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Title QUALITY EVALUATION OF CANNED WHOLE KERNEL CORN GROWN IN OREGON.

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Abstract approved

(Major Professor)

The purpose of this work was to analyze whole kernel corn for such factors as succulence, pericarp content and size of kernels and to check for possible relationships between these values and the subjective tests for tenderness and maturity and flavor.

In addition the purpose of this investigation was to accumulate values for succulence, pericarp content and kernel size for sweet corn grown in this area.

All varieties were harvested in August 1952, when their moisture content was close to 70 per cent. Succulence of this canned corn ranged from 24.7 to 15.2 ml. for 17 varieties; and the six varieties recommended ranged from 24.7 to 22.8 ml.

Pericarp content was determined by the standard method, and it was found to be very low when compared with similar data from other sections of the country. Values ranged from 0.6230 to 1.1951 per cent, and the six best varieties recommended for all factors together, from 0.6230 to 0.7872 per cent.

The largest diameters in inches of twenty kernels were measured with a micrometer. Size ranged from 7.0685 to 8.5005 inches for twenty kernels. The same six best varieties ranged from 7.0685 to 7.8730 inches.

In addition to these three objective tests a panel of seven members graded this corn for maturity and tenderness on a basis of forty points, and flavor on a basis of twenty points. For maturity and tenderness all varieties lie between 37.1 and 26.4, with the six varieties recommended between 37.1 and 35.7. For flavor the range for all varieties is from 17.6 to 13.3. The same six varieties are from 17.6 to 15.7.

Results show that the combination test proposed by Kramer can be applied successfully, and that pericarp content can be omitted in this combination test for corn grown under irrigation in this part of the country. In fact, succulence and kernel size predicted maturity with a multiple correlation of 0.936.

QUALITY EVALUATION OF CANNED WHOLE KERNEL CORN GROWN IN OREGON

by

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QUALITY EVALUATION OF CANNED WHOLE KERNEL CORN GROWN IN OREGON

CHAPTER 1

INTRODUCTION

This work was undertaken, after a need was recognized, to determine scientifically the best varieties of corn adapted to Oregon growing conditions. Practically all the work, with objective tests, for the determination of quality in canned whole kernel corn, has been done in Maryland and Minnesota. The literature reports only one article on corn grown in Idaho. Variables, like climatic and soil conditions between these states and the Willamette Valley, can influence appreciably the desirability of a variety of corn. This problem appears more urgent than ever when we observe the increasing quantities of corn canned in Washington and Oregon since 1938:

Year	Cases
1938	309,690
1939	230,365
1940	346,264
1941	655,492
1942	836,372
1943	1,069,916

1944	1,346,040
1945	915,702
1946	1,210,522
1947	1,721,644
1948	1,677,211
1949	2,193,674

This research deals with seventeen varieties of yellow sweet corn. Some of these varieties are quite popular, while some others are practically unknown.

Many variables, such as variety differences, soil conditions, mean temperature, maturity, color, pericarp content, flavor, etc., are responsible for the quality of the final product. This work deals with the determination of succulence, pericarp content, and size of the kernels and relationships between these factors and the evaluation of maturity and flavor. This evaluation was carried out by a panel of seven competent tasters who graded these varieties of corn in accordance with the descriptions of maturity and tenderness and flavor for United States grades (Production and Marketing Administration).

The literature of the past thirty years contains quite a few objective tests for determination of maturity. Succulometer was found to be one of the most desirable, due to its high correlation with organoleptic tests, and also, to its simple operation.

All methods for pericarp content determination have the same principle. The new ones are only slight modifications of the original one. Determination of the size of the kernels is something rather new. The advantage of these tests, in determining the quality of corn, is that they are objective. This means, they can be duplicated anywhere by a careful laboratory technician after proper training.

CHAPTER 2

REVIEW OF LITERATURE

According to Kramer (24, p. 6), quality of food is 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 user. The characteristics of quality are determined by the human senses of sight, taste and smell, and feel. Therefore, they are classified in three general categories: appearance, flavor, and kinesthesis. This last characteristic is defined as the muscle sense, or the sense of feel, and would include characteristics of quality which are frequently described by such terms as firmness, tenderness, crispness, fibrousness, grittiness, hardness, mealiness, juiciness, succulence, texture, and also thickness, mushiness, and sensations of heat or cold.

The standard system gives the desired weight to various factors which indicate that one can of corn is more desirable than another one. This is the Production and Marketing Administration grading system for this particular product. After all, is not the profit per case directly proportional to the grade of the final product? This grade is determined as follows:

Color	10 points
Maturity and tenderness	40 "
Absence of defects	20 "
Cut	10 "
Flavor	20 "

In this grading system, "maturity and tenderness" are given the highest rating.

The variety factor, together with climatic considerations, has been regarded as of great importance in determining the quality of the canned corn. Other important factors are stage of maturity, the promptness in handling after harvesting, the pericarp content, color, flavor, etc. According to Culpepper and Magoon (8, pp. 403-443), the most prominent factor seems to be the maturity of the corn at the time of harvesting, which influences the condition of the carbohydrates, the delicacy of flavor, and the toughness of the kernels. They believe that toughness of kernel is very important. Immaturity is sometimes masked in the canned corn, in part at least, by the addition of starch, and too heavy consistency, due to the use of overmature corn, is often avoided by the use of a greater proportion of liquor; but general toughness cannot be masked, and it is this more than anything else which unfavorably affects the quality of canned corn.

