ELSEVIER

Postharvest Biology and Technology 28 (2003) 159–167

Postharvest Biology and Technology

www.elsevier.com/locate/postharvbio

Consumer acceptance of 'Brooks' and 'Bing' cherries is mainly dependent on fruit SSC and visual skin color

Carlos H. Crisosto *, Gayle M. Crisosto, Paul Metheney

Department of Pomology, University of California at Davis Kearney Agricultural Center, 9240 South Riverbend Ave., Parlier, CA 93648, USA

Received 2 April 2002; accepted 28 July 2002

Abstract

During two seasons, 'in-store' consumer acceptance tests were performed to determine the relationship between soluble solids concentration (SSC), titratable acidity (TA) and visual skin color on 'Brooks' and 'Bing' cherry consumer acceptance. For this, approximately 600 consumers were presented cherry samples at targeted skin colors with SSC in the range of ca. 13.0–20.0% and TA in the range of ca. 0.50–1.00%. For each cherry sample, one half of the whole cherry was tasted and the other half was used to determine SSC and TA. TA > 0.60% reduced consumer acceptance on 'Brooks' cherries with < 16.0% SSC compared to cherries with ≤ 0.60% TA, while in 'Bing' the same situation only occurred on cherries with ≤ 13.0% SSC. High consumer acceptance was determined on 'Brooks' and 'Bing' cherries when SSC were > 16.0% without regard to TA. For both cultivars, the highest percentage of American consumers would buy cherries based on dark skin color without regard to ethnic group (Caucasian, Asian American, Hispanic, or Black) or gender. However, consumer age was related to making the 'buy' or 'not to buy' decision based on cherry skin color. Consumers under 18 years old were less biased to buy cherries based on visual skin color. Thus, this work demonstrated that for 'Brooks' and 'Bing' cherries, a full bright red or dark mahogany skin color should be reached, respectively, in addition to a minimum SSC of 16.0% to satisfy the majority of American consumers.

Keywords: *Prunus avium* L.; In-store consumer tests; Soluble solids concentration; Titratable acidity; Degree of liking; Consumer preferences; Demographics; Age

1. Introduction

High soluble solids concentration (SSC) and aroma have been associated with high fruit consumer preference and/or acceptance for different commodities (Pehrson and Ivans, 1988; Robertson and Meridith, 1989; Rodan, 1988; Nelson et al., 1963; Gorini and Lasorella, 1990); other quality attributes may also be important in consumer acceptance (Kader, 1999). For example, in peaches and nectarines, consumers will prefer full red color fruit to less full red color fruit (Bruhn, 1995). Furthermore, it has been pointed out in mango (Malundo et al., 2001) and other fruits (Crisosto,

* Corresponding author. Tel.: +1-559-646-6596; fax: +1-559-646-6593

E-mail address: carlos@uckac.edu (C.H. Crisosto).

0925-5214/02/$ - see front matter © 2002 Elsevier Science B.V. All rights reserved.
PII: S0925-5214(02)00173-4

unpublished) that aroma may play an important compensation role when SSC is lacking.

Minimum quality standards based on SSC to assure consumer satisfaction have been proposed for 'Bing' (Cliff et al., 1996; Dever et al., 1996; Drake et al., 1989; Kappel et al., 1996; Guyer et al., 1993; Schotzko, 1993) and 'Ranier' (Drake and Fellman, 1987) cherries. We believe that the relationship between SSC and TA and visual appearance plays an important role in consumer acceptance as it is reported for other commodities such as citrus (Pehrson and Ivans, 1988); table grapes (Guelf-Reich and Safran, 1971; Nelson et al., 1973; Crisosto and Crisosto, 2002); kiwifruit (Gorini and Lasorella, 1990; Crisosto and Crisosto, 2001) and mango (Malundo et al., 2001). Therefore, it is important to understand the potential involvement of TA in cherry consumer acceptance prior to proposing a minimum quality standard. This relationship between SSC and TA, and consumer acceptance may also be cultivar specific and even related to ethnic group.

'Bing' has been the dominant commercial cherry cultivar, but recently new cultivars that mature earlier or later than 'Bing' are now becoming commercially important (Crisosto et al., 2002; Kappel et al., 2002). For example, 'Brooks' ripens 5–7 days after 'Early Burlat' and about 7–12 days before 'Bing' (Crisosto et al., 1993). 'Brooks' was selected in the University of California cherry-breeding program among the progeny of a cross between 'Ranier' (white flesh) and 'Early Burlat' (Hansche et al., 1988).

