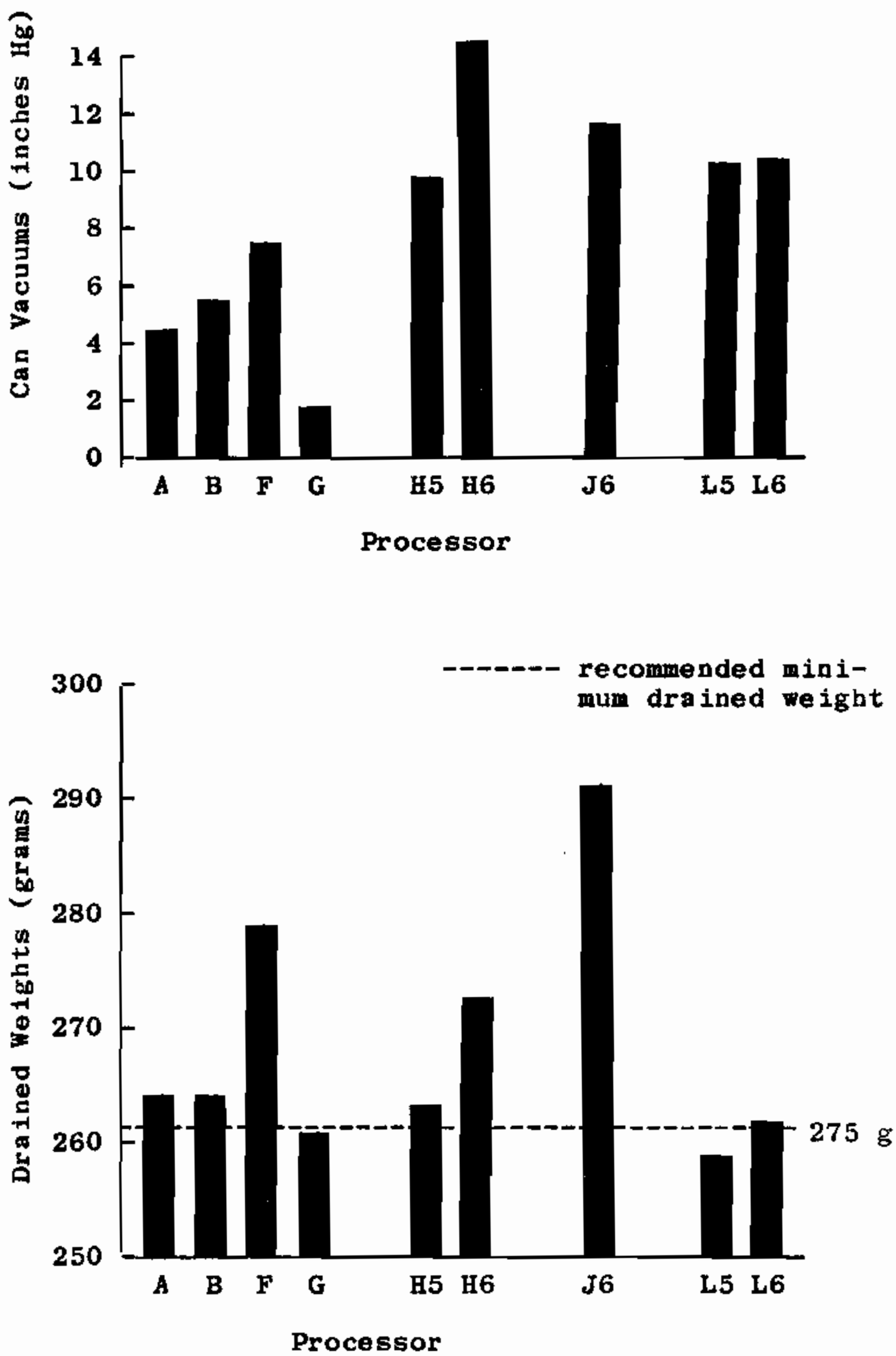


Figure 13. Mean Can Vacuum and Mean Drained Weights for green beans.

TABLE 47

GREEN BEANS - DRAINED WEIGHT (grams)

PROCESSOR	MEAN ± sd[a]	RANGE
A	264.0 ± 17.7	241.0 - 307.0
B	263.6 ± 12.2	246.0 - 283.0
F	279.1 ± 6.8	270.0 - 291.0
G	261.3 ± 13.9	232.0 - 282.0
H	267.7 ± 15.4	232.0 - 299.0
J	291.2 ± 16.2	250.0 - 314.0
L	260.5 ± 14.8	222.0 - 291.0
H5	262.5 ± 17.1	232.0 - 289.0
H6	272.9 ± 11.9	255.0 - 299.0
J6	291.2 ± 16.2	250.0 - 314.0
L5	258.8 ± 14.0	230.0 - 281.0
L6	262.1 ± 16.0	222.0 - 291.0
COMMERCIAL	267.1 ± 14.8	232.0 - 307.0
EXPTL PACKS-75[b]	260.7 ± 15.5	230.0 - 289.0
EXPTL PACKS-76[b]	275.4 ± 18.9	222.0 - 314.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

<u>Hunter color values (Tables 48 through 50)</u>. The Hunter color values "L" (lightness), "a" (redness versus greenness), and "b" (blueness versus yellowness), showed some variation among the packs. However, these differences were not significant in terms of their effect on appearance and general quality. There appeared to be no

TABLE 48

GREEN BEANS - COLOR "L" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	32.13 ± 1.55	30.00 - 34.80
B	35.84 ± 2.73	31.80 - 40.90
F	35.15 ± 0.95	33.70 - 36.90
G	31.91 ± 1.71	29.90 - 35.60
H	34.37 ± 1.32	32.60 - 39.20
J	36.33 ± 1.12	33.90 - 38.10
L	34.35 ± 1.31	32.40 - 37.20
H5	34.77 ± 1.69	32.60 - 39.20
H6	33.96 ± 0.65	32.80 - 35.50
J6	36.33 ± 1.12	33.90 - 38.10
L5	34.99 ± 1.48	32.60 - 37.20
L6	33.70 ± 0.68	32.40 - 34.70
COMMERCIAL	33.79 ± 2.53	29.90 - 40.90
EXPTL PACK-75[b]	34.88 ± 1.56	32.60 - 39.20
EXPTL PACK-76[b]	34.66 ± 1.46	32.40 - 38.10

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

correlation between the three Hunter color values and bean maturity as represented in fiber content and seed to bean ratio. The differences in color may have been

TABLE 49

GREEN BEANS - COLOR "a" VALUE

PROCESSOR	MEAN ± sd[a]	RANGE
A	-0.09 ± 0.31	-0.60 - 0.50
B	-0.68 ± 0.61	-1.80 - 0.10
F	-0.69 ± 0.40	-1.40 - -0.10
G	-0.41 ± 0.24	-1.00 - -0.10
H	-0.72 ± 0.39	-1.40 - 0.30
J	-0.60 ± 0.28	-1.10 - 0.00
L	-0.50 ± 0.48	-1.30 - 0.40
H5	-0.53 ± 0.44	-1.20 - 0.30
H6	-0.91 ± 0.19	-1.40 - -0.70
J6	-0.60 ± 0.28	-1.10 - 0.00
L5	-0.76 ± 0.50	-1.30 - 0.40
L6	-0.23 ± 0.27	-0.50 - 0.40
COMMERCIAL	-0.48 ± 0.47	-1.80 - 0.50
EXPTL PACKS-75[b]	-0.65 ± 0.48	-1.30 - 0.40
EXPTL PACKS-76[b]	-0.58 ± 0.37	-1.40 - 0.40

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

brought about by any one of several different factors such as variety, farm cultural practices, blanching and processing conditions, and others.

TABLE 50

GREEN BEANS - COLOR "b" VALUE

PROCESSOR	MEAN ± sd[a]	RANGE
A	15.88 ± 0.74	15.10 - 17.40
B	17.66 ± 1.07	16.10 - 19.40
F	16.87 ± 0.51	15.90 - 17.70
G	15.91 ± 0.99	14.80 - 17.90
H	16.80 ± 0.48	15.90 - 17.60
J	18.03 ± 0.66	17.20 - 19.80
L	17.17 ± 0.69	15.90 - 18.70
H5	16.79 ± 0.53	15.90 - 17.60
H6	16.80 ± 0.44	15.90 - 17.60
J6	18.03 ± 0.66	17.20 - 19.80
L5	17.49 ± 0.80	15.90 - 18.70
L6	16.85 ± 0.34	16.20 - 17.30
COMMERCIAL	16.60 ± 1.12	14.80 - 19.40
EXPTL PACKS-75[b]	17.14 ± 0.76	15.90 - 18.70
EXPTL PACKS-76[b]	17.23 ± 0.75	15.90 - 19.80

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

Number of units per can (Table 51). The number of units per can was measured as an index of unit size. This number value was also used in calculating the percentage of blemished units in individual cans. The larger numbers found in CP "F" is a result of the slightly shorter cut of the beans. EP "H" also had more of the shorter cuts. In neither case was the quality of the beans impaired.

TABLE 51

GREEN BEANS - NUMBER OF UNITS PER CAN

PROCESSOR	MEAN ± sd[a]	RANGE
A	129.5 ± 13.3	106.0 - 149.0
B	111.7 ± 6.4	101.0 - 123.0
F	266.1 ± 48.9	178.0 - 375.0
G	134.4 ± 12.8	116.0 - 158.0
H	195.1 ± 47.9	113.0 - 267.0
J	226.9 ± 25.2	198.0 - 268.0
L	182.2 ± 27.5	125.0 - 242.0
H5	154.9 ± 26.1	113.0 - 201.0
H6	235.2 ± 24.6	183.0 - 267.0
J6	226.9 ± 25.2	198.0 - 268.0
L5	184.5 ± 34.3	125.0 - 242.0
L6	179.9 ± 19.5	131.0 - 216.0
COMMERCIAL	160.4 ± 67.2	101.0 - 375.0
EXPTL PACKS-75[b]	169.7 ± 33.5	113.0 - 242.0
EXPTL PACKS-76[b]	214.0 ± 33.5	131.0 - 268.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Number of units under 1/2 inch length (Table 52). The number of units under 1/2 inch length is considered excessive when that number exceeds 60 per 12 ounces (4.2 grams) drained weight (21 CFR 155.120). Since the majority of the cans contained between 9 and 10 ounces (255 and 284 grams), the corresponding limits were between 45 and 50 units per can. The mean values and ranges given in Table 52 would indicate that only a few of the commercial packs and most of the experimental packs contained cans with excessive numbers of small beans. For instance, of the commercial packs only CP "F" had deviants. On the other hand only EP "L6" of the experimental packs had no deviants. In most instances the small units were very close to 1/2 inch and did not detract from the overall quality of the beans.

TABLE 52

GREEN BEANS - NUMBER OF UNITS UNDER 1/2 INCH

PROCESSOR	MEAN ± sd[a]	RANGE
A	2.7 ± 2.3	0.0 - 7.0
B	0.5 ± 0.6	0.0 - 2.0
F	46.2 ± 28.8	11.0 - 93.0
G	1.5 ± 1.3	0.0 - 3.0
H	46.5 ± 23.4	14.0 - 95.0
J	52.6 ± 17.7	28.0 - 84.0
L	25.6 ± 11.1	2.0 - 61.0
H5	38.7 ± 21.1	14.0 - 89.0
H6	54.3 ± 23.7	27.0 - 95.0
J6	52.6 ± 17.7	28.0 - 84.0
L5	27.2 ± 13.7	2.0 - 61.0
L6	23.9 ± 7.9	12.0 - 36.0
COMMERCIAL	12.7 ± 24.1	0.0 - 93.0
EXPTL PACKS-75[b]	32.9 ± 18.4	2.0 - 89.0
EXPTL PACKS-76[b]	43.6 ± 22.3	12.0 - 95.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Loose seed (Table 53). Loose seed is an indicator of poor bean integrity and is considered to be a defect in cut green beans. None of the packs had an excessive amount of loose seed. EP "H5" had considerably more seed than any of the others, but was not sufficiently excessive to downgrade the product. Reasons for EP "H5" having a higher percentage of loose seed appears to relate to the fact that the beans were more mature, the seeds were larger in size, and the percentage of seed to whole bean was relatively high.

TABLE 53

GREEN BEANS - LOOSE SEED (PERCENT DRAINED WT)

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.17 ± 0.25	0.00 - 0.90
B	0.01 ± 0.01	0.00 - 0.10
F	0.09 ± 0.14	0.00 - 0.40
G	0.02 ± 0.04	0.00 - 0.10
H	0.21 ± 0.34	0.00 - 1.50
J	0.07 ± 0.12	0.00 - 0.40
L	0.05 ± 0.10	0.00 - 0.40
H5	0.37 ± 0.42	0.00 - 1.50
H6	0.04 ± 0.06	0.00 - 0.20
J6	0.07 ± 0.12	0.00 - 0.40
L5	0.03 ± 0.06	0.00 - 0.20
L6	0.07 ± 0.12	0.00 - 0.40
COMMERCIAL	0.07 ± 0.16	0.00 - 0.90
EXPTL PACKS-75[b]	0.20 ± 0.34	0.00 - 1.50
EXPTL PACKS-76[b]	0.06 ± 0.11	0.00 - 0.40

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

Units 27/64 inches diameter or greater (Table 54). CP "F" had the greatest number of the larger diameter units (see Figure 14). In spite of this, the fiber content in the same pack was very low, indicating good

TABLE 54

GREEN BEANS - UNITS 27/64 INCHES DIAMETER AND GREATER

PROCESSOR	MEAN ± sd[a]	RANGE
A	2.5 ± 2.5	0.0 - 7.0
B	3.9 ± 6.6	0.0 - 23.0
F	16.2 ± 20.7	0.0 - 85.0
G	1.5 ± 1.6	0.0 - 6.0
H	8.3 ± 8.3	0.0 - 29.0
J	3.9 ± 5.2	0.0 - 19.0
L	5.1 ± 5.2	0.0 - 20.0
H5	13.5 ± 8.6	3.0 - 29.0
H6	3.5 ± 4.1	0.0 - 12.0
J6	3.9 ± 5.2	0.0 - 19.0
L5	5.1 ± 6.0	0.0 - 20.0
L6	5.1 ± 4.4	0.0 - 15.0
COMMERCIAL	6.0 ± 12.2	0.0 - 85.0
EXPTL PACKS-75[b]	9.3 ± 8.4	0.0 - 29.0
EXPTL PACKS-76[b]	4.2 ± 4.5	0.0 - 19.0

