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Preserving Characteristics of **Hood, Marshall, and Northwest Strawberry Varieties**

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PRESERVING CHARACTERISTICS
OF HOOD, MARSHALL, AND NORTHWEST
STRAWBERRY VARIETIES

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In March 1965, research was initiated to determine the suitability of the new strawberry variety, Hood, for the manufacture of preserves. The performance of the Hood variety in the process of making preserves and during a period of controlled storage was compared with that of Marshall, the standard preserving variety, and with that of Northwest, the major variety grown in Oregon and Washington. The research was limited to the preparation and evaluation of small lots of preserves of each variety.

Processing and Storage Procedures

Preserves of 68% soluble solids were produced by a standard vacuum-pan method from frozen whole 4 + 1 strawberries of Hood, Marshall, and Northwest varieties grown in the 1963 and 1964 seasons. The raw fruit was procured from experimental or commercial plantings, packed in sugar, frozen in 10-pound containers at -15°F, and stored at 0°F until needed.

Six lots of preserves, representing each of the three varieties and two harvest seasons, were produced to a standard 45% fruit:55% sugar formula and were packed in 12-ounce glass jars. Jars in each lot were randomly subdivided for storage as follows:

1. 40°F in the dark.
2. 70°F in the dark.
3. 70°F under 100 foot-candles of white fluorescent light simulating supermarket shelf conditions. Jars were placed on their sides and were rotated 90° twice weekly to assure uniform exposure to the light source.

Evaluation Method

An examination of the preserves was made shortly after processing and other examinations were made after 3 and 6 months of storage. Evaluation methods included the following:

1. The samples were rated for color, flavor, texture, and overall appearance by the panel of 12 members using a 9-point hedonic scale from 1, dislike extremely, to 9, like extremely. Samples were scored for flavor and texture while illuminated with red light, and for color and appearance in white bowls under natural north daylight. The sample preserves were coded and presented in random order to the panel.
2. Measurement of color change was accomplished with the Gardner AC-2a Color Difference Meter (L, a, b values) and by determination of total anthocyanin retention using the method of Sondheimer and Kertesz (2).*

* Numbers in parentheses denote references cited, page 14.

Processing Observations

Differences in performance among the three varieties and the two seasons were noted during preparation of the preserves. The 1963 berries of all varieties produced preserves in which the fruit pieces were more tender and more easily dispersed through the body of the preserves during cooking than in the 1964 packs. Hood ranked midway between Marshall and Northwest in respect to the time required for the fruit to disperse uniformly through the preserves during the cooking process and in the wholeness of the fruit in the finished preserves. The following range of fruit characteristics was noted during processing of the individual preserves:

Marshall-'63 --- Softened rapidly and produced a jam consistency by end of process.

Marshall-'64, Hood-'63, Northwest-'63 --- Became tender and dispersed satisfactorily during process.

Hood-'64, Northwest-'64 --- Tended to toughen and shrink during process. Floating persisted, and poor equalization of color between fruit and jelly resulted.

The 1964 strawberry season in Oregon was cool and resulted in late-maturing fruit of generally lower soluble solids and firmer texture than observed in 1963. This character difference in the raw fruit may account for the reduced tenderness of the fruit units in the preserves prepared from fruit of the 1964 season.

Sensory Evaluation of the Preserves

A panel of 12 individuals evaluated each of the six variety-year samples of preserves at zero storage time and at 3- and 6-month intervals of storage under the three prescribed conditions. The average ratings of the panel for color, overall appearance (character and distribution of fruit units), flavor, and texture are presented in Table 1. Significance values for differences within each storage treatment are presented also.

Color

Panel results for varietal samples processed from 1963 fruit indicate that Hood preserves were consistently superior in color to Marshall and Northwest preserves under all storage conditions except 6 months at 70°F light storage when the ratings were not significantly different. Marshall and Northwest varieties were judged similar in color quality and were considered to be dark.