Culpepper and Magoon (8, pp. 403-443) state that the thumbnail test may be applied with considerable accuracy in

judging the maturity of a single strain with which the person making the test is familiar. Results may be rather inaccurate if the person has to judge different varieties, and even different strains, as is the case for most field men. For instance, Crosby corn at the 20-day stage, by the thumbnail test, would have been judged to be at about the same stage of maturity as Stowell's Evergreen at the 25-day stage, but the chemical analysis showed that they were far from having the same composition, particularly with respect to sweetness.

The succulometer is an instrument for measuring the maturity of raw and canned whole kernel corn. It was introduced in 1946 by Kramer (18, pp. 11-13). Succulence, as determined by the succulometer, simulates the amount of juice that is squeezed out of the food during mastication. In addition to this property, succulence is a measure of the maturity. The determination of pericarp content, is a measure of the toughness of the corn.

According to Kramer (21, pp. 342-356), the succulometer and moisture tests may be used interchangeably, and are very satisfactory in estimating the quality of the raw corn. After cooking, these tests were found to be good indicators of succulence and skin character, but not of flavor. He also found that the succulometer was more accurate in moisture and maturity determinations at the optimum canning stage with progressively greater deviations

for immature and overmature corn.

The succulometer makes possible the measurement of the maturity of canned whole kernel corn as well as the measurement of the raw corn anywhere during the canning procedure after the kernels are cut off the cob. In accuracy it is approximately equal to the moisture test on the raw corn and the alcohol insoluble test on the canned corn, but it is much more rapid and simpler to carry out than either of the other tests.

The maximum amount of extractable juice coincides with the optimum (very young) stage of maturity. When the corn is too young for commercial purposes, there is less extractable juice. As the corn passes this optimum stage and becomes overmature, the volume of extractable juice decreases.

During maturing and ripening of corn, there is a continual increase in solids content and a consequent decrease in moisture as the kernels successively pass through the blister, milk, dough and ripening stages. The decrease in moisture content may be used to provide an index of maturity. A moisture content of 72 per cent has been found to be optimum.

Fresh corn % moisture	Grade of canned product
71.7	Fancy
66.3 - 70.4	Extra standard
62.0 - 65.1	Standard
61.0 - below	Sub-standard

Over the years quite a few objective tests have been proposed to measure the moisture content of raw corn. The vacuum oven method for determination of moisture is used as standard method. Some of the proposed tests correlate very highly with the oven determination, others have a rather low correlation coefficient. Succulometer was used, because this test is rapid (3-5 minutes), adaptable to processing procedure (19, pp. 9-10, 21) and (20, pp. 55-56, 59-60, 62-63), and according to Andrew (1, pp. 42,44), an accurate index of maturity.

In addition to the grade of the canned product, the yield of a field is also a function of maturity. According to Berth and Weckel (4, pp. 1215-1217, 1336, 1338, 1340), if corn is picked too soon, at 76-78 per cent moisture, the yield from the field will be low and there will be a high tare weight of useless corn. This same corn will tend to turn grey in the can when processed. It will yield a low value in cases per ton because the per cent cut off will be low and, further, much of the corn moisture will be lost in cutting and handling. Such corn when canned is objectionable to the consumer because of its shrunken appearance in the can.

If corn is picked late, when the moisture level is 68-69 per cent, the field yield and the in-plant yield will be greater. However, as whole kernel style corn, the product usually possesses a chewy, overmature quality.

The maximum period the canner has to pick corn for a quality pack will be considerably less than ten days.

Unfortunately, according to Kramer (19, pp. 9-10, 21), the maximum yields of cut kernels do not coincide with optimum maturity. However, whereas maximum yields of Golden Cross Bantam and Country Gentleman are reached when the material may be expected to produce young (extra standard) quality, the maximum yields of cut kernels of Aristogold and Narrowgrain Evergreen are not reached until the corn averages a low standard of quality.

As seen previously, pericarp content influences largely the quality of the canned product. It is a varietal characteristic which intensifies as prime maturity is approached and passed.

Haber (15, pp. 13-15) has shown that the pericarp content of corn in the dry state may vary from 4.76 per cent for Golden Cross Bantam to 8.34 per cent for Stowell Evergreen. Kramer (21, pp. 342-356) found that very young Country Gentleman corn contains 1.88 per cent pericarp while mature Country Gentleman contains 4.13 per cent pericarp. He has shown that the pericarp test is inferior to the succulometer as an indicator of raw appearance or succulence, but equal or perhaps slightly better for predicting skin character and flavor.

Recently Kramer (23, pp. 86-88, 139-141) stated that the quality of processed sweet corn can now be predicted by

a combination test. For Maryland, Kramer includes succulence, pericarp content and kernel size in his combination test. This test is not affected by varietal differences or climatic conditions.

His results indicated that no single factor (as the moisture content, succulence, or pericarp content) is responsible for the quality of sweet corn. Hence, two or more tests were combined and multiple correlations calculated to determine whether a suitable combination method could be found which might predict the quality of processed sweet corn regardless of variety or climate.

He also found that there is an interesting negative correlation coefficient between maturity and the size of the kernels.

Some of these multiple correlations indicate that very satisfactory combinations may be obtained if, in addition to a moisture test, such as succulometer, pericarp content and kernel size are also determined. He obtained for instance:

		Combined with	
	Alone	Pericarp	Pericarp and Kernel size
Succulometer	0.705	0.803	0.912

Unfortunately, the integration of several factors is complex due to the additional time and expense involved in either objective evaluation, subjective evaluation, or in

both. Assignment of the appropriate portion of the quality grade to each factor, in determining a quality grade, appears to be a difficult problem.

