SURVEY OF THE USE OF PROCESSING WATER IN CANNERIES AND FREEZING PLANTS IN THE WILLAMETTE VALLEY, OREGON

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INTRODUCTION

The history of commercial food canning and freezing in the Willamette Valley indicates that there has been a plentiful supply of water available for use in processing fruits and vegetables. Because of this, the food industry in this area generally has not considered water as a particularly scarce or costly resource. Nevertheless, companies have realized that a saving of money could be made by economizing on the use of water. The over-all picture, however, shows that little attention has been given to methods of saving water. Furthermore, from observing other areas that are more advanced industrially, it is indicated that industries in the Willamette Valley may have to regulate more carefully their use of water if the area continues its present development.

In an editorial printed four years ago in Food Industries (now Food Engineering) (1) the point of water economy was clearly stated: "As a result of waste, plus increasing requirements, the country has been using up its water supply faster than nature has been replenishing it. From the long-range industrial viewpoint, the situation is most serious. Which makes it essential that industries, as well as individuals, conserve water as carefully as they do other valuable materials. Management not only should eliminate wasteful water usage, but should study processes to determine where improved methods or equipment will reduce water requirements."

In an article in Western Industry (2) R. W. Hawksley stated, "Certain West Coast localities are suffering from an increasing scarcity of water. While new sources of water are under study, and being developed, it is probable that a definite policy of water conservation will always be necessary on the Pacific Coast, and particularly so with increasing population and increasing industrial activity."

The National Canners Association has recognized the need for developing a program of water conservation and has done some good work both in surveying the problem in California and working out methods of reusing water in canneries. E. S. Doyle (3) of the Western Branch Laboratory of the National Canners Association, in his survey of water use practices in canneries in California, pointed out the major water uses in canneries and also some of the questions needing answers and some problems to be solved in conserving water. Doyle's results showed that the water consumption in California per $2\frac{1}{2}$ equivalent case varied between 57 gallons and 255 gallons depending on the product packed. He also found that canneries

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varied in their water consumption in packing the same products and indicated that some canneries may be using more water than is necessary.

Mercer and York (4) of the Western Branch Laboratories of the National Canners Association have reported some of their work on methods of re-using water. They developed a water re-use program in canning peas by employing the counterflow principle; that is, the sequence in uses of the water is counter to the movement of the peas along the preparation line. They stated that, "On the basis of the studies discussed, it is reasonable to conclude that re-use of water in accordance with the principles of the counterflow system is not hazardous with respect to deterioration of product quality or can spoilage losses, while it saves up to 50 per cent of the water which would otherwise have been consumed."

The supply of water for processing foods in the Willamette Valley is still sufficient and greater than some other areas but it seems prudent to study the processing needs now rather than wait until the supply becomes critical. Also, data obtained on the water used at the present time for canning and freezing in this area should aid in planning programs for the future.

While there are many reports expressing concern over the increasing use of water it must be remembered that in many instances the same water is used several times--not necessarily in one plant operation but in one watershed. In many agricultural, industrial, and municipal operations the water after being used is returned to the ground or directly to the river from which it was originally drawn.

PROCEDURE AND RESULTS

The area studied was the Willamette Valley in Oregon. Both canneries and freezing plants were visited. The work fell into two main divisions: (1) Visitation of the plant management to obtain answers to general questions concerning water usage and to obtain data on the annual consumption of water for the season of 1952 and the annual pack of that year to make comparisons between plants. The annual water consumption figures were those covering the complete water usage for the year, i.e., water used for all purposes. (2) Visitation during production to actually measure "down the line" the amounts of water being used at different points in the preparation of the product prior to retorting or freezing. No actual water measurements were made on water used in retorting, can cooling, or in the refrigeration systems. The data obtained by actual measurement were concerned only with the preparation of the product.

Every effort has been made to keep the data gathered strictly confidential. At no time during the plant visits were any data of any type carried from one plant into another plant. The data were recorded on individual sheets of paper and later copied into a data book. This confidence will be maintained.

Approximately fifty visits were made to get data, study operations, and check schedules at twenty-five plants in the Willamette Valley. No distinction was made between canning and freezing nor as to the size of the operation at any plant.

1. General survey on water usage.

At the initial plant visit the following questions were asked:

1. What is your source of water?
2. Do you meter it into the plant?
3. In your estimation how much water do you use per commodity packed?
4. Is your water in short supply?
5. Do you make a serious effort to conserve water?
6. Do you have any special water problems?
7. Do you re-use or re-circulate any water in any of your processing operations?
8. Do you have a water cooling tower for product preparation water?
9. Do you have in-plant chlorination?

The tabulated answers to these questions are shown in Table I. There are several points that need clarification and emphasis. Of the 25 plants sampled, 16 buy their total water consumption from the city in which the plant is located. The managers of these plants know exactly how much water they use in the plants every year. The annual water bill for 1952 was obtained from 12 of these plants. The bills varied from $309 to $15,000 with an average for the 12 of $5,148.

Every plant visited indicated a general knowledge of how much water was used per commidity packed by indicating that more water was used for this pack than that pack and during some months more water was used. But only one plant could say specifically that so much water was used for each commodity packed.

Only one plant stated definitely that its water was in short supply, but three others indicated that at times the water pressure was low--one drawing water from its own wells and two from cities. These two were located in different cities.

Seven plants definitely tried to conserve water. Two of these plants stated that they conserve water only at certain times during the season.

Apparently no plant had a continuous, serious water problem.

