Contribution of Periderm Material and Blanching Time to the Quality of Pasteurized Peach Puree

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Fresh peaches were blanched for either a long (20 min) or short (2 min) time, with and without periderm material. Samples were then macerated into purees and pasteurized in boiling water for 30 min. Samples were subsequently stored at 40 °C for 4 weeks to determine physicochemical and sensory changes affecting overall quality and nutritional content. Purees containing periderm had higher antioxidant activity (AOX) and individual phenolic acid content after processing and storage, with good correlation to AOX observed with chlorogenic acid ($r = 0.82$). Long blanch times resulted in increased levels of extraction and retention of both total soluble phenolics and ascorbic acid. Quantitative descriptive analysis demonstrated increased aromatic perception of skin in samples containing periderm material, but the remaining sensory attributes were indistinguishable between treatments. Macerating peaches without periderm removal was demonstrated to increase levels of bioactive phytochemicals and increase the processing yield by 7.6%, without significantly impacting product quality, color, or sensory attributes.

Keywords: *Peaches; phenolic acids; antioxidant activity; periderm; blanching*

INTRODUCTION

Eliminating peeling steps prior to maceration into purees may enhance the processing yield, phenolic content, and antioxidant characteristics of clingstone peaches. Currently, peach periderm is removed by either abrasive peeling or hot alkali dips followed by thorough washing. These steps can remove significant portions of edible tissue, especially in overripe fruit, resulting in significant reductions in processing yield. Studies to determine the antioxidant and sensory response to peach purees containing periderm material are needed to justify eliminating these steps prior to puree manufacture.

Phenolic compounds, in conjunction with ascorbic acid added during processing, are the main constituents affecting the antioxidant activity (AOX) of peach puree; however, little information is available on their changes during processing and storage. Much attention has been given to the antioxidant compounds in fresh fruits and vegetables due to the potential health benefits of phenolic compounds (Wang et al., 1996; Kähkönen et al., 1999; Rapisarda et al., 1999). Furthermore, antioxidant retention in processed foods may be an important measure for determining chemical reactions affecting product quality. Cinnamic acid derivatives are the most prevalent phenolic compounds present in peaches, and these common phenolics have been well characterized in peach flesh (Senter et al., 1989; Senter and Callahan, 1990; Cheng and Crisosto, 1995; Bengoechea et al., 1997). Peach periderm is especially rich in anthocyanins and flavonoids compared to the remainder of the fruit, and imparts pigmentation in the flesh. Young et al. (1989) observed flavonoids in the skin of peaches not present in the mesocarp, while Cheng and Crisosto (1995) found that the presence of chlorogenic acid and epicatechin in the peach periderm was related to surface browning potential. However, Lee et al. (1990) reported little contribution of chlorogenic acid to browning reactions in peach flesh compared to other phenolics that are present.

Senter and Callahan (1990) defined peach quality as the culmination of fruit size, color, texture, flavor, and aroma. For processed peaches, these characteristics must be maintained throughout pasteurization and storage while preventing significant physicochemical or sensory changes affecting quality. Retaining maximum quality during both fresh fruit storage and thermal pasteurization has been a research goal of numerous investigators. Robertson et al. (1990) determined a maximum storage life of 4 weeks at 0 °C for fresh peaches prior to quality deterioration, while Gorney et al. (1999) showed that ascorbic acid, calcium lactate, and modified atmospheres were marginal in extending the shelf life of fresh-cut peaches. Residual polyphenoloxidase (PPO) activity was hypothesized to cause a decrease in color characteristics in partially processed peach puree during storage (Bian et al., 1994), while nonenzymatic browning in pasteurized peach purees was attributed to reducing the extent of sugar degradation and HMF formation (Garza et al., 1999).

The objective of our study was to determine the physicochemical, sensory, and shelf life stability of pasteurized peach puree with and without peeling as affected by blanch time prior to maceration. Maintaining desirable color, flavor, and antioxidant properties of purees macerated without peeling may justify removing this commercial unit operation.

