FINAL PROJECT REPORT

PROJECT TITLE: Sensory and consumer acceptance of advanced apple breeding selections

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TOTAL PROJECT FUNDING: **Year 1:** $28,580 **Year 2:** $ 28,895

Budget History:

Item	**Year 1: 2008**	**Year 2: 2009**
Salaries	14000	22014
Benefits	9380	1881
Wages		
Benefits		
Equipment		
Supplies	4200	4000
Travel	1000	1000
Miscellaneous		
Total	$28,580	$28,895

ORIGINAL OBJECTIVES:
The overall objective of this study is to characterize the sensory properties of newly developed selections from WSU Apple Breeding Program (WABP) and determine the preference of these various apple selections. The sensory properties of these apple selections will then be related to consumer acceptance. Specific objectives are to:

Objective 1: To perform trained sensory panel analysis to characterize new selections of WABP

Objective 2: To perform consumer sensory panel evaluation to determine preference (overall and specific attributes) of new selections of WABP.

SIGNIFICANT FINDINGS:

- The project was conducted over 2 years with 3 harvest years of apples: Sensory work performed in January/February 2008 (with 2007 harvest year apples), Sensory work performed in January/February 2009 (2008 harvest year apples) and Sensory work performed in November 2009 (2009 harvest year apples)
- For each harvest year of apples, Objectives 1 (trained panel characterization) and 2 (consumer panel evaluation) were met. Specific findings are listed below.
- For the 2007 harvest year, based on the trained panel and consumer panel results, Allan 2, Fuller 10, 17, 24 and 36 were the most accepted to the consumer panel. The trained panel evaluation of these apples showed that they were high in sweetness and texture attributes.
- For the 2007 harvest year, results showed that flavor intensity and sweetness had a greater influence on the overall acceptance of the apple selection, while the other sensory attributes had a slightly lesser impact.
- For the 2008 harvest year, WSU2 and WSU38 were the most accepted while WSU5 C&C and WSU30 were the least accepted. These consumer results were supported by the trained panel evaluations of the apples in that texture properties (juiciness, crispness and hardness) of these highly accepted selections were high in intensity, along with sweetness. Fuller20 and Fuller7 were the least accepted.
- For the 2008 harvest year, results showed that apple flavor intensity and sweetness had a greater influence on the overall acceptance of the apple selection, while the other sensory attributes had a slightly lesser impact.
- For the 2009 harvest year, based on overall consumer acceptance, the most highly accepted apple selections were WSU38, WSU45, WSU2 and WSU46. From the trained panel evaluations, these apples possessed the sensory properties of high crispness, firmness, juiciness and low mealiness. The apples were also high in sweetness intensity.
- Results from the 2008 and 2009 harvest years were consistent in that WSU2 and WSU38 were the most accepted of the selections evaluated in both years.
- The sensory and consumer data on the advanced and elite selections from the Washington Apple Breeding Program provided useful feedback to the breeding team confirming decisions about which selection or selections to take forward for release and commercialization. The differentiation between the individual sensory attributes and the visual presentation of the range of each attribute was particularly helpful in presenting the qualities of each selection to a wider audience.

RESULTS and DISCUSSION:

Overview of Methods:

Trained Panel Evaluation of Apple Selections: The composition of the trained panel varied: 2007, n=9; 2008, n=10 and 2009, n=9. Each harvest year, the panelists were trained over 11-13 hours using techniques described by Meilgaard et al. (1999). The apple attributes were selected using reported literature (Gomez et al. 1998, Harker et al. 2002; Mehinagic et al. 2004) and previous studies performed in our lab (Chauvin et al. 2007). Panelists were trained to recognize apple flavor (sweetness, sourness, apple flavor intensity and astringency) and texture (firmness, crispness, juiciness and mealiness). Attribute definitions and references are presented in **Table 1**.

Table 1. Attributes and definitions of sensory attributes used by the trained panelists.

