EVALUATION OF POTATO CULTIVARS BEFORE AND AFTER STORAGE REGIMES FOR CHIPPING[1]

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Abstract

An experiment was conducted beginning in 1969 to determine the chipability of several cultivars of potato (*Solanum tuberosum*) grown under similar cultural regimes at different locations throughout Ohio. The experiment included 19 cultivars and 11 locations. The tubers from a particular location were harvested and transported to the laboratory where a portion was chipped and other portions were stored at 40, 45, 50, and 55°F for 3 and 6 months and subsequently chipped. The chips were analyzed for color both objectively using the Agtron M-30-A and subjectively using the PC/SFA color chart. In addition, specific gravity and count were also determined before storage. Not all cultivars were included for the duration of the experiment as they proved consistently superior or inferior in the early stages of the experiment or they were unavailable. Also, not all locations were included each year due to non-availability of acreage. The data indicate that there was a high degree of variability among cultivars and growers. They also indicate considerable variability among years of production although good cultivars were rated highest within seasons. Most notable was the variability among locations; the variation from one location to another was often as great as that among cultivars. Storage difference was pronounced as expected due to temperature regimes.

Resumen

A inicios de 1969 se condujo un experimento para determinar la capacidad de procesamiento en rodajas de varios cultivares de papa (*Solanum tuberosum*) cultivados bajo regímenes similares en localidades diferentes a través de todo el Estado de Ohio. El experimento incluyó 19 cultivares y 11 localidades. Los tubérculos de una localidad determinada fueron cosechados y transportados al laboratorio en donde una porción fué procesada en rodajas (chipped) y otras porciones fueron almacenadas a 40, 45, 50 y 55°F durante 3 y 6 meses para subsecuentemente ser procesadas. El color de las rodajas de papa fué analizado en forma objetiva utilizando el

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Agtron M-30-A y subjetivamente utilizando el muestrario de colores PC/SFA. Además, se determinó también la gravedad específica y número, antes del almacenamiento. No todos los cultivares fueron incluidos durante el experimento debido a que su comportamiento era consistentemente superior o inferior durante la etapa inicial del experimento o porque no fué posible conseguirlos. Tampoco fueron incluidas todas las localidades cada año debido a falta de terrenos.

Los datos indican que hay un alto grado de variabilidad entre cultivares y agricultores. También indican una considerable variabilidad entre los años de producción, aunque los cultivares buenos tuvieron calificativos altos dentro de una campaña. Más notable fué la variabilidad entre localidades; la variación entre una localidad y otra fué frecuentemente tan alta como entre cultivares. Las diferencias de almacenamiento fueron pronunciadas como era de esperar debido a los diferentes regímenes de temperatura.

Introduction

The potato chipping industry is dependent upon the development of new cultivars to maintain and continually improve the quality of the processed product.

Cultivar evaluation must integrate the requirements of the processors with those of the grower. Therefore, a cultivar must not only be a good producer (high yield, specific gravity suitable for chips, disease resistant, etc.) and well adapted to specific climatic conditions, but it must also meet the processor requirements for storability and chipability. The processor can make certain concessions in ranges of acceptability on only a few parameters of quality and these ranges are often very narrow. On the other hand, the grower must have a cultivar that will yield sufficiently to provide a profitable return on his investment.

One of the most important attributes of a possible new cultivar, or an old cultivar, being considered for utilization in chip production is the ultimate color of the finished product. The complexities of the color problem are not well understood, although color has been extensively studied. The color of the chips is in great part related to the reducing sugar content of the tuber, which is in turn affected by certain storage temperatures and/or time in storage. In general, lower temperatures during storage cause an accumulation of reducing sugars, usually resulting in dark colored chips. Reconditioning at room temperature may result in metabolism of these sugars with a commensurate improvement in color of the manufactured chip.

The objective of this study was to evaluate available cultivars used by Ohio growers to determine their suitability for processing by the chip industry.

Materials and Methods

The potatoes for this study were produced on 11 farms throughout the state of Ohio during the period 1969 to 1976. Nineteen cultivars, or selections, were evaluated during this period and were grown at one or more of the locations. They were produced using the standard cultural practices of the commercial farmers who cooperated in the study. Production data are published elsewhere.