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

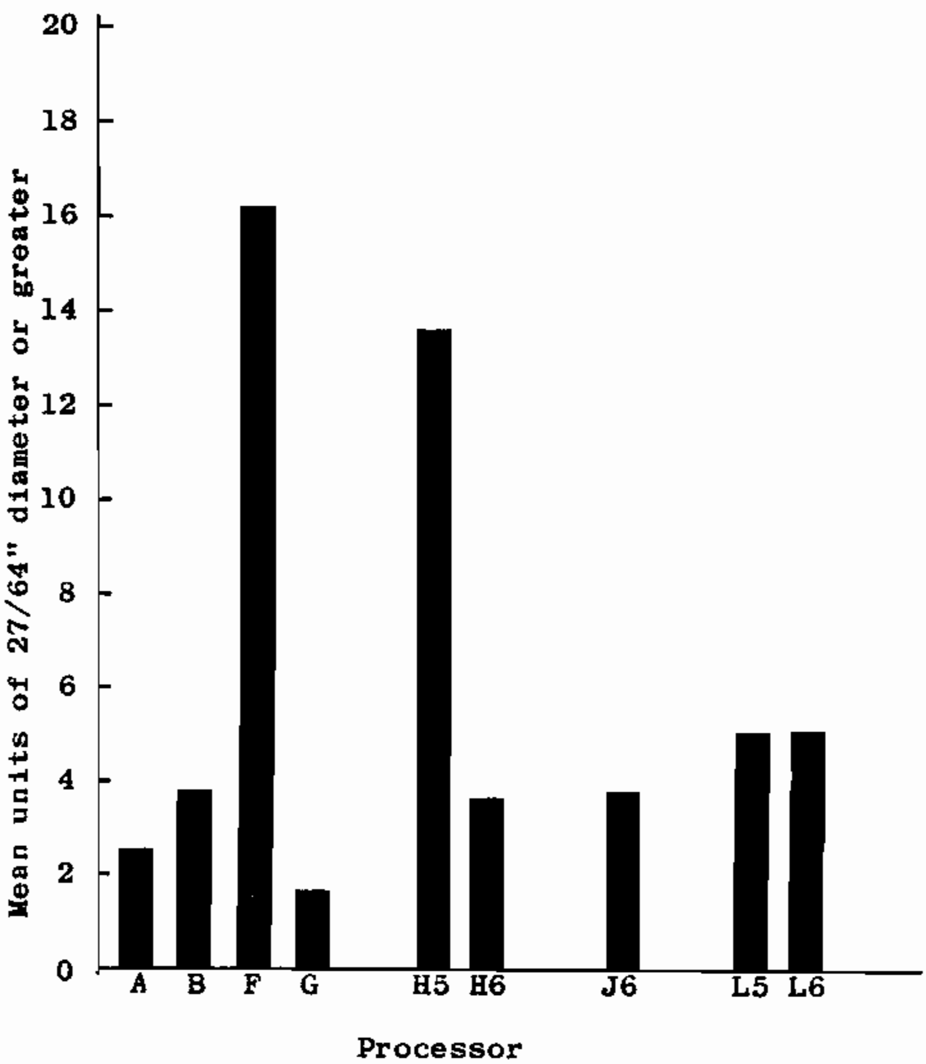


Figure 14. Mean number of green bean units having a diameter of 27/64 inches or greater.

acceptability based on tenderness. EP "H5" had a mean value of 13.5 large diameter units. This correlated well with the increased fiber content (see Table 59). During the next year EP "H6" showed great improvement, possibly indicating an increased emphasis in quality control to eliminate the more mature beans at the sorting table.

Strings supporting 1/2 lb weight (Table 55). Very few strings were found in any of the cans. The numbers were well below the maximum permissible limit of 12 strings per 12 ounces or 340 grams drained weight. The maximum number of strings found in any can was two, but this number was found in two packs. Varieties of commercially grown beans appear to be practically free from tough strings. Proper harvest time and suitable cultural conditions help prevent their occurrence.

TABLE 55

GREEN BEANS - STRINGS SUPPORTING 1/2 LB WEIGHT

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.0 ± 0.0	0.0 - 0.0
B	0.0 ± 0.0	0.0 - 0.0
F	0.1 ± 0.4	0.0 - 1.0
G	0.4 ± 0.5	0.0 - 1.0
H	0.1 ± 0.3	0.0 - 1.0
J	0.0 ± 0.0	0.0 - 0.0
L	0.3 ± 0.6	0.0 - 2.0
H5	0.1 ± 0.4	0.0 - 1.0
H6	0.0 ± 0.0	0.0 - 0.0
J6	0.0 ± 0.0	0.0 - 0.0
L5	0.2 ± 0.6	0.0 - 2.0
L6	0.4 ± 0.6	0.0 - 2.0
COMMERCIAL	0.1 ± 0.3	0.0 - 1.0
EXPTL PACKS-75[b]	0.2 ± 0.5	0.0 - 2.0
EXPTL PACKS-76[b]	0.1 ± 0.4	0.0 - 2.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Percent blemished units (Table 56). The number of blemished units was low in both commercial and experimental packs. The largest number found in any single can was 8.6, found in CP "A", mostly as a result of insect damage. These units are normally eliminated at the inspection belt in the processing plant.

TABLE 56

GREEN BEANS - PERCENT BLEMISHED UNITS

PROCESSOR	MEAN ± sd[a]	RANGE
A	2.2 ± 2.2	0.0 - 8.6
B	1.0 ± 1.1	0.0 - 3.6
F	0.6 ± 0.9	0.0 - 3.4
G	0.1 ± 0.3	0.0 - 0.9
H	1.1 ± 1.4	0.0 - 4.9
J	0.4 ± 0.4	0.0 - 1.0
L	0.4 ± 0.5	0.0 - 2.0
H5	2.0 ± 1.5	0.0 - 4.9
H6	0.1 ± 0.2	0.0 - 0.5
J6	0.4 ± 0.4	0.0 - 1.0
L5	0.4 ± 0.4	0.0 - 1.3
L6	0.3 ± 0.5	0.0 - 2.0
COMMERCIAL	1.0 ± 1.5	0.0 - 8.6
EXPTL PACKS-75[b]	1.2 ± 1.3	0.0 - 4.9
EXPTL PACKS-76[b]	0.3 ± 0.4	0.0 - 2.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Unstemmed units (Table 57). The low number of unstemmed units found in both commercial and experimental packs indicates that no serious problems existed. The largest number of unstemmed units found in any single can was 5 in EP "H5". This defect relates directly to the mechanical efficiency of the destemmer. The majority of the unstemmed units coming from the mechanical destemmer should have been subsequently removed at the inspection belt.

TABLE 57

GREEN BEANS - UNSTEMMED UNITS

PROCESSOR	MEAN ± sd[a]	RANGE
A	1.1 ± 1.3	0.0 - 4.0
B	0.7 ± 0.7	0.0 - 2.0
F	1.1 ± 1.0	0.0 - 3.0
G	1.2 ± 0.9	0.0 - 3.0
H	1.3 ± 1.3	0.0 - 5.0
J	1.1 ± 1.0	0.0 - 3.0
L	1.2 ± 1.0	0.0 - 4.0
H5	1.7 ± 1.4	0.0 - 5.0
H6	0.9 ± 0.9	0.0 - 3.0
J6	1.1 ± 1.0	0.0 - 3.0
L5	1.2 ± 1.1	0.0 - 4.0
L6	1.3 ± 0.9	0.0 - 3.0
COMMERCIAL	1.0 ± 1.0	0.0 - 4.0
EXPTL PACKS-75[b]	1.5 ± 1.3	0.0 - 3.0
EXPTL PACKS-76[b]	1.5 ± 1.3	0.0 - 5.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

<u>Percent seed of whole bean (Table 58)</u>. The percent seed of whole bean is a good gauge of bean maturity. Both CP "A" and EP "H5" have higher mean values as shown in the bar graph in Figure 15, indicating more mature beans. However, CP "A" had a much lower mean percent fiber than EP "H5" indicating a more

TABLE 58

GREEN BEANS - PERCENT SEED OF WHOLE BEAN

PROCESSOR	MEAN ± sd[a]	RANGE
A	8.7 ± 1.8	4.0 - 11.6
B	5.4 ± 1.5	3.4 - 8.4
F	3.8 ± 1.8	1.2 - 7.8
G	3.5 ± 1.1	2.4 - 5.5
H	5.8 ± 3.0	2.0 - 11.4
J	3.9 ± 1.0	2.0 - 5.9
L	3.9 ± 1.0	1.6 - 5.7
H5	8.4 ± 1.8	5.5 - 11.4
H6	3.3 ± 0.9	2.0 - 5.2
J6	3.9 ± 1.0	2.0 - 5.9
L5	3.6 ± 1.2	1.6 - 5.4
L6	4.2 ± 0.6	3.5 - 5.7
COMMERCIAL	5.4 ± 2.6	1.2 - 11.6
EXPTL PACKS-75[b]	6.0 ± 2.9	1.6 - 11.4
EXPTL PACKS-76[b]	3.8 ± 0.9	2.0 - 5.9

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

acceptable bean (see Table 59). In general, the high amount of seed found in CP "A" or any of the other commercial packs did not detract from the overall acceptability of the beans. In the experimental packs there was a high correlation between the fiber content and the percentage of seed in whole bean as shown in the regression plot in Figure 16. When the experimental packs were compared separately, the correlation coefficient was 0.95. Likewise, when commercial packs were compared separately, the correlation coefficient was 0.77. However, when both the commercial and experimental packs were compared together, there was very poor if any correlation ($r = 0.49$). There are several possible reasons for differences between the experimental and commercial packs. These differences may include those mentioned in the literature review: namely farm cultural practices, weather variables, as well as variety.

Percent fiber (Table 59). Commercial packs of green beans had less fiber content than the experimental packs as illustrated by the bar graphs in Figure 15. The amount of fiber is an important aspect of green bean quality and relates closely to the palatability of the beans. EP "H5" had by far the highest fiber content of any of the packs that were tested, with a mean value of 0.056 percent. FDA standards allow as much as 0.150

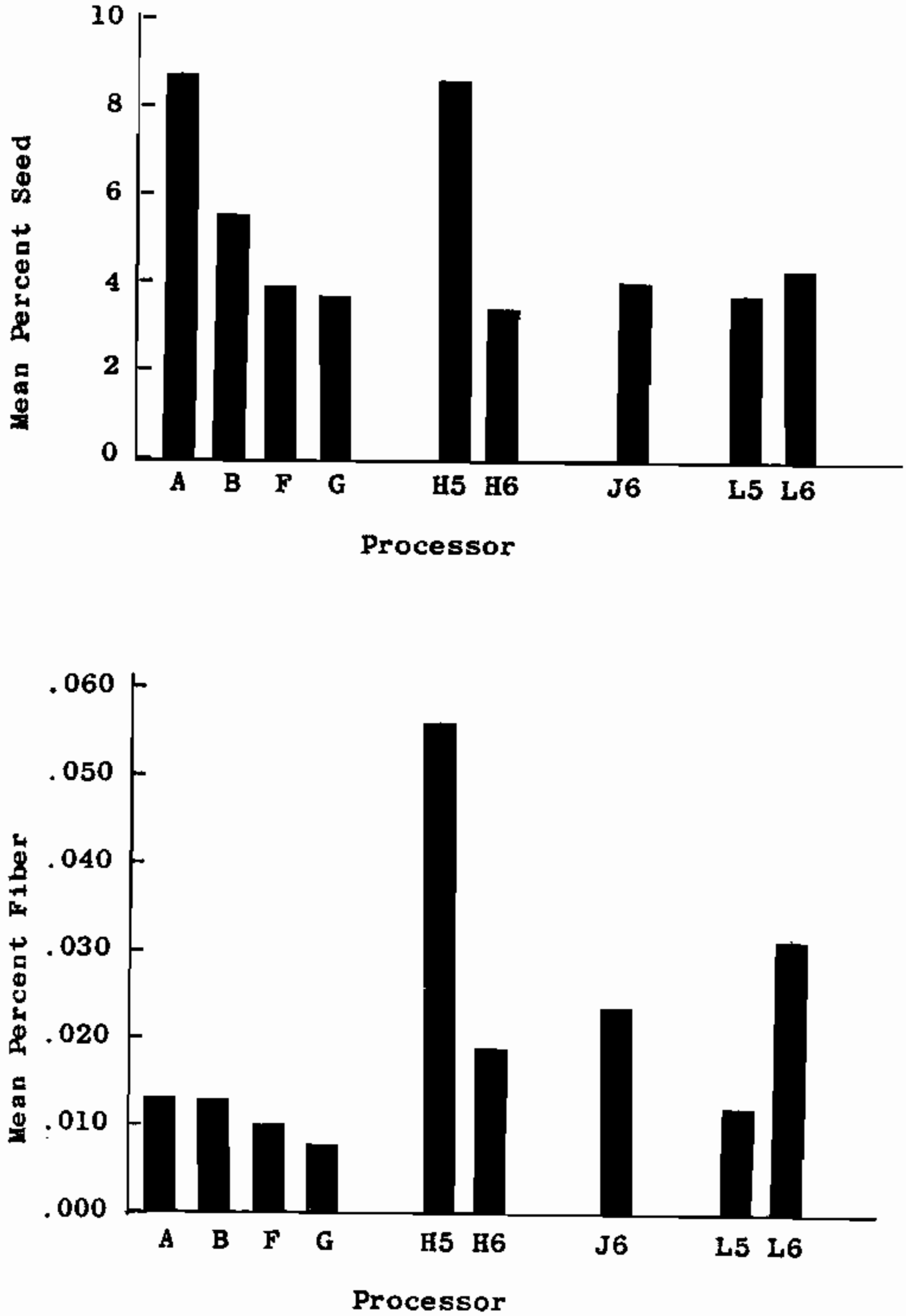


Figure 15. Mean percent seed portion of bean and mean percent fiber in green beans.