Slightly more than half of the plants visited (15 out of 25) re-used or re-circulated some of the processing water. All of this re-use was done with make-up of fresh water and almost all was in initial product washing equipment and in fluming operations.

No plant had a water cooling tower from which water was drawn for product preparation purposes (up to freezing or retorting).

Eight of the twenty-five plants used in-plant chlorination equipment.

TABLE I

Answers to Nine Questions Asked of the Management of Twenty-Five Packing Plants and Water Used per Case Packed

Plant code	Question number (See text) 1. Source	2. Meter	3. Amount per product	4. Short supply	5. Con-serve	6. Problems	7. Re-use	8.* Cooling tower	9. Chlori-nate	Water used per case ***
										Gallons
1...	City	Yes	Don't Know	No	No	No	Some	No	No	122
2...	City	Yes	"	No	No	No	No	No	No	77
3...	City & Well	No	"	No	No	No	Some	No	No	
4...	City	Yes	""	**	No	No	No	No	No	185
5...	City	Yes	"	No	Yes	No	Some	No	Yes	246
6...	Wells	No	"	No	Yes	No	Some	No	Yes	
7...	City	Yes	"	No	Yes	No	Some	No	Yes	148
8...	City	Yes	"	No	No	No	Some	No	No	132
9...	Wells	No	"	No	Yes	No	Some	No	Yes	
10..	City	Yes	"	No	No	No	Some	No	No	27
11..	City	Yes	"	No	No	No	No	No	No	51
12..	Wells	No	"	No	No	No	Some	No	Yes	
13..	City	Yes	"	No	No	No	No	No	No	47
14..	City	Yes	"	No	No	No	No	No	No	
15..	City	Yes	"	No	No	No	Some	No	No	70
16..	City	Yes	"	--	Some	No	Some	No	Yes	176
17..	City	Yes	"	**	No	No	Some	No	No	112
18..	Wells	Partial	"	**	No	No	Some	No	No	
19..	City	Yes	"	No	No	No	Some	No	No	54
20..	City	Yes	"	No	No	No	--	No	No	115
21..	Well	No	"	No	No	No	No	No	Yes	
22..	City & Well	Partial	Do Know	No	Yes	No	No	No	Yes	
23..	City	Yes	Don't Know	No	Some	No	Some	No	No	43
24..	City & Well	No	"	No	No	No	No	No	No	
25..	City & Well	No	"	Yes	No	**	No	No	No	
										107 Average

* For water used in preparation.

** Low pressure at times.

*** Gallons of water per equivalent case of $24/2\frac{1}{2}$. Annual water usage compared to annual pack. All commodities.

The last column in Table I shows the annual water consumption compared to equivalent 24/2½ cases total production for the 1952 season. These figures, except in a few instances, are estimated because of the necessity of converting tons of product frozen to cases canned and converting other cases to 24/2½. The average net weight of a case of 24/2½ was used for conversion purposes (5). Standard conversion factors (6) for canned foods were used. There are no significant points brought out by these data other than the variability between the processing plants. As far as is known the quantities of water are normal. Some of the smaller plants, volume-wise, used a large amount of water and some of the larger plants used a relatively small amount of water per case packed. Although it was not specifically calculated from these data, undoubtedly the kinds of products packed by different plants have a bearing on water usage as some products require more water than others.

2. Water used per product packed.

In addition to the plant visits made for general information regarding water, studies were made at different plants during the 1953 season in an effort to obtain specific information concerning the amount of water used at different points in the processing line on different products. These data are shown in Tables II, III, and IV. Several methods were considered for measuring the water at different points. The method used consisted of several containers that had been carefully calibrated as to the quantity of water each held when filled completely. In measuring the water flow at a point in a plant one of these containers, depending on accessibility and quantity of the water flow, was filled and the time recorded by a stopwatch. Generally, several readings were taken at each point. The containers ranged in size from 3.14 gallons to 0.38 gallons. The products covered during the 1953 packing season were canned and frozen green beans and frozen cane berries. A total of twenty processing lines were measured.

In Tables II and III data are present for green beans, canned and frozen, showing the per cent of total water used for different preparation purposes and total gallons of water used per pound of beans processed. Of the five plants canning green beans only one plant (Code E) was out of line as to total quantity of water used per pound of beans. In this plant an excessive amount of water was used for cooling the beans after blanching.

An interesting point brought out by these data and confirmed by unreported data from other plants is that, in general, considerably more water is used in cooling blanched beans for canning than in blanching them. Very little is known about the exact reactions that occur when beans are blanched for canning but it is considered desirable practice to cool them before placing them in the cans. If beans could be placed in the cans at blanching temperature with uniform good quality assured, a large saving could be made--both in water and heat.

In freezing green beans the total gallons of water used per pound of beans processed was generally greater than in canning. This is due to the amount of water used in fluming the beans--in most cases after blanching. However, there were some instances of flumes being used merely for transportation before the beans were blanched.

TABLE II

Per cent of Total Water Used for Different Preparation Purposes and Total Gallons of Water Used per Pound of Beans Processed for Canning

Code	Blanching % of total	Cooling % of total	Dripline % of total	Other % of total	Total Gals. per lb.
A...	1	8	71	20	0.78
B...	12	57	27	4	0.93
C...	10	74		16	0.42
D...	46 (blanching & cooling)	54			0.59
E...	2	95		3	1.97

Average - 0.94 gals./lb.