MATERIALS AND METHODS

Materials and Processing. Clingstone peaches (*Prunus persica)* were obtained from Gerber Products Co. (Ft. Smith, AR) and stored at 4 °C until they were processed. Whole

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Table 1. Sensory Lexicon Used for Training and Quantitative Descriptive Analysis

sensory term[a]	definition[b]	reference[c]	intensity[d]
sweet	the basic taste perceived on the tongue, stimulated by sugars and high-potency sweeteners	solutions of sucrose in water	based on "sweet" solutions
sour	the basic taste perceived on the tongue, stimulated by acids	solutions of citric acid in water	based on "sour" solutions
bitter	the basic taste perceived on the tongue, stimulated by solutions of caffeine, quinine, and certain other alkaloids	solutions of caffeine in water	based on "bitter" solutions
cooked peaches	the aromatic associated with cooked or processed peaches; "cooked" generally implies processed notes	Gerber and Heinz brands of strained peaches	based on universal references
uncooked peaches (raw peaches)	the aromatic associated with unprocessed and/or uncooked or unheated peaches	raw and fresh frozen peaches	based on universal references
green	the aromatic characteristic of certain green fruits and underripe fruits in general	fresh frozen peaches	based on universal references
pitty/woody	the aromatic associated with peach pits; often a woody note	fresh peach pits	based on universal references
musty/moldy	aromatic characteristic of damp/wet basements or turned soil	geosmin (0.01% in water)	based on universal references
skin	the aromatic associated with peach skins; often described as having a musty note	fresh peach periderm	based on universal references
metallic	the aromatic associated with metals and/or the flat chemical feeling factor stimulated on the tongue and teeth by metal	metal can and tin foil	based on universal references
astringent	the chemical feeling factor on the tongue or other skin surfaces of the oral cavity described as puckering/dry mouth and associated with tannin or alum	solutions of alum in water	based on universal references

[a,b] From Ceville and Lyon (1996). [c,d] From Meilgaard et al. (1991).

peaches were randomly divided into two homogeneous groups of which half were washed in a 0.5% NaOCl and 0.2% Tween 20 solution for 3 min according to the method of Li et al. (1996), which was designated as the "peel on" treatment. Remaining peaches were peeled in an 8.5% lye solution at 100 °C for 1 min and then immediately rinsed with water to remove visible periderm (Bian et al., 1994), which was designated as the "peel off" treatment. All samples were pitted and peach halves (peel on and peel off) randomly divided in half again and steam blanched for either 2 min ("short blanch") or 20 min ("long blanch") in a stainless steel pan. Each treatment sample (four total) was blended into a puree with 25% added water and 0.03% ascorbic acid (fresh weight) and passed through a 1 mm finishing screen to remove residual peel. Processing yield was determined by average weight differential of the final puree between peel on and peel off treatments. All treatment samples were filled at 30 °C into 211 × 300 metal cans, sealed and immersed in boiling water for 30 min. Samples were stored at 40 °C and analyzed at 0, 1, 2, and 4 weeks of storage for physicochemical attributes and at 0, 2, and 4 weeks for sensory evaluation. An unpasteurized sample from each treatment was kept immersed in ice until analysis the next day, and was used to compare physicochemical changes that occurred during processing.

Physicochemical Analysis. Phenolic acids were extracted by blending 50 g of peach puree with 100 mL of methanol acidified with HCl (1000:1) for 1 min. The homogenate was filtered through Miracloth (Calbiochem, La Jolla, CA), washed four times with 25 mL of methanol, and then concentrated to 25 mL on a rotary evaporator at 45 °C. A 3 mL portion was then centrifuged at 2500*g* for 5 min at 18 °C, filtered through a 0.45 μm filter, and analyzed by HPLC for individual phenolic acids. Separation was conducted on a 100 mm × 4.6 mm Alltech Sperisorb ODS C_{18} column (Alltech Associates, Inc., Deerfield, IL) connected in series to a 150 mm × 3.9 mm Waters Nova-Pak C_{18} column (Waters Corp., Milford, MA), and peaks were monitored using a Waters 996 photodiode array detector at 280 nm. A gradient mobile phase was run consisting of 98% water and 2% acetic acid in phase A and 68% water, 30% acetonitrile, and 2% acetic acid in phase B (Ramamurthy et al., 1992). The gradient of phase B ran from 0 to 30% for 20 min, from 30 to 50% for 10 min, from 50 to 70% for 20 min, and from 70 to 100% for 5 min at a rate of 0.8 mL/min. Phase B ran for an additional 15 min to elute remaining nonpolar compounds, and the column was equilibrated with 100% phase A prior to the next sample injection. Spectral characteristics of phenolic acids and 5-(hydroxymethyl)-2-furaldehyde (HMF) were compared to those of external standards (Sigma Chemical Co., St. Louis, MO) for identification and quantification.