The purpose of our research was to determine consumer acceptance of 'Brooks' and 'Bing' cherries in relation to SSC and TA, and the importance of visual cherry skin color on consumers' decision to buy. Understanding the relationships between the consumer, cherry quality attributes and industry-wide quality surveys will help to develop a minimum eating quality index for these two cultivars.

2. Materials and methods

'In-store' consumer tests were carried out on 'Brooks' and 'Bing' cherries for two seasons. A total of 581 and 596 consumers at a major supermarket, located in Fresno County, were interviewed for 'Brooks' and 'Bing' cherries, respectively. Based on our previous years' industry-wide surveys (Crisosto, 1997; Crisosto et al., 2002; Mitcham et al., 1998, 1999, 2000) to define a minimum quality index, each consumer was presented four cherry samples at the four targeted skin colors for each cultivar. Prior to tasting, nondestructive firmness (Durofel, COPA-TECHNOLOGY S.A., France) and color (Minolta colorimeter, Minolta, CR-200, Japan) were measured on one cheek of each whole cherry sample before cutting it in half to taste to avoid using too soft cherries. As hue angle was the most important color descriptor, cherry skin color was expressed only as hue angle (h°). The hue angle is expressed in degrees and is a measure of color that, for example, from 0 to 90° spans from red to orange to yellow. 'Brooks' cherries were segregated according to skin color based on our previous work (Crisosto et al., 1993, 2002) as full light red (Hue ~26.15), 50% bright red (Hue ~21.96), full bright red (Hue ~16.90), and full dark red (Hue ~11.85), while 'Bing' cherries were segregated using the chart from the *Centre Technique Interprofessionel des Fruits et legumes* (CTIFL, France). 'Bing' cherry skin color was defined as salmon (Hue ~27), red (Hue ~20.4), mahogany (Hue ~15.0), and dark mahogany (Hue ~13.3). One cherry half from each sample in a covered, labeled 29.6 ml soufflé cup was immediately placed in an ice chest and kept cold for immediate transport to the F. Gordon Mitchell Postharvest Laboratory for subsequent chemical analysis of SSC and TA (Crisosto and Crisosto, 2002). For both cultivars, each consumer that said he/she ate fresh cherries was asked to taste four cherry half samples presented in random order in coded 29.6 ml soufflé cups at room temperature. In both seasons, each consumer interviewed was asked to indicate their age range on a chart; the interviewer noted their gender and ethnic group. The consumer was instructed to wear dark glasses during the tasting to mask the skin color. For each cherry sample, the consumer was asked if he/she 'liked', 'disliked', or 'neither liked nor disliked' the sample. Then, the consumer was asked to indicate

his/her degree of liking/disliking: slightly, moderately, very much, or extremely. The consumer's response was recorded using a 9-point hedonic scale (1—dislike extremely to 9—like extremely). The consumer was instructed to sip bottled water in between samples to cleanse his/her palate.

Consumer acceptance was measured as both degree of liking (1–9) and percentage acceptance (O'Mahony, 1986). The percentage of consumers liking the cherry sample was calculated as the number of consumers liking the cherry sample (score > 5.0) divided by the total number of consumers within the sample (Lawless and Heymann, 1998). The percentage of consumers disliking the cherry sample (score < 5.0) was calculated as the number of consumers disliking the cherry sample divided by the total number of consumers within the sample. The percentage of consumers that neither liked nor disliked the cherry sample was calculated as the number of consumers that neither liked nor disliked the cherry sample (score $= 5.0$) divided by the total number of consumers within the sample.

After tasting the four samples, the consumer was instructed to remove the dark glasses. Then, he/she was presented one of three sets of 'Brooks' or 'Bing' cherries. Each set consisted of four cups in random order of three whole cherries with stems per cup of each of the four 'Brooks' or 'Bing' cherry skin colors previously tasted. The consumer was asked to look at the four cups of cherries and indicate just by looking at them which one he/she would buy. The percentage of consumers that would buy a specific skin color based solely on the visual skin color was calculated as the number of consumers choosing each skin color divided by the total number of consumers.

The degree of liking data was subjected to analysis of variance (ANOVA) prior to the Least Significant Differences (LSD) mean separation (Lawless and Heymann, 1998) using the SAS program.

