ABSTRACT

SWIFT, JENNIFER ELIZABETH. Effects of Frozen Storage and Harvest Time on the Textural and Sensory Properties of Rabbiteye Blueberries (*Vaccinium virgatum* Aiton). (Under the direction of James R. Ballington.)

Rabbiteye blueberries (*V. virgatum* Aiton), while praised for small stem scars, improved firmness over highbush cultivars, ease of mechanical harvesting, and superior keeping quality in storage, have also been reported to be have tougher skins after extended frozen. Growers and processors alike fear that significant increases in blueberry skin toughness following extended frozen storage could lead to a decrease in demand for the species. Furthermore, industry representative have been of the opinion that later harvests produce the toughest berries. The objectives of this study were to objectively determine by mechanical textural analysis if there is a change in the toughness of rabbiteye blueberry skins over time when frozen, and also if later harvests resulted in fruit with tougher skins before, and especially after frozen storage. In addition, the objective data were compared to sensory panel data to determine whether consumers could detect any changes in firmness and/or toughness, and if they found them to be unpalatable. In the first year four rabbiteye cultivars; Premier, Tifblue, Powderblue, and Ira, one highbush cultivar; Beaufort, and one rabbiteye - highbush hybrid variety NC 3465 were picked, individually quick frozen (IQF) and stored at -14° F for a total of 13 months. A second harvest of Premier, Powderblue and Tifblue were picked two weeks after the first, frozen and stored in the same manner. In the second year, cultivars Powderblue, Tifblue, Premier, and Beaufort were picked again, as well as Brightwell, another rabbiteye cultivar. Three harvests were picked of Powderblue, Tifblue, Beaufort and Brightwell, and two harvests of Premier were collected. All harvests and cultivars were simultaneously tested every three months by puncture and compression tests

on a TA-XT Plus Texture Analyzer to measure skin toughness and berry firmness. Large, untrained sensory panels of approximately 75 persons each evaluated skin firmness and firmness liking every three months. Also in the second year, small samples from each harvest were separated at six months and stored for an additional seven months at 6° F to evaluate toughness at temperatures closer to consumer freezers.

Results over two years did not reflect increased toughness over time, except in the small test for treatments at 6°F, which confirmed past research, and indicated a storage temperature threshold at which toughness increased significantly. In both years, most cultivars tested as being much firmer and as having tougher skins while fresh than after freezing. Results did not indicate later harvests result in increased toughness among rabbiteye cultivars.

Mechanical textural analysis and sensory results both indicate cultivar effect to be much more significant than time. Furthermore, year-to-year differences due to environmental conditions, location and ripeness all had impact.

In both years, Beaufort was found to have the least tough skins both by mechanical testing and sensory panels. In the first year, Powderblue had significantly tougher skins than all other cultivars, and in the second year, Brightwell was the toughest by a significant margin, whereas Powderblue was average in skin toughness.

Effects of Frozen Storage and Harvest Time on the Textural and Sensory Properties of Rabbiteye Blueberries (*Vaccinium virgatum* Aiton)

by
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DEDICATION

This Master's Thesis is dedicated to my mother, Nancy, who, when speaking to me as a young child about college, always used the word "when" rather than "if."

BIOGRAPHY

Jennifer Swift was born in San Francisco, CA in the summer of 1974 to parents Nancy and Thomas Swift. She grew up primarily in the southern California desert, and relocated to Encinitas, CA, a coastal beach town north of San Diego, just before entering high school. In years 1992 through 1998, she attended San Francisco State University, where she received a Bachelor of Arts in English Literature. In November of 2001, she and her future husband pulled up stakes and headed east to Raleigh, NC. This move would end up being very pivotal in Jen's life. What started as a mere desire to learn about the native flora soon flourished into a decision to enter the field of horticulture. In 2006, she earned her Bachelor of Science in Horticulture from North Carolina State University, and had immediate plans for graduate school. Jennifer presently lives in Raleigh with her husband, their son, and two cattle dogs.

ACKNOWLEDGMENTS

This project would not have been possible without the assistance of many people. First, I must thank the Southern Region Small Fruit Consortium and the North Carolina Blueberry Council for funding this project. I thank my committee advisors, Dr. Jim Ballington, Dr. Gina Fernandez, Dr. Leon Boyd, and Dr. Shyam Tallury for their time, guidance and support through this endeavor. Dr. Ballington, working for you has been an absolute pleasure. Your vast knowledge of small fruit breeding and genetics is both awe-inspiring and intimidating. Thank you for helping me to achieve my lifelong dream of attending graduate school, and for the chance to work on such an interesting and tasty project.

I need to give big thanks to Terry Bland, Kerry Olive, and Adam Bensley, for all of their help harvesting all the many cultivars and harvests for my project for two summers. Along with helping harvest through rain and shine, Kerry and Adam also graciously helped separate boxes of berries into zillions of plastic freezer bags inside a very cold freezer, for which I will be forever grateful (and for which they may never forgive me). I send huge thanks to Tim Kelly of Solo Foods in Burgaw, NC for graciously accommodating my batches of blueberries for freezing in the middle of his very busy summer days. And I must thank the people of Sanderson Farms, and Chester Barnhill of Barnhill farms for allowing me to pick Beaufort and Brightwell for my second year test.

In the Food Science department, I am grateful to Mary Anne Drake and Michele Yates for their knowledge, advice and support in all things sensory. I thank the department secretary, Beth McGlamery, for her help in sending alert emails during sensory panels. I owe a large

thank you to Jack Davis and the graduate students in the peanut processing lab for allowing me so many hours on the texture analyzer. And I thank all students, faculty and staff who participated in the many sensory panels for their time, their tongues, and their judgment.

While I sincerely thank the entire staff and faculty within the NCSU Horticulture department, there are a few names that must be mentioned specifically. First, Rachel McLaughlin, the tireless, generous, and chipper graduate secretary who always answered my frantic questions, kept my paperwork on track, and fueled my brain with chocolate. I thank Bryce Lane and Helen Krauss for their constant support, their open-door policy, and their help in recruiting undergrads for sensory panels. The wonderful women of the accounting office, Sandie Wash, Kim Eaton, Christie Gordon, and Angela Begley are all in my debt for their patience with my many queries, numerous purchase orders and receipts, and especially for their enthusiastic participation in sensory panels. I thank and heartily salute all my fellow graduate students, but Peter Dittmar, Ryan Pekarek, Lis Meyer, Steve Meyers, Cary Hebert and Ramon Molina-Bravo all get special mention for keeping me laughing.

I absolutely must thank Dr. Jason Osborne for his tremendous help with my project statistics. Without his time and expertise, I could not have made proper sense of my data.

Last but not least, I thank my family for every ounce and hour of support and encouragement they have given me. I owe my husband, Sam, many nights of fun that had to be delayed due to studying, my mother-in-law, Rebecca, for the numerous hours of babysitting she graciously supplied, my father-in-law, Alva, for all the scrumptious food, my mother, Nancy, for her unwavering belief in my abilities, and finally my son, Alistair, for instilling in me a new sense of purpose and need for completion, no matter how tired I might be.

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Introduction and Review of Literature

In the southern United States, rabbiteye blueberries (*Vaccinium virgatum* Aiton) are attractive to growers for commercial production. Native to the south, they have tolerance to upland soils, are later ripening than highbush blueberries and have a low-chilling requirement (Ballington et al., 1984). Also noted for small stem scars and improved firmness over highbush cultivars, rabbiteye blueberries can be mechanically harvested and have superior keeping quality in storage (Ballington et al., 1984; Makus and Morris, 1993). Rabbiteye blueberry fruit is later ripening than highbush blueberry fruit, and as such, the ripening season for southeastern rabbiteye overlaps with highbush fruit from more northern production regions. Considerable competition from these other areas results in lower prices, and generally at least half of the crop from rabbiteye fruit production is utilized for processed products, primarily frozen fruit. While a nice firm texture is desirable in fresh fruit, growers and producers fear that any significant increase in skin toughness following extended frozen storage could lead to a decrease in demand (Ballington, personal conversation, 2006). Furthermore, it has been observed that progressive harvests of berries appear to have increasingly tougher skins (Tim Kelly, Solo Foods blueberry processing plant manager, personal conversation, 2007).

Previous studies have looked at both berry skin and flesh for answers. The earliest studies found rabbiteye fruit skins to be “tough” and “gritty” after months in frozen storage at 0 °F and -10 °F, with quality degrading as freezing and storage temperature increased (Dekazos, 1977). Woodroof (1939, 1961) and Dekazos (1977) both pointed to elevated frozen storage

temperatures and the development of sclereids, or highly lignified cells, as causes for grittiness in the epidermis.

Woodroof (1939) concluded the grittiness of the skin of rabbiteye blueberries resulted from cell inclusions formed in epidermal and sub-epidermal cells, which start out small and enlarge over time in storage. It was also reported that cell rupture by ice crystal formation and granular cell nuclei pushed to the side of the cell were consequences of frozen storage conditions (Woodroof, 1939). Dekazos (1977) reported cell rupture and disorganization as well, and observed sclereids in the mesocarp increasing with prolonged storage times in temperatures warmer than -30° F. A study on sclereids in cultivated highbush blueberry fruit mesocarps found continuous growth of these cells through berry maturation and a positive correlation between numbers of sclereids with lateness in harvest season (Gough, 1983). Although these early studies focused on sclereids and cellular structures, none have quantified the structures for comparison.

Silva et al. (2005) reported lower water-soluble pectin and higher protopectin in rabbiteye varieties than in highbush varieties. Rabbiteye cultivars were also found to have higher amounts of neutral and acid detergent fiber (NDF, ADF), or the hemicellulose, cellulose and lignin, which contribute to the rigidity of cell walls (Silva et al., 2005; Marshall et al., 2006). These factors point towards cell wall components as responsible for firmness. However, these analyses included whole berry samples, so pectin, lignin and fiber quantities were not separated from flesh and epidermis. Silva et al. (2005) tested fresh samples of rabbiteye and highbush cultivars by puncture and compression tests, and found rabbiteye to require twice as much force to rupture the skin, again indicating differences in cell wall components, this time

specifically in the epidermis of the berry. Makus and Morris (1993) also found rabbiteye berries to be firmer than highbush after five to six months of frozen storage at -20 °C/ -4 °F, but like the Silva study, sensory panels found no significant difference in texture, other than seediness. Woodroof (1939) and Dekazos (1977) both used informal 10 person sensory panels, whereas Makus and Morris (1993) used 17 trained panelists and Silva et al., (2005) employed 10 trained panelists.

The first objective of this study was to determine by mechanical textural analysis whether there is a change in firmness of rabbiteye blueberry skins over time when frozen, and if lateness of harvest date was a factor in increasing berry skin toughness. For the second objective, sensory panels were utilized to determine whether consumers could detect any changes in firmness, toughness, or seediness over time and if they found any changes that made the berries unpalatable. This objective used large, untrained panels in contrast to smaller trained panels in past research to gain a more accurate gauge of general consumer acceptance. .

Materials and Methods

Plant Material In the first year, 2007, four rabbiteye cultivars; Premier, Tifblue, Powderblue, and Ira, one highbush cultivar; Beaufort, and one rabbiteye - highbush hybrid unnamed selection, NC 3465, were harvested at the Horticultural Crops Research Station at Castle Hayne, NC. All cultivars were picked when at least 50% of the berries were ripe. Only blue fruit was picked. A second harvest of Premier, Tifblue, and Powderblue was collected two weeks after the first harvest. All harvests underwent exactly the same

treatments in order to determine if picking date affects toughness. In the second year, 2008, the cultivars Premier, Tifblue and Powderblue were again harvested from the same plants at Castle Hayne. Beaufort was picked from Sanderson Farms near Harrells, NC, because it was no longer available at Castle Hayne, and Brightwell was picked at Chester Barnhill Farm in Rowan, NC, as a replacement for Ira. Three harvests were taken of Powderblue, Tifblue, Beaufort and Brightwell. Only two harvests of Premier were available.

A one quart plastic bag of each cultivar was kept separated on ice in an air conditioned van and transported back to North Carolina State University for fresh berry tests of soluble solids, pH, titratable acidity, and firmness. Four to six berries of each cultivar were also immediately put into a formalin-acetic acid-alcohol (FAA) mixture for later histological analysis (Johansen, 1940). The rest of the berries were then transported to Solo Foods in Burgaw, NC, where they were washed with a 30 ppm chlorine and water solution and individually quick-frozen (IQF) to approximately -30° F/ -34° C, according to industry standard. Once transported back to campus in freezing coolers, berries were separated into poly freezer bags and stored at approximately -14° F for a minimum of 3 months to a maximum of 13 months. Testing of acidity, firmness and by sensory panels occurred every three months. In the second year, an additional test was conducted in which a small sample of berries from each cultivar and harvest were separated out of the -14° F freezer at six months and stored at 6° F in a Kenmore Frostless Freezer model series 69261 (Sears, Roebuck and Co., Chicago, IL, USA) until the 13 month round of testing. Puncture and dryweight tests were performed on these groups of berries for comparison to the 13 month test at -14° F in terms of skin toughness and moisture loss.

Acid Composition Soluble solids were determined by a portable Chase Brix refractometer. 25 g of each cultivar and harvest were homogenized in a Black and Decker Handy Chopper food processor (Towson, MD, USA) for 30 seconds, and then diluted to 100 ml with deionized water. Determination of pH and titratable acidity were measured with an Orion Research model 601A digital IONALYZER (Beverly, MA, USA). Moisture content was determined by weighing 25 g of homogenized sample and drying it at 72° C for 24 hours in an ISOTEMP oven model 630G by Fisher Scientific (Hampton, NH), as determined by Silva *et al*. (2005). Drip loss was determined by 25 g of each sample immediately being weighed upon removal from the freezer then placed on paper towels to thaw at 71° F for six hours. Samples were then re-weighed. Post-thaw measurements were subtracted from pre-thaw measurements to calculate amount of leakage from each sample.

Skin Toughness & Berry Firmness Testing All cultivars were evaluated by puncture and compression tests for each harvest, similar to the protocol utilized by Silva *et al.* (2005), using a TA-XT Plus Texture Analyzer (Texture Technologies, Hamilton, MA). Puncture tests, used to measure skin toughness, utilized a 2 mm steel needle probe (TA-52) to press a berry placed on its side to the point of puncture at a rate of .833 mm per second with a 5 kg load cell. The peak force needed for the probe to puncture the berry skin measures skin toughness (Souza et al., 2003). Only the peak force of the probe entering the skin of the berry was measured as many berries split during testing after frozen storage, and not all exit punctures could be measured. Compression tests that measure fruit firmness were determined by lowering a two inch diameter, 25 mm thick steel cylinder down onto each

berry, calyx side up, until the point that the berry skin breaks. The peak force needed for berry rupture measures berry firmness. Fifteen berries per harvest per cultivar were separately measured per test. Berries were removed from the freezer and thawed for 30 minutes at 71° F before measurements were taken. Berries were measured when fresh, and at every three months for a total of 13 months.

Sensory Panels Every three months consumer sensory panels, consisting of 75 untrained participants, tasted and evaluated the berries. Panels consisted of students, staff and faculty of the Horticultural Science and Food Science Departments at NCSU in Raleigh, NC. Berries were thawed for thirty minutes before the panels began. Subjects received a tray with coded plastic sample cups, each containing three berries per sample, a plastic spoon, a napkin, and a small cup of water to rinse between samples if desired. Subjects were given a ballot sheet pre-numbered with a randomized order of the sample cup codes. After tasting each sample, subjects rated sweetness, acidity, skin firmness, seediness, as well as their liking of each, on a hedonic 9-point scale. As required by the NCSU Institutional Review Board for the Protection of Human Subjects in Research (IRB), review and approval of the project was sought on June 24, 2007, and granted on June 29, 2007.

Histological Examination Small quantities, approximately six to eight berries, were collected at every three month testing interval and fixed in a formalin-acetic acid-alcohol (FAA) mixture (Johansen, 1940). Two 5 mm square sections of epidermis were peeled off each of four berries per sample, stained with .04% aniline blue and examined under a long

pass fluorescence laser on an American Optical Vertical Fluorescence microscope model 2070 (American Optical Scientific Instrument Division, Buffalo, NY). Epidermal sclereids fluoresced yellow-green and counts were taken to determine the mean sclereids number for each sample.

Statistical Analysis This was a two year, replicated study, with a randomized incomplete block split plot design, with cultivar as whole plot factor, harvests as sub-samples, and freeze time as the split plot factor. Data were analyzed using the analysis of variance procedure (ANOVA) by way of SAS Software (SAS, 2006). Tukey's Honestly Significant Difference Test (HSD) ($P \leq 0.05$) was employed for means separation on both mechanical textural analysis, as well as sensory panel evaluations. Tukey's test was chosen for its correction for experiment-wise error rate in the face of pair-wise comparisons among means (Ott and Longnecker, 2001).

Results and Discussion

Year one (2007-2008)

Acidity, Dryweight and Drip loss Data for each sample at each testing period was taken once, rather than in triplicate. Subsequent statistical analysis was weak.

Testing of soluble solids, pH, and titratable acids all varied by cultivar. Only pH had a time effect, as the mean for pH was higher in the sixth month test across cultivars (Appendix, Table 1).

All cultivars demonstrated a loss in dryweight between fresh testing and month three of frozen storage, although Powderblue harvest two and Tifblue harvest one did not decrease as much as others (Fig. 1, Appendix, Table 2).