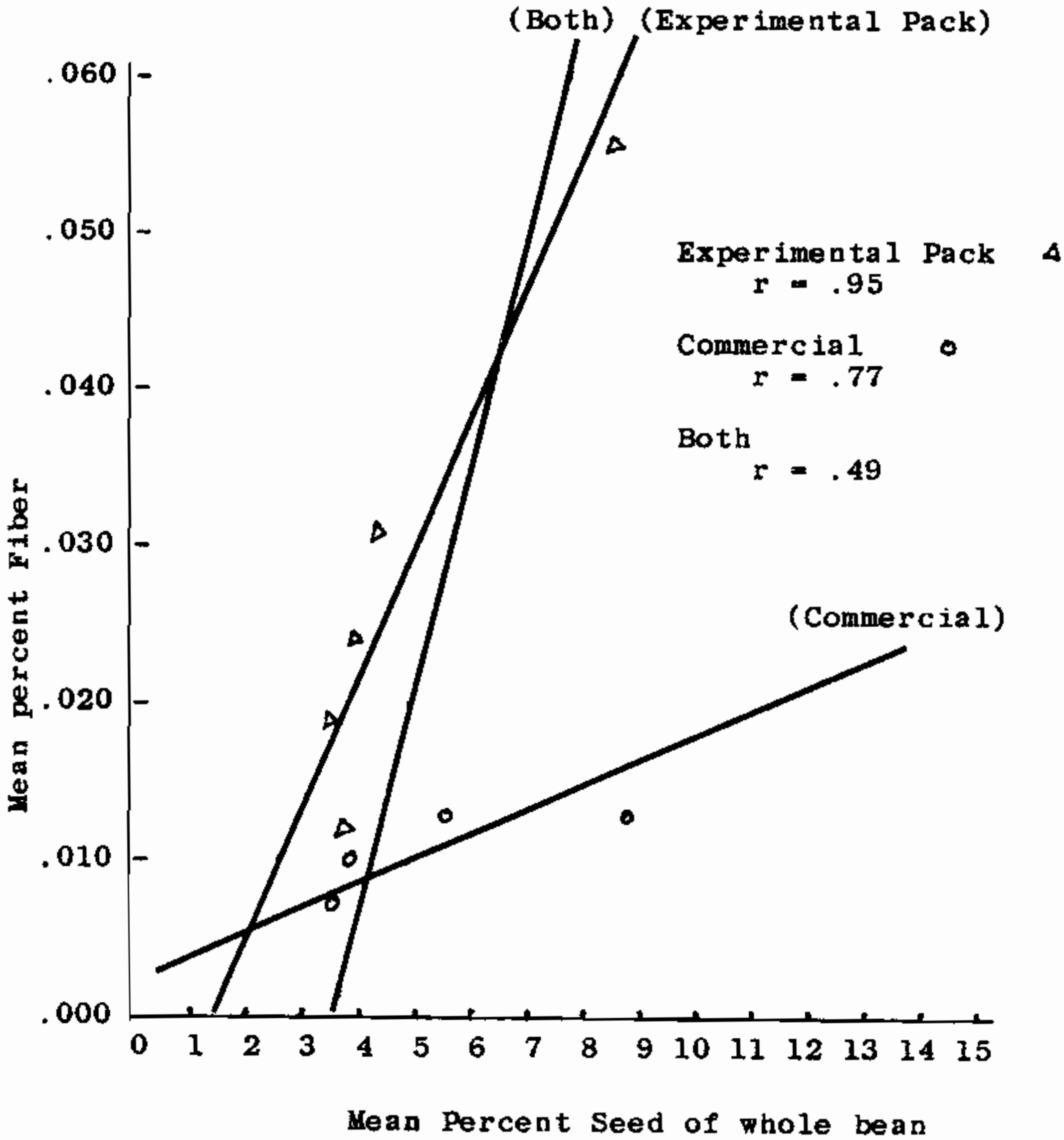


Figure 16. Mean percent seed of whole bean versus mean percent fiber in green beans.

percent fiber without a requirement of substandard labeling. This amount is the maximum allowable for the equivalent of grade C under USDA grading standards. None of the cans in EP "H5" went above that limit. However, one can in EP "L6" had a fiber content of 0.193 which would have limited that particular can to "substandard". Most of the beans in that pack were well below 0.050 percent, a tolerable level.

TABLE 59

GREEN BEANS - PERCENT FIBER

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.013 ± 0.014	0.002 - 0.058
B	0.013 ± 0.024	0.000 - 0.095
F	0.010 ± 0.008	0.002 - 0.030
G	0.007 ± 0.006	0.000 - 0.019
H	0.038 ± 0.030	0.003 - 0.109
J	0.023 ± 0.016	0.003 - 0.057
L	0.022 ± 0.035	0.001 - 0.193
H5	0.056 ± 0.032	0.007 - 0.109
H6	0.019 ± 0.010	0.003 - 0.041
J6	0.023 ± 0.016	0.003 - 0.057
L5	0.012 ± 0.009	0.001 - 0.033
L6	0.031 ± 0.047	0.002 - 0.193
COMMERCIAL	0.011 ± 0.014	0.000 - 0.095
EXPTL PACKS-75[b]	0.034 ± 0.032	0.001 - 0.109
EXPTL PACKS-76[b]	0.024 ± 0.029	0.002 - 0.193

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Whole Kernel Corn

Results of quality tests on whole kernel sweet corn have been summarized to include mean values, standard deviations, and ranges in Tables 60 through 73. Some discussion of the results follows.

Can vacuum (Table 60). Mean can vacuums were higher in experimental than in commercial packs of sweet whole kernel corn. CP "A" had one can with zero vacuum. The other two cans from the same lot had low vacuums of 2.0 inches Hg each. Both the containers and contents were in satisfactory condition, indicating that the problem was likely the result of poor adjustment in the steam-flow closure at the time of processing. Can vacuums are illustrated by bar graphs in Figure 17.

TABLE 60

WHOLE KERNEL CORN - CAN VACUUM (inches Hg)

PROCESSOR	MEAN ± sd[a]	RANGE
A	4.5 ± 2.0	0.0 - 8.0
E	7.1 ± 1.2	5.0 - 9.0
F	9.6 ± 3.2	6.0 - 15.0
G	8.7 ± 1.1	7.0 - 10.0
H	9.8 ± 1.2	7.0 - 12.0
I	13.0 ± 1.6	10.0 - 18.0
J	15.0 ± 1.6	10.0 - 17.0
K	14.3 ± 2.0	12.0 - 17.0
H5	9.4 ± 1.6	7.0 - 12.0
H6	10.1 ± 0.6	9.0 - 11.0
I5	13.0 ± 1.2	12.0 - 15.0
I6	12.9 ± 2.0	10.0 - 18.0
J5	14.7 ± 1.4	11.5 - 17.0
J6	15.3 ± 1.8	10.0 - 17.0
K5	14.3 ± 2.0	12.0 - 17.0
COMMERCIAL	7.5 ± 2.8	0.0 - 15.0
EXPTL PACKS-75[b]	12.6 ± 2.6	7.0 - 17.0
EXPTL PACKS-76[b]	12.8 ± 2.7	9.0 - 18.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Head space (Table 61). Mean headspace values were greater in the experimental packs than in the commercial packs. For instance, the mean value for all of the commercial packs was 11.0/32 inches as compared to 16.3/32 inches and 14.3/32 inches in the experimental packs (see Figure 17). EP "I5" and EP "I6" had mean values of 21.1/32 inches and 14.8/32 inches respectively. Most of the cans in EP "I5" had headspaces greater than

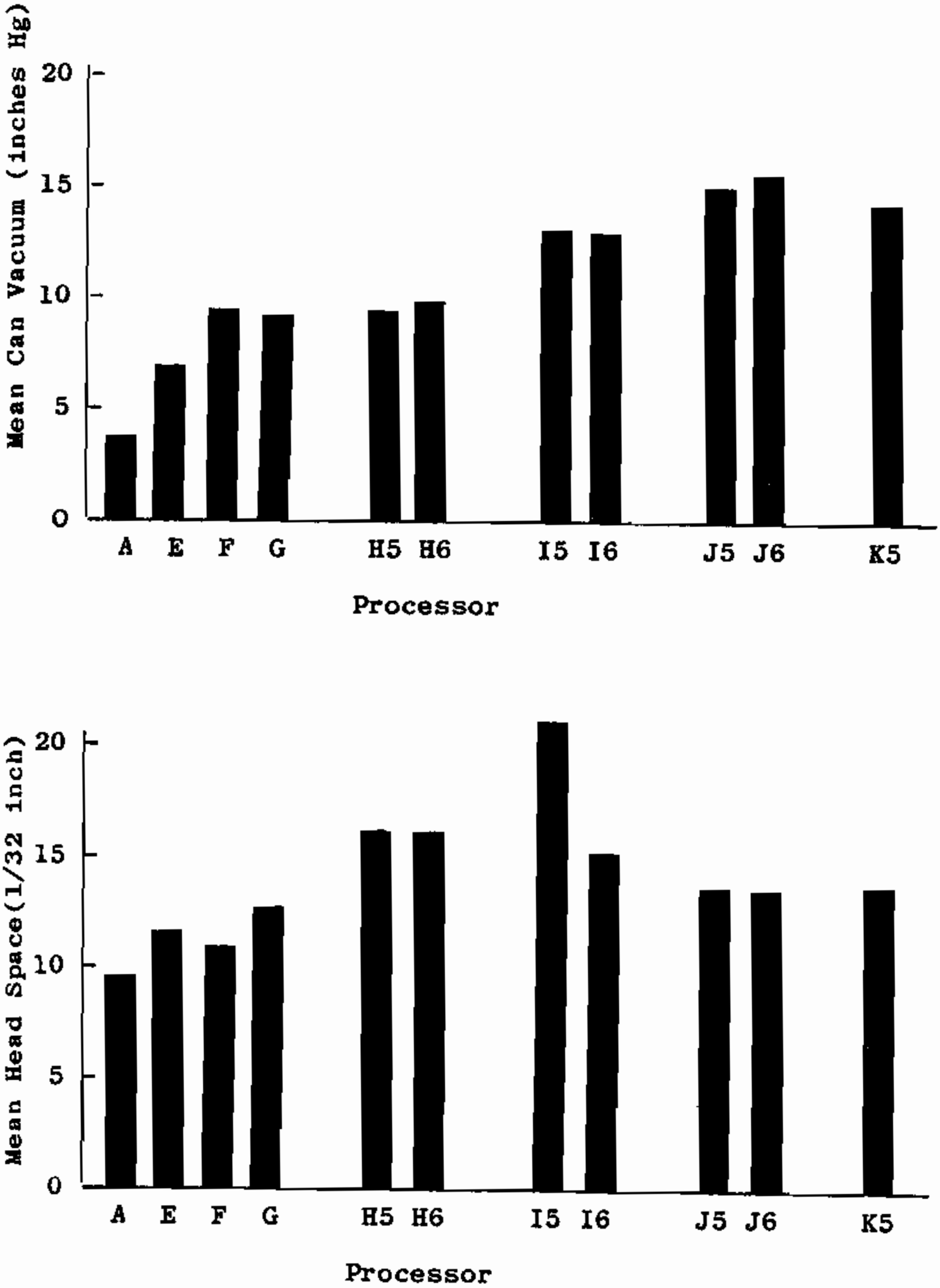


Figure 17. Mean can vacuums (inches Hg) and mean head space values (32nd of inch) for whole kernel corn.

the upper limit of 19/32 inches for a size 303 can, designating such cans as "slack filled". One can had a headspace of 35/32 inches.

TABLE 61

WHOLE KERNEL CORN - HEAD SPACE (1/32 inch)

PROCESSOR	MEAN ± sd[a]	RANGE
A	9.2 ± 1.4	7.0 - 12.0
E	11.4 ± 0.8	10.0 - 12.0
F	10.9 ± 2.4	8.0 - 15.0
G	12.5 ± 1.3	10.0 - 15.0
H	15.6 ± 1.0	13.0 - 19.0
I	18.0 ± 5.0	10.0 - 35.0
J	13.0 ± 1.0	11.0 - 15.0
K	13.3 ± 1.2	12.0 - 15.0
H5	15.6 ± 1.2	14.0 - 19.0
H6	15.7 ± 0.8	13.0 - 16.0
I5	21.1 ± 4.6	15.0 - 35.0
I6	14.8 ± 2.9	10.0 - 19.0
J5	13.3 ± 0.8	12.0 - 15.0
J6	12.7 ± 1.1	11.0 - 15.0
K5	13.3 ± 1.2	12.0 - 15.0
COMMERCIAL	11.0 ± 2.0	7.0 - 15.0
EXPTL PACKS-75[b]	16.3 ± 4.2	12.0 - 35.0
EXPTL PACKS-76[b]	14.3 ± 2.2	10.0 - 19.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Drained weight (Table 62). All cans in EP "K" were below the minimum standard recommended drained weight of 10.5 ounces or 298 grams (USDA, 1952). This is illustrated by the bar graph in Figure 18. Approximately half of all the cans in EP "H5" and EP "H6" were below the established minimum limit. When taken together, mean values for the commercial packs were slightly higher than the experimental packs. When commercially canned items fall below federally established minimum weights, it should be so indicated in the label. Otherwise, the sale of such items is illegal.

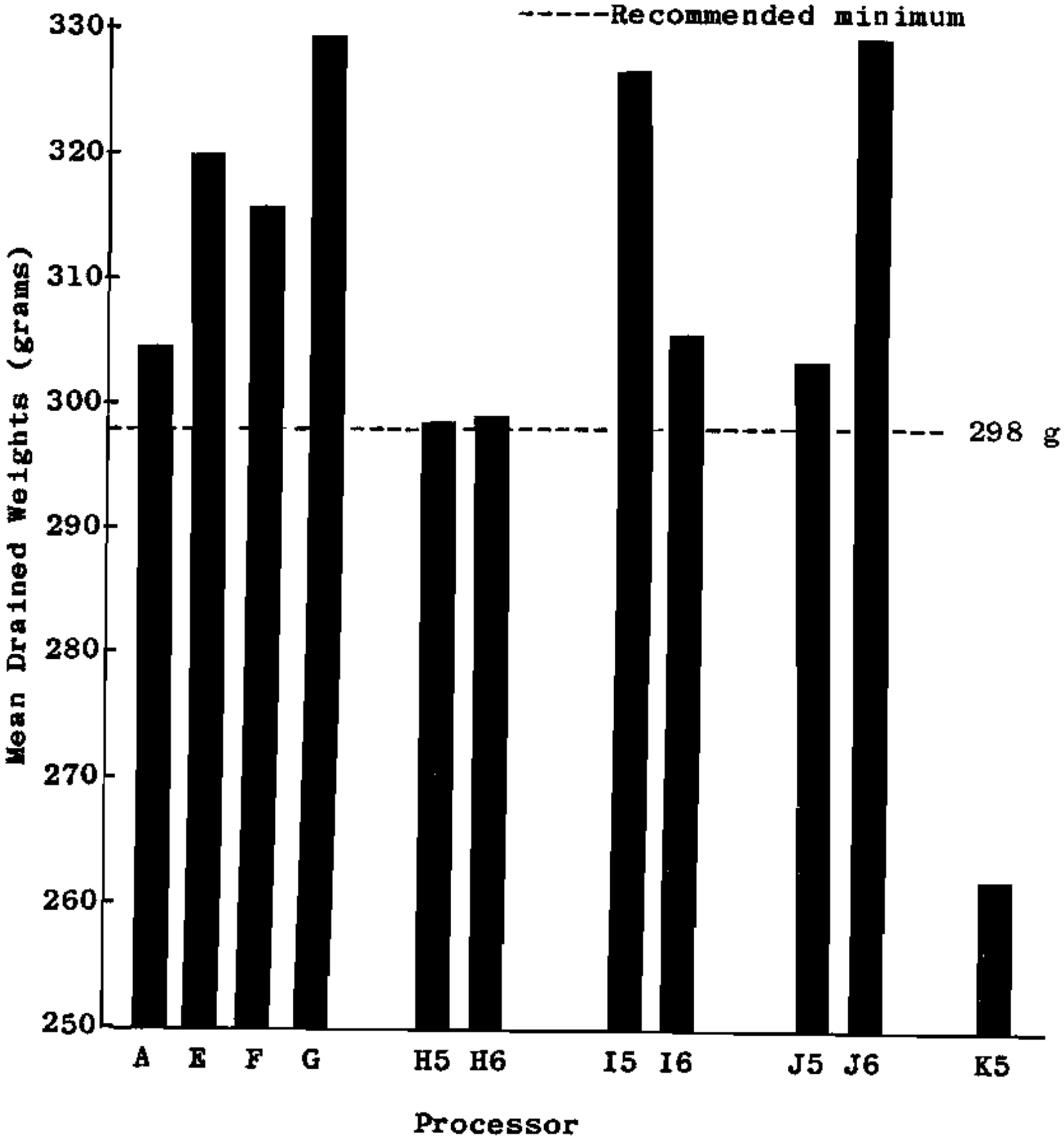


Figure 18. Mean drained weights for whole kernel corn.