Panel results for samples using 1964 fruit showed that Marshall was clearly superior to Hood and Northwest for all but one of the storage conditions where Marshall was represented (no 70°F dark samples of Marshall were available). Color ratings for the three varietal samples after 6 months at 70°F under light were not significantly different. Hood was judged superior to Northwest when stored in the dark at 40° or 70°F, but no difference could be established after storage at 70°F under light.

The overall panel results obtained in this study, covering a 2-year sampling of raw fruit, suggest that Hood and Marshall will produce preserves with a similar range of color acceptance. These results also indicate that Hood preserves can be expected to retain their color quality equally as well as Marshall preserves over a storage period of 6 months when held at 70°F either in darkness or exposed to fluorescent light of 100 foot-candle intensity. After 6 months of storage at 70°F in light, all samples of preserves in the study developed a perceptible brown cast and all received a marginal acceptance rating from the panel.

Appearance

Panel ratings for appearance were based on the degree of softening, fragmentation, and dispersion of the fruit units in the preserves. Results for samples containing 1963 fruit indicated that Hood preserves compared favorably with Marshall and Northwest samples for the storage conditions tested. The Marshall preserves were judged inferior in appearance to the Hood in two of the seven storage treatments, due to a disintegrated, jam-like fruit character.

A preference was shown by the panel for the appearance of the Marshall preserves in all samples made from 1964 fruit. Samples of Hood and Northwest in this group contained an uneven distribution of fruit units in the preserves, and showed varying degrees of shrinkage of the fruit. In several comparisons, however, Hood preserves were preferred to those prepared from the Northwest variety, indicating that the Northwest variety was most seriously affected by fruit shrinkage and toughness during manufacture. An overall comparison of panel ratings for both years indicated that Marshall preserves, which exhibited a tendency toward soft fruit character, were slightly preferred in appearance to Hood preserves.

Flavor

The panel did not demonstrate a significant flavor preference between the varieties or years represented by the samples for any given storage condition. The flavor ratings obtained over the full 6 months storage period, as presented in Table 1, show only a very minor decline in average value from the zero time levels. It is noted that samples of the Hood variety showed the least decline in flavor ratings, while samples of Northwest variety exhibited the greatest decline in value.

Texture

It is useful to consider separately the panel ratings for the preserves produced from fruit of the 1963 and 1964 seasons. Panel results for the 1963 season shown in Table 1 indicate that the preserves representing the three varieties were not noticeably different in eating texture (mouth-feel). In one storage treatment evaluation (6 months/40°F dark), the texture of the Hood-'63 sample was judged superior to the more jam-like texture of Marshall-'63.

A comparison of texture ratings obtained for preserves made from 1964 fruit indicates that the texture of the Marshall and Hood preserves was usually not

significantly different. In one comparison out of five, the texture of Marshall preserves was rated significantly above that of Hood preserves. In all comparisons with Northwest samples, Marshall preserves were judged superior in texture. Hood preserves were preferred over Northwest preserves in two comparisons, while no preference was established in the four remaining comparisons.

Table 1. Sensory Panel Mean Scores¹ for Samples of Strawberry Preserves by Storage Treatment

A. Color

Variety	Year	Zero time	Storage treatment					
			40°F dark		70°F dark		70°F light	
			3 mos.	6 mos.	3 mos.	6 mos.	3 mos.	6 mos.
Hood	1963	6.5	6.9	6.6	6.4	5.0	6.0	4.6
	1964	5.5	5.7	5.2	6.9	5.8	5.4	5.2
Marshall	1963	4.6	5.3	4.3	4.2	3.7	4.5	4.1
	1964	7.6	6.8	7.2	---	---	6.8	5.4
Northwest	1963	3.8	4.9	4.3	4.7	3.7	4.6	4.5
	1964	4.7	4.6	3.3	5.1	4.5	5.7	4.6
F value ²		9.14**	6.99**	10.96**	6.01**	5.58**	4.00**	1.54
LSD p<0.05		1.22	1.03	1.27	1.16	1.11	1.21	NSD