Attribute	Definition	Technique	Standards
Flavour and Taste:			
Acidity/Sourness	Sharp, tart or tangy	Will feel on the tongue; tends to be along the sides	Tartaric acid
Sweet	Intensity caused by sucrose	Will feel on the tongue; tends to be at the tip	Sucrose solutions
Apple flavor intensity	Degree to which apple flavors are pronounced and clearly observable.	Notice all over the mouth and tongue	Organic apple juice (high intensity)=15 Diluted juice=6
Mouthfeel			
Astringency	Drying, puckery mouthfeel Found in strong red wines, black teas, banana skins	Will tend to feel at the back of the tongue; may take longer to develop	Tannic acid
Texture:			
1) Crispness	Primarily an acoustic sensation that is detected by the ear during the fracturing on crisp foods	Using a whole 1/8th apple slice (skin on), place the sample between the front teeth and bite down evenly. Measure the amount of sound produced on the first chew of the mechanical mastication.	whole canned water chestnut (~2-3), Gala apple (7-9), carrot (15)
2) Juiciness	Amount of juice released on mastication in the first three chews	Place piece of apple sample between molar teeth and bite down evenly – ensure that piece is skin-side down. Evaluate amount of fluid released on the first chew of the mechanical mastication.	banana (1), Gala apple (5-7.5), canned mandarin oranges (15)
2) Firmness	Force required to completely bite through sample placed between molars	Place apple between molars and press firmly at steady rate – ensure that piece is skin-side down. Evaluate the strength needed to break the sample	banana (1) Gala apple (7.5-9), carrot (15),
3) Mealiness	Degree to which the flesh breaks down to a fine lumpy mass. Consider cohesiveness the opposite of mealiness.	Place sample apple between molars and press down- ensure that piece is skin-side down. Notice the amount of time that the sample takes to break down to a mass. If the sample falls apart quickly, it is considered to highly mealy.	Granny Smith (2) Gala (6-7) Red Delicious (9-10)

Panelists were trained to recognize the attributes using specific evaluative techniques and assign an intensity rating to each attribute using a 15-cm unstructured line scale, with a 1 cm indent at the left end of the scale corresponding to "extremely low" and 1 cm indent at the right end corresponding to "extremely high."

Evaluations took place in individual sensory booths equipped with laptop computers for recording data. Following training sessions, apple selections were presented to each panelist for evaluation in replicate. Panelists were presented with 1/8 of the apple under study. The apple selections were randomly presented to the panelists at room temperature and under white lighting conditions. Panelists were asked to indicate the intensity of the apple attributes described above. Results were collected using Compusense 5.0 software (Guelph, ON) and analyzed using XLSTAT.

Consumer Panel: The panel took place in the sensory evaluation facility at Washington State University. The number of consumers varied with the year: 2007, n=100; 2008, n= 100; 2009, n=80. Evaluations took place in individual sensory booths equipped with laptop computers for recording data. On each evaluation day, consumers were presented with 1/8 apple of the apple selections and a control sample (Fuji). The apple selections were randomly presented to the panelists at room temperature. Consumers indicated their overall acceptance and the acceptability of flavor (sweetness, sourness, astringency and apple flavor intensity) and texture (firmness, crispness, juiciness and mealiness) attributes for each apple selection. The apple flavor and texture attributes were evaluated by the panel using a 7-point scale (1 = dislike very much, 7 = like very much). Results were collected and analyzed as described above.

2007 harvest year:

The apple selections evaluated were: Allan2, Fuller7, Fuller10, Fuller17, Fuller18, Fuller20, Fuller24, Fuller30, Fuller34 and Fuller36.

For the trained panel, results from the analysis of variance indicated that the sensory attributes were significantly influenced by the apple selection. In **Table 2**, the separation of the different apple selections based on specific sensory attributes evaluated by the trained panelists is shown. Results indicated specific attribute differences between selections. Based on range of intensity, the smallest differences between apple selections were observed with astringency, flavor intensity and juiciness while the largest differences between selections were observed with sourness, crispness and mealiness. Fuller 24 was the lowest in sweetness but was the highest in sourness. Fuller 30 was the highest in sweetness but was not significantly different from Allan 2, Fuller 17, 18, 34 and 36. Fuller 20 was the lowest in sourness. Large differences were not observed between the apple selections in astringency. Apples were similar in apple flavor intensity, with Fuller 20 having the lowest flavor. For texture attributes, firmness showed the greatest variation between the apple selections. Fuller 20 had the lowest firmness, crispness and juiciness and the highest perceived mealiness. Fuller 24 was highest in firmness, crispness and lowest in mealiness.

