Fruit Varieties Journal 46(1):37-43 1992

Sensory Evaluation of 'Gala' and 'Jonagold' Strains

FRANK KAPPEL, MARJ DEVER AND MICHEL BOUTHILLIER[1]

Abstract

The differences in sensory characteristics for 4 strains each of 'Gala' and 'Jonagold' apples were characterized by trained judges using the technique of descriptive analysis with deviation from reference. There were no significant differences in the taste or texture attributes evaluated for either cultivar except for acidity of the 'Gala' strains. Judges were able to perceive differences in the taste and texture attributes among the 3 fruit maturities that were evaluated for the 'Gala' strains. Significant differences in visual attributes were found among the strains for both cultivars.

Introduction

'Gala' and 'Jonagold' are two apple cultivars quickly gaining acceptance in apple producing areas of the world (5, 9, 13). Both cultivars have unique characteristics that make them popular with consumers. A number of highly colored strains have been identified for each cultivar and these strains are now being planted by growers (13). Growers are choosing these strains primarily based on information regarding their appearance because little information exists concerning the sensory attributes of the different strains compared to "standard" strain for either cultivar. Walsh and Volz (12) suggest that growers question the quality of the new strains of 'Gala' but provide no data. Stebbins (10) reported that tasters (26 judges) had similar preferences for 'Gala' or 'Royal Gala.' In another study, 'Jonagold' had higher preference ratings than an array of other cultivars grown in B.C. (7) but no information was provided about any strains of 'Jonagold.' Crassweller and Hollender (2) reported that there were some differences in ranking in overall acceptance of a number of 'Delicious' strains. The objective of this study was to assess the sensory attributes of four strains of each cultivar.

Materials and Methods

Fruit were obtained from the B.C.F.G. Test Orchard in Oliver B.C. and from the Agriculture Canada, Research Station, Summerland, B.C. The strains of 'Gala' were Royal, Imperial, Kidd's D-8 (the standard strain) and Regal and the strains of 'Jonagold' were Wilmuta, 2361 and 2451, (virus indexed clones) and Standard. Harvest maturity standards of Test Orchard apples were similar to those used by local growers for commercial production. Both cultivars required multiple picks and the apples used for the sensory evaluations were obtained from the second pick. The trees at the Test Orchard and Research Station were propagated from the same source of budwood and planted in 1987. At harvest the following determinations were taken for each cultivar, flesh firmness (FF) with a Magness-Taylor penetrometer with a 11.1 mm diameter tip, percent soluble solids (SS) using an ABBE refractometer, titratible acidity (TA) by titration to pH 8.1 with NaOH with a Metrohm titrator, and the starch index (SI). Because no SI scale has been developed for 'Gala' the SI for 'Jonagold' was used for both cultivars (7). A visual rating of percentage blush and of ground color was also recorded. The ground color rating scale was 1 = green, 2 = green-white, 3 = white, and 4 = yellow. The color of

[1]Agriculture Canada, Research Station, Summerland, British Columbia, Canada. V0H 1Z0.

We would like to acknowledge the support and cooperation of the Board of Directors and the Manager of the B.C.F.G. Test Orchard, Oliver B.C. The diligent participation of the judges is greatly appreciated.

the blush portion of the fruit was measured with a Minolta Chroma Meter CR-200. The 'L,' 'a,' and 'b' values were assessed and from the a/b ratio the hue angle was determined (4).

'Gala' from the Test Orchard was harvested Sept. 7 and stored in cold storage 1°C) until assessed on Sept. 26 to 28. This was referred to as the "commercial maturity" (CM) sample. The room ripened (RR) fruit were stored until Oct. 20, when they were placed in a ripening room at 20°C for 7 days then stored again in cold storage until the assessments were completed Oct. 27-31. The 'Gala' from the Research Station designated as "tree-ripened" (TR) were harvested Oct. 5 and stored in cold storage until assessed on Oct. 9-10. The 'Jonagold' were harvested at the Test Orchard (the only site) on Oct. 5 and stored in cold storage until assessed Nov. 21-22.