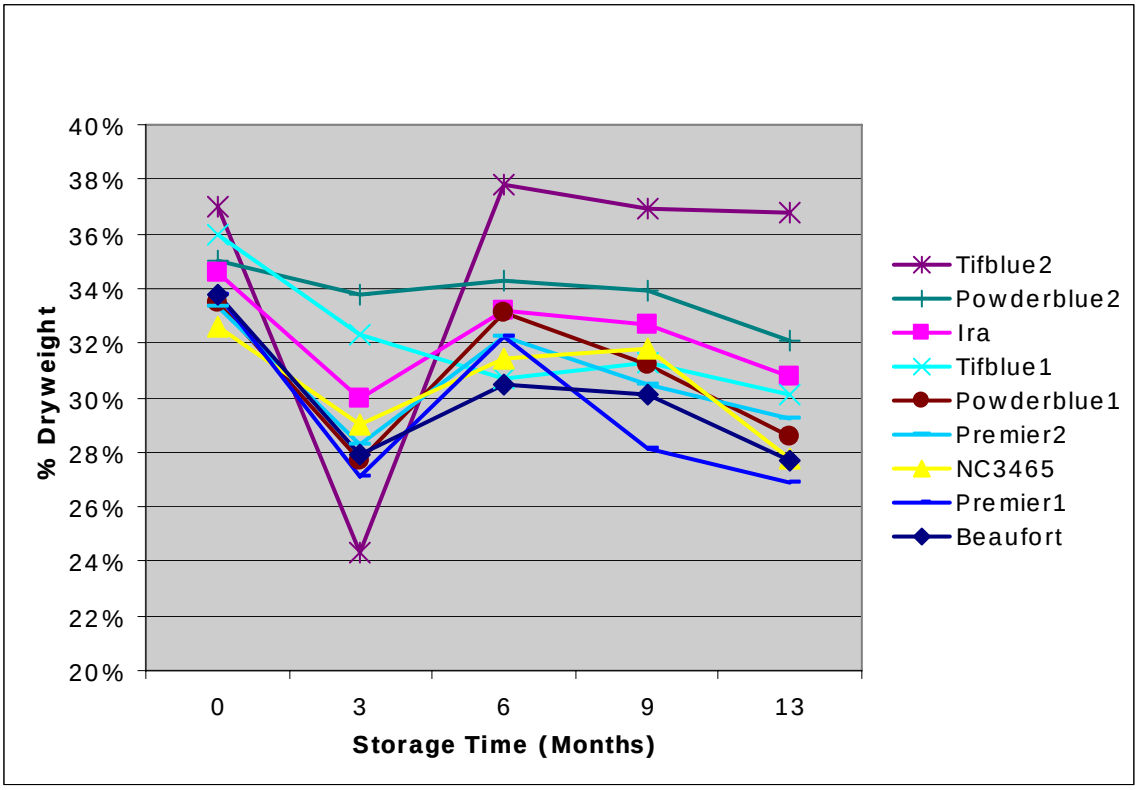

Fig. 1. Percent dryweight for year one. Fresh berry testing is denoted by 0 storage time.

However, most cultivars then rose again in dryweight measurements for month six. Cultivar effects are seen as Powderblue harvest two and Tifblue harvest one did not dip severely in the third month, and Tifblue harvest one did not follow the subsequent rise either. When fresh tests were included, there was an overall trend toward a mild decrease in dryweight over time, with the exception of Tifblue harvest two, which remained at approximately 37 % dryweight. When fresh tests were excluded, there was no trend; dry weights remained relatively constant over time in frozen storage. Beaufort, NC3465, Tifblue harvest one,

Premier harvest one, and Powderblue harvest two all had mild decreases in dryweight between 3 and 13 months storage, whereas Ira, Tifblue harvest two, Premier harvest two, and Powderblue harvest one all had increases.

Drip loss had cultivar and time effects (Fig. 2).

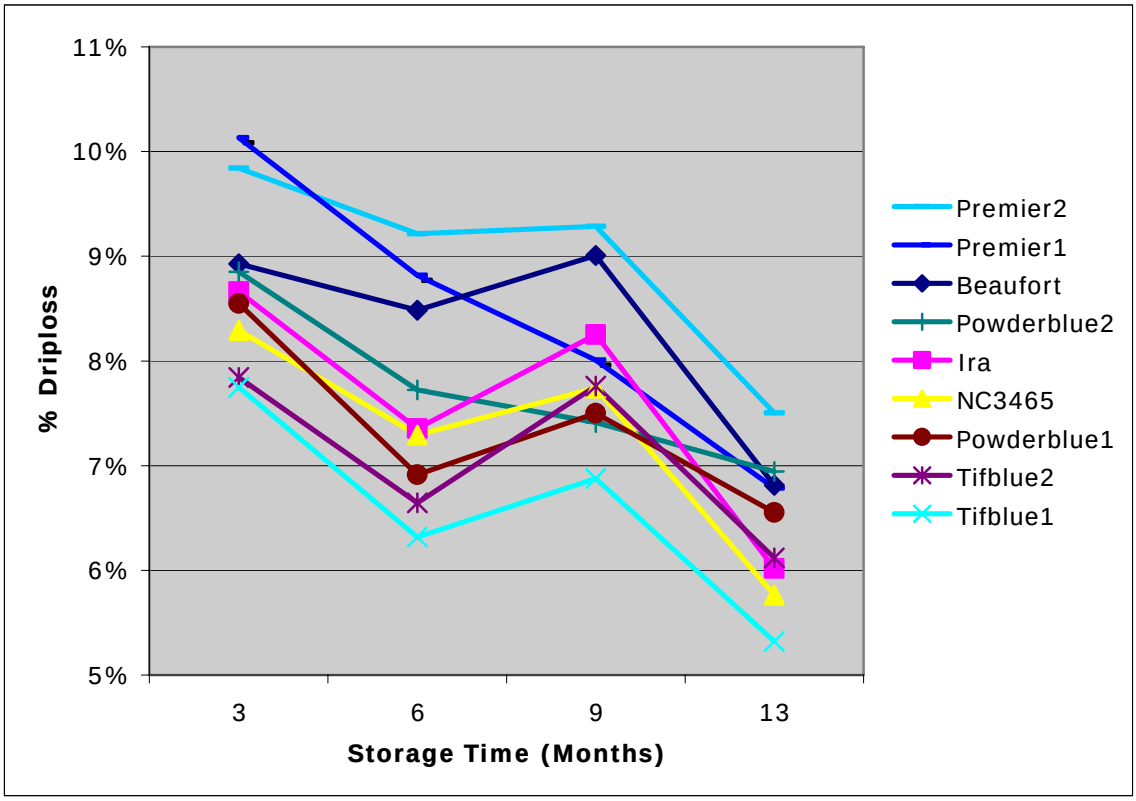

Fig. 2. Percent drip loss for year one.

The first harvest of Tifblue was consistent in having the least loss over time, while the second harvest of Premier was consistent in having the most drip loss over time. While most cultivars trended toward decreased drip loss over time, the first harvest of Premier had an almost linear decrease in drip loss across storage time (Appendix, Table 3). Powderblue harvest two also showed a continuous decrease in drip loss over time. Drip loss for Beaufort,

on the other hand, remained about the same up through month nine, and then decreased. Overall, results indicate lower amounts of moisture loss over time, which could denote increasing dehydration in storage over time. However, differences in drip loss are not easily correlated to skin toughness, as seen by the wide difference between Premier harvest two and Tifblue harvest one in drip loss, and their close proximity in skin toughness means (Table 1). Conversely, Powderblue harvest two and Beaufort had almost identical drip loss in months three and thirteen, but were widely separated in skin toughness throughout frozen storage.

Skin Toughness Puncture testing revealed cultivar and storage time to always be significant. Interaction between cultivar and time was significant only when fresh berry tests were included (Fig. 3).

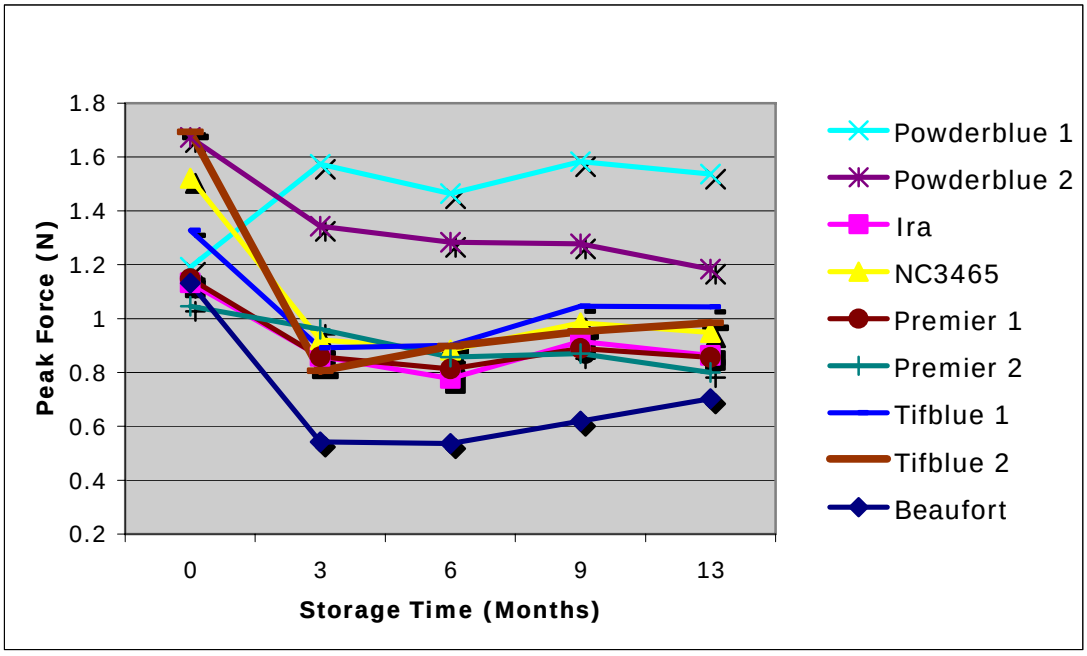

Fig. 3. Skin toughness as measured by texture analyzer in Newtons (N) for year one. Each point indicates a mean for 20 berries.

Overall, between three and 13 months, no consistent trend was found in either increasing or decreasing toughness across time. Powderblue harvest one was the only harvest to increase in toughness after being frozen. Toughness over time varied by cultivar, and also within cultivar by harvest, however, skin toughness means for both harvests of Powderblue were significantly higher than all other cultivars.

Peak force for Powderblue harvest one decreased in month six, and rose in month nine, but overall change from month three to thirteen was relatively flat. However, Powderblue harvest two decreased in skin toughness in a constant linear fashion. Like Powderblue, Premier's harvest one saw practically no change in skin toughness over the duration of frozen storage, whereas the second harvest steadily decreased in toughness over time. Both harvests of Tifblue underwent a slight increase in toughness between three and 13 months storage. Ira and NC3465 had elevated force means in the ninth month, but return down to roughly the means they had in the third month (Appendix, Table 4). Beaufort was lowest in skin toughness and showed a slight increase in toughness between months three and 13. In terms of significant separation of means, the first and second harvests of Powderblue had the highest means for skin toughness with significant differences from the other cultivars, and between themselves (Table 1). Beaufort was significantly less tough skinned than the rabbiteye cultivars, as well as the NC3465, the rabbiteye hybrid genotype. There were no significant differences among the Premier, Tifblue, Ira and NC3465 harvests.

Table 1. Texture analyzer peak force means across frozen storage in year one (3-13 months).

Cultivar	n	Skin Toughness (N)*		Berry Firmness (N)*	
Powderblue 1[y]	80	1.54	a[z]	3.71	a
Powderblue 2	80	1.27	b	2.52	b
Tifblue 1	80	.970	c	1.88	c
NC3465	80	.934	c	2.60	b
Tifblue 2	80	.902	c	1.95	c
Premier 2	80	.872	c	2.09	c
Ira	80	.854	c	1.74	c,d
Premier 1	80	.854	c	2.64	b
Beaufort	80	.599	d	1.39	d

[Y] Indicates harvest. [Z]Means separation by Tukey's HSD; p≤.05. *(N)= Newtons

Berry Firmness Like skin toughness, cultivar, time, and interaction of the two were significant factors when fresh berry tests were included. With fresh tests excluded, storage time was not significant (Fig. 4).

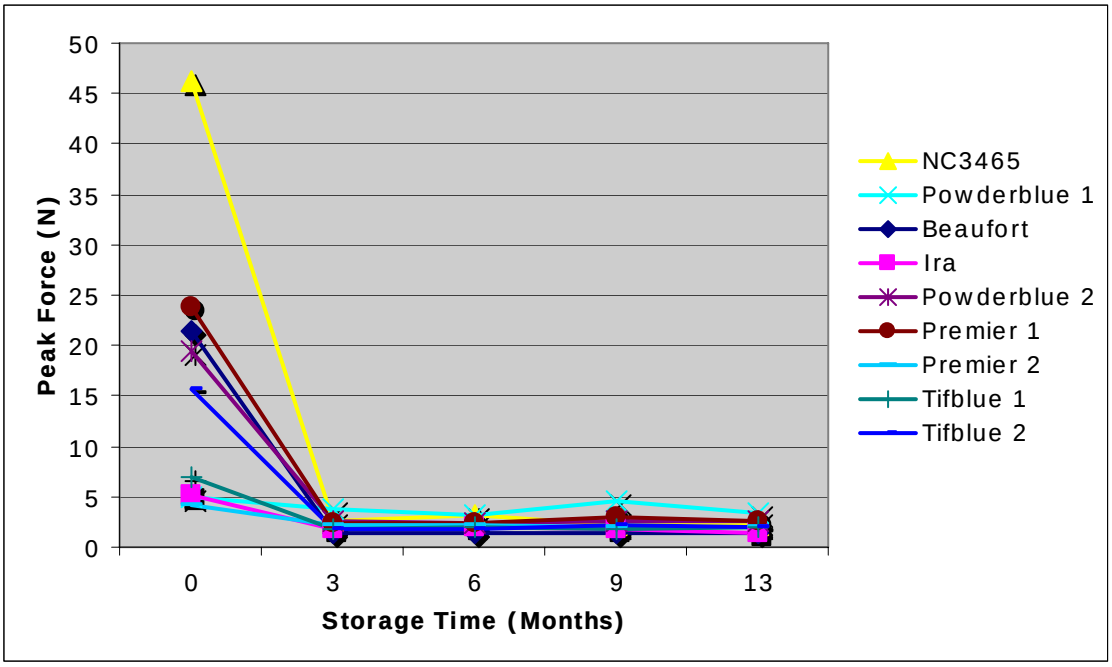

Fig. 4. Berry firmness as measured by texture analyzer in Newtons (N) in year one. Each point indicates a mean for 20 berries.

Most cultivars were significantly firmer when fresh than after freezing. Again, the first harvest of Powderblue was the exception, having had a smaller decrease in firmness between fresh berry testing and the third month test (Appendix, Table 5). The first harvest of Powderblue was significantly firmer than all other cultivars, including the second harvest of Powderblue (Table 2). Powderblue harvest two, NC3465, and Premier harvest one were significantly firmer than all other cultivars except Powderblue harvest one. The first harvest of Premier was also significantly firmer than the second harvest. The second harvest of Tifblue was slightly firmer than the first harvest, but not significantly. Beaufort was significantly less firm than the hybrid cultivar, NC3465, and all of the rabbiteye cultivars except Ira.

Sensory Testing Though all panelists were asked to rate berries for sweetness, acidity and seediness as well as skin firmness, skin firmness was the true focus for comparison to the objective texture analyzer tests. However, discussion on other sensory components will follow.

For skin firmness ratings, cultivar was a significant factor, storage time was not. Even though storage time was not significant, changes over time varied by cultivar and harvest, so there was an interaction between the two effects (Fig. 5).

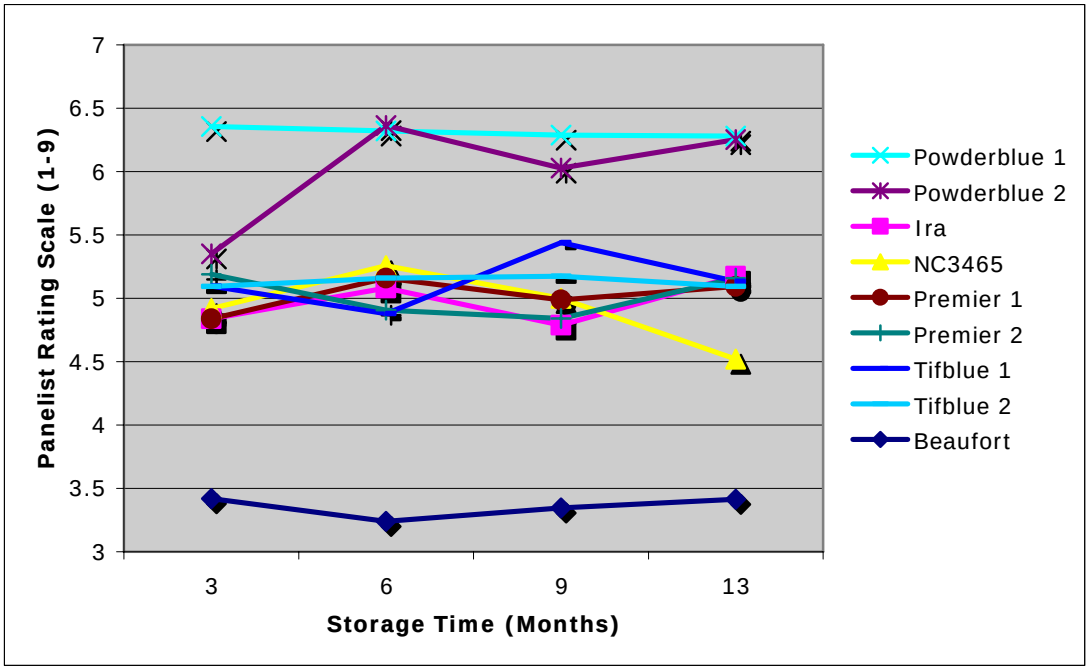

Fig.5. Sensory skin firmness ratings for year one. Each point is a rating mean of 75 participants.