A high correlation coefficient provides no definite information on factors which influence the judge's decisions nor on the relative importance of these factors.

According to Geise (11, pp. 15-20), the relative influence of these quality factors upon the decisions of a panel of judges, in determining the difference between lots of canned sweet corn, would be about 46% for canned moisture, 32% for pericarp, and 22% for kernel volume (which one may correlate very highly with the largest diameters of twenty kernels).

CHAPTER 3

EXPERIMENTAL PROCEDURE

A - MATERIALS.

The corn processed for this work was harvested during the summer of 1952, by the Horticulture Department, from their vegetable farm. After harvesting, in the early morning, the corn was brought without delay to the Food Technology Building, and kept in the storage room (34°F.) until 1 P.M. when the processing was carried out.

The procedure was as follows:

1 - Corn was removed from the storage room, and husked by hand.

2 - It was then blanched five minutes in boiling water.

3 - Sprayed with cold water until the ears could be handled easily. After this cold water spray, it was fed into a mechanical cutter.

4 - The cut corn was poured into an aluminum kettle, and covered with cold water. Free pieces of skin, cobs, and silks floated and were removed.

5 - 13.5 ounces of corn were filled into each #2 can (C-enamel). A 30 grain salt tablet and sufficient hot water were then added to the can of corn.

6 - After vacuum sealing (18" vacuum), the corn was processed for fifty minutes at 240°F.

7 - Finally, the cans were cooled by covering them with cold water.

In this way, 225 cans of corn representing seventeen varieties were processed under the same conditions.

B - METHODS OF ANALYSIS.

1 - Succulence.

Succulence was determined in duplicate on two cans of each variety (4 samples). This design was found desirable, after preliminary analysis showed that the standard deviation for duplicates is practically equal to the standard deviation for the seventeen varieties. A hand operated succulometer was used following as closely as possible the method recommended by Kramer (18, pp. 11-13). From a freshly opened can of whole kernel corn, pour off the liquid, wash the contents of the can with twice its volume of water, and transfer to an eight-mesh screen, eight inches in diameter. Spread the corn evenly over the screen surface and allow it to drain in a tilted position for two minutes. Then transfer the screen contents to a dish, and remove all silks, parts of cob, etc. Weigh out a 100-gram sample for the test.

Transfer the 100-gram sample to the chamber of the succulometer. Insert the plunger and put the sample unit in position against the backstop. With the graduated cylinder in position, turn the handle of the screw rod rapidly

until a pressure of 500 pounds per square inch is shown on the gauge. Maintain this pressure for exactly three minutes by continuing to turn the handle slowly as needed. Note the volume of liquid in the graduated cylinder.

At the end of each test draw out the plunger, remove the corn residue, rinse with water, and dry with a towel. Rinse the cylinder and hang inverted to drain. It is well to have several cylinders to be used in rotation and an extra sample unit. A 25 ml. cylinder, graduated in 0.2 ml., was found to be satisfactory.

The same procedure for this determination should be rigorously adhered to if reproducible results are to be secured.

According to studies made by Kramer (18, pp. 11-13), there is practically no difference in the total volume of juice expressed as a result of differences in pressure application from 500 to 5,000 pounds per square inch. However, the volume of expressed juice began to decline when the pressure applied dropped below 500 pounds. This pressure must be maintained for at least three minutes. It should be noted that succulence can be determined on corn after blanching (uncanned) or on the samples after canning.

2 - Pericarp content.

Pericarp content was determined in duplicate on two cans of each variety. For this determination the method described by Kramer (21, pp. 342-356) was followed.

Blend 100 grams of kernels (the same corn used for succulometer determinations) with 200 ml. of water in a Waring blendor for five minutes. Weigh 50 grams of this blend and wash through a 30-mesh screen for three minutes, using a 1/8 inch glass tube as the outlet for water. Dry the screen and pericarp at 100°C. for two hours and weigh. Flame the screen until the organic material has been destroyed, cool, and weigh. The weight of the screen plus dry sample, minus the weight of the screen, multiplied by six, equals the per cent pericarp.

3 - Size of the kernels.

One can of each variety was used for this determination. By a small hole in the lid of the can, the liquid was drained out. The corn was transferred to a small pan, and very well mixed. As much as possible, a random sample was drawn from the pan. Using a micrometer (0.0001"), the maximum diameter of twenty kernels in inches was measured.

4 - Grading of maturity and flavor by a panel.

Maturity and flavor were determined by a panel of six members selected from the Department of Food Technology and one from the Department of Horticulture. The members of this panel were quite familiar with this vegetable. Maturity was determined on a basis of forty points, and flavor on a basis of twenty points, in agreement with the scores set up for the Production and Marketing Administration grades.

CHAPTER 4

RESULTS

PRESENTATION.

The varieties of corn tested have been ranked in order under the headings succulence, pericarp content, size of the kernels, maturity and flavor as graded by the panel in Tables I, II, III, IV and V.

Additional tables have been placed in the Appendix. Table VI includes a list of the seventeen varieties. Table VII shows the means of each test for all varieties. Readings, means and standard deviations for succulometer, pericarp content, size of the kernels and grading by the panel are summarized in Tables VIII, IX, X and XI.