TABLE III

Per cent of Total Water Used for Different Preparation Purposes and Total Gallons of Water Used per Pound of Beans Processed for Freezing

Code	Blanching % of total	Fluming % of total	Other % of total	Total Gals. per lb.
F...	3	96	1	0.73
G...				2.39
H...	1	87	12	2.24
I...	2	79	19	1.95
J...	6	76	18	2.36

Average - 1.93 gals./lb.

TABLE IV

Gallons of Water Used per Pound of Cane Berries Processed in Preparation for Freezing

Code	Washing	Pkg. washer	Belt washer	Total
A...	.60 gal.			.60 gal.
B...	1.68			1.68
C...	.53			.53
D...	.40			.40
E...	.07	.12 gal.		.19
F...	.65			.65
G...	.94	.29	.03 gal	1.26
H...	.47	.02	.03	.52
I...	.40			.40
J...	.29	.24		.53

Average - 0.68 gals./lb.

Water usage data for frozen cane berries (mainly raspberries) are shown in Table IV. The outstanding point shown is the wide variation in the amount of water used per pound of berries going through the line. Of particular interest are the figures on water used per pound for washing the berries. The extreme variation in the amount of water used for washing berries suggests this question--when is a berry washed clean? Many instances were observed in which the berries were grossly overwashed. Overwashing was effected in some cases by the type of equipment used. However, it is believed that overwashing of the fruit is better than underwashing. Nevertheless, it seems desirable that some standard or objective method of measuring dirt on berries would enable processors to make savings in water used for washing fruits and vegetables by avoiding overwashing.

3. Total water used in the Willamette Valley.

During the 1952 packing season, 9,816,572 equivalent cases 24/2½ basis of fruits and vegetables were canned and frozen in the Willamette Valley of Oregon. The average water usage for that fiscal year (12 months) of 15 plants out of approximately 35 was 107 gallons per equivalent case of 24/2½ (Table I). Using these figures an estimate was made of the total water consumed in that year by the canneries and freezing plants of 1,050,373,204 gallons or 140,405,400 cubic feet.

In comparison it has been stated (7) that the amount of water required by moderately large cities that are not highly industrialized is 100 gallons per capita per day. Using this figure, the amount of water used by the canneries and freezing plants in the one year would be about the same as that used annually by a city with a population of 30,000.

SUMMARY

1. Twenty-five canning and freezing plants in the Willamette Valley of Oregon were surveyed in an effort to determine water use practices.

   a. Sixteen of these plants bought their total water consumption from the city in which the plant was located.
   b. The annual cost for total water for 1952 of twelve of these plants varied from $309 to $15,000 with an average cost of $5,148.
   c. The management of only one plant knew how much water was used specifically for each commodity packed.
   d. Water was in short supply at only one plant.
   e. Fifteen plants re-used or re-circulated some of the product preparation water.
   f. Eight plants used in-plant chlorination equipment.
   g. The individual total annual water consumption of fifteen plants was compared to the annual production of each respective plant in 1952 of equivalent 24/2½ cases. Gallons of water per equivalent 24/2½ case varied from 27 to 246 gallons with an average of 107 gallons consumed in the plant for all uses and commodities packed per equivalent case of 24/2½.

2. Actual measurements of the amount of water used at different points "down the line" in seventeen plants were made on ten green bean processing lines (5 freezing and 5 canning) and ten cane berry processing lines.

No water measurements were made on water used in retorting, can cooling, or in the refrigeration systems. The data obtained by actual measurement were concerned only with the preparation of the product.

a. The average total amount of water used in the preparation of green beans for canning was 0.94 gallons per pound whereas for freezing preparation it was 1.93 gallons per pound.
b. The average total amount of water for preparation of berries was 0.68 gallons per pound. In water used for washing berries a tremendous variation was found. The range was from 0.07 to 1.68 gallons of water per pound of berries washed.

3. During the 1952 packing season 9,816,572 equivalent cases 24/2½ basis of fruits and vegetables were canned and frozen in the Willamette Valley of Oregon. The average water usage for that fiscal year (12 months) by 15 plants out of approximately 35 was 107 gallons per equivalent case of 24/2½. Using these figures an estimate was made of the total water consumed in that year by the canneries and freezing plants of 1,050,373,204 gallons.

SUGGESTIONS FOR CONSERVING WATER

In all of the plants visited it seemed that there were many obvious ways to save water. However, the greatest obstacle to making this saving was the apparent belief by the people in the plants that it was unnecessary. At the present time there seems to be plenty of water available generally. But it is the belief of many persons concerned that the supply of water in this area is being depleted. Even if the supply was limitless a monetary saving could be made. Suggested ways of saving water are:

1. Survey all operations from the viewpoint of saving water. Tabulate and know exactly how much water is being used per commodity packed.
2. Use water sprays for cooling blanched vegetables and mechanical conveyors for transporting them.
3. Install automatic temperature control valves on can coolers in open cookers and retorts so that an operator may do other things while the water would automatically cut off at proper can temperature.
4. Re-circulate water in some types of equipment.
5. Consider the cost of installing a water cooling tower against the increased efficiency of cool water.
6. Consider the advantages of using in-plant chlorination of water in water re-use programs.
7. Re-use water for flushing gutters and for other purposes where it has been proved safe to do so.