TABLE 62

WHOLE KERNEL CORN - DRAINED WEIGHT (grams)

PROCESSOR	MEAN ± sd[a]	RANGE
A	304.7 ± 10.4	288.0 - 325.0
E	319.6 ± 5.4	310.0 - 330.0
F	315.5 ± 7.8	301.0 - 328.0
G	329.6 ± 5.8	320.0 - 340.0
H	299.6 ± 5.5	290.0 - 311.0
I	317.5 ± 43.5	134.0 - 368.0
J	317.3 ± 30.2	224.0 - 368.0
K	261.2 ± 8.6	251.0 - 277.0
H5	299.4 ± 5.5	290.0 - 311.0
H6	299.7 ± 5.6	292.0 - 310.0
I5	326.8 ± 24.2	287.0 - 363.0
I6	305.9 ± 58.9	134.0 - 368.0
J5	303.0 ± 8.6	282.0 - 320.0
J6	328.9 ± 36.3	224.0 - 368.0
K5	261.2 ± 8.6	251.0 - 277.0
COMMERCIAL	317.3 ± 11.8	288.0 - 340.0
EXPTL PACKS-75[b]	304.1 ± 24.6	251.0 - 363.0
EXPTL PACKS-76[b]	312.3 ± 39.5	134.0 - 368.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Hunter color values (Tables 63 through 65). The Hunter color "L" values or degree of lightness, was generally higher among the commercial packs of whole kernel corn. These differences were quite apparent in

TABLE 63

WHOLE KERNEL CORN - COLOR "L" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	66.40 ± 0.62	65.10 - 67.60
E	61.53 ± 0.98	60.00 - 63.00
F	65.06 ± 0.72	63.60 - 66.20
G	63.07 ± 0.75	61.90 - 64.50
H	57.71 ± 1.34	55.10 - 59.50
I	60.29 ± 2.45	55.20 - 65.20
J	60.43 ± 1.56	55.70 - 62.50
K	61.53 ± 1.59	59.70 - 63.20
H5	58.71 ± 0.61	57.40 - 59.50
H6	56.71 ± 1.08	55.10 - 58.70
I5	60.30 ± 3.13	55.20 - 65.20
I6	60.29 ± 1.52	57.50 - 62.00
J5	59.45 ± 1.61	55.70 - 61.60
J6	61.34 ± 0.77	60.00 - 62.50
K5	61.53 ± 1.59	59.70 - 63.20
COMMERCIAL	64.02 ± 2.02	60.00 - 67.60
EXPTL PACKS-75[b]	59.73 ± 2.16	55.20 - 65.20
EXPTL PACKS-76[b]	59.47 ± 2.31	55.10 - 62.50

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

the brighter appearance of the commercial packs. The experimental packs had a slightly dark cast which may have resulted at least in part from non-enzymatic browning reactions. This comparison is illustrated by the bar graphs in Figure 19. According to Huelson (1954), there are three recognized ways by which such browning or darkening may be brought about in corn: 1) overprocessing, 2) inadequate cooling immediately following the processing, and 3) immaturity of the corn. According to test results, the maturity of the corn was not a major factor in the darkening. It is the opinion of the writer that the darker experimental packs may have resulted from over-processing. The practice of "playing it safe" by processing at two or

TABLE 64

WHOLE KERNEL CORN - COLOR "a" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	1.71 ± 0.48	0.70 - 2.30
E	3.22 ± 0.41	2.20 - 3.90
F	1.27 ± 0.32	0.70 - 1.90
G	3.65 ± 0.75	2.50 - 4.80
H	4.87 ± 0.64	3.10 - 5.80
I	4.90 ± 0.52	3.70 - 5.60
J	4.62 ± 0.65	3.10 - 5.80
K	3.82 ± 0.39	3.40 - 4.50
H5	5.15 ± 0.44	4.40 - 5.80
H6	4.59 ± 0.70	3.10 - 5.60
I5	4.71 ± 0.62	3.70 - 5.60
I6	5.10 ± 0.28	4.60 - 5.50
J5	4.94 ± 0.38	4.40 - 5.70
J6	4.32 ± 0.71	3.10 - 5.80
K5	3.82 ± 0.39	3.40 - 4.50
COMMERCIAL	2.47 ± 1.12	0.70 - 4.80
EXPTL PACKS-75[b]	4.80 ± 0.62	3.40 - 5.80
EXPTL PACKS-76[b]	4.65 ± 0.67	3.10 - 5.80

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

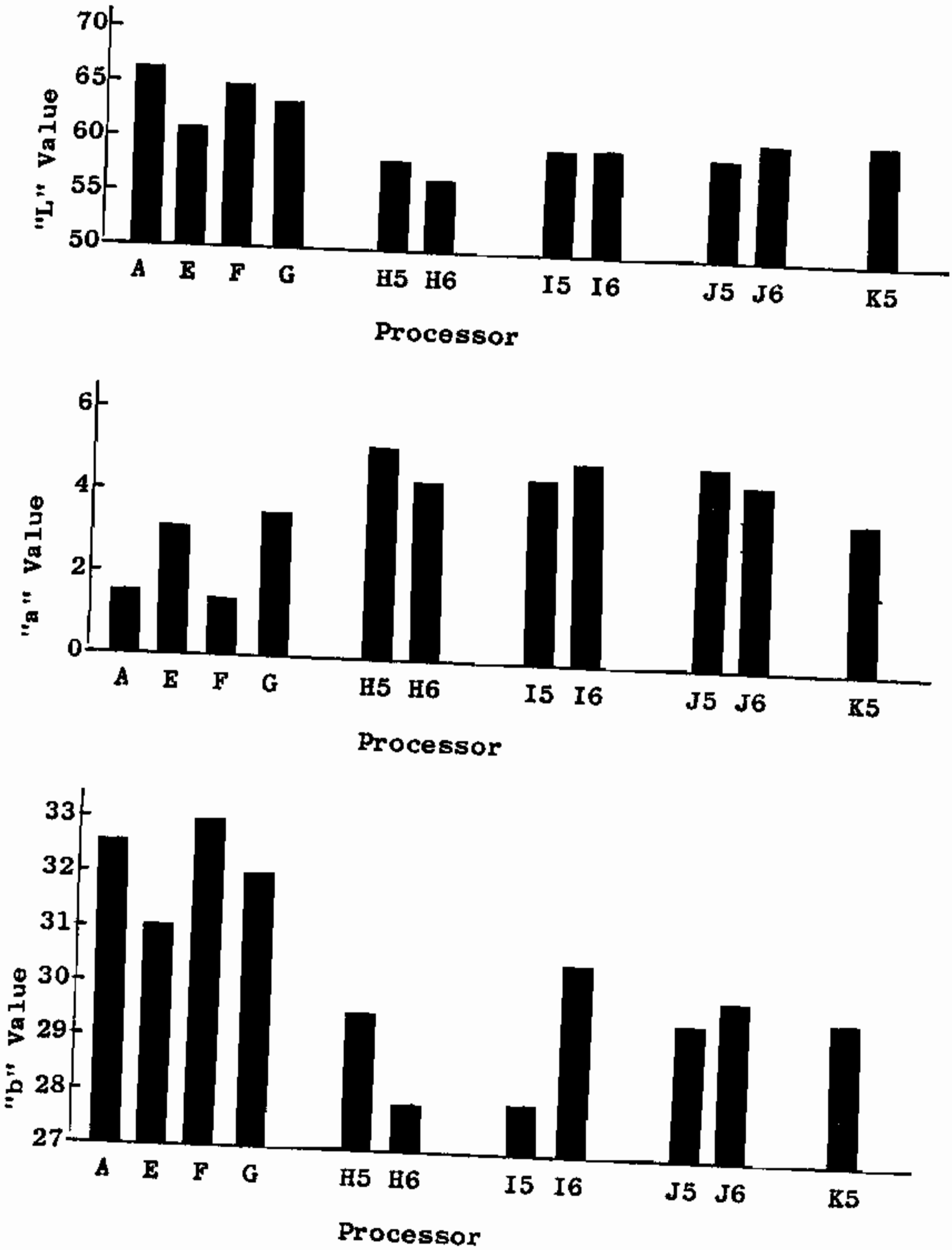


Figure 19. Mean Hunter color values for whole kernel corn.

three degrees fahrenheit above the recommended temperature and for as many as five or ten minutes beyond the scheduled cook time, may have resulted in the darker-colored corn.

Hunter color "a" values, degree of greenness versus redness, were generally higher among the experimental packs. The higher "a" or redness values appeared to correspond to lower "L" values which may be related to the production of browning compounds.

Hunter color "b" values, degree of blueness versus yellowness, were higher in the commercial packs, indicating a more intense yellowness. Higher "b" and "L" values corresponded to higher flavor scores in commercial packs as shown by bar graphs in Figure 24.

TABLE 65

WHOLE KERNEL CORN - COLOR "b" VALUES

PROCESSOR	MEAN ± sd[a]	RANGE
A	32.56 ± 0.79	31.30 - 34.30
E	31.07 ± 1.08	29.70 - 32.90
F	32.95 ± 0.42	32.20 - 33.70
G	32.47 ± 0.93	30.90 - 34.40
H	28.70 ± 1.09	26.90 - 30.90
I	29.12 ± 2.26	24.60 - 33.20
J	29.83 ± 0.99	27.10 - 31.70
K	29.60 ± 0.46	28.90 - 30.20
H5	29.61 ± 0.62	28.60 - 30.90
H6	27.79 ± 0.54	26.90 - 28.60
I5	27.85 ± 2.36	24.60 - 33.20
I6	30.48 ± 1.08	28.40 - 31.70
J5	29.47 ± 1.01	27.10 - 30.70
J6	30.17 ± 0.88	28.50 - 31.70
K5	29.60 ± 0.46	28.90 - 30.20
COMMERCIAL	32.26 ± 1.09	29.70 - 34.40
EXPTL PACKS-75[b]	29.05 ± 1.61	24.60 - 33.20
EXPTL PACKS-76[b]	29.47 ± 1.47	26.90 - 31.70

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Silk length (Table 66). Mean silk length varied considerably from one pack to another. EP "K" and CP "A" had essentially zero mean values for silk length, while EP "H5", EP "H6", and CP "F" showed significantly higher mean values. One can in CP "F" contained 150 inches of silk. Even though the amounts of silk seemed excessive in some instances, only the one can indicated above resulted in a substandard rating due to excessive silk. According to federal standards, canned whole kernel corn cannot contain more than 180 mm (7 inches) of silk per 28 grams (1 ounce) of drained weight without a substandard labeling requirement indicating "excessive silk" (21 CFR 155.130).

TABLE 66

WHOLE KERNEL CORN - SILK LENGTH (inches)

PROCESSOR	MEAN ± sd[a]	RANGE
A	00.0 ± 00.0	0.0 - 000.0
E	7.7 ± 7.7	0.0 - 26.0
F	13.1 ± 38.5	0.0 - 152.0
G	4.1 ± 4.3	0.0 - 11.0
H	14.9 ± 10.5	0.0 - 42.0
I	6.1 ± 2.7	2.0 - 11.0
J	3.4 ± 3.3	0.0 - 10.0
K	0.5 ± 1.2	0.0 - 3.0
H5	16.7 ± 11.7	0.0 - 42.0
H6	13.0 ± 9.1	0.0 - 32.0
I5	3.8 ± 2.7	2.0 - 11.0
I6	6.4 ± 2.8	2.0 - 11.0
J5	4.2 ± 3.5	0.0 - 10.0
J6	2.6 ± 3.0	0.0 - 10.0
K5	0.5 ± 1.2	0.0 - 3.0
COMMERCIAL	6.2 ± 19.9	0.0 - 152.0
EXPTL PACKS-75[b]	7.9 ± 8.9	0.0 - 42.0
EXPTL PACKS-76[b]	7.2 ± 7.1	0.0 - 32.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Husk area (Table 67). Relatively high mean values for husk were found in EP "H5", EP "H6", and

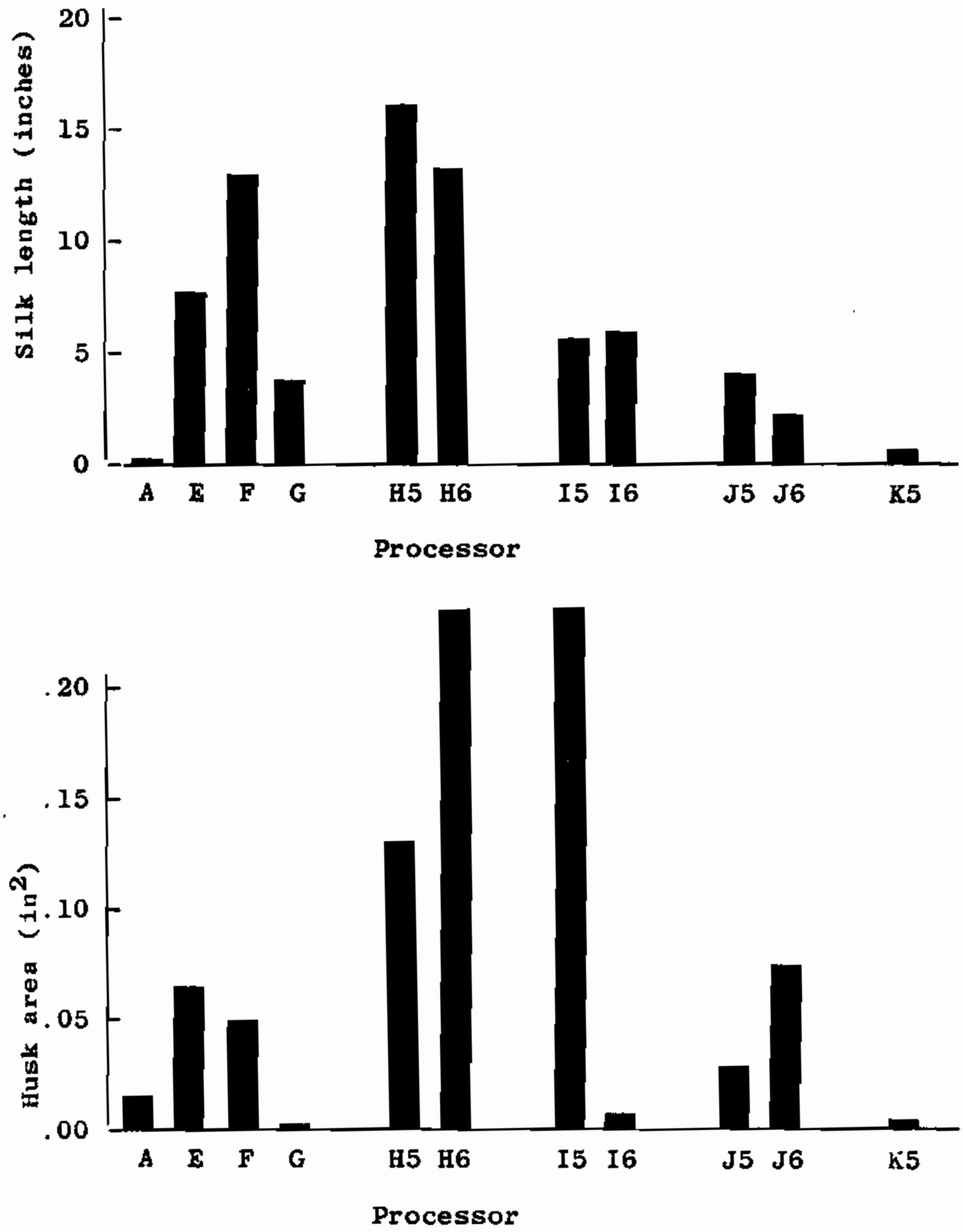


Figure 20. Mean silk length (inches) and mean husk area (in^2) in whole kernel corn.