Color, pH, sugars, total carotenoids, and total soluble phenolics (Folin−Ciocalteau assay) were analyzed according to the method of Howard et al. (1996) in an aqueous extract (5 g/30 mL). Total phenolics were expressed in chlorogenic acid equivalents. Total solids were measured by drying puree in a forced air oven (2 h at 135 °C) and all data expressed on a dry weight (DW) basis. Antioxidant activity was determined with 50 μL of the aqueous extract, filtered through a 0.45 μm filter, using the coupled oxidation of β-carotene and the linoleic acid assay described by Lee et al. (1995) with 90 mM hydrogen peroxide as the oxidant source.

Sensory Analysis. Six professionally trained panelists (Sensory Spectrum, Chatham, NJ), employed by the Institute of Food Science and Engineering at the University of Arkansas, performed quantitative descriptive analysis on the four treatment samples at 0, 2, and 4 weeks of storage. All samples were randomly evaluated under red light in a sensory testing laboratory consisting of individual testing booths and positive pressure. Panelists were trained in two separate sessions to evaluate the attributes of sweet, sour, bitter, cooked, uncooked, green, pitty/woody, musty/moldy, skin, metallic, and astringent. Sensory terms and references (Civille and Lyon, 1996) are listed in Table 1, while reference products and sensory scale values were obtained from Meilgaard (1991). Three cans from each treatment were homogenized into a composite sample for serving, and 1.5 oz of puree was randomly presented in three-digit-coded 2 oz plastic soufflé cups with lids at room temperature. Plastic spoons were provided for product evaluation. Samples were expectorated after evaluation, and panelists were instructed to cleanse their palate between samples using unsalted crackers and water. The intensities of each attribute were quantified to one significant digit on a

Table 2. Chlorogenic Acid, Neochlorogenic Acid, Total Phenolics, and Ascorbic Acid Content of Peach Puree As Influenced by Preprocessing Peeling Treatments (peel on and peel off) and Blanching Times [short (SB) and long (LB)][a]

	chlorogenic acid (mg/kg of DW)		neochlorogenic acid (mg/kg of DW)		total soluble phenolics[b] (mg/kg of DW)		ascorbic acid (mg/kg of DW)	
	SB	LB	SB	LB	SB	LB	SB	LB
peel on								
unprocessed	38.6 c[c]	111 d	13.7 c	58.1 bc	10600 a	14100 b	143 c	2620 b
day 0	167 a	179 a	76.4 a	79.2 ab	10200 a	14700 a	549 a	3120 a
week 1	141 b	149 b	62.7 b	62.1 ab	10400 a	13900 b	406 b	2010 c
week 2	139 b	151 b	57.4 b	56.4 c	9550 b	13900 b	173 c	943 d
week 4	131 b	132 c	59.1 b	52.4 c	9680 b	12900 c	26.4 d	896 d
mean[d]	123 b	144 a	53.9 b	61.6 a	10100 b	13900 a	259 b	1918 a
peel off								
unprocessed	52.8 c	59.4 c	33.1 c	40.8 d	11900 a	13100 b	1530 b	455 d
day 0	117 a	111 a	72.6 a	74.9 a	12400 a	14400 a	1860 a	2110 a
week 1	91.7 b	81.6 b	49.7 b	51.7 bc	11900 a	13600 b	1340 c	1680 b
week 2	95.8 b	93.6 b	50.2 b	57.1 bc	10900 b	13300 b	482 d	1250 c
week 4	92.5 b	85.5 b	50.1 b	48.9 c	10100 c	13100 b	472 d	995 c
mean	89.9 a	86.2 a	51.1 a	54.7 b	11400 b	13500 a	1140 b	1300 a

[a] Peach puree was analyzed prior to pasteurization (unprocessed), after pasteurization (day 0), and after storage for 1, 2, and 4 weeks at 40 °C. [b] Expressed as chlorogenic acid equivalents. [c] Similar letters between columns indicate that the overall effects due to processing and storage (within peel on and peel off treatments) are not significantly different (LSD test, $P < 0.05$). [d] Similar letters between columns for mean values indicate that the overall effect due to time of blanch (within peel on and peel off treatments) is not significantly different (LSD test, $P < 0.05$).