For firmness, panelists were asked to rate each sample's "skin firmness/ chewiness" on a hedonic 9 point scale, one meaning not firm at all, and nine meaning too firm or very chewy. Chewiness would indicate a shift from merely firm to tough, and possibly unpalatability. In year one, both harvests one and two of Powderblue were rated significantly firmer than the other cultivars, Beaufort had the lowest mean for firmness, and there were no significant differences between the other cultivars and harvests (Table 2).

Table 2. Sensory skin firmness and liking rating for year one.

Cultivar	N	Skin Firmness		Skin Firmness Liking		Overall Texture Liking	
Powderblue1 [Y]	296	6.31	a[z]	5.04	c,d	5.22	c
Powderblue2	298	6	a	4.84	d,e	5.18	c
Tifblue1	298	5.14	b	5.44	a,b,c	5.86	a,b

Table 2. continued.

Tifblue2	299	5.13	b	5.19	b,c,d	5.43	b,c
Premier2	299	5.02	b	5.14	c,d	5.43	b,c
Premier1	299	5.02	b	5.7	a	5.87	a,b
Ira	299	4.97	b	5.1	c,d	5.2	c
NC3465	299	4.92	b	5.63	a,b	5.93	a
Beaufort	299	3.35	c	4.36	e	4.6	d

[Y] Indicates harvest. [Z]Means separation by Tukey's HSD; p≤.05.

When asked to rate their liking of a berry's firmness, panelists rated Beaufort as significantly lower than all other cultivars and harvests, except Powderblue harvest two (Table 2). Premier harvest one rated the highest for firmness liking, significantly higher than all other cultivars except NC3465 and Tifblue harvest one. Powderblue harvests one and two were rated fairly average in firmness liking, not differing much from Tifblue harvests one and two, Premier harvest two and Ira. Premier harvest one ranked higher than most other cultivars, except Tifblue harvest one and NC3465. As a check to verify firmness liking ratings, panelists were asked to rate overall texture. Whereas the firmness question focused on the fruit skin, overall texture was open-ended and may have encouraged consumers to include judgments about berry flesh. The results for firmness liking and overall texture were fairly consistent. Again, Beaufort ranked significantly lower in liking than all other cultivars, and Ira, Powderblue harvests one and two, and harvest two of both Premier and Tifblue rated low, just above Beaufort. NC3465 was significantly higher than all other cultivars except Premier harvest one and Tifblue harvest one for overall texture liking. Panelists found the firmest skinned berries (Powderblue) unfavorable, but they liked the berry with the least firmness (Beaufort) even less. Furthermore, while the first harvest of Powderblue was determined to have firmer skins, panelists also gave it a higher rating for liking than the

second harvest, which may denote that a certain level of firmness is required for liking. However, Premier harvest one, and especially NC3465, were low in skin firmness rating, but rated high on liking and overall texture. Thus, if there is a required firmness threshold for consumer liking, it may not be very high.

Sweetness ratings varied among cultivars and harvests, but storage time and interaction between time and cultivar were not significant. Sweetness liking was very similar, with significant cultivar effects, but also had a time effect, as means for liking elevated slightly in the ninth month (Appendix, Table 6). Panelists were asked to rate sample sweetness from 1 to 9, one being not sweet at all, to nine being extremely sweet. Ratings for berry sweetness and sweetness liking were very similar (Table 3).

Table 3. Sensory sweetness and liking ratings, year one.

Cultivar	N	Sweetness		Sweetness Liking	
Premier 2[Y]	299	5.71	a[z]	6.06	a
Tifblue 2	298	5.54	a	6.02	a
Tifblue 1	298	5.51	a	5.95	a,b
Beaufort	299	5.27	a,b	5.51	b,c
NC3465	298	5.03	b,c	5.40	c
Premier 1	299	5.02	b,c	5.49	b,c
Ira	298	4.64	c,d	5.16	c,d
Powderblue 2	298	4.37	d,e	4.84	d,e
Powderblue 1	298	4.07	e	4.55	e

[Y] Indicates harvest. [z] Means separation by Tukey's HSD; $p \leq .05$.

Premier harvest two and Tifblue harvests one and two were rated significantly higher than all other cultivars and harvests except Beaufort for sweetness. The two Powderblue harvests had the lowest ratings for sweetness and sweetness liking, with Powderblue harvest one

significantly lower than all other cultivars except Powderblue harvest two. Premier harvest two and Tifblue harvest two were rated significantly higher than all other cultivars and harvests for sweetness liking except Tifblue harvest one.

Acidity had significant cultivar and time effects, as means for acidity peaked at six months for Beaufort, Ira, Premier harvest two and Tifblue harvest two (Appendix, Table 7). Acidity peaked for NC 3465, Powderblue harvest two and the first harvest of Premier in month 13. Only Tifblue harvest one had highest acidity in month nine. No treatments had their highest acid rating in the third month. Since peak means for acidity were split between six and 13 months, no trend in increasing or decreasing acidity was seen over time. Only Premier saw a small, steady increase in acidity ratings over time.

Acidity liking also had a significant time effect. Mean panelist ratings for acidity liking peaked in month nine for all treatments except NC3465, Powderblue harvest two, and Tifblue harvest one. In the case of NC3465 and Powderblue harvest two, both of these treatments had their highest rating for liking in the third month, then had fairly sizeable dips in liking in month six, and then saw a rise again in month nine, after which liking for the two dipped again (Appendix, Table 8).

Overall, sensory ratings for acidity and acidity liking were negatively correlated. The more acidic the berry was judged to be, the lower the panelist tended to rate their liking of it (Table 4).

Table 4. Sensory acidity and liking ratings, year one.

Cultivar	N	Acidity		Acidity Liking	
Powderblue 1[Y]	297	5.36	a[z]	4.66	d
Powderblue 2	298	5.08	a,b	5.20	b,c
Ira	298	5.07	a,b	5.09	c,d
Premier 1	298	4.91	a,b	5.50	a,b,c
Tifblue 1	298	4.73	b,c	5.77	a
Tifblue 2	298	4.29	c,d	5.82	a
NC3465	298	4.27	c,d	5.44	a,b,c
Beaufort	298	4.00	d,e	5.43	a,b,c
Premier 2	298	3.77	e	5.61	a,b

[Y]Indicates harvest. [z]Means separation by Tukey's HSD; $p \leq .05$.

Powderblue harvest one was rated as the most acidic, significantly more acidic than all cultivars and harvests except Powderblue harvest two, Ira and Premier harvest one. Powderblue harvest one was significantly lower than all other cultivars and harvests for liking except Ira. Premier harvest two rated lowest in acidity, significantly lower than all other cultivars except Beaufort. Premier harvest two was rated high for acidity liking and was only significantly different from Ira and Powderblue harvest one. The one exception to the negative correlation between ratings for acidity and acidity liking was Premier one, which was not significantly different from Powderblue one in acidity rating, however it was also not significantly different from the highest rated harvests for acidity liking; Tifblue one and two. This indicates that the sensory threshold for acceptable acidity level may be fairly high, relative to the range of scores.

Like other attributes, for seediness, panelists were asked to rate each treatment on a scale of 1 to 9, one meaning no seeds at all, and 9 meaning too many seeds. The ratings indicated

significant cultivar and time effects. The time effect was due to NC3465, which had a significant peak (3.81) in rating for seediness in month six, although ratings in months nine and thirteen returned to a lower, more stable level (Appendix, Table 9).

Seediness liking also had a significant time and cultivar effects. The time effect was due to Beaufort having a significantly elevated rating in month nine, while all other treatments remained stable over time (Appendix, Table 10).

Like acidity, seediness and seediness liking were also negatively correlated (Table 5).

Table 5. Sensory seediness and liking ratings, year one.

Cultivar	N	Seediness		Seediness Liking	
Ira	299	4.95	a[z]	5.16	d,e
Powderblue 2[Y]	297	4.75	a,b	5.21	d,e
Powderblue 1	297	4.75	a,b	5.13	e
Premier 1	297	4.46	b,c	5.59	c,d
Premier 2	299	4.31	c,d	5.72	c
Tifblue 1	298	4.08	c,d	5.89	c
Tifblue 2	298	3.98	d	5.96	b,c
NC3465	298	3.35	e	6.42	a
Beaufort	299	3.03	e	6.34	a,b

[Y] Indicates harvest. [z] Means separation by Tukey's HSD; $p \leq .05$.

Ira rated highest in seediness, though not significantly higher than Powderblue harvests one and two. NC3465 and Beaufort were rated the least seedy by a significant margin. NC3465 was significantly higher than all other cultivars and harvests except Beaufort for seediness liking. Powderblue harvest one was rated significantly lower than all cultivars except Ira and Powderblue harvest two for seediness liking. As a pentaploid, it was expected that NC3465

would have reduced seed numbers (Galletta and Ballington, 1996), and Beaufort is a southern highbush cultivar, which typically have smaller seeds than rabbiteye.

Overall liking had no time effect, only cultivar effects. Both harvests of Tifblue top the list for overall liking ratings, however, they were not significantly higher than both harvests of Premier (Table 6).

Table 6. Sensory overall liking ratings, year one

Cultivar	N	Overall Liking	
Tifblue 1 [Y]	298	5.93	a [z]
Tifblue 2	297	5.89	a,b
Premier 2	293	5.70	a,b
Premier 1	295	5.53	a,b,c
NC3465	297	5.46	b,c
Ira	295	5.18	c,d
Beaufort	293	5.08	c,d,e
Powderblue 2	297	4.99	d,e
Powderblue 1	293	4.66	e

[Y] Indicates harvest. [z] Means separation by Tukey's HSD; $p \leq .05$.

Tifblue harvests one and two, along with Premier harvest two were significantly higher in overall liking than Ira, Beaufort and both harvests of Powderblue. Only Tifblue harvest one was rated significantly higher than NC3465 for overall liking. The first harvest of Powderblue, which was lowest in sweetness and sweetness liking, highest in acidity and lowest in acidity liking, and highest in firmness, had the lowest sensory rating for overall liking. There were no significant differences between Tifblue and Premier, or between

harvests within the two cultivars. There was also no significant difference between the two harvests of Powderblue.

Year two, (2008-2009).

Acidity, Dryweight and Drip loss Data for each sample at each testing period was taken once, rather than in triplicate. Subsequent statistical analysis was weak.

Soluble solids, pH, and titratable acidity had cultivar effects. Beaufort had a significantly higher pH than other cultivars across time (Appendix, Table 11).

*Note: As with year one acid testing, statistics were weak due to lack of proper replication.

Second year dryweight had cultivar and time effects (Fig. 6).

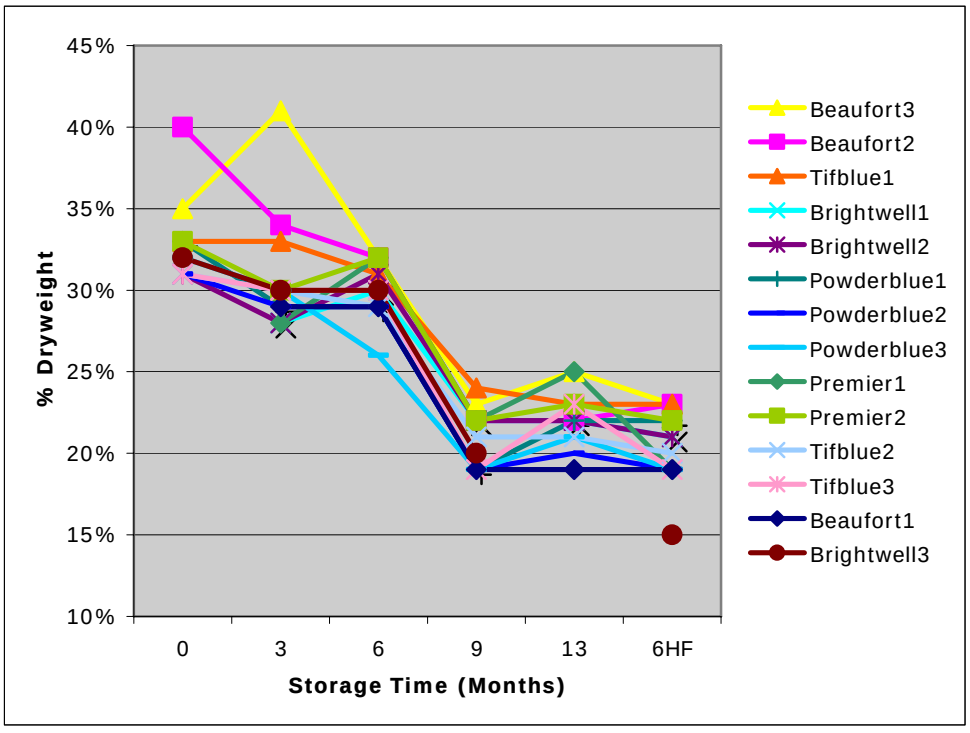

Fig. 6. Percent dryweight for year two. Fresh measurements denoted by 0 time storage. Measurement of samples switched to 6° F, denoted by 6HF.

Unlike year one, where dryweight stayed fairly constant across time, in year two there was a significant drop in dryweight between six and nine months, after which dryweights leveled off (Appendix, Table 12). No significant change is seen between the 13 month test and the samples held at 6° F (6 HF), except for the third harvest of Brightwell, for which there was no data at 13 months, due to shortage of sample. The loss in dryweight between fresh and three months of frozen storage was less in the second year for most cultivars than in the first year. There were minimal differences of dryweight among cultivars after six months of frozen storage in year two. Unlike year one in which dryweight ranged between 27 percent and 32 percent after 13 months storage, cultivars in year two were more tightly grouped and generally lower in dryweight between 20 percent and 25 percent.

Drip loss in the second year had significant cultivar effects, time effects and an interaction between the two. Time effect and interaction were primarily due to month nine (Fig. 7). While most treatments had a significant increase in month nine, Beaufort harvest three, and Powderblue harvest one, and Brightwell harvest two and three decreased (Appendix, Table 13).

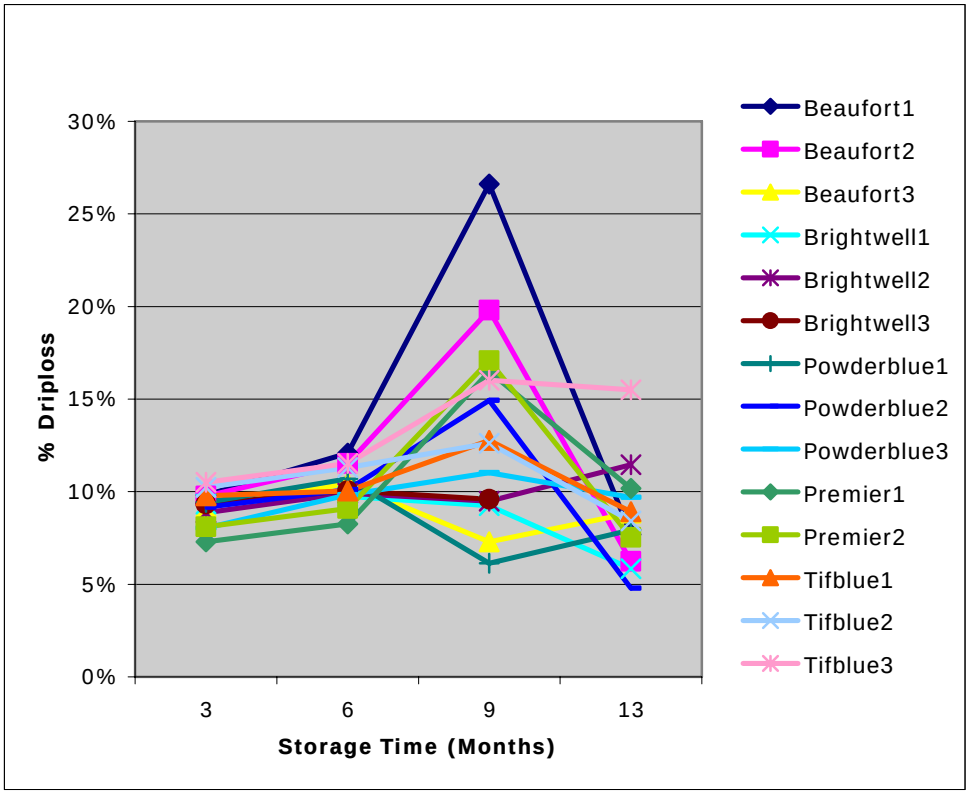

Fig. 7. Percent drip loss for year two.

