AN EVALUATION OF SEVERAL METHODS OF DETERMINING
THE OPTIMUM MATURITY OF SWEET CORN FOR PROCESSING

by

Elizabeth M. McKerlie

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ABSTRACT

A study was undertaken to assess various methods which could be used to determine the maturity of sweet corn and the proper harvest date for processing.

Two commercial varieties were grown and a series of harvests was made, ranging from immature to overmature. Ten characteristics of the fresh corn were measured. Samples of each harvest were canned and frozen and the same characteristics of these samples were measured. The canned and frozen samples were rated by a sensory panel.

Moisture content was assumed to be the standard measurement of maturity and the other methods were compared to it. Simple correlation coefficients between the various characteristics were determined. An analysis of variance was made on the sensory panel scores.

The refractive index was the most reliable and accurage method of determining maturity and it could be determined more quickly and simply than any of the other measurements. Alcohol-insoluble solids content and trimetric rating were accurate and reliable methods but they were too slow to be of practical use. Pericarp content and shear press rating were not sufficiently accurate. The sensory panel results were not always consistent with the objective measurements.

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INTRODUCTION

Sixteen hundred acres of sweet corn are grown in Manitoba for canning. Most of this is for cream style corn since, until recently, there were no varieties which were of high enough quality for whole kernel canning or freezing and which, at the same time, matured early enough in Manitoba. One of the major problems of the whole kernel processing industry is that of deciding when to harvest the corn in order to get the desired quality in the canned or frozen product. This is much more critical in canning whole kernel corn than in cream style because deficiencies in quality cannot be easily overcome by additives. Since well adapted, high quality varieties are now available in Manitoba, it is important that methods be developed for determining the optimum stage of maturity for harvest.

A test of raw corn maturity and quality must be simple and rapid, since under favorable weather conditions a field of corn can rapidly reach optimum quality and begin to deteriorate. Processors employ various methods to determine the harvest time of sweet corn. The success of these tests in determining the quality of the corn can be influenced by such factors as weather and seasonal conditions, varietal differences, and the accuracy of the method itself. The eating quality of corn is determined by the toughness and amount of pericarp, starch and sugar content, color, succulence, and flavor; any test of quality should take these factors into account.

Some processors still use the thumbnail test of maturity; although it is a subjective test an experienced person is able to determine the maturity fairly accurately by observing the color, firmness, size of ear, and puncture of the kernels. However, this test does not give any indication of flavor or sweetness, and the results may vary between individuals.

The moisture content is used as a standard index of sweet corn maturity. There are several methods of measuring moisture content, but many of them are either too slow or too inaccurate for practical use. The value of moisture content as a maturity index lies in its close association with such factors as starch content, sugar content, sugar: starch ratio, succulence, and pericarp content. The refractive index of the juice is a measure of the total soluble solids. The procedure is a rapid one, and the results are closely correlated with the sugar: starch ratio, moisture content, sugar content, and starch content.

Determinations of pericarp content and alcohol-insoluble solids content are indicators of certain of the quality factors, namely tenderness and starchiness. Both of these tests take considerable time to complete and must be done with care if they are to be accurate.

A trimetric rating, consisting of a combination of moisture content, pericarp content, and kernel diameter is considered to be a reliable index of maturity and quality, although its usefulness is limited by the time required to carry out the determinations.

There are several instruments which measure succulence, such as the succulometer and the compression cell of the shear press. The texturemeter, tenderometer, and the shear cell of the shear press measure the texture or toughness of the kernels. The shear and compression readings of the shear press can be combined into a single value by means of a regression equation and several workers have reported that this rating is an accurate indication of sweet corn maturity.

There is as yet no instrumental method of measuring the flavor aspect of sweet corn quality. Sensory panels can be used to evaluate eating quality if they are selected with care and conducted under the proper conditions. Attempts are being made to relate the results of sensory panels to objective, instrumental tests which could then be used to evaluate the maturity of the corn. Ultimately these objective methods must be correlated with consumer preferences.

REVIEW OF LITERATURE

A complex series of chemical and physical changes occurs in the corn kernel during maturity, and many studies have been made of these changes and methods of measuring them. Culpepper and Magoon (9) found that during growth and maturity, dry matter increased, total sugar increased up to 15 days after silking and then decreased rapidly, reducing sugar decreased, non-reducing sugar (sucrose) increased up to 15 days after silking and then decreased, water-soluble polysaccharides increased rapidly, and total polysaccharides calculated as starch increased rapidly. Total solids increased more or less regularly as maturity advanced (9,10, 34) and were closely associated with total polysaccharides as starch, total sugars, and the sugar: starch ratio. The edible stage is between 25 and 35% total solids and in this range the relationships between total solids and the carbohydrate constituents are essentially linear and are closely correlated (21).

Percent reducing sugars and total sugars showed a downward trend with maturity. Flavor, skin texture, endosperm texture, and color deteriorated as the corn matured. This lowering of quality was most rapid after the moisture content fell below 70% (19).

The pericarp increased in toughness as maturity advanced (3,20). The toughness of pericarp is difficult to measure since factors such as endosperm firmness, variation between kernels on the same ear, varietal differences, and seasonal differences influence the measurements (20). Puncture index was very significantly correlated with moisture content (24). Kramer (27) stated that texture must be measured and defined in physical-numerical terms. The forces which may be used to measure texture are compression, tensile strength, cutting force, and shearing force. In evaluating maturity, texture is involved, but its measurement is made more difficult by other quality factors such as flavor, size and color.

The following factors were considered to determine the quality of canned corn: 1) degree of tenderness or toughness of the pericarp, 2) the nature of the polysaccharides and the ratio of water-soluble to total polysaccharides, 3) sugar content, and 4) the compactness of the polysaccharides in the endosperm (10).

Several methods of estimating the stage of plant growth on the basis of seasonal temperatures are described by Huelsen (20). The degree-hour summation above the base-line of 50°F is the only one in practical use. Although this method may give a rough approximation of maturity, the variation from season to season is too great to allow it to be used with confidence (33). The number of heat units required for the maturity of a crop is influenced by environmental factors such as rainfall, soil type and fertility, and topography (4,38).

The tests of raw product quality which have been developed are based on visual inspection, moisture content, toughness and amount of pericarp, total soluble polysaccharides, succulence, and specific gravity.

Some packers use the thumbnail test in which the maturity is determined by the amount of dough in relation to the milk. A trained fieldman can determine maturity fairly reliably (2).

Dry matter increases as maturity advances and is a good indication of quality and maturity. To measure the dry matter accurately it is necessary to dry the sample at 80°C in a vacuum oven until the weight is constant; the disadvantage of this method is the time required to complete the test (20). The Brown Duvel moisture test (37) is more rapid, but less accurate, showing a variation of 1.5 - 2.0% from vacuum oven moisture (7,20). Nine samples would be required to yield moisture values approximately equivalent to one vacuum oven sample (13). The Steinlite moisture tester is accurate and rapid, and is considered to be an adequate test of maturity (13, 19, 20). The Brabender test is an accurate method of measuring moisture content, but it is too slow (6, 20, 37).

Several tests have been developed to measure toughness and amount of pericarp. There is a fairly good correlation between the amount of pericarp and the maturity of corn (30). The amount of pericarp is determined by grinding a sample, washing it through a screen, and drying it in an oven. Several puncturing devices have been used in attempts to measure pericarp toughness (3,9,11,21,44). Although the accuracy of these instruments is influenced by extraneous factors, some of the puncture tests demonstrated significant differences in tenderness. Percent moisture was negatively and very significantly correlated with puncture index (3,11,44).

The use of the refractometer to measure total soluble solids is described by Scott, Belkengren, and Ritchell (41). The Gaertner refractometer is more suitable for this work than the Abbe-type. Since the liquid from the sample is not a clear solution, the image seen is not a sharp line; in the Gaertner instrument the light is divided and recombined, giving two light fields separated by a dark field. The correct setting is that at which the dark line just disappears. Calibration charts should be prepared for each variety by determining both refractive index and moisture (or some other index of maturity). The refractive index varies less than moisture tests with changes in the weather, and there is a close correlation between refractive index and sugar: starch ratio (41).

Sacklin, Kyle, and Wolford (39) found that a single calibration chart could have been used to predict the moisture of all varieties tested. Other workers have also reported the refractive index to be an accurate and rapid method of determining maturity (7,19).

Since starch and insoluble polysaccharides are closely associated with moisture content, the determination of these substances is an accurate method of determining maturity (20). Jenkins (22) developed a method using the alcohol-insoluble residue, that is the starches, hemicelluloses, fibre, and proteins, as a measure of quality; the method was later simplified (24). Several other methods of determining starch, insoluble polysaccharides, reducing sugars, and non-reducing sugars have been proposed but are not in general use (20). A method of measuring maturity based on the light-scattering effect of the components of the kernel when blended and suspended in water has been suggested (23). It is stated that the method is highly sensitive, reproducible, and rapid.

The succulometer is a hydraulic press which expresses the juice from the corn kernels. The succulometer readings correlate well with the alcohol-insolubles test for canned corn and with moisture content of the raw corn (30,31). The texturemeter operates on the principle of forcing a multiple spindle through the corn kernels in a perforated cup (20). A shear press has been devised with a shear cell consisting of a set of blades which shear through the kernels in a slotted box, and a compression cell which expresses the juice from a sample (5). A bimetric procedure was developed consisting of tests with the shear and compression cells of the shear press; the method was found to be rapid and accurate in determining the tenderness-maturity factor of quality of the raw corn and for canned corn (29). It was equal in accuracy to alcohol-insoluble solids measurement and somewhat less accurate but more rapid than the trimetric test (42). In use on peas, the shear press was equal in precision and accuracy to the tenderometer and superior to the texturemeter (28). Several modifications and attachments of the shear press were described by Hartman, Isenberg, and Ang (17). They tested two of these new attachments and the universal cell, and found that none of them gave consistent correlations with subjective estimates of texture(1).

Specific gravity values obtained from fresh and processed whole kernel corn showed good relationship with fresh product moisture content and with fresh and processed product alcohol-insoluble solids (8). Total solids, moisture content, alcohol-insoluble solids, and total reserve polysaccharides could be predicted by the use of specific gravity techniques. The specific gravity method is the simplest method of estimating maturity (14,35).

Kramer described a trimetric test for sweet corn quality; this test consists of moisture, pericarp, and kernel size determinations and was found to predict processed corn quality accurately, regardless of variations caused by varietal differences or climatic conditions(26).

Although many methods are available for the objective measurement of appearance and kinesthetic factors of quality, evaluation of flavor factors must still be done largely by sensory panels (25). Hening (18) outlines the methods used in flavor evaluation and consumer acceptance tests, and the selection of taste panel members. Kramer and Twigg (32) describe the various types of sensory panels, their proper use, and the statistical analysis and interpretation of the results. Good correlations were obtained between the results of the subjective panel evaluation of the tenderness-maturity factor and the results of the trimetric test (43). Sather and Calvin (40) found that flavour preference scores were related to maturity factors as measured by trained-panel scores for tenderness and maturity, shear resistance, percent moisture, soluble solids, and USDA maturity scores. Flavor intensity and maturity were the only factors affecting preference. Shear resistance, percent moisture, and percent soluble solids were the only physicochemical factors significantly correlated with flavor preference.

There is good correlation between the results of the trimetric test and those of the subjective panel evaluation of the tenderness-maturity factor. The trimetric test may be used with considerable reliability to evaluate the tenderness maturity of canned or frozen whole kernel corn, but the extent of its practical application may be limited by the time required to complete the test (42). The alcohol-insoluble solids content is the most reliable method of determining the maturity of fresh, frozen, and canned corn. Percent soluble solids determined by the refractometer is the most reliable quick method (16). Steinlite moisture meter, succulometer, vacuum oven moisture, and percent soluble solids by refractometer are adequate tests of maturity; the refractive index requires the least amount of time (19). Vacuum oven moisture, crude starch, and alcohol-insoluble solids are not adaptable to quality control for processing because they are too slow. Refractive index was the most rapid, accurate, and useful method of determining maturity (7,15).

MATERIALS AND METHODS

Several methods were used to measure the changes which take place in the quality of sweet corn as maturity advances. These methods were assessed to ascertain their suitability for determining the time of harvest.

Three commercial varieties of sweet corn representing a range of maturities were grown. The varieties and their relative maturities are as follows:

Variety	Seed Source	Maturity
1. Carmelcross	Northrup-King	early
2. NK51036	Northrup-King	mid-season
3. 58-1804C	Rogers Bros.	late

Two 30-foot rows of each variety were planted in each plot, and varieties were randomized within the plots. Nine plots, each corresponding to a different harvest date, were randomized within each of four replicates. The seed was planted at the rate of 60 seeds per row on June 8; hand seeders were used because the soil was too wet to permit the use of a power seeder. The plants were thinned to about 11 inches apart on July 7. Ammonium phosphate fertilizer (11-48-0) was banded about six inches to the side of the row and two inches deep at the rate of 100 pounds per acre on July 8. Urea (45-0-0) was side-dressed on July 23 at the rate of 200 pounds per acre. Two irrigations were made on July 27 and August 11.

When the plants began to silk, the number of silked plants was counted each day. The date of silking for a variety was considered to be the date on which 80% or more of the plants had silked. When the 80% silking mark was reached, the ears on the plants which had not yet silked were removed to prevent the harvest of any extremely young ears.

Beginning September 7, a series of harvests of Carmelcross and NK51036 was made, ranging from immature to overmature. The variety 58-1804C was abandoned because it was extremely late. Eight harvests of Carmelcross and seven of NK51036 were made. Heavy frost occurred on September 25 and 26, preventing further harvesting.

All the ears were picked from each plot and weighed. The ears from the four replicates were bulked. A sample of approximately 90 ears was taken and the kernels removed. Samples were canned and frozen according to directions supplied by the Ontario Department of Agriculture and the United States Department of Agriculture. The following measurements were made on the fresh kernels:

1) Moisture content was determined using both the vacuum oven and the electric oven. A sample of kernels was ground in a Waring Blender for three minutes. Ten grams of the ground material were placed in previously weighed aluminum dishes. Two dishes were dried in the electric oven for two hours at 100°C and two were dried for 45 minutes in the electric oven and then moved to the vacuum oven and dried for three hours at 80°C. The weight of the dried sample minus the weight of the dish, times ten equals percent dry matter.