The strains of the two cultivars were evaluated for sensory differences (visual, aroma, texture, and taste) using quantitative descriptive analysis (QDA) with deviation from reference. This technique profiles the sensory characteristics of the apple by isolating and scoring the different components that contribute to the overall sensory perception. The apples were evaluated in triplicate by each judge and for the 'Gala' cultivar, the same judges were used to evaluate all three maturities.

Judges scored the sensory attributes from low to high placing a vertical mark on a 10 cm linescale that was anchored at either end by a verbal descriptor. In order to help the judges use the linescales consistently, a reference apple was selected for the aroma, taste, and texture terms. This apple was also included in the evaluations. 'Royal Gala' from the CM (Test Orchard) was used as the reference for 'Gala' for the tasting of all three maturities because the industry in B.C. appears to have chosen this strain as their standard. The standard strain was used as the reference for 'Jonagold.'

For each attribute, judges were asked to compare each sample to the reference indicating the degree of any differences on the linescale. A training session was held to explain the general tasting procedure, to discuss and select the important sensory attributes, and to determine appropriate verbal descriptors for the linescale anchors. In this session the judges tasted the reference apple and consensus was reached on where this reference should be located on the linescale.

The visual assessment was done in natural light on a sample of eight apples. For each replication a new sample of apples was selected and a three digit number code assigned. The visual attributes evaluated for the 'Gala' were brightness of red color, uniformity of red color around the apple, stripped or solid coloring, ribbed or smooth shape, distinctive varietal appearance, and attractiveness. For 'Jonagold' the visual attributes assessed were brightness of red, uniformity of red color, ground color (green to white, and pale yellow to dark yellow), distinctive varietal character, and attractiveness.

Texture and taste evaluations were done in individual tasting booths under red light which eliminated any visual cues. New three digit random codes were assigned for each replication and the presentation was randomized to remove any effect from the order of tasting. Each sample consisted of half an apple served at room temperature. Any apples with obvious defects were eliminated. The textural attributes, skin toughness, and crispness were evaluated and the intensity of fruitiness scored for both aroma and flavor. Sweetness, sourness, and starchiness were evaluated for both cultivars. For 'Gala,' juiciness was also evaluated.

Ten judges were used for the evaluations of the strains and maturities of the 'Gala' and 12 judges were used for evaluating the strains of 'Jonagold.' Analysis of variance (ANOVA) was

used to determine sensory differences among strains. A preliminary 3-way (10 or 12 judges, 4 strains, 3 reps) ANOVA of sensory data showed replication to be non-significant and so replication was pooled into the error and a 2-way (judge, strain) ANOVA calculated (1). The consistency of the judges was good therefore there was no interaction between judge and strain. Fruit maturity data were collected on a random sample of 20 fruit of each strain for the 'Jonagold' and the CM and TR 'Gala.' Ten fruit of each strain were used for the RR 'Gala.' The maturity and fruit color data were reported as a mean ± standard error.

Results

There was no consistent pattern among the 'Gala' strains for the maturity indices measured (Table 1). Regal and Imperial were the softest fruit, whereas Kidd's D-8 and Regal had the highest SS readings. The CM fruit was the firmest and had the lowest SI and the highest TA reading. The RR fruit had the softest fruit, the highest SI and the highest SS.

The color evaluations were different among the 'Gala' strains (Table 2). Imperial strain had the greatest portion of its skin covered by a red blush and Kidd's D-8 had the least. There were some differences in the rankings at the different maturities (data not shown). Kidd's D-8 had the highest L reading and the greatest hue angle for the "green" cheek of Kidd's D-8 means that the "green" cheek of this strain is more yellow and the other strains are closer to orange. For the blush portion of the fruit, Kidd's D-8 had the highest L reading and the greatest hue angle. The hue angle reading indicates that the blush of Kidd's D-8 was more

Table 1. Maturity indices for four strains of 'Gala' evaluated at different fruit maturities.

