

LONGITUDINAL BARK CRACKING ON TRUNKS OF YOUNG ASIAN PEAR TREES

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Comparison of the Physical, Chemical and Sensory Characteristics of Five Raspberry Cultivars Evaluated Fresh and Frozen

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Abstract

The physical, chemical and sensory characteristics of five raspberry cultivars ('Newburg,' 'Taylor,' 'Latham,' 'Festival' and 'Boyne') harvested at the red-ripe stage were evaluated at harvest and after 1, 6 and 9 months of frozen storage at -20°C. 'Newburg' was preferred for flavor ($p \leq 0.05$) over 'Festival,' 'Latham' and 'Boyne' and was significantly higher ($p \leq 0.05$) in pH, % soluble solids and total sugars than 'Boyne' after 1, 6 and 9 months frozen storage. 'Boyne' was the least preferred for color and texture ($p \leq 0.05$) at 6 and 9 months of frozen storage and was significantly less ($p \leq 0.05$) red (lower chroma value) than the other cultivars. Values for 'Taylor,' 'Latham' and 'Festival' fell between 'Newburg' and 'Boyne.'

Introduction

Raspberry growers in the State of Maine are interested in the selection of red raspberry cultivars suitable for preservation by freezing, which maintain sensory quality during frozen storage. Reports in the literature regarding fresh and frozen raspberries include the effect of harvest methods (11), postharvest storage conditions (10) and type of freezant (13). Other publications are related to the selection of cultivars which are suitable for freezing and fresh market (3, 5-7, 9). In

some instances, chemical analyses (titratable acidity, pH, soluble solids, total sugars), color measurements and compression were a part of these studies (5-7).

This investigation was designed to evaluate the physical, chemical and sensory properties of several raspberry varieties at harvest and following one, six and nine months of frozen storage. The interrelationships of physical, chemical and sensory characteristics in this research may prove useful for evaluating the quality of raspberry cultivars adapted to growing conditions in other geographic areas.

Materials and Methods

Five cultivars of red raspberries ('Boyne,' 'Festival,' 'Latham,' 'Newburg,' and 'Taylor') grown at the University of Maine's Highmoor Farm, Monmouth, ME under traditional cultivation methods were harvested at red-ripe stage (9) and directly transported on ice to the Department of Food Science laboratories (within 2 hours of harvest). The fresh raspberries were cleaned and prepared for

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physical and chemical analyses and for evaluation of sensory properties. These analyses were performed on the day of harvest.

Physical and chemical analyses

Three 60 g samples of each cultivar were taken for objective evaluations of quality at each testing period. Color of the whole berries was measured using a Hunter LabScan II spectrophotometer (Reston, VA) with 10 degree D65 (daylight) illuminant and a 4-5 cm aperture. Textural measurements were made using an Instron Universal Testing Instrument (Model 1000, Canton, MA) equipped with a standard Kramer shear cell. The crushed berries with the juice were used for determining percent soluble solids (using an Abbe refractometer at 20°C standardized with a 10% sucrose solution), pH (Beckman model), and titratable acidity (titration was to a pH 8.1 endpoint) (1). Sugar concentrations (fructose, glucose, sucrose, total sugars) were determined by HPLC methods (12). All analyses were performed in triplicate. Additional berries (3 - 200 g

samples) were frozen on cookie sheets in a blast freezer at -30°C, packaged in polyethylene Ziploc freezer bags and held at -20°C until analyzed after 1, 6 and 9 months of frozen storage.

Sensory evaluation

Intact berries for sensory quality evaluation were washed carefully in a colander, allowed to drain and placed on trays lined with paper towels to absorb excessive moisture. The samples were coded, placed in white paper baking cups and presented in a randomized complete block design (2) with three replications to a sensory panel for evaluation of quality. Panelists were asked to rank the samples in order of their preference for color, flavor and texture and to indicate the term that best described their acceptance of each sample for the above quality attributes.

Table 1. Summary of statistical significance of main and interaction effects on physical, chemical and sensory characteristics of five raspberry cultivars by analysis of variance techniques.