2) Percent pericarp was determined using the method described by Gould, et al (15). Duplicate 25 gram samples were ground with 200 ml. of water in a Waring Blender for three minutes. The slurry was washed onto previously weighed wire mesh screens and dried in an electric oven at 100°C for two hours. The weight of the dried sample minus the weight of the screen, times four equals the percent pericarp.

3) Percent alcohol-insoluble solids was determined using the method described by Gould, et al (15). Duplicate ten gram samples were ground with 150 ml. of 80% ethyl alcohol in a Waring Blender for three minutes.

The samples were washed into 600 ml. beakers with 150 ml. of 80% ethyl alcohol and simmered for 30 minutes. They were then filtered onto previously weighed filter papers, dried at 100°C for two hours, and weighed. The difference in weight times ten equals the percent alcohol-insoluble solids.

4) The shear press rating was determined using the method outlined by Kramer and Cooler (29) and modified slightly. A 100 gram sample was placed in the compression cell and the cell was placed in position in the shear press. The speed of stroke was set at one minute and the sample was compressed until no more juice was being collected. The volume of juice collected was reported as ml. of juice expressed from the 100 gram sample.

For the shear test, 100 grams of kernels were placed in the shear cell and placed in position in the shear press. The speed of stroke was set at one minute. The force required was recorded on the recorder chart.

The predicted grade score for the tenderness-maturity factor was calculated according to the following regression equation:

$M = 31.5 + 0.461C - 0.00657\ S$, where M is the predicted grade score, C is the ml. of juice expressed, and S is the shear value in pounds force.

5) Kernel diameter was measured by lining up 20 kernels side by side and measuring them at their widest point.

6) Kernel volume was measured by placing 100 kernels in a measured volume of water and noting the increase in volume.

7) The trimetric rating was calculated using the following regression

equation:

U.S. score for maturity = $6.44 + 0.530\ S - 5.396\ P - 1.261\ D$, where S is percent moisture, P is percent pericarp, and D is the length in inches of 20 kernels placed side by side (26).

8) The refractive index of the corn juice was measured using a Gaertner refractometer. A small amount of the sample prepared for moisture determination was placed on a cotton wool pad and the juice was squeezed through into the space between the prisms.

The following measurements were made on the canned and frozen corn:

1) Percent pericarp was determined in the same manner as for fresh corn.
2) Percent alcohol-insoluble solids was determined as for fresh corn.
3) The shear press rating was determined as for fresh corn after the samples had been drained for three minutes. The grade score was calculated from the following regression equation:

   $M = 36.28 + 0.529\ C - 0.0266\ S$, where M is the maturity score, C is the ml. of juice expressed, and S is the shear value in pounds force.
4) The kernel diameter and kernel volume were measured as for fresh corn.
5) The trimetric rating was obtained using the same regression equation used for fresh corn.

The canned and frozen samples were evaluated by a five-member sensory panel made up of three laboratory technicians who had had no previous experience in this type of work, a plotman and a professor, both of whom could be considered quite experienced. The panel members were selected from a group of nine people who were given two training sessions. In each of the training sessions the panelists were required to score two identical sets of four samples each. The panelists were asked to score the samples objectively rather than according to their own preferences. Each sample was rated on a scale of 0 for poor to 5 for excellent for each of the following characteristics: color intensity, brightness, uniformity of color, kernel size, uniformity of size, pericarp tenderness, succulence, flavor, and sweetness (Appendix Table A). The data were analysed according to the "Weighted-Rankit" method of Mickelson, Lachman, and Allen (36) (Appendix Table B). The samples were served hot to the panelists who sat in individual booths. An entire group of samples, that is, one variety either canned or frozen, was evaluated at any one session. The four groups were evaluated on different days and each group was evaluated once.

Simple correlation coefficients were calculated between the various characteristics to determine their relationship. Correlation coefficients were calculated between refractive index and the following measurements of the raw corn: vacuum oven moisture content, trimetric rating, shear press rating, pericarp content, and alcohol-insoluble solids content, and between refractive index and the following measurements of canned and frozen corn: shear press ratings, trimetric ratings, and alcohol-insoluble solids content.

Correlation coefficients were calculated between vacuum oven moisture content and the following characteristics of fresh corn:

electric oven moisture content, refractive index, alcohol-insoluble solids content, pericarp content, compression, shear, and shear press rating, as well as the shear press ratings, trimetric ratings, and alcohol-insoluble solids content of the canned and frozen corn.

Correlation coefficients were calculated between the trimetric rating of the fresh corn and the shear press rating, refractive index, and alcohol-insoluble solids content of the fresh corn, and the shear press rating, trimetric rating, and alcohol-insoluble solids content of the canned and frozen corn.

Correlation coefficients were calculated between the shear press rating of the fresh corn and the moisture content, refractive index, trimetric rating, alcohol-insoluble solids content, and pericarp content of the fresh corn and the shear press rating, trimetric rating, and alcohol-insoluble solids content of the canned and frozen samples.

RESULTS AND DISCUSSION

Several kernel characteristics of the raw corn were evaluated to determine their relationship to each other and to the characteristics of canned and frozen corn. From the results, an attempt was made to select a simple, accurate, and rapid method which processors could use to evaluate the maturity and quality of the corn.

Weather conditions

The 1965 growing season was abnormally cool and wet. Seeding was delayed until June 10 by 3.74 inches of rain in May and a further 1.81 inches in early June. A total of 8.83 inches fell in June, July, and August compared with an average for the previous five years of 8.11 inches. A further 2.87 inches fell in September before harvesting was complete. The monthly mean temperatures, the monthly degree-days above 50^{o} F, and the total number of degree-days for June, July, August, and September were lower than the average of the previous five years. Only 30 degree-days above 50^{o} F were received in September when the corn was harvested (Table 1). Normally, the harvesting would be done in August, when 400 to 500 degree-days would be received to promote maturation. The total number of degree-days from seeding to last harvest was 1245 and the total precipitation was 9.89 inches.

Silking dates

The average silking dates of the varieties Carmelcross and NK51036 were August 13 and August 15 respectively, as shown in Table 2. Several plots of each variety failed to reach the 80% silking mark by these dates, probably due to field variations and the abnormally cool, wet summer. Any effect that these late ears would have had was eliminated by

Table 1. Precipitation, mean temperature, and degree-days at Winnipeg.

a) Precipitation (inches)

	June	July	August	Total
1960-'64 ave.	2.51	2.61	2.99	8.11
1965	3.50	3.55	1.78	8.83

b) Mean temperature (^{o}F).

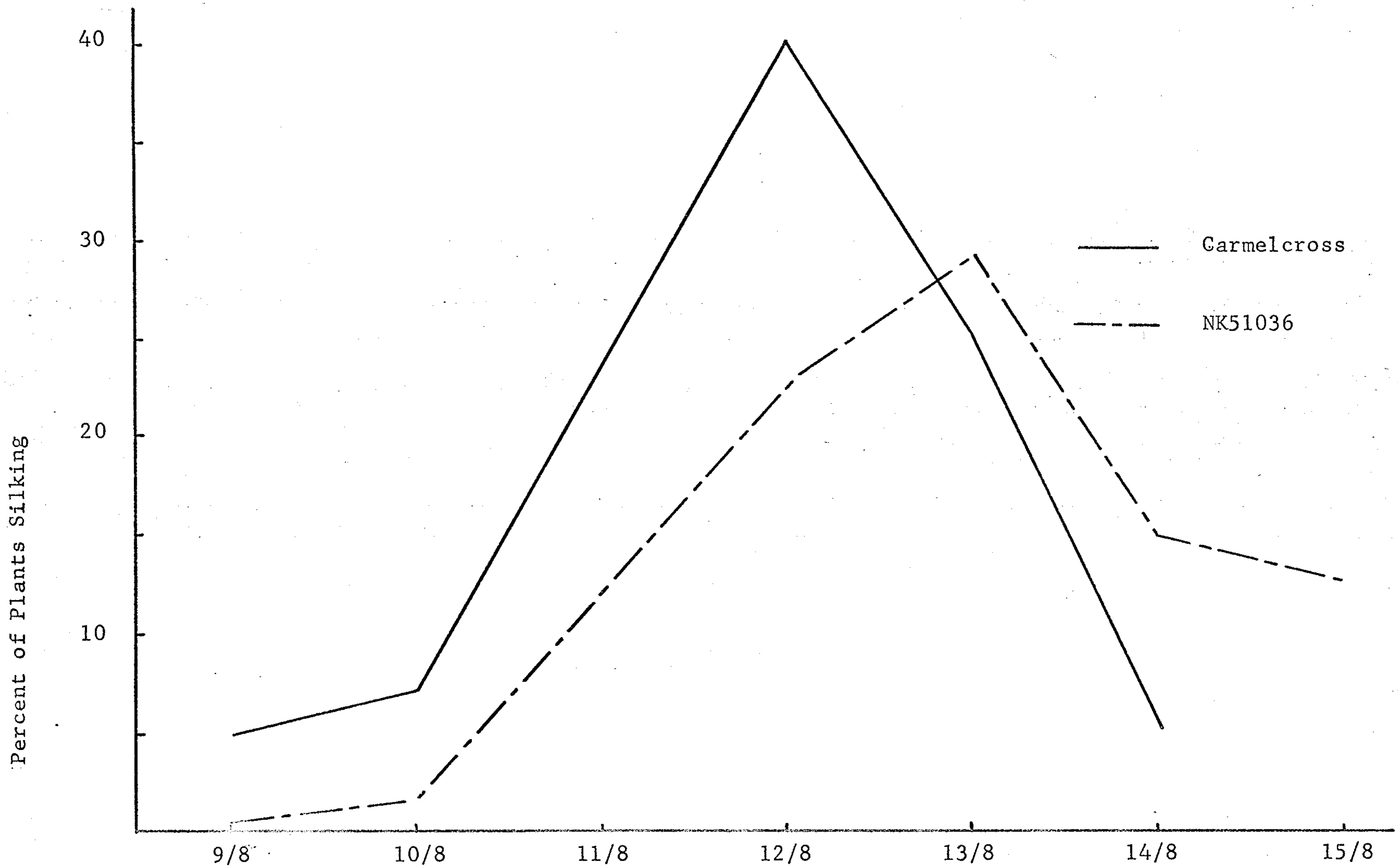
	June	July	August	September
1960-'64 ave.	64.1	68.9	66.6	54.7
1965	62.5	65.0	64.2	47.3

c) Degree-days above 50^{o}F.

	June	July	August	September	Total
1960-'64 ave.	423	586	515	140	1664
1965	395	456	442	30	1323

the removal of all ears which had not silked by these dates. Generally, silking increased rapidly to a peak and then declined sharply as shown in Figure 1. The silking period ranged over approximately six days. The unevenness of silking and the length of the silking period may have been due to the uneven germination, which in turn was caused by the difficulty experienced in planting the seed in wet soil.

The characteristics of the fresh corn which were measured are shown in Table 3 and those of canned and frozen corn in Tables 4 and 5 respectively.



gure 1. The percentage of plants silking on any one day.

(a) Variety - Carmelcross

Harvest	9/8				10/8				12/8				13/8				14/8			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	6	4	11	4	8	17	17	7	24	60	70	56	64	$\underline{89}$	$\underline{91}$	$\underline{87}$	$\underline{79}$	98	96	98
2	9	4	4	0	26	11	7	3	74	48	55	44	$\underline{81}$	$\underline{81}$	$\underline{91}$	78	81	87	98	$\underline{83}$
3	5	6	9	10	17	7	17	10	63	38	52	33	$\underline{85}$	52	63	57	85	56	72	69
4	4	5	5	8	11	13	13	21	66	68	55	69	$\underline{87}$	$\underline{88}$	75	$\underline{92}$	91	95	$\underline{84}$	96
5	3	4	14	6	8	10	31	15	43	70	61	40	$\underline{84}$	$\underline{92}$	$\underline{94}$	66	86	92	100	$\underline{79}$
6	3	12	6	0	6	27	17	3	31	78	55	16	61	$\underline{96}$	$\underline{81}$	35	69	98	89	62
7	2	2	9	2	7	12	13	7	36	48	57	44	64	66	78	77	76	70	$\underline{87}$	$\underline{83}$
8	4	0	0	6	7	5	6	8	45	36	46	63	$\underline{80}$	57	$\underline{85}$	79	87	62	92	$\underline{90}$

(b) Variety - NK51036

Harvest	9/8				10/8				12/8				13/8				14/8				15/8			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	0	0	0	0	0	3	5	2	2	28	48	28	39	70	71	60	59	78	$\underline{83}$	77	$\underline{93}$	$\underline{88}$	93	$\underline{93}$
2	0	0	0	0	0	0	4	3	11	6	43	34	73	53	77	61	$\underline{89}$	63	$\underline{91}$	$\underline{82}$	95	66	100	89
3	0	0	0	0	2	0	0	0	33	13	13	18	64	39	34	47	$\underline{80}$	47	51	75	96	50	70	$\underline{78}$
4	0	0	0	5	3	0	2	11	50	15	16	45	78	50	44	66	$\underline{80}$	79	70	74	88	$\underline{92}$	$\underline{78}$	$\underline{83}$
5	0	0	2	0	0	7	6	0	32	25	43	23	57	54	79	53	70	70	$\underline{91}$	65	$\underline{86}$	$\underline{86}$	96	74
6	0	2	0	0	0	7	4	0	16	41	27	10	39	78	65	38	50	$\underline{93}$	71	50	63	100	$\underline{82}$	65
7	0	0	0	4	0	5	0	6	25	23	40	30	52	64	$\underline{84}$	58	66	71	86	75	73	$\underline{82}$	92	$\underline{85}$

$\underline{\quad}$ underlined figures indicate the day on which 80% of the plants were silked.

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Table 3. Some characteristics of the fresh corn at different harvest dates.