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FIELD BEHAVIOR AND PROCESSING CHARACTERISTICS OF BLUE LAKE BEANS

By

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The processing of green beans is one of the major activities of the food processors of Oregon. In Oregon some 3,192,000 cases of 24 No. 2 cans of canned green beans were packed during the 1952 season. During this same period, some 23,000,000 pounds were processed as a frozen product in Washington and Oregon. The continued research in developing new varieties particularly adapted to environmental conditions in the Northwest make it mandatory that the quality evaluation of the new processing varieties be made before release of the planting stock to growers. New varieties are also produced by commercial seedsman and these must likewise be subjected to quality evaluation. This report gives the results of the quality evaluation of six varieties of green beans packed as a canned and frozen product during the 1953 season.

EXPERIMENTAL

A. Raw Product

The varieties of beans included in the test were: (1) Associated 92, (2) Associated 231, (3) F. M.-1, (4) Germain 21, (5) U.S.D.A. 2006 and (6) U.S.D.A. 2053. The source of these varieties were respectively: (1) and (2), Associated Seed Co., (3) Ferry-Morse Seed Co., (4) Germain Seed Co., (5) and (6) B. F. Dana, Oregon State College.

These varieties were planted May 13, 1953 at the Beech Farm of the Department of Horticulture. The plots were 24 feet long and arranged in a 6x6 Latin Square design. Thus each variety was replicated six times. The plants were thinned to 3.5 plants per foot of row except F.M.-1, which was thinned to 2.3 plants per foot of row. At the time of planting, the plots were fertilized at the rate of 550 lbs./acre with 10-16-8 applied in a band 1½ inches to the side of and 2½ inches deeper than the seed. The plots were side dressed with 200 lbs. per acre of ammonium nitrate on July 22, 1953. They were irrigated at approximately 7-day intervals.

The plots were harvested at the intervals outlined in Table 1. After harvest the beans were brought into the laboratories of the Department of Food Technology and graded into sieve sizes 1 and 2's, 3's, 4's, 5's and 6's and over.

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For the processing evaluation sieve size 3's and the combined group of size 4's and 5's were selected and kept separate throughout the remainder of the study.

B. Processing Technique

After the lots were snipped and cut into 1" lengths, they were placed on stainless steel wire trays and steam blanched 3 minutes. After blanching, the beans were water spray cooled and the lot equally divided for canning and freezing tests.

For the canning tests, the cut and blanched beans were filled into plain 301 x 411 cans to 9 oz. net weight. One 30-grain salt tablet was added, the container filled with water and exhausted 8 minutes at 190°F. After sealing, the cans were processed 20 minutes at 240° F., water cooled and stored until later examination.

For the freezing evaluation, the blanched and cooled beans were filled into cellophane inner-liners, the liner sealed and inserted into a Marathon No. 5 carton and the product frozen at -20° F. over night and then transferred to 0° F. storage until examined.

C. Processing Characteristics Evaluated

1. Color

The color of each lot of beans was measured after blanching by the use of the Hunter Color Difference Meter. In the use of the instrument, a clear plastic sample box was used which permitted one to make 5 readings. The 5 readings were averaged and recorded. The beans were placed in the box, at random, the interstices filled with water and the Hunter Rd, a and b readings obtained after prior standardization of the instrument to the values for the SKC-15 "Kitchen Green" color plaque supplied by the National Bureau of Standards.

The color of each lot of canned or frozen beans was measured in a like manner except that, in the case of canned beans, the interstices were filled with the liquid contents of the container. Water was used to fill the interstices of the frozen beans. The color readings were determined after thawing of the frozen beans. Thawing techniques are described in the section under Shear Press determinations.

2. Crude Fiber

Crude fiber determinations were made on the canned product only. The determination was made approximately 2 months after processing and consisted of crushing 100 gms. of deseeded pods in a mortar. To the crushed pods were added 200 mls. of hot water and the contents transferred to a malted milk cup. After heating to boiling, 25 mls. of 50% NaOH were added and boiling continued 5 minutes. The cup was then transferred to the malted milk mixer and mixed 5 minutes. The contents of the mixer were then poured onto a tared 30-mesh Monel screen and washed with water at a standard pressure until free of alkali. The screen was dried at 212° F. for 2 hours and re-weighed. The gain in weight was recorded as per cent crude fiber.

3. Per cent Seed

The seed percentage data are based upon the weight, as per cent, of the seed extracted from 100 gms. of pods.

4. Shear Press Determinations

Shear press determinations were made on both the canned and frozen product. The Maryland Shear Press was utilized yielding shear press values in Kgs. per square inch. The determination was made by pouring 150 gms. of beans into the cup and lightly pressing them down in such a manner as to assure that the ends of the beans did not stick out of the cup. The shear press was operated in the usual manner. Shear press determinations were made on the canned beans soon after opening. The frozen beans were thawed in 250 mls. of boiling water. When the water had come to a boil, the frozen beans were inserted and cooked 8 minutes after the water had returned to a boil. The beans were then cooled at 34° F. before shear press readings were obtained.

5. PMA Grading

Approximately 2 months after processing the canned and frozen samples were graded by PMA officials at Salem. The samples were given random numbers to conceal their identity. The canned samples were graded for clearness of liquor, color and maturity. Frozen beans were graded for color and "texture and maturity".

DISCUSSION OF RESULTS

A. Field Behavior

Yield, sieve size, and maturity data for the Blue Lake type beans grown at the O.S.C. vegetable farm are shown in Tables 1 and 2. The six varieties listed in Tables 1 and 2 were grown in a well replicated test, so that careful comparisons of data on yielding ability are possible.