B. Appearance

Variety	Year	Zero time	Storage treatment					
			40°F dark		70°F dark		70°F light	
			3 mos.	6 mos.	3 mos.	6 mos.	3 mos.	6 mos.
Hood	1963	5.9	5.9	6.3	6.2	5.1	6.1	5.7
	1964	4.3	3.9	4.4	4.9	4.8	4.5	3.5
Marshall	1963	4.8	5.7	3.9	4.5	4.3	5.2	4.8
	1964	7.3	6.5	5.9	---	---	5.8	5.1
Northwest	1963	4.6	5.2	3.8	5.2	4.1	5.0	4.8
	1964	4.4	2.9	3.2	2.7	3.7	3.7	2.9
F value		4.36**	10.87**	9.38**	6.10**	7.91**	3.61**	7.88**
LSD p<0.05		1.48	1.16	1.16	1.39	1.17	1.31	1.05

¹Hedonic 9-point scale where: 9 = like extremely, 1 = dislike extremely.

**Variance significant at p = 0.01.

NSD = No significant difference.

LSD = Least significant difference between scores of any two samples in a treatment.

²F value is a test of significance of the differences in sample scores within a treatment, based on the variation of repeated scores for the same sample. An F value of 2.4 or higher indicates the presence of a significant difference.

Table 1. Continued

C. Flavor

Variety	Year	Zero time	Storage treatment					
			40°F dark		70°F dark		70°F light	
			3 mos.	6 mos.	3 mos.	6 mos.	3 mos.	6 mos.
Hood	1963	5.8	6.9	6.3	5.5	6.4	5.3	5.2
	1964	6.3	6.0	6.4	5.3	5.8	4.9	6.0
Marshall	1963	5.9	5.9	5.4	6.2	5.3	5.1	5.3
	1964	6.2	6.4	5.6	---	---	6.4	5.4
Northwest	1963	6.1	6.3	5.9	5.5	5.7	5.5	5.0
	1964	4.7	6.1	4.6	5.8	5.7	5.5	3.8
F value		1.15	0.83	1.79	1.21	0.87	1.03	1.75
LSD p<0.05		NSD	NSD	NSD	NSD	NSD	NSD	NSD

D. Texture

Variety	Year	Zero time	Storage treatment					
			40°F dark		70°F dark		70°F light	
			3 mos.	6 mos.	3 mos.	6 mos.	3 mos.	6 mos.
Hood	1963	5.6	6.6	6.3	5.9	6.4	6.0	5.8
	1964	5.8	5.3	5.5	5.3	4.2	4.8	5.3
Marshall	1963	4.9	5.1	4.3	6.0	5.5	5.8	5.1
	1964	6.1	6.5	5.8	---	---	7.0	5.4
Northwest	1963	5.4	6.2	5.3	5.4	6.1	5.6	5.4
	1964	4.3	4.8	3.5	4.2	4.6	4.5	2.3
F value		1.47	2.86*	3.68**	2.80*	2.58*	2.49*	7.59**
LSD p<0.05		NSD	1.31	1.39	1.26	1.70	1.80	1.31

*Variance significant at p = 0.05.

**Variance significant at p = 0.01.

NSD = No significant difference.

An examination of texture ratings through the full range of storage conditions provides no conclusive evidence of a consistent decline in quality with time. This suggests that storage conditions in this study had no effect on the texture of the preserves.

Interaction Effects

An analysis of the panel preference scores was made for interaction effects between varieties, storage conditions, and time of storage. Judges and years of raw-fruit harvest were both considered to be random variables in the study and were combined in the error term used to test significance. Table 2 shows the interaction effects found to be significant by quality factor.