Tubers from each location were harvested and transported to The Ohio State University Processing Laboratory where a portion of each lot was chipped immediately and other portions were stored at 40°F (4.4°C), 45°F (7.2°C), 50°F (10°C), and 55°F (12.8°C) with 90% RH (± 5%) for 3 and 6 mo. and subsequently chipped. In addition, specific gravity and tuber count per 8 lb. sample were determined prior to storage.

The potatoes were abrasively peeled and mechanically sliced into 16-18 slices per inch. The slices were washed in cold water, air dried and immediately fried in oil with a 375°F inlet temperature and a 350°F outlet temperature of the oil for 90 to 100 seconds. The manufactured chips were subjectively scored for color and assigned a value according to the 0-10 scale (lower numbers-better color) of the PC/SFA. Color of the same sample was also determined objectively using the Agtron M-30-A colorimeter with the red mode standardized at 0 and 90 with respective color reference disks black at 0 and gray at 90 (higher numbers - better color).

Not all cultivars or selections were included for the full duration of the study as they proved consistently superior or inferior, or they were unavailable. Also, not all locations were included each year. The study was also continued into 1977 and those data are included where available.

Results and Discussion

Only 3 cultivars were included in all of the 8 seasons of the study. They were 'Katahdin,' 'Norchip,' and 'Superior' while 11 cultivars were included in the experiment for 3 or more years. A list of cultivars is presented in Table 1. The results of the color evaluations for the 19 cultivars and selections are also presented in Table 1. Cultivars are ranked by number of years included in the test. Of the cultivars that were evaluated 3 or more years there was little difference in overall averages of both Agtron red and PC/SFA color of the raw product. The cultivars producing the lightest chips at harvest through the years under study were 'Monona,' 'Peconic,' 'Alamo,' 'Shurchip,' 'Superior,' 'Norchip,' and 'Katahdin.'

Those cultivars that were used 3 years or more in the study are separated from the others due to the availability of data and reliability of averages (Tables 2 and 3). All cultivars produced acceptable light colored chips when processed directly from the field, that is, prior to storage. However, after 3 or 6 months of storage at 40°F and subsequent recondi-

TABLE 1. — *Summary of evaluation of cultivars for % blisters, specific gravity, and chip color (Agtron Red and PC/SFA) at harvest.*

Cultivar	No. Seasons	% Blisters*	Prior to Storage		
			Sp. Gr.	Agtron Red	PC/SFA
Katahdin	8	7.5	1.069	50.6	5.1
Norchip	8	19.6	1.075	52.8	5.0
Superior	8	14.0	1.071	53.3	4.9
Shurchip	7	--	1.070	53.9	5.0
Kennebec	5	4.2	1.072	43.8	4.5
Hudson NY 41	5	--	1.072	42.6	5.4
Abnaki	4	--	1.074	46.5	4.4
6CX6	3	3.1	1.076	47.3	5.4
Monona	3	--	1.068	63.0	5.7
Alamo	3	--	1.068	56.3	6.6
Peconic	3	--	1.078	62.7	6.2
MS 709	2	0.0	1.078	52.0	5.6
New Haig	2	--	1.074	50.0	4.7
Penn 71	2	--	1.070	44.0	3.8
Wauseon	2	--	1.076	61.5	3.9
Iopride	2	--	1.073	62.0	5.9
W 710	2	5.8	1.058	43.0	5.2
W 718	2	13.0	1.064	48.5	4.5
NY 30	2	--	1.070	67.0	7.0

*Evaluated in 1976 only.

tioning of u to 20 days, many cultivars produced chips that were very nearly acceptable in color. After the same reconditioning time from storage at 45°F, 'Hudson NY 41' and 'Abnaki' were the only two cultivars still bordering on unacceptable. Approximately the same situation existed at 50°F except that these two cultivars were somewhat improved.

There appears to have been marked improvement in color when tubers were reconditioned after 40°F storage and somewhat less after 45°F (Tables 2 and 3). However, this was not the case when reconditioned after storage at 50°F and 55°F. There appeared to be no necessity for reconditioning after storage at 50°F and 55°F for 3 or 6 months for many of the cultivars.