Most cultivars, with the exception of Tifblue harvest three, return to a percentage in month thirteen that is close to that of month six, the steep increase and wide variability seen in month nine is most likely an anomaly due to an external factor. In contrast to year one, reduced drip loss in not apparent in year two. Overall, mean drip loss for all cultivars was slightly more elevated in year two than in year one.

Histological Examination

Preliminary investigation of Powderblue and Beaufort from year one found differences in numbers of sclereids in fruit epidermal cells to suggest a trend that followed puncture tests

for skin toughness, as Beaufort and NC3465 had very few epidermal sclereids and Powderblue harvests one and two had very large quantities (Table 7).

Table 7. Blueberry epidermal sclereid count.

Cultivar	Fresh	3 mo	9mo	6HF
Powderblue 1 (2007)	668	559	550	
Powderblue 2 (2007)	443	668	561	
Beaufort (2007)	30	53	55	
NC3465 (2007)	19	25	55	
Brightwell 1 (2008)		30	25	32
Brightwell 2 (2008)	39	30	30	30

However, further inquiry in year two on Brightwell showed that the correlation between sclereid count and skin toughness was weak, as Brightwell had the highest force means for skin toughness, but a very low sclereid count. Observed differences in epidermal sclereid counts did uphold significance of cultivar effects. Further investigation may also show greater sclereid numbers over storage time in some cultivars, as suggested by a slight increase in Beaufort and NC3465.

Skin Toughness In the second year, a mini experiment was included in which a small sample of all cultivars were removed from the -14° F freezer at six months and stored at 6° F for approximately seven more months, when they were tested along with the other 13 month tests for skin toughness.

As in the first year, the change in skin toughness from fresh to frozen is significant, as was the difference between the standard 13 month storage and the mini test, denoted by 6HF (Fig. 8).

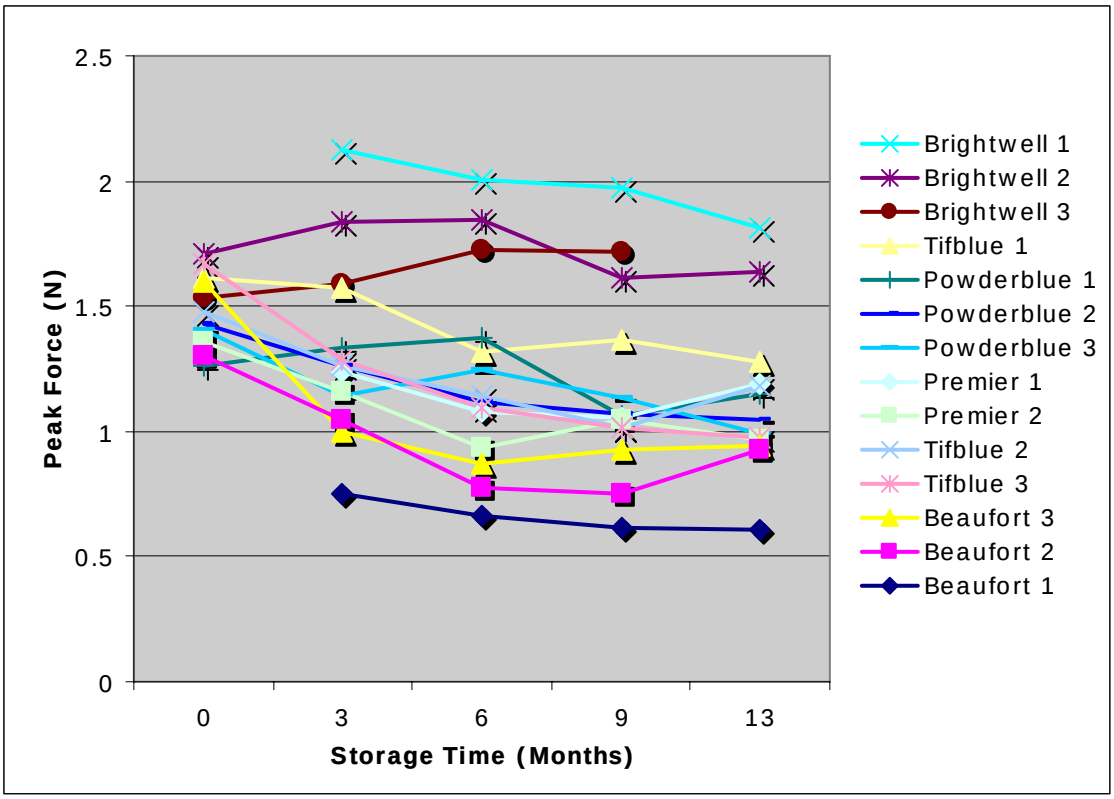

Fig. 8. Skin toughness as measured by texture analyzer in Newtons (N) over time in year two.

Puncture testing for skin toughness had significant time, and cultivar effects, regardless of whether fresh tests were included. There was no data for fresh skin toughness for the first harvests of Beaufort, Brightwell and Premier. As in year one, most cultivars exhibited a decrease in firmness after freezing, with the exception of Brightwell harvest two and three, and Powderblue harvest one. In this respect, harvest one of Powderblue was consistent with the change from fresh to frozen in year one, though the second year's increase in skin toughness after freezing was less steep than the first year.

When fresh berry tests were excluded, there was no longer a significant interaction between time and treatment. Cultivar was significant, and time was significant due to a slight trend of

decreasing skin toughness over time in year two, as most cultivars had their highest mean in the first testing at three months of storage (Appendix, Table 14).

Only Brightwell, which was included in year two to replace Ira, had significantly tougher skins than all other cultivars, and the first harvest of Brightwell was significantly tougher than the second and the third harvest (Table 8).

Table 8. Texture analyzer peak force means across frozen storage, year two.

Cultivar	N	Skin Toughness Months 3-13		Skin Toughness at 6HF		Berry Firmness	
Brightwell 1 [Y]	60	1.98*	a[z]	2.14	a,b	7.94	a
Brightwell 2	60	1.73	b	1.82	a,b,c	5.15	b
Brightwell 3	60	1.68	b	2.20	a,b	4.08	b,c
Tifblue 1	60	1.38	c	2.38	a,b	3.62	c
Powderblue 1	60	1.23	c,d	2.41	a	2.47	d
Tifblue 2	60	1.15	d,e	2.27	a,b	2.36	d
Premier 1	60	1.14	d,e	1.80	b,c	4.56	b,c
Powderblue 3	60	1.13	d,e	2.16	a,b	2.01	d
Powderblue 2	60	1.12	d,e	1.99	a,b	2.1	d
Tifblue 3	60	1.09	d,e,f	2.01	a,b	1.81	d
Premier 2	60	1.03	d,e,f	1.91	a,b,c	2.19	d
Beaufort 3	60	0.94	e,f	1.89	a,b,c	1.89	d
Beaufort 2	60	0.88	f,g	1.36	c,d	2.15	d
Beaufort 1	60	0.66	g	1.05	d	1.55	d

[Y] Indicates harvest. [z]Means separation by Tukey's HSD; p≤.05. *Means measured in Newtons.

Within cultivars replicated from year one, Beaufort again had the lowest mean peak force in than the rabbiteye genotypes. The first harvest of Tifblue tested significantly higher in force required than the second and third harvest. There was no significant difference in skin toughness between the two harvests of Premier. Peak force means for Powderblue in the second year were not significantly different from Premier or Tifblue, and within the cultivar,

no individual harvest was significantly tougher than another. Only Beaufort, all harvests of which had the lowest mean peak force of year two, had a pattern in which the third harvest tested significantly tougher than the first. Since only one harvest of Beaufort was picked in the first year, these results were not replicated. Furthermore, since the second year Beaufort was picked from a different location than the first, differing environmental and nutritional elements may have been a factor.

The second column of Table 8 includes a means separation for the 6° F test (6HF). Most cultivars underwent a critical jump in skin toughness during the test at 6° F (6HF). Although Brightwell harvest one had the toughest skins across all the months of storage at -14 °F, Powderblue harvest one had the highest mean for skin toughness at 6° F. Beaufort harvest one was significantly lower in skin toughness than all other cultivars and harvests except Beaufort harvest two. While our findings dispute Dekazos (1977) and Woodroof (1961) in terms of increasing toughness due to temperatures generally above -30° F, this test indicated that there was a critical temperature threshold.

Berry Firmness In year two, cultivar, time, and interaction between cultivar and time were all significant. As in year one, all cultivars tested much firmer while fresh than after freezing. When fresh tests were excluded, the time effect was due to most monthly means across cultivars being highest in the third month test and decreasing from there. The interaction was significant because Brightwell harvest three and Beaufort harvest two increased in firmness after month three, as most others decreased in firmness (Fig. 9, Appendix, Table 15).

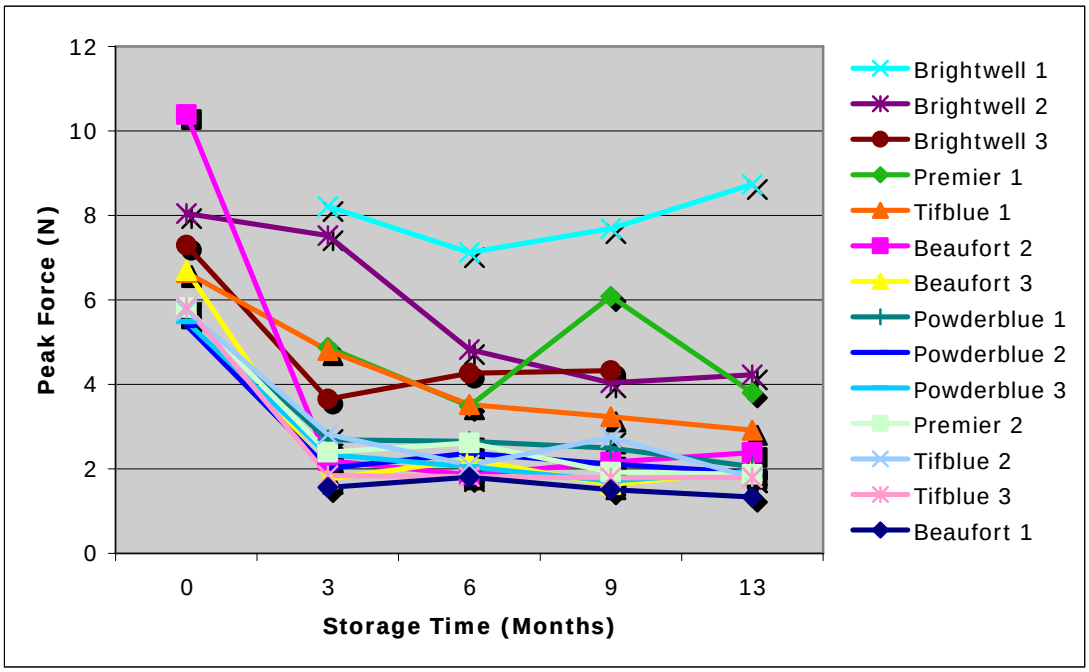

Fig. 9. Berry Firmness as measured in Newtons (N) for year two.

There was very little change in firmness between three and 13 months of frozen storage across cultivars in both years. Brightwell harvest one was significantly firmer than all others (Table 8). Brightwell harvest two was significantly firmer than all remaining cultivars except Brightwell harvest three and Premier harvest one. In turn, Brightwell harvest three and Premier harvest one were significantly firmer than all other remaining cultivars and harvests except Tifblue harvest one. Like Brightwell, Premier and Tifblue also had first harvests that tested firmer than the second harvests. Only Beaufort broke this trend, with the second and third harvests testing firmer than the first. There were no significant differences among the remainder of the harvests.

In contrast to Powderblue measuring as most firm in year one, all Powderblue harvests were only average for firmness in year two. Similar to year one when Beaufort was significantly less firm than all other cultivars except Ira, in year two, all three harvests of Beaufort measured as least firm, though only significantly less firm than the three harvests of Brightwell and the first harvest of Premier and Tifblue.

Results for whether skin toughness or berry firmness may be related to first harvest were mixed. In year one, the first harvest of Powderblue had significantly higher means for skin toughness and berry firmness, and the first harvest of Premier was significantly higher in berry firmness than the second harvest. Tifblue had no significant differences between harvests. Second year results indicated no differences in skin or berry toughness between harvests of Powderblue, Tifblue harvest one was found to have higher berry firmness than later harvests, and the first harvest of Premier was again found to have significantly firmer fruit than the later harvest. Brightwell's first harvest was significantly tougher than the later harvests in both skin toughness and berry firmness, but the cultivar was not replicated in both years. However, Beaufort, the one highbush cultivar included, was found to have significantly tougher skins in the third harvest than the first harvest, but the test was not replicated.

Sensory Panels Sensory tests in year two did not include the third harvest from Beaufort, Brightwell, Powderblue and Tifblue in order to keep sample sizes small enough to avoid panelist fatigue. Like year one, sensory panel skin firmness tests in year two had significant

cultivar effects. Time had a very slight effect due to the second harvest of Tifblue having a lower mean in the third month testing (Appendix, Table 16).

In sensory skin firmness, panelists rated Beaufort harvest one to be the least firm. Brightwell harvest one was rated significantly firmer than all other cultivars, including Brightwell harvest two, which placed just below it (Table 9).

Table 9. Sensory skin firmness and liking rating for year two.

Cultivar	N	Skin Firmness		Skin Firmness Liking		Overall Texture Liking	
Brightwell 1[Y]	193	7.80	a[z]	2.88	f	2.85	g
Brightwell 2	193	7.12	b	3.83	e	4.07	f
Premier 1	193	5.78	c	4.69	d	4.83	e
Tifblue 1	193	5.68	c	4.95	c,d	5.02	d,e
Powderblue 1	193	5.49	c,d	5.34	b,c	5.59	b,c,d
Powderblue 2	193	5.10	d,e	5.56	a,b	5.60	b,c,d
Beaufort 2	193	4.94	e	6.06	a	6.32	a
Tifblue 2	193	4.91	e	5.16	b,c,d	5.22	c,d,e
Premier 2	193	4.79	e	5.27	b,c,d	5.66	b,c
Beaufort 1	192	4.22	f	5.70	a,b	6.02	a,b

[Y] Indicates harvest. [z] Means separation by Tukey's HSD; $p \leq .05$.

Unlike the first year, the first harvests of both Tifblue and Premier rate significantly firmer than their second harvests. Sensory firmness rating for Powderblue in year two were average to below average in contrast to year one, and there were no significant differences between harvests one and two for skin firmness ratings in year two. There were no significant differences between the first harvests of Powderblue, Premier and Tifblue. Likewise, there were no significant differences between the second harvests of Powderblue, Premier and Tifblue. Beaufort harvest one was rated significantly less firm than all other cultivars including Beaufort harvest two.

Skin firmness liking and overall texture liking were very consistent. As in year one, sensory ratings for firmness and firmness liking were generally negatively correlated. Unlike year one, Beaufort rated near the top in firmness liking and overall texture liking. Beaufort harvest two was significantly higher in firmness liking than most other cultivars and harvests except Beaufort harvest one and Powderblue harvest one. Beaufort harvest two was rated significantly higher than all other harvests except Beaufort harvest one for overall texture liking. Both Powderblue harvests were significantly higher than Premier harvest one for firmness liking and overall texture liking. Powderblue harvest two was rated significantly higher than Tifblue harvest one for firmness liking. There were no significant differences between Premier and Tifblue or between harvests for either of these for firmness liking. The Brightwell harvests were rated significantly lower than all other harvests for firmness liking and overall texture liking, and within Brightwell the first harvest was liked significantly less than the second for these traits. There were no significant differences in firmness liking ratings between Powderblue harvest one and Tifblue harvest one, or between both Powderblue harvests, Premier harvest two, Tifblue harvest two and Beaufort harvest one. The second harvest of Premier was rated significantly higher than the first as well as Tifblue harvest one for overall texture liking. There were no significant differences between the Powderblue and Tifblue harvests or between any of these and Premier harvest two for overall texture liking in year two.

Both sensory sweetness and sweetness liking ratings had significant cultivar effects, but did not have significant time or interaction effects. Sweetness and sweetness liking were almost identical in ratings. Beaufort harvest two was rated significantly higher than all other

cultivars in both (Table 10). Premier harvest two, while rated significantly lower than Beaufort harvest two, was significantly higher than all other cultivars except Beaufort harvest one and Brightwell harvest two for sweetness, and all except these two plus Powderblue harvest two for sweetness liking. Brightwell harvest one rated as significantly least sweet and least liked.

Table 10. Sensory sweetness and liking ratings, year two.

Cultivar	N	Sweetness		Sweetness Liking	
Beaufort 2[Y]	193	6.42	a[z]	6.35	a
Premier 2	193	5.58	b	5.68	b
Beaufort 1	193	5.35	b,c	5.64	b
Brightwell 2	193	5.34	b,c	5.54	b,c
Powderblue 2	193	4.89	c,d	5.41	b,c
Tifblue 1	193	4.82	c,d	4.97	c,d
Premier 1	193	4.78	c,d	4.76	d,e
Tifblue 2	193	4.67	c,d	5.03	c,d
Powderblue 1	193	4.49	c,d	4.97	c,d
Brightwell 1	193	4.17	e	4.26	e

[Y] Indicates harvest. [z] Means separation by Tukey's HSD; $p \leq .05$.

Sensory acidity rating did have significant time and cultivar effects, but no significant interaction.