Table 2. Significant Interaction Effects in Variety-Storage Study of Strawberry Preserves

Quality factor	Interaction	F	Level of significance
Color	Var. x storage	1.73	p = 0.05
Appearance	Var. x storage x time	1.79	p = 0.01

The color-related interaction in Table 2 shows that the three strawberry varieties responded differently, in terms of color preference, to the three storage conditions in the study. Analyses of the color scores indicate that Hood preserves were more stable in color quality between 40°F dark and 70°F light storage than were Marshall and Northwest preserves. The significant three-way interaction related to the appearance factor in Table 2 indicates that the varieties were affected differently in appearance when exposed to the three storage conditions over a period of 6 months. An evaluation of the scores reveals that the appearance attribute of the Marshall and Northwest preserves declined progressively under the three storage conditions as time of storage increased, but the appearance of the Hood preserves remained relatively stable with time. No reference is made to the quality level of the appearance factor but only to its stability in each varietal product. No significant interactions were found in the analysis of sensory scores for texture or flavor.

Industry Evaluation

Three preserving companies in 1965 were designated by the National Preservers Association to conduct regular production scale processing tests with the Hood strawberry, and to evaluate the quality of the preserves produced in comparison with preserves of other strawberry varieties normally used. The test at each plant required 900 pounds of frozen Hood berries supplied by the Conroy Packing Company, Woodburn, Oregon, from plantings at the North Willamette Experiment Station, Aurora, Oregon. Separate communications received from these processors

by Mr. Robert Conroy (1) after the tests were completed (shelf-testing conducted by one company only), indicated unanimous agreement that the Hood preserves were very similar in color and flavor to the Marshall preserves. When ranked for overall quality, Hood ranked just below Marshall but above all other varieties included in the testing. The industry report appears to substantiate the general results of the sensory evaluation obtained in this study.

Physico-chemical Measurements of Color

Color is an important attribute of strawberry preserves and since color degradation during storage frequently limits the acceptance of strawberry preserves, the color of the preserves was measured in terms of Gardner "L", "a", and "b" values and also in terms of total anthocyanin content. These measurements were made on single jar samples drawn from each variety-treatment lot at initial time and again after storage intervals of 3 and 6 months. The samples were transferred to a circular cup with optical glass bottom and $1\frac{1}{4}$ inch depth for the Gardner color measurement. "L", "a", and "b" values were obtained as averages of five readings against the Gardner CSRO093 standard red plaque.

Anthocyanin pigments were determined in duplicate on 40 g aliquots drawn from each sample after macerating the fruit units and mixing the samples well. The difference in absorbance readings at 500 mu using a Beckman model B spectrophotometer was obtained on the filtrate adjusted to pH 3.4 and 2.0 respectively and was converted to anthocyanin chloride concentration (mg-%) by means of a calibration curve developed with Congo Red. Reduction in anthocyanins was calculated as percent loss based on the anthocyanin content of the samples after 3 months' storage at 40°F dark (no data available for zero storage time). Data resulting from the measurement of color in the preserves are reported in Tables 3 and 4. Correlation coefficients given in Table 5 show the degree of relationship between panel preference scores for color and the physico-chemical color indices according to variety over two seasons.

Table 3. Gardner Color Values¹ for Samples of Strawberry Preserves

Gardner "L"

		Storage treatment						
		Zero time	40°F dark		70°F dark		70°F light	
Variety	Year		3 mos.	6 mos.	3 mos.	6 mos.	3 mos.	6 mos.
Hood	1963	8.6	8.4	8.9	9.1	9.4	9.4	9.5
	1964	8.1	8.6	8.3	8.2	8.2	8.6	8.3
Marshall	1963	9.5	9.8	9.8	10.2	10.0	10.0	10.3
	1964	8.9	9.5	9.0	---	---	9.9	9.6
Northwest	1963	8.4	8.3	8.8	8.6	8.8	8.6	9.0
	1964	7.6	8.8	8.6	9.1	8.0	9.0	8.1

Gardner "a"