The data (Figures 1, 2, 3, 4) indicated a high degree of variability in color of chips among cultivars, growers, and years. The former would be expected purely on the basis of genetic differences in the metabolic patterns of the particular cultivars. However, it seems clear that these metabolic patterns are also affected by cultural practices, soil types, and other locational characteristics as evidenced by the variability present among growers within the same year using the same cultivar.

There was considerable variation in color readings of chips among growers between and within years. Using 'Norchip' for purposes of illustration, in 1976 there was only slight variation in the color of the chips produced from freshly harvested potatoes from the different growers (Fig-

TABLE 2. — *Summary of evaluation of Agtron Red color of cultivars at different storage temperatures (40, 45, 50, 55°F) and following reconditioning for 1, 10, and 20 days after each storage period.*

Cultivar*	At Harvest	40°F Days Recond.	40°F Months 3	40°F Months 6	40°F Months $\bar{X}$	45°F Days Recond.	45°F Months 3	45°F Months 6	45°F Months $\bar{X}$	50°F Days Recond.	50°F Months 3	50°F Months 6	50°F Months $\bar{X}$	55°F Days Recond.	55°F Months 3	55°F Months 6	55°F Months $\bar{X}$
Norchip	53	1	16	20	18	1	40	37	38	1	47	49	48	1	49	48	49
(8)		10	30	33	32	10	46	39	43	10	47	47	47	10	46	46	46
		20	36	34	35	20	48	42	45	20	47	47	47	20	49	44	46
Superior	50	1	16	15	16	1	36	37	36	1	43	42	43	1	50	44	47
(8)		10	30	34	32	10	44	46	45	10	42	41	41	10	49	43	46
		20	36	34	35	20	45	49	47	20	41	34	38	20	48	41	44
Katahdin	51	1	15	17	16	1	35	34	34	1	44	45	45	1	51	47	49
(8)		10	24	34	29	10	39	39	39	10	36	43	40	10	50	45	48
		20	32	33	33	20	43	40	41	20	40	45	43	20	51	48	50
Shurchip	54	1	15	18	16	1	34	32	33	1	40	39	40	1	50	42	46
(7)		10	29	37	33	10	42	38	40	10	36	42	39	10	50	44	47
		20	35	40	37	20	45	37	41	20	40	41	41	20	49	42	46
Kennebec	44	1	16	19	18	1	36	40	38	1	45	48	46	1	48	50	49
(5)		10	31	39	35	10	40	41	41	10	46	45	46	10	40	45	43
		20	34	38	36	20	41	45	43	20	43	47	45	20	48	66	57
Hudson NY 41	43	1	14	15	14	1	22	24	23	1	34	35	34	1	37	40	38
(5)		10	22	31	26	10	30	34	32	10	34	40	37	10	38	43	41
		20	27	37	32	20	34	34	34	20	37	39	38	20	42	42	42
Abnaki	47	1	14	14	14	1	30	27	29	1	39	33	36	1	43	40	42
(4)		10	22	30	26	10	32	33	33	10	37	36	37	10	43	39	41
		20	28	35	32	20	35	36	35	20	39	36	38	20	44	40	42
Monona	62	1	--	--	--	1	47	36	42	1	--	--	--	1	60	46	53
(3)		10	--	--	--	10	58	42	52	10	--	--	--	10	63	46	54
		20	--	--	--	20	60	39	50	20	--	--	--	20	66	43	54
Alamo	56	1	--	--	--	1	32	23	27	1	--	--	--	1	54	40	47
(3)		10	--	--	--	10	39	34	37	10	--	--	--	10	57	42	50
		20	--	--	--	20	42	36	39	20	--	--	--	20	58	39	49
Peconic	63	1	--	--	--	1	48	39	43	1	--	--	--	1	50	45	48
(3)		10	--	--	--	10	55	43	49	10	--	--	--	10	61	44	53
		20	--	--	--	20	59	39	49	20	--	--	--	20	65	43	54
6CX6	47	1	16	25	21	1	43	48	46	1	51	54	52	1	51	53	52
(3)		10	36	48	42	10	45	40	42	10	43	48	46	10	45	48	47
		20	41	47	44	20	43	51	47	20	46	52	49	20	48	51	49
$\bar{X}$	52	1	15	18	17	1	37	34	36	1	43	43	43	1	49	45	47
		10	28	36	32	10	43	39	41	10	40	43	42	10	49	44	47
		20	34	37	35	20	45	41	43	20	42	43	42	20	52	45	48

*Numbers in paranthesis represent number of years in study.

