Is Dry Matter a Reliable Quality Index for 'Hayward' Kiwifruit?

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Abstract

        Dry matter (DM) measurement at harvest is being proposed as a quality index for 'Hayward' kiwifruit because it includes both soluble solids (mainly sugars) and insoluble solids (largely structural carbohydrates and starch). From two seasons' data, in-store consumer acceptance was well related to DM. However, in a harvest season when kiwifruit exhibited high ripe titratable acidity (RTA), RTA also played an important role in consumer acceptance. In both seasons, regardless of RTA, consumers 'liked' kiwifruit that had DM ≥16.1%. In the 2008 growing season, when RTA was high (RTA ≥1.2%), a high DM (≥16.1) was needed to satisfy consumers. However, with RTA <1.2%, a lower DM (≥15.1%) was required allowing a large proportion of the kiwifruit to satisfy a high percentage of consumers. Many of the DM survey kiwifruit samples had a DM content exceeding 15.1%, but DM varied among vineyards and seasons. DM did not change during cold storage. Thus, DM is a reliable candidate for a quality index, but RTA should also be considered.

INTRODUCTION

        Currently, kiwifruit is marketed worldwide. This globalization has created economic advantages for early and late harvest kiwifruit sales, when commodity availability is low and prices are high. This situation has created an incentive for early harvest, which can result in low quality kiwifruit in the market, reducing repeat purchases of kiwifruit and overall demand (Woodward and Clearwater, 2008).

        Therefore, a more reliable, faster, and simpler quality index that assures taste quality, thereby protecting consumers, is needed. Because dry matter (DM) includes starch and is highly correlated with RSSC (ripe soluble solids content) and final soluble sugars after ripening (Beever and Hopkirk, 1990; Jordan et al., 2000; Crisosto et al., 2008; Harker et al., 2009; Jordan and Seelye, 2009), researchers from various countries have proposed the use of DM concentration as a quality index. Thus, some industries have started its use for trade. This approach overcomes the current SSC limitations created by postharvest starch conversion to soluble sugars. However, there is no agreement on a standardized DM measurement protocol for kiwifruit or the minimum DM level that should be established as a quality index. In New Zealand, it was reported that there were no significant differences in consumer acceptance for kiwifruit DM ranging between 15 and 20% (Burdon et al., 2004). Furthermore, DM varied depending on the season, orchard location, vineyard management, and harvest date (Burdon et al., 2004; Mowat and Maguire, 2007; Taylor et al., 2007). Therefore, the objectives of this study were to understand the relationship between DM, RSSC, RTA (ripe titratable acidity), and consumer acceptance; to investigate DM variability according to California growing regions and maturity, and to survey kiwifruit marketed during the low availability season (February-March) in the USA.

MATERIALS AND METHODS

In-Store Consumer Test

Groups of 142 and 124 consumers at a major supermarket, located in Fresno County, California, were tested during the 1999 and 2008 seasons, respectively. Quality attributes measured on each piece of fruit in addition to firmness included DM, RSSC and RTA. The consumer was asked "All things considered, which statement best describes how you feel about the sample?" and the consumer's response was recorded using a 9-point hedonic scale (1, dislike extremely to 9, like extremely). Consumer acceptance was measured as both a degree of liking and a percentage (Crisosto and Crisosto, 2001). The percentage of consumers liking the kiwifruit sample was calculated as number of consumers liking the kiwifruit sample (score >5.0) divided by the total number of consumers within the sample (Lawless and Heymann, 1998).

Data Analysis

Degree of liking data were analyzed in a completely randomized model using the analysis of variance (ANOVA) procedure of the Statistical Analysis System (SAS version 9.2, SAS Institute, Cary, NC). The degree of liking scores were square-root transformed prior to the ANOVA and the means were reported after back-transforming. Means of degree of liking within DM classes were separated by least significant differences (LSD) of Fisher's test at $P \leq 0.05$. The relationship among fruit quality attributes was analyzed by linear regression analysis using the GLM (general linear model) procedure of SAS.