TABLE I

VARIETIES OF CORN RANKED IN ORDER OF SUCCULOMETER VALUES

Number	Variety	Succulence (ml.)	Rank
10	Golden Cross Bantam	24.7	1
11	Golden Cross Bantam	24.1	2
2	Tendergold A	24.0	3
8	Golden Cross Bantam	23.9	4
12	Golden Crown	23.1	5
15	Golden Cross Bantam	23.0	6
5	Golden Cross Bantam	22.8	7
1	Seneca Chief	21.7	8
3	Iogold 51	21.7	8
4	Hoosier Gold	21.5	10
6	Golden Cross Bantam	21.1	11
9	Seneca Arrow	20.8	12
14	Golden Harvest	20.7	13
13	Wisconsin 103 x 6932	19.9	14
17	F M Cross	18.9	15
7	Carmelcross	15.9	16
16	Golden Hybrid 52-A	15.2	17

TABLE II

VARIETIES OF CORN RANKED IN ORDER OF PERICARP CONTENT

Number	Variety	Pericarp content (percent)	Rank
10	Golden Cross Bantam	0.6230	1
15	Golden Cross Bantam	0.7130	2
5	Golden Cross Bantam	0.7553	3
2	Tendergold A	0.7769	4
12	Golden Crown	0.7800	5
8	Golden Cross Bantam	0.7872	6
4	Hoosier Gold	0.8111	7
13	Wisconsin 103 x 6932	0.8163	8
9	Seneca Arrow	0.8325	9
11	Golden Cross Bantam	0.8672	10
6	Golden Cross Bantam	0.8720	11
1	Seneca Chief	0.8754	12
3	Iogold 51	0.9044	13
7	Carmelcross	0.9281	14
17	F M Cross	1.0863	15
16	Golden Hybrid 52-A	1.0872	16
14	Golden Harvest	1.1951	17

TABLE III

VARIETIES OF CORN RANKED IN ORDER OF SIZE OF THE KERNELS

Number	Variety	Size in inches of 20 kernels	Rank
2	Tendergold A	7.0685	1
3	Iogold 51	7.1535	2
17	F M Cross	7.2470	3
9	Seneca Arrow	7.4548	4
10	Golden Cross Bantam	7.4756	5
5	Golden Cross Bantam	7.4844	6
12	Golden Crown	7.5096	7
1	Seneca Chief	7.6413	8
7	Carmelcross	7.6496	9
15	Golden Cross Bantam	7.7157	10
6	Golden Cross Bantam	7.7903	11
8	Golden Cross Bantam	7.8730	12
13	Wisconsin 103 x 6932	7.9707	13
11	Golden Cross Bantam	8.1941	14
14	Golden Harvest	8.2298	15
4	Hoosier Gold	8.3573	16
16	Golden Hybrid 52-A	8.5005	17

TABLE IV

VARIETIES OF CORN RANKED IN ORDER OF MATURITY AS DETERMINED BY THE PANEL

Number	Variety	Maturity	Rank
8	Golden Cross Bantam	37.1	1
12	Golden Crown	37.0	2
2	Tendergold A	35.7	3
5	Golden Cross Bantam	35.7	3
10	Golden Cross Bantam	35.7	3
15	Golden Cross Bantam	35.7	3
6	Golden Cross Bantam	35.4	7
3	Iogold 51	35.0	8
11	Golden Cross Bantam	34.6	9
1	Seneca Chief	33.7	10
14	Golden Harvest	33.7	10
4	Hoosier Gold	33.0	12
17	F M Cross	33.0	12
9	Seneca Arrow	32.9	14
13	Wisconsin 103 x 6932	32.3	15
7	Carmelcross	28.3	16
16	Golden Hybrid 52-A	26.4	17

TABLE V

VARIETIES OF CORN RANKED IN ORDER OF FLAVOR AS DETERMINED BY THE PANEL

Number	Variety	Flavor	Rank
12	Golden Crown	17.6	1
10	Golden Cross Bantam	17.3	2
2	Tendergold A	16.4	3
11	Golden Cross Bantam	16.3	4
15	Golden Cross Bantam	16.1	5
8	Golden Cross Bantam	16.0	6
5	Golden Cross Bantam	15.7	7
3	Iogold 51	15.6	8
6	Golden Cross Bantam	15.4	9
9	Seneca Arrow	15.4	9
13	Wisconsin 103 x 6932	14.7	11
17	F M Cross	14.6	12
4	Hoosier Gold	14.4	13
1	Seneca Chief	14.1	14
7	Carmelcross	14.0	15
16	Golden Hybrid 52-A	13.7	16
14	Golden Harvest	13.3	17

DISCUSSION OF RESULTS

Succulence

The first thing to note in Table I, where the succulence ranges from 15.2 to 24.7 ml., is that this corn has a relatively high succulence. According to Kramer (18, pp. 11-13), a canned corn having 20.0 ml. and more of extractable juice by the succulometer can be classed as fancy as far as maturity is concerned. In this work thirteen of the varieties produced more than 20.0 ml. of juice.

The various strains of Golden Cross Bantam tested seem to be well adapted to climatic conditions of Oregon. The lowest one in succulence gave 21.1 ml., and the mean for the six strains of Golden Cross Bantam was 23.3 ml. Tendergold A is very desirable as far as succulence is concerned with a value of 24.0 ml.