	Variety	Time	Variety* Time
pH	**	**	**
% Soluble solids	**	**	**
% Titratable acidity	**	*	NS
Instron Peak Force (kg)	NS	**	**
Fructose (g/100g)	**	**	**
Glucose (g/100g)	**	**	**
Sucrose (g/100g)	**	**	**
Total Sugars (g/100g)	**	**	**
Chroma	**	**	NS
Hue	**	**	NS
Acceptance: Color	**	**	NS
Flavor	**	**	**
Texture	**	**	NS

* P ≤ 0.05, ** P ≤ 0.01, NS - not significant.

Table 2. Summary of statistical significance of the effect of storage time on the physical, chemical and sensory characteristics of five raspberry cultivars.

	Boyne	Festival	Latham	Newburg	Taylor
pH	NS	**	NS	NS	**
% Soluble solids	NS	NS	NS	NS	*
% Titratable acidity	NS	NS	NS	NS	NS
Instron Peak Force (kg)	**	**	**	*	**
Fructose (g/100g)	**	**	NS	**	**
Glucose (g/100g)	**	**	**	**	**
Sucrose (g/100g)	**	*	NS	**	**
Total Sugars (g/100g)	*	NS	NS	NS	*
Chroma	*	*	NS	NS	**
Hue	NS	NS	NS	NS	NS
Color	**	NS	NS	NS	NS
Flavor	NS	*	**	**	*
Texture	**	**	**	**	**

* P ≤ 0.05, ** P ≤ 0.01, NS - not significant.

Additional washed berries were frozen by the same procedures as those used for the unwashed berries. Following 1, 6 and 9 months of frozen storage, the frozen berries were placed in baking cups and allowed to thaw before being evaluated by sensory panelists.

Statistical analyses

Data for the physical and chemical analyses were analyzed by the analysis of variance method using the Statistical Analysis System package (8).

Table 3. Physical and chemical characteristics of five raspberry cultivars evaluated fresh and following 1, 6 and 9 months of frozen storage.¹

Cultivar	pH	% Soluble solids	% Titratable acidity	Instron peak force (kg)
<i>Fresh</i>				
Boyne	3.04 b ³	9.6 d	1.46 c	7.30 b
Festival	3.02 b	10.0 cd	1.85 b	8.97 ab
Latham	3.05 b	10.6 cd	1.43 c	9.63 ab
Newburg	3.13 a	12.3 a	1.81 b	10.97 a
Taylor	2.98 b	11.1 b	2.09 a	10.00 a
K-ratio 100	0.07	0.64	0.16	2.54
<i>1 Month</i>				
Boyne	2.98 ab	9.8 d	1.59 c	4.00 b
Festival	2.91 c	10.9 c	1.90 b	4.17 ab
Latham	2.97 abc	11.3 bc	1.36 d	4.33 ab
Newburg	3.02 a	13.2 a	2.00 b	3.30 c
Taylor	2.92 bc	11.3 b	2.21 a	4.57 a
K-ratio 100	0.06	0.36	0.11	0.42
<i>6 Months</i>				
Boyne	2.81 abc	9.7 c	1.50 c	4.64 a
Festival	2.75 bc	10.9 b	1.93 b	3.55 cd
Latham	2.84 ab	11.2 b	1.42 c	3.90 bc
Newburg	2.86 a	12.8 a	1.86 b	3.14 d
Taylor	2.72 c	11.3 b	2.14 a	4.30 ab
K-ratio 100	0.11	0.55	0.13	0.71
<i>9 Months</i>				
Boyne	2.93 b	9.3 d	1.50 c	2.45 a
Festival	2.82 c	10.9 b	1.88 b	2.40 a
Latham	2.95 b	10.2 c	1.38 c	2.43 a
Newburg	3.08 a	12.3 a	1.78 b	1.74 b
Taylor	2.82 c	10.6 bc	2.11 a	2.01 b
K-ratio 100	0.11	0.37	0.14	0.35

¹Mean of three determinations.

²Titratable acidity reported as citric acid.