(a) Variety - Carmelcross

Harvest Date	Vacuum Oven Moisture, %	Electric Oven Moisture, %	Ear Wt., lb.	Pericarp, %	A.I.S., %	Shear, lb.	Compression, ml.	Diam. 20 Kernels, in.	Vol. 100 Kernels, ml.	Refract. Index	Trimetric Rating	Shear Press Rating
7/9	83.0	83.9	0.91	0.60	7.1	275	20.0	7.0	22.0		38.4	38.9
10/9	80.7	81.4	0.96	1.56	11.7	280	17.5	7.8	25.5	3°35'	31.2	37.7
13/9	80.0	80.6	0.94	1.42	10.1	285	17.5	7.4	26.5	3°43'	32.0	37.2
16/9	76.8	77.7	0.94	1.56	14.5	238	20.0	7.9	28.5	4°36'	29.0	39.2
20/9	75.3	76.4	0.97	1.70	16.4	258	20.8	8.4	31.0	4°38'	26.8	39.4
22/9	73.8	75.0	0.96	1.68	16.6	260	19.5	8.4	30.0	5°05'	26.1	38.8
24/9	73.5	73.7	0.99	1.78	18.7	243	19.3	8.3	34.0	5°11'	25.5	38.8
27/9	73.2	73.8	0.96	1.92	16.4	223	18.8	8.4	33.0	5°14'	24.5	38.7

(b) Variety - NK51036

Harvest Date	Vacuum Oven Moisture, %	Electric Oven Moisture, %	Ear Wt., lb.	Pericarp, %	A.I.S., %	Shear lb.	Compression, ml.	Diam. 20 Kernels, in.	Vol. 100 Kernels, ml.	Refract. Index	Trimetric Rating	Shear Press Rating
8/9	82.3	82.1	0.70	1.20	9.7	245	18.3	6.0	19.5	3°19'	36.2	38.3
10/9	80.9	81.4	0.76	1.50	10.1	250	17.8	6.0	19.5	3°29'	33.9	38.1
14/9	80.1	80.7	0.75	1.60	9.4	253	21.3	6.3	22.0	3°44'	32.5	39.7
16/9	78.3	79.2	0.81	1.46	12.8	213	19.0	6.5	24.0	4°07'	32.1	38.9
20/9	74.9	76.1	0.77	1.46	15.6	218	19.8	6.9	24.0	4°53'	29.8	39.2
22/9	75.2	76.5	0.80	1.58	16.5	203	19.3	7.2	25.0	4°51'	28.9	39.1
27/9	73.7	74.2	0.77	1.60	18.2	193	18.5	7.2	25.5	5°15'	28.0	38.8

Table 4. Some characteristics of the canned corn at different harvest dates.

(a) Variety - Carmelcross

Harvest Date	Pericarp, %	A.I.S., %	Shear, lb.	Compression, ml.	Shear Press Rating	Diam. 20 Kernels, in.	Vol. 100 Kernels, ml.	Trimetric Rating
7/9	1.08	7.2	488	32.4	40.4	7.2	25.0	35.5
10/9	1.10	8.2	456	29.9	40.0	7.3	25.0	34.1
13/9	1.24	10.0	454	29.3	39.7	8.0	28.0	31.8
16/9	1.28	12.0	419	28.6	40.3	8.1	29.5	31.1
20/9	1.32	14.1	385	27.3	40.5	8.0	30.5	30.4
22/9	1.36	14.0	404	25.8	39.2	8.2	32.0	29.1
24/9	1.40	14.1	385	26.6	40.1	8.2	32.5	29.2
27/9	1.44	14.9	420	26.0	38.9	8.3	33.5	28.6

(b) Variety - NK51036

Harvest	Pericarp, %	A.I.S., %	Shear, lb.	Compression, ml.	Shear Press Rating	Diam. 20 Kernels, in.	Vol. 100 Kernels, ml.	Trimetric Rating
8/9	1.10	7.3	479	32.3	40.6	5.9	17.5	37.4
10/9	1.10	8.5	439	30.0	40.5	6.4	20.0	33.5
14/9	1.20	9.3	444	31.8	41.3	6.6	20.5	35.5
16/9	1.20	11.0	366	28.8	41.8	7.0	23.0	33.4
20/9	1.16	12.5	340	26.9	41.5	6.8	24.5	33.1
22/9	1.30	13.9	366	26.8	40.7	7.1	24.5	31.7
27/9	1.18	15.4	311	26.9	42.2	7.1	26.5	32.5

Table 5. Some characteristics of the frozen corn at different harvest dates.

(a) Variety - Carmelcross

Harvest Date	Pericarp, %	A.I.S., %	Shear, lb.	Compression, ml.	Shear Press Rating	Diam. 20 Kernels, in.	Vol. 100 Kernels, ml.	Trimetric Rating
7/9	1.42	7.8	534	30.5	38.2	6.9	21.0	33.0
10/9	1.56	10.7	543	28.8	37.1	7.6	23.5	30.3
13/9	1.64	12.0	458	26.5	38.1	8.0	25.5	28.1
16/9	1.80	13.2	491	25.9	36.9	7.9	27.0	27.0
20/9	1.94	14.6	468	24.4	36.7	8.0	28.5	25.2
22/9	1.84	17.5	448	26.0	38.1	8.1	27.0	26.4
24/9	1.74	16.8	420	25.3	38.5	8.2	29.0	26.6
27/9	1.94	17.6	458	24.3	37.0	8.7	31.0	24.1

(b) Variety - NK51036

Harvest Date	Pericarp, %	A.I.S., %	Shear, lb.	Compression, ml.	Shear Press Rating	Diam. 20 Kernels, in.	Vol. 100 Kernels, ml.	Trimetric Rating
8/9	1.54	9.2	538	31.4	38.6	5.9	17.5	34.3
10/9	1.44	9.9	471	29.6	39.4	6.3	18.5	33.4
14/9	1.52	10.9	439	29.1	40.0	6.5	18.5	32.4
16/9	1.68	12.6	431	25.8	38.5	6.8	20.0	29.4
20/9	1.64	14.6	438	25.0	37.9	7.3	21.0	28.5
22/9	1.60	16.0	425	24.4	37.9	7.0	22.5	28.9
27/9	1.62	16.2	389	26.1	39.7	6.8	22.5	29.9

Moisture content

Moisture content is generally regarded as the most accurate index of sweet corn maturity. Of the several methods of determining moisture content, the vacuum oven method is the most accurate and was used as a standard in comparing other maturity indices. The moisture values determined by drying the samples in an electric oven at 100°C averaged 0.5% higher than the vacuum oven values at 80°C. This suggested that the electric oven was too hot and was causing some burning of the samples. The vacuum oven moisture percentages are shown graphically in Figure 2. The results of the two methods were extremely well correlated. Highly significant negative correlations were obtained between moisture content and refractive index and alcohol-insoluble solids content of the fresh corn, as shown in Table 6. The correlation with shear reading was significant at the 5% level for the variety Carmelcross and at the 1% level for NK51036. The pericarp content, the compression reading, and the shear press rating gave non-significant correlation coefficients with moisture content for both varieties.

The moisture content of the fresh corn was negatively and significantly correlated with alcohol-insoluble solids content of both canned and frozen corn, as shown in Table 7. The correlations of moisture content with the trimetric rating of Carmelcross were significant at the 1% level for both canned and frozen corn, and those of NK51036 were significant at the 1% level for frozen and at the 5% level for canned corn. The correlations between moisture content and the shear press ratings of the canned and frozen product were not significant.

Pericarp content

The pericarp content of the fresh corn increased rather sharply in the early stages and then gradually as

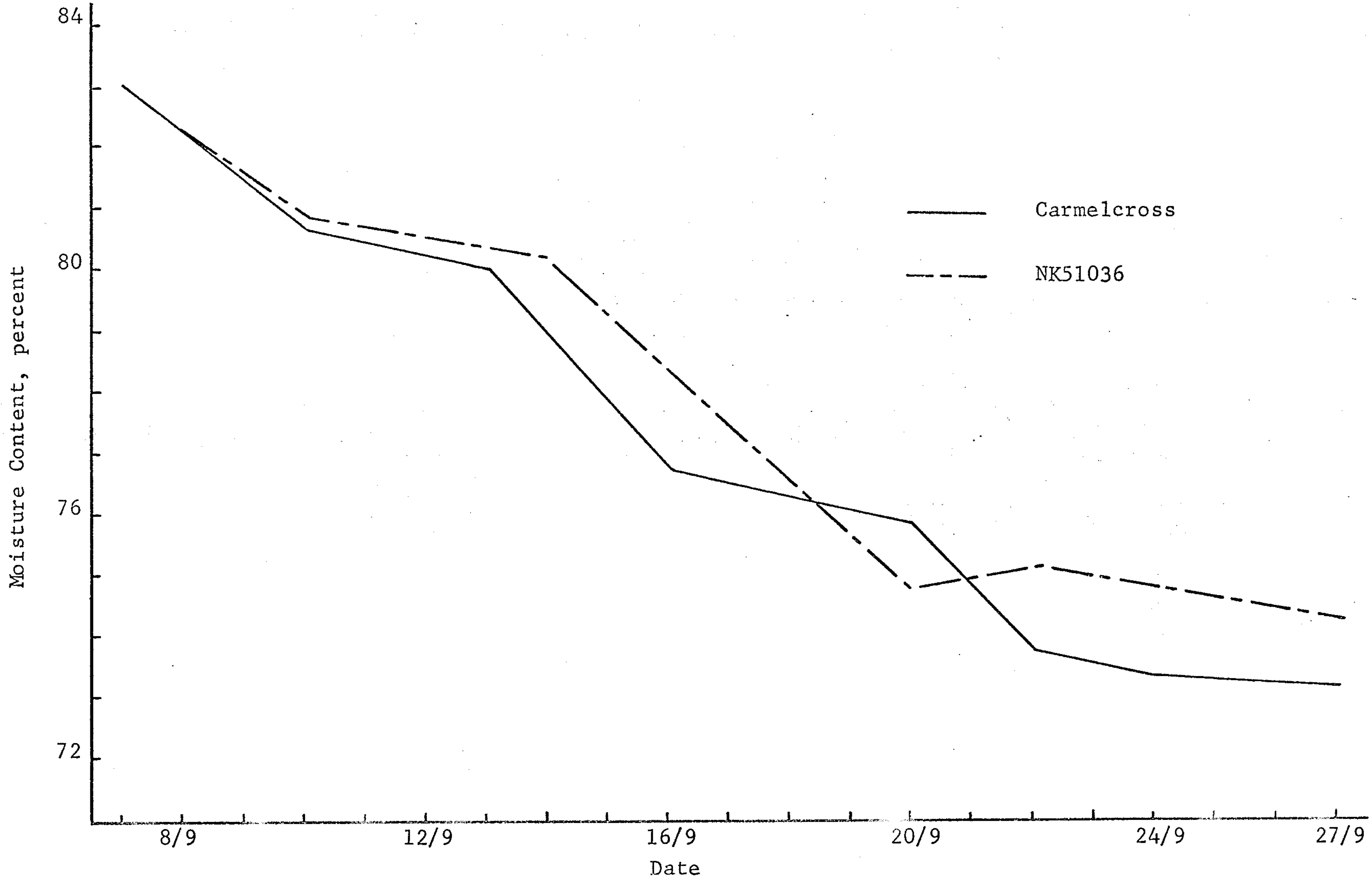

Figure 2. The relationship between moisture content and maturity of fresh corn kernels.

Table 6. Simple correlation coefficients between the moisture content of the fresh corn, as determined by the vacuum oven method, and each of seven characteristics of the fresh corn.

Variety	Electric oven Moisture	Refractive Index	A.I.S. Content	Pericarp Content	Shear	Compression	Shear Press Rating
Carmelcross[1]	.99**	-.99**[2]	-.96**	-.82*	.79*	-.29	-.46
NK51036[2]	.99**	-.99**	-.97**	-.58	.89**	-.13	-.40

1. n = 8
 * r 5% = .707
 ** r 1% = .834

2. n = 7
 * r 5% = .754
 ** r 1% = .874

From R.A. Fisher. Statistical Methods for Research Workers. Oliver and Boyd, Edinburgh.

Table 7. Simple correlation coefficients between the moisture content of the fresh corn and each of three characteristics of the canned and frozen corn.

Variety	Shear Press Rating (Frozen)	Shear Press Rating (Canned)	Trimetric Rating (Frozen)	Trimetric Rating (Canned)	A.I.S. Content (Frozen)	A.I.S. Content (Canned)
Carmelcross[1]	.14	.46	.92**	.97**	-.98**	-.98**
NK51036[2]	.28	.61	.90**	.82*	-.99**	-.98**

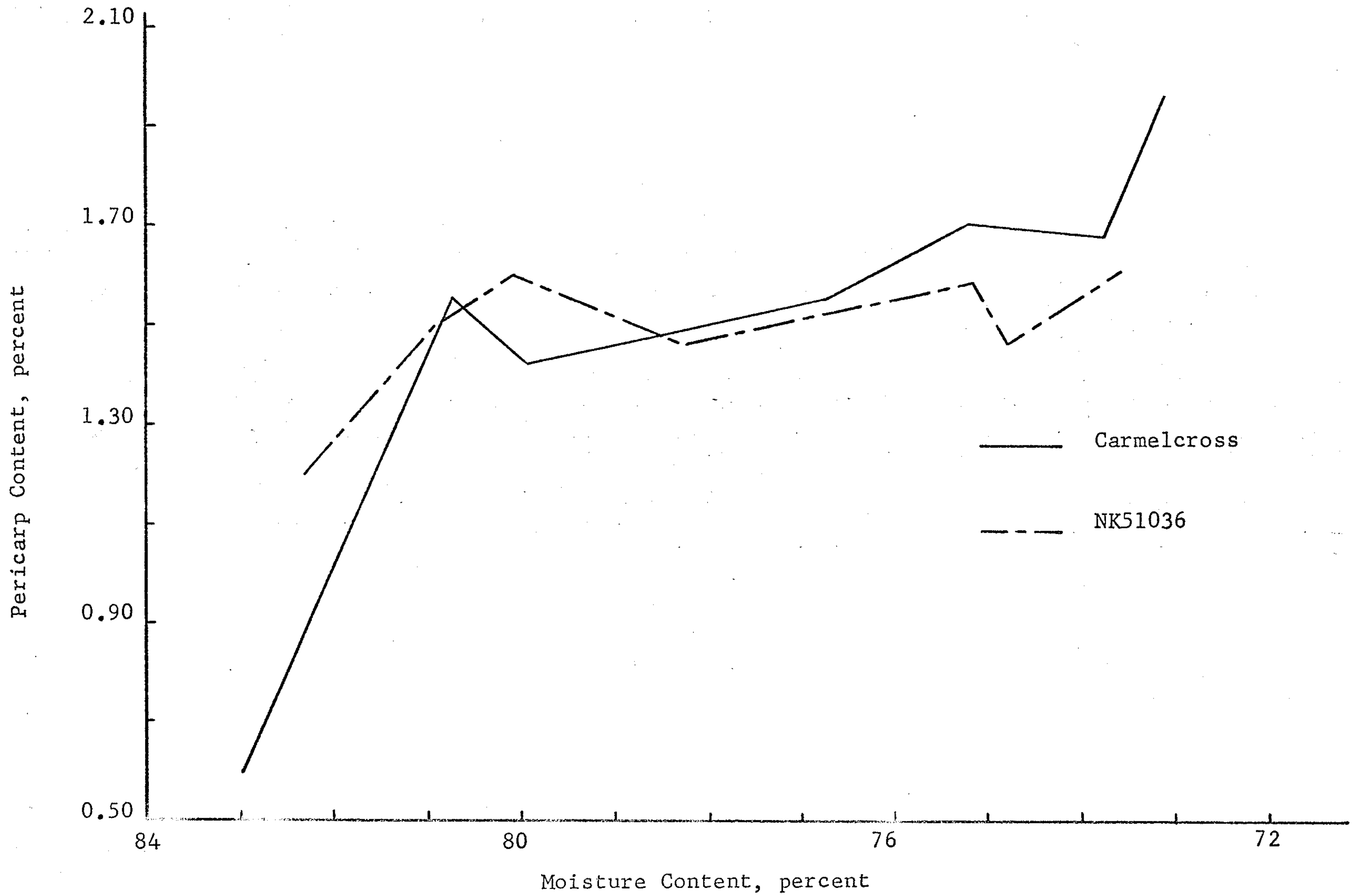

Figure 3. The relationship between pericarp content and moisture content of fresh corn.