The best six varieties for succulence are:

Number	Variety*	Succulence	Rank
10	Golden Cross Bantam	24.7 ml.	1
11	Golden Cross Bantam	24.1	2
2	Tendergold A	24.0	3
8	Golden Cross Bantam	23.9	4
12	Golden Crown	23.1	5
15	Golden Cross Bantam	23.0	6

* See Table VI in the Appendix for the seed sources.

Pericarp content

The values for pericarp content of the seventeen varieties are tabulated in Table II. According to Haber (15, pp. 13-15), the lowest pericarp content for Golden Cross Bantam would be about 1.33 per cent. Gould (14, pp. 28-29, 62) found 1.16 per cent. A comparison of these values with those in the present work, shows that the pericarp content for this corn grown in Oregon is much lower. In fact, the pericarp content of fourteen of these varieties was less than 1.0000 per cent.

The pericarp content mean, for the six varieties of Golden Cross Bantam included in the seventeen varieties of corn, is 0.7696 per cent, which is about half the value given by Haber (15, pp. 13-15) as minimum.

Also, Tendergold A was desirable with a value of 0.7769 per cent.

The six varieties with lowest pericarp content are:

Number	Variety*	Pericarp	Rank
10	Golden Cross Bantam	0.6230 per cent	1
15	Golden Cross Bantam	0.7130	2
5	Golden Cross Bantam	0.7553	3
2	Tendergold A	0.7769	4
12	Golden Crown	0.7800	5
8	Golden Cross Bantam	0.7872	6

* See Table VI in the Appendix for the seed sources.

Size of the kernels

The size of twenty kernels for each variety can be found in Table III. These values range from 7.0685 to 8.5005 inches. No values for kernel size of the different varieties were found in the literature.

Number	Variety*	Size in inches	Rank
2	Tendergold A	7.0685	1
3	Iogold 51	7.1535	2
17	F M Cross	7.2470	3
9	Seneca Arrow	7.4548	4
10	Golden Cross Bantam	7.4756	5
5	Golden Cross Bantam	7.4844	6

* See Table VI in the Appendix for the seed sources.

It is interesting to note that of the best six varieties for succulence and pericarp content, four were Golden Cross Bantam. For the size of the kernels, only two are Golden Cross Bantam, and they rank fifth and sixth.

Maturity

The scores for the subjective grading of the canned corn are tabulated in Table IV. The seventeen varieties range from 37.1 to 26.4. This grading is in very good agreement with the objective test for succulence. A correlation coefficient of 0.923 between maturity values and the succulometer readings was found.

If a multiple correlation coefficient, as recommended by Kramer (23, pp. 86-88, 139-141), is determined between

maturity and succulence plus pericarp content, the new value is 0.926. The difference is only 0.003, whereas Kramer (23, pp. 86-88, 139-141) found 0.098. In as much as the pericarp content is rather low for this corn grown under irrigation its influence may be smaller.

It is also possible to add the size of the kernels to succulence and pericarp content. If this is done, a correlation coefficient of 0.942 is reached.

Using the equation given by Kramer (23, pp. 86-88, 139-141) to determine maturity of corn, and running a correlation coefficient between this maturity and the one determined by the panel of seven members, we get a value of 0.876. This correlation coefficient shows that his equation predicts the quality of processed sweet corn regardless of climate. In as much as the succulence values for this corn in the raw condition have not been determined, it was necessary to use the values for canned corn. To calculate this new factor, the means of succulence for raw corn (22.16 ml.) and of canned corn (16.38 ml.) as given by Kramer (23, p. 87) were used. The new equation is:

$$\text{Maturity} = 38.10 + 0.641s - 6.075p - 1.581d \qquad 1$$

In this equation, maturity is on a basis of 35, "s" is the cubic millimeters of juice extracted by the succulometer, "p" is percent pericarp, and "d" is the sum in inches of the largest diameters of twenty kernels.

A new equation that will give maturity on a basis of

40 according to the new standards issued July 30, 1952 by the Production and Marketing Administration, was calculated with this work. This equation is:

$$\text{Maturity} = 19.367 + 1.02s + 2.955p - 1.267d \qquad 2$$

Due to the low pericarp content that we noted previously, maturity for this region can be predicted very well with succulence and size of the kernels. A correlation coefficient of 0.936 exists between maturity and these two objective determinations. This is very fortunate, because the pericarp content determination is very time consuming. When the pericarp values were omitted the equation for maturity was calculated to be:

$$\text{Maturity} = 22.896 + 0.918s - 1.123d \qquad 3$$

Flavor

Flavor was evaluated by the same panel which rated maturity. According to Production and Marketing Administration standards, a maximum value of 20 is allowed for this factor. The flavor scores for the seventeen varieties ranged from 17.6 to 13.3. The panel members were quite severe in their flavor evaluations. However, it should be noted that some of this corn was lacking in sweetness.

Correlation coefficients were calculated to see if the objective tests, which were used to predict maturity, could also be used to predict flavor. Values of -0.762 were found with pericarp content, 0.833 with pericarp content and succulometer, and if the size of the kernels was

included, the value was 0.854.

It is interesting to note that the three objective tests can predict maturity plus flavor with a correlation coefficient of 0.950. As color can also be determined objectively, that means that the factors which make up 70 per cent of the grade for whole kernel corn can be determined objectively. Absence of defects and cut are the other factors for the remaining 30 per cent of the United States grades.