Strain	Fruit firmness (N)	Starch Index[x]	Soluble Solids (Brix)	Titratible acidity (% Malic acid)	Soluble solids-Titratible acid ratio
		Commercial Maturity			
Imperial	91±2[y]	3.7±0.2	11.9±0.2	0.42±0.02	28.4±1.0
Kidd's D-8	94±1	3.7±0.2	12.5±0.2	0.45±0.01	27.4±0.4
Regal	96±2	3.0±0.2	12.1±0.1	0.47±0.01	26.1±0.5
Royal	97±2	3.6±0.4	12.4±0.2	0.45±0.01	27.5±0.5
Mean	95±1	3.5±0.1	12.2±0.1	0.45±0.01	27.4±0.4
		Room Ripened			
Imperial	64±1	9.0±0.1	13.1±0.1	0.35±0.01	37.1±0.7
Kidd's D-8	65±1	9.0±0.1	13.9±0.1	0.38±0.01	36.5±1.6
Regal	57±2	8.7±0.2	13.7±0.2	0.38±0.001	35.5±0.4
Royal	65±2	8.7±0.2	13.8±0.2	0.42±0.02	33.1±1.4
Mean	63±1	8.9±0.1	13.6±0.1	0.38±0.01	35.5±0.7
		Tree Ripened			
Imperial	82±1	8.0±0.4	10.5±0.1	0.30±0.01	35.5±0.8
Kidd's D-8	83±1	6.5±0.5	12.3±0.2	0.42±0.02	29.2±1.0
Regal	79±1	8.5±0.2	12.8±0.1	0.35±0.02	37.4±2.1
Royal	85±1	8.1±0.2	11.5±0.6	0.32±0.01	35.6±0.2
Mean	82±1	7.8±0.2	11.8±0.2	0.35±0.01	34.4±0.9

[z]Starch index is based on a scale of 0 to 9 where 0 = whole fruit filled with starch and 9 = cortex without starch.
[y]Mean ± standard error. Twenty fruit per strain were used to determine the mean for each of the maturity indices except for Room Ripened where only 10 fruit per strain were used.

orange than the other strains and that Regal was more red.

There were no differences among the strains of 'Gala' for any of the texture and attributes except for acidity (Table 3); where Imperial was less acidic than Regal or Kidd's D-8. Royal was rated as being between Imperial and the other two cultivars. Although there were significant maturity differences in both taste and texture attributes, within each maturity there were not differences among the strains (except for firmness in CM fruit and acidity in RR and TR fruit) (data not shown).

The judges detected significant differences for the visual attributes among the strains of 'Gala' (Table 4). Regal had the brightest red fruit whereas Kidd's D-8 had the least red fruit and the least uniform color. Regal had the most solid red color whereas the other strains were perceived to have the most stripey fruit. Regal and Kidd's D-8 were the smoothest fruit. The distinctiveness attribute compared these strains to other apple cultivars. That is, was the appearance of these strains distinctive or were they similar to other cultivars? Regal appeared to be the least distinctive of these strains. The Royal strain was perceived by these judges to be the most attractive.

Judges found significant maturity differences in the 'Gala' fruit for the texture, aroma, and taste terms. CM fruit was the firmest, the most acidic, the most starchy, and had the least fruit flavor. TR fruit was the sweetest, the most juicy and had the most fruit flavor, while RR fruit had the lowest juiciness, firmness, acidity, and starchy flavor.

There were no differences among the strains of 'Jonagold' for any of the

Table 2. Fruit color evaluations of four strains of 'Gala' at different fruit maturities.