TABLE 3. — *Summary of evaluation of PC/SFA* color of cultivars at different storage temperatures (40, 45, 50, and 55°F) and following reconditioning for 1, 10, and 20 days after each storage period.*

Cultivar**	At Harvest	40°F Days Recond.	40°F Months 3	40°F Months 6	40°F Months X̄	45°F Days Recond.	45°F Months 3	45°F Months 6	45°F Months X̄	50°F Days Recond.	50°F Months 3	50°F Months 6	50°F Months X̄	55°F Days Recond.	55°F Months 3	55°F Months 6	55°F Months X̄
Norchip	48	1	89	88	89	1	69	67	68	1	45	47	46	1	47	50	49
(8)		10	71	69	70	10	56	62	49	10	40	44	42	10	48	43	46
		20	61	65	63	20	53	55	54	20	38	39	39	20	45	48	47
Superior	50	1	92	96	94	1	72	71	72	1	54	57	56	1	52	55	54
(8)		10	72	68	70	10	64	64	64	10	51	54	54	10	54	51	53
		20	62	63	63	20	61	62	62	20	50	54	52	20	49	50	50
Katahdin	51	1	93	95	94	1	76	74	75	1	54	54	54	1	54	53	54
(8)		10	79	68	74	10	68	63	66	10	59	45	52	10	52	46	49
		20	71	63	67	20	63	57	60	20	50	45	48	20	48	47	48
Shurchip	50	1	93	90	92	1	76	69	73	1	51	61	56	1	54	56	55
(7)		10	68	62	65	10	65	62	64	10	52	54	53	10	53	49	51
		20	62	56	59	20	58	58	58	20	50	47	49	20	50	46	48
Kennebec	45	1	93	91	92	1	70	63	67	1	49	51	50	1	43	47	45
(5)		10	71	61	66	10	60	55	58	10	47	49	43	10	54	41	48
		20	65	56	61	20	46	45	46	20	50	36	43	20	44	28	36
Hudson NY 41	54	1	97	96	97	1	84	80	82	1	65	66	66	1	57	63	60
(5)		10	81	72	77	10	73	69	71	10	61	56	59	10	62	54	58
		20	78	64	71	20	71	67	69	20	63	56	60	20	63	51	57
Abnaki	44	1	92	95	94	1	73	74	74	1	45	64	55	1	44	60	52
(4)		10	79	71	75	10	68	67	68	10	48	60	54	10	54	52	53
		20	66	60	63	20	64	61	63	20	48	52	50	20	52	51	52
Monona	57	1	--	--	--	1	69	68	69	1	--	--	--	1	54	55	55
(3)		10	--	--	--	10	61	55	58	10	--	--	--	10	54	55	55
		20	--	--	--	20	60	60	60	20	--	--	--	20	55	58	57
Alamo	66	1	--	--	--	1	85	85	85	1	--	--	--	1	65	65	65
(3)		10	--	--	--	10	78	76	77	10	--	--	--	10	63	65	64
		20	--	--	--	20	78	75	77	20	--	--	--	20	62	65	64
Peconic	62	1	--	--	--	1	73	67	70	1	--	--	--	1	60	57	59
(3)		10	--	--	--	10	65	63	64	10	--	--	--	10	56	56	56
		20	--	--	--	20	61	66	64	20	--	--	--	20	57	59	59
6CX6	51	1	91	83	87	1	64	50	57	1	46	42	44	1	45	38	41
(3)		10	68	48	58	10	60	60	60	10	53	42	48	10	46	40	43
		20	61	44	53	20	45	36	41	20	42	35	39	20	40	37	39
X̄	53	1	93	92	93	1	74	70	72	1	51	55	53	1	52	54	53
		10	74	65	70	10	65	63	64	10	51	49	50	10	54	50	52
		20	66	59	63	20	60	58	59	20	49	46	48	20	51	49	50

*The 0-10 scale was expanded from 0 to 100 to reflect the data in whole numbers.

