of contaminants (Table 1). Combination treatments of benomyl/acetone for 24 hr either before or after a 30 min soak in bleach (treatments 11 and 12) were superior in that contamination by bacteria and fungi was reduced. Fungicide treatments reduced fungal incidence to 0% to 4%, but were not as effective in eliminating bacteria. Seed germination was not significantly affected by the fungicide treatments, but they tended to have a stimulatory effect, as had been observed by others (2). Seed germination significantly decreased when seeds were treated with 70% ethanol (treatment 9). However, Daniels (3) reported no decrease in germination of corn seeds with the identical ethanol treatment. When seeds were washed in water for 24 hr before the benomyl/acetone treatment (treatment 10), seed germination was reduced 96%. It is likely that the prolonged initial washing of treatment 10 softened the seed coat and exposed the embryo to toxic levels of benomyl/acetone.

Since asparagus seed coats have very deep crevices where bacteria and fungal spores can lodge and escape disinfestation treatments (2, 5), it was not surprising that 11 out 13 treatments failed to give greater than 90% eradication. The inability of the fungicides to significantly reduce bacteria demonstrates the specificity of these compounds for fungi. Since the genera of the contaminating fungi were not identified, the frequency of dematiaceous and other fungi was not determined; however their presence was noted in several instances.

To detect possible internal contamination of the seed embryo, seeds that were surface-sterilized by treatment 11 were germinated on potato-dextrose agar (9) for 4 days. Uncontaminated seedlings were placed into test tubes (150 mm × 18 mm diameter) containing 7 ml of agar (0.6%) with Hoagland's (4) salt solutions supplemented with sorbitol at rates sufficient to impose water deficits at osmotic potentials of 0, −500, and −1000 kPa (0%, 7%, and 14% sorbitol, w/v, respectively). These water potentials were estimated from previously derived standard curves. Tubes were sealed with sterile foam plugs, placed in sterile plastic bags, and incubated at 21° to 23°C under a 16-hr photoperiod for 2 months. Tubes were examined weekly for evidence of Fusaria.

No Fusaria or other fungi were detected in asparagus seedlings growing in agar medium supplemented with any level of sorbitol. Seedling fern height was decreased ≈20% in agar possessing an osmotic potential of −1000 kPa as compared to agar having no sorbitol or agar having an osmotic potential of −500 kPa. Failure to detect internal seed infections by *Fusarium* spp. in our experiments may only imply that internal infection is not common in asparagus. Nevertheless, if internal seed infections occur in 'Viking' asparagus, it is not likely that they present a significant source of inoculum since external seed infestations by *Fusarium* spp. can reach 9% (2).

By adopting the two-phase sterilization procedure with sodium hypochlorite and benomyl/acetone, axenic culture of large numbers of asparagus seedlings is possible. Treatment 11 is routinely used in our laboratory (8) for producing aseptic seeds, with contamination incidence rarely reaching 2%.

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Characteristics of Fruit from High- and Low-quality Peach Cultivars

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Abstract. **The chemical composition and sensory acceptability of two low-quality ('Bailey' and 'Boone County') and two high-quality ('Jefferson' and Selection B612615) peach genotypes were compared. The high-quality fruit were firmer and much larger than low-quality fruit. The most striking difference between high- and low-quality peaches was that the low-quality fruit contained about seven times more total phenolics. Glucose and sorbitol were at higher levels in low-quality fruit, whereas fructose was higher in the high-quality genotypes. Sensory data substantiated the classification of the cultivars into high- and low-quality fruit. 'Jefferson' and B612615 peaches were rated between acceptable and good after ripening, whereas 'Bailey' and 'Boone County' were rated unacceptable. The flavor of the low-quality cultivars was described as bitter and astringent with a strong aftertaste. The high polyphenolic content, which has been associated with the astringent flavor of fresh peaches, may partially explain the poor flavor of the low-quality fruit.**