The six best varieties, as determined by the panel, for these two factors are:

Number	Variety*	Rank
12	Golden Crown	1
8	Golden Cross Bantam	2
10	Golden Cross Bantam	3
2	Tendergold A	4
15	Golden Cross Bantam	5
5	Golden Cross Bantam	6

* See Table VI in the Appendix for the seed sources.

For anyone interested in the correlation coefficients between each of the objective tests and each of the subjective tests, namely maturity and tenderness and flavor (Production and Marketing Administration scores), we have recorded them here:

Succulence and Maturity	0.923
Pericarp content and Maturity	-0.556

Kernel size and Maturity	-0.431
Succulence and Flavor	0.758
Pericarp content and Flavor	-0.762
Kernel size and Flavor	-0.149

CHAPTER 5

SUMMARY AND CONCLUSIONS

This work was an attempt to evaluate the quality of corn, grown in Oregon, for use in canning of whole kernel corn. In order to determine the quality, the following tests were performed on the canned samples.

1 - Determination of maturity and succulence by the succulometer. The seventeen varieties included in this project lie between 24.7 and 15.2 ml. of extractable juice squeezed from 100 grams of canned corn. In general the succulence was very good.

2 - Pericarp content for corn grown in this part of Oregon (Corvallis) was rather low. This is a very desirable quality. One possible explanation would be the cool nights during summer months. The desirable irrigation practices for this corn may have been influential.

The pericarp content for the seventeen varieties ranged from 0.6230 per cent to 1.1951 per cent.

3 - Most of these varieties have large size kernels. Consumers, in general, prefer a small kernel because they associate a large kernel with overmature corn. This is not always true. The varieties with which this work was dealing range from 7.0685 to 8.5005 inches for the largest diameters of twenty kernels.

4 - The maturity and flavor scores, determined by the panel of seven members, indicated that some of these varieties are very desirable for the canning of whole kernel corn. These include Golden Crown (number 12), Golden Cross Bantam (numbers 5, 8, 10 and 15), and Tendergold A (number 2).

5 - The Kramer equation may be used regardless of varieties and climatic conditions. In fact, a correlation coefficient of 0.876 was obtained between maturity and succulence, plus pericarp content, plus size of kernels using his equation.

6 - For this work the same three objective tests predict maturity and tenderness with a correlation coefficient of 0.942. This is shown by equation 2 on page 26.

7 - The low pericarp content for the corn grown in Oregon (Corvallis) allows the determination of maturity by succulence and size of the kernels with a correlation coefficient of 0.936. This permits us to use equation 3 on page 26, which has only two variables in place of the three in the equation which Kramer used.

It should be noted that all these six varieties had good bright color in the processed corn.

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APPENDIX

TABLE VI

List of Varieties

Number	Food Technology Code	Variety	Source
1	1090	Seneca Chief	1
2	1262	Tendergold A	7
3	1371	Iogold 51	3
4	1372	Hoosier Gold	3
5	1373	Golden Cross Bantam	3
6	1422	Golden Cross Bantam	5
7	1423	Carmelcross	5
8	1424	Golden Cross Bantam	2
9	1607	Seneca Arrow	1
10	1608	Golden Cross Bantam	1
11	1610	Golden Cross Bantam	8
12	1643	Golden Crown	1
13	1700	Wisconsin 103 x 6932	6
14	1706	Golden Harvest	4
15	1711	Golden Cross Bantam	4
16	1713	Golden Hybrid 52-A	4
17	1716	F M Cross	2

Key to seed sources:

1 - Robson Seed Farms, Hall, New York.

2 - Ferry-Morse Seed Company, Mountain View, California.

3 - Crookham Company, Caldwell, Idaho.

4 - Rogers Bros. Seed Company, Caldwell, Idaho.

5 - Associated Seed Growers, New Haven, Connecticut.

6 - University of Wisconsin, Madison, Wisconsin.

7 - F.H. Woodruff & Sons, Incorporated, Toledo, Ohio.

8 - Northrup-King Company, Minneapolis, Minnesota.

TABLE VII

Experimental Data

Number	Succulence	Pericarp (Per cent)	Kernel Size (Inches)	Maturity Score	Flavor Score
1	21.7 ml.	0.8754	7.6413	33.7	14.1
2	24.0	0.7769	7.0685	35.7	16.4
3	21.7	0.9044	7.1535	35.0	15.6
4	21.5	0.8111	8.3573	33.0	14.4
5	22.8	0.7553	7.4844	35.7	15.7
6	21.1	0.8720	7.7903	35.4	15.4
7	15.9	0.9281	7.6496	28.3	14.0
8	23.9	0.7872	7.8730	37.1	16.0
9	20.8	0.8325	7.4548	32.9	15.4
10	24.7	0.6323	7.4756	35.7	17.3
11	24.1	0.8672	8.1941	34.6	16.3
12	23.1	0.7800	7.5096	37.0	17.6
13	19.9	0.8163	7.9707	32.3	14.7
14	20.7	1.1951	8.2298	33.7	13.3
15	23.0	0.7130	7.7157	35.7	16.1
16	15.2	1.0872	8.5005	26.4	13.7
17	18.9	1.0863	7.2470	33.0	14.6

The explanation for such terms as succulence, pericarp, etc. will be found on the following page.

Succulence: Number of ml. of extractable juice per 100 grams of corn.

Pericarp: Per cent of pericarp content.

Kernel Size: Largest diameters in inches of twenty kernels.

Maturity Score: As determined by the panel of seven members on a basis of 40.

Flavor Score: As determined by the panel of seven members on a basis of 20.