**Numbers in parenthesis represent number of years in trial.

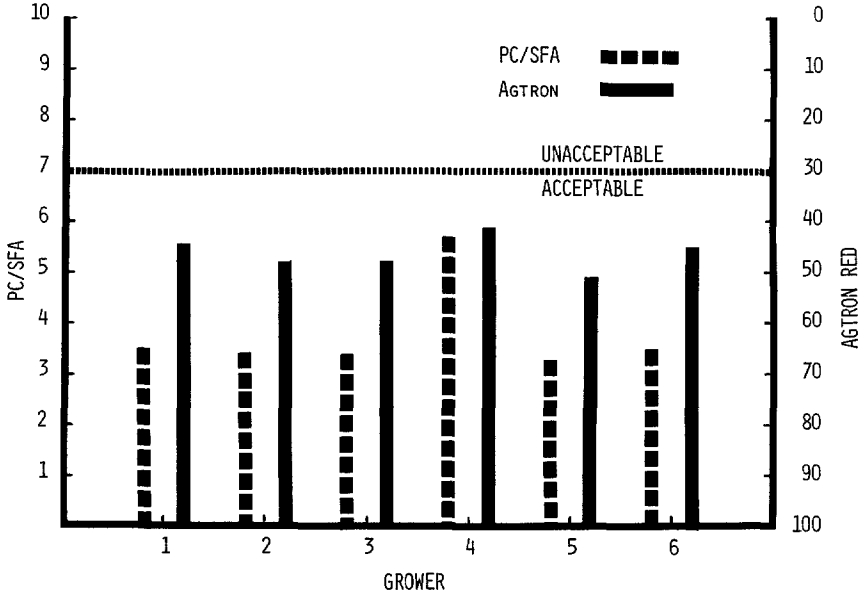

FIG. 1. PC/SFA and Agtron Red color for chips prior to storage for Norchip cultivars from 6 growers — 1976.

ure 1). However, as shown in Figure 2, considerable variation in color of chips from freshly harvested potatoes occurred among growers in 1977.

The variations in color of chips from potatoes taken from different growers were often as great as that found among cultivars. Unfortunately, this makes more critical analysis of the data very difficult, and, even hazardous, if these analyses are to be used in making recommendations for all areas of production.

There was also considerable variation in color and specific gravity among years. Once again, using 'Norchip' for illustration, the specific gravity was observed on a year to year basis (Figure 3). Although in some years the range in color of chips was not great, it was often as great as, or greater than, the differences found between years.

The data in Figure 4 illustrate the variation in color of chips produced from tubers grown in the various years. Although the range in color readings within a particular year is considerable, there were differences between years that were considerably greater. These data indicate that variation in climatic conditions probably affected the chipability of various tubers. Although there was considerable variation in both color readings and specific gravity among years, in general, the cultivars which proved to be consistently good throughout the study were rated highest within years.