EP "I", but in no case was the federal maximum limit exceeded that requires substandard labeling. Federal standards for canned whole kernel corn allow not more than 7 square centimeters (1.1 square inch) of husk per 400 grams (14 ounces) drained weight (21 CFR 155.130). Differences in mean husk area are illustrated in Figure 20.

TABLE 67

WHOLE KERNEL CORN - HUSK AREA (in^2)

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.02 ± 0.05	0.00 - 0.15
E	0.07 ± 0.18	0.00 - 0.60
F	0.05 ± 0.11	0.00 - 0.35
G	0.00 ± 0.00	0.00 - 0.00
H	0.18 ± 0.24	0.00 - 0.88
I	0.13 ± 0.24	0.00 - 0.84
J	0.06 ± 0.12	0.00 - 0.48
K	0.00 ± 0.00	0.00 - 0.00
H5	0.13 ± 0.20	0.00 - 0.63
H6	0.23 ± 0.27	0.00 - 0.88
I5	0.23 ± 0.30	0.00 - 0.84
I6	0.01 ± 0.05	0.00 - 0.20
J5	0.03 ± 0.10	0.00 - 0.40
J6	0.08 ± 0.13	0.00 - 0.48
K5	0.00 ± 0.00	0.00 - 0.00
COMMERCIAL	0.03 ± 0.11	0.00 - 0.60
EXPTL PACKS-75[b]	0.11 ± 0.22	0.00 - 0.84
EXPTL PACKS-76[b]	0.11 ± 0.19	0.00 - 0.88

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Cob volume (Table 68). Cob volume was significantly higher in EP "I5" than in any of the other packs tested (see Figure 21). However, most of the problem with cob in this pack occurred in only a few cans which resulted in the downgrading of two lots to "substandard". Federal standards state that not more than 1 cubic centimeter of pieces of cob for each 400 grams (14 ounces) of drained weight are permitted without the substandard labeling requirement indicating "excessive cob" (21 CFR 155.130).

TABLE 68

WHOLE KERNEL CORN - COB VOLUME (cubic centimeters)

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.00 ± 0.00	0.00 - 0.00
E	0.02 ± 0.06	0.00 - 0.20
F	0.00 ± 0.00	0.00 - 0.00
G	0.04 ± 0.06	0.00 - 0.20
H	0.03 ± 0.08	0.00 - 0.40
I	0.34 ± 6.27	0.00 - 18.00
J	0.05 ± 0.13	0.00 - 0.50
K	0.10 ± 0.09	0.00 - 0.20
H5	0.03 ± 0.11	0.00 - 0.40
H6	0.02 ± 0.04	0.00 - 0.10
I5	6.39 ± 7.61	0.00 - 18.00
I6	0.06 ± 0.10	0.00 - 0.30
J5	0.05 ± 0.15	0.00 - 0.50
J6	0.04 ± 0.11	0.00 - 0.40
K5	0.10 ± 0.09	0.00 - 0.20
COMMERCIAL	0.02 ± 0.04	0.00 - 0.20
EXPTL PACKS-75[b]	1.92 ± 4.98	0.00 - 18.00
EXPTL PACKS-76[b]	0.04 ± 0.09	0.00 - 0.40

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Cob is present when the corn cutting machines are not properly adjusted. Too deep of a cut will result in excessive amounts of cob which appeared to be the problem in EP "I5". In addition, "pulled kernels" or those kernels that are ripped from the cob, often have cob material attached.

Discolored kernels (Table 69). The presence of discolored kernels was well within limits in both commercial and experimental packs. The mean values in experimental packs were slightly lower than those found in commercial. This relates to careful trimming of wormy ears of corn.

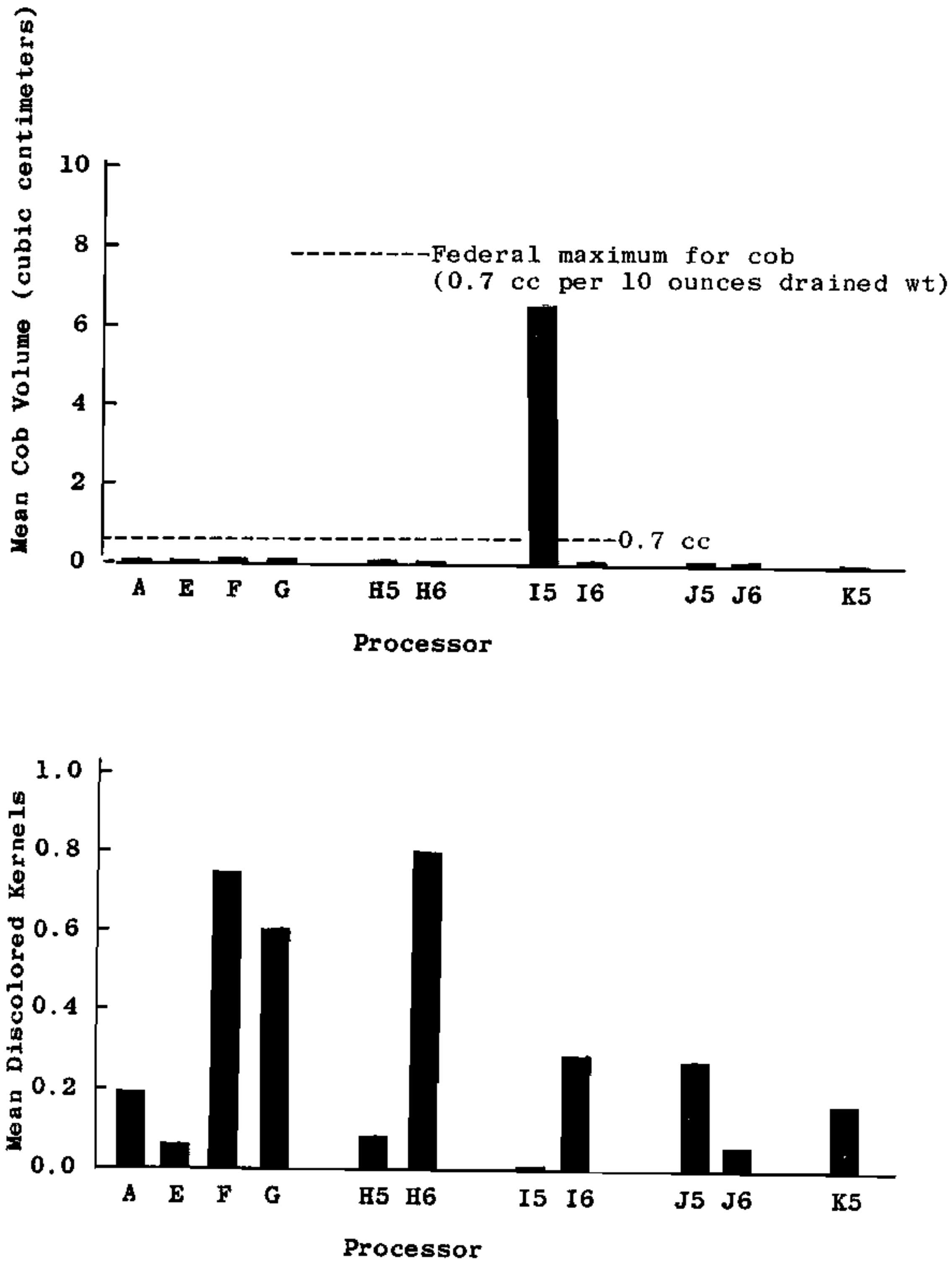


Figure 21. Defects in whole kernel corn. Mean cob volume and mean number of discolored kernels per can.

TABLE 69

WHOLE KERNEL CORN - DISCOLORED KERNELS

PROCESSOR	MEAN ± sd[a]	RANGE
A	0.02 ± 0.41	0.00 - 1.00
E	0.07 ± 0.26	0.00 - 1.00
F	0.73 ± 0.96	0.00 - 3.00
G	0.60 ± 0.74	0.00 - 2.00
H	0.43 ± 0.63	0.00 - 2.00
I	0.14 ± 0.44	0.00 - 2.00
J	0.16 ± 0.45	0.00 - 2.00
K	0.17 ± 0.41	0.00 - 1.00
H5	0.07 ± 0.26	0.00 - 1.00
H6	0.80 ± 0.68	0.00 - 2.00
I5	0.00 ± 0.00	0.00 - 0.00
I6	0.29 ± 0.61	0.00 - 2.00
J5	0.27 ± 0.59	0.00 - 2.00
J6	0.06 ± 0.25	0.00 - 1.00
K5	0.17 ± 0.41	0.00 - 1.00
COMMERCIAL	0.40 ± 0.69	0.00 - 3.00
EXPTL PACKS-75[b]	0.12 ± 0.38	0.00 - 2.00
EXPTL PACKS-76[b]	0.38 ± 0.61	0.00 - 2.00

[a]sd - standard deviation
[b]Experimental packs for 1975 and 1976

Alcohol insoluble solids (Table 70). The alcohol insoluble solids (AIS) test is used as a measurement of maturity in canned corn. According to Kramer (1946), AIS values below twenty percent would give the corn a fancy rating based on maturity. In only one instance did any can exceed twenty percent (EP "H5"). However, mean values on this pack were well below twenty percent (see Figure 22). EP "I5" was different in cut than the other corn, more like a cream style corn. AIS test results would indicate that this pack was very young and tender, when in fact, it was not. The two minute drained weight of the corn appears to have been higher due to the "cream style" cut. This higher amount of moisture then resulted in a lower AIS value. Thus, the AIS appears to be closely related to kernel size and cut.

TABLE 70

WHOLE KERNEL CORN - ALCOHOL INSOLUBLE SOLIDS (PERCENT)

PROCESSOR	MEAN ± sd[a]	RANGE
A	15.5 ± 1.7	13.2 - 19.1
E	17.7 ± 0.9	15.9 - 19.3
F	16.2 ± 1.4	13.6 - 18.4
G	18.3 ± 1.1	16.5 - 19.7
H	17.3 ± 1.3	13.6 - 20.1
I	15.0 ± 2.1	11.2 - 18.8
J	16.9 ± 1.7	13.8 - 19.8
K	12.9 ± 1.3	11.5 - 14.4
H5	17.6 ± 1.1	16.4 - 20.1
H6	17.7 ± 1.4	13.6 - 18.6
I5	13.8 ± 2.1	11.2 - 18.8
I6	16.3 ± 1.2	13.8 - 18.1
J5	17.6 ± 0.9	16.3 - 19.5
J6	16.1 ± 1.9	13.8 - 19.8
K5	12.9 ± 1.3	11.5 - 14.4
COMMERCIAL	17.0 ± 1.7	13.2 - 19.7
EXPTL PACKS-75[b]	16.0 ± 2.5	11.2 - 20.1
EXPTL PACKS-76[b]	16.5 ± 1.6	13.6 - 19.8

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Succulometer values (Table 71). The succulometer instrument is used to evaluate the maturity in both fresh and canned corn. The evaluation is based on the amount of liquid that can be expressed from a 100 gram (3.5 ounce) sample of corn within three minutes under a pressure of 500 pounds per square inch. Kramer (1946) states that the accuracy of the succulometer test is approximately equal to the moisture tests on raw corn and the alcohol insoluble solids test on both canned and raw corn. In addition, the test is much more rapid and much simpler to carry out than either of the other two tests. Data from this study confirm the claims by Kramer concerning the speed and accuracy of the succulometer test as applied to canned whole kernel corn. This is pointed out by the regression plot shown in Figure 23. Results of the succulometer tests show