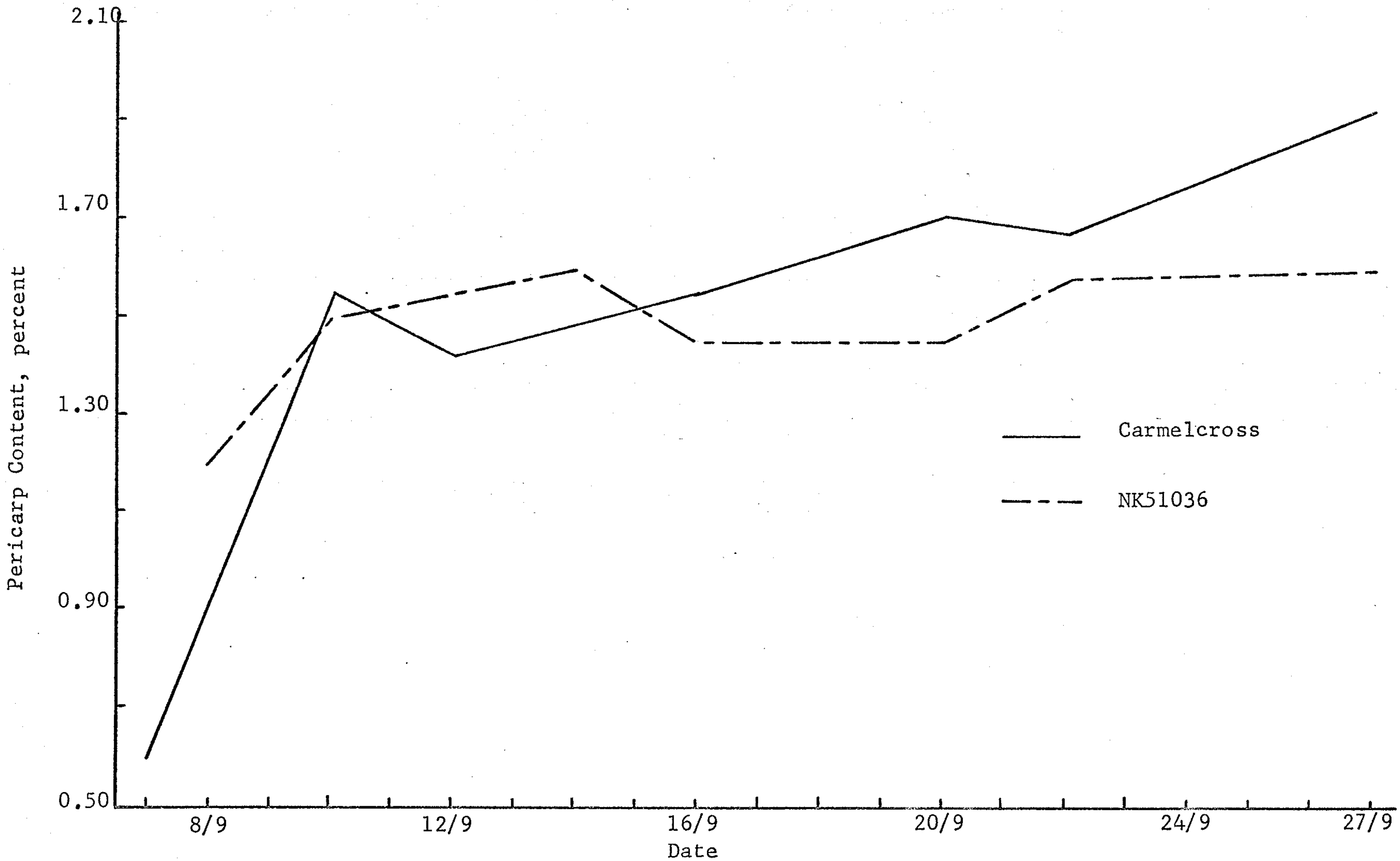

Figure 4. The relationship between pericarp content and maturity of fresh corn.

the corn matured (Table 3, Figures 3 and 4). As shown in Table 6, the correlation between pericarp and moisture content was significant at the 5% level for Carmelcross, but non-significant for NK51036. The correlation between pericarp content and the shear reading of the shear press was not significant for either variety when fresh or frozen or for canned NK51036, but was highly significant for canned Carmelcross (Table 8).

Table 8. Simple correlation coefficients between the pericarp content and the shear reading.

Pericarp (fresh) vs. Shear Reading (fresh)	-	Carmelcross	.53
		NK51036	.36
Pericarp (frozen) vs. Shear Reading (frozen)	-	Carmelcross	.66
		NK51036	.49
Pericarp (canned) vs. Shear Reading (canned)	-	Carmelcross	.84**
		NK51036	.49

Alcohol-insoluble solids content

The alcohol-insoluble solids content of both varieties increased with maturity, ranging from 7.1 to 18.7% in Carmelcross and from 9.4 to 18.2% in NK51036 (Table 3). These changes are shown graphically in Figures 5 and 6. Percent alcohol-insoluble solids of both varieties, as indicated in Table 9, was significantly correlated with moisture content, refractive index, and trimetric rating, but was not correlated with the shear press rating.

Table 9. Simple correlation coefficients between the alcohol-insoluble solids content of the fresh corn and each of four characteristics of the fresh corn.

Variety	Moisture Content	Refractive Index	Trimetric Rating	Shear Press Rating
Carmelcross[1]	-.96**	.93[2]**	-.97**	.40
NK51036[2]	-.97**	.97**	-.92**	.20

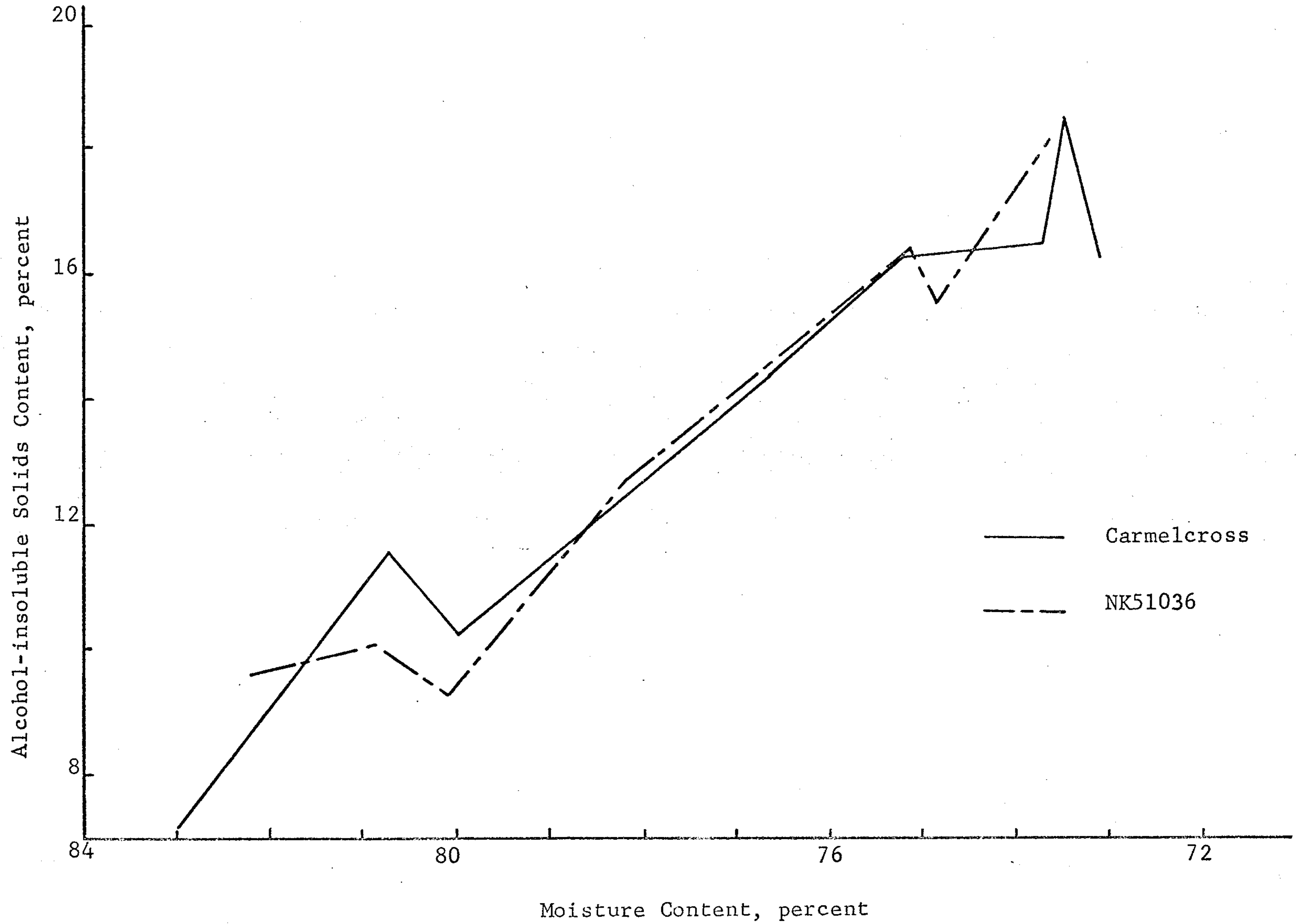

Figure 5. The relationship between alcohol-insoluble solids content and moisture content of fresh corn.

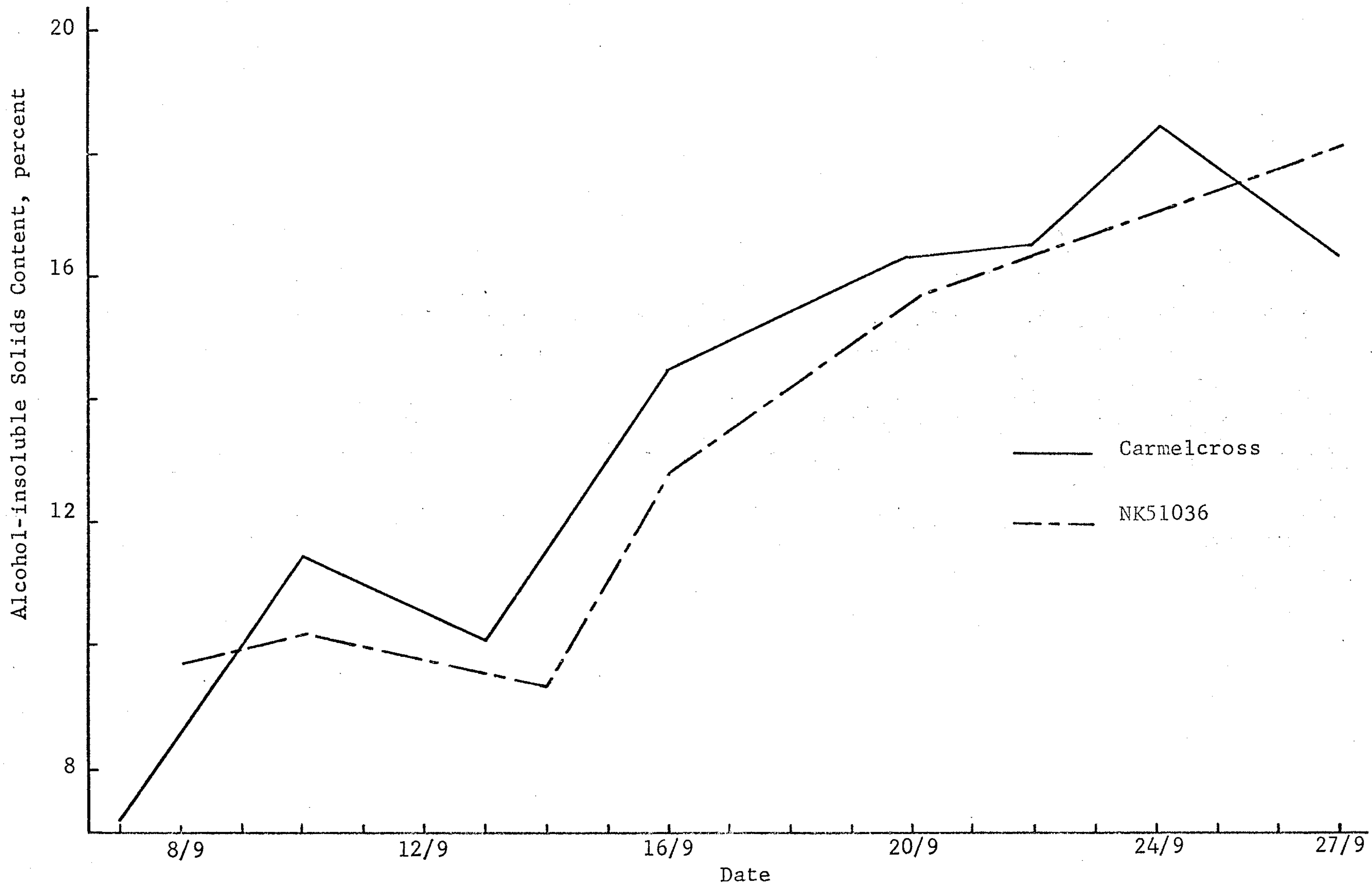

Figure 6. The relationship between alcohol-insoluble solids content and maturity of fresh corn.