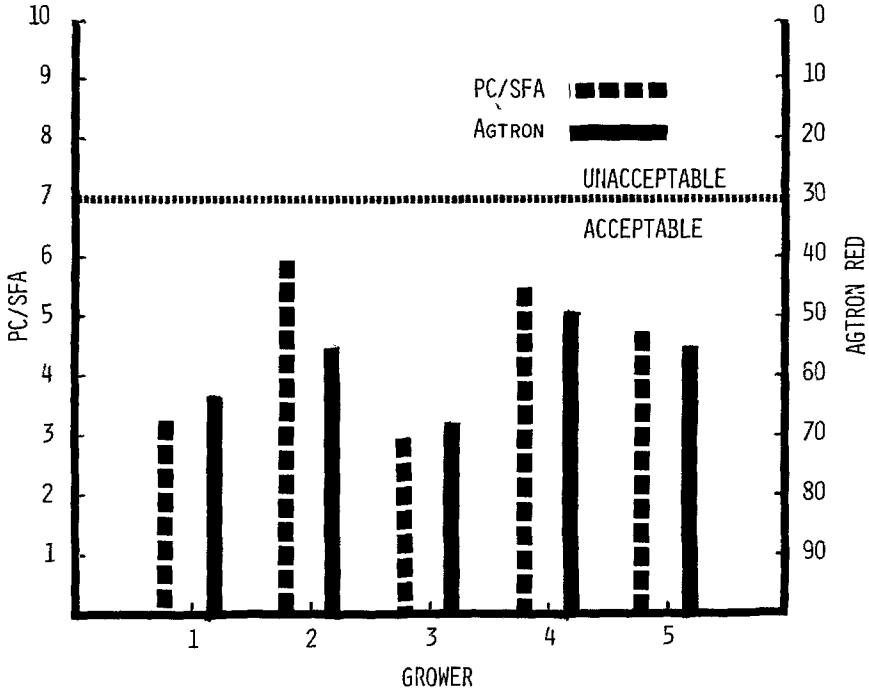

FIG. 2. PC/SFA and Agtron Red color for chips prior to storage for Norchip cultivars from 5 growers — 1977.

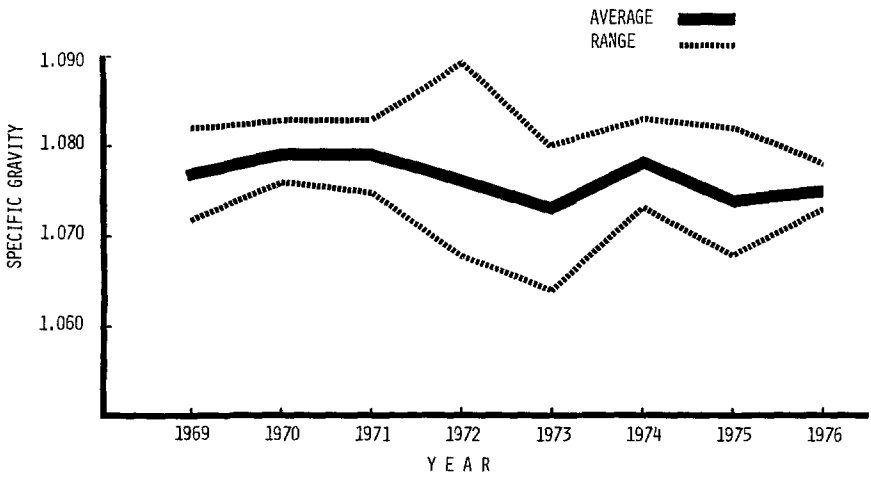

FIG. 3. Specific gravity average and range values for Norchip cultivar by years.

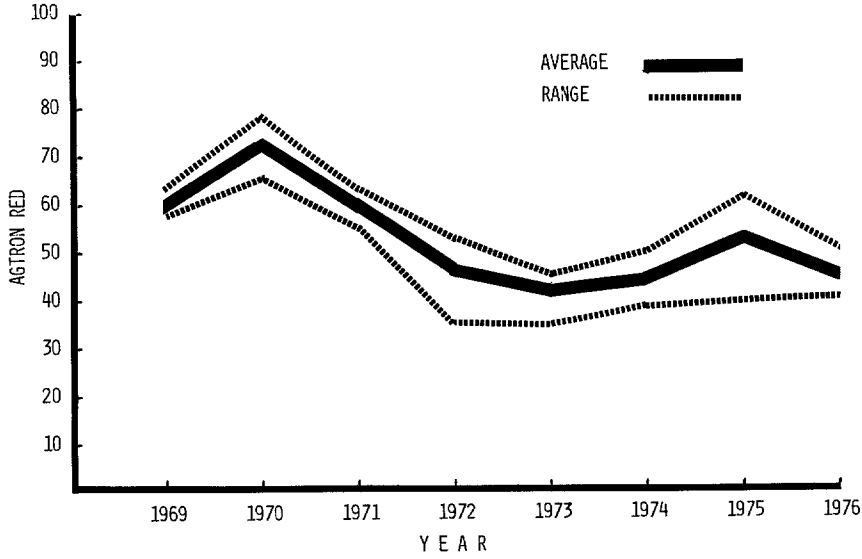

FIG. 4. Agtron Red color (average and range) for Norchip cultivar by years.