		Storage treatment						
		Zero time	40°F dark		70°F dark		70°F light	
Variety	Year		3 mos.	6 mos.	3 mos.	6 mos.	3 mos.	6 mos.
Hood	1963	3.7	4.0	4.2	3.5	2.9	3.5	2.6
	1964	4.0	3.8	3.5	3.3	2.2	2.8	2.1
Marshall	1963	6.1	6.8	5.9	5.7	4.9	5.4	4.9
	1964	4.8	5.7	5.1	---	---	4.4	3.6
Northwest	1963	4.5	3.5	4.1	3.5	3.7	3.7	3.5
	1964	3.2	5.1	4.8	4.6	2.6	4.2	2.4

Table 3. Continued

Gardner "b"

Variety	Year	Zero time	Storage treatment					
			40°F dark		70°F dark		70°F light	
			3 mos.	6 mos.	3 mos.	6 mos.	3 mos.	6 mos.
Hood	1963	1.8	1.7	2.1	1.7	2.2	2.0	2.4
	1964	1.5	1.2	1.4	1.3	1.4	1.4	1.6
Marshall	1963	2.5	2.5	2.6	2.6	2.9	2.6	2.9
	1964	2.2	2.5	2.0	---	---	2.3	2.6
Northwest	1963	1.1	1.4	1.4	1.3	1.8	1.5	1.7
	1964	1.0	1.8	1.7	1.5	1.5	1.7	1.6

¹Readings obtained on complete sample with Gardner Color Difference Meter, model AC-2a, calibrated against Gardner standard color plaque No. CSR0093 (L = 26.8, a = + 45.4, b = + 15.1).

Table 5. Correlation Coefficients Between Color Preference Scores and Physico-Chemical Measurements

Color measurement	Variety (1963-1964)	Correlation coef. (r) Color
Gardner "L"	Hood	-0.27
	Marshall	-0.79**
	Northwest	+0.11
Gardner "a"	Hood	0.56*
	Marshall	-0.10
	Northwest	-0.17
Gardner "b"	Hood	-0.22
	Marshall	-0.88**
	Northwest	-0.04
Anthocyanin content	Hood	0.45
	Marshall	-0.06
	Northwest	-0.20

* $p < 0.05$.

** $p < 0.01$.

Gardner Color Values

Gardner "L" values found in Table 3 represent the darkness-lightness attribute of sample color. The "L" values show a small average increase between zero time and 3 months storage, but no further consistent change between 3 and 6 months storage for corresponding conditions. Although varying between variety and growing year, the average increase in "L" within 3 months was least for 40°F dark storage and greatest for 70°F light storage. These observations suggest that changes occurring in "L" value are due not to storage but rather to a color equalization between berry units and the gelled matrix during the early weeks of storage. Thus preserves such as the Northwest-'64 sample, which contained firm intact berries

in a relatively clear gel, require considerable equalization before color readings become stabilized. A significant negative correlation was obtained between preference scores and "L" values in the Marshall variety, indicating that a meaningful relationship may be possible if fruit is well dispersed and color is uniform throughout the preserves. The Marshall variety gave consistently higher "L" values over the 6 months storage period than did the two other varieties.

Degree of redness in the samples is indicated by the Gardner "a" values in Table 3. A number of the "a" readings increased as did the "L" values between zero time and 3 months storage at 40°F dark, indicating that color equalization was occurring in this period. The general pattern of Gardner "a" data shows that "a" values decreased steadily during 6 months of storage. The rate of decline in "a" value is temperature-dependent but is not appreciably accelerated by exposure of the preserves to 100 foot-candles of fluorescent light during the 6 months period. The average decline in "a" values for the three varieties after 6 months storage was negligible at 40°F dark, 25% at 70°F dark, and 28% at 70°F light storage. Both variety and year of fruit production had a definite effect on Gardner "a" values. Average "a" readings for the two years indicated that Marshall preserves had most redness, Northwest an intermediate amount, and Hood the least amount for the three varieties. The rate of decline in "a" readings for any given storage condition was similar for the three varieties tested. A statistically significant correlation was shown between panel preference scores for color and Gardner "a" values in the Hood variety only. Increased variation in "a" value due to year effect contributed to the poor correlation obtained for the other two varieties.