United States peach cultivars are grown worldwide and are esteemed for their high fruit quality and acceptable shipping characteristics (24). Selection for a standard fruit type: freestone, yellow, firm, melting flesh, large size, and red-blushed exocarp has led to the intensive use of relatively few cultivars and a restriction in the germplasm base (24). Peach genotypes with resistance to nematodes (25), brown rot (10), gummosis (19), peach tree borer (4) leaf curl (1), and aphids (15) and exhibiting significantly higher levels of cold hardiness in terms of rapid defoliation in the fall, flower bud and xylem midwinter hardiness, and delayed bloom in the spring have been identified. In general, these genotypes produce fruit of commercially unacceptable quality. Results of hybridizations between poor fruit quality *Prunus* spp. and commercial quality *P. persica* genotypes have indicated that poor fruit quality predominated in F_1 and F_2 generations, as

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Table 1. Relation of Minolta "a" value to maturity of high- and low-quality peach cultivars.[z,y]

Cultivar	Degree of maturity			
	Immature	Threshold mature	Mature	Ripened[x]
		Minolta a value		
High-quality				
Jefferson	ND	−4.1	−0.1	10.3
Selection B612615	−8.6	−2.8	ND	3.0
Low-quality				
Bailey	−7.9	−2.9	2.2	3.0
Boone county	ND	−4.6	ND	ND

[z]Mean values of 30 fruit.
[y]ND = no data because fruit was unavailable on date of harvest.
[x]Ripened 3 to 4 days at 20°C, 85% RH (Jefferson—mature; B612615, Bailey, and Boone County—threshold mature).

defined by subjective evaluation of flavor, color, and size, (6, 16, 17).

While subjective evaluations of fruit quality are common, knowledge of the biochemistry of fruit quality is limited (9) and differences between low- and high-quality peaches, particularly in terms of their chemistry, are not well-documented. Information on the biochemistry and inheritance of fruit quality attributes is important for the genetic improvement of peaches, particularly in those cases where poor fruit quality genotypes are to be used as sources of unique genes.

The purpose of this study was to compare the chemical composition and sensory acceptability of low- and high-quality peaches.

Fruit were obtained from the USDA/ARS, Appalachian Fruit Research Station, Kearneysville, W. Va., on one harvest date in Sept. 1986. Freestone genotypes with melting flesh and similar ripening dates were selected. 'Jefferson' is a commercial-quality cultivar with yellow flesh; B612615 is a high-quality white-fleshed selection (developed by H.W. Fogle); 'Bailey' and 'Boone County' are both white-fleshed cultivars of poor fruit quality, generally used as cold-hardy rootstocks (14). Fruit on these trees were thinned in the spring to about 15 to 20 cm between fruit.

Because of the differences in genotype color, size, and firmness of the high- and low-quality cultivars, freshly harvested fruit were sorted into three stages of maturity using a combination of visual appearance, feel, color chips, and Minolta a values. Color chips, developed for yellow-fleshed cultivars (8), were used only to sort 'Jefferson' peaches. The three maturity stages were designated as immature, threshold mature, and mature, as described by Delwiche and Baumgardner (7). Because of differences in ripening of the cultivars, some maturity grades were unavailable.

Immediately after sorting, 30 peaches from each available maturity grade were tested for L, a, and b color values. Color was measured on the greenest area of ground color of each fruit using a tristimulus colorimeter (Minolta CR-100 Chroma Meter equipped with a Minolta DP-100 data processor) and employing d/0 geometry illuminating system and an 8-mm viewing aperture. The instrument was calibrated with a white reference plate (Y = 87.1, x = 0.311, y = 0.318) and measurements were recorded using L, a, and b color coordinates.