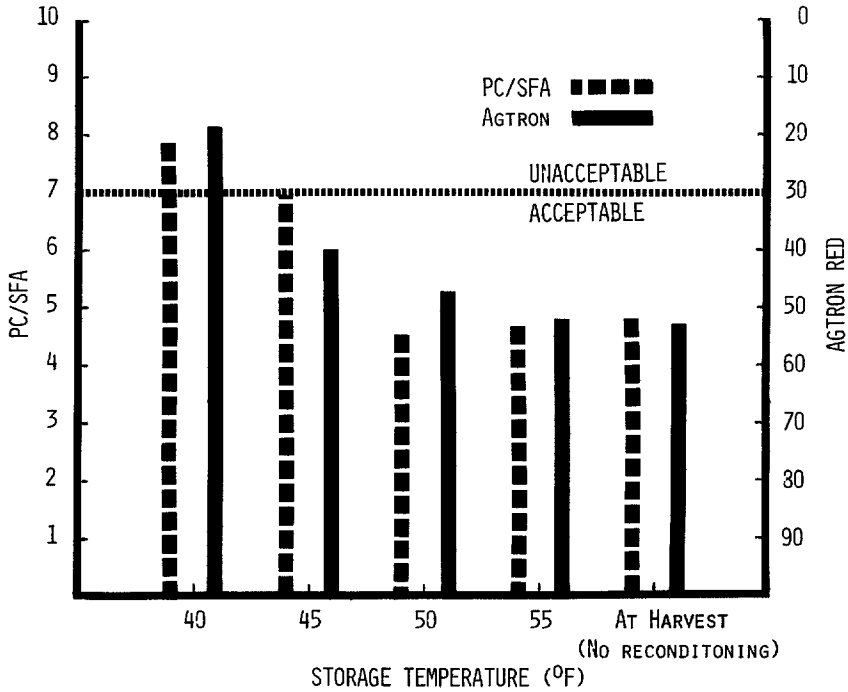

FIG. 5. Color of Norchip potato chips after 1 day reconditioning from storage (40, 45, 50, and 55°F).

The effects of storage on chip color were observed. In general, the color quality of the chips produced from tubers stored at low temperatures was markedly decreased. However, this discoloration, probably due to accumulation of reducing sugars, was acceptable after 20 days of reconditioning. Once again, using 'Norchip' for purposes of illustration, overall averages were given to show the effect of temperature as well as time of reconditioning. Potatoes stored at 40°F and 45°F produced chips that were either unacceptable or borderline after only one day of reconditioning (Figure 5). However, after 10 days of reconditioning, the tubers stored at 45°F produced acceptable chips (Figure 6) and after 20 days, those stored at 40°F were also acceptable (Figure 7).

However, this was not always the case for all cultivars. At the lower temperatures of storage, the tubers of some cultivars produced dark chips that often did not improve to acceptable levels even after 20 days reconditioning.

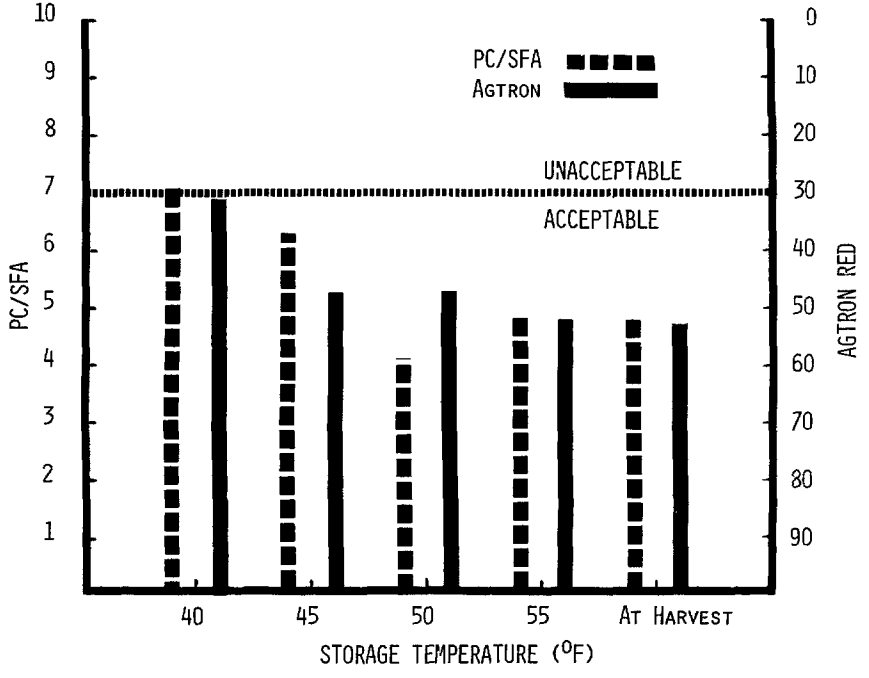

FIG. 6. Color of Norchip potato chips after 10 days reconditioning from storage (40, 45, 50, and 55°F).