The Gardner "b" values reported in Table 3 indicate that a yellowness of low intensity was present in all samples of preserves in the study. Marshall samples gave consistently higher "b" readings than either Hood or Northwest samples which gave similar values. The presence of yellow achenes imbedded in the fruit surface of the Marshall berry may account for the higher "b" values found with this variety. The "b" readings were found to increase gradually over a 6-month storage at 70°F dark and 70°F light, while no change was observed during storage at 40°F dark. A high negative correlation was obtained between preference scores for color and Gardner "b" values for the Marshall samples, but the panel apparently was insensitive to the small changes in "b" value which occurred with the Hood and Northwest varieties.

Total Anthocyanin Content

Results given in Table 4 show that anthocyanins in all lots were degraded rapidly when the preserves were exposed to 70°F storage but were relatively stable when samples were held at 40°F dark storage. Preserves stored at 70°F in the dark lost nearly 50% of the anthocyanin after 3 months and 60 to 70% after 6 months. Storage in light at 70°F increased anthocyanin losses by 10 to 15% over storage in the dark. The rate of reduction of the anthocyanin appears to be the same in the three varieties under similar storage conditions. Destruction of anthocyanin results in loss of redness and development of degradation products which give to the preserves an objectionable brown cast. However, total anthocyanin values obtained during the study failed to correlate with the panel scores for color.

Summary

The suitability of the new Hood strawberry for preserves was compared with that of the Marshall and Northwest varieties in terms of the initial quality of the preserves and quality stability over a 6-month storage period at three storage conditions. Single experimental lots of preserves were produced from frozen whole berries of each variety, representing the 1963 and 1964 harvests. The preserves were evaluated for color, appearance, texture, and flavor by a 12-member sensory panel upon processing and again after 3 and 6 months of storage. Color quality was also measured in terms of total anthocyanin content and Gardner "L", "a", and "b" values. Although the textural quality of the preserves varied significantly between years of raw product within varieties, the overall evaluation of fruit texture in the preserves showed that Marshall berries were least firm, Hood berries were of intermediate firmness, and Northwest berries were most firm. Preference scores for texture indicated that the Hood variety may provide a range of fruit texture in preserves which varies from optimum quality to slightly too firm when related to Marshall. Hood and Marshall varieties produced preserves having a similar range of acceptance for color and appearance. The Northwest variety tended to produce preserves having dark, firm to tough, poorly dispersed fruit units which lowered the color, appearance, and texture quality for this variety. Significant interaction effects obtained in the analysis of panel scores for color and appearance factors indicated that Hood preserves retained initial color and appearance quality better than did Marshall or Northwest varieties under the storage conditions of the study.

Two objective color indices, Gardner "L" and Gardner "b", showed a high negative correlation with panel preference scores for color in Marshall preserves, but similar correlations were not obtained for the other two varieties. The rate of decline in redness of strawberry preserves for the three varieties was shown by Gardner "a" data to be primarily a function of temperature and was not significantly affected by exposure to fluorescent light at 70°F during storage. The sensory panel in this study did not find a distinguishable difference in flavor between preserves of the three varieties. This study presents evidence indicating that the Hood strawberry will produce preserves slightly inferior to Marshall but superior to Northwest preserves in overall quality. This evidence is substantiated by the results of an industry evaluation conducted during 1965.

References

- (1) Conroy, R. L. 1966. Private communication reporting results of preserving tests made by three member companies of the National Preservers Association in 1965. Conroy Packing Company, Woodburn, Oregon.
- (2) Sondheimer, E. and Z. I. Kertesz, 1948. Colorimetric determination in strawberries and strawberry products. Anal. Chem., 20, 245.