Strain	Percent of Surface with red blush (%)	Rating of ground color[z]	Green cheek		Blushed cheek	
			L	Hue angle	L	Hue angle
Commercial Maturity						
Imperial	83±3[y]	2.8±0.1	62±3	62±5	44±1	20±1
Kidd's D-8	63±3	2.6±0.2	72±1	88±2	48±1	24±1
Regal	77±2	2.5±0.1	69±1	74±5	47±1	21±1
Royal	82±2	3.0±0.1	65±1	61±4	46±1	22±1
Mean	76±4	2.7±0.1	67±1	71±2	46±1	22±2
Room Ripened						
Imperial	79±5	4±0	65±2	71±6	44±1	27±1
Kidd's D-8	51±6	4±0	73±2	88±4	48±1	31±1
Regal	80±3	4±0	65±2	70±5	46±1	20±1
Royal	80±4	4±0	64±2	63±5	46±1	23±1
Mean	72±3	4±0	67±1	73±3	46±1	25±1
Tree Ripened						
Imperial	76±2	2.7±0.2	57±2	49±5	38±1	11±1
Kidd's D-8	67±4	3.2±0.2	67±2	71±5	44±1	16±1
Regal	79±2	3.1±0.3	56±1	48±4	38±1	7±1
Royal	65±3	3.5±0.2	62±2	61±5	42±1	15±1
Mean	72±2	3.1±0.1	60±1	57±3	40±1	12±1

[z]Rating of ground color: 1 = green; 2 = green-white; 3 = white; 4 = yellow.
[y]Mean ± standard error. Twenty fruit per strain were used to determine the mean for each of the fruit color indices except for Room Ripened where only 10 fruit per strain were used.

Table 3. Sensory evaluation of the texture and taste of four strains of 'Gala.'

Strain	Toughness of skin	Juiceness	Firmness	Fruit aroma	Fruit flavor	Sweetness	Acidity	Starch
Imperial	4.7	5.2	5.8	1.8	2.9	5.0	1.9	6.1
Kidd's D-8	4.8	5.2	5.8	2.0	3.2	5.2	2.4	5.8
Regal	5.0	5.3	5.9	1.9	3.2	5.1	2.5	6.0
Royal	4.7	5.5	5.9	1.9	3.2	5.3	2.2	6.0
SEM[z]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Significance[y]	ns	ns	ns	ns	ns	ns	ns	ns
Maturity								
Commercial	5.4	5.3	7.3	1.5	2.8	4.7	2.9	7.1
Room ripened	4.7	4.4	4.4	2.2	2.8	4.9	1.8	5.1
Tree ripened	4.4	6.3	5.9	2.0	3.7	5.7	2.2	5.8
SEM	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Significance	•••	•••	•••	•••	•••	•••	•••	•••

[z]SEM = standard error of the means.
[y]Significance = °, °°, °°°, and ns, significant at the 0.05, 0.01, 0.0001 level, and not significant respectively.

maturity indices evaluated (Table 5) however, there were differences in some of the color attributes. Strain 2361 had the highest percentage of its skin surface covered in red blush. Also the hue angle for strain 2361 was the lowest; that is it was more yellow than the other strains which were closer to the green-yellow portion of the quadrant. The Standard strain had the highest L reading for the blush portion of the fruit.

Judges were able to perceive differences among the 'Jonagold' strains for some of the visual attributes (Table 6). Strain 2361 had the brightest red fruit and the Standard strain the least uniform. Of the strains evaluated, Strain 2361 was the most attractive and the Standard strain the least attractive. The judges were not able to detect any differences among the strains for the texture and taste attributes.

Discussion

Sensory evaluation of apple cultivars has generally taken the form of preference testing where judges rate their degree of liking for a cultivar using a hedonic scale (2, 5, 7, 8, 10, 11). This study pioneers the use of Qualitative Descriptive Analysis (QDA) in the evaluation of apple strains. QDA was developed to provide objective sensory profiles that could be analyzed statistically (14). This method requires a

Table 4. Sensory evaluation of the visual attributes of four strains of 'Gala' at commercial maturity.

Strain	Brihtness of red	Uniformity of color	Solidity of red color	Smoothness	Distinctiveness	Attractiveness
Imperial	5.4	5.0	2.8	2.9	5.1	5.8
Kidd's D-8	4.5	3.2	3.2	4.4	5.5	4.6
Regal	6.8	5.4	7.1	4.8	4.7	5.3
Royal	6.0	5.5	2.9	3.4	5.5	6.3
SEM[z]	0.2	0.2	0.2	0.2	0.2	0.2
Significance	•••	•••	•••	•••	ns	•••

[z]SEM = standard error of the means.
[y]Significance = °, °°, °°°, and ns, significant at the 0.05, 0.01, 0.0001 level, and not significant respectively.