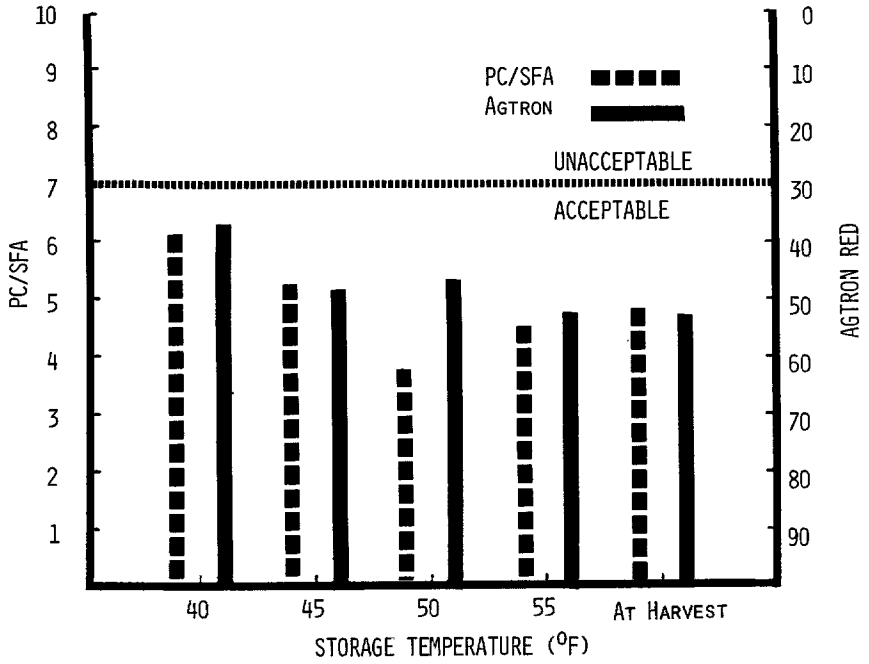

FIG. 7. Color of Norchip potato chips after 20 days reconditioning from storage (40, 45, 50, and 55°F).

Summary and Conclusions

Based on these data for cultivars grown in the Ohio trials for 3 or more years, all cultivars evaluated were found suitable for chip manufacture. However, after storage for 3 and 6 mo. at 40°F none of the cultivars produced acceptable chips without 10 to 20 days reconditioning, and then some of the cultivars were only marginal for acceptable chip color. Two cultivars, 'Hudson NY 41' and 'Abnaki' did not give acceptable colored chips even after being reconditioned 20 days after storage at 40°F. After storage for 3 and 6 mo. at 45°F, all cultivars but two produced acceptable chips without reconditioning. Once again, chips from 'Hudson NY 41' and 'Abnaki' were unacceptable after 10 and 20 days of reconditioning. After storage at 50°F and 55°F for 3 and 6 mo., all cultivars produced chips of acceptable quality; however, there was considerable sprouting and shriveling at these storage temperatures for the longer storage period. Overall, the following cultivars were rated highest for chip color after all storage regimes: 'Monona,' 'Peconic,' 'Kennebec,' '6CX6,' 'Katahdin,' 'Norchip,' 'Shurchip,' and 'Superior.'

Due to low specific gravity 'W 710,' 'W718,' 'Monona,' 'Alamo,' and 'Katahdin' were found to be highly unacceptable.

This study has indicated that the more extensively evaluated cultivars, with noted exceptions, can be suitably produced in Ohio for processing for chips. However, some growers, as evaluated in this study, consistently produced cultivars that were rated higher for chipping than similar cultivars from other growers. Further, cultivars from specific growers stored better than similar cultivars from other growers.

With the above facts in mind, we can conclude that methods for evaluating cultivars from growers at the time of harvest to predict storability for potential chipping are most important.