In **Table 3,** the separation of the different apple selections based on consumer acceptance of sensory attributes is shown. Based on the acceptance of all attributes, including overall acceptance, Fuller 17 was the most accepted selection, followed by Allan 2. Fuller17 and Allan 2 were higher in their consumer acceptance of apple flavour intensity and apple texture attributes. Compared to Fuji (control), the apple selections significantly lower in overall acceptance were Fuller34 and Fuller7. This result corresponded to low acceptance of specific attributes in that Fuller34 and Fuller7 were lowest in acceptance of the specific sensory attributes.

Table 2. Mean separation of all apple selections and sensory attributes as analyzed by the trained panel (n=9) along a 15-cm line scale. Within each attribute, different letters indicate a significant difference ($p<0.05$).

Apple Attribute	Allan 2	Fuller 7	Fuller 10	Fuller 17	Fuller 18	Fuller 20	Fuller 24	Fuller 30	Fuller 34	Fuller 36
Sweetness	9.75^{abc}	7.94^{cd}	10.32^{ab}	9.75^{abc}	9.14^{abcd}	8.88^{bcd}	7.05^{d}	11.38^{a}	9.42^{abc}	9.11^{abcd}
Sourness	5.94^{cd}	7.54^{bc}	6.43^{cd}	6.61^{cd}	9.29^{ab}	4.69^{d}	11.71^{a}	7.08^{bcd}	6.59^{cd}	7.26^{bcd}
Astringency	4.79^{ab}	4.23^{abc}	4.29^{abc}	5.34^{a}	4.79^{ab}	2.75^{c}	5.71^{a}	4.59^{ab}	3.45^{bc}	4.32^{abc}
Apple Flavor Intensity	6.39^{ab}	6.33^{ab}	6.85^{ab}	7.73^{ab}	7.12^{ab}	5.12^{b}	6.69^{ab}	8.65^{a}	6.01^{ab}	6.39^{ab}
Firmness	10.84^{abc}	8.11^{de}	11.58^{ab}	11.93^{a}	8.49^{de}	6.07^{f}	12.11^{a}	9.74^{bcd}	6.71^{ef}	9.31^{cd}
Crispness	10.57^{abc}	8.62^{d}	11.84^{ab}	11.59^{ab}	9.35^{cd}	6.24^{e}	12.36^{a}	10.08^{bcd}	6.56^{e}	9.94^{bcd}
Juiciness	8.06^{a}	8.07^{a}	7.99^{a}	7.74^{a}	8.28^{a}	5.09^{b}	8.19^{a}	8.63^{a}	7.14^{ab}	7.89^{a}
Mealiness	3.05^{e}	6.87^{bc}	3.39^{de}	3.35^{de}	5.82^{bcd}	9.68^{a}	3.31^{de}	4.09^{de}	7.21^{ab}	4.49^{cde}

Table 3. Mean separation of all apple selections and sensory attributes as analyzed by the consumer panel (n=162). Values represent acceptance along a 7-pt hedonic scale (1=dislike very much and 7=like very much).