Time was significant for acidity as all cultivars, with the exception of the second harvests of Brightwell and Powderblue, had highest means in month three. Even if the decrease in acidity was not perfectly linear, all cultivars were judged as having minor decreases in acidity over time (Appendix, Table 17). Ratings for acidity liking also had a time effect, and

though it was not significant at the p≤ .05 level, there was a trend. Most cultivars had highest rating means for the thirteenth month panel, with the exception of Powderblue harvest one and the two harvests of Tifblue, both of which had highest liking means in the sixth month (Appendix, Table 18).

The two harvests of Tifblue and Powderblue were rated significantly more acidic than all other harvests except Brightwell harvest one (Table 11).

Table 11. Sensory acidity and liking ratings, year two.

Cultivar	N	Acidity		Acidity Liking	
Tifblue 2[Y]	193	4.98	a[z]	5.02	c,d
Powderblue 1	193	4.97	a	5.34	b,c,d
Tifblue 1	193	4.96	a	4.92	c,d
Powderblue 2	193	4.93	a	5.42	b,c
Brightwell 1	193	4.49	a,b	4.78	d
Beaufort 1	193	4.35	b,c,d	5.60	a,b
Premier 1	193	4.22	b,c	4.96	c,d
Premier 2	193	3.86	d,e	5.39	b,c
Brightwell 2	193	3.61	e	5.41	b,c
Beaufort 2	193	3.52	e	6.11	a

[Y]Indicates harvest. [z]Means separation by Tukey's HSD; p≤.05.

The second harvests of Brightwell and Beaufort were rated significantly lower in acidity than all other harvests except Premier two. The second harvest of Beaufort was significantly higher than all other cultivars except for Beaufort one for acidity. The first harvest of Brightwell was rated lowest for acidity liking; however it was not significantly lower than both Tifblue harvests, Premier harvest one or Powderblue harvest one. While there was no significant difference between the two harvests of Tifblue and Powderblue for acidity or

acidity liking, there were significant differences for the two harvests of Brightwell and Beaufort for both. There were significant differences among the Premier treatments for acidity ratings, but not for acidity liking. Brightwell harvest one rated high in acidity and low in liking, while harvest two was relatively low in acidity and average for liking. Beaufort harvest one rated as having significantly higher acid than the second harvest, but both were rated high for acidity liking.

Panelist rating for seediness did not have any significant time effects, but ratings for liking of seediness did. Time was significant as the highest means for seediness liking for every harvest were received in the last panel (Appendix, Table 19). Increases in liking were minimal, and only linear for the first harvests of Beaufort, Powderblue and Premier. Like the first year, seediness and liking were negatively correlated (Table 12).

Table 12. Sensory seediness and liking ratings, year two.

Cultivar	N	Seediness		Seediness Liking	
Brightwell 1[Y]	192	5.51	a[z]	4.15	d
Brightwell 2	191	4.98	a,b	4.99	c
Tifblue 1	192	4.72	b,c	5.24	b,c
Premier 1	192	4.69	b,c,d	5.28	b,c
Powderblue 1	193	4.49	b,c,d	5.53	b,c
Powderblue 2	193	4.47	b,c,d	5.57	b
Tifblue 2	193	4.30	c,d	5.65	b
Premier 2	193	4.16	d	5.69	b
Beaufort 1	192	3.56	e	6.29	a
Beaufort 2	193	3.24	e	6.65	a

[Y] Indicates harvest. [z] Means separation by Tukey's HSD; $p \leq .05$.

Brightwell harvest one was rated significantly seedier than all other harvests, except Brightwell harvest two. The first harvest of Brightwell rated significantly lower than all other cultivars and harvests for seediness liking. The two harvests of Beaufort were rated significantly less seedy than all other harvests and significantly higher than all other harvests for seediness liking. There were no differences between the ratings for the two harvests of Powderblue, Premier or Tifblue for either seediness or seediness liking. Premier harvest two was rated significantly less seedy than Tifblue harvest one, as well as both harvests of Brightwell, but was not significantly different from Tifblue harvest one in seediness liking. Ratings for overall liking had a significant time effect. Cultivars were split between having highest means for overall liking in the sixth month and the thirteenth month (Appendix, Table 20). Beaufort harvest two had the highest mean, but not significantly higher than Beaufort harvest one and Powderblue harvest two (Table 13). Brightwell harvest one was rated significantly lower than all other cultivars and harvests for overall liking.

Table 13. Sensory ratings for overall liking, year two.

Cultivar	N	Overall Liking	
Beaufort 2[Y]	188	6.11	a[z]
Beaufort 1	191	5.59	a,b
Powderblue 2	191	5.52	a,b
Premier 2	188	5.52	b
Powderblue 1	187	5.30	b,c
Tifblue 2	191	5.02	b,c,d
Brightwell 2	188	4.83	c,d
Tifblue 1	190	4.78	c,d
Premier 1	187	4.55	d
Brightwell 1	187	3.24	e

[Y] Indicates harvest. [z] Means separation by Tukey's HSD; $p \leq .05$.

Rating cultivars for overall liking served as a good summary. Beaufort harvest two was rated highest in liking for overall texture, sweetness, acidity, firmness and seediness, and overall liking. Brightwell harvest one had the lowest scores for liking in overall texture, sweetness, acidity, firmness and seediness. Brightwell harvest one was rated significantly lower in rating than Brightwell harvest two. Premier's first harvest was also significantly lower in overall liking than the second harvest. There was no difference between the two harvests of Tifblue, Powderblue or Beaufort. Premier's first harvest often ranked closely to Brightwell's first harvest; low in liking for sweetness, acidity, firmness and overall texture, while the second harvest of Premier tended to have higher means for these attributes. While Premier harvest two had higher means than Premier harvest one for liking for most attributes in the first year as well, Premier harvest one had higher average means for most attributes in the first year, and was well liked for firmness and overall texture. Thus, it could be concluded that the first harvest of Premier was not fully ripe when harvested in the second year. The first harvest of Brightwell may have suffered for the same reason, though its proximity to the second harvest in all firmness ratings, as well as its proximity to both of its later harvests in puncture and compression tests over time indicates that this cultivar tends to have tougher skins no matter the ripeness or lateness in harvest.

Conclusions

In contrast to dryweight remaining relatively stable over time in frozen storage in year one, in year two there was a steep drop in dryweight between six and nine months of frozen storage,

followed by leveling off. In year two there was little difference in dryweight between 13 months in frozen storage at -14°F and frozen storage from six to 13 months at 6°F.

In year one, results indicated reduced drip loss over time in frozen storage, which suggested increasing dehydration over the 13 month frozen storage period. Reduced drip loss was not apparent over time in year two. In contrast to year one, drip loss increased slightly between three and six months of frozen storage in year two. Mean drip loss across cultivars was slightly more elevated in year two than in year one.

Sclereid numbers in epidermal cells did not correlate positively with objective skin toughness determinations.

In skin toughness puncture tests, there were time and cultivar effects in both years, though the profiles over time varied. There was no consistent trend in either increasing or decreasing objectively determined skin toughness across cultivars. In both years, most cultivars measured as having much tougher skins when fresh than after being frozen, though the difference was less severe in year two. Most cultivars underwent a significant increase in toughness when transferred from -14°F to 6°F from months six through 13 in year two. These experiments did not find increasing toughness with prolonged storage at -14°F, which disputes the findings of Dekazos (1977) and Woodroof (1961) who indicated that this would occur at any storage temperature above -30°F, however; storage results at 6°F did substantiate that there is a critical temperature threshold, above which skin toughness will increase in prolonged frozen storage. In year one, Powderblue had significantly tougher skins than all other cultivars. In year two, Brightwell had significantly tougher skins than all

other cultivars. In both years, Beaufort was significantly lower in berry skin toughness than all of the rabbiteye cultivars.

Results did not indicate a correlation between skin toughness and lateness of harvest in the rabbiteye cultivars studied.

Berry firmness compression tests had constant treatment effects and treatment by time interaction effects. Overall, there was very little change in firmness between three and 13 months frozen storage across cultivars in both years. First year results indicated no increase or decrease in firmness over time, while second year results indicated a slight trend toward decreasing firmness. Most cultivars were significantly firmer when fresh than after freezing. Powderblue harvest one was significantly firmer than all other cultivars, including Powderblue harvest two in year one. Powderblue harvest two, NC 3465, and Premier harvest one were significantly firmer than all other cultivars, except Powderblue harvest one. Beaufort was significantly less firm than all other cultivars except Ira in year one. In year two, Brightwell harvest one was significantly firmer than all other cultivars including Brightwell harvests two and three. Powderblue harvests were only average for firmness in year two. While all three Beaufort harvest were among the least firm in year two, they were only significantly less firm than all three Brightwell harvests, Tifblue harvest one, and Premier harvest one. There were no significant differences among the remaining cultivars in year two.

Sensory panel ratings of firmness were very consistent with puncture tests in the first year, varied only slightly in the second year, and showed no significant change over time. Sensory panels also confirmed texture analyzer results that first harvest among rabbiteye cultivars

tended to have firmer skins. In year one, Powderblue harvests one and two were rated significantly firmer than all the other cultivars, Beaufort was rated significantly less firm than all other cultivars, and there were no significant rating differences among the other cultivars. In year two, Brightwell harvest one was rated significantly firmer than all other cultivars, including Brightwell harvest two. Sensory firmness ratings for Powderblue in year two were average to below average, and panelists found no significant differences between harvests one and two. Beaufort harvest one was rated as the least firm among all cultivars, including Beaufort harvest two. Unlike the first year, the first harvests of Premier and Tifblue were rated significantly firmer than their second harvests.

Sensory ratings for firmness and firmness liking were generally negatively correlated in both years, while ratings for firmness liking and overall texture liking were generally positively correlated. The major exception among firmness and firmness liking ratings was Beaufort in year one, which had both the significantly lowest mean for sensory firmness and firmness liking. In year one, Beaufort was significantly lower in firmness liking ratings than all other cultivars except Powderblue harvest two. However, in the second year, the two harvests of Beaufort were rated significantly higher in firmness liking than all other cultivars except Powderblue harvest two, and they were also significantly higher than all other cultivars in overall textural liking. Premier harvest one was rated significantly higher than all other cultivars in the first year, except NC 3465 and Tifblue harvest one, and all three cultivars were within average range for firmness liking. Similarly, NC 3465 was rated significantly higher than all other cultivars for overall texture liking except the first harvests of Premier and Tifblue. In year two, Brightwell harvests one and two were rated significantly lower than

all other cultivars for firmness liking and overall texture liking, in direct opposition to their high firmness ratings. Unlike year one, in which Powderblue harvests were rated average to below average for firmness liking, in year two, Powderblue harvests were rated much higher, even above the first harvests of Premier and Tifblue. The positive change in firmness liking ratings for Beaufort harvest one, as well as the less dramatic, but still more positive ratings for Powderblue harvests one and two in year two, highlight the effect of year-to-year changes in environmental and cultural factors.

Sensory ratings for sweetness and sweetness liking were generally positively correlated in both years. Premier harvest two and both Tifblue harvests were rated significantly higher than all other cultivars except Beaufort for sweetness in year one. Similarly, Premier harvest two and Tifblue harvest two were rated significantly higher than all other cultivars except Tifblue harvest one for sweetness liking in year one. Powderblue harvest one was rated significantly lower for both sweetness and sweetness liking than all other cultivars except Powderblue harvest two in year one.

In year two, Beaufort harvest two rated significantly higher than all other cultivars for both sweetness and sweetness liking. Premier harvest two rated second highest in sweetness in year two, higher than all other cultivars except Beaufort harvest one and Brightwell harvest two. Premier harvest two and Beaufort harvest one also rated second highest in sweetness liking in year two, higher than all others except Brightwell harvest two and Powderblue harvest two. The second harvests of both Beaufort and Premier rated significantly higher in sweetness and sweetness liking than the first harvest. The first and second harvests of both Powderblue and Tifblue both rated average in sweetness and sweetness liking, without

significant differences between the harvests. The first harvest of Brightwell rated significantly lower than all other cultivars for both sweetness and sweetness liking in year two, whereas as the second harvest rated higher in both attributes.

Ratings for acidity and acidity liking were generally negatively correlated in both years. Powderblue harvest one was rated significantly more acidic than all other cultivars except Powderblue harvest two, Ira, and Premier harvest one in year one. Powderblue harvest one was also rated significantly lower in acidity liking than all other cultivars except Ira in year one. In contrast to the first harvest, Premier harvest two was rated significantly lower in acidity than all other cultivars except Beaufort in year one. Tifblue harvest one and two were rated highest for acidity liking, but only significantly higher than Powderblue harvests one and two and Ira in year one.

In year two, the two harvests of Tifblue and Powderblue were rated significantly more acidic than all of the other cultivars except Brightwell harvest one. Beaufort harvest two and Brightwell harvest two were significantly lower in acidity than all other cultivars except Premier harvest two in year two. Beaufort harvest two was significantly higher than all other cultivars for acidity liking in year two except for Beaufort harvest one. Brightwell harvest one was rated lowest for acidity liking in year two, though not significantly lower than Tifblue harvest one and two, Premier harvest one, or Powderblue harvest one.

Seediness and seediness liking ratings were also generally negatively correlated for the two years. In year one, Ira rated highest in seediness, though not significantly more so than Powderblue harvest one and two. Powderblue harvest one was rated significantly lower than all other cultivars except Ira and Powderblue harvest two for seediness liking in year one.

NC3465 and Beaufort were rated significantly less seedy than all other cultivars, and NC3465 was rated significantly higher in seediness liking than all others except Beaufort in year one. The two harvests of both Premier and Tifblue rated average for seediness and seediness liking in year one, without any significant differences. In year two, Brightwell harvest one was rated as being significantly seedier than all other cultivars except Brightwell harvest two, and similarly, Brightwell harvest one was rated significantly lower in seediness liking. Powderblue harvests one and two rated average for seediness and seediness liking in year two, as were the two harvests of both Premier and Tifblue. Both harvests of Beaufort were rated significantly least seedy than all other cultivars, and significantly higher than all others in seediness liking in year two.

Sensory ratings for overall liking served as a good summary for a cultivar's performance in liking for all attributes. Tifblue harvests one and two topped sensory ratings for overall liking in year one, though they were not significantly higher than Premier harvests one and two. Powderblue harvest one was rated significantly lower than all other cultivars except Powderblue harvest two and Beaufort for overall liking in year one. In contrast to year one, Beaufort harvests one and two, and Powderblue harvest two topped the ratings for overall liking in year two. Premier harvest two rated significantly higher than harvest one in year two, and was similar to Beaufort harvest one and Powderblue harvest two in overall liking. Harvests one and two of Tifblue received average ratings for overall liking in year two. Brightwell harvest one was rated significantly lower than all other cultivars for overall liking in year two, including it's own second harvest.

REFERENCES

Ballington, J.R., C.A. Walker, Jr., and A.D. Draper. 1984. Strategies for developing hexaploid blueberries adapted to spring frost or freeze prone areas in the coastal plain of the southeastern United States. Proc. Fifth North Amer. Blueberry Research Workers Conf., Gainsville Fla. P. 38-43. Feb. 1-3.

Dekazos, E. D. 1977. Sclereid development and prevention of woodiness and/or grittiness in rabbiteye blueberries. Proc Fla State Hort Soc 90:218-224

Galletta, G. J. and J. R. Ballington. 1996. Blueberries, cranberries and ligonberries. Pp. 1-107. In J. Janick and J. N. Moore (eds.) Fruit Breeding, Vol II: Vine and Small Fruit Crops. John Wiley and Sons, Inc.

Gough, R. E. 1983. The occurrence of mesocarpic stone cells in the fruit of cultivated highbush blueberry. J. Amer. Soc. Hort. Sci. 108(6):1064-1067

Johansen, D. A. 1940. Plant Microtechnique. McGraw-Hill Book Co. New York, New York.

Makus, D. J. and J. R. Morris. 1993. A comparison of highbush and rabbiteye blueberry cultivars. J. Food Quality 16:417-428

Marshall, D., Spiers, J.M., Silva, J., and Curry, K.J. 2006. Fiber content of two rabbiteye and two southern highbush blueberry cultivars. Proc. 10th North Amer. Blueberry Research and Ext. Workers Conf., Tifton GA. P. 176-179.

Ott, R.L. and M. Longnecker. 2001. An introduction to statistical methods and data analysis. 5th ed. Duxbury, Pacific Grove, CA.

SAS 9.1.3, SAS Institute Inc., Cary, NC. USA.

Silva, J. L., Marroquin, E., Matta, F. B., Garner, J. O., and Stojanovic, J. 2005. Physiochemical, carbohydrate and sensory characteristics of highbush and rabbiteye blueberry cultivars. J Sci Food Agric 85:1815-1821.