1. Yield

The varieties 2006 and 2053 developed by Mr. B. F. Dana, of the U.S.D.A. in cooperation with the Oregon Agricultural Experiment Station, gave the heaviest total yields, as they have done in previous tests at this location. As shown in Table 1, there was no significant difference in total yield of FM-1, Asgrow 92, and Asgrow 231. Since the stand of FM-1 was 2.3 plants per foot, compared to 3.5 plants for other varieties, it would be purely speculative as to whether a thicker stand of the variety would have resulted in distinctly heavier yields. The stand count for FM-1 was made at the end of harvest, since plants continued to come up throughout the summer. Many of these came up so late that they obviously contributed little to the yields.

2. Earliness

The yield data for various harvest dates in Table I indicate that Asgrow 92 is as early or earlier than FM-1. Actually, this is not the case and is due to the erratic, prolonged, germination of FM-1 seed. For plants germinating on the same date, maturity of FM-1 appears to be slightly earlier. Both are a few days earlier than Germain 21, and roughly 10 days earlier than Asgrow 231. The two U.S.D.A. varieties were slightly earlier than 231.

3. Vine Characteristics

Both Asgrow 92 and FM-1 are relatively "open" at the base and light in foliage production compared to Asgrow 231 and U.S.D.A. 2006 and 2053. Germain 21 is intermediate in this characteristic.

4. Continued Production

Asgrow 231 and U.S.D.A 2006 and 2053 tended to "concentrate" their pod set, with the crop maturing over a relatively short period. Asgrow 92 may mature the crop over a longer period, under favorable conditions, while FM-1, during 1953, produced pods over a longer period than any other variety. Here again, however, it is felt that the prolonged germination period and wider spacing of plants within the row influenced this characteristic. With more uniform germination and closer spacing in the row, one should expect to see some change in this characteristic, although the variety appears to hold up over a relatively long period.

5. Germination

Germination of all varieties was satisfactory, with the exception of FM-1. Low germination was not due to non-viable or "dead" seed, but to their inability to take up moisture. This "hard" seed develops within this particular variety under distinctly low humidity storage conditions, but can be overcome by storage at relatively high humidity. There is thus reason to expect that with more favorable storage of seed the variety will show better germination in 1954.

6. Pod Characteristics

The grade-out data in Table II show that Germain 21 produced a relatively low percentage of large sieve size beans. This is due at least partly to its slightly oval shape. All of the other varieties are round. The U.S.D.A. varieties 2006 and 2053 graded out moderately heavy in 5 and 6 sieve sizes, as they have done in past tests.

Asgrow 92 has a distinctly dark green pod, while FM-1 is darker than the U.S.D.A. varieties. Germain 21 raw pod color appeared to be slightly lighter than FM-1.

B. Evaluation of Processing Characteristics

The results of the processing quality evaluation are presented in Table III.

1. Color

In the concept of color, the dominant factor with respect to lightness or darkness is Rd. The location of the sample with respect to color is concerned with the ordinates -a and +b in the case of beans. Thus, a particular locus, as determined by -a and +b values, may appear light or dark as influenced by the Rd. Increasing values of Rd represent a shift toward lightness. Increasing of -a values, a shift toward less yellow, more green and increasing concentration; while increasing values of +b denote a shift toward

more yellow, less green while tending to hold the concentration or saturation level of the color rather constant. Thus the hue and chroma of the product is rather closely defined by the Hunter a and b value while the lightness or darkness of the color is defined by the Hunter Rd value.

2. Hunter Rd, for Freshly Blanched Beans

In size 3's, Associated 92 was the darkest variety. F.M.-1 and Associated 231 were in the second position while Germain 21, USDA 2006 and 2053 were the lightest colored. The difference between the varieties levels out with increasing maturity as evidenced by the breakdown of color groups in size 4-5's. In this size classification there are two broad groups with respect to Hunter Rd. In the darker group, Associated 231, Associated 92, and F.M.-1 are observed Germain 21 and the two USDA varieties are considerably lighter, not different from one another but are significantly lighter than the balance of the varieties at the 5% level.

3. Hunter -a, for Freshly Blanched Beans

Increasing values in Hunter -a indicate a slight shift away from yellow toward green. This is not to be construed as a radical shift in apparent color as the dominant factor in the concept of color is the Rd value. These data (Table III) indicate that there are three groups with respect to increasing Hunter -a values irrespective of size classification. The low value group includes F.M.-1 and Associated 92. In the medium value group are to be found Associated 231 and Germain 21. The higher value group included the two USDA selections. These classifications are significant at the 5% level.

4. Hunter +b, for Freshly Blanched Beans

Hunter +b indicate a slight shift toward yellow. Observe that this is diametrically opposed to the shift in Hunter -a values. These shifts tend to neutralize one another yielding to the dominant factor Hunter Rd. In this factor, irrespective of classification there are 4 groups each significantly different from one another. In order of increasing Hunter +b values, the varieties may be grouped as follows: group 1, Associated 92; group 2, F.M.-1; group 3, Associated 231 and Germain 21, and group 4, USDA 2006 and 2053.

5. Hunter Rd, Canned Samples

As observed in Table III, size 3 classification, there are three major groups in order of increasing Rd or lightness. In the darker group Associated 231 and 92 are observed. Significantly lighter was F.M.-1 while Germain 21 and the two USDA selections were the lightest of all. In the size 4-5's the arrangement of the varieties with respect to lightness or darkness is somewhat revised, indicating a shift of the apparent color due to increased maturity. In this size group are observed 4 color classifications all significantly different: group 1, Associated 92, the darkest; group 2, Associated 231 and F.M.-1; group 3, USDA 2006; and group 4, the lightest, Germain 21 and USDA 2053.