The alcohol-insoluble solids content of both canned and frozen corn was lower than that of the fresh corn, suggesting that some of the starch was lost during processing; the alcohol-insoluble solids content of the canned product was lower than that of the frozen. The alcohol-insoluble solids content of the frozen Carmelcross averaged 1.4% less than that of the fresh corn and the canned Carmelcross 2.1% less. The corresponding values for NK51036 were 0.4% less for frozen and 2.1% less for canned.

Trimetric rating

The trimetric rating, a combination of pericarp content, moisture content, and kernel diameter, decreased steadily with increasing maturity, as shown in Figure 7. Correlations between the trimetric rating and the refractive index and percent alcohol-insoluble solids of the fresh corn were negative and highly significant for both varieties. Trimetric ratings and shear press ratings were not significantly correlated as shown in Table 10.

The trimetric rating of the fresh corn was negatively and significantly correlated with alcohol-insoluble solids content of the canned and frozen corn of both varieties (Table 11). It was significantly correlated with the canned and frozen trimetric ratings at the 1% level for Carmelcross and at the 5% level for NK51036. Correlations with the shear press ratings were not significant.

Table 10. Simple correlation coefficients between the trimetric rating of the fresh corn and each of three characteristics of the fresh corn.

Variety	Refractive Index	Shear Press Rating	A.I.S. Content
Carmelcross[1]	-.91**[2]	-.27	-.97**
NK51036[2]	-.98**	-.48	-.92**

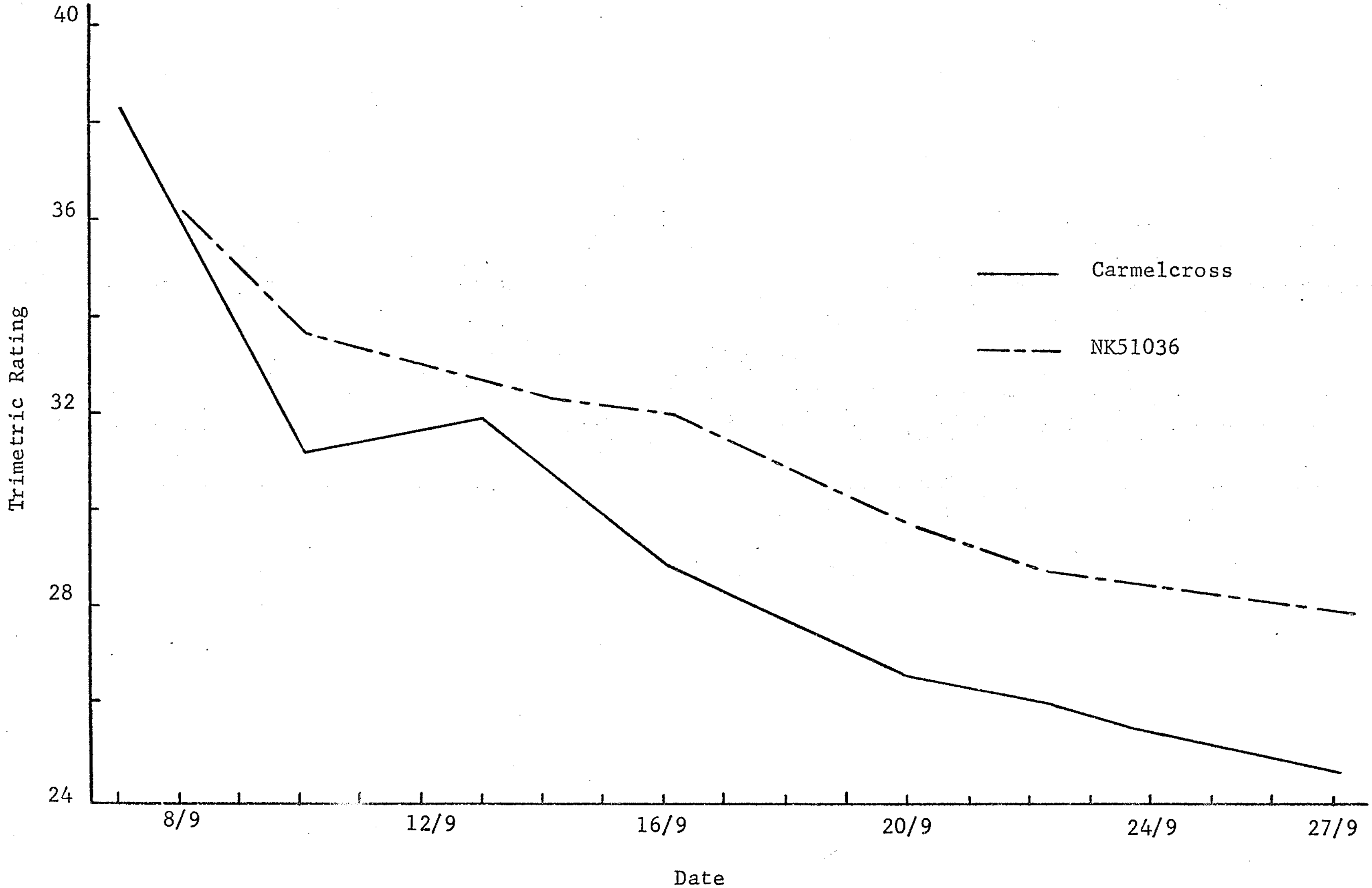

Figure 7. The relationship between trimetric rating and maturity of fresh corn.

Table 11. Simple correlation coefficients between the trimetric rating of the fresh corn and each of three characteristics of the canned and frozen corn.

Variety	Shear Press Rating (Frozen)	Shear Press Rating (Canned)	Trimetric Rating (Frozen)	Trimetric Rating (Canned)	A.I.S. Content (Frozen)	A.I.S. Content (Canned)
Carmelcross[1]	.27	.48	.95**	.94**	-.97**	-.94**
NK51036[2]	.15	.59	.86*	.85*	-.98**	-.98**

Shear press

The shear reading, measuring the toughness of the corn, showed a general decrease as maturity advanced (Figures 8 and 9). The compression readings showed no definite pattern (Figures 10 and 11) and were not correlated with either moisture content or alcohol-insoluble solids content as shown in Table 12. The shear press ratings were not significant when correlated with moisture content, refractive index, trimetric rating, percent alcohol-insoluble solids, or percent pericarp of the fresh corn (Table 13). The shear press ratings of the fresh corn are shown graphically in Figures 12 and 13.

The shear press ratings of the fresh corn were not significantly correlated with those of the canned and frozen corn or with the trimetric ratings or percent alcohol-insoluble solids of the canned and frozen product, as shown in Table 14.

The shear readings of the canned and frozen corn decreased with advancing maturity. The compression readings of the processed corn showed a more marked decrease with maturity than did those of the fresh corn. The compression readings of the canned corn were highly correlated with the moisture content of the fresh corn and the alcohol-insoluble solids content of the canned corn (Table 15).

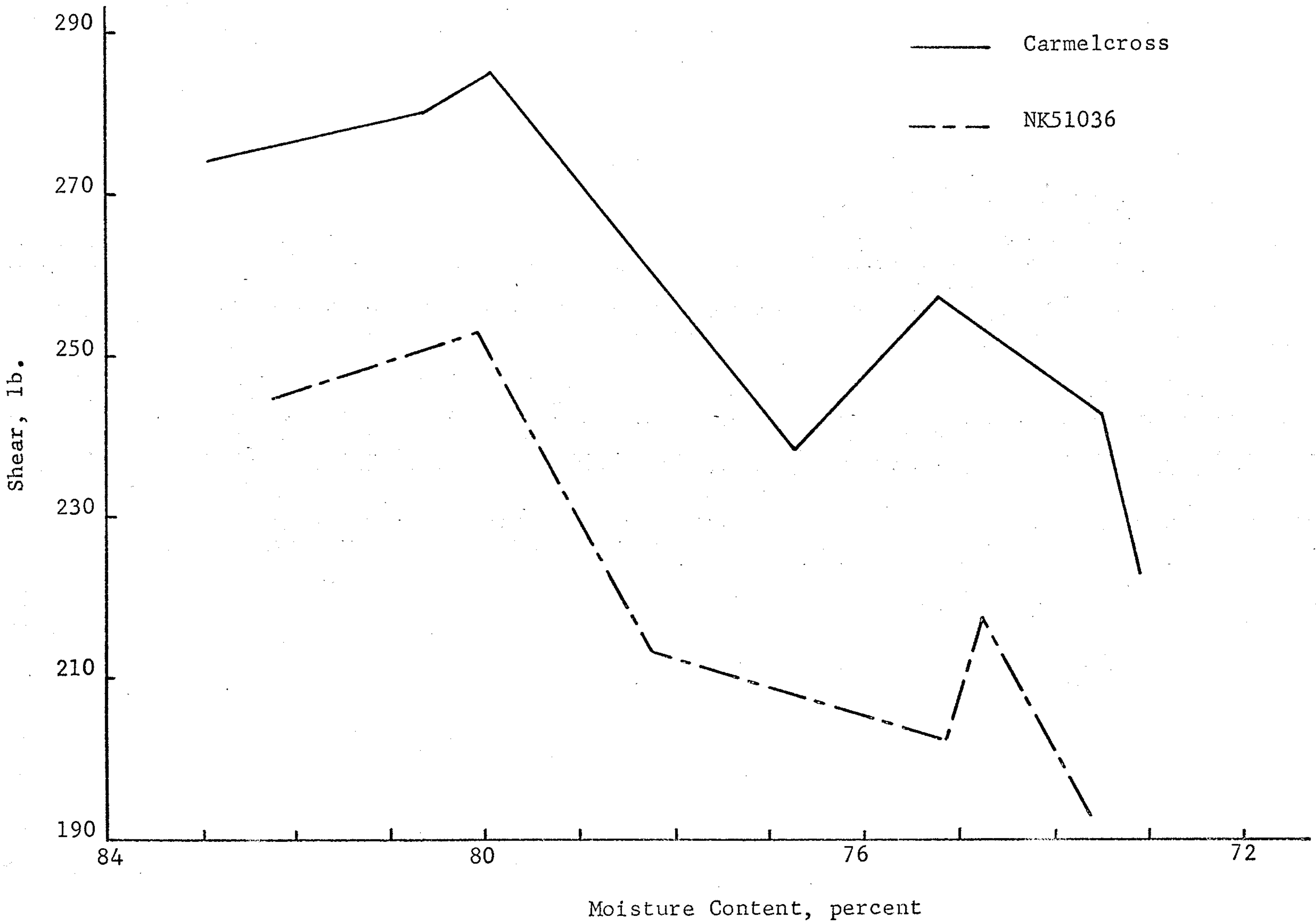

Figure 8. The relationship between shear reading and moisture content of fresh corn.

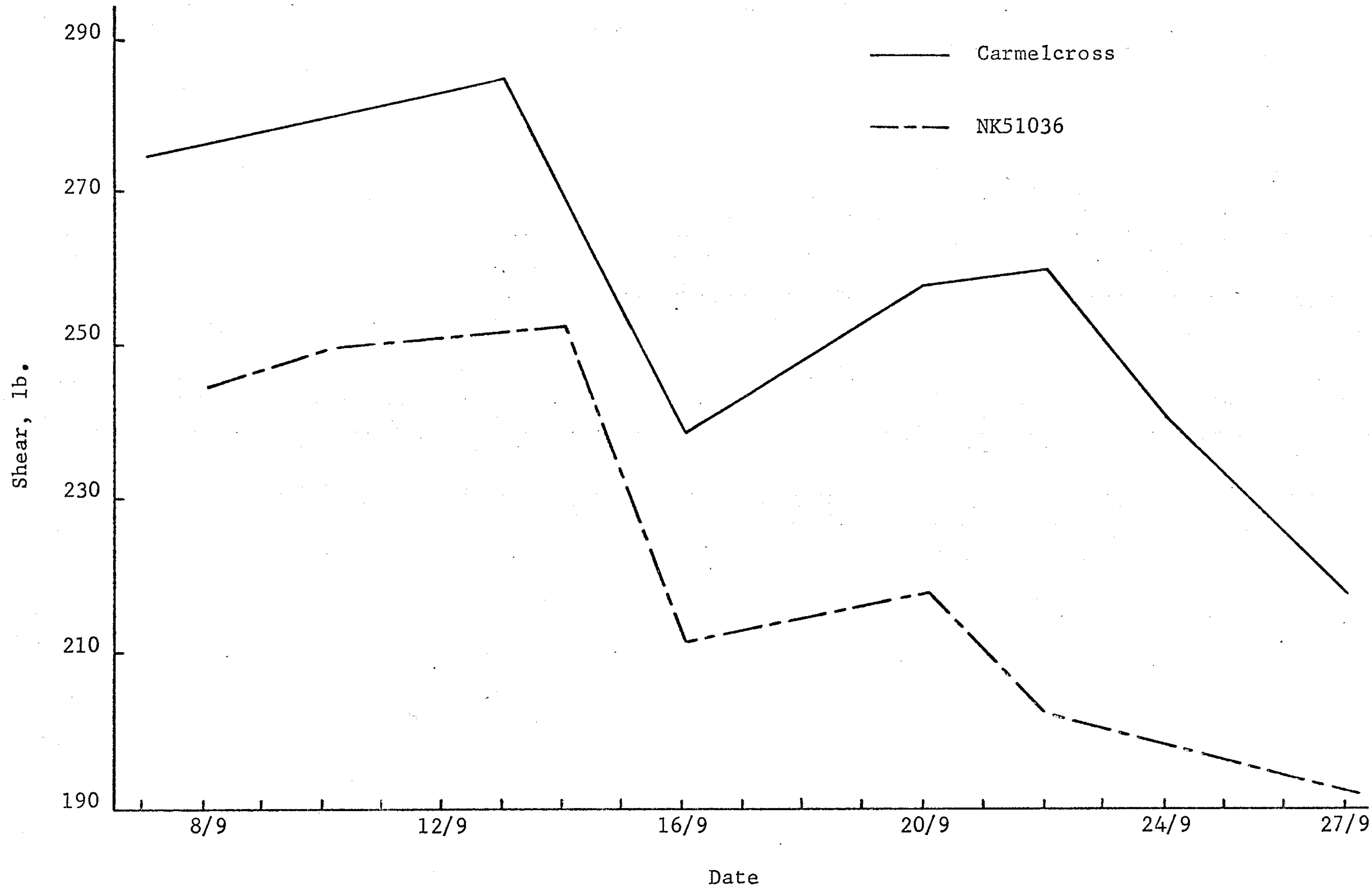

Figure 9. The relationship between shear reading and maturity of fresh corn.