Sousa, L., Almeida, R., Rodrigues, P.B., and Oliveira, C.M. 2003. A small contribution to the mechanical assessment of fruit texture. J. Port. Soc. Rheo. 3:1-6

Woodroof, J.G. 1939. Microscopic studies of frozen fruits and vegetables. Ga. Agr. Expt. Sta. Bull. 201:1-46

Woodroof, J. G. and I. S. Atkinson. 1944. Blueberries for freezing improved by blanching. Refrig. Eng. 48(4):275-278, 314

Woodroof, J. G. 1961. Processing blueberries. Ga. Agr. Expt. Sta. Bull. :3-14

APPENDIX

Table 1. Acid composition, year one

Cultivar	Month	SS	pH	%TA	SS/TA ratio
Beaufort	0	12	3.35	0.483	24.850
Beaufort	3	12	3.52	0.444	27.042
Beaufort	6	12	3.73	0.446	26.884
Beaufort	9	11	3.56	0.444	24.789
Beaufort	13	12.5	3.53	0.418	29.930
Ira	0	12.5	3.11	0.632	19.788
Ira	3	13	3.12	0.666	19.531
Ira	6	12	3.42	0.731	16.419
Ira	9	13	3.27	0.496	26.212
Ira	13	12.5	3.32	0.535	23.360
NC3465	0	12.5	3.14	0.405	30.895
NC3465	3	13	3.57	0.412	31.521
NC3465	6	13	3.73	0.444	29.296
NC3465	9	12	3.6	0.499	24.069
NC3465	13	14	3.48	0.399	35.055
Tifblue1	0	14	3.11	0.517	27.088
Tifblue1	3	13	3.11	0.496	26.212
Tifblue1	6	14	3.36	0.501	27.935
Tifblue1	9	12	3.18	0.535	22.425
Tifblue1	13	14	3.24	0.423	33.108
Tifblue2	0	15.5	3.1	0.444	34.930
Tifblue2	3	15	3.25	0.470	31.925
Tifblue2	6	15	3.4	0.493	30.405
Tifblue2	9	14	3.28	0.491	28.529
Tifblue2	13	16	3.15	0.504	31.760
Powderblue1	0	12	3.13	0.504	23.820
Powderblue1	3	12	3.15	0.509	23.576
Powderblue1	6	10	3.35	0.561	17.819
Powderblue1	9	11	3.25	0.585	18.813
Powderblue1	13	11.5	3.13	0.629	18.281
Powderblue2	0	12	3	0.553	21.685
Powderblue2	3	13	3.35	0.425	30.554
Powderblue2	6	12	3.48	0.626	19.155
Powderblue2	9	12	3.3	0.491	24.453
Powderblue2	13	11	3.48	0.305	36.018
Premier1	0	14	3.3	0.431	32.506
Premier1	3	13	3.11	0.587	22.135
Premier1	6	12	3.48	0.577	20.802
Premier1	9	13	3.35	0.470	27.668
Premier1	13	14	3.31	0.579	24.160
Premier2	0	13	3.43	0.271	47.888
Premier2	3	12.5	3.48	0.261	47.888

Premier2	6	11	3.62	0.373	29.469
Premier2	9	11	3.55	0.345	31.925
Premier2	13	11	3.48	0.305	36.018

Table 2. Dryweight, year one

Cultivar	Harvest	Month	%dryweight
Beaufort	1	0	0.338
Beaufort	1	3	0.279
Beaufort	1	6	0.305
Beaufort	1	9	0.301
Beaufort	1	13	0.277
Ira	1	0	0.346
Ira	1	3	0.300
Ira	1	6	0.332
Ira	1	9	0.327
Ira	1	13	0.308
NC3465	1	0	0.326
NC3465	1	3	0.290
NC3465	1	6	0.314
NC3465	1	9	0.318
NC3465	1	13	0.278
Tifblue	1	0	0.360
Tifblue	1	3	0.323
Tifblue	1	6	0.307
Tifblue	1	9	0.313
Tifblue	1	13	0.301
Tifblue	2	0	0.370
Tifblue	2	3	0.243
Tifblue	2	6	0.378
Tifblue	2	9	0.369
Tifblue	2	13	0.368
Powderblue	1	0	0.335
Powderblue	1	3	0.277
Powderblue	1	6	0.331
Powderblue	1	9	0.312
Powderblue	1	13	0.286
Powderblue	2	0	0.350
Powderblue	2	3	0.338
Powderblue	2	6	0.343
Powderblue	2	9	0.339
Powderblue	2	13	0.321
Premier	1	0	0.338
Premier	1	3	0.271
Premier	1	6	0.322
Premier	1	9	0.281
Premier	1	13	0.269
Premier	2	0	0.333

Premier	2	3	0.283
Premier	2	6	0.322
Premier	2	9	0.305
Premier	2	13	0.292

Table 3. Drip loss, year one

Cultivar	Harvest	Month	% loss
Beaufort	1	3	0.084391643
Beaufort	1	3	0.087782157
Beaufort	1	3	0.095688749
Beaufort	1	6	0.094125973
Beaufort	1	6	0.074720211
Beaufort	1	6	0.085663717
Beaufort	1	9	0.086300543
Beaufort	1	9	0.090191315
Beaufort	1	9	0.093690249
Beaufort	1	13	0.0697
Beaufort	1	13	0.0597
Beaufort	1	13	0.0750
Ira	1	3	0.076391415
Ira	1	3	0.076653944
Ira	1	3	0.079401993
Ira	1	6	0.06026007
Ira	1	6	0.072806303
Ira	1	6	0.056421446
Ira	1	9	0.063708399
Ira	1	9	0.074863055
Ira	1	9	0.067713787
Ira	1	13	0.0458
Ira	1	13	0.0521
Ira	1	13	0.0617
NC3465	1	3	0.079259777
NC3465	1	3	0.097833935
NC3465	1	3	0.088477366
NC3465	1	6	0.070096685
NC3465	1	6	0.080846634
NC3465	1	6	0.080717489
NC3465	1	9	0.090240642
NC3465	1	9	0.06701995
NC3465	1	9	0.06506611
NC3465	1	13	0.0697
NC3465	1	13	0.0651
NC3465	1	13	0.0735
Tifblue	1	3	0.117602996
Tifblue	1	3	0.089174312
Tifblue	1	3	0.107549121
Tifblue	1	6	0.102985075
Tifblue	1	6	0.092710545

Tifblue	1	6	0.092044707
Tifblue	1	9	0.108097484
Tifblue	1	9	0.105359877
Tifblue	1	9	0.085290055
Tifblue	1	13	0.0649
Tifblue	1	13	0.0866
Tifblue	1	13	0.0785
Tifblue	2	3	0.102773988
Tifblue	2	3	0.090992227
Tifblue	2	3	0.087694484
Tifblue	2	6	0.086538462
Tifblue	2	6	0.089612127
Tifblue	2	6	0.086512866
Tifblue	2	9	0.076292883
Tifblue	2	9	0.081270434
Tifblue	2	9	0.077239488
Tifblue	2	13	0.0480
Tifblue	2	13	0.0525
Tifblue	2	13	0.0561
Powderblue	1	3	0.069842292
Powderblue	1	3	0.071981164
Powderblue	1	3	0.128658952
Powderblue	1	6	0.065452092
Powderblue	1	6	0.068118949
Powderblue	1	6	0.063876652
Powderblue	1	9	0.074350765
Powderblue	1	9	0.059434881
Powderblue	1	9	0.088435374
Powderblue	1	13	0.0604
Powderblue	1	13	0.0586
Powderblue	1	13	0.0611
Powderblue	2	3	0.042738589
Powderblue	2	3	0.04576659
Powderblue	2	3	0.05031185
Powderblue	2	6	0.056451613
Powderblue	2	6	0.053741215
Powderblue	2	6	0.049015501
Powderblue	2	9	0.057086614
Powderblue	2	9	0.048742138
Powderblue	2	9	0.062787777
Powderblue	2	13	0.0381
Powderblue	2	13	0.0314
Powderblue	2	13	0.0316
Premier	1	3	0.06358209
Premier	1	3	0.063852243
Premier	1	3	0.064720812
Premier	1	6	0.054339623
Premier	1	6	0.05324418
Premier	1	6	0.056014004
Premier	1	9	0.054350308

Premier	1	9	0.053920414
Premier	1	9	0.052455889
Premier	1	13	0.0550
Premier	1	13	0.0641
Premier	1	13	0.0653
Premier	2	3	0.094373866
Premier	2	3	0.096594245
Premier	2	3	0.104046243
Premier	2	6	0.087851078
Premier	2	6	0.084026128
Premier	2	6	0.084662976
Premier	2	9	0.092257002
Premier	2	9	0.08766756
Premier	2	9	0.084798995
Premier	2	13	0.0619
Premier	2	13	0.0735
Premier	2	13	0.0969

Table 4. Skin toughness peak force means, year one.

Cultivar	Time	N	Peak Force	
			Mean (N)	Std Dev
Beaufort	0	15	1.13166667	0.13224472
Beaufort	3	20	0.54245	0.22890206
Beaufort	6	20	0.5363	0.26040315
Beaufort	9	20	0.61875	0.1594051
Beaufort	13	20	0.7019	0.259176
Ira	0	15	1.133	0.29975429
Ira	3	20	0.8595	0.25519167
Ira	6	20	0.7778	0.36249626
Ira	9	20	0.9155	0.21016297
Ira	13	20	0.8632	0.24611456
NC3465	0	15	1.52133333	0.24452656
NC3465	3	20	0.9214	0.19482446
NC3465	6	20	0.8827	0.24787754
NC3465	9	20	0.9843	0.19857972
NC3465	13	20	0.94835	0.19270465
Powderblue 1	0	15	1.1906	0.20829574
Powderblue 1	3	20	1.5735	0.34899623
Powderblue 1	6	20	1.46355	0.23042626
Powderblue 1	9	20	1.5825	0.2708679
Powderblue 1	13	20	1.53595	0.3990025
Powderblue 2	0	15	1.67326667	0.34952201
Powderblue 2	3	20	1.343	0.36849352
Powderblue 2	6	20	1.28355	0.29582525
Powderblue 2	9	20	1.2775	0.30395109
Powderblue 2	13	20	1.18395	0.28111741
Premier 1	0	15	1.14813333	0.31345765
Premier 1	3	20	0.85815	0.15029665
Premier 1	6	20	0.8129	0.1757465
Premier 1	9	20	0.8886	0.14046179
Premier 1	13	20	0.8561	0.16985254
Premier 2	0	15	1.04553333	0.09183282
Premier 2	3	20	0.9604	0.21805007
Premier 2	6	20	0.85645	0.24477863
Premier 2	9	20	0.8697	0.18088353
Premier 2	13	20	0.80015	0.20506309
Tifblue 1	0	15	1.32706667	0.29334949
Tifblue 1	3	20	0.89175	0.2457144
Tifblue 1	6	20	0.90035	0.24283464
Tifblue 1	9	20	1.046	0.32041815
Tifblue 1	13	20	1.04325	0.22537171
Tifblue 2	0	15	1.69253333	0.28713806
Tifblue 2	3	20	0.8063	0.31860272
Tifblue 2	6	20	0.8971	0.29324409
Tifblue 2	9	20	0.952	0.28509851
Tifblue 2	13	20	0.98405	0.23089858

Table 5. Berry firmness peak force means, year one.

Cultivar	Time	N	Force (N)	
			Mean	Std Dev
Beaufort	0	15	21.4401333	8.8476872
Beaufort	3	20	1.383	0.3898515
Beaufort	6	20	1.3628	0.4581236
Beaufort	9	20	1.39565	0.4841414
Beaufort	13	20	1.3986	0.3922261
Ira	0	15	5.1426	1.6698943
Ira	3	20	1.80355	0.4486514
Ira	6	20	1.90755	0.7213111
Ira	9	20	1.78205	0.6087226
Ira	13	20	1.45725	0.3752081
NC3465	0	15	46.3266667	10.2535766
NC3465	3	20	2.62805	1.0721961
NC3465	6	20	3.2122	1.4617288
NC3465	9	20	2.27965	0.7256476
NC3465	13	20	2.2681	0.941675
Powderblue 1	0	15	5.0432	0.9543267
Powderblue 1	3	20	3.78525	1.0196602
Powderblue 1	6	20	3.21515	0.701173
Powderblue 1	9	20	4.47565	1.3288838
Powderblue 1	13	20	3.3582	0.6942982
Powderblue 2	0	15	19.3901333	5.2203351
Powderblue 2	3	20	2.4856	0.7173538
Powderblue 2	6	20	2.4225	0.7063839
Powderblue 2	9	20	2.56255	0.6315228
Powderblue 2	13	20	2.60915	0.6574381
Premier 1	0	15	23.7274286	9.3785361
Premier 1	3	20	2.4697	0.6447349
Premier 1	6	20	2.4684	0.484812
Premier 1	9	20	3.00665	1.179538
Premier 1	13	20	2.5952	0.7885901
Premier 2	0	15	4.2540667	0.7360055
Premier 2	3	20	2.24045	0.76933
Premier 2	6	20	2.10815	0.8413149
Premier 2	9	20	2.042	0.6615524
Premier 2	13	20	1.98095	0.6360881
Tifblue 1	0	15	6.9704667	1.475695
Tifblue 1	3	20	1.75385	0.5657162
Tifblue 1	6	20	2.0012	0.5969476
Tifblue 1	9	20	1.82595	0.4963347
Tifblue 1	13	20	1.9535	0.7148455
Tifblue 2	0	15	15.6748	5.9622649
Tifblue 2	3	20	1.8463	0.933848
Tifblue 2	6	20	1.8479	0.8209387
Tifblue 2	9	20	2.09655	0.9543895
Tifblue 2	13	20	2.0282	0.9160054

Table 6. Sensory sweetness liking ratings, year one				
Level of cultivar	**Level of Month**	**N**	**Sweetness Liking**	
			Mean	**Std Dev**
BEAUFORT	3	74	5.14864865	2.18138094
BEAUFORT	6	75	5.45333333	1.79559019
BEAUFORT	9	75	5.64	2.22175971
BEAUFORT	13	75	5.77333333	2.07672646
IRA	3	74	5.10810811	2.17436854
IRA	6	75	5.08	2.01856251
IRA	9	74	5.54054054	2.19082263
IRA	13	75	4.90666667	2.10644656
NC3465	3	74	5.83783784	2.1646413
NC3465	6	73	4.82191781	2.10384876
NC3465	9	75	5.56	2.0150783
NC3465	13	75	5.37333333	2.21037684
POWDERBLUE1	3	74	4.24324324	1.86393905
POWDERBLUE1	6	75	4.6	2.00674538
POWDERBLUE1	9	74	4.94594595	2.18896292
POWDERBLUE1	13	75	4.41333333	1.87510961
POWDERBLUE2	3	74	4.66216216	2.15988982
POWDERBLUE2	6	74	5.06756757	1.98163542
POWDERBLUE2	9	73	5	1.86338998
POWDERBLUE2	13	75	4.64	2.08365583
PREMIER1	3	74	5.24324324	2.06610487
PREMIER1	6	75	5.52	2.02257529
PREMIER1	9	75	5.66666667	2.10105079
PREMIER1	13	74	5.54054054	2.23416307
PREMIER2	3	74	5.98648649	1.82444019
PREMIER2	6	74	6.02702703	1.85777133
PREMIER2	9	74	6.17567568	2.12846403
PREMIER2	13	75	6.04	2.04965389
TIFBLUE1	3	74	5.95945946	1.91203248
TIFBLUE1	6	75	5.86666667	1.99549041
TIFBLUE1	9	74	5.90540541	2.08825101
TIFBLUE1	13	75	6.08	1.86547581
TIFBLUE2	3	74	5.93243243	1.69067613
TIFBLUE2	6	75	6.22666667	1.61557732
TIFBLUE2	9	74	6.31081081	2.07348344
TIFBLUE2	13	75	5.6	2.13718683

Table 7. Sensory acidity rating, year one.

Level of Cultivar	Level of Month	N	Acid	
			Mean	Std Dev
BEAUFORT	3	74	3.90540541	1.91725345
BEAUFORT	6	74	4.36486486	1.93436354
BEAUFORT	9	75	3.78666667	2.18899788
BEAUFORT	13	75	3.93333333	2.15816071
IRA	3	74	5	2.24523849
IRA	6	74	5.2972973	1.97053452
IRA	9	75	4.74666667	2.18776285
IRA	13	75	5.22666667	2.25156602
NC3465	3	74	3.7972973	2.07384052
NC3465	6	74	4.44594595	2.08807371
NC3465	9	75	4.36	2.33446562
NC3465	13	75	4.46666667	2.06209899
POWDERBLUE1	3	74	5.27027027	2.10216651
POWDERBLUE1	6	74	5.14864865	2.16878498
POWDERBLUE1	9	74	5.43243243	2.08110272
POWDERBLUE1	13	75	5.58666667	1.92489616
POWDERBLUE2	3	74	4.78378378	2.07575878
POWDERBLUE2	6	74	5.28378378	1.80197966
POWDERBLUE2	9	75	4.97333333	2.07932768
POWDERBLUE2	13	75	5.29333333	2.14837043
PREMIER1	3	74	4.78378378	1.88192753
PREMIER1	6	74	4.83783784	1.95866202
PREMIER1	9	75	4.84	2.05360593
PREMIER1	13	75	5.17333333	2.13322072
PREMIER2	3	74	3.68918919	1.87211459
PREMIER2	6	74	3.97297297	1.94424316
PREMIER2	9	75	3.76	1.79969967
PREMIER2	13	75	3.65333333	1.92770227
TIFBLUE1	3	74	4.59459459	2.06682152
TIFBLUE1	6	74	4.87837838	1.97208396
TIFBLUE1	9	75	5	2.24210326
TIFBLUE1	13	75	4.44	2.11966341
TIFBLUE2	3	74	4.21621622	1.89642974
TIFBLUE2	6	74	4.41891892	1.82829179
TIFBLUE2	9	75	4.34666667	1.89945464
TIFBLUE2	13	75	4.18666667	1.8577328

Table 8. Sensory acidity liking rating, year one.