In addition, for threshold-mature fruit of three cultivars (no samples for 'Boone County'), firmness was measured on opposite pared cheeks using the Magness–Taylor pressure tester with an 8-mm tip. For each cultivar, 30 threshold mature fruit were stored at −30°C for chemical analyses. The remaining peach samples were placed into 0° to 1° storage for ≈ 2 days. Then, 10 fruit of threshold maturity grade from each available cultivar were ripened at 20° and 85% RH for 3 to 4 days. After ripening, samples were removed for Minolta color analyses.

For chemical analyses, three replicated composite samples that contained 10 sliced peaches each were prepared by grinding in a Waring blender into a puree and analyzed in duplicate. Soluble solids concentration was determined with a Bausch & Lomb Abbé-56 refractometer on an aliquot of the puree that was filtered through Mira-cloth. Sucrose, glucose, fructose, and sorbitol contents were determined by HPLC on a Bio-Rad HPX-87C carbohydrate column using procedure of Meredith et al. (18). Total phenolics were determined by the method of Singleton and Rossi (23). The pH was determined with a Radiometer digital pH meter on 2.5 g of sample diluted with distilled water, and titratable acidity as percent malic acid was determined on the same solution by titration to pH 8.1 with 0.1 N NaOH. Analysis of variance and Duncan's multiple range test were performed on data by Statistical Analysis System (SAS) for personal computers (22).

Sensory evaluation was conducted only on threshold mature fruit that were stored for 2 days at 0°C and then ripened for 2 to 4 days at 20°. Five to 6 fruit of each sample were washed, peeled, sliced and placed into coded trays for evaluation. A panel of eight to 10 people rated each sample for taste using the following simplified scale: 1 = unacceptable; 2 = poor; 3 = acceptable; 4 = good; and 5 = excellent.

The high-quality fruit were very large compared to low-quality fruit. Mature 'Jefferson' peaches averaged 75 mm in diameter and weighed 250 g, compared to a diameter of 40 mm and a weight of 40 g for 'Bailey' peaches. As peaches of all cultivars ripened, a values increased (Table 1). At threshold maturity, combined a values for high- and low-quality fruit were not significantly different. This was expected because we attempted to select the four cultivars at the same color-threshold maturity level. Delwiche and Baumgardner (7), in a study of 13 cultivars, reported that both L and b values tended to level off as peaches approached harvest, whereas a values increased as fruit approached harvest and were highly correlated with maturity.

Firmness of the three cultivars evaluated differed significantly ($P < 0.01$) (Table 2). 'Jefferson' had a typical firmness (4.3 kg) for a threshold mature, yellow-flesh cultivar. Selection B612615 (2.9 kg) had a significantly lower ($P < 0.01$) firmness value than 'Jefferson', whereas 'Bailey', the low-quality cultivar, was very soft for threshold maturity, with a firmness of 0.9 kg, that of an eating-ripe peach. Rood (20) reported that flesh firmness, as indicated by Magness–Taylor test, was the best index of maturity of seven maturity indices examined. Haller and Harding (11) found that the firmness of eastern-grown peach cultivars were fairly uniform and that, at 4.5 to 6.4 kg, at harvest, the fruit would hold up well for shipping. In

Table 2. Characteristics of threshold mature fruit from high- and low-quality peach cultivars.[z]

Cultivar	Firmness (N)	Acidity (% as malic)	pH	Soluble solids concn (%)	Sucrose (%)	Glucose (%)	Fructose (%)	Sorbitol (%)	Total phenolics (mg %)	Sensory evaluation[y]
High-quality										
Jefferson	42 a	0.65 a	3.92 a	11.9 a	5.4 a	0.70 a	0.88 a	0.31 a	17 a	3.7 a
Selection B612615	28 b	0.48 c	4.12 bc	13.1 b	6.1 ab	0.71 a	0.92 a	0.32 a	21 a	3.4 a
Low-quality										
Bailey	13 c	0.44 d	4.19 c	13.7 b	6.1 ab	1.1 b	0.21 b	0.92 b	120 b	1.1 b
Boone county	ND	0.56 b	4.04 b	14.7 c	6.7 b	1.3 c	0.28 b	1.1 c	141 c	1.2 b

[z]Mean separation in columns by Duncan's multiple range test, 5% level.
[y]Average panel rating: 1 = unacceptable; 2 = poor; 3 = acceptable; 4 = good; and 5 = excellent.

this study, the white-fleshed cultivars at similar maturity (threshold) were softer and more variable in firmness.