6. Hunter -a, Canned Samples

In size 3's, there were two general groups which were significantly different. In the first group, those with a lower Hunter -a value, were

Associated 231 and 92, while in the second group the remainder of the varieties in the test are to be found. The grouping is slightly more distinctive with increasing maturity as evidenced by the data for the larger sizes. In size 4-5's, Associated 92 and 231 had the lowest value, F.M.-1 was the next highest, Germain 21 and USDA 2006 in the third position, while USDA 2053 had the highest value.

7. Hunter +b, Canned Samples

In size 3's, Associated 231 and 92 had the lowest value and were not significantly different. F.M.-1 was significantly different from Associated 92 but not from Associated 231. Germain 21, USDA 2006 and 2053 were not significantly different but as a group were significantly different in that they had higher values from the balance of the varieties in the test. These same relationships hold true in the larger sizes.

8. Per cent Seeds

In size 3's, Associated 92 and F.M.-1 had the lowest percentage of seed and were not significantly different. F.M.-1, Associated 231, USDA 2006 and 2053 were not significantly different but did have a significantly lower seed percentage than Germain 21. F.M.-1, Associated 92 and the two USDA numbers were not significantly different in the larger size. Associated 92 was significantly different from Associated 231 but the latter variety was not significantly different from F.M.-1 or the two USDA varieties. Germain 21 was in a class of its own with the highest seed percentage 5.32%. Evidently this variety matures its seed at a much faster rate than the other varieties in the test and in the large size classification segmentation was evident. Note the large increase in seed percentage between size 3's and the 4-5's for this variety in contrast with the small increase for Associated 92.

9. Per cent Fiber

There was no significant difference between varieties in either of the size classifications with respect to fiber. All of the varieties had a low fiber content and it may be concluded on the basis of this test that the newer Blue Lake varieties have low fiber content.

10. Shear Press, Canned Samples

At the 5% significance level, there was significant difference between two groups of the varieties on the basis of the shear press values. In the lower reading group, Associated 231, USDA 2006 and 2053 were found. A second group comprised the balance of the varieties and these in addition to Associated 231 were significantly different from the two USDA selections at the 5% level. In the larger sizes the difference in shear press values leveled out and there was no significant difference between any of the varieties with the exception of Germain 21 which had a significantly higher shear press value in these larger sizes.

11. PMA Color Score, Canned Samples

F.M.-1 and Associated 92 had the highest PMA color score in the smaller size and together with Associated 231 were significantly higher than the balance of the varieties. USDA 2006, Germain 21 and Associated 231 had

higher scores, significant at the 5% level, as compared with USDA 2053. In the larger sizes, Associated 92, 231 and F.M.-1 received significantly higher scores than the balance of the varieties. USDA 2053 received the lowest score, 12.67, which was not significantly different from that score received by USDA 2006 but was different from that score received by the other light colored bean, Germain 21.

12. PMA Maturity Score, Canned Samples

In size 3's, there was no significant difference between any of the varieties in the test. In the larger size, USDA 2006 and 2053 had significantly lower scores than the other varieties.

13. Hunter Rd, Frozen Samples

There was no significant difference between the two USDA selections which had the highest Hunter Rd reading in size 3's. These two varieties were significantly lighter than the other light colored bean, Germain 21. Associated 92 was significantly darker than any of the other varieties in the test. There was no significant difference between F.M.-1 and Associated 231. In size 4-5's combined, the two USDA selections were lighter than any of the other varieties in the test. Germain 21 was significantly darker than the USDA selections but lighter than Associated 231. There was no significant difference between Associated 92 and F.M.-1. These varieties were the darkest frozen beans.

14. Hunter -a, Frozen Samples

In size 3's, Associated 92 and F.M.-1 had a significantly lower reading than Germain 21 or Associated 231. The two USDA selections were not significantly different from each other but had the highest value in the test. In size 4-5's, there was no significant difference between F.M.-1 and Associated 92 but each of the other varieties were significantly different from each other. The two USDA selections had the highest Hunter -a value.

15. Hunter +b , Frozen Samples

Associated 92 had a significantly lower reading than any of the other varieties in size 3's. Associated 231, Germain 21 and F. M.-1 were not significantly different and as a group had significantly lower readings for this color ordinate than the two USDA selections.

16. Shear Press, Frozen Samples

There was no significant difference between the varieties in size 3's. In size 4-5's, two large groups were observed. Those varieties with lower readings included Associated 231, USDA 2006 and 2053. The varieties with the higher readings included Associated 92, Germain 21 and F.M.-1. Associated 231 had a significantly lower reading than any of the varieties in the high reading group, but it was not different from those in the lower group.

17. PMA Color Score, Frozen Samples

There was no significant difference between the samples in size 3's. In the larger sizes, Germain 21, F.M.-1, USDA 2006 and 2053 received

significantly lower scores than Associated 231. Associated 92 was not significantly different from any of the varieties except Associated 231 which received a higher score and F. M.-1 which received a lower score.

18. PMA Texture and Maturity Score, Frozen Samples

There was no significant difference between the varieties in size 3's. In size 4-5's, USDA 2053 was not significantly different from F.M.-1 but it did receive a significantly lower grade than any of the other varieties in the test. F. M.-1 was not significantly different from the other varieties which received high scores with the exception of Associated 92 which received the highest score in the series.

C. Change in Hunter Color Reading as a Result of Inter-Relationships of Varieties and Processing.

During heat processing or freezing processing of beans a change in color occurs. The extent of such changes is indicated in the following section.