³Means followed by similar letters do not differ significantly at $p \leq 0.05$ using Waller Duncan's K-ratio t test.

For statistical analyses of the sensory preference data, ranks were transformed to scores according to Fisher and Yates (4) to normalize ranked data. Scores assigned to the 6-point acceptance scale ranged from 6 = Like very much/Excellent/Very firm to 1 = Dislike very much/Very poor/Very soft (mushy). The data for the preference and the acceptance tests were analyzed by the analysis of variance method with the Waller-Duncan K-ratio t test being used to determine significant differences between adjacent means within each characteristic.

Results

A summary of the statistical significance of the main and interactive effects on the physical, chemical and sensory characteristics of the raspberry selections are shown in Table 1. A significant two-way interaction (variety*time) was observed for pH, % soluble solids, Instron, sugars and flavor acceptance during sampling, indicating that the effect on these variables over the sampling period is different based on variety. Due to this interaction, the effect of storage time on the physical, chemical and sensory characteristics of each variety sampled was examined and the results are shown in Table 2. The effect of freezing on pH, % soluble solids, % titratable acidity, hue and sensory color was not significant over time. Significant differences did occur in both the Instron and sensory texture evaluations for all five selections. A closer look at the mean changes at selected times within the freezing period indicate shear values decreased over time. Significant variation occurred in the individual sugars, however, in the total sugars only 'Boyne' and 'Taylor' showed significant changes through the freezing period.

The means for the five selections evaluated fresh and following freezing are shown in Tables 3-6. Significant differences ($p \leq 0.05$) in chemical characteristics were observed among

Table 4. Sugar content of five raspberry cultivars evaluated fresh and following 1, 6 and 9 months of frozen storage.¹

Cultivar	Fructose (g/100g)	Glucose (g/100g)	Sucrose (g/100g)	Total Sugars (g/100g)
<i>Fresh</i>				
Boyne	2.28 d	1.93 b	1.93 b	6.14 b
Festival	2.09 c	1.88 b	0.87 d	4.84 c
Latham	3.71 a	2.39 a	0.00 e	6.10 b
Newburg	3.01 b	2.43 a	2.24 a	7.68 a
Taylor	2.67 c	2.28 a	1.35 c	6.30 b
K-ratio 100	0.07	0.17	0.29	0.40
<i>1 Month</i>				
Boyne	2.40 d	1.88 d	1.94 b	6.22 c
Festival	2.77 c	2.49 b	1.99 b	7.25 b
Latham	4.34 a	2.94 a	0.00 d	7.28 b
Newburg	3.38 b	2.54 b	2.66 a	8.59 a
Taylor	2.75 c	2.25 c	1.21 c	6.21 c
K-ratio 100	0.27	0.19	0.31	0.67
<i>6 Months</i>				
Boyne	2.75 d	2.40 c	0.80 b	5.95 c
Festival	3.35 c	3.06 b	0.52 c	6.93 b
Latham	4.76 a	3.41 a	0.00 d	8.17 a
Newburg	4.33 b	3.35 ab	1.21 a	8.89 a
Taylor	3.67 c	3.22 ab	0.41 c	7.30 b
K-ratio 100	0.35	0.31	0.22	0.86
<i>9 Months</i>				
Boyne	2.77 c	2.46 d	0.59 a	5.82 d
Festival	3.63 b	3.36 b	0.35 b	7.34 b
Latham	4.37 a	2.91 c	0.00 c	7.28 b
Newburg	4.48 a	3.56 a	0.80 a	8.84 a
Taylor	3.50 b	2.86 c	0.36 b	6.74 c
K-ratio 100	0.26	0.18	0.22	0.48

¹Mean of three determinations.

²Titrateable acidity reported as citric acid.