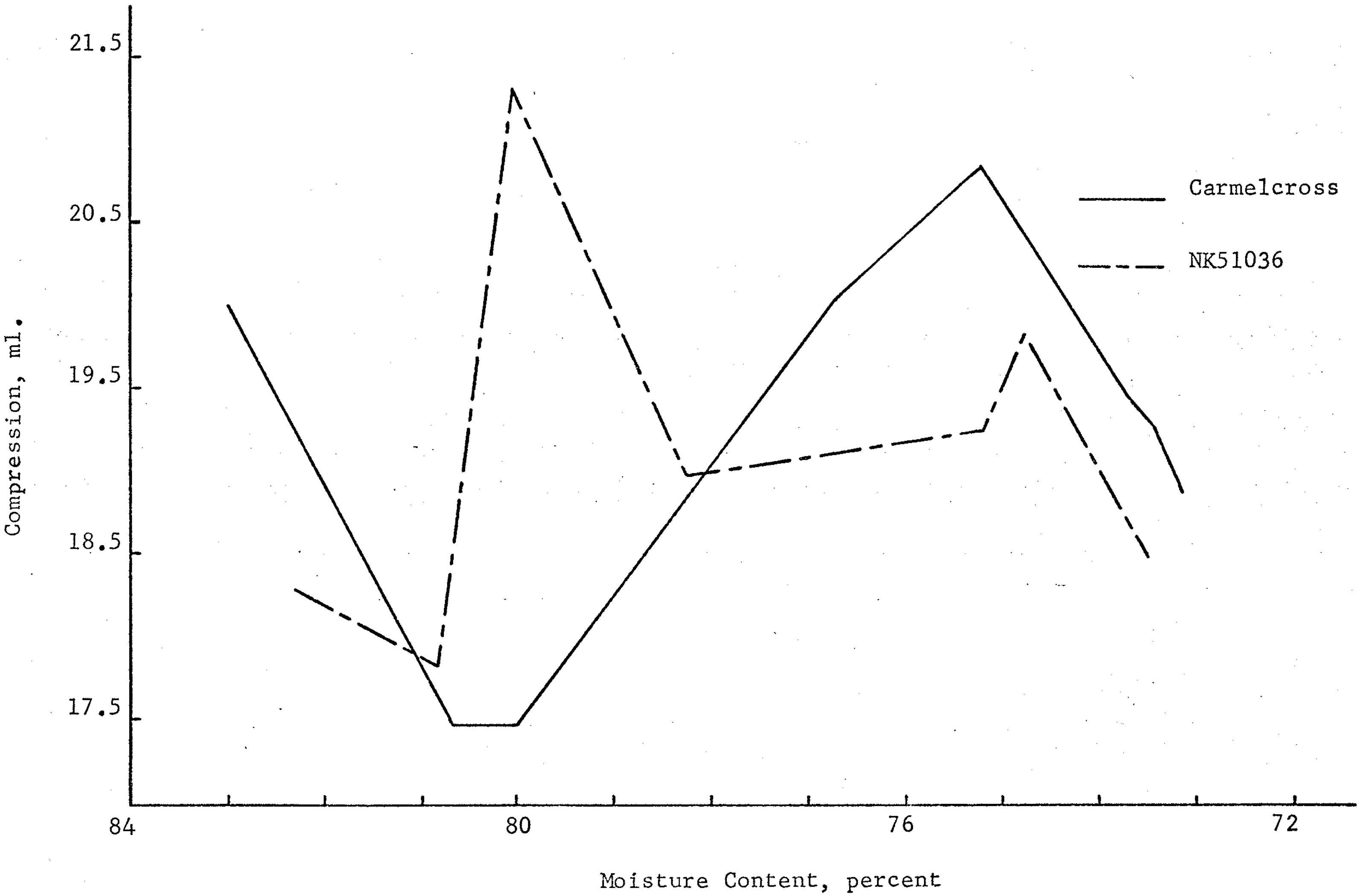

Figure 10. The relationship between compression reading and moisture content of fresh corn.

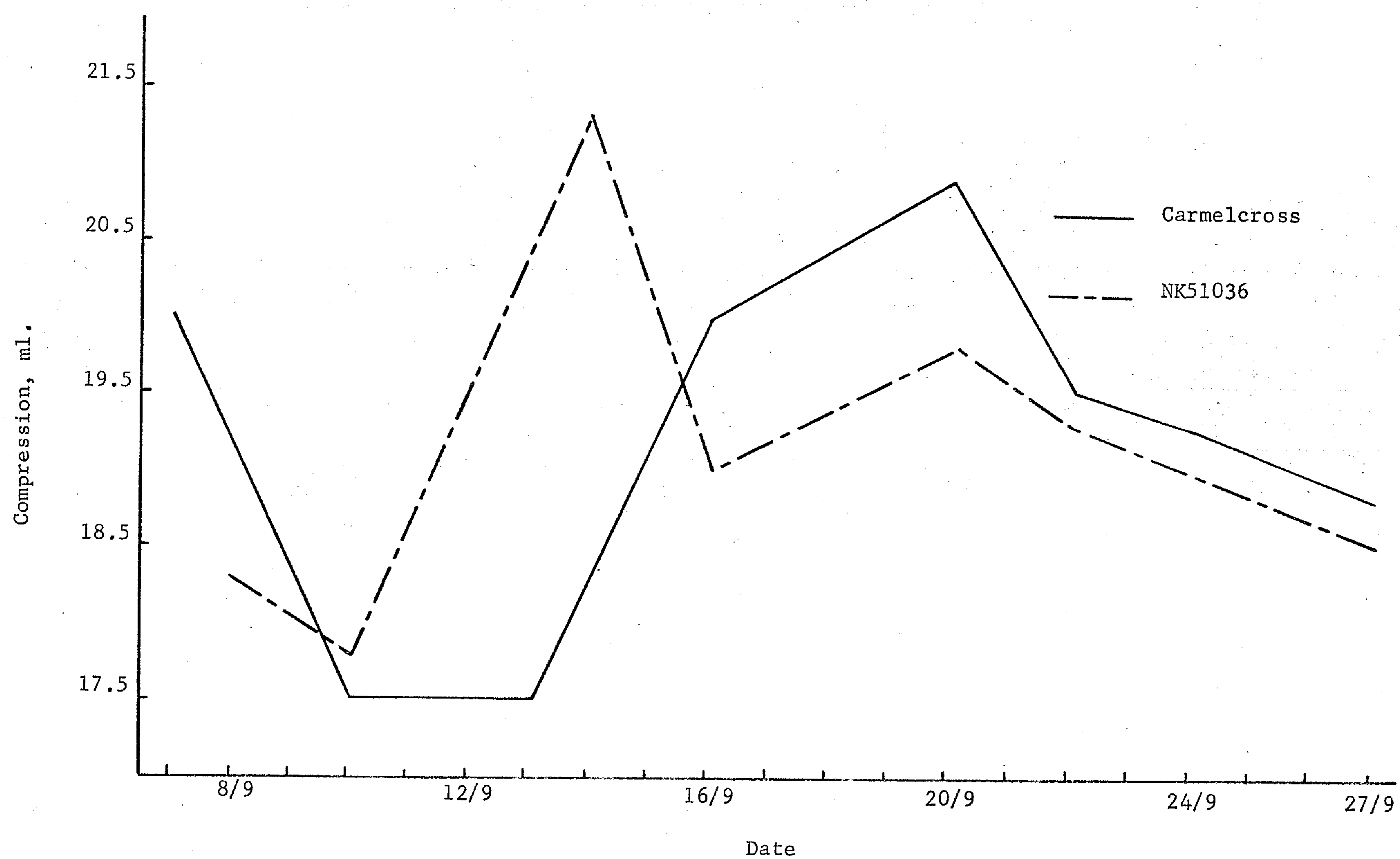

Figure 11. The relationship between compression reading and maturity of fresh corn.

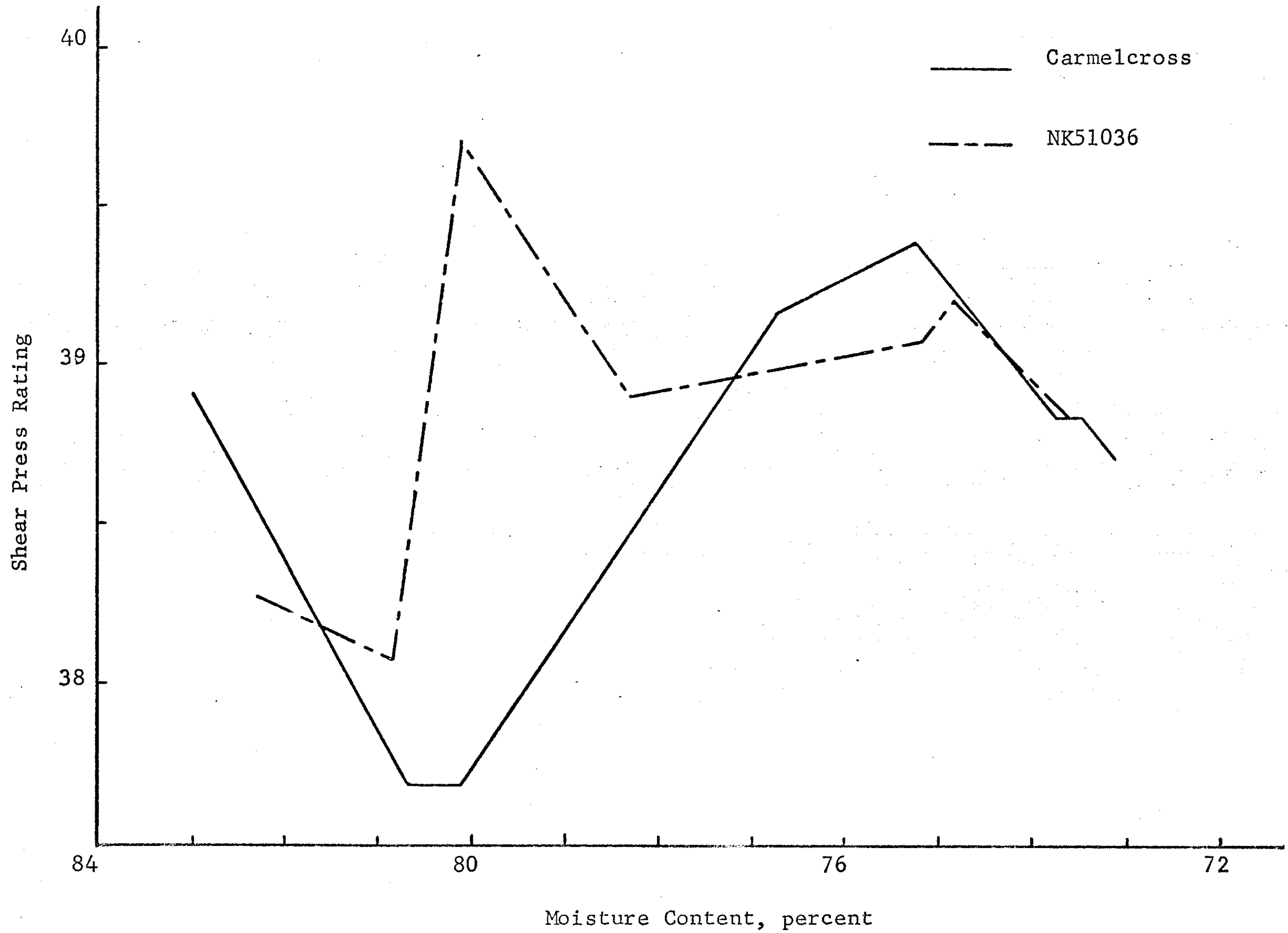

Figure 12. The relationship between shear press rating and moisture content of fresh corn.

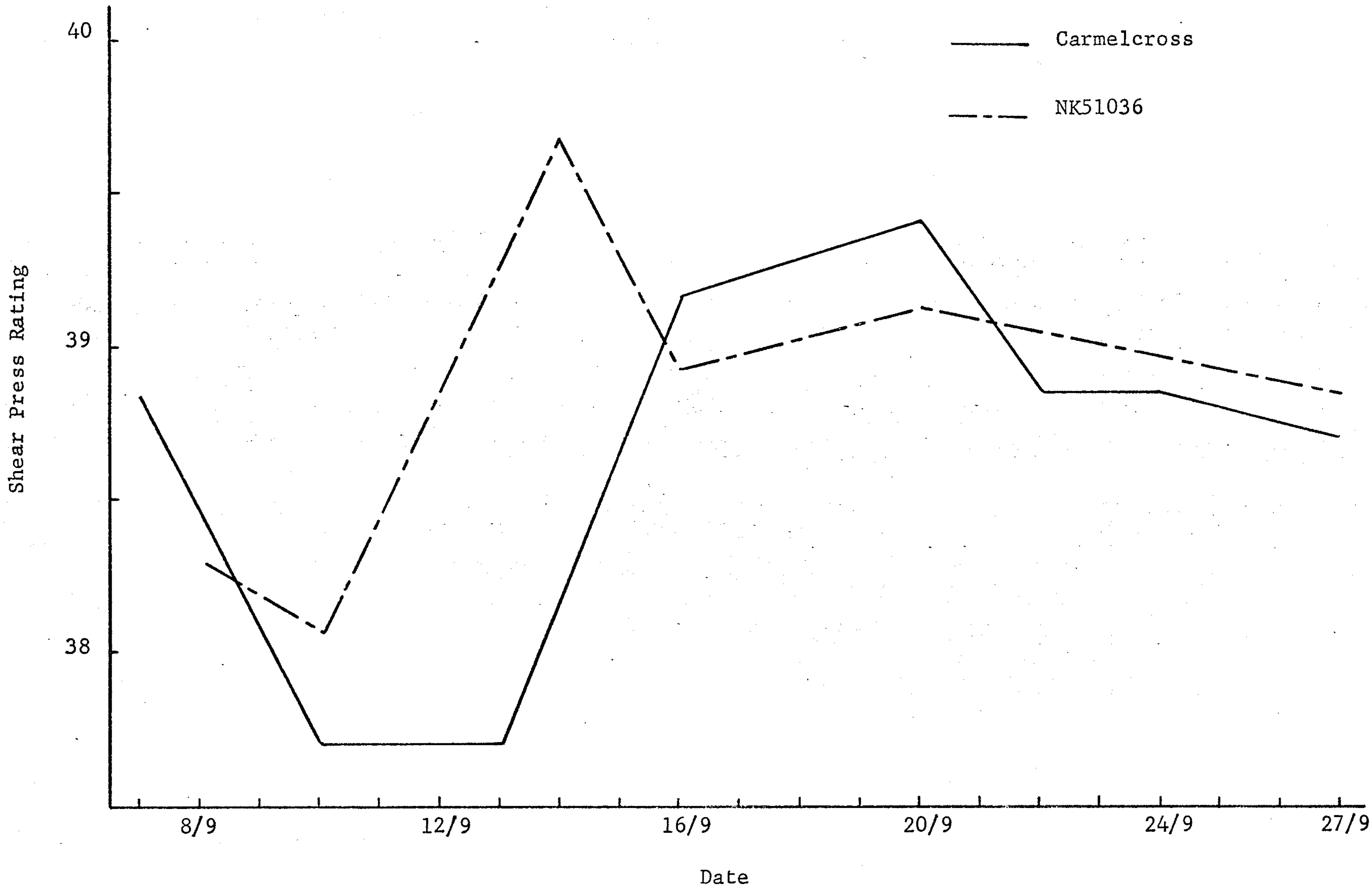

Figure 13. The relationship between shear press rating and maturity of fresh corn.