Table 3. (+)-Catechin, Caffeic Acid, and Two Unidentified Phenolic Acids in Peach Puree As Influenced by Preprocessing Peeling Treatments (peel on and peel off) and Blanching Times [short (SB) and long (LB)][a]

	(+)-catechin (mg/kg of DW)		caffeic acid (mg/kg of DW)		average at 266.2 nm[b] (mg/kg of DW)		average at 275.7 nm[c] (mg/kg of DW)	
	SB	LB	SB	LB	SB	LB	SB	LB
peel on								
unprocessed	19.2 a[d]	5.41 ab	32.1 a	22.8 a	512 bc	518 a	65.7 b	76.8 a
day 0	8.66 bc	11.6 a	ND[e] c	ND c	539 ab	495 a	87.6 a	70.1 a
week 1	6.95 c	9.14 ab	8.64 b	7.18 b	571 ab	529 a	87.4 a	68.4 a
week 2	3.59 d	2.61 b	11.4 b	10.7 b	561 ab	529 a	87.1 a	82.3 a
week 4	12.6 b	2.69 b	10.1 b	15.2 ab	561 ab	547 a	81.8 a	75.6 a
mean[f]	10.2 a	6.29 b	15.6 a	11.2 a	549 a	524 b	81.9 a	74.6 a
peel off								
unprocessed	11.2 a	4.87 a	35.5 a	24.6 a	406 b	364 b	68.7 b	68.7 b
day 0	3.24 c	3.00 a	ND c	ND c	495 a	428 a	88.2 a	84.4 a
week 1	6.02 b	3.87 a	6.03 b	8.06 b	478 a	432 a	81.7 ab	78.7 ab
week 2	6.61 b	4.49 a	8.16 b	9.80 b	478 a	458 a	79.9 ab	81.6 a
week 4	1.22 d	ND b	8.94 b	8.10 b	507 a	462 a	89.8 a	83.6 a
mean	5.66 a	3.25 b	11.7 a	10.1 a	473 a	429 b	81.7 a	79.4 b

[a] Peach puree was analyzed prior to pasteurization (unprocessed), after pasteurization (day 0), and after storage for 1, 2, and 4 weeks at 40 °C. [b] Average of six unknown isomeric/polymeric compounds (t_R = 22.8, 32.2, 40.9, 45.2, 52.0, and 53.0 min) with UV spectral characteristics at 266.2 nm. [c] Average of four unknown isomeric/polymeric compounds (t_R = 36.8, 51.3, 54.1, and 59.4 min) with UV spectral characteristics at 275.7 nm. [d] Similar letters between columns indicate that the overall effects due to processing and storage (within blanching and peeling treatments) are not significantly different (LSD test, $P < 0.05$). [e] ND, not detected. [f] Similar letters between columns for mean values indicate that the overall effect due to time of blanch (within peel on and peel off treatments) is not significantly different (LSD test, $P < 0.05$).

0−15 Spectrum intensity scale. Each treatment sample at each storage time was evaluated twice by each of the panelists.

Statistical Analysis. Chemical data represent the means of three subsamples (three cans of puree) taken from each treatment, at each sampling time. The experiment was designed as a 2 × 2 factorial with the factors peeling (on or off) and blanching (short or long) tested over time. Sensory data represent the means of two subsamples evaluated by each of the panelists. Multiple linear regression, analysis of variance, and Pearson correlations were conducted using JMP software (SAS Institute, 1996), and mean separation using the LSD test ($P < 0.05$).

RESULTS AND DISCUSSION

Chemical Analysis. *Antioxidant Activity*. Chemical attributes of strained peaches were significantly impacted by leaving the periderm intact and by preprocessing blanching times (Tables 2 and 3; $P < 0.05$). Purees containing periderm tissue after a long blanch were initially 7−11% higher in AOX after pasteurization compared to peeled samples (Figure 1). Short blanch samples containing periderm material had the lowest initial AOX, but the level of retention was greater during storage than that of peeled samples. The margin between peel on and peel off samples increased to 22% on average after 2 weeks storage at 40 °C due to significant declines in AOX of peeled samples. Additional anthocyanin, flavonoid, or other phenolic compounds present in the periderm likely accounted for these differences, which have been shown to affect the AOX of numerous commodities (Miller and Rice-Evans, 1997; Kähkönen et al., 1999; Ju and Bramlage, 1999; Prior et al., 1998). After processing and storage, large differences in AOX were observed between samples from the two peeling treatments after a long or short blanch, but on average no significant overall difference based on blanch time was observed. The lack of overall difference was caused by the long blanch having a