³Means followed by similar letters do not differ significantly at $p \leq 0.05$ using Waller Duncan's K-ratio t test.

cultivars. 'Newburg' was higher ($p \leq 0.05$) in % soluble solids than the other cultivars at each evaluation and in total sugars ($p \leq 0.05$) with the exception that, at 6 months, the total sugars of 'Newburg' and 'Latham' did not differ significantly. 'Taylor' was consistently higher in % titrateable acidity (as citric acid) than the other cultivars at all testing periods. 'Boyne' was consistently low in % soluble solids, % titrateable acidity and concentrations of fructose and glucose. Of note was

the fact that 'Latham' contained no detectable sucrose while the sucrose concentration in the other cultivars decreased after 1 month of frozen storage with a concomitant increase in glucose and fructose.

The Hunter color data (Table 5) indicated that 'Boyne' fruits were less red ($p \leq 0.05$) than the other cultivars examined after 6 and 9 months of frozen storage. Among the other cultivars no significant differences ($p \leq 0.05$) in redness were observed during

Table 5. Hunter color values of five raspberry cultivars at harvest and following 1, 6 and 9 months of frozen storage.¹

Cultivar	L value ²	a/b ³	E ³
<i>Fresh</i>			
Boyne	18.25 bc ³	17.97 b	15.93 b
Festival	17.58 c	22.93 a	16.20 b
Latham	21.17 a	22.40 a	16.87 b
Newburg	21.27 a	22.46 a	18.03 a
Taylor	20.59 ab	22.53 a	16.57 b
K-ratio 100	2.65	2.99	2.36
<i>1 Month</i>			
Boyne	13.30 c	26.64 a	15.53 bc
Festival	17.86 b	30.77 a	16.40 ab
Latham	19.20 ab	31.03 a	15.87 b
Newburg	20.15 a	32.09 a	16.90 a
Taylor	19.70 ab	28.51 a	14.80 c
K-ratio 100	1.85	NS	1.01
<i>6 Months</i>			
Boyne	14.31 c	26.47 b	15.53 c
Festival	18.71 b	31.08 a	16.87 b
Latham	19.69 ab	31.93 a	16.70 b
Newburg	20.99 a	31.77 a	17.80 a
Taylor	20.80 a	31.73 a	16.03 c
K-ratio 100	1.87	2.32	2.24
<i>9 Months</i>			
Boyne	14.81 b	27.09 b	15.70 c
Festival	18.47 a	31.12 a	16.58 b
Latham	19.79 a	30.19 a	16.50 b
Newburg	19.35 a	30.76 a	17.73 a
Taylor	20.58 a	31.11 a	15.83 c
K-ratio 100	2.16	2.49	2.24

¹Mean of three determinations performed on whole raspberries.

²The greater the value the lighter the color (L), the more red than yellow (a/b) and the more intense (E) the color.

³Means followed by similar letters do not differ significantly at $p \leq 0.05$ using Waller Duncan's K-ratio t test.

Table 6. Color, flavor and texture of five raspberry cultivars at harvest and following 1, 6 and 9 months of frozen storage.

Cultivar	Preference tests ¹			Acceptance ²		
	Color	Flavor	Texture	Color	Flavor	Texture
<i>Fresh</i>						
Boyne	-0.12	-0.17	0.27	4.38	3.40	2.82
Festival	0.14	0.00	0.19	5.02	3.78	3.51
Latham	0.17	0.03	0.10	4.71	4.00	3.22
Newburg	0.11	0.23	-0.03	4.69	4.13	3.44
Taylor	-0.30	-0.09	0.01	4.20	3.78	3.18
K-ratio 100	NS ³	NS	NS	NS	NS	NS
<i>1 Month</i>						
Boyne	-0.31	-0.25 c ⁴	-0.25	3.89	3.13	2.09
Festival	0.29	-0.09 bc	0.09	4.60	3.07	2.22
Latham	0.09	-0.11 bc	0.04	4.40	3.11	2.20
Newburg	-0.08	0.30 a	0.00	4.07	3.60	2.20
Taylor	0.01	0.15 ab	0.12	4.07	3.40	2.29
K-ratio 100	NS	0.30	NS	NS	NS	NS
<i>6 Months</i>						
Boyne	-0.71 b	-0.38 c	-0.28 b	3.40 b	3.02 c	1.96 b
Festival	0.20 a	0.17 b	0.09 a	4.49 a	3.89 b	2.18 ab
Latham	0.34 a	-0.22 c	-0.08 ab	4.67 a	3.18 c	2.18 ab
Newburg	0.19 a	0.72 a	0.10 a	4.56 a	4.67 a	2.31 ab
Taylor	-0.02 a	-0.29 c	0.17 a	4.29 a	3.02 c	2.56 a
K-ratio 100	0.36	0.34	0.37	0.62	0.59	0.50
<i>9 Months</i>						
Boyne	-0.50 b	-0.54 c	-0.42 b	3.24 b	2.68 c	2.29 b
Festival	0.21 a	0.08 b	0.08 a	4.39 a	3.68 b	2.84 ab
Latham	0.33 a	-0.12 b	-0.04 ab	4.58 a	3.45 b	2.82 ab
Newburg	0.10 a	0.70 a	0.14 a	4.24 a	4.84 a	2.89 ab
Taylor	-0.14 ab	-0.12 b	0.24 a	3.92 ab	3.16 bc	3.34 a
K-ratio 100	0.48	0.30	0.41	0.83	0.53	0.68