3. Results and discussion

On cherries used for these 'in-store' consumer tests, single 'Brooks' cherry SSC measurements (581 cherries) varied from 9.0 to 27.0% (Fig. 1) and TA from 0.24 to 1.02% (Fig. 2) across skin color stages, while single 'Bing' cherry SSC measurements (596 cherries) varied from 11.4 to 27.0% (Fig. 3) and TA from 0.53 to 1.19% (Fig. 4) across skin color stages. For 'Brooks', average SSC varied from 12.8 to 21.6% and average TA changed from 0.47 to 0.67% as cherries turned from full light red to full dark red. For 'Bing', average SSC varied from 16.5 to 20.6% and average TA changed from 0.78 to 0.90% as cherries turned from salmon to dark mahogany. In both cultivars, at each given skin color stage, there was a large overlap of SSC and TA among the different skin color stages. For example, the distribution of SSC in 'Brooks' was similar between cherries at the 50% bright red and full bright red stages, while the distribution of SSC in 'Bing' cherries was similar between cherries at the mahogany and dark mahogany stages. An even larger overlap of TA occurred between different skin color stages for 'Brooks' and 'Bing' cherries,

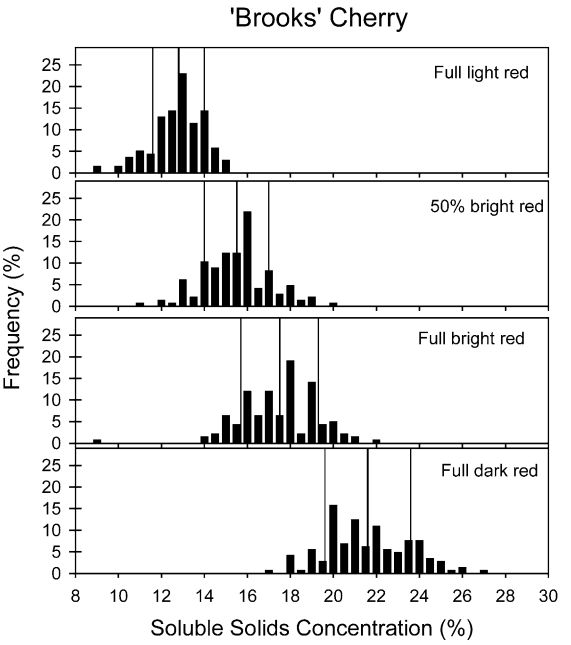

Fig. 1. Single cherry soluble solids concentration (SSC) for 'Brooks' across maturity based on skin color using 581 cherries. Central vertical line is the mean of the sample, outer vertical lines represent ± 1 S.D. about the mean.

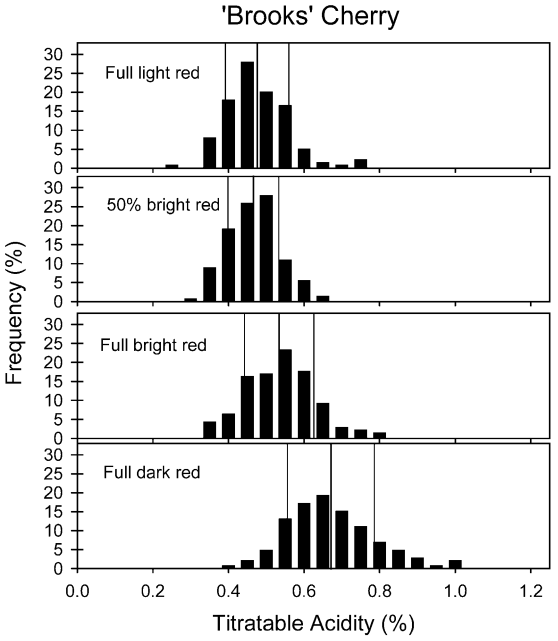

Fig. 2. Single cherry titratable acidity (TA) for 'Brooks' across maturity based on skin color using 581 cherries. Central vertical line is the mean of the sample, outer vertical lines represent ±1 S.D. about the mean.

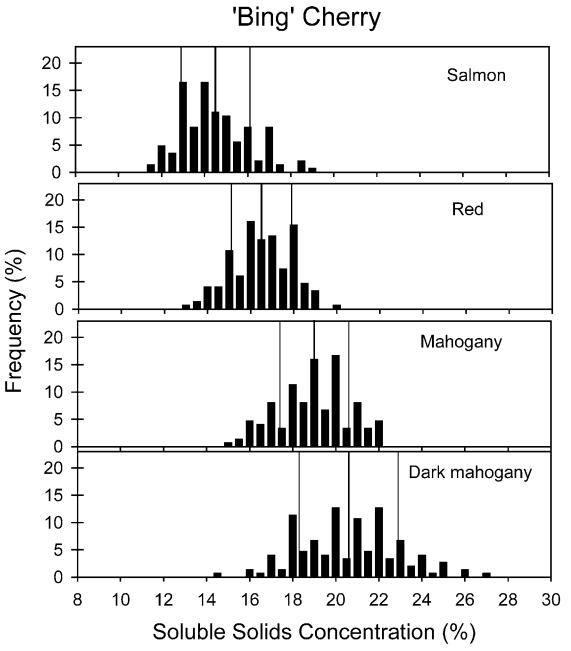

Fig. 3. Single cherry soluble solids concentration (SSC) for 'Bing' across maturity based on skin color using 596 cherries. Central vertical line is the mean of the sample, outer vertical lines represent ±1 S.D. about the mean.