Apple Attribute	Allan 2	Fuller 7	Fuller 10	Fuller 17	Fuller 18	Fuller 20	Fuller 24	Fuller 30	Fuller 34	Fuller 36	Fuji (Control)
Overall Acceptance	5.47^{ab}	4.40^{e}	5.17^{abc}	5.70^{a}	4.57^{cd}	3.32^{e}	5.00^{abcd}	4.95^{bcd}	4.41^{d}	5.36^{ab}	5.24^{abc}
Sweetness	5.40^{ab}	4.47^{de}	5.14^{abc}	5.63^{a}	4.68^{cde}	4.23^{e}	4.73^{cde}	5.11^{abcd}	4.82^{bcde}	5.22^{abc}	5.25^{abc}
Sourness	5.04^{a}	4.36^{cde}	4.80^{abc}	5.09^{a}	4.51^{bcd}	3.95^{e}	4.70^{abcd}	4.54^{bcd}	4.32^{de}	4.94^{ab}	4.60^{abcd}
Flavor Intensity	5.32^{ab}	4.60^{bc}	4.83^{abc}	5.50^{a}	4.34^{cd}	3.68^{d}	4.91^{abc}	4.68^{bc}	4.41^{c}	5.16^{ab}	4.94^{abc}
Hardness	5.77^{a}	4.36^{cd}	5.48^{ab}	5.74^{a}	4.41^{cd}	2.62^{e}	5.70^{a}	4.84^{bc}	3.73^{d}	5.49^{ab}	4.93^{bc}
Crispness	5.75^{a}	4.21^{bc}	5.91^{a}	6.07^{a}	4.55^{b}	2.63^{d}	5.87^{a}	4.83^{b}	3.70^{c}	5.67^{a}	4.83^{b}
Juiciness	5.52^{a}	4.85^{bcd}	5.43^{ab}	5.50^{a}	4.72^{cd}	3.49^{e}	5.21^{abc}	5.37^{ab}	4.39^{d}	5.43^{ab}	5.27^{abc}

From correlation analysis, the results showed that flavor intensity and sweetness had a greater influence on the overall acceptance of the apple selection ($r > 0.70$) , while the other sensory attributes had a slightly lesser impact ($r < 0.70$).

2008 harvest year:

The apple selections evaluated were WSU2, WSU5C&C, WSU5T19, WSU7, WSU17, WSU30, WSU36, WSU38 and Fuji as a control apple.

Results from the trained panel analysis of variance indicated that the sensory attributes were significantly influenced by the apple selection. The separation of the different apple selections based on specific sensory attributes is shown in **Table 4**. Based on range of intensity, the smallest differences between apple selections were observed with sourness and astringency, while the largest differences between selections were observed with sweetness, firmness, crispness, juiciness and mealiness.

Table 4. Mean separation of all apple selections and sensory attributes as analyzed by the trained panel (n=10) along a 15-cm line scale. Within each attribute, different letters indicate a significant difference ($p<0.05$).

Apple Attributes	WSU2	WSU5 C&C	WSU5 T19	WSU7	WSU17	WSU30	WSU36	WSU38	Fuji
Sweetness	8.63^{bcd}	8.79^{bcd}	6.55^{e}	7.74^{cde}	9.01^{bc}	7.90^{cde}	7.44^{de}	9.76^{ab}	11.18^{a}
Sourness	8.57^{a}	7.55^{abc}	7.98^{ab}	8.70^{a}	7.29^{abc}	6.60^{bc}	9.13^{a}	8.87^{a}	5.66^{c}
Astringency	5.37^{ab}	6.41^{ab}	6.03^{ab}	7.26^{a}	5.57^{ab}	7.23^{a}	5.63^{ab}	5.39^{ab}	4.62^{b}
Apple Flavor Intensity	8.89^{abc}	8.45^{abc}	6.15^{d}	7.83^{c}	8.15^{bc}	7.37^{cd}	7.31^{cd}	9.81^{a}	9.68^{ab}
Firmness	10.89^{a}	6.06^{e}	9.65^{abc}	9.19^{abc}	7.98^{cd}	6.64^{de}	8.84^{bc}	10.53^{ab}	10.75^{a}
Crispness	11.88^{a}	6.71^{e}	10.53^{abc}	9.48^{bc}	9.03^{cd}	7.35^{de}	9.53^{bc}	11.81^{a}	11.12^{ab}
Juiciness	10.80^{a}	6.70^{d}	9.65^{abc}	9.01^{bc}	8.83^{bc}	8.03^{cd}	8.47^{c}	11.29^{a}	10.54^{ab}
Mealiness	3.68^{d}	7.87^{a}	4.43^{cd}	4.75^{cd}	5.32^{bc}	6.63^{ab}	5.60^{bc}	3.49^{d}	3.56^{d}

For sweetness, results showed that WSU5 T19 was the least sweet, but was not significantly different from WSU7, WSU30, and WSU36. The sweetest selections were Fuji and WSU38 ($p<0.05$). Based on sourness, the apple selections with the lowest sourness were Fuji, WSU17, WSU5 C&C and WSU30. For apple flavor intensity, Fuji, WSU38, WSU2 and WSU5 C&C had the highest values.