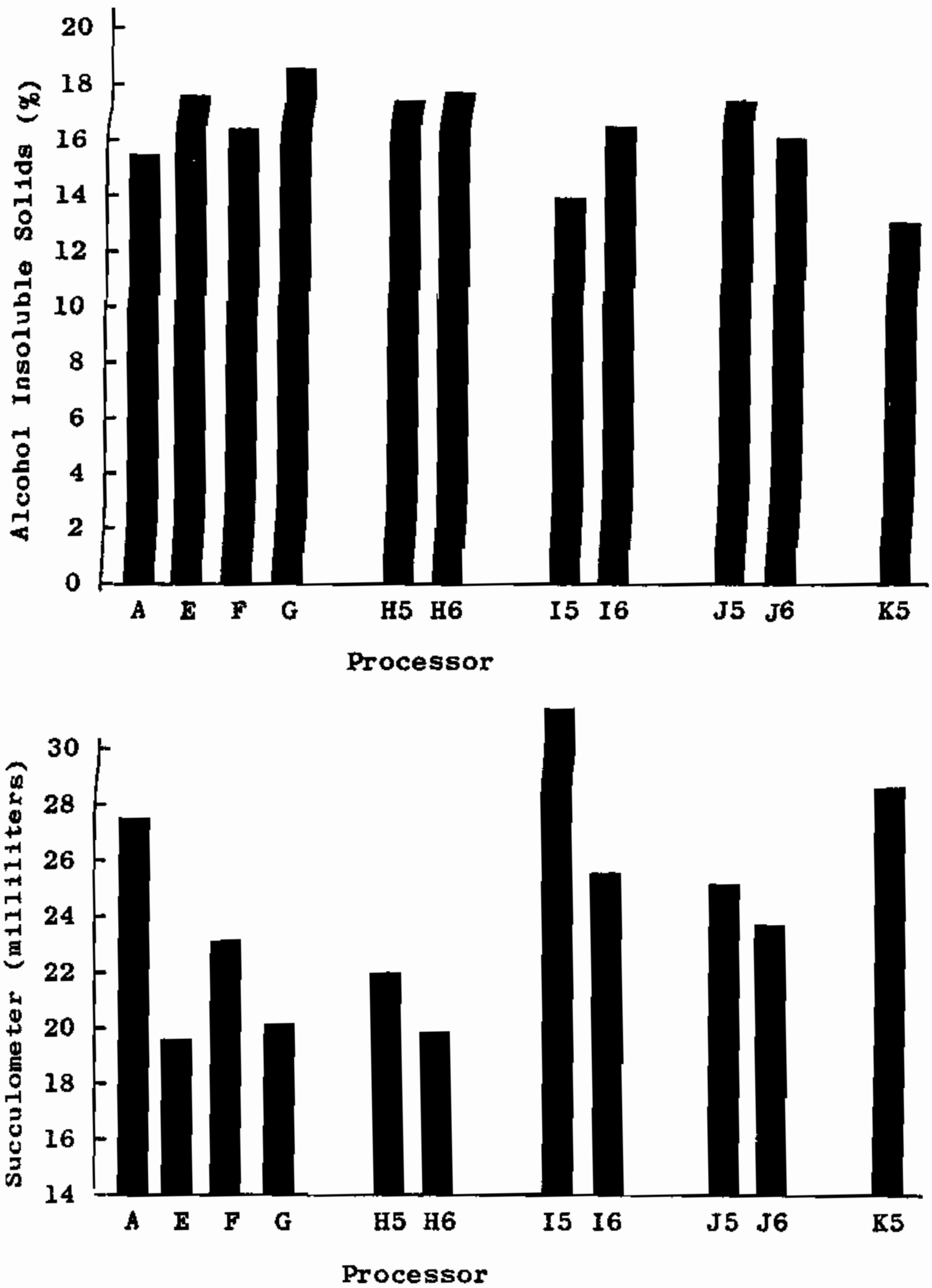


Figure 22. Mean alcohol insoluble solids (AIS) and succulometer measurements for whole kernel corn.

a very close correlation (r = 0.87) with AIS results. Both tests indicated that the corn in EP "I5" was very succulent and tender, when in fact, it was not. In both AIS and succulometer tests, the final results were misleading for this particular pack. Reasons appear to be related to the water holding capacity of samples that were weighed out after a two minute drain. Because of the "cream style" cut, the water holding capacity of the drained sample was increased. These results point out the importance of considering the kernel size and cut in evaluating whole kernel corn by either AIS or succulometer tests.

TABLE 71

WHOLE KERNEL CORN - SUCCULOMETER TEST (ml)

PROCESSOR	MEAN ± sd[a]	RANGE
A	27.3 ± 2.4	23.4 - 32.0
E	19.6 ± 1.8	16.5 - 22.3
F	23.1 ± 2.7	18.5 - 29.0
G	20.0 ± 2.6	15.9 - 25.9
H	21.0 ± 2.1	17.5 - 24.5
I	28.8 ± 3.6	22.2 - 35.0
J	24.4 ± 2.1	20.5 - 28.2
K	28.5 ± 1.8	26.0 - 31.0
H5	22.0 ± 1.4	18.6 - 24.4
H6	20.0 ± 2.3	17.5 - 24.5
I5	31.7 ± 1.9	29.1 - 35.0
I6	25.8 ± 2.2	22.2 - 29.2
J5	25.2 ± 1.8	22.2 - 28.2
J6	23.7 ± 2.1	20.5 - 27.1
K5	28.5 ± 1.8	26.0 - 31.0
COMMERCIAL	22.6 ± 3.9	15.9 - 32.0
EXPTL PACKS-75[b]	26.5 ± 4.2	18.6 - 35.0
EXPTL PACKS-76[b]	23.1 ± 3.2	17.5 - 29.2

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976

Cut (Table 72). The cut refers to the degree of smoothness of the cut surface of the kernels, uniformity and depth of cut, and the degree of freedom from

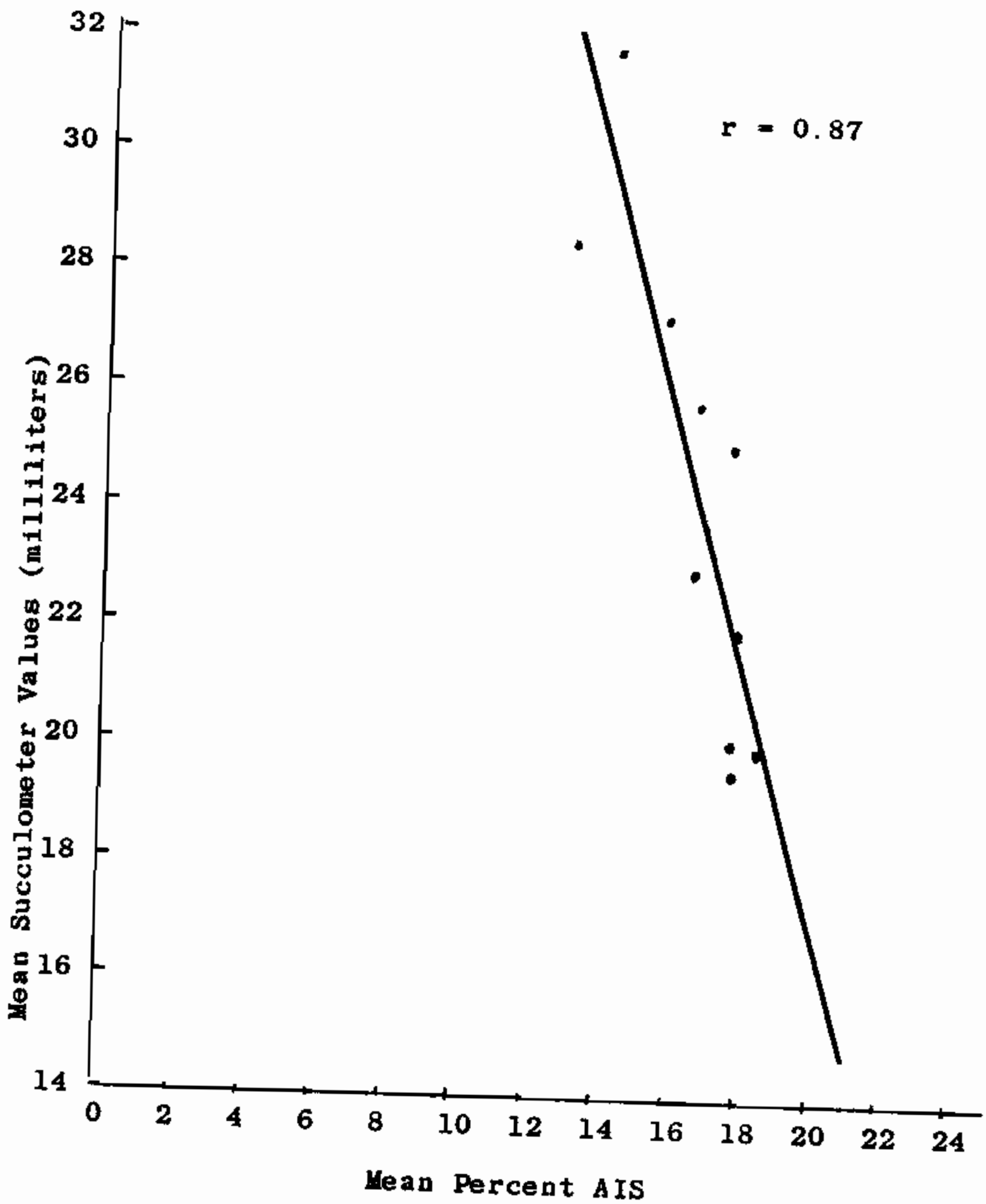


Figure 23. Mean percent alcohol insoluble solids (AIS) versus mean succulometer values for whole kernel corn.

adhering cob tissue (USDA, 1952). The cut of the corn was reasonably good in most instances. However, the poor cut in EP "I5" gave the corn almost a cream style appearance. The probable cause of this defect was a dull or unsharpened corn cutter. The second year showed a marked improvement as demonstrated in EP "I6".

TABLE 72

WHOLE KERNEL CORN - CUT[c]

PROCESSOR	MEAN ± sd[a]	RANGE
A	3.9 ± 0.3	3.0 - 4.0
E	4.0 ± 0.0	4.0 - 4.0
F	3.9 ± 0.3	3.0 - 4.0
G	3.1 ± 1.0	2.0 - 4.0
H	3.6 ± 0.7	2.0 - 4.0
I	2.6 ± 1.2	1.0 - 4.0
J	3.9 ± 0.3	3.0 - 4.0
K	3.5 ± 0.6	3.0 - 4.0
H5	3.5 ± 0.8	2.0 - 4.0
H6	3.8 ± 0.4	3.0 - 4.0
I5	1.7 ± 0.8	1.0 - 3.0
I6	3.6 ± 0.5	3.0 - 4.0
J5	3.9 ± 0.4	3.0 - 4.0
J6	3.9 ± 0.3	2.0 - 4.0
K5	3.5 ± 0.6	3.0 - 4.0
COMMERCIAL	3.8 ± 0.6	2.0 - 4.0
EXPTL PACKS-75[b]	3.1 ± 1.1	1.0 - 4.0
EXPTL PACKS-76[b]	3.8 ± 0.4	3.0 - 4.0

[a]sd = standard deviation
[b]Experimental packs for 1975 and 1976
[c]Evaluation of the kernel cut: (4) well cut, (3) reasonably well cut, (2) fairly well cut, (1) poorly cut.

<u>Flavor (Table 73)</u>. The overall flavor of the commercial packs was significantly better than that of the experimental packs as illustrated by the bar graphs in Figure 24. One of the reasons for the lower scores in the experimental packs was the lack of the typical sweet corn flavor. Some of these same packs also had slight off-flavors that closely resembled those found in overprocessed foods. Both flavor deterioration and

color degradation often occur together where over-processing occurs. This would involve processing at either too high of a temperature or for excessive time periods. Also, inadequate post-process cooling might cause or accentuate these problems. According to Huelson (1954), another contributing factor to darker corn and flavor deterioration is the higher sugar content. Immature corn has a relatively higher reducing sugar content which contributes to the caramelized flavor and dull color. This would appear to correlate with the lower AIS (lower maturity) of the experimental packs. Flavor evaluation was done by the writer only.

TABLE 73

WHOLE KERNEL CORN - FLAVOR[c]

PROCESSOR	MEAN ± sd[a]	RANGE
A	5.1 ± 1.3	2.0 - 6.0
E	4.5 ± 1.4	2.0 - 6.0
F	5.5 ± 0.8	4.0 - 6.0
G	4.7 ± 1.2	2.0 - 6.0
H	2.2 ± 1.0	1.0 - 4.0
I	2.3 ± 1.0	1.0 - 3.0
J	2.7 ± 1.5	1.0 - 6.0
K	2.3 ± 1.0	1.0 - 4.0
H5	2.3 ± 1.1	1.0 - 4.0
H6	2.1 ± 1.0	1.0 - 4.0
I5	2.1 ± 0.7	1.0 - 4.0
I6	3.0 ± 1.1	1.0 - 5.0
J5	1.5 ± 0.8	1.0 - 4.0
J6	3.9 ± 1.1	2.0 - 6.0
K5	2.3 ± 1.0	1.0 - 4.0
COMMERCIAL	4.9 ± 1.2	2.0 - 6.0
EXPTL PACKS-75[b]	2.0 ± 1.0	1.0 - 4.0
EXPTL PACKS-76[b]	3.0 ± 1.3	1.0 - 6.0

[a]sd - standard deviation

[b]Experimental packs for 1975 and 1976

[c]Flavor scores: (6) very good, (5) good to very good, (4) good, (3) fairly good to good, (2) fairly good, (1) poor.

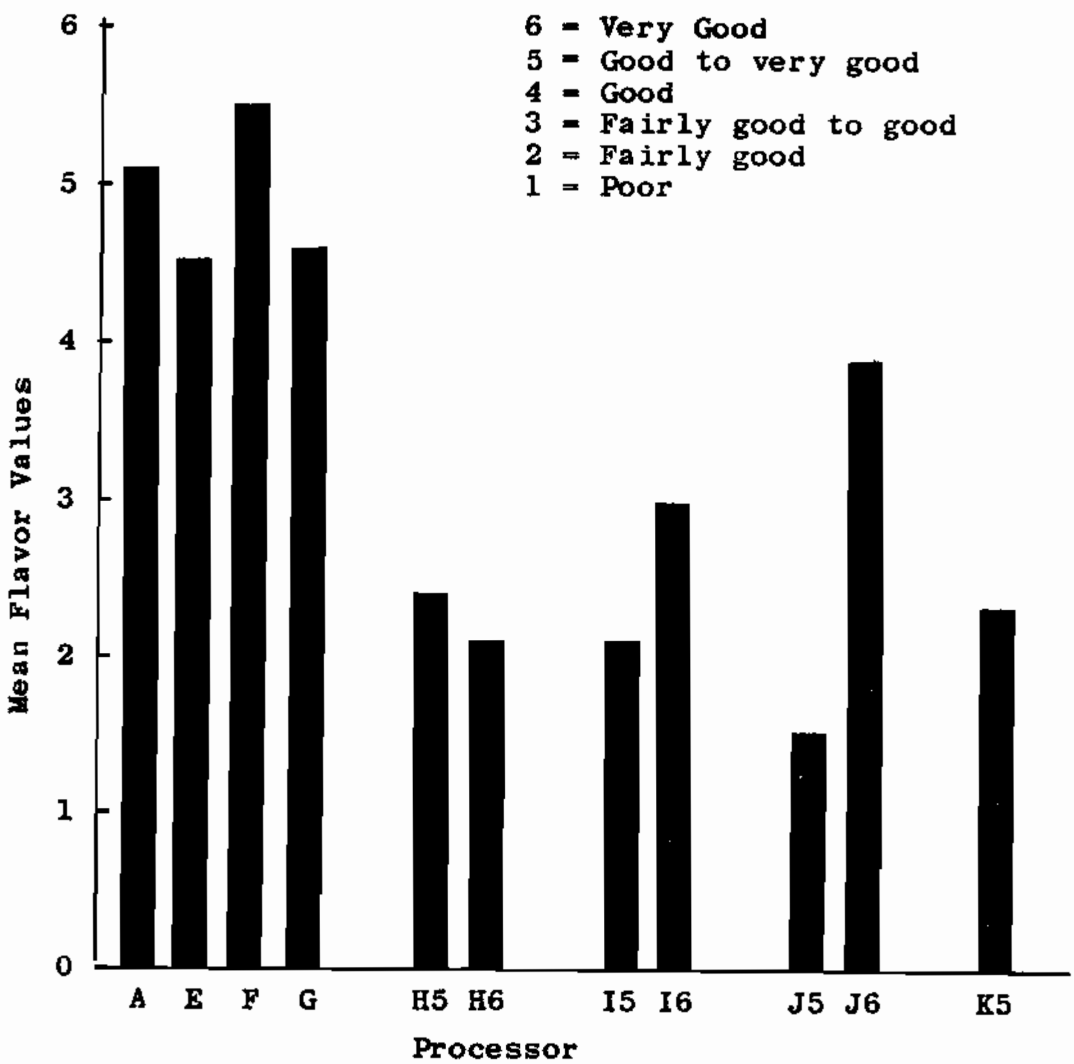


Figure 24. Mean flavor scores for whole kernel corn.