although the average TA for 'Brooks' was always lower (ca. 0.30%) than the average TA for 'Bing' at each given skin color stage. This variability in quality attributes (SSC and TA) within a given skin color stage and its relationship to sensory perception variability was reported earlier on table grapes (Nelson et al., 1963).

In both cherry cultivars, there was a large increase in SSC and a small increase in TA as skin color turned from light to dark resulting in an increase in SSC:TA. A similar situation occurred in our 3 year industry-wide quality survey on 'Brooks' (Crisosto et al., 2002), which indicated that average TA changes during maturation/ripening (based on skin color changes) are small but depend on the orchard's specific conditions and year influence. For example, average TA for 'Brooks' across orchards and years changed from 0.81 to 0.77% during maturation/ripening while skin color changed from full light red to full dark red. During this same maturity period, SSC increased from 15.3 to 20.4% and SSC:TA increased from 20.3 to 27.6. This small change in TA during maturation/ripening was also observed in our 1997 quality attributes survey for 'Bing' carried out during May 8–22 in 36 orchards located in the Stockton area (Crisosto, 1997). In this survey, SSC ranged from 13.8 to 18.0%, TA varied from 1.00 to 1.20%, and SSC:TA ranged from 12 to 16 for 'Bing' cherries with skin color from red to dark mahogany. Mitcham's group has described similar TA changes for a 'Bing' orchard in their 3 years of work in California. (Mitcham et al., 1998, 1999, 2000). In this orchard, 'Bing' cherry average TA was 0.85% when measured at the salmon or the dark mahogany skin color. TA decreased from 0.85 to 0.81% when the skin color changed from salmon to red, but TA increased from 0.81 to 0.85% when skin color changed from mahogany to dark mahogany. During this same maturity period, SSC increased from 13.0 to 20.6% and SSC:TA from 15.3 to 24.2. While skin color turned from light to dark, there was a large increase in cherry SSC and a small increase in TA. In all of these cases, the increase in SSC:TA

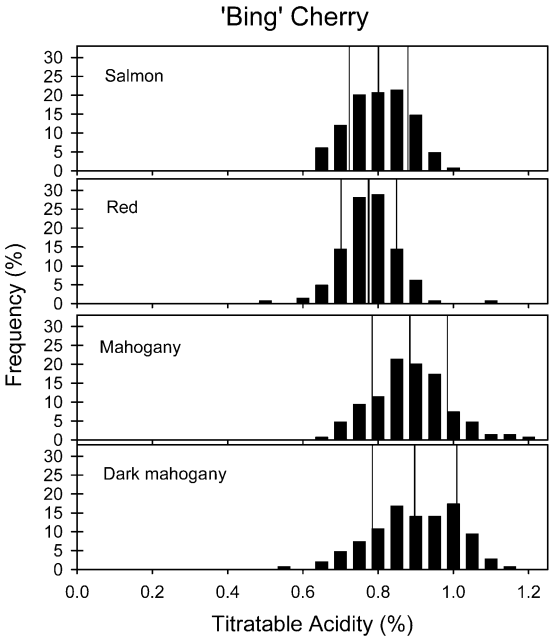

Fig. 4. Single cherry titratable acidity (TA) for 'Bing' across maturity based on skin color using 596 cherries. Central vertical line is the mean of the sample, outer vertical lines represent ±1 S.D. about the mean.

that occurred at the end of the maturation/ripening period was mainly related to an increase in SSC rather than a decrease in TA. It appears that TA level varied according to cultivar, environmental and orchard management conditions, but TA changes and the final TA level were not highly influenced by maturation/ripening. During our previous work, we observed a decrease in TA during storage for 'Brooks', 'Tulare', 'King,' and 'Garnet' cherries (unpublished data). Similar observations have been published for other sweet cherry cultivars such as 'Bing', 'Lapins', 'Santina', 'Skeena',' Sumnue Cristalina', 'Sweetheart', etc. (Kappel et al., 2002).