All texture attributes showed variation between the apple selections with a wide range of intensities observed. Fuji was the firmest apple, but did not significantly differ from WSU38, WSU7, WSU5 C&C and WSU2. For crispness, WSU2 was the highest, but was not significantly different from WSU5 T10, WSU38 or Fuji. WSU2, WSU38 and Fuji were the highest in juiciness, while for mealiness, WSU5 C&C and WSU30 were the highest ($p<0.05$). Overall, WSU5 C&C had low firmness, crispness and juiciness and the highest perceived mealiness. WSU2 was high in firmness, crispness, juiciness and one of the lowest in mealiness.

In **Table 5 and 6**, the separation of the different apple selections based on consumer acceptance of sensory attributes is shown. In Table 5 (Day 1), based on overall acceptance, WSU2 and Fuji were the highest and not significantly different from each other. The trend same persisted for acceptance of sweetness, sourness, apple flavor intensity, firmness and juiciness: Fuji and WSU2 had the highest acceptance ratings for all of these attributes. Based on taste and flavor, WSU5 T19, was consistently rated

low for acceptance of these attributes, while for texture attribute acceptance, WSU5 C&C was consistently rated low.

Table 5. Mean separation of all apple selections and sensory attributes as analyzed by the consumer panel. Day 1 selections (n=100): WSU 2, 5 C&C, 5 T19, 7 and Fuji. Values represent acceptance along a 7-pt hedonic scale (1=dislike very much and 7= like very much). Within each attribute, different letters indicate a significant difference ($p<0.05$).

Variables	WSU2	WSU5 C&C	WSU7	WSU5 T19	Fuji Day 1
Overall Acceptance	5.84^{a}	4.17^{b}	4.63^{b}	4.28^{b}	5.77^{a}
Sweetness	5.57^{a}	4.46^{b}	4.37^{bc}	3.89^{c}	5.63^{a}
Sourness	5.00^{a}	3.94^{bc}	4.26^{b}	3.57^{c}	4.79^{a}
Apple Flavor Intensity	5.37^{a}	4.17^{b}	4.41^{b}	3.59^{c}	5.50^{a}
Crispness	6.21^{b}	3.75^{c}	4.90^{b}	5.17^{b}	5.81^{a}
Firmness	6.04^{a}	3.49^{c}	4.59^{b}	4.99^{b}	5.64^{a}
Juiciness	5.71^{a}	4.50^{c}	5.04^{b}	4.85^{bc}	5.87^{a}

In **Table 6**, WSU38 had the highest overall acceptance along with Fuji ($p<0.05$). WSU38 was also high in acceptance of apple flavor intensity, crispness, firmness and juiciness ($p<0.05$). WSU38 and Fuji were highest in acceptance for sweetness, and WSU38 and WSU 36 were highest in acceptance for sourness ($p<0.05$). Consistently low in acceptance of many of the attributes were WSU17 and WSU30.

Table 6. Mean separation of all apple selections and sensory attributes as analyzed by the consumer panel: Day 2 selections (n=114): WSU 17, 30, 36, 38 and Fuji. Values represent acceptance along a 7-pt hedonic scale (1=dislike very much and 7=like very much). Within each attribute, different letters indicate a significant different ($p<0.05$).