U. S. Grades

The results of grading are contained in Tables 74 through 78. Each can was evaluated separately and given a numerical score and corresponding grade. In some instances, and particularly among the experimental packs, grades were restricted to lower categories due to "limiting factors" of quality. These limiting factors are denoted in the tables where applicable. In most situations the limiting factors were of such a nature that they might have been avoided or significantly reduced had the processors been sensitive to causative factors and/or an effective quality assurance program been in existence. With a minimal amount of effort or product loss, many of the grades could have been improved dramatically. Results of the grading are discussed below according to product.

Grades of clingstone peaches (Table 74). The general quality of the clingstone peaches was quite high. There were a few instances in which the assigned grades were lower than the numerical scores would have indicated due to limiting factors of quality. Most of the lots that were restricted to a lower grade as a result of a single limiting factor, would have received a rating of "Fancy" or Grade A based only on the score. Lot number 3 of EP "M6" was generally of very high quality, but was limited to "Substandard" as a result

TABLE 74

CLINGSTONE PEACHES - U. S. GRADES

PROCESSOR	LOT NUMBER	CAN # 1	CAN # 2	CAN # 3	MEAN SCORE	ASSIGNED GRADE	LIMITING FACTORS**
A	1	95-B(1)*	97-A	92-A	95	B	BU
	2	97-A	95-A	97-A	96	A	-
	3	90-B(1)*	98-A	92-A	93	B	BU
	4	96-A	99-A	90-A	95	A	-
	5	90-B(1)*	91-B(1)*	88-C(2)*	90	C	H
B	1	94-A	89-C(2)*	91-B(1)*	91	C	S
	2	98-A	93-A	93-A	95	A	-
	3	93-B(1)*	96-B(1)*	96-A	95	A	-
	4	98-A	95-B(1)*	100-A	98	B	BU
	5	93-C	88-B	90-C(2)*	90	C	H
C	1	93-A	95-A	93-A	94	A	-
	2	95-A	93-A	97-A	95	A	-
	3	93-A	95-A	92-A	93	A	-
	4	93-A	93-A	90-B(1)*	92	B	BU
	5	92-A	95-A	94-A	94	A	-
M5	1	91-A	92-A	90-B(1)*	91	B	BU
	2	98-A	96-A	99-A	98	A	-
	3	95-A	94-A	97-A	95	A	-
	4	98-A	97-A	96-A	97	A	-
	5	98-A	93-A	91-A	94	A	-
M6	1	96-A	98-A	95-A	96	A	-
	2	92-B(1)*	99-A	100-A	97	B	P
	3	93-A	93-A	82-S(1)*	89	S***	P
	4	92-A	91-B(1)*	92-A	92	B	BU
	5	98-A	98-A	92-C(2)*	96	C	H

*Has a limiting factor: 1 = defects, 2 = character, 3 = color
**BU = blemished units, H = hard, S = soft, P = peel, E = extraneous
***S = substandard

of excessive amounts of peel in one of the cans. Some of the other clingstone lots were restricted to grades B or C because of blemished units, hardness, and peel.

The category of size and symmetry is one of the four main areas that is scored for the purpose of grading peaches. For instance, under the grading criteria, the weight of the largest full-size unit in a can must not exceed the size of the smallest full-size unit by more than 40 percent for grade A; 60 percent for grade B; or 100 percent for grade C. Uniformity of size and symmetry is not scored in certain designated types of packs such as those labeled with "Pieces or Irregular Pieces" or "Solid-Pack". Those packs so designated cannot receive a grade above U. S. grade B. Most of the commercial peaches rated within the grade A or B range based on size only. However, most of the experimental packs were within the "Substandard" range on the same basis. Nevertheless, because processors of experimental packs place very little emphasis on size and symmetry, the option was taken to omit this category from the grading criteria in order to better compare and evaluate some of the remaining areas of quality.

Grades of freestone peaches (Table 75). Considerable variation in quality existed throughout the individual packs of freestone peaches. Those factors having the greatest impact on reduced quality were the

TABLE 75

FREESTONE PEACHES - U. S. GRADES

PROCESSOR	LOT NUMBER	CAN # 1	CAN # 2	CAN # 3	MEAN SCORE	ASSIGNED GRADE	LIMITING FACTORS**
A	1	92-A	89-B(1)*	90-A	90	B	BU
	2	95-A	97-A	84-S(2)*	92	S***	H
	3	88-B	88-B	88-C(1)*	88	C	BU
	4	92-A	97-A	96-A	95	A	-
	5	88-C(2)*	77-S(2)*	89-C(2)*	85	S***	H
H5	1	91-B(1)*	90-C(1)*	90-C(1)*	90	C	BU
	2	96-A	93-B(1)*	93-A	94	B	E
	3	97-A	91-B(1)*	96-A	95	B	P
	4	89-B(1)*	85-C(1)*	89-B(1)*	87	C	E
	5	93-A	94-A	96-A	94	A	-
H6	1	96-A	99-A	99-A	98	A	-
	2	94-A	95-A	94-B(1)*	94	B	P
	3	94-B(1)*	100-A	93-A	96	B	P, BU
	4	98-A	98-A	99-A	98	A	-
	5	97-A	97-A	96-A	97	A	-
L5	1	90-B(1)*	86-C(1)*	92-B(1)*	89	C	P
	2	96-A	93-A	98-A	96	A	-
	3	91-B(1)*	87-B(1)*	80-S(1)*	86	S***	P
	4	93-A	96-A	97-A	95	A	-
	5	84-S(1)*	92-B(1)*	92-B(1)*	89	S***	P
L6	1	83-S(1)*	94-A	95-A	91	S***	P
	2	97-A	92-B(1)*	94-A	94	B	P
	3	96-A	96-A	91-A	94	A	-
	4	96-A	86-C(1)*	98-A	93	C	P
	5	89-B(1)*	93-B(1)*	90-B(1)*	90	B	P
N6	1	95-B(1)*	92-B(1)*	87-S(2)*	91	S***	H
	2	98-A	96-A	87-C(2)*	94	C	H
	3	95-A	83-C(1)*	78-S(2)*	85	S***	H
	4	94-B(1)*	94-B(1)*	96-A	95	B	BU
	5	91-B(1)*	97-A	92-A	93	B	BU
O5	1	92-B(1)*	96-A	95-A	94	B	P
	2	96-A	96-A	91-B(1)*	94	B	BU
	3	91-B(1)*	96-A	98-A	94	B	P
	4	96-A	92-B(1)*	96-A	95	B	BU
	5	91-B(1)*	96-A	96-A	94	B	BU
O6	1	90-B(1)*	83-S(1)*	82-S(1)*	85	S***	P
	2	96-A	82-S(1)*	95-A	91	S***	P
	3	91-B(1)*	93-A	96-A	93	B	BU
	4	92-B(1)*	96-A	89-C(1)*	92	C	P
	5	90-B(1)*	78-S(1)*	86-C(1)*	85	S***	P

*Has a limiting factor: 1 = defects, 2 = character, 3 = color
**BU = blemished units, H = hard, S = soft, P = peel, E = extraneous
***S = substandard

hardness of the fruit and presence of excessive amounts of peel. In most instances, these became a limiting factor which resulted in lower grades. Two different lots in each EP "A" and EP "N6" contained peaches with hardness ratings above the 300 gram limit, resulting in "substandard" U. S. grades. "Substandard" grades were also assigned to some lots within EP "L5", EP "L6", and EP "06" as a result of excessive amounts of peel. Federal standards allow not more than one square inch of peel for each 16 ounces (454 grams) net content which is equivalent to a 2 1/2 size can. In the event that this limit is exceeded, substandard labeling requirements are imposed.

Some grades were limited because of blemished units both in commercial and experimental packs. Most of these blemished units were so designated because of darkened areas or bruises. This often occurs due to mishandling or overhandling the fruit during and after harvest, especially when the fruit is harvested too late or if sorting is carelessly done. Selective picking as opposed to "stripping" a tree helps not only in reducing the amount of post harvest sortings, but also adds to the flavor and general quality of the fruit. From three to five pickings are recommended to obtain all of the fruit at the proper maturity. For optimum quality it is suggested that fruit be harvested six to seven days before full-ripe maturity (Anon., 1959). By so doing the fruit is less susceptible to bruising and should ripen quite evenly while in storage and attain a uniform and desirable degree of texture or hardness for canning.

Grades of pears (Table 76). Experimental packs were severely downgraded due to various limiting factors, most frequently hardness. Other factors such as excess peel, external and internal stems, color, and loose seed also caused quality loss. Hard canned pears usually result from processing fruit that have not been allowed to adequately ripen. Unless a carefully controlled atmosphere environment is used, pears usually ripen unevenly. As a result, pears for processing may require several sortings in order to avoid using the immature fruit. Apparently this happened in the processing of the experimental packs since most of the pears were within the ideal hardness range, and only a very few exceeded the substandard hardness limit of 300 grams (10.6 ounces). There were several instances in which the hardness rating went off scale at 820 grams (28.9 ounces), indicating some extremely hard pears including lots found in EP "L5" and EP "M6".

The category of size and symmetry is one of the four main general groups involved in the scoring of canned pears. As was the case with peaches, most of the

TABLE 76

PEARS - U. S. GRADES

PROCESSOR	LOT NUMBER	CAN # 1	CAN # 2	CAN # 3	MEAN SCORE	ASSIGNED GRADE	LIMITING FACTORS**
A	1	95-B(1)*	99-A	92-B(1)*	95	B	LS
	2	93-C(1)*	96-B(1)*	99-A	96	C	LS
	3	96-A	96-A	-	96	A	-
	4	96-A	92-A	91-A	93	A	-
	5	99-A	96-A	97-A	97	A	-
B	1	93-C(1)*	91-A	93-C(1)*	92	C	LS, P
	2	89-S(1)*	98-A	97-A	95	S***	ITS
	3	96-A	95-A	100-A	97	A	-
	4	100-A	95-A	100-A	98	A	-
	5	96-A	99-A	97-A	97	A	-
C	1	91-A	93-A	96-A	93	A	-
	2	95-A	91-A	93-A	94	A	-
	3	91-A	97-A	95-A	94	A	-
	4	83-S(1)*	88-C(1)*	89-C(1)*	87	S***	LS
	5	93-A	95-A	96-A	95	A	-
D	1	95-A	94-A	100-A	96	A	-
	2	94-A	98-A	96-A	96	A	-
	3	94-A	92-A	96-A	94	A	-
	4	96-A	92-A	93-C(2)*	94	C	H
	5	100-A	96-A	94-A	97	A	-
L5	1	88-C(1)*	86-S(1)*	89-C(1)*	87	S***	P, C, ITS
	2	89-C(1)*	84-S(1)*	87-C(1)*	87	S***	P, ITS
	3	96-A	91-A	92-A	93	A	-
	4	84-S(2)*	85-S(1)*	72-S(1)*	80	S***	H, ITS
	5	73-S(1,2)*	78-C	80-S(1)*	77	S***	H, ITS, ETS
L6	1	81-S(2)*	84-S(2)*	90-C(1)*	85	S***	H
	2	88-C(1)*	83-S(2)*	96-A	89	S***	H
	3	89-S(2)*	93-C(2)*	96-A	93	S***	H
	4	77-S(2)*	96-A	82-C(1)*	85	S***	H
	5	75-S(1,2)*	96-A	98-A	89	S***	H, ITS
M5	1	92-A	92-A	93-A	92	A	-
M6	1	85-C(2)*	87-S(2)*	86-C(1)*	86	S***	H
	2	83-C(1)*	90-C(2)*	85-S(2)*	86	S***	H
	3	82-C(2,3)*	80-C(1,3)*	86-S(2)*	83	S***	H
	4	84-S(2)*	85-S(2)*	89-C(2)*	86	S***	H
	5	76-S(2)*	84-C(2,3)*	87-S(2)*	82	S***	H
O5	1	85-S(1)*	90-C(1)*	86-S(1)*	87	S***	P
	2	76-S(3)*	81-S(3)*	86-S(3)*	81	S***	PNK
	3	87-C(1)*	87-S(1)*	93-C(1)*	89	S***	C
	4	95-A	95-A	86-C(1)*	92	C	ITS, LS, C
	5	89-C(1)*	87-S(1)*	84-S(2)*	87	S***	H, P, ITS
O6	1	82-C(1,2)*	81-C(1,2)*	84-C(1)*	82	C	LS, S, ITS
	2	85-C(2)*	83-C(1,2)*	87-C(1)*	85	C	S, ITS
	3	81-C(2)*	85-C(2)*	89-C(2)*	85	C	S
	4	95-A	88-B	91-A	91	A	-
	5	88-B	89-B	93-A	90	A	-

*Has a limiting factor: 1 = defects, 2 = character, 3 = color
**LS = loose seed, H = hard, S = soft, ITS = internal stem, ETS = external stem, P = peel, PNK = pink color, C = core material
***S = substandard

experimental packs showed considerable variation in individual "half" or unit size. Under grading criteria for pears, the weight of the largest full-size unit cannot exceed the size of the smallest full-size unit by more than 50 percent for grade A; 75 percent for grade B; or 100 percent for grade C. Inasmuch as severe downgrading would have occurred in the pears as with the peaches throughout the experimental packs, and since very little emphasis was placed on size and symmetry by those processors, this category was not judged or scored for inclusion in the final grade.