TABLE VIII

Succulence Data

Number	Variety	Reading	Mean	Standard Deviation
1	Seneca Chief	21.7 ml.		
		21.6		
		23.4		
		20.0	21.7 ml.	1.39 ml.
2	Tendergold A	24.4		
		23.6		
		23.7		
		24.1	24.0	0.37
3	Iogold 51	21.2		
		22.0		
		21.5		
		22.0	21.7	0.40
4	Hoosier Gold	23.0		
		19.3		
		21.5		
		22.2	21.5	1.59
5	Golden Cross Bantam	23.1		
		21.5		
		23.1		
		23.4	22.8	0.86

TABLE VIII (Continued)

Number	Variety	Reading	Mean	Standard Deviation
6	Golden Cross Bantam	21.2 ml.		
		21.6		
		20.5		
		21.1	21.1 ml.	0.46 ml.
7	Carmelcross	16.0		
		16.1		
		16.9		
		14.6	15.9	0.95
8	Golden Cross Bantam	22.7		
		24.1		
		24.5		
		24.3	23.9	0.82
9	Seneca Arrow	21.0		
		21.0		
		21.7		
		19.4	20.8	0.97
10	Golden Cross Bantam	24.1		
		25.2		
		26.1		
		23.4	24.7	1.19
11	Golden Cross Bantam	24.7		
		24.0		
		23.6		
		23.9	24.1	0.47

TABLE VIII (Continued)

Number	Variety	Reading	Mean	Standard Deviation
12	Golden Crown	23.8 ml.		
		22.5		
		22.9		
		23.2	23.1 ml.	0.55 ml.
13	Wisconsin 103 x 6932	19.8		
		19.6		
		20.0		
		20.0	19.9	0.20
14	Golden Harvest	21.3		
		20.0		
		21.1		
		20.4	20.7	0.61
15	Golden Cross Bantam	24.4		
		23.9		
		23.5		
		20.3	23.0	1.85
16	Golden Hybrid 52-A	15.6		
		13.8		
		15.1		
		16.1	15.2	0.99
17	F M Cross	18.8		
		19.3		
		19.5		
		18.1	18.9	0.62

TABLE IX

Pericarp Content Data

Number	Variety	Reading (Per cent)	Mean (Per cent)	Standard Deviation (Per cent)
1	Seneca Chief	0.8874		
		1.0788		
		0.8640		
		0.6714	0.8754	0.1666
2	Tendergold A	0.7350		
		0.7338		
		0.8088		
		0.8298	0.7769	0.0498
3	Iogold 51	1.0368		
		0.9072		
		0.7638		
		0.9096	0.9044	0.1116
4	Hoosier Gold	0.8574		
		0.8334		
		0.8856		
		0.6678	0.8111	0.0979
5	Golden Cross Bantam	0.7494		
		0.7764		
		0.7368		
		0.7584	0.7553	0.0167
6	Golden Cross Bantam	0.8400		

TABLE IX (Continued)

Number	Variety	Reading (Per cent)	Mean (Per cent)	Standard Deviation (Per cent)
		0.8604		
		0.8382		
		0.9492	0.8720	0.0525
7	Carmelcross	0.8394		
		0.8454		
		1.0650		
		0.9624	0.9281	0.1071
8	Golden Cross Bantam	0.6822		
		0.8532		
		0.8994		
		0.7140	0.7872	0.1052
9	Seneca Arrow	0.8814		
		0.8322		
		0.8070		
		0.8094	0.8325	0.0345
10	Golden Cross Bantam	0.6762		
		0.5940		
		0.6276		
		0.6312	0.6323	0.0338
11	Golden Cross Bantam	0.8142		
		0.8730		
		0.8412		
		0.9402	0.8672	0.0543

TABLE IX (Continued)

Number	Variety	Reading (Per cent)	Mean (Per cent)	Standard Deviation (Per cent)
12	Golden Crown	0.7440		
		0.8082		
		0.7770		
		0.7908	0.7800	0.0272
13	Wisconsin 103 x 6932	0.7722		
		0.8328		
		0.8088		
		0.8514	0.8163	0.0342
14	Golden Harvest	1.3242		
		1.4532		
		0.9810		
		1.0218	1.1951	0.2303
15	Golden Gross Bantam	0.7500		
		0.6744		
		0.6900		
		0.7374	0.7130	0.0364
16	Golden Hybrid 52-A	1.0974		
		1.1370		
		1.0404		
		1.0740	1.0872	0.0406
17	F M Cross	1.1160		
		1.0590		
		1.0770		
		1.0932	1.0863	0.0242