Variables	WSU17	WSU30	WSU36	WSU38	Fuji Day 2
Overall Acceptance	4.49^{c}	4.62^{c}	4.96^{bc}	5.75^{a}	5.27^{ab}
Sweetness	4.54^{c}	4.72^{bc}	4.88^{bc}	5.56^{a}	5.07^{ab}
Sourness	4.26^{bc}	4.13^{c}	4.68^{ab}	5.11^{a}	4.21^{bc}
Apple Flavor Intensity	4.15^{c}	4.25^{bc}	4.77^{b}	5.55^{a}	4.69^{bc}
Crispness	4.25^{d}	3.40^{cd}	4.87^{c}	6.35^{a}	5.39^{b}
Firmness	4.06^{c}	3.92^{c}	4.86^{b}	6.25^{a}	5.26^{b}
Juiciness	4.89^{b}	4.98^{b}	5.00^{b}	6.19^{a}	5.30^{b}

From the correlation analysis, the results showed that apple flavor intensity and sweetness had a greater influence on the overall acceptance of the apple selection ($r > 0.70$) , with the other sensory attributes having a slightly lesser impact ($r < 0.70$).

2009 harvest year:

The apple selections evaluated were Fuji (control), WSU 2, WSU 5, WSU 7, ,WSU 37, WSU 38, WSU 39,WSU 45 and WSU 46.

Results from the trained panel analysis of variance indicated that the sensory attributes were significantly influenced by the apple selection. The separation of the different apple selections based on significant

sensory attributes is shown in **Table 7**. Based on the range of intensity, the smallest differences between apple selections were observed for astringency and sweetness, while the largest differences between selections were observed for the texture attributes of firmness and mealiness. Based on texture attributes, the apple selection that showed the greatest difference from the other selections was WSU39. Compared to the other selections, this selection was significantly lower in intensity of crispness, firmness and juiciness, while being significantly higher in mealiness ($p<0.05$). WSU2, WSU38, WSU45 and Fuji were all high in crispness, firmness, juiciness but low in mealiness intensity.

Table 7. Mean separation of apple selections and significant sensory attributes as analyzed by the trained panel (n=10) along a 15-cm line scale. Within each attribute, different letters indicate a significant difference ($p<0.05$).

Apple Attribute	**WSU 2**	**WSU 5**	**WSU 7**	**WSU 37**	**WSU 38**	**WSU 39**	**WSU 45**	**WSU 46**	**Fuji**
Crispness	10.2ab	9.2c	10.5c	9.4bc	10.6a	7.1d	10.6a	10.6a	10.2ab
Firmness	10.2a	8.4cd	7.6d	9.3ab	9.5ab	6.3c	9.2bc	9.7ab	9.6ab
Juiciness	9.4a	8.3b	8.2b	8.3b	9.8a	6.7c	9.7a	10.1a	9.4a
Mealiness	3.3c	4.6bc	5.2b	3.8cde	3.8cde	7.5a	4.3bcd	3.7de	3.7dc
Sweetness	9.0a	8.7ab	7.7cd	6.8d	8.7ab	8.7ab	8.7ab	8.0bc	8.8abc
Sourness	5.6e	6.7cde	6.9cd	9.7a	7.1cd	6.4de	7.8bc	8.4b	6.3de
Astringency	4.0c	4.9ab	4.8abc	5.4a	4.1bc	4.2bc	4.4bc	4.2bc	4.6abc

Based on flavor and taste attributes, the apple selection with the lowest sweetness intensity compared to the other selections was WSU37 ($p<0.05$), which also had the highest sourness intensity. Based on sourness, Fuji, WSU5, WSU39 and WSU2 were significantly lower compared to the other selections ($p<0.05$). While astringency did not show a large range, significant differences were observed between the apple selections. The apple selections with the highest perceived astringency intensity were Fuji, WSU7, WSU5 and WSU37.

In **Tables 8 and 9,** the separation of the different apple selections based on consumer acceptance of sensory attributes is shown. In **Table 8** (Day 1), based on overall acceptance, WSU38 and WSU45 were the most accepted, significantly higher than all of the other selections, including Fuji. Based on acceptance of the texture attributes, WSU38 was significantly higher than the other apple selections and Fuji, except for crispness and firmness where WSU45 was also high. WSU5 and WSU7 were consistently lower in acceptance of texture attributes.