¹Values, which range from +1.16 = most preferred to -1.16 = least preferred, are means for 12-15 judges, three replications.

²Based on a 6-point scale where 6 = best and 1 = poorest.

³NS = Not significant.

⁴Means followed by similar letters do not differ significantly at $p \leq 0.05$ using Waller Duncan's K-ratio t test.

fresh or frozen analysis. 'Newburg' was found to have the most intense color (E value) at each of the testing periods. Analyses of the sensory data (Table 6) for the fresh raspberries showed no significant ($p \leq 0.05$) preference for the cultivars in terms of color, flavor or texture. 'Newburg' was preferred ($p \leq 0.05$) for flavor over 'Latham,' 'Festival' and 'Boyne' at 1, 6 and 9 months and over 'Taylor' at 6 and 9 months of frozen storage. Although the difference was not significant ($p \leq 0.05$) 'Newburg' had the highest preference score when eval-

uated fresh. 'Boyne' was the least preferred ($p \leq 0.05$) for color and texture when compared to 'Newburg,' 'Taylor' and 'Festival' at 6 and 9 months of frozen storage. Significant differences ($p \leq 0.05$) in color of the raspberries were not noted until months 6 and 9 frozen storage when 'Boyne' was rated the poorest.

Discussion

The significance of this research was related to the ability to identify physical and chemical characteristics of raspberry cultivars that can predict

long term storage quality. Although researchers have determined the % soluble solids, % titratable acidity and total sugars (5-7, 9-11, 13), this was the first time that texture, Hunter color values and the fructose, glucose and sucrose content of raspberries was examined during frozen storage. The results indicated that % titratable acidity, sucrose and total sugar content could serve as a predictor of flavor in frozen raspberries since the variety ('Newburg') with the highest concentration of sucrose and total sugars was most preferred by panelists at 1, 6 and 9 months of frozen storage.

Also, panelists appeared to prefer the more traditional red color in frozen raspberry cultivars ('Festival,' 'Latham' and 'Newburg') as opposed to the deeper purple color of cultivars like 'Boyne.'

Overall, the physical, chemical and sensory characteristics of 'Newburg' were the most conducive to high quality fresh or frozen raspberries while 'Boyne' would not be recommended for processing by freezing.

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Stability of 'MacSpur McIntosh' Trees

In a recent report on a study of 9 year old 'MacSpur' trees in a commercial orchard in New Brunswick trees were grouped according to 3 degrees of spuriness. Reduced terminal growth, fewer limbs per tree, more flowering spurs in 2 and 3 year wood were associated with the highest degrees of spuriness and coupled with less yield and less yield efficiency. The trees in this orchard ranged from a growth habit similar to standard 'McIntosh' all the way to a group with the true spur habit. The variability suggest that 'MacSpur' may be unstable.

From: Embree et al. 1991. Variation in Growth, Spur Density and Yield of 'MacSpur McIntosh.' *HortScience* 26(2):188-190.