Table 5. Fruit maturity and color evaluations of four 'Jonagold' strains.

Strains	Fruit firmness (N)	Starch index[z]	Soluble solids (Brix)	Titratible acidity (% Malic acid	Soluble solids—titratible acidity	Percent of surface with red blush (%)	Rating of ground color[y]	Green cheek		Blushed cheek	
								L	Hue angle	L	Hue angle
2361	59±1[x]	8.4±0.1	14.4±0.2	0.60±0.02	24.2±0.4	48±5	1.8±0.1	70±1	101±2	48±1	43±4
2451	58±1	8.6±0.1	13.8±0.4	0.53±0.01	25.6±0.4	40±4	1.6±0.1	70±1	105±1	50±1	45±3
Standard	61±1	8.6±0.1	14.2±0.2	0.60±0.01	23.9±0.7	30±4	1.8±0.1	70±1	106±1	52±1	51±3
Wilmuta	58±1	8.7±0.1	13.9±0.3	0.56±0.01	24.6±0.2	40±3	2.0±0.1	70±1	106±1	50±1	45±2

[z]Starch index is based on a scale of 0 to 9 where 0 = whole fruit filled with starch and 9 = cortex without starch.
[y]Rating of ground color: 1 = green; 2 = green-white; 3 = white; 4 = yellow.
[x]Mean ± standard error. Twenty fruit per strain were used to determine the mean of the maturity and fruit color indices.

trained panel and it does not allow the panel members likes or dislikes to influence their answers, whereas for hedonic methods larger numbers of untrained persons are used in panels and their evaluations are subjective (6). However, there are some difficulties associated with descriptive analysis when sensory differences are small and there is variability within strains from one apple to the next.

QDA reduces judge variability through both training panelists and providing objective references for the different sensory terms. The significant judge variability found for all terms in this study (data not shown) indicated either insufficient judge training, differences in judge perception, differences in interpreting sensory terms, or differences in the reference apples presented to each judge.

For both 'Gala' and 'Jonagold' cultivars the judges were unable to detect strain differences in texture, aroma, or taste. This is similar to work reported by Stebbins (10) for 'Gala' using a hedonic scale. Crassweller and Hollender (2) report that there were some differences in ranking in overall acceptance of a number of strains of 'Delicious.' Again, this was using a preference testing technique. In another study, Stebbins (11) reported a preference rating for 'Imperial Gala' of 7.3 on a 9-point hedonic scale whereas 'Royal Gala' received a 6.5 rating (the statistical significance of these two ratings was not indicated). It is much easier to perceive differences among cultivars than among strains of the same cultivar. However, with more intensive training of judges and the appropriate selection of standard references for the sensory terms, QDA will become more sensitive and more effective in detecting any sensory differences among strains.

The significant maturity differences found in the 'Gala' apples, indicated that judges understood the sensory terms and used them to differentiate

Table 6. Sensory evaluation of the visual attributes of four strains of 'Jonagold.'

Strain	Brightness of red	Uniformity of color	Ground color		Varietal character	Attractiveness
			green to white	pale yellow to dark yellow		
2361	4.8	2.6	4.7	3.4	4.5	4.1
2451	3.7	2.0	3.8	3.2	3.8	3.3
Standard	3.1	1.7	3.8	2.8	3.8	2.8
Wilmuta	3.9	2.2	4.2	2.6	3.7	3.5
SEM[z]	0.2	0.1	0.2	0.2	0.2	0.2
Significance[y]	***	*	ns	ns	ns	**

[z]SEM = standard error of the means.
[y]Significance = *, **, ***, and ns, significant at the 0.05, 0.01, 0.001 level, and not significant respectively.

samples. Therefore, strain differences in texture, aroma, and taste would have been detected had these differences been larger. The effect of apple maturity on sensory attributes as demonstrated in this study, clearly shows the importance of controlling maturity in strain or cultivar evaluations.