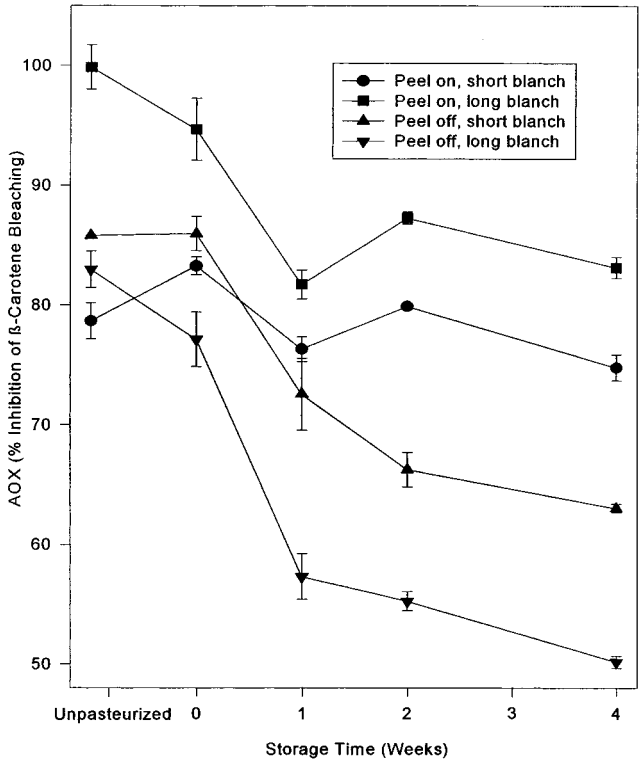

Figure 1. Changes in antioxidant activities (AOX) of pasteurized peach puree with and without periderm material as affected by a long (20 min) or short (2 min) blanch time. Puree was analyzed prior to pasteurization (unprocessed), after pasteurization (day 0), and after storage for 1, 2, and 4 weeks at 40 °C. Bars represent the standard error of the mean ($n = 3$).

higher AOX than the short blanch when the periderm was intact, but the opposite was observed in peeled samples.

Antioxidant Compounds. Total water-soluble phenolic compounds (Folin−Ciocalteau assay) were significantly affected by the long blanch time and were present at a level 3000 mg/kg of DW higher than that after the short blanch, due to increased tissue softening and enhanced chemical extraction with the additional heat applied prior to pasteurization (Table 2). Minor differences were observed for total phenolics between the peeling treatments, which was unexpected since the periderm has been shown to contain higher levels of phenolic compounds (Chang et al., 2000). Ascorbic acid, which was added to prevent browning reactions during maceration, was present at a level 900 mg/kg of DW higher on average in long blanch samples after pasteurization and storage, while levels were 280 mg/kg of DW lower on average during storage with the periderm intact. The long blanch was likely instrumental in inactivating PPO (not measured), resulting in enhanced retention of both phenolic compounds and ascorbic acid. Levels of total soluble phenolics and ascorbic acid decreased after storage at 40 °C, and despite decreases in AOX over time, these two variables were poorly correlated to AOX ($r = 0.18$ and 0.36, respectively).

Numerous individual phenolic compounds in peach puree were identified by HPLC, and levels were affected by the presence of the periderm and blanching time (Tables 2 and 3). A typical HPLC chromatograph of unpasteurized peach puree is shown in Figure 2A and a chromatogram recorded after storage for 4 weeks at 40 °C in Figure 2B. The predominant phenolic acids