Level of cultivar	Level of Month	N	Acidity Liking	
			Mean	Std Dev
BEAUFORT	3	73	5.32876712	1.85633147
BEAUFORT	6	74	5.32432432	1.58855589
BEAUFORT	9	75	5.62666667	2.18578536
BEAUFORT	13	75	5.42666667	2.07412198
IRA	3	73	4.78082192	2.19371941
IRA	6	74	4.91891892	1.78084755
IRA	9	75	5.48	2.06881609
IRA	13	75	5.18666667	2.11617537
NC3465	3	73	5.83561644	1.99313892
NC3465	6	73	5.19178082	1.8383079
NC3465	9	75	5.65333333	2.19023221
NC3465	13	75	5.09333333	1.75663478
POWDERBLUE1	3	73	4.38356164	1.9266417
POWDERBLUE1	6	74	4.71621622	2.03745927
POWDERBLUE1	9	74	4.77027027	2.10379499
POWDERBLUE1	13	75	4.74666667	2.03412331
POWDERBLUE2	3	73	5.32876712	2.03479998
POWDERBLUE2	6	74	5.18918919	1.86294564
POWDERBLUE2	9	75	5.32	2.05439542
POWDERBLUE2	13	75	4.93333333	2.12662233
PREMIER1	3	73	5.16438356	1.96506784
PREMIER1	6	74	5.41891892	1.84321605
PREMIER1	9	75	5.94666667	1.90229828
PREMIER1	13	75	5.45333333	2.06183684
PREMIER2	3	73	5.53424658	1.82636701
PREMIER2	6	73	5.43835616	1.87072699
PREMIER2	9	74	5.90540541	1.84442083
PREMIER2	13	75	5.54666667	2.02212982
TIFBLUE1	3	73	5.53424658	1.94423787
TIFBLUE1	6	74	5.75675676	1.819309
TIFBLUE1	9	75	5.78666667	2.05527228
TIFBLUE1	13	75	5.98666667	1.84898316
TIFBLUE2	3	73	5.93150685	1.58402412
TIFBLUE2	6	74	5.74324324	1.64742066
TIFBLUE2	9	75	6.09333333	1.94639885
TIFBLUE2	13	75	5.53333333	2.11387523

Table 9. Sensory seediness rating, year one.

Level of cultivar	Level of Month	N	Seediness	
			Mean	Std Dev
BEAUFORT	3	74	3.01351351	1.75556449
BEAUFORT	6	75	3.18666667	1.65785056
BEAUFORT	9	75	2.93333333	1.81832514
BEAUFORT	13	75	3	1.71637582
IRA	3	74	4.71621622	2.32037001
IRA	6	75	5.05333333	2.02613554
IRA	9	75	5.05333333	2.22936989
IRA	13	75	4.97333333	2.22378624
NC3465	3	74	3	1.77501688
NC3465	6	74	3.81081081	1.92087078
NC3465	9	75	3.22666667	1.59876078
NC3465	13	75	3.34666667	2.05658687
POWDERBLUE1	3	74	4.55405405	2.33579585
POWDERBLUE1	6	74	4.82432432	2.12846403
POWDERBLUE1	9	74	4.86486486	2.11533426
POWDERBLUE1	13	75	4.72	2.18446604
POWDERBLUE2	3	74	4.33783784	2.10203442
POWDERBLUE2	6	73	4.89041096	2.17665418
POWDERBLUE2	9	75	4.78666667	2.24387053
POWDERBLUE2	13	75	4.97333333	2.14333242
PREMIER1	3	74	4.25675676	2.09409353
PREMIER1	6	74	4.48648649	2.11480912
PREMIER1	9	74	4.51351351	2.25281099
PREMIER1	13	75	4.57333333	2.08062707
PREMIER2	3	74	4.10810811	2.11690888
PREMIER2	6	75	4.52	2.13313625
PREMIER2	9	75	4.18666667	2.14156632
PREMIER2	13	75	4.42666667	2.18207274
TIFBLUE1	3	74	3.75675676	2.0924575
TIFBLUE1	6	74	4.05405405	1.97859707
TIFBLUE1	9	75	4.05333333	2.08529817
TIFBLUE1	13	75	4.44	2.33214899
TIFBLUE2	3	74	4.2027027	2.3289702
TIFBLUE2	6	74	3.90540541	1.851833
TIFBLUE2	9	75	3.82666667	1.9616136
TIFBLUE2	13	75	4	2.19335606

Table 10. Sensory seediness liking, year one.				
Level of cultivar	**Level of Month**	**N**	**Seed Liking**	
			Mean	**Std Dev**
BEAUFORT	3	73	6.28767123	1.74387382
BEAUFORT	6	73	6.08219178	1.60514299
BEAUFORT	9	75	6.78666667	1.78804841
BEAUFORT	13	75	6.2	1.90305586
IRA	3	73	5.36986301	2.13767039
IRA	6	74	5.12162162	1.85023288
IRA	9	75	5.16	2.13110807
IRA	13	75	5.01333333	2.21477431
NC3465	3	72	6.76388889	1.71565333
NC3465	6	73	6.06849315	1.8358223
NC3465	9	75	6.52	1.69546294
NC3465	13	75	6.33333333	1.92658032
POWDERBLUE1	3	73	5.08219178	2.10656002
POWDERBLUE1	6	74	5.37837838	2.01842678
POWDERBLUE1	9	74	5.06756757	2.02944814
POWDERBLUE1	13	75	5	2.11813278
POWDERBLUE2	3	73	5.5890411	1.8168625
POWDERBLUE2	6	73	5.06849315	1.81298378
POWDERBLUE2	9	75	5.08	2.11020686
POWDERBLUE2	13	75	5.09333333	1.96711707
PREMIER1	3	73	5.79452055	1.77136877
PREMIER1	6	74	5.33783784	1.90368804
PREMIER1	9	73	5.8630137	2.0433841
PREMIER1	13	75	5.36	2.14753158
PREMIER2	3	73	5.84931507	1.91971665
PREMIER2	6	73	5.4109589	1.7937826
PREMIER2	9	75	5.96	2.06279789
PREMIER2	13	75	5.65333333	2.05000549
TIFBLUE1	3	73	6.04109589	1.81382313
TIFBLUE1	6	74	6.10810811	1.71669935
TIFBLUE1	9	75	5.8	1.91014362
TIFBLUE1	13	75	5.61333333	1.99927915
TIFBLUE2	3	73	5.93150685	2.10375832
TIFBLUE2	6	74	6.09459459	1.71351532
TIFBLUE2	9	75	6.2	1.72423113
TIFBLUE2	13	75	5.6	2

Table 11. Acid composition, year two.

Cultivar	Month	SS	pH	TA (ml)	TA (%)
Beaufort1	0	.	.	.	.
Beaufort1	3	12	3.7	18.6	0.49
Beaufort1	6	11	3.6	25	0.65
Beaufort1	9	10	3.84	19.5	0.51
Beaufort1	13	11	3.7	20.2	0.53
Beaufort2	0	16	4	14	0.37
Beaufort2	3	13.5	3.84	14.6	0.38
Beaufort2	6	15	4.15	10.6	0.28
Beaufort2	9	15	4	14	0.37
Beaufort2	13	15	4	16	0.42
Beaufort3	0	16	4.1	13.5	0.35
Beaufort3	3	15	4.04	13.2	0.34
Beaufort3	6	14	4	17.5	0.46
Beaufort3	9	13	4.09	13	0.34
Beaufort3	13	15	4.34	10.5	0.27
Brightwell1	0	.	.	.	.
Brightwell1	3	12	3.3	15	0.39
Brightwell1	6	10	3.33	14.8	0.39
Brightwell1	9	10	3.33	21	0.55
Brightwell1	13	11	3.52	17	0.44
Brightwell2	0	13	3.4	10.4	0.27
Brightwell2	3	12.5	3.43	12.7	0.33
Brightwell2	6	11.5	3.48	10.5	0.27
Brightwell2	9	13	3.4	11.2	0.29
Brightwell2	13	11	3.41	12.8	0.33
Brightwell3	0	11.5	3.1	18.3	0.48
Brightwell3	3	11.5	3.1	20.2	0.53
Brightwell3	6	12	3.34	17.4	0.45
Brightwell3	9	11	3.27	19	0.50
Brightwell3	13	.	.	.	.
Premier1	0	.	.	.	.
Premier1	3	12	3.36	13.3	0.35
Premier1	6	13	3.35	15.9	0.42
Premier1	9	11	3.5	10.6	0.28
Premier1	13	11	3.4	13.7	0.36
Premier2	0	12	3.28	11.5	0.30
Premier2	3	13	3.4	13.7	0.36
Premier2	6	13	3.43	14	0.37
Premier2	9	13	3.5	14	0.37
Premier2	13	13	3.43	15.1	0.39
Powderblue1	0	14	3.2	17.6	0.46
Powderblue1	3	10	3.14	20.4	0.53
Powderblue1	6	11	3.25	16.8	0.44
Powderblue1	9	10	3.3	17.2	0.45
Powderblue1	13	10	3.2	16.5	0.43
Powderblue2	0	11	3.18	15.8	0.41
Powderblue2	3	11	3.16	19.5	0.51

Powderblue2	6	11	3.21	20.7	0.54
Powderblue2	9	10	3.24	19.5	0.51
Powderblue2	13	10	3.23	19.5	0.51
Powderblue3	0	11	3.1	16	0.42
Powderblue3	3	10	3.17	19.7	0.51
Powderblue3	6	12	3.24	18.4	0.48
Powderblue3	9	10	3.24	15	0.39
Powderblue3	13	10	3.29	17	0.44
Tifblue1	0	12.5	3.09	18.5	0.48
Tifblue1	3	13	3.04	22.2	0.58
Tifblue1	6	14	3.13	25	0.65
Tifblue1	9	14	3.2	23.5	0.61
Tifblue1	13	13	3.1	21.7	0.57
Tifblue2	0	13	3.05	18.1	0.47
Tifblue2	3	12	3	21.9	0.57
Tifblue2	6	11	3.15	20.3	0.53
Tifblue2	9	12	3.25	19	0.50
Tifblue2	13	10	3.04	22	0.57
Tifblue3	0	11.5	3.1	17.9	0.47
Tifblue3	3	12	3.11	18.5	0.48
Tifblue3	6	12	3.19	23	0.60
Tifblue3	9	11	3.16	22	0.57
Tifblue3	13	11	3.09	23	0.60

Table 12. Dryweight, year two.

Cultivar	**Month**	% dryweight
Beaufort1	0	.
Beaufort1	3	0.293
Beaufort1	6	0.285
Beaufort1	9	0.190
Beaufort1	6HF	0.191
Beaufort1	13	0.193
Beaufort2	0	0.401
Beaufort2	3	0.343
Beaufort2	6	0.320
Beaufort2	9	0.224
Beaufort2	6HF	0.228
Beaufort2	13	0.220
Beaufort3	0	0.346
Beaufort3	3	0.414
Beaufort3	6	0.320
Beaufort3	9	0.229
Beaufort3	6HF	0.234
Beaufort3	13	0.246
Brightwell1	0	.
Brightwell1	3	0.277
Brightwell1	6	0.303
Brightwell1	9	0.221
Brightwell1	6HF	0.211

Brightwell1	13		0.224
Brightwell2	0		0.309
Brightwell2	3		0.281
Brightwell2	6		0.305
Brightwell2	9		0.221
Brightwell2	6HF		0.206
Brightwell2	13		0.220
Brightwell3	0		0.316
Brightwell3	3		0.303
Brightwell3	6		0.302
Brightwell3	9		0.203
Brightwell3	6HF		0.151
Brightwell3	13	.	
Premier1	0	.	
Premier1	3		0.276
Premier1	6		0.315
Premier1	9		0.217
Premier1	6HF		0.195
Premier1	13		0.245
Premier2	0		0.327
Premier2	3		0.303
Premier2	6		0.323
Premier2	9		0.224
Premier2	6HF		0.223
Premier2	13		0.231
Powderblue1	0		0.326
Powderblue1	3		0.286
Powderblue1	6		0.290
Powderblue1	9		0.194
Powderblue1	6HF		0.222
Powderblue1	13		0.225
Powderblue2	0		0.313
Powderblue2	3		0.289
Powderblue2	6		0.286
Powderblue2	9		0.185
Powderblue2	6HF		0.189
Powderblue2	13		0.201
Powderblue3	0		0.319
Powderblue3	3		0.299
Powderblue3	6		0.256
Powderblue3	9		0.189
Powderblue3	6HF		0.193
Powderblue3	13		0.209
Tifblue1	0		0.330
Tifblue1	3		0.327
Tifblue1	6		0.313
Tifblue1	9		0.243
Tifblue1	6HF		0.227
Tifblue1	13		0.230

Tifblue2	0	0.313
Tifblue2	3	0.297
Tifblue2	6	0.293
Tifblue2	9	0.208
Tifblue2	6HF	0.197
Tifblue2	13	0.214
Tifblue3	0	0.314
Tifblue3	3	0.298
Tifblue3	6	0.298
Tifblue3	9	0.189
Tifblue3	6HF	0.191
Tifblue3	13	0.234

Table 13. Drip loss, year two.

Cultivar	Harvest	Month	%loss
Beaufort	1	3	0.0949
Beaufort	1	3	0.1132
Beaufort	1	3	0.0862
Beaufort	1	6	0.1097
Beaufort	1	6	0.1217
Beaufort	1	6	0.131
Beaufort	1	9	0.2694
Beaufort	1	9	0.2546
Beaufort	1	9	0.2744
Beaufort	1	13	0.0748
Beaufort	1	13	0.0813
Beaufort	1	13	0.0747
Beaufort	2	3	0.0935
Beaufort	2	3	0.0950
Beaufort	2	3	0.0916
Beaufort	2	6	0.0929
Beaufort	2	6	0.0893
Beaufort	2	6	0.1103
Beaufort	2	9	0.1652
Beaufort	2	9	0.2158
Beaufort	2	9	0.2133
Beaufort	2	13	0.0576
Beaufort	2	13	0.0634
Beaufort	2	13	0.0661
Beaufort	3	3	0.0794
Beaufort	3	3	0.1087
Beaufort	3	3	0.0942
Beaufort	3	6	0.0980
Beaufort	3	6	0.0934
Beaufort	3	6	0.1295
Beaufort	3	9	0.0704
Beaufort	3	9	0.0663
Beaufort	3	9	0.0823
Beaufort	3	13	0.0759

Beaufort	3	13	0.0937
Beaufort	3	13	0.0961
Brightwell	1	3	0.0718
Brightwell	1	3	0.0752
Brightwell	1	3	0.0720
Brightwell	1	6	0.0805
Brightwell	1	6	0.0851
Brightwell	1	6	0.0822
Brightwell	1	9	0.0909
Brightwell	1	9	0.0893
Brightwell	1	9	0.0970
Brightwell	1	13	0.0548
Brightwell	1	13	0.0564
Brightwell	1	13	0.0641
Brightwell	2	3	0.0959
Brightwell	2	3	0.1254
Brightwell	2	3	0.0855
Brightwell	2	6	0.1052
Brightwell	2	6	0.1138
Brightwell	2	6	0.1202
Brightwell	2	9	0.0889
Brightwell	2	9	0.1008
Brightwell	2	9	0.0950
Brightwell	2	13	0.1100
Brightwell	2	13	0.1283
Brightwell	2	13	0.1056
Brightwell	3	3	0.1045
Brightwell	3	3	0.1003
Brightwell	3	3	0.1066
Brightwell	3	6	0.1118
Brightwell	3	6	0.1098
Brightwell	3	6	0.1276
Brightwell	3	9	0.1031
Brightwell	3	9	0.0875
Brightwell	3	9	0.0972
Brightwell	3	13	.
Brightwell	3	13	.
Brightwell	3	13	.
Tifblue	1	3	0.0795
Tifblue	1	3	0.0819
Tifblue	1	3	0.1166
Tifblue	1	6	0.1354
Tifblue	1	6	0.1256
Tifblue	1	6	0.1111
Tifblue	1	9	0.1135
Tifblue	1	9	0.1301
Tifblue	1	9	0.1395
Tifblue	1	13	0.0885
Tifblue	1	13	0.0868

Tifblue	1	13	0.0925
Tifblue	2	3	0.0994
Tifblue	2	3	0.1075
Tifblue	2	3	0.1060
Tifblue	2	6	0.1243
Tifblue	2	6	0.1150
Tifblue	2	6	0.1266
Tifblue	2	9	0.1325
Tifblue	2	9	0.1139
Tifblue	2	9	0.1323
Tifblue	2	13	0.0798
Tifblue	2	13	0.0799
Tifblue	2	13	0.0929
Tifblue	3	3	0.1134
Tifblue	3	3	0.1236
Tifblue	3	3	0.1227
Tifblue	3	6	0.1182
Tifblue	3	6	0.1179
Tifblue	3	6	0.1423
Tifblue	3	9	0.1443
Tifblue	3	9	0.1520
Tifblue	3	9	0.1842
Tifblue	3	13	0.1397
Tifblue	3	13	0.1356
Tifblue	3	13	0.1896
Powderblue	1	3	0.0527
Powderblue	1	3	0.0531
Powderblue	1	3	0.0662
Powderblue	1	6	0.0768
Powderblue	1	6	0.0825
Powderblue	1	6	0.0838
Powderblue	1	9	0.0578
Powderblue	1	9	0.0587
Powderblue	1	9	0.0676
Powderblue	1	13	0.0774
Powderblue	1	13	0.0719
Powderblue	1	13	0.0885
Powderblue	2	3	0.0540
Powderblue	2	3	0.0487
Powderblue	2	3	0.0772
Powderblue	2	6	0.0568
Powderblue	2	6	0.0704
Powderblue	2	6	0.0787
Powderblue	2	9	0.1392
Powderblue	2	9	0.1660
Powderblue	2	9	0.1429
Powderblue	2	13	0.0398
Powderblue	2	13	0.0475
Powderblue	2	13	0.0564
Powderblue	3	3	0.0713

Powderblue	3	3	0.0668
Powderblue	3	3	0.0700
Powderblue	3	6	0.0882
Powderblue	3	6	0.0847
Powderblue	3	6	0.0992
Powderblue	3	9	0.0997
Powderblue	3	9	0.1092
Powderblue	3	9	0.1220
Powderblue	3	13	0.0902
Powderblue	3	13	0.0970
Powderblue	3	13	0.1037
Premier	1	3	0.0576
Premier	1	3	0.0647
Premier	1	3	0.0726
Premier	1	6	0.0848
Premier	1	6	0.0797
Premier	1	6	0.0805
Premier	1	9	0.1600
Premier	1	9	0.1630
Premier	1	9	0.1715
Premier	1	13	0.0697
Premier	1	13	0.1191
Premier	1	13	0.1166
Premier	2	3	0.0512
Premier	2	3	0.0730
Premier	2	3	0.0710
Premier	2	6	0.0910
Premier	2	6	0.0980
Premier	2	6	0.0892
Premier	2	9	0.1506
Premier	2	9	0.1854
Premier	2	9	0.1764
Premier	2	13	0.0530
Premier	2	13	0.0605
Premier	2	13	0.1123

Table 14. Skin toughness peak force means, year two.