Analysis of variance of chemical composition data showed that a few traits differed consistently between low- and high-quality genotypes (Table 2). Glucose and sorbitol were at higher levels in low-quality fruit, while fructose concentration was higher in the high-quality genotypes. The effect of these sugars on flavor is not known, but is presumed to be minor since these three sugars combined were one-third to one-half the level of sucrose, the concentration of which was not significantly different between the low- and high-quality cultivars. The most striking difference between high- and low-quality peaches was that the low-quality fruit contained about seven times more total phenolics, which probably affects the flavor of the fruit. Sandhu and Dhillon (21), in a study of 'Flordasun' peaches, reported that total phenolics content reached a maximum at the inception of stage III growth and then decreased continually until harvest, which agrees with findings with 'Elberta' peaches (5).

Sensory evaluation of peaches from high- and low-quality cultivars (Table 2) showed that 'Jefferson' and Selection B612615 peaches scored between acceptable and good after 2 days of storage at 0°C and ripening at 20°, whereas 'Bailey' and 'Boone County' peaches were rated unacceptable. The flavor of the high-quality peaches was not as good as expected—they lacked sweetness and overall peach flavor. This probably was due to the environmental conditions at harvest—rainy weather and short day lengths. The flavor of the low-quality cultivars was described by the panel as bitter and astringent with a strong aftertaste. Polyphenolic compounds are associated with the astringent flavor of fresh and frozen peaches (3, 5), which may partially explain the poor flavor of the low-quality fruit. The fruits also had an unusual floral odor and flavor. The textures were described as poor and soft, with low fracturability. Preliminary analysis of the volatiles by GC–mass spectrometry failed to identify the compounds responsible for the floral notes. Although the volatiles responsible for the floral flavors of the low-quality fruit were not identified, the threshold maturity fruit had a higher concentration of volatiles than mature 'Jefferson' peaches. These compounds are predominantly esters, terpene esters, and lactones. Spencer et al. (26) reported that volatile compounds responsible for the odor of clingstone peaches were predominantly esters, monoterpenes, and γ- and δ- lactones. They found that differences among peach cultivars were due more to the relative concentration of esters and monterpenes than to the γ- and δ- lactones. In addition, they concluded that γ- and δ- lactones contributed to the necessary "peach" background, while lower boiling components (esters and monoterpenes) contributed fruity and floral notes.

Our study indicates that the cold-hardy, poor-quality genotypes differ in fruit from commercial types in at least three major aspects: quality from commercial types in at least three major aspects: size, polyphenol content, and degree of softening at maturity. In the genotypes studied, flavor appeared to be more a function of polyphenol content and aroma than of acidity, soluble solid content, or individual sugars. Small size, high polyphenol content, and rapid fruit softening are all cited as being genetically dominant over the high-quality extremes (2). The difference between soft flesh types such as 'Bailey' and 'Boone County' and the firmer melting flesh types such as 'Jefferson' has been reported to be controlled by a single gene (2). Variability in softening between these two extremes, such as that displayed by Selection B612615, suggests that other factors affect the degree of softening. Polyphenol content and fruit size have been shown to have moderately high heritabilities (12, 13). Efficient progress in the use of poor-quality fruit germplasm for the development of stress-resistant peach cultivars would be aided by knowledge of the biochemistry and genetic control of fruit size, polyphenol biosynthesis, and fruit softening, since these appear to be major factors contributing to poor fruit quality.

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