Degree of liking in our single cherry samples was significantly related to SSC and TA. In general, consumer acceptance responses were divided into two groups based on the relationship between degree of liking and TA within the SSC range tested. There was a significant separation in liking between 'Brooks' cherries with $\leq 0.60\%$ TA and $> 0.60\%$ TA (Table 1). 'Brooks' cherries with

Table 1
Consumer acceptance of 'Brooks' cherries by American consumers at different levels of titratable acidity within the SSC range tested

TA range[z] (%)	Degree of liking[y] (1–9)	Acceptance (%)
< 0.50	5.9b	49
0.50–0.60	6.3b	64
0.61–0.70	6.6a	76
0.71–0.80	7.0a	80
0.81–1.00	7.4a	95
$LSD_{0.05}$	0.85	–
P-value	0.0001	–

[z] TA, single cherry measurements expressed as percentage malic acid.

[y] Degree of liking: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely. Same letters within the same column indicate no significant difference between means.

TA $\leq 0.60\%$ were accepted by 49–64% of consumers while degree of liking score varied from 5.9 to 6.3. On cherries with TA $> 0.60\%$ acceptance ranged from 76 to 95%, while degree of liking score varied from 6.6 to 7.4. For 'Bing' cherries, consumer acceptance was also divided into two groups based on the relationship between degree of liking and TA across the SSC range tested. There was a significant separation in degree of liking between cherries with TA $\leq 0.80\%$ and TA $> 0.80\%$. 'Bing' cherries with TA $\leq 0.80\%$ were accepted by 49 to 55% of consumers while degree of liking score varied from 5.5 to 5.7. On cherries with TA $> 0.80\%$ acceptance ranged from 66 to 80% while degree of liking score varied from 6.0 to 6.6 (Table 2). In general, 'Brooks' cherries with TA $> 0.60\%$ and 'Bing' cherries with TA $> 0.80\%$ had the highest SSC levels and thus, the highest SSC:TA. The increase in SSC:TA during the maturation/ripening period resulted from the higher increase in SSC than the increase in TA. This explains why consumer acceptance increased as TA increased in these samples. In all of the cases, the increase in TA was accompanied with an increase in SSC:TA.

Because there was significant interaction between SSC and TA on the degree of liking, consumer acceptance based on SSC for two levels

Table 2
Consumer acceptance of 'Bing' cherries by American consumers at different levels of titratable acidity within the SSC range tested

TA range[z] (%)	Degree of liking[y] (1–9)	Acceptance (%)
0.50–0.70	5.5b	49
0.71–0.80	5.7b	55
0.81–0.90	6.0a	66
0.91–1.20	6.6a	80
$LSD_{0.05}$	0.73	
P-value	0.0001	

[z] TA, single cherry measurements expressed as percentage malic acid.

[y] Degree of liking: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely. Same letters within the same column indicate no significant difference between means.

of TA was analyzed for both cultivars. In both cultivars, consumer acceptance increased as SSC increased. For 'Brooks' cherries with $\leq$13.0% SSC, degree of liking was not significantly different for cherries with $>$0.60% TA (score 3.9) and for cherries with $\leq$0.60% TA (score 3.7). The number of consumers that liked the cherries within this category ranged from 11.1 to 26.6%. Thus for 'Brooks' cherries with SSC $\leq$ 13.0% TA did not play a role in consumer acceptance. For cherries within the 13.1–16.0% SSC range, consumers liked 'slightly' (5.9 score) 'Brooks' cherries with $\leq$ 0.60% TA, while they 'neither liked nor disliked' (4.7 score) cherries with $>$0.60% TA. For cherries within the 13.1–16.0% SSC range with $\leq$0.60% TA consumer acceptance was 66.7% while it was only 42.9% for cherries within the same SSC range with $>$0.60% TA. For 'Brooks' cherries with $>$ 16.0% SSC, TA did not influence consumer responses. TA played an important role in consumer acceptance of cherries with $\leq$16.0% SSC and TA $>$ 0.60%. Within this range of SSC and TA, high SSC compensated for high TA, or low TA compensated low SSC, thus SSC:TA was more sensitive to consumer acceptance than SSC within this range of SSC and TA. Consumers liked 'moderately' (ca. 7.3 score), cherries with $>$ 16.0% SSC disregarding TA reaching the highest consumer acceptance (86.5–96.7%). Cherry acceptance did not significantly increase on cherries with $>$20% SSC (Table 3). In a previous work carried out on 'Ranier', one of 'Brooks' parents (Drake and Fellman, 1987), a minimum quality index of 16.0% SSC was proposed.