Level of Cultivar	Level of time	N	Peak Force (N)	
			Mean	Std Dev
Beaufort 1	0	15		
Beaufort 1	3	15	0.75426667	0.26008336
Beaufort 1	6	15	0.66033333	0.21327737
Beaufort 1	9	15	0.61346667	0.19782022
Beaufort 1	13	15	0.61093333	0.27129148
Beaufort 1	6HF	15	1.04913333	0.26544756
Beaufort 2	0	20	1.30185	0.16662794

Beaufort 2	3	15	1.0492	0.28753912
Beaufort 2	6	15	0.77173333	0.30775906
Beaufort 2	9	15	0.75426667	0.25476585
Beaufort 2	13	15	0.9254	0.23355201
Beaufort 2	6HF	15	1.3634	0.49770241
Beaufort 3	0	20	1.60025	0.28799486
Beaufort 3	3	15	0.99793333	0.38367201
Beaufort 3	6	15	0.8706	0.24952893
Beaufort 3	9	15	0.93026667	0.41796078
Beaufort 3	13	15	0.9454	0.48272216
Beaufort 3	6HF	15	1.88626667	0.4220583
Brightwell 1	0	15		
Brightwell 1	3	15	2.12453333	0.50158233
Brightwell 1	6	15	2.0048	0.44669712
Brightwell 1	9	15	1.97026667	0.35218633
Brightwell 1	13	15	1.8146	0.26627934
Brightwell 1	6HF	15	2.13906667	0.45627834
Brightwell 2	0	20	1.71305	0.21434563
Brightwell 2	3	15	1.83973333	0.44603851
Brightwell 2	6	15	1.84226667	0.45900023
Brightwell 2	9	15	1.613	0.61478138
Brightwell 2	13	15	1.63626667	0.36103234
Brightwell 2	6HF	15	1.82293333	0.36590679
Brightwell 3	0	20	1.5302	0.31221915
Brightwell 3	3	15	1.59073333	0.53178385
Brightwell 3	6	15	1.7284	0.46141782
Brightwell 3	9	15	1.7158	0.56052096
Brightwell 3	13	15		
Brightwell 3	6HF	15	2.20493333	0.6296951
Powderblue 1	0	20	1.265	0.24722289
Powderblue 1	3	15	1.3306	0.30971549
Powderblue 1	6	15	1.37053333	0.2939832
Powderblue 1	9	15	1.0596	0.20885532
Powderblue 1	13	15	1.1484	0.1773136
Powderblue 1	6HF	15	2.41093333	0.42346284
Powderblue 2	0	20	1.43185	0.35082523
Powderblue 2	3	15	1.2606	0.32863936
Powderblue 2	6	15	1.1218	0.25911421
Powderblue 2	9	15	1.0712	0.18628442
Powderblue 2	13	15	1.04626667	0.33988012
Powderblue 2	6HF	15	1.99006667	0.34630034
Powderblue 3	0	20	1.40735	0.46552181
Powderblue 3	3	15	1.14226667	0.32857908
Powderblue 3	6	15	1.24806667	0.20786378
Powderblue 3	9	15	1.1316	0.2029123
Powderblue 3	13	15	0.99346667	0.21982814
Powderblue 3	6HF	15	2.15766667	0.51899982
Premier 1	0	15		

Premier 1	3	15	1.23413333	0.32750788
Premier 1	6	15	1.07833333	0.25344869
Premier 1	9	15	1.0542	0.25616211
Premier 1	13	15	1.18926667	0.22398644
Premier 1	6HF	15	1.80206667	0.36910035
Premier 2	0	20	1.3559	0.20367515
Premier 2	3	15	1.16046667	0.28724451
Premier 2	6	15	0.9322	0.22495149
Premier 2	9	15	1.0496	0.26704275
Premier 2	13	15	0.966	0.23132568
Premier 2	6HF	15	1.9142	0.3788466
Tifblue 1	0	20	1.61325	0.2716005
Tifblue 1	3	15	1.5728	0.44775618
Tifblue 1	6	15	1.31526667	0.27350332
Tifblue 1	9	15	1.36726667	0.29553353
Tifblue 1	13	15	1.2748	0.31709106
Tifblue 1	6HF	15	2.3752	0.72589307
Tifblue 2	0	20	1.4774	0.29701434
Tifblue 2	3	15	1.2648	0.19991648
Tifblue 2	6	15	1.1408	0.33512326
Tifblue 2	9	15	1.01393333	0.33905719
Tifblue 2	13	15	1.18406667	0.7148252
Tifblue 2	6HF	15	2.2706	0.60965585
Tifblue 3	0	20	1.6712	0.31616295
Tifblue 3	3	15	1.28366667	0.44660556
Tifblue 3	6	15	1.091	0.31504694
Tifblue 3	9	15	1.01733333	0.37934467
Tifblue 3	13	15	0.97406667	0.36686344
Tifblue 3	6HF	15	2.00693333	0.59655768

Table 15. Berry firmness peak force means, year two.

Level of			**Peak Force (N)**	
Cultivar	**Time**	**N**	**Mean**	**Std Dev**
Beaufort 1	3	15	1.5629333	0.59228365
Beaufort 1	6	15	1.8056	0.96733137
Beaufort 1	9	15	1.5063333	0.54503023
Beaufort 1	13	15	1.3368	0.26358387
Beaufort 2	0	20	10.3863	2.85799735
Beaufort 2	3	15	2.2004	0.55237808
Beaufort 2	6	15	1.8526	0.94441174
Beaufort 2	9	15	2.1565333	1.25139812
Beaufort 2	13	15	2.3828	1.6191261
Beaufort 3	0	20	6.6934	2.32118263
Beaufort 3	3	15	1.7598667	0.69728718
Beaufort 3	6	15	2.2226667	0.98619859

Beaufort 3	9	15	1.6274	0.94424284
Beaufort 3	13	15	1.9596667	1.0400723
Brightwell 1	3	15	8.215	4.44043368
Brightwell 1	6	15	7.1176667	2.36750341
Brightwell 1	9	15	7.6882667	2.11373534
Brightwell 1	13	15	8.7334	3.4040061
Brightwell 2	0	20	8.04195	1.89571332
Brightwell 2	3	15	7.5212	7.03444053
Brightwell 2	9	15	4.0392	1.26598636
Brightwell 2	13	15	4.2254	1.61630848
Brightwell 3	0	20	7.29185	1.63149884
Brightwell 3	3	15	3.6548	1.35305534
Brightwell 3	6	15	4.2668	2.10617396
Brightwell 3	9	15	4.3228667	1.54026347
Powderblue 1	0	20	5.6948	1.20145511
Powderblue 1	3	15	2.6904667	0.50480574
Powderblue 1	6	15	2.6502667	0.71873604
Powderblue 1	9	15	2.4916	0.50610767
Powderblue 1	13	15	2.0532667	0.55681011
Powderblue 2	0	20	5.3957	1.11115019
Powderblue 2	3	15	2.0116	0.58062661
Powderblue 2	6	15	2.3739333	0.79491882
Powderblue 2	9	15	2.1139333	0.83842859
Powderblue 2	13	15	1.9064667	0.53348502
Powderblue 3	0	20	5.4879	2.04033333
Powderblue 3	3	15	2.3386	0.77359659
Powderblue 3	6	15	2.0490667	0.83015829
Powderblue 3	9	15	1.7088667	0.65431358
Powderblue 3	13	15	1.9382667	0.57322577
Premier 1	3	15	4.878	2.11075731
Premier 1	6	15	3.4817333	0.76146808
Premier 1	9	15	6.0834	6.13667426
Premier 1	13	15	3.8022667	1.32258354
Premier 2	0	20	5.81945	1.31540462
Premier 2	3	14	2.3907857	0.65367249
Premier 2	6	15	2.6104	1.00928198
Premier 2	9	15	1.921	0.46036523
Premier 2	13	15	1.87	0.48480791
Tifblue 1	0	20	6.65245	1.67481834
Tifblue 1	3	15	4.8032	1.58367435
Tifblue 1	6	15	3.5207333	0.92947554
Tifblue 1	9	15	3.2382	0.99892222
Tifblue 1	13	15	2.9149333	1.20650934
Tifblue 2	0	20	5.7523	2.3439839
Tifblue 2	3	15	2.8159333	0.95801681
Tifblue 2	6	15	2.0900667	0.63765592
Tifblue 2	9	15	2.7410667	1.2485846
Tifblue 2	13	15	1.7874	0.51850758

Tifblue 3	0	20	5.8258	1.17261249
Tifblue 3	3	15	1.8392667	0.75490893
Tifblue 3	6	15	1.8208667	0.67103533
Tifblue 3	9	15	1.7884667	0.50777805
Tifblue 3	13	15	1.8014667	0.54925194

Table 16. Sensory skin firmness, year two.

Cultivar	Month	Means	std dev
Beaufort 1	3	4.55	1.46
Beaufort 1	6	4.18	1.65
Beaufort 1	13	4	1.99
Beaufort 2	3	4.86	1.73
Beaufort 2	6	5.13	1.84
Beaufort 2	13	4.81	2.2
Brightwell 1	3	7.57	1.73
Brightwell 1	6	7.82	1.37
Brightwell 1	13	7.96	1.67
Brightwell 2	3	7.2	1.79
Brightwell 2	6	7.15	1.71
Brightwell 2	13	7.03	1.68
Powderblue 1	3	5.13	1.9
Powderblue 1	6	5.57	1.52
Powderblue 1	13	5.7	1.68
Powderblue 2	3	5.21	1.66
Powderblue 2	6	5.1	1.62
Powderblue 2	13	5.01	1.65
Premier 1	3	5.61	1.8
Premier 1	6	5.7	1.99
Premier 1	13	6	1.77
Premier 2	3	4.68	1.79
Premier 2	6	4.99	1.84
Premier 2	13	4.69	1.82
Tifblue 1	3	5.25	1.82
Tifblue 1	6	5.99	2.06
Tifblue 1	13	5.74	1.81
Tifblue 2	3	4.45	1.94
Tifblue 2	6	5.09	1.76
Tifblue 2	13	5.1	1.54

Table 17. Sensory acidity rating, year two.

Cultivar	Month	Means	std dev
Beaufort 1	3	4.482	1.788
Beaufort 1	6	4.477	1.901
Beaufort 1	13	4.114	2.216
Beaufort 2	3	3.91	1.919
Beaufort 2	6	3.417	1.801
Beaufort 2	13	3.314	2.102
Brightwell 1	3	4.767	2.231
Brightwell 1	6	4.373	1.968
Brightwell 1	13	4.367	2.412
Brightwell 2	3	3.839	1.713
Brightwell 2	6	3.85	1.69
Brightwell 2	13	3.185	2.023
Powderblue 1	3	5.232	2.256
Powderblue 1	6	4.746	1.956
Powderblue 1	13	4.985	1.959
Powderblue 2	3	4.964	2.173
Powderblue 2	6	5.164	2.041
Powderblue 2	13	4.685	1.996
Premier 1	3	4.303	1.934
Premier 1	6	4.283	2.036
Premier 1	13	4.085	2.406
Premier 2	3	4	1.629
Premier 2	6	3.848	1.907
Premier 2	13	3.771	1.927
Tifblue 1	3	5.339	1.984
Tifblue 1	6	5.044	1.837
Tifblue 1	13	4.585	2.109
Tifblue 2	3	5.125	2.174
Tifblue 2	6	4.88	1.903
Tifblue 2	13	4.971	2.315

Table 18. Sensory acidity liking, year two.

Cultivar	Month	means	std dev
Beaufort 1	3	5.381	1.649
Beaufort 1	6	5.5	1.729
Beaufort 1	13	5.871	2.105
Beaufort 2	3	6.072	1.874
Beaufort 2	6	5.818	1.838
Beaufort 2	13	6.42	1.995
Brightwell 1	3	4.584	2.088
Brightwell 1	6	5.076	1.873
Brightwell 1	13	4.656	2.041
Brightwell 2	3	5.196	1.803
Brightwell 2	6	5.333	1.908
Brightwell 2	13	5.671	2.139
Powderblue 1	3	5.203	1.594

Powderblue 1	6	5.606	1.644
Powderblue 1	13	5.185	1.935
Powderblue 2	3	5.4	1.749
Powderblue 2	6	5.409	1.78
Powderblue 2	13	5.449	1.859
Premier 1	3	4.803	2.012
Premier 1	6	4.984	2.003
Premier 1	13	5.057	2.251
Premier 2	3	5.25	1.75
Premier 2	6	5.307	1.959
Premier 2	13	5.585	1.868
Tifblue 1	3	4.8	2.031
Tifblue 1	6	5.06	1.855
Tifblue 1	13	4.87	2.112
Tifblue 2	3	4.74	2.102
Tifblue 2	6	5.5	1.729
Tifblue 2	13	4.771	2.022

Table 19. Sensory seediness liking, year two.

Cultivar	Month	Means	std dev
Beaufort 1	3	6.127	1.856
Beaufort 1	6	6.215	1.849
Beaufort 1	13	6.48	1.827
Beaufort 2	3	6.472	1.762
Beaufort 2	6	6.318	1.865
Beaufort 2	13	7.11	1.508
Brightwell 1	3	4.226	2.189
Brightwell 1	6	3.984	1.901
Brightwell 1	13	4.242	2.235
Brightwell 2	3	5.053	2.021
Brightwell 2	6	4.812	2.014
Brightwell 2	13	5.1	2.285
Powderblue 1	3	5.462	2.053
Powderblue 1	6	5.5	1.858
Powderblue 1	13	5.6	2.017
Powderblue 2	3	5.5	1.923
Powderblue 2	6	5.227	1.68
Powderblue 2	13	5.928	1.951
Premier 1	3	4.872	2.064
Premier 1	6	5.359	2.184
Premier 1	13	5.514	2.104
Premier 2	3	5.607	2.033
Premier 2	6	5.515	1.782
Premier 2	13	5.914	1.931
Tifblue 1	3	5.218	2.208
Tifblue 1	6	5.121	2.323
Tifblue 1	13	5.362	2.388

Tifblue 2	3	5.4	2.165
Tifblue 2	6	5.363	1.966
Tifblue 2	13	6.1	1.72

Table 20. Sensory overall liking, year two.

Cultivar	Month	means	std dev
Beaufort 1	3	5.517	1.906
Beaufort 1	6	5.611	1.874
Beaufort 1	13	5.632	2.171
Beaufort 2	3	6.089	2.002
Beaufort 2	6	8.86	1.878
Beaufort 2	13	6.323	1.864
Brightwell 1	3	3.054	1.879
Brightwell 1	6	3.43	1.74
Brightwell 1	13	3.208	1.762
Brightwell 2	3	4.625	2.041
Brightwell 2	6	4.769	2.044
Brightwell 2	13	5.059	2.282
Powderblue 1	3	5.107	1.658
Powderblue 1	6	5.5	1.851
Powderblue 1	13	5.283	1.952
Powderblue 2	3	5.589	1.914
Powderblue 2	6	5.358	1.554
Powderblue 2	13	5.617	1.861
Premier 1	3	4.214	2.068
Premier 1	6	4.636	2.102
Premier 1	13	4.753	1.912
Premier 2	3	5.428	1.915
Premier 2	6	5.712	1.879
Premier 2	13	5.393	2.037
Tifblue 1	3	4.553	2.19
Tifblue 1	6	4.984	2.072
Tifblue 1	13	4.768	2.156
Tifblue 2	3	4.571	2.087
Tifblue 2	6	5.388	1.833
Tifblue 2	13	5.029	1.962