TABLE X

	Size of the Kernels					
Number	1	2	3	4	5	6
Reading	0.3467	0.3727	0.3721	0.4286	0.3870	0.3912
	0.3476	0.3282	0.3697	0.4088	0.3767	0.4210
	0.3707	0.3435	0.3546	0.4097	0.3671	0.3847
	0.4304	0.3340	0.2993	0.4472	0.4019	0.3177
	0.3718	0.3824	0.3824	0.3831	0.3831	0.4239
	0.4045	0.3287	0.3502	0.4082	0.3889	0.3635
	0.3694	0.4073	0.3601	0.3852	0.3955	0.3298
	0.3959	0.4262	0.3963	0.3933	0.3574	0.4143
	0.3293	0.4078	0.3457	0.4106	0.3597	0.4167
	0.3961	0.2939	0.3661	0.4369	0.3140	0.4066
	0.3704	0.3865	0.3037	0.4211	0.4289	0.3355
	0.4211	0.3686	0.2977	0.4463	0.3559	0.3357
	0.3466	0.3623	0.3623	0.3880	0.3886	0.3758
	0.3770	0.3281	0.3922	0.4095	0.3466	0.4662
	0.4315	0.2339	0.3799	0.4325	0.3967	0.3722
	0.4287	0.3511	0.4022	0.4752	0.3851	0.3880
	0.3578	0.3689	0.3511	0.4816	0.3221	0.4215
	0.3795	0.3206	0.3526	0.4477	0.3831	0.4357
	0.3662	0.3471	0.3441	0.3790	0.3541	0.4267
	0.4001	0.3767	0.3712	0.3648	0.3920	0.3636
Sum	7.6413	7.0685	7.1535	8.3573	7.4844	7.7903
Mean	0.3821	0.3534	0.3577	0.4179	0.3742	0.3895
Standard Deviation	0.0304	0.0434	0.0297	0.0317	0.0274	0.0402

TABLE X (Continued)

Number	7	8	9	10	11	12
Reading	0.3066	0.3498	0.3592	0.3342	0.4431	0.4616
	0.4604	0.3891	0.3150	0.4004	0.4474	0.4189
	0.3621	0.3910	0.4092	0.3785	0.4066	0.3753
	0.3308	0.3640	0.3763	0.4382	0.3730	0.3410
	0.3489	0.4066	0.3923	0.4540	0.3654	0.3555
	0.3911	0.4124	0.3651	0.3378	0.3820	0.4136
	0.3823	0.4350	0.4502	0.3549	0.3870	0.3731
	0.4213	0.4586	0.2887	0.3571	0.3785	0.3413
	0.4003	0.3924	0.3454	0.3346	0.4791	0.3611
	0.4144	0.3787	0.3942	0.3476	0.3642	0.3746
	0.4026	0.3801	0.3790	0.4059	0.4304	0.3785
	0.3226	0.3994	0.3307	0.4104	0.4412	0.3958
	0.3421	0.4182	0.3577	0.3247	0.4114	0.3752
	0.4158	0.3208	0.3597	0.4195	0.4376	0.3656
	0.4437	0.4272	0.3598	0.3122	0.3724	0.3570
	0.3485	0.3686	0.4193	0.3721	0.3998	0.3196
	0.3706	0.3881	0.3746	0.3301	0.3821	0.3371
	0.3851	0.4088	0.4174	0.4110	0.4205	0.3446
	0.3871	0.3793	0.4035	0.3920	0.4436	0.4100
	0.4133	0.4049	0.3575	0.3604	0.4288	0.4102
Sum	7.6496	7.8730	7.4548	7.4756	8.1941	7.5096
Mean	0.3825	0.3937	0.3727	0.3738	0.4097	0.3755
Standard Deviation	0.0408	0.0307	0.0379	0.0407	0.0333	0.0344

TABLE X (Continued)

Number	13	14	15	16	17
Reading	0.4495	0.4540	0.3953	0.3787	0.3656
	0.3993	0.4332	0.3956	0.5278	0.3466
	0.3626	0.4003	0.3512	0.4097	0.3890
	0.3721	0.4502	0.3281	0.4108	0.3087
	0.4032	0.3948	0.3327	0.3956	0.3360
	0.4282	0.4006	0.3995	0.4444	0.4196
	0.3992	0.3602	0.4141	0.4669	0.3761
	0.3126	0.3913	0.3941	0.4484	0.4002
	0.4193	0.4222	0.3546	0.4676	0.2707
	0.4339	0.4344	0.4171	0.4291	0.3445
	0.3839	0.4043	0.3466	0.4506	0.4017
	0.3861	0.3667	0.4028	0.4132	0.3193
	0.4204	0.4191	0.4150	0.3781	0.3886
	0.4089	0.3860	0.4775	0.4380	0.4144
	0.3383	0.4465	0.4244	0.4245	0.3676
	0.4300	0.3744	0.3506	0.3696	0.3378
	0.4091	0.3742	0.3504	0.4262	0.3601
	0.3940	0.4428	0.4068	0.4474	0.3355
	0.4035	0.3998	0.3362	0.3945	0.4390
	0.4166	0.4748	0.4231	0.3794	0.3260
Sum	7.9707	8.2298	7.7157	8.5005	7.2470
Mean	0.3985	0.4115	0.3858	0.4250	0.3624
Standard Deviation	0.0329	0.0323	0.0397	0.0386	0.0420

TABLE XI

Department Grading

Number	Maturity Mean	Standard Deviation	Flavor Mean	Standard Deviation
1	33.7	2.2	14.1	1.3
2	35.7	2.8	16.4	2.1
3	35.0	2.1	15.6	1.0
4	33.0	4.2	14.4	2.6
5	35.7	2.6	15.7	3.7
6	35.4	1.7	15.4	2.1
7	28.3	6.0	14.0	3.3
8	37.1	1.2	16.0	3.7
9	32.9	2.4	15.4	2.3
10	35.7	2.8	17.3	1.7
11	34.6	3.4	16.3	2.9
12	37.0	1.3	17.6	2.1
13	32.3	2.7	14.7	1.5
14	33.7	2.8	13.3	4.3
15	35.7	1.7	16.1	2.1
16	26.4	5.7	13.7	2.5
17	33.0	4.0	14.6	2.1