Lot number two of EP "05" contained very pink pears, excellent negative examples of this type of coloring defect. From the appearance of these pears, the problem was very likely accentuated by a combination of extended processing and delayed can cooling. The frequent occurrence of internal stems in the experimental packs resulted in some "substandard" grades. Although most of the internal stems were not extremely woody or fibrous, their occurrence did lower the eating quality to some extent.

Grades of green beans (Table 77). The four factors of quality used to evaluate the green beans were clearness of liquor, color, absence of defects, and character. Of these categories, the quality factor which was most significant in limiting the grades was

TABLE 77

GREEN BEANS - U. S. GRADES

PROCESSOR	LOT NUMBER	CAN # 1	CAN # 2	can # 3	MEAN SCORE	ASSIGNED GRADE	LIMITING FACTORS**
A	1	93-A	90-A	92-A	92	A	-
	2	91-A	94-A	90-A	92	A	-
	3	96-A	96-A	96-A	96	A	-
	4	92-A	92-A	87-B(1)*	90	B	F
	5	91-A	87-C(2)*	92-A	90	C	BU
B	1	97-A	96-A	97-A	97	A	-
	2	91-B(1)*	97-A	85-B(1)*	91	B	F
	3	95-A	96-A	99-A	97	A	-
	4	95-A	94-A	97-A	95	A	-
	5	93-A	94-A	94-A	94	A	-
F	1	92-A	96-A	94-A	94	A	-
	2	95-A	98-A	92-A	95	A	-
	3	99-A	97-A	100-A	99	A	-
	4	98-A	98-A	95-A	97	A	-
	5	99-A	98-A	97-A	98	A	-
G	1	95-A	98-A	97-A	97	A	-
	2	98-A	98-A	96-A	97	A	-
	3	95-A	96-A	97-A	96	A	-
	4	94-A	93-A	98-A	95	A	-
	5	99-A	98-A	98-A	98	A	-
L5	1	98-A	93-A	96-A	96	A	-
	2	91-B(1)*	95-A	97-A	94	B	F
	3	96-A	94-A	97-A	96	A	-
	4	95-A	96-A	96-A	96	A	-
	5	98-A	96-A	90-B(1)*	95	B	F
L6	1	90-B(1)*	98-A	89-B	92	B	F
	2	92-B(1)*	97-A	91-B(1)*	93	B	F
	3	85-S(1)*	94-A	96-A	91	S***	F
	4	96-A	91-B(1)*	90-B(1)*	92	B	F
	5	95-A	94-B(1)*	97-A	95	B	F
H5	1	89-B(1)*	88-B(1)*	85-C(1)*	87	C	F
	2	90-B(1)*	89-B(1)*	93-A	91	B	F
	3	93-B(1)*	86-B(1)*	88-B(1)*	89	B	F
	4	92-B(1)*	84-C(1)*	83-C(1)*	86	C	F
	5	91-B(1)*	92-B(1)*	94-A	92	B	F
H6	1	95-A	95-A	94-B(1)*	95	B	F
	2	96-A	96-A	92-B(1)*	95	B	F
	3	95-B(1)*	93-B(1)*	94-A(1)*	94	B	F
	4	95-A	95-A	95-A	95	A	-
	5	94-A	98-A	94-B(1)*	95	B	F
J6	1	93-B(1)*	92-A	88-B(1)*	91	B	F
	2	99-A	94-A	94-A	96	A	-
	3	96-A	93-B(1)*	94-A	94	B	F
	4	97-A	93-A	91-B(1)*	94	B	F
	5	94-A	91-B(1)*	91-B(1)*	91	B	F

*Has a limiting factor: 1 = character, 2 = defects
**F = fiber, BU = blemished units
***S = substandard

the character or tenderness. In general, very few problems were encountered in the green beans; consequently, the grades were high. It becomes apparent from Table 77 that limiting factors involving fiber, a good gauge of character, were found almost exclusively within the experimental packs. Lot number 3 in EP "L6" "L6" was restricted to "substandard" as a result of its high fiber content of 0.193 percent (see Table 59). The upper federal limit for fiber is 0.150 percent. The majority of grade limitations were the result of excess fiber. Such defects as blemished units and unstemmed units occurred in almost every pack but caused very little reduction in total scores. Blemished units became a limiting factor in only one instance, lot number 5 of CP "A", restricting the quality rating to "standard" or U. S. grade C.

Grades of whole kernel corn (Table 78). Those factors involved in the grading of whole kernel corn are color, cut, absence of defects, tenderness and maturity, and flavor. Significant deficiencies in each of these main categories were found in some commercial and experimental packs. However, the quality in commercial packs was significantly better than in the experimental packs. Among the commercial packs, tenderness and maturity were the factors having the greatest overall impact, limiting some lots to U. S.

TABLE 78

WHOLE KERNEL CORN - U. S. GRADES

PROCESSOR	LOT NUMBER	CAN # 1	CAN # 2	CAN # 3	MEAN SCORE	ASSIGNED GRADE	LIMITING FACTORS**
A	1	92-B(1)*	92-B(1)*	91-B(1)*	92	B	TM
	2	95-A	95-A	99-A	96	A	-
	3	93-A	92-A	95-A	93	A	-
	4	100-A	99-A	100-A	100	A	-
	5	94-A	94-A	95-A	94	A	-
E	1	87-B	84-B	86-C(1)*	86	C	TM
	2	92-B(1)*	86-B	90-A	89	B	TM
	3	92-B(1)*	84-C(2)*	83-C(2)*	86	C	F
	4	90-B(1)*	87-B	87-B	88	B	-
	5	91-B(1)*	88-B	95-A	91	B	TM
F	1	90-B(1)*	95-A	84-S(3)*	89	S***	S
	2	98-A	96-A	95-B(3)*	96	B	DK
	3	92-B(1)*	95-A	93-A	93	B	TM
	4	95-A	99-A	100-A	98	A	-
	5	91-B(1)*	89-B(1,3	89-B(1)*	90	B	TM, H
G	1	85-C(1)*	85-C(1)*	86-C(1)*	85	C	TM
	2	87-B(1)*	91-A	85-B(1,3)*	88	B	TM, S
	3	86-C(1)*	85-B(1)*	88-B(1)*	86	C	TM
	4	95-A	93-A	86-B(1)*	91	B	TM
	5	86-C(1)*	87-C(1)*	86-C(1)*	86	C	TM
H4	1	88-B(4)*	85-C(2)*	85-C(2)*	86	C	D, F
	2	83-C(2)*	81-B	83-C(2)*	82	C	F
	3	85-C(2)*	83-B	85-C(2,4)*	84	C	D, F
	4	84-C(3)*	79-C	86-B	83	C	S, H
	5	81-C(2)*	85-B	77-C(1,2)	81	C	TM, F
H6	1	81-C(1,2)	80-C(2,4)	81-C(2,4)*	81	C	D, F
	2	88-C(2)*	92-B(4)*	91-C(2)*	90	C	F
	3	81-C(4)*	88-C(4)*	81-C(4)*	83	C	D, F
	4	81-S(4)*	83-C(4)*	83-C(4)*	82	S***	D
	5	79-C(4)*	81-C(4)*	77-S(4)*	79	S***	D
I5	1	76-S(1)*	67-S(1)*	73-S(1)*	72	S***	TM
	2	80-C(5)*	80-C(2)*	80-C(2)*	80	C	F
	3	73-C(3)*	66-S(5)*	76-C(1,3)*	72	S***	CT
	4	66-S(2)*	66-S(1,3,5)	66-S(1,3,5)*	66	S***	CT, TM, CB
	5	64-S(2)*	64-S(3,5)	64-S(5)*	64	S***	CT, CB
I6	1	87-S(2)*	92-C(4)*	91-C(4)*	90	S***	F
	2	84-C(2)*	90-B(4)*	87-B(1)*	87	C	F
	3	86-B	87-C(2)*	88-B	87	C	F
	4	90-C(2)*	88-B	87-C(2)*	88	C	F
	5	87-B	86-B	88-B	87	B	-
J5	1	86-C(2)*	84-C(2)*	83-C(2)*	84	C	F
	2	83-C(2)*	88-B	87-C(2)*	86	C	F
	3	81-S(4)*	81-C(2)*	83-C(2)*	82	S***	D
	4	82-C(2)*	84-C(2)*	84-C(2)*	83	C	F
	5	85-C(2)*	81-C(2)*	86-C(2)*	84	C	F
J6	1	96-A	96-A	90-B(1,3)	94	B	TM
	2	95-A	93-A	91-A	93	A	-
	3	89-B	93-A	93-A	92	A	-
	4	87-C(1)*	86-C(1)*	86-C(1)*	86	C	TM
	5	81-C(1)*	92-A	94-A	89	C	TM
K5	1	93-C(2)*	94-A	93-A	93	C	F
	2	92-C(2)*	92-C(2)*	91-C(2)*	92	C	F

*Has a limiting factor: 1 = tenderness, 2 = flavor, 3 = defects, 4 = color, 5 = cut

**TM = tenderness and maturity, F = flavor, S = silk, DK = discolored kernels, H = husk, D = dark (browning), CT = cut, CB = cob

***S = substandard

grades B and C. Only one lot in the commercial packs received a "substandard" grade. This lot, found in CP "F", was limited because of excessive amounts of silk (152 inches) found in one of the cans.

There was considerable downgrading among the experimental packs due to many different factors. For instance, flavor and color problems were found scattered throughout the packs, often occurring together in the same lots. Two lots within EP "H6" and one within EP "J5" received a rating of "substandard" as a result of severe darkening. One can in EP "I6" was limited to "substandard" because of poor flavor. Four of the five lots in EP "I5" resulted in "substandard" grades as a result of a combination of factors including presence of cob, tenderness and maturity deficiencies, and poor cut. The cut of the corn was more nearly like cream style corn than whole kernel and contained large amounts of cob. The "pericarp" or the outer layer of the corn kernel was extremely tough and unpalatable.

The majority of the problems associated with lower grades may have been reduced significantly or even eliminated if the processor would have had an effective quality control program. More stringent control of the processing parameters of cooking times and temperatures, may have improved the quality in the experimental packs to a considerable degree. The processes that are established for the canning of low acid vegetables have a safety factor built in as an extra precaution. The National Food Processors Association (NFPA) has established a compilation of thermal processes for various low acid products. These are given the most stringent tests and are considered to be well within the safety range for protection against the occurrence of "botulism". The tendency for processors to exceed these parameters is not only unnecessary but is destructive to product quality. In commercial practice, processors operate close to the level required for sterilization and very carefully avoid overprocessing.

CONCLUSION

Quality was measured in commercially and experimentally packed freestone and clingstone peaches, pears, green beans, and whole kernel corn. It was assumed that the commercial packs were carefully monitored for quality during processing and that quality assurance on the experimental packs was largely not in force. Objective tests and measurements of quality characteristics were used in the comparisons with some subjective analysis preliminary to assigning grades based on the USDA grading system.

Among clingstone peaches the commercial and experimental packs were not significantly different in can vacuum, headspace, Hunter color values (L, a, and b), pH, pit volume, blemished units, unit weights, and unit hardness. However, experimental packs were significantly lower in quality with regard to drained weights, soluble solids, and peel area. Among the freestone peaches there were major deficiencies in headspace, peel area, and unit hardness among experimental packs. Hard units were also a significant problem in commercial packs.

The commercial pears were of significantly higher quality than those of the experimental packs. Severe quality reduction in the experimental packs resulted from excessive peel, internal stems, and hard units. Other problems included loose seed, pink color (high color "a" values), core material, and low drained weights. Lack of uniformity in size was a problem among most of the experimentally packed pears. This, however, was not a problem with the commercial packs.

In green beans there were few significant problems relating to quality. However, as a general rule, the experimental packs had higher amounts of fiber than the commercial packs, but only exceeded federal limits in one instance. Low drained weights existed among both experimental and commercial packs.

Commercial packs of whole kernel corn were generally of higher quality as compared to the experimental packs. Some of the major factors involved in lowering the quality in experimental packs included flavor, cut, color, tenderness and maturity, presence of cob, and lower drained weights. Can vacuums were generally much better in the experimental packs.

USDA grading demonstrated some significant quality differences between commercial and experimental packs. For instance, due to "limiting factors", final grades that were assigned were generally lower than would have been given based alone on numerical scores. The differences between numerical scores and letter grades were as a rule greater among experimental packs, indicating the great impact of single "limiting factors" on the final grades.

Commercial clingstone peaches were of comparable quality with experimental packs, the average assigned grades at about the B+ level. One experimental lot was limited to "substandard" grade due to excess peel. Grades varied considerably among freestone commercial and experimental packs, the overall grades being slightly higher among experimental packs. Two commercial lots were downgraded to "substandard" grade as a result of hard units. Several lots of freestone experimental packs were downgraded to "substandard" due to either excess peel or hard units.

Commercial pears graded generally in the A category while experimental pears were mostly in the "substandard" area. The severe downgrading among experimental packs came about as a result of several different limiting factors including hard units, internal stems, peel, loose seed, pink discoloration, and core material. In spite of the very low grades among the experimental packs, overall scores were relatively high, generally in the B category.

Green beans were generally graded A among the commercial packs with practically no limiting factors in the grading. Experimental packs were practically all in the B grade category, limited only slightly in grade as a result of fiber content. Otherwise, experimental packs had numerical scores in the A grade category.

Commercial packs of whole kernel corn averaged about a grade B while experimental packs fell slightly below grade C. Those experimental packs receiving a "substandard" grade were limited due to one or a combination of factors including dark discoloration, presence of cob, poor cut, lack of tenderness, and poor flavor.

Most of those factors involved in lowering product quality could have been reduced or eliminated with minimal effort or expense. This in turn would have had a dramatic effect on raising the overall quality and consequent grades of the products.

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QUALITY CHARACTERISTICS OF CANNED FOODS: A COMPARISON OF COMMERCIALLY AND EXPERIMENTALLY PACKED PEACHES, PEARS, GREEN BEANS, AND WHOLE KERNEL CORN

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ABSTRACT

General quality was measured in commercial (CP) and experimental packs (EP) of clingstone and freestone peaches, pears, green beans, and whole kernel corn. CP pears and corn were significantly superior in quality to the EP. EP pears were hard textured and had excessive defects. EP corn had excessive defects and poor flavor and color. EP green beans had more, but not excessive, fiber than CP; otherwise, quality was good. Freestone and clingstone peaches were of comparable quality among CP and EP. Peel and hardness were problems in EP, while hardness was a problem in CP.

USDA grades were also assigned. EP corn averaged below grade C; CP corn averaged grade B. EP corn was limited in grade due to defects, cut, color, and flavor. CP green beans graded A while EP fell to grade B, limited slightly by high fiber content. EP pears graded mostly "substandard" while CP pears graded B+. Both EP and CP clingstone peaches graded B+. Freestone peaches graded C in CP and B in EP. Most grade reductions resulted from single "limiting factors".

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