1. Hunter Rd values

The average canned Hunter Rd values for each of the six varieties in the test were compared against the value for freshly blanched beans. An increase in Hunter Rd (blanched to either process) represents an increase in the lightness of the product. Inspection of the data in Table IV, Hunter Rd readings, shows that the varieties Associated 231 and 92, in size 3's, were not significantly different with respect to the extent of increased Rd due to canning. There was no significant difference in the change of Rd due to canning among the other varieties in the test but it must again be emphasized that the Associated varieties had a significantly smaller change when compared to the balance of the varieties.

In the change in Rd from freshly blanched to frozen, size 3's, Germain 21 darkened more than any of the other varieties in the test, however the extent of decrease in Rd was not significantly different from the Associated varieties. F. M.-1 and the two USDA varieties were not significantly different from each other.

In size 4-5's, there was no significant difference in the way the varieties reacted during processing to the change in Rd.

2. Hunter -a values

The change in Hunter -a values as a result of canning was significantly larger in USDA 2006 than in F. M.-1 and Associated 92 in the size 3, and 4-5 classification. When one observes the loci of these Hunter values on the color ordinates for the Hunter Rd in question, it is to be noted that as a result of the canning operation there is a shift toward yellow in the hue of the product. The shift is much greater from freshly blanched to canned than that which occurs in the freezing preservation of the product.

No significant differences could be shown in the way the varieties reacted to the freezing preservation.

3. Hunter +b values

There was no significant difference in the way the varieties reacted with respect to the shift in Hunter +b values.

SUMMARY AND CONCLUSION

In the replicated tests, Associated 92 was superior to the other varieties in the canned pack. F. M.-1 and Associated 231 were also good but the former variety was troubled by poor germination while the latter had a flat yellow mutant which caused excessive pick-out on the belt.

There were two classifications of beans based upon the color of the canned product. In the first or light varieties, Germain 21 and the two USDA varieties were considered to be inferior to the balance of the varieties. Germain 21 also had a low yield, however, it scored well in PMA grading despite the high pe centage of seed in the product. The two USDA selections, despite their high yield, were too light in color and were rated lower in PMA color and maturity scor

When frozen, Associated 92 and 231 received high PMA color scores, but the former variety was considerably darker. It is believed that the variety may be too dark and its lack of luster resulted in grading to the same level as Associated 231 even though 231 was considerably lighter in color. F. M.-1 was graded down in color due to lack of uniformity. As far as PMA color was concerned the only real difference was between USDA 2053 and F. M.-1 as compared with the balance of the varieties. With respect to PMA maturity USDA 2053 graded significantly lower than the other varieties.

The concept of the change in color as result of canning or freezing disclosed that the change in Hunter color classifications is not only the result of processing, but that the varieties react somewhat differently. The calculation of the reaction of varieties to processing with respect to color show that:

1. The general lightening due to canning was modified by variety.

2. The general darkening due to freezing was modified by variety only in size 3 classification.

3. The decrease in Hunter -a value due to both canning and freezing was very great. There were some significant differences in changes in Hunter -a readings of the varieties, but these differences were minor in comparison with the change brought about by processing.

4. The general increase in Hunter +b readings brought about by canning was modified slightly by varieties in either size groups.

5. The change in Hunter +b due to freezing was minor and not significantly modified by variety.

Table I

Blue Lake Variety Behavior
Corvallis, 1953
Yields at Various Harvest Dates

Variety	Yield in Tons Per Acre at Each Harvest Date							Per Acre Yield
	Aug. 5	Aug. 10	Aug. 13	Aug. 19	Aug. 24	Aug. 31	Sept. 3	Total
FM-1	1.24	1.10	0.70	2.85	1.42	1.89	1.25	10.45
Asgrow 92	1.31	2.26	1.06	3.58	1.23	0.89	----	10.33
Germain 21	----	1.97	0.78	2.47	1.67	1.98	----	8.87
Asgrow 231	----	----	1.27	4.65	2.21	2.08	----	10.21
U.S.D.A. 2006	----	----	3.27	3.62	3.30	2.03	----	12.22
U.S.D.A. 2053	----	----	3.63	3.31	3.29	1.55	----	11.78

Significant Difference, odds 19:1	1.03
Significant Difference, odds 99:1	1.41

Table II

Blue Lake Variety Behavior
Seasonal Averages for Various Sieve Sizes
Corvallis, 1953

Variety	Per Cent of Beans in Various Sieve Sizes					Total Yield
	1 & 2	3	4	5	6 & over	Tons per Acre
FM-1	14.24	21.04	24.65	22.50	17.57	10.45
Asgrow 92	8.93	19.08	27.23	27.70	17.06	10.33
Germain 21	13.21	26.18	29.46	21.59	9.56	8.87
Asgrow 231	9.55	17.12	25.89	26.52	20.92	10.21
U.S.D.A. 2006	8.34	15.88	24.86	29.25	21.67	12.22
U.S.D.A. 2053	8.04	14.97	24.50	29.21	23.28	11.78