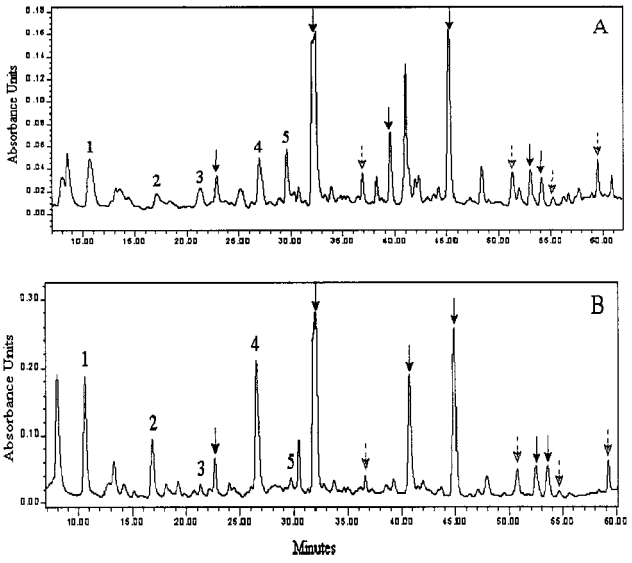

Figure 2. Typical HPLC chromatograph of peach puree recorded at 280 nm (A) unpasteurized and (B) after storage for 4 weeks at 40 °C: (1) HMF, (2) neochlorogenic acid, (3) (+)-catechin, (4) chlorogenic acid, and (5) caffeic acid. Arrows indicate unidentified compounds with maximum absorbance at 266.2 nm (solid arrows) and 275.7 nm (dotted arrows).

positively identified were chlorogenic acid and its more polar isomer, neochlorogenic acid. The level of chlorogenic acid was poorly correlated to levels of total soluble phenolics, presumably due to reactions of fructose or ascorbic acid in the Folin−Ciocalteau assay, but the level of chlorogenic acid detected by HPLC showed the best relationship to AOX in the study ($r = 0.82$). Along with that of (+)-catechin, the levels of chlorogenic and neochlorogenic acid increased as a result of thermal processing and slowly declined during storage due to autoxidative degradation. Concentrations of these compounds were not appreciably different between a long or short blanch time, but chlorogenic acid was present at a level that was 52 mg/kg of DW higher with the periderm intact. Initial levels of caffeic acid (28 mg/kg of DW on average) were lost during pasteurization, but increased slightly in response to chlorogenic acid hydrolysis during storage. The sums of individual phenolic compounds quantified by HPLC were also in poor agreement with Folin−Ciocalteau values ($r = 0.17$), but overall were 110 mg/kg of DW higher in samples processed with the periderm intact.

In addition to the common cinnamic acid derivatives found in peach puree, two additional compounds, quantified as chlorogenic acid equivalents, were identified that appeared to have either multiple isomeric or polymeric forms. The first of these compounds had a single absorption maximum at 266.2 nm and had at least six isomeric/polymeric forms that ranged widely in polarity (Figure 2, solid arrows). When summed together to study their overall trends, the levels of these compounds generally increased with pasteurization and they were more prevalent in peaches processed with the periderm intact and with a short blanch. The presence of this compound(s) in the short blanch samples may provide evidence for PPO-catalyzed reactions causing either polymer formation or isomerization of the parent compound. The second unknown compound also had a single absorption maximum at 275.7 nm with at least four isomeric/polymeric forms present (Figure 2, dotted arrows). The levels of the two most polar isomers ($t_R =$

Table 4. Changes in Color and pH of Peach Puree As Influenced by Preprocessing Peeling Treatments (peel on and peel off) and a Short (SB) and Long Blanch (LB)[a]

	lightness		chroma		hue angle		pH	
	SB	LB	SB	LB	SB	LB	SB	LB
peel on								
unprocessed	45.1 a[b]	46.1 a	30.1 abc	29.9 a	87.1 b	86.8 b	4.33 a	4.26 a
day 0	44.7 a	45.5 ab	30.8 a	29.8 a	88.1 a	87.8 a	4.32 b	4.22 b
week 1	43.9 b	44.8 b	27.6 c	29.1 a	88.1 a	87.6 a	4.29 c	4.19 c
week 2	44.1 b	45.1 b	28.6 bcd	29.3 a	87.6 a	88.3 a	4.27 d	4.18 d
week 4	43.1 c	44.7 b	26.1 d	27.6 b	86.1 c	86.4 c	4.26 e	4.15 e
mean[c]	44.2 b	45.2 a	28.6 a	29.1 a	87.4 a	87.4 a	4.29 a	4.20 b
peel off								
unprocessed	45.6 a	45.2 a	29.7 a	29.9 a	91.2 a	90.6 b	4.49 a	4.46 a
day 0	44.4 bc	44.2 b	28.1 ab	28.2b	91.4 a	92.6 a	4.35 b	4.29 b
week 1	43.7 bc	43.7 b	27.9 b	27.6 b	91.3 a	92.3 a	4.29 c	4.24 c
week 2	43.5 c	43.8 b	27.1 b	28.2 b	90.7 a	92.1 a	4.29 d	4.22 d
week 4	43.7 bc	43.6 b	26.8 b	26.1 c	89.1 b	90.1 b	4.26 e	4.20 e
mean	44.2 a	44.1 a	27.9 a	28.0 a	90.7 b	91.5 a	4.34 a	4.28 b