RESULTS

In-Store Consumer Test

The main effect of DM content significantly influenced the degree of liking in both seasons. In the 1999 growing season, consumers rated kiwifruit from 'like slightly' (6.0) to 'like moderately' (7.0). The percentage of consumers that 'liked' (score >5.0) these kiwifruit varied from ≈71 to 87% depending on DM, while the percentage of consumers that 'disliked' (score <5.0) the fruit ranged between ≈6 and 26%. Only a few consumers (≈3 to 6%) chose the 'neither like nor dislike' option (Table 2). Degree of liking was significantly higher (6.6-7.1) and acceptance was approximately 85% for kiwifruit with DM ≥16.1%. For the 2008 growing season, in-store consumer test results were similar to the 1999 results (Table 1). In the 2008 growing season, consumers rated kiwifruit from 'dislike slightly' (4.6) to 'like slightly- moderately' (6.5). The percentage of consumers that said they 'liked' the fruit varied from ≈35 to 76% increasing as DM increased, while the percentage of consumers that 'disliked' the fruit tended to decrease from ≈50 to 20% as DM increased (Table 1).

Data Analysis

The main effect of DM and RTA significantly influenced the degree of liking in the 2008 consumer test. However, the F ratio for RTA was higher than for DM. Therefore, the data set was divided into two RTA classes for further analyses using DM and RTA as combined factors on degree of liking. One class had a RTA ≥1.2 and the other one had a RTA <1.2, with the same DM classes (Table 2). Consumers rated kiwifruit with RTA ≥1.2 from 'dislike slightly' (≈4) to 'like slightly' (≈6) and the percentage of acceptance ranged from ≈36 to 65%. A high percentage of consumers (28 to 57%) 'disliked' the kiwifruit, while ≈0 to 17% of consumers chose the 'neither like nor dislike' option. In this high RTA class, the degree of liking was significantly higher (≈54 to 63%) when kiwifruit DM was ≥ 16.1%. Consumers rated kiwifruit with RTA <1.2, from 'dislike slightly' (4.5) to 'like moderately' (6.8) and the percentage of acceptance ranged from ≈33 to 82%. A high percentage of consumers (≈13 to 33%) disliked kiwifruit in the low RTA class. In this low RTA class, the degree of liking was significantly higher when kiwifruit DM was ≥15.1 with the percentage of acceptance ranging from 33 to 82%.

In this class, the percentage of consumers that chose the 'dislike' option decreased from ≈33 to 13% as DM increased. In contrast, the percentage of consumers that chose the 'neither like nor dislike' option varied among DM classes, ranging between ≈0 and 33% (Table 2).

CONCLUSIONS

There was a strong variation according to year and/or orchard for DM, RSSC, and RTA. DM did not change during the storage period, and kiwifruit either harvested early in the season or from low quality potential orchards with DM ≤15.1-16.1% would not satisfy most consumers. Based on these results, we propose using a minimum of 16.1% DM as a quality index. However, a protected DM index can be used in which RTA is also included. For kiwifruit with RTA <1.2%, a protected DM index of 15.1% would be the minimum quality index required for consumer acceptance. This amendment will enable the marketing of a large number of kiwifruits that have a high level of consumer acceptance.

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Literature Cited

Beever, D.J. and Hopkirk, G. 1990. Fruit development and fruit physiology. p.97-126. In I.J. Warrington and G.C. Wetson (eds.), Kiwifruit: Science and Management. Ray Richards Publisher, Auckland, New Zealand.

Burdon, J., McLeod, D., Lallu, N., Gamble, J., Petley, M. and Gunson, A. 2004. Consumer evaluation of 'Hayward' kiwifruit of different at-harvest dry matter contents. Postharvest Biol. Technol. 34:245-255.

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

Crisosto, C.H., Hasey, J., Cantin, C., Garibay, S. and Crisosto, G.M. 2008. New kiwifruit dry weight protocol. Central Valley Postharvest Newsletter. Cooperative Extension. University of California 17:11-15.

Harker, F.R., Carr, B.T., Lenjo, M., MacRae, E.A., Wismer, W.V., Marsh, K.B., Williams, M., White, A., Lund, C.M., Walker, S.B., Gunson, F.A. and Pereira, R.B. 2009. Consumer liking for kiwifruit flavor: A meta-analysis of five studies on fruit quality. Food Qual. Preference 20:30-41.