Least significant difference, odds 19:1 1.03

Least significant difference, odds 99:1 1.41

Table III. Quality of Pole Bean Varieties in Replicated Plots--1953

Variety and Season	FRESH Hunter Blanched Rd	FRESH Hunter Blanched -a	FRESH Hunter Blanched +b	CANNED Hunter Rd	CANNED Hunter -a	CANNED Hunter +b	CANNED Seed %	CANNED Crude Fiber %	CANNED S.P.[1] Kgs.	CANNED PMA Scoring C[2]	CANNED PMA Scoring M[3]	FROZEN Hunter Rd	FROZEN Hunter -a	FROZEN Hunter +b	FROZEN S.P.[1] Kgs.	FROZEN PMA Scoring C[2]	FROZEN PMA Scoring T&M[4]
SIEVE SIZE 3'S																	
Asso. 231 Med.late	7.01	13.59	10.92	7.72	4.56	12.96	2.91	0.0131	25.25	14.33	38.67	6.27	8.45	10.89	50.54	19.08	38.50
Germain 21 Med.early	7.95	13.68	11.31	9.16	5.18	14.36	3.47	0.0133	27.17	14.00	38.75	6.83	8.06	11.06	52.46	18.08	38.42
F. M.-1 Early	6.89	12.71	10.43	8.33	5.10	13.41	2.65	0.0106	27.25	14.58	38.92	6.45	7.52	10.84	54.66	18.08	38.92
Assoc. 92 Early	6.38	12.43	9.58	7.32	4.67	12.38	2.33	0.0112	27.40	14.58	38.92	5.65	7.31	9.55	51.66	18.33	38.92
USDA 2006 Med.late	7.66	14.65	11.90	9.03	5.33	14.24	2.91	0.0103	23.17	13.83	38.42	7.37	9.60	12.40	46.87	18.75	38.50
USDA 2053 Med.late	7.68	14.20	11.86	9.09	5.26	14.29	2.81	0.0108	23.17	13.58	37.75	7.37	9.19	12.14	48.16	18.66	38.33
L.S.D.(.05)	0.44	0.75	0.48	0.54	0.40	0.78	0.45	N.S.	2.68	0.50	N.S.	0.49	0.54	0.33	N.S.	N.S.	N.S.
SIEVE SIZE 4-5'S																	
Asso. 231 Med.late	7.38	13.75	11.53	8.42	4.86	13.58	3.94	0.0130	26.58	14.00	37.50	7.21	8.77	11.91	44.71	18.83	37.83
Germain 21 Med. early	8.33	14.13	11.88	10.28	5.66	15.36	5.32	0.0180	29.17	13.42	37.42	7.82	8.26	12.20	48.58	18.08	37.67
F.M.-1 Early	7.13	12.73	10.70	8.68	5.17	13.93	3.55	0.0120	26.79	13.92	37.36	6.32	7.54	10.67	51.29	17.58	37.33
Asso. 92 Early	6.92	12.41	10.00	7.83	4.81	13.15	3.01	0.0152	25.79	14.33	37.50	5.94	7.53	10.21	52.00	18.33	38.08
USDA 2006 Med.late	8.63	15.26	13.24	9.60	5.53	14.89	3.51	0.0177	26.20	13.00	36.58	8.46	9.90	13.37	46.12	18.17	37.75
USDA 2053 Med.late	8.26	14.99	13.16	10.30	6.03	15.50	3.40	0.0142	24.38	12.67	36.75	8.38	9.59	13.39	42.96	17.92	36.92
L.S.D.(.05)	0.41	0.74	0.58	0.40	0.38	0.44	0.67	N.S.	2.74	0.46	0.62	0.44	0.14	0.56	4.90	0.67	0.71

1. Shear press Kgs.
2. Color
3. Maturity
4. Texture and maturity

Replications consisted of two harvest dates from single plots.

Table IV. Changes in Hunter Rd, -a, +b Values of Beans as a Result of Processing

HUNTER Rd

Variety	Hunter Rd, Size 3's		Hunter Rd, Size 4-5's	
	Fresh to Canned	Fresh to Frozen	Fresh to Canned	Fresh to Frozen
Assoc. 231	+0.71	-0.74	+1.04	-0.17
Germain 21	+1.21	-1.12	+1.95	-0.51
F. M.-1	+1.44	-0.44	+1.55	-0.81
Assoc. 92	+0.94	-0.73	+0.91	-0.98
USDA 2006	+1.37	-0.29	+1.07	-0.17
USDA 2053	+1.41	-0.31	+2.04	-0.12
L.S.D. (.05) = .69			L.S.D. (.05) = 1.29	

HUNTER a

Variety	Hunter -a, Size 3's		Hunter -a, Size 4-5's	
	Fresh to Canned	Fresh to Frozen	Fresh to Canned	Fresh to Frozen
Assoc. 231	-9.03	-5.13	-8.89	-4.98
Germain 21	-8.50	-5.62	-8.47	-5.87
F. M.-1	-7.61	-5.19	-7.56	-5.19
Assoc. 92	-7.76	-5.12	-7.60	-5.88
USDA 2006	-9.32	-5.05	-9.73	-5.38
USDA 2053	-8.94	-5.01	-8.96	-5.40
L.S.D. (.05) = 1.50			L.S.D. (.05) = 2.11	

HUNTER b

Variety	Hunter +b, Size 3's		Hunter +b, Size 4-5's	
	Fresh to Canned	Fresh to Frozen	Fresh to Canned	Fresh to Frozen
Assoc. 231	+2.04	-0.03	+2.05	+0.38
Germain 21	+3.05	-0.25	+3.48	+0.32
F. M.-1	+2.98	+0.41	+3.23	-0.03
Assoc. 92	+2.80	-0.03	+3.15	+0.21
USDA 2006	+2.34	+0.50	+1.65	+0.13
USDA 2053	+2.43	+0.28	+2.34	+0.23
L.S.D. (.05) = 1.43			L.S.D. (.05) = 1.83	