[a] Peach puree was analyzed prior to pasteurization (unprocessed), after pasteurization (day 0), and after storage for 1, 2, and 4 weeks at 40 °C. [b] Similar letters indicate that overall effect due to processing and storage (within peel on and peel off) is not significantly different (LSD test, $P<0.05$). [c] Similar letters between columns for mean values indicate that overall effect due to time of blanch (within peel on and peel off treatments) is not significantly different (LSD test, $P<0.05$).

36.8 and 51.3 min) decreased continuously during storage, indicating possible oxidation, while the levels of the two least polar compounds (t_R = 54.1 and 59.4 min) increased continuously during storage. However, only small differences were observed due to blanch time and the presence of periderm material. Cheng and Crisosto (1995) also encountered unidentified phenolic acids in peach skins, thought to be hydroxybenzoic acid derivatives, which were related to enzymatic browning potential. On the basis of spectral properties of common phenolic compounds (Bartolomé et al., 1993) and comparison to co-injected standards, the unidentified compounds in our study were also likely hydroxy or methoxy substitutions of benzoic acid.

Sugars. Only small overall differences were observed after pasteurization and storage between the peeling and blanching treatments for sucrose, glucose, and fructose (40.1, 8.4, and 9.3 g/100 g of DW, respectively). Levels of sucrose decreased by 5.3 g/100 g of DW during pasteurization and storage due to acid hydrolysis, subsequently increasing levels of glucose and fructose (5.9 and 6.7 g/100 g of DW, respectively), confirming changes previously observed during storage (Kluter et al., 1994; Garza et al., 1999). Additionally, degradation of either reducing sugars or ascorbic acid occurred, which promoted the formation of HMF. Levels of HMF increased from nondetectable before pasteurization to 32 mg/kg of DW after pasteurization. In all treatments, the final and maximum concentration of HMF (190 mg/kg of DW) was attained during the second week of storage.

Quality Attributes. *Color.* Processing peaches into a puree with the periderm intact had some advantages over conventional processing methods where the peel is removed prior to additional unit operations. Periderm intact samples had additional anthocyanin-based pigments incorporated into the product that resulted in a slightly orange and less yellow product. Additionally, processing yield was increased by 7.6%, and may be especially beneficial for overripe fruit where losses due to peeling can be minimized. The additional pigmentation from the periderm served to lower the hue angle by 3.93° prior to processing and by an average of 3.60° after processing and storage (Table 4). Hue angles for periderm intact samples were not appreciably different between the long and short blanch, but hue angles for peeled peaches with a short blanch were 0.86° lower after processing and storage, indicating possible PPO-induced browning in these samples prior to pasteurization. Despite the decreased hue angle caused by periderm material, their lightness values were actually higher than that of peeled peaches by 0.55 unit. Lightness values were likely dependent on blanch time and thermal inactivation of PPO, which has been shown to retard browning reactions (Bian et al., 1994; Bucheli and Robinson, 1994; Tourjee et al., 1998). However, no difference was observed in chroma values between peeling or blanching treatments, indicating equal color intensities for all samples. During storage, both lightness and chroma values decreased steadily with time, indicating that additional browning reactions were occurring from either phenolic oxidation (Talcott and Howard, 1999), HMF formation (Garza et al., 1999), or carotenoid oxidation (Tourjee et al., 1998).

pH. An increase of 0.18 pH unit was observed in peeled, unpasteurized purees as compared to periderm intact samples, which may be attributed to residual levels of alkali on the fruit surface. However, after processing and storage, this difference was no longer apparent. The long blanch appeared to cause additional tissue softening and destruction of cellular membranes, resulting in a decrease of 0.07 unit compared to that of short blanch samples. The pH declined continuously during storage at 40 °C for all treatments, but lye-peeled samples decreased by an average of 0.25 pH unit compared to 0.09 unit for periderm intact samples.