Jordan, R.B. Walton, E.F., Klages, K.U., Seelye, R.J. 2000. Postharvest fruit density as an indicator of dry matter and ripened soluble solids of kiwifruit. Postharvest Biol. Technol. 20:163-173.

Jordan, R.B. and Seelye, R.J. 2009. Relationship between taste perception, density and soluble solids concentration in kiwifruit (*Actinida deliciosa*). New Zealand J. Crop Hort. Sci. 37:303-317.

Lawless, H.T. and Heymann, H. 1988. Acceptance and preference testing. p.430-470. In: H.T. Lawless and H. Heymann (eds.), Sensory Evaluation of Food, Principles and Practices. Chapman and Hall, New York.

Mowat, A. and Maguire, K. 2007. Canopy management and dry matter of 'Hayward' kiwifruit. Acta Hort. 753:333-340.

Taylor, J.A., Praat, J.P. and Bollen, A.F. 2007. Spatial variability of kiwifruit quality in orchards and its implications for sampling and mapping. HortScience 42:246-250.

Woodward, T.J. and Clearwater, M.J. 2008. Relationship between 'Hayward' kiwifruit weight and dry matter content. Postharvest Biol. Technol. 48:378-382.

Tables

Table 1. Relationship between dry matter (DM) and consumer acceptance of 'Hayward' kiwifruit, 1999 and 2008 growing seasons.

DM (% fresh weight)	n[a]	Degree of liking[b]	Consumer acceptance (%)		
			Like	Neither like nor dislike	Dislike
1999 growing season					
≤15.0	34	6.1b[c]	70.6	2.9	26.5
15.1 – 16.0	33	6.3b	72.7	3.1	24.2
16.1 – 17.0	114	6.6ab	81.6	5.3	13.1
17.1 – 18.0	174	7.1a	87.4	6.3	6.3
> 18.0	213	6.9a	86.4	6.1	7.5
LSD $_{0.05}$		0.6			
$P >$ F		<0.0001			
2008 growing season					
≤15.0	20	4.6b	35.0	15.0	50.0
15.1 – 16.0	82	5.1b	48.8	6.1	45.1
16.1 – 17.0	84	6.1a	65.5	11.9	22.6
17.1 – 18.0	80	6.3a	71.3	7.5	21.2
> 18.0	106	6.5a	76.4	3.8	19.8
LSD $_{0.05}$		0.8			
$P >$ F		<0.0001			

[a]n is the number of samples.
[b]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.
[c]Mean separations within a column were by Fisher's LSD test (P≤0.05). Mean values followed by the same letters were not significantly different.

Table 2. Consumer acceptance of 'Hayward' kiwifruit at different levels of dry matter (DM) and ripe titratable acidity (RTA) measured as percentage citric acid, 2008 growing season.

DM (% fresh weight)	n[a]	Degree of liking[b]	Consumer acceptance (%)		
			Like	Neither like nor dislike	Dislike
RTA ≥ 1.2					
≤15.0	14	4.5b[c]	35.7	7.2	57.1
15.1 – 16.0	58	4.4b	34.5	8.6	56.9
16.1 – 17.0	46	5.6a	54.3	17.4	28.3
17.1 – 18.0	26	5.7a	65.4	0	34.6
> 18.0	30	5.7a	63.3	0	36.7
LSD $_{0.05}$		1.2			
$P >$ F		0.01			
RTA < 1.2					
≤15.0	6	4.5b	33.3	33.3	33.3
15.1 – 16.0	24	6.8a	83.3	0	16.7
16.1 – 17.0	38	6.7a	78.9	5.3	15.8
17.1 – 18.0	54	6.5a	74.1	11.1	14.8
> 18.0	76	6.8a	81.6	5.2	13.2
LSD $_{0.05}$		1.2			
$P >$ F		0.05			

[a]n is the number of samples.
[b]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.
[c]Mean separations within a column were by Fisher's LSD test (P≤0.05). Mean values followed by the same letters were not significantly different.