The influence of SSC on 'Bing' cherry consumer acceptance with $\leq$0.80% TA and $>$0.80% TA was determined (Table 4). For 'Bing' cherries with $\leq$13.0 SSC, degree of liking was significantly lower on cherries with $>$0.80% TA (score 2.4) than for cherries with $\leq$0.80% TA (score 4.1). In both cases, consumer acceptance was 31.8% or lower. Cherries within the 13.1–16.0% SSC range were 'neither liked nor disliked' (5.3 score) disregarding TA and acceptance varied from 47.7 to 58.3%. The same situation occurred on cherries within the 16.1–20.0% SSC range; cherries were liked 'slightly' (6.1 score) and acceptance varied from 70.0 to 72.3%. Consumer acceptance increased significantly for cherries with SSC $>$ 20.0%. These cherries were liked 'moderately' disregarding TA (ca. 7.3 score) and acceptance reached approximately 90%. In this cultivar, TA only influenced consumer acceptance for cherries with $\leq$13.0% SSC. However, consumer acceptance was the highest for cherries with $>$20% SSC.

In both cultivars, the number of consumers that chose the 'neither like nor dislike' option varied from 22.2 to 0%. Based on the results of our work, 'Bing' cherries with $>$16.0% SSC without regard to TA were always liked by consumers but with different degrees of liking. A minimum SSC of 17.0–19.0% was considered optimum by trained sensory panels for several sweet cherry cultivars grown in British Columbia (Kappel et al., 1996). For 'Bing', a minimum of 17.0% SSC has been suggested after an informal consumer test (Schotzko, 1993).

The influence of cherry skin color on the decision to 'buy' or 'not to buy' 'Brooks' and 'Bing' cherries was also tested for demographics, i.e. gender, ethnic group, and age range. Consumers decided to buy cherries according to skin color; the darker the skin color the higher the percentage of consumers that would buy them. Gender and ethnic group (Caucasian, Asian,

Table 3
Consumer acceptance of 'Brooks' cherry by American consumers at different levels of soluble solids concentration (SSC) and titratable acidity (TA) measured as percentage malic acid

Quality attributes	Degree of liking (1–9)[z]	Acceptance (%)	Neither like nor dislike (%)	Dislike (%)
TA ≤ 0.60%				
SSC ≤ 13.0%	3.9c[y]	26.7	17.4	55.8
SSC 13.1–16.0%	5.9b	66.7	12.2	21.1
SSC 16.1–20.0%	7.2a	86.5	5.0	8.5
SSC > 20.0%	7.0a	87.5	4.2	8.3
TA > 0.60%				
SSC ≤ 13.0%	3.7c	11.1	22.2	66.7
SSC 13.1–16.0%	4.7c	42.9	0.0	57.1
SSC 16.1–20.0%	7.2a	90.0	2.5	7.5
SSC > 20.0%	7.7a	96.7	0.0	3.3
$LSD_{0.05}$	1.1	–	–	–
P-value	0.0001			

[z] Degree of liking: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely.
[y] Same letters within the same column indicate no significant difference between means.

Hispanic and Black) did not affect the decision to 'buy' according to skin color (data not shown). Approximately 64% of the consumers decided to 'buy' 'Brooks' cherries with full dark red color, approximately 22% of consumers decided to ''buy'' full bright red color, and approximately less than 14% of consumers decided to 'buy' cherries with less than full bright red color (data not shown). In general, approximately 80% of the consumers decided to 'buy' 'Bing' cherries with dark mahogany color, approximately 10% decided to 'buy' mahogany color, and approximately less than 10% of consumers decided to 'buy' 'Bing' cherries lighter than mahogany color.

Consumer age range influenced the decision to 'buy' according to skin color in both cultivars

Table 4
Consumer acceptance of 'Bing' cherry by American consumers at different levels of soluble solids concentration (SSC) and titratable acidity (TA) measured as percentage malic acid

Quality attributes	Degree of liking (1–9)[z]	Acceptance	Neither like nor dislike	Dislike
TA ≤ 0.80%				
SSC ≤ 13.0%	4.1d[y]	31.8	9.1	59.1
SSC 13.1–16.0%	5.3cd	47.7	14.4	37.9
SSC 16.1–20.0%	6.1bc	70.0	10.0	20.0
SSC > 20.0%	7.5a	93.3	6.7	0.0
TA > 0.80%				
SSC ≤ 13.0%	2.4e	18.2	0.0	81.8
SSC 13.1–16.0%	5.4c	58.3	10.7	31.0
SSC 16.1–20.0%	6.1bc	72.3	6.3	21.4
SSC > 20.0%	7.1ab	86.5	4.5	9.0
$LSD_{0.05}$	1.2	–	–	–
P-value	0.001			

[z] Degree of liking: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely.
[y] Same letters within the same column indicate no significant difference between means.