The compression readings of the frozen corn were significantly correlated with moisture content of the fresh corn; the correlation coefficient between the compression reading of the frozen corn and alcohol-insoluble solids content of the frozen corn was negative and highly significant for Carmelcross, but not significant for NK51036 (Table 16). Also, the combined shear press ratings of the processed corn still failed to show any definite trend.

Table 12. Simple correlation coefficients between the compression reading of the fresh corn and each of two characteristics of the fresh corn.

Variety	Moisture Content	A.I.S. Content
Carmelcross[1]	-.29	.26
NK51036[2]	-.02	-.09

Table 13. Simple correlation coefficients between the shear press rating of the fresh corn and each of five characteristics of the fresh corn.

Variety	Moisture Content	Refractive Index	Trimetric Rating	A.I.S. Content	Pericarp Content
Carmelcross[1]	-.46	.75[2]	-.27	.40	.01
NK51036[2]	-.40	.41	-.48	.20	.54

Table 14. Simple correlation coefficients between the shear press rating of the fresh corn and each of three characteristics of the canned and frozen corn.

Variety	Shear Press Rating (Frozen)	Shear Press Rating (Canned)	Trimetric Rating (Frozen)	Trimetric Rating (Canned)	A.I.S. Content (Frozen)	A.I.S. Content (Canned)
Carmelcross[1]	-.23	.30	-.34	-.33	.31	.49
NK51036[2]	.03	.42	-.50	-.16	.38	.35

Table 15. Simple correlation coefficients between the compression reading of the canned corn and each of two characteristics of the fresh and canned corn.

Variety	Moisture Content (Fresh)	A.I.S. Content (Canned)
Carmelcross[1]	.97**	-.96**
NK51036[2]	.94**	-.91**

Table 16. Simple correlation coefficients between the compression reading of the frozen corn and each of two characteristics of the fresh and frozen corn.

Variety	Moisture Content (Fresh)	A.I.S. Content (Frozen)
Carmelcross[1]	.90**	-.94**
NK51036[2]	.90**	-.55

Refractive index

The refractive index of the fresh corn juice increased as the total solids increased, as shown in Figures 14 and 15. It was negatively and very closely correlated with moisture content and trimetric rating of the fresh corn; refractive index and alcohol-insoluble solids content of the fresh corn were also significantly correlated. Refractive index of Carmelcross was significantly correlated with pericarp content at the 5% level, but refractive index and pericarp content of NK51036 were not significantly correlated. Shear press ratings and refractive indices were not significantly correlated for either variety (Table 17).

The refractive index was significantly correlated with the alcohol-insoluble solids content of both canned and frozen corn, as shown in Table 18. Refractive index of Carmelcross was negatively and significantly correlated

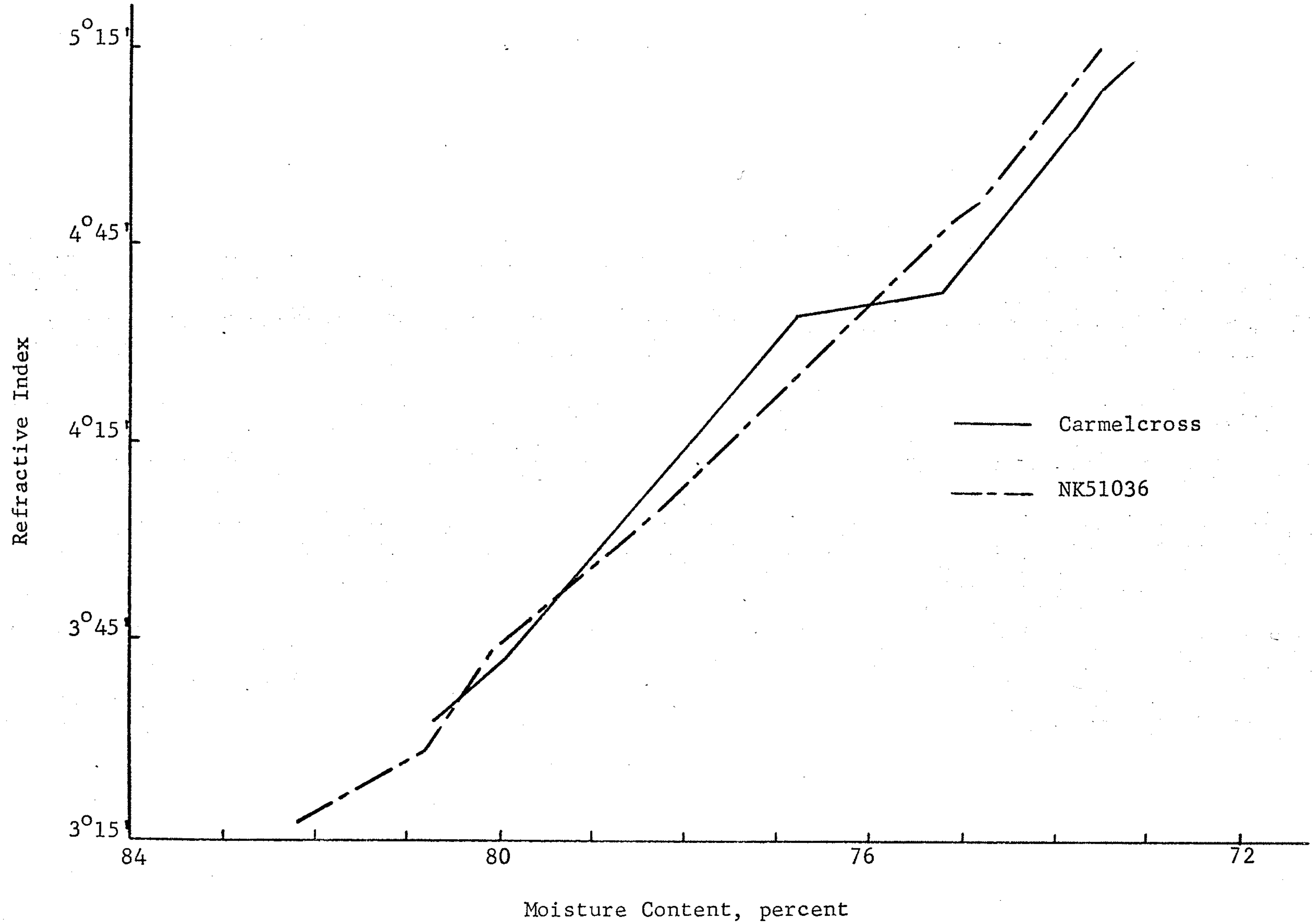

Figure 14. The relationship between refractive index and moisture content of fresh corn.

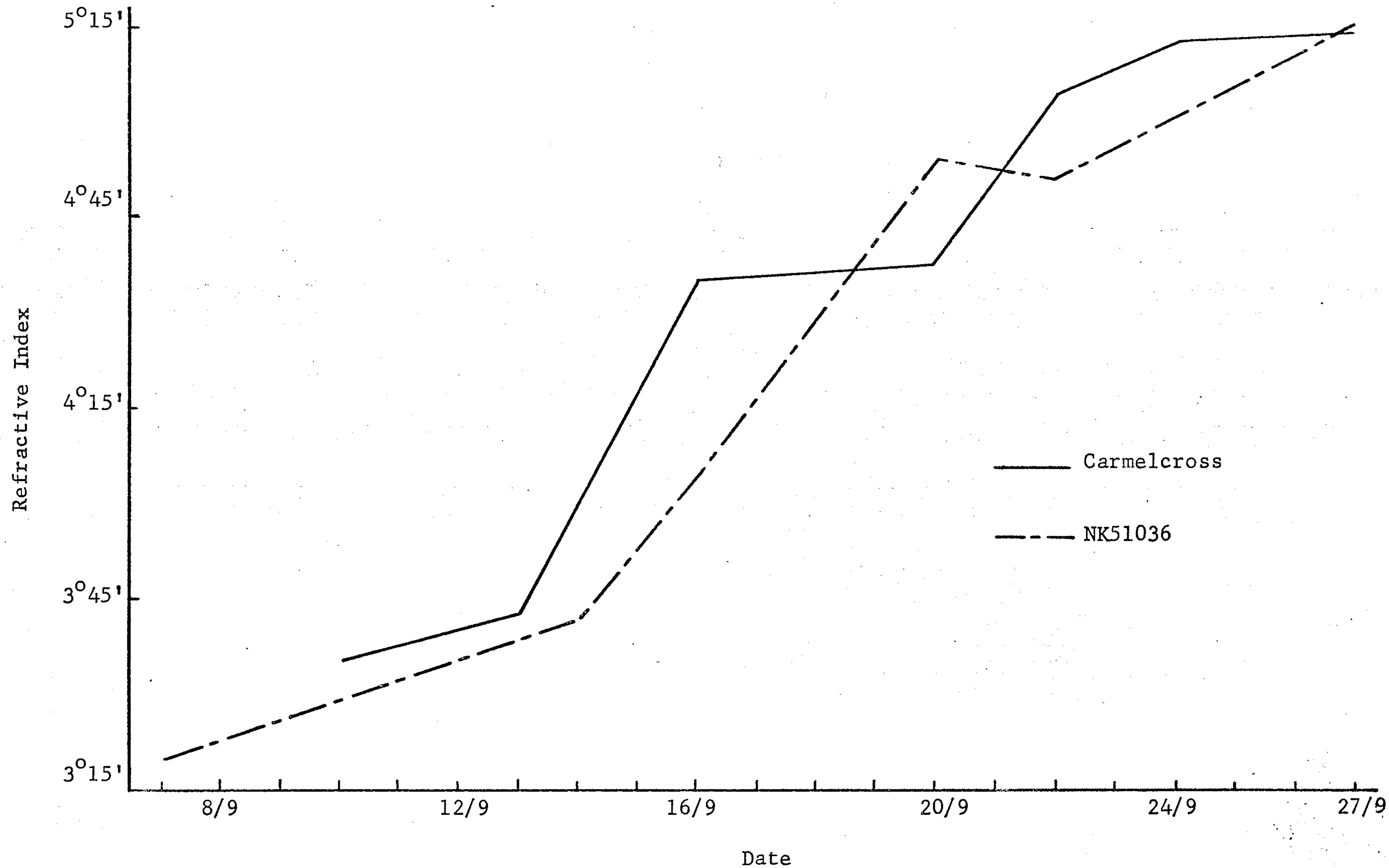

Figure 15. The relationship between refractive index and maturity of fresh corn.

with trimetric rating at the 5% level for frozen corn and at the 1% level for canned corn. For NK51036, the correlations between refractive index and trimetric rating were negative and significant at the 1% level for frozen and at the 5% level for canned corn. The shear press ratings of the processed corn were not significantly correlated with the refractive indices.

Table 17. Simple correlation coefficients between the refractive index of the fresh corn juice and each of five characteristics of the fresh corn.

Variety	Moisture Content	Trimetric Rating	Shear Press Rating	Pericarp Content	A.I.S. Content
Carmelcross[2]	-.99**	-.96**	.75	.83*	.93**
NK51036[2]	-.99**	-.98**	.41	.59	.97**

Table 18. Simple correlation coefficients between the refractive index of the fresh corn juice and each of three characteristics of the canned and frozen corn.

Variety	Shear Press Rating (Frozen)	Shear Press Rating (Canned)	Trimetric Rating (Frozen)	Trimetric Rating (Canned)	A.I.S. Content (Frozen)	A.I.S. Content (Canned)
Carmelcross[2]	.13	-.31	-.83*	-.94**	.96**	.95**
NK51036[2]	-.26	.63	-.89**	-.80*	.99**	.99**

Sensory panels

Both varieties showed an increase in eating quality from the early to the late harvests, with a slight decrease for the latest harvests, as shown in Table 19. The highest quality of Carmelcross was found in the sixth harvest for canned and the fifth harvest for frozen corn. (Figure 16). The panelists generally rated the early harvests high in succulence, tenderness, and sweetness, but criticized them for poor color and lack of flavor. After the optimum was reached, the kernels became tougher and more starchy. The frozen corn was found to be tougher than the corresponding canned samples, probably due to the much shorter processing time. This toughness is reflected in the fact that the peak for frozen corn was reached one harvest earlier than that for canned.

The quality of the canned NK51036 as measured by the sensory panel showed marked fluctuations and no conclusions can be drawn from these results. Harvests three and five had an off-flavor and off-color, probably due to the canning process. The taste panel scores for the variety NK51036 frozen were the only ones showing a consistent enough trend to be used for prediction purposes. The quality of the frozen corn showed a regular increase up to harvest five and then decreased (Figure 17). At this point the moisture content was 74.9% and the refractive index was $4^{o}53'$. These two figures could possibly be used as a guide in determining the optimum harvest date for this variety.