Sensory Analysis. The trained descriptive analysis panel was able to differentiate between the attributes of cooked, uncooked, skin, and musty/moldy between sample treatments and during storage. The remaining attributes (sweet, sour, bitter, green, pitty/woody, metallic, and astringent) were insignificant between blanch time and peeling treatments ($P > 0.43$, Table 5). The lack of perceived difference between the taste attributes of sweet (3.3 ± 0.2), sour (3.4 ± 0.3), bitter (1.1 ± 0.1), and astringent (3.1 ± 0.1) and the aromatic attributes of green (2.8 ± 0.3), pitty/woody (2.3 ± 0.3), and metallic (2.5 ± 0.2) were important aspects for determining the feasibility of processing without periderm removal. Additionally, peaches containing periderm material were perceived as being less cooked, and likewise more uncooked, than peeled samples (-0.67 ± 0.2 and 0.74

Table 5. Sensory Attributes of Peach Puree As Influenced by Preprocessing Peeling Treatments (peel on and peel off)[a]

	day 0		week 2		week 4	
	peel on	peel off	peel on	peel off	peel on	peel off
sweet	3.38 a[b]	3.15 a	3.19 a	3.16 a	3.41 a	3.34 a
sour	3.40 a	3.49 a	3.46 a	3.32 a	3.38 a	3.27 a
bitter	1.05 a	1.01 a	1.26 a	1.26 a	1.03 a	0.81 a
cooked	3.19 b	4.28 a	4.16 a	4.59 a	4.23 a	4.73 a
uncooked	3.10 a	2.08 b	2.50 a	2.22 a	3.28 a	2.35 a
green	3.59 a	2.69 a	2.30 a	2.74 a	2.76 a	2.55 a
pitty/woody	2.92 a	2.54 a	2.15 a	1.85 a	2.55 a	2.11 a
musty/moldy	2.97 a	2.01 a	0.63 a	0.74 a	ND[c] a	ND a
skin	2.63 a	0.67 b	2.61 a	1.12 b	3.43 a	2.03 b
metallic	3.36 a	3.48 a	3.08 a	3.26 a	3.57 a	3.48 a
astringent	3.16 a	3.06 a	3.12 a	3.02 a	3.13 a	3.06 a

[a] Peach puree was analyzed after pasteurization (day 0) and after storage for 2 and 4 weeks at 40 °C. [b] Columns with similar letters not significantly different for each sensory attribute at each sampling time (LSD test, $P < 0.05$). [c] ND, not detected.

± 0.3, respectively). Reduced cooked perception in peach puree may indicate retention of desirable attributes of the raw fruit. However, the aromatic perception of skin was also enhanced with the periderm tissue intact (1.61 ± 0.3). The use of a 1 mm finishing screen in the study may have allowed for more peel material to be incorporated in the puree than would be expected from commercial finishing operations. Musty/moldy perceptions, often in close association with skin aroma, were indistinguishable between blanch and peeling treatments, but overall level of perception decreased from 2.5 ± 0.2 immediately after processing to an indistinguishable level after storage for 4 weeks at 40 °C. By using a descriptive panel, no information was obtained on overall sample preference or acceptability of peach puree containing periderm material; therefore, additional work utilizing a consumer sensory panel is recommended prior to commercial application.

CONCLUSIONS

The physicochemical and sensory feasibility of eliminating peeling steps prior to maceration into peach puree was evaluated. Despite an increased level of perception of undesirable aromatics in samples containing periderm material, these samples contained elevated levels of individual phenolic compounds with a resultant increase in AOX. Incorporation of these additional phenolic compounds from the periderm did not alter basic taste attributes, thus supporting the benefits of enrichment of bioactive phytochemicals. A long prepasteurization blanch time appeared to be critical for inactivating oxidizing enzymes, resulting in increased levels of ascorbic acid and total water-soluble phenolic compounds. Periderm material served to lower hue angles from yellow to slightly orange due to changes from skin pigmentation. This study demonstrated increased AOX and processing yield when peaches were macerated without periderm removal. Thus, the potential for maintaining desirable sensory quality when peach puree is processed with periderm intact appears to be promising for commercial processing applications.

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