Table 5
Percentage of American consumers that 'will buy' 'Brooks' and 'Bing' cherries at each skin color according to age ranges

Cultivar	Age range					
Skin color	Under 18	18–29	30–39	40–49	50–59	60 or older
'Brooks'[z]						
Full light red	11.5	4.8	3.8	1.1	8.7	1.7
50% Bright red	17.0	9.5	6.3	6.6	6.1	6.6
Full bright red	29.7	33.3	27.6	19.9	12.2	13.3
Full dark red	41.7	52.4	62.4	72.4	73.0	78.4
'Bing'[y]						
Salmon	20.6	7.1	0.0	0.0	0.0	0.0
Red	8.8	0.1	0.0	0.0	0.0	2.7
Mahogany	9.4	7.1	13.3	9.2	15.4	8.1
Dark mahogany	61.2	85.7	86.7	90.8	84.6	89.2

[z] 581 consumers interviewed.
[y] 596 consumers interviewed.

(Table 5). For 'Brooks' cherries, the percentage of consumers that decided to 'buy' full dark red cherries ranged from 41.7 to 78.4% as consumer age changed from under 18 to 60 years old or older. Percentage of consumers choosing to 'buy' darker skin color cherries increased as they became older but it reached a plateau (ca. 74%) for consumers 40 years old or older. The percentage of consumers choosing to "buy" darker color 'Bing' cherries dramatically increased from under 18 years old to 18 years old or older. The percentage of consumers that decided to buy dark mahogany 'Bing' cherries remained close to 85% within the 18 years old or older range, while only 61.2% of consumers under 18 years old chose to buy them.

This work points out that SSC, SSC:TA and visual skin color influence consumer acceptance of these two cherry cultivars. Although TA plays a role in consumer acceptance, within a given SSC range the importance of TA measurement is less relevant than SSC because TA changes are small in comparison to SSC changes during the cherry maturation/ripening period within a given orchard. SSC, which is easily measured in contrast to TA, is the major contributor to the SSC:TA, and therefore, consumer acceptance. Because high consumer acceptance and a high percentage of consumers making the decision to buy was based on full bright red ('Brooks') or dark mahogany ('Bing') skin color, we propose the use of SSC combined with full color development dictated by the cultivar as a minimum quality index for 'Brooks' and 'Bing' cherries in California. The full skin color requirement will also help to assure a large number of cherries with SSC > 16.0% SSC at the picking time for both cultivars. Our proposed minimum quality index is higher than the current US Grade and Standards and the more demanding California Agricultural Code indexes (Kader, 2002). The California Agricultural Code requires a cherry surface with at least a 'solid light red' and/or 14.0–16.0% SSC, depending on the cultivar. Further work to understand the interaction of cultural practices and storage period, and on consumer acceptance during the maturation/ripening changes should be pursued.

Acknowledgements

We would like to thank Dr. Anne Noble for her help in planning the sensory evaluation work. Thanks to the California Cherry Commission and California Cherry Growers Association for funding this work.

References

Bruhn, C.M., 1995. Consumer and retail satisfaction with the quality and size of California peach and nectarines. J. Food Qual. 18, 241–256.

Cliff, M.A., Dever, M.C., Hall, J.W., Girard, B., 1996. Development and evaluation of multiple regression models for prediction of sweet cherry liking. Food Res. Int. 28, 583–589.

Crisosto, C.H., 1997. Survey of 'Bing' cherry harvest quality. California Department of Food and Agriculture, Stockton, CA, 3 pp.

Crisosto, C.H., Crisosto, G.M., 2001. Understanding consumer acceptance of early harvested 'Hayward' kiwifruit. Postharvest Biol. Technol. 22, 205–213.

Crisosto, C.H., Crisosto, G.M., 2002. Understanding American and Chinese consumer acceptance of 'Redglobe' table grapes. Postharvest Biol. Technol. 24, 155–162.

Crisosto, C.H., Garner, D., Doyle, J., Day, K.R., 1993. Relationship between fruit respiration, bruising susceptibility, and temperatures in sweet cherries. HortScience 28, 132–135.

Crisosto, C.H., Crisosto, G.M., Ritenour, M.A., 2002. Testing the reliability of skin color as an indicator of quality for early season 'Brooks' (*Prunus avium* L.) cherry. Postharvest Biol. Technol. 24, 147–154.