Table 19. The average sensory panel scores for the frozen and canned corn.

(a) Variety - Carmelcross

	Panel Scores (weight x Rankit)	
Harvest	Canned	Frozen
1	-25.10	-22.90
2	-12.06	-34.54
3	- 8.44	- 2.18
4	7.32	6.25
5	-15.57	27.30
6	32.42	2.24
7	27.46	16.32
8	- 6.59	7.16

(b) Variety - NK51036

Harvest	Canned	Frozen
1	20.67	-64.82
2	- 0.05	-37.32
3	-41.53	-10.13
4	21.90	17.66
5	-27.27	50.93
6	11.71	15.30
7	10.86	28.76

An analysis of variance of the taste panel scores gave non-significant F values for Carmelcross canned and frozen and for NK51036 canned (Appendix Table C). The F value for NK51036 frozen was significant at the 1% level. A Duncan's test showed that in canned Carmelcross, the three harvests with the best quality - 4, 7, and 6 - were not significantly different from each other; by the time the eighth harvest was reached, however, the quality was significantly lower than in harvest six (Appendix Table D). In the frozen Carmelcross, the top five harvests were not significantly different. No definite conclusions can be drawn from the canned NK51036; in the frozen NK51036, harvests five and seven were not significantly different. Harvest five was significantly superior to all other harvests except the seventh.

It was very difficult from the results of this study to suggest the relationship between the sensory panel results and the objective measurements. The panel should be larger than five people to reduce the effect of any one person. It would also be advantageous to have a less diverse panel and to give the panel members more training. Even although the panelists were asked to score the samples on the basis of the standards set up for them, personal bias probably had some effect on the results. This would be partly eliminated by using ranks rather than absolute scores and by weighting the various quality factors, but it was still evident in the results. Because of the difficulties of obtaining a large enough panel and training the panelists, it is desirable to develop simpler objective measurements of quality.

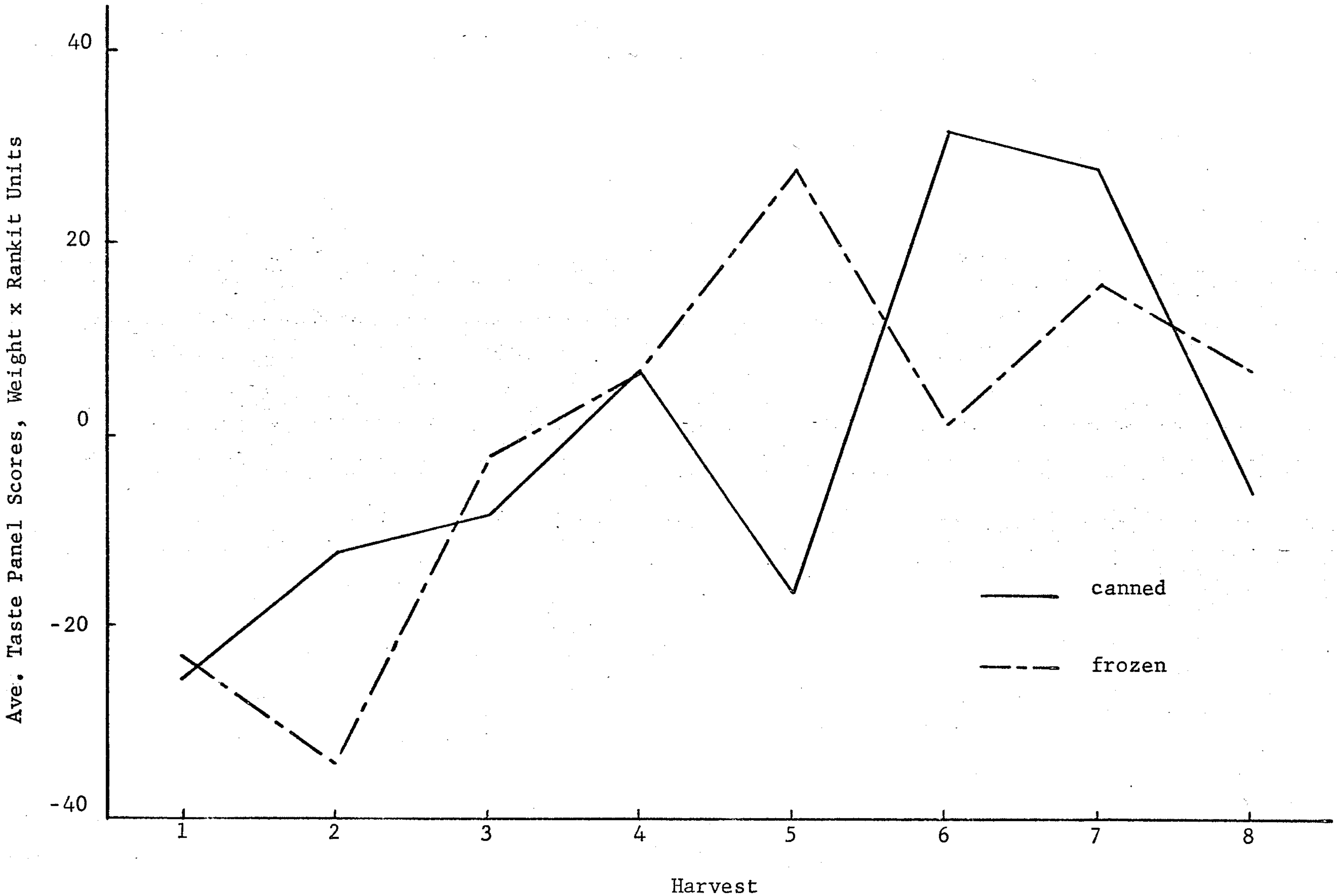

Figure 16. The relationship between average sensory panel scores and maturity for the variety Carmelcross.

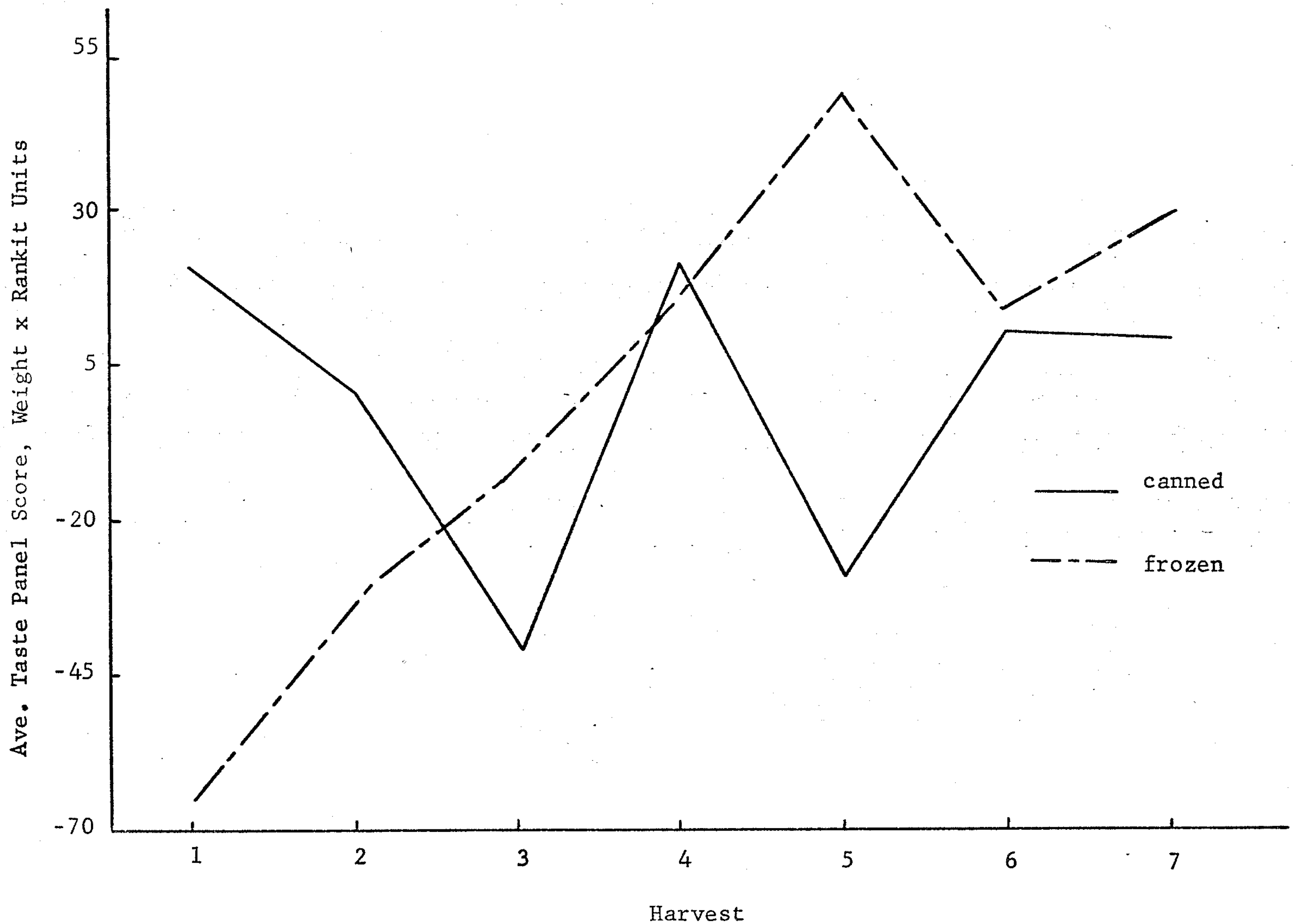

Figure 17. The relationship between average sensory panel scores and maturity for the variety NK51036.

CONCLUSIONS

The moisture content as determined by vacuum oven drying appears to be one of the most reliable and accurate indices of sweet corn maturity, since it decreased steadily with advancing maturity. The electric oven, although it caused some burning, is much faster than the vacuum oven and could be used if allowances were made for the higher moisture values.

Refractive index was extremely well correlated with moisture content and could be used to determine maturity. It appears to be a very promising method because of its simplicity and rapidity. It is not possible to say on the basis of one year's work whether refractive index is affected by weather conditions; the 1965 harvesting period was abnormally cold and wet, and this may have influenced the values.

The alcohol-insoluble solids content was well correlated with moisture content and refractive index, indicating that this measurement would be a good index of maturity; however, it could be used only in situations in which time was not an important factor, such as establishing the characteristics of a variety or determining the quality of canned and frozen corn. Since alcohol-insoluble solids determination is no more accurate or reliable than refractive index in assessing maturity and since it takes a much longer time to complete, there is no advantage in its use in determining the stage of maturity.

The trimetric rating was well correlated with moisture content, alcohol-insoluble solids content, and refractive index and could be used as an indication of maturity and quality. However, this method is limited by the amount of time required for the pericarp and moisture determinations.

The pericarp content was less reliable than the previously mentioned methods of maturity determination, being less well correlated with moisture content than were the other measurements.

The shear press ratings were not significantly correlated with moisture content, refractive index, trimetric rating, alcohol-insoluble solids content, or pericarp content. The difficulty experienced in obtaining reproducible results, particularly with the compression cell, indicate that more work should be done with the shear press before it can be used in the processing industry. The decrease in shear readings on the canned and frozen corn as maturity progressed is difficult to explain in view of the increases in pericarp and total solids. It is possible that the inconsistent results obtained with the shear press could be overcome with more experience in calibrating and operating the instrument.

The results of this study indicate that moisture content, alcohol-insoluble solids content, and trimetric rating are adequate indicators of sweet corn maturity and quality, but their use is limited by the amount of time required to complete their determination. Refractive index appears to be a very promising method of determining maturity for processing but it requires further investigation. More study is needed in the selection and training of sensory panels and the interpretation of panel results. The greatest difficulty encountered in this study was in relating sensory panel results to objective results.

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Appendix - Table A. Weighting of the quality factors of canned and frozen corn evaluated by sensory panels.

Factor	Weight
Color intensity	12
Color brightness	8
Color uniformity	6
Kernel size	6
Uniformity of size	6
Pericarp tenderness	20
Succulence	10
Flavor	20
Sweetness	12
	100

Appendix - Table B. Rankit values used in the sensory panel evaluation of the canned and frozen corn (36).

(a) Variety - Carmelcross

Rank	1	2	3	4	5	6	7	8
Rankit	1.42	.85	.47	.15	-.15	-.47	-.85	-1.42

(b) Variety - NK51036

Rank	1	2	3	4	5	6	7
Rankit	1.35	.76	.35	0	-.35	-.76	-1.35

Appendix - Table C. Analysis of variance of sensory panel scores.

(a) Variety - Carmelcross canned.

Variations due to	d.f.	s.s.	m.s.	F
harvest dates	7	11960.00	1708.57	1.63
panelists	3	3.65	1.22	
error	21	22034.17	1049.25	
total	31	33997.82		

(b) Variety - Carmelcross frozen.

Variations due to	d.f.	s.s.	m.s.	F
harvest dates	7	14146.38	2020.91	1.62
panelists	4	156.67	39.17	
error	28	34900.31	1246.44	
total	39	49203.36		

(c) Variety - NK51036 canned.

Variations due to	d.f.	s.s.	m.s.	F
harvest dates	6	18141.10	3023.52	1.99
panelists	4	86.85	21.71	
error	24	36513.60	1521.40	
total	34	54741.55		

(d) Variety - NK51036 frozen.

Variations due to	d.f.	s.s.	m.s.	F
harvest dates	6	48317.56	8052.93	12.48**
panelists	4	0.30	0.08	
error	24	15483.49	645.15	
total	34	63801.35		

Appendix - Table D. Duncan's Multiple Range Test for sensory panel scores.

(a) Variety - Carmelcross canned.

Harvest	1	5	2	3	8	4	7	6
Ave. Score	-25.10	-15.57	-12.06	-8.44	-6.59	7.32	27.46	32.42

(b) Variety - Carmelcross frozen.

Harvest	2	1	3	6	4	8	7	5
Ave. Score	-34.54	-22.90	-2.18	2.24	6.25	7.16	16.32	27.30

(c) Variety - NK51036 canned.

Harvest	3	5	2	7	6	1	4
Ave. Score	-41.53	-27.27	-0.05	10.86	11.71	20.67	21.90

(d) Variety - NK51036 frozen.

Harvest	1	2	3	6	4	7	5
Ave. Score	-64.82	-37.32	-10.13	15.30	17.66	28.76	50.93