The increased sweetness, juiciness, and fruitiness associated with the 'Gala' TR fruit was consistent with studies indicating that apples picked for commercial storage have not attained optimum flavor development. Lau (7) reported that for 'Jonagold,' harvest date had a strong influence on preference ratings while Dirnck et al. (3) found that late picked apples had immediate aroma development and reached a higher maximum compared to early picked apples.

In this study, only the visual attributes (except for acidity in 'Gala') were found to be significantly different among the strains. This provides some justification for the apple industry practice of choosing new strains predominately on improved red coloring. The most desirable appearance will be influenced by the intended market and this should be considered when selecting strains for commercial production. Attributes such as yield and vigor of the tree are also important factors, however, for the 'Gala' and 'Jonagold' strains evaluated in this work, texture and taste were not important in choosing the best strain.

Literature Cited

1. Cliff, M., M. C. Dever, and R. Gayton. 1991. Juice extraction process and apple cultivar influences on juice properties. J. Food Science (in press).
2. Crassweller, R. M. and R. A. Hollender. 1989. Consumer evaluations of 'Delicious' apple strains. Fruit Var. J. 43(4):139-142.
3. Dirinck, P., H. De Pooter and N. Schamp. 1989. Aroma development in ripening fruits. In: Flavor Chemistry Trends and Developments. ACS Symposium Series 338. R. Teranishi, R. G. Buttery and R. F. Shahidi. Eds. Amer. Chem. Soc. Washington D.C.
4. Francis, F. J. and F. M. Clydesdale. 1975. Food colorimetry: theory and applications. AVI, Westport, Conn. pg. 206-209.
5. Greene, D. W. and W. R. Autio. 1990. Comparison of ripening and fruit quality of Gala and McIntosh apples at harvest and following air storage. Fruit Var. J. 22(2):1-4.
6. Jellinek, G. 1964. Introduction to and critical review of modern methods of sensory analysis (odour, taste and flavour evaluation) with special emphasis on descriptive sensory analysis (flavour profile method). J. Nutr. Diet. 1:219-260.
7. Lau, O. L. 1988. Harvest indices, dessert quality, and storability of 'Jonagold' apples in air and controlled atmosphere storage. J. Amer. Soc. Hort. Sci. 113(4):564-569.
8. Redalen, G. 1986. Quality tests of apple cultivars grown in Norway. Gartenbauwissenschaft 51(5):207-211.
9. Schecter, I. and J. T. A. Proctor. 1989. 'Jonagold': an apple for the 21st century. Fruit Var. J. 43(1):4-6.
10. Stebbins, R. 1989. Apple variety taste preferences. Good Fruit Grower. May 1:44-45.
11. Stebbins, R. 1991. New apple varieties. Good Fruit Grower. Jan. 1:8-12.
12. Walsh, C. S. and R. Volz. 1990. 'Gala' and the red 'Gala' sports: a preliminary comparison of fruit maturity. Fruit Var. J. 44(1):18-22.
13. White, A. G. 1991. The 'Gala' apple. Fruit Var. J. 45(1):2-3.
14. Zook, K. L. and J. H. Pearce. 1988. Quantitative descriptive analysis. In: Applied Sensory Analysis of Food. Vol. 1. H. Moskowitz. Ed. CRC Press, Inc. Boca Raton, FL.

Row Covers Enhance Strawberries

Early autumn row cover followed by removal at bloom increased mean diurnal temperatures and degree day accumulation in autumn and spring compared with no row covers. Under row covers leaf growth continued longer in autumn and started earlier in spring and resulted in more trusses and flowers. In 1987-88 increased production of marketable fruit with row cover occurred in the absence of an increase in flowers primarily due to the development of tertiary berries. From Gast and Pollard. 1991. *HortScience* 146:7-14, 69