Dever, M.C., MacDonald, R.A., Cliff, M.A., Lane, W.D., 1996. Sensory evaluation of sweet cherry cultivars. HortScience 31, 150–153.

Drake, S.R., Fellman, J.K., 1987. Indicators of maturity and storage quality of 'Ranier' sweet cherry. HortScience 22, 283–285.

Drake, S.R., Williams, M.W., Fountain, J.B., 1989. Stemless sweet cherry (*Prunus avium* L.) fruit quality and consumer purchase. J. Food Qual. 11, 411–416.

Hansche, P.E., Beres, W., Doyle, J., Micke, W.C., 1988. 'Brooks' sweet cherry. HortScience 23, 644.

Gorini, F., Lasorella, M., 1990. Sensory and objective evaluation of kiwifruit. Acta Hortic. 282, 309–314.

Guelf-Reich, S., Safran, B., 1971. Indices of maturity for table grapes as determined by variety. Volcani Institute of Agricultural Research, Bet-Dagan, Israel. XVIII International Horticulture Congress, Tel-Aviv, Israel, March 17–25, 1970. Series No. 1672E, 13–18.

Guyer, D.E., Sinha, N.K., Chang, T.S., Cash, J.N., 1993. Physiochemical and sensory characteristics of selected Michigan sweet cherry (*Prunus avium* L.) cultivars. J. Food Qual. 16, 355–370.

Kader, A.A., 1999. Fruit maturity, ripening, and quality relationships. In: Symposium on Effect of Pre and Post Harvest Factors on Storage of Fruit. Acta Hortic. 485, 203–208.

Kader, A.A., 2002. Standardization and inspection of fresh fruit and vegetables. In: Kader, A.A. (Ed.), Postharvest and Technology of Horticultural Crops, chapter 23. University of California, Agricultural and National Resources Publication 3311.

Kappel, F., Fisher-Fleming, B., Hogue, E., 1996. Fruit characteristics and sensory attributes of an ideal sweet cherry. HortScience 31, 443–446.

Kappel, F., Toivonen, P., Mckenzie, D.L., Stan, S., 2002. Storage characteristics of new sweet cherry cultivars. HortScience 37, 139–143.

Lawless, H.T., Heymann, H., 1998. Acceptance and preference testing. In: Lawless, H.T., Heymann, H. (Eds.), Sensory Evaluation of Food, Principles and Practices. Chapman and Hall, New York, pp. 430–479.

Malundo, T.M.M., Shewfelt, R.L., Ware, G.O., Baldwin, E.A., 2001. Sugars and acids influence flavor properties of mango (*Mangifera indica*). J. Am. Soc. Hort. Sci. 126, 115–121.

Mitcham, E., Tayfun, A., Biasi, B., Crisosto, C., Gillespie, D., 1998. Determination of the relationship between 'Bing' cherry harvest maturity and postharvest quality. Report to the California Cherry Advisory Board, 29 pp.

Mitcham, E., Tayfun, A., Southwick, S., Biasi, B., 1999. Determination of the relationship between 'Bing' cherry harvest maturity and postharvest quality. Report to the California Cherry Advisory Board.

Mitcham, E., Tayfun, A., Southwick, S., Biasi, B., 2000. Determination of the relationship between 'Bing' cherry harvest maturity and postharvest quality. Report to the California Cherry Advisory Board.

Nelson, K.W., Baker, G.A., Winkler, A.J., Amerine, M.A., Richardson, H.B., Jones, F.R., 1963. Chemical and sensory variability in table grapes. Hilgardia 34, 1–26.

Nelson, K.E., Schutz, H.G., Ahmedullah, M., McPherson, J., 1973. Flavor preferences of supermarket customers for 'Thompson Seedless' grapes. Am. J. Enol. Viticult. 24, 31–40.

O'Mahony, M., 1986. Sensory Evaluation of Food. Marcel Dekker, New York.

Pehrson, J.E., Ivans, E.M., 1988. Variability in early season navel orange clone maturity and consumer acceptance. Proc. Int. Soc. Citriculture, pp. 1631–1635.

Robertson, J.A., Meridith, F.I., 1989. Characteristics of fruit from high- and low-quality peach cultivars. HortScience 23, 1032–1034.

Rodan, L., 1988. Consumer acceptance of Florida grapes and grape products. Proceedings of the Viticulture Sciences Symposium Tallahassee, FL. Florida A&M University, Center for Viticultural Sciences, pp. 119–121.

Schotzko, R.T., 1993. Fresh sweet cherry eating characteristics: some baseline data. Washington State Univ. Res. Bull. XB1028, 3–14.