Table 8. Mean separation of apple selections and significant sensory attributes as analyzed by the consumer panel (n=80) along 7-pt hedonic scale (1=dislike extremely and 7=like extremely) on Consumer Day 1. Within each attribute, different letters indicate a significant difference ($p<0.05$).

Apple Attribute	**WSU 5**	**WSU 7**	**WSU 38**	**WSU 45**	**Fuji**
Crispness	5.2b	5.3b	6.3a	6.2a	5.4b
Firmness	5.2b	5.2b	6.2a	5.9a	5.2b
Juiciness	5.4c	5.6c	6.3a	5.9b	5.7bc
Mealiness	5.0c	4.9c	5.8a	5.4b	5.0bc
Sweetness	5.1b	5.3ab	5.6a	5.6a	5.3ab
Sourness	4.8bc	5.0abc	5.4a	5.2ab	4.8c
Apple flavor intensity	4.8c	5.1bc	5.6a	5.5ab	5.1bc
Overall Acceptance	4.9c	5.0bc	5.6a	5.4a	5.0bc

In **Table 9**, apple selections from Day 2 are shown. Based on overall acceptance, WSU2, WSU46 and Fuji were the most accepted ($p<0.05$), with WSU39 being the least well accepted. Based on acceptance of texture attributes, WSU2 was consistently the highest, followed by WSU46 and Fuji. WSU39 was consistently rated the lowest in acceptance for all texture attributes evaluated, with the exception of WSU37 which has also rated low for acceptance of juiciness ($p<0.05$). Based on sweetness, a similar trend to overall acceptance was observed in that WSU2, WSU46 and Fuji were the most accepted and WSU39 and WSU37 being the least accepted. The same trend was observed with astringency.

Table 9. Mean separation (Fisher's LSD) for apple selections and significant sensory attributes as analyzed by the consumer panel (n=80) along 7-pt hedonic scale (1=dislike extremely and 7=like extremely) on Consumer Day 2. Within each attribute, different letters indicate a significant difference ($p<0.05$).

Apple Attribute	**WSU 2**	**WSU 37**	**WSU 39**	**WSU 46**	**Fuji**
Crispness	6.2a	5.9ab	4.8c	6.1a	5.8b
Firmness	6.1a	5.7bc	4.5d	6.0ab	5.6c
Juiciness	5.9a	5.6bc	5.3c	5.9a	5.8ab
Mealiness	5.6a	5.4ab	4.6c	5.5ab	5.3b
Sweetness	5.6a	4.9c	5.2c	5.4ab	5.5ab
Astringency	5.1a	4.6c	4.7c	4.9abc	5.1ab
Overall Acceptance	5.4a	4.8bc	4.6c	5.3a	5.3ab

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EXECUTIVE SUMMARY

Significant Progress/Outcomes

The overall objective of this study was to characterize the sensory properties of newly developed selections from the WABP using a trained sensory evaluation panel and determine acceptance of these apple selections using a consumer panel. Both objectives of the study were conducted over 2 calendar years or 3 harvest years (2007, 2008 and 2009 apples).

- For the 2007 harvest year, based on the trained panel and consumer panel results, Allan 2, Fuller 10, 17, 24 and 36 showed the most promise for commercialization. The trained panel evaluation of these apples showed that they were high in sweetness and texture attributes.
- For the 2008 harvest year, WSU2 and WSU38 were the most accepted while WSU5 C&C and WSU30 were the least accepted. These consumer results were supported by the trained panel evaluations of the apples in that the texture properties (juiciness, crispness and hardness) of these highly accepted selections were high in intensity, along with sweetness.
- For the 2009 harvest year, based on overall consumer acceptance, the most highly accepted apple selections were WSU38, WSU45, WSU2 and WSU46. From the trained panel evaluations, these apples possessed the sensory properties of high crispness, firmness, juiciness and low mealiness. The apples were also high in sweetness intensity.
- Results from the 2008 and 2009 harvest years were consistent in that WSU2 and WSU38 were the most accepted of the selections evaluated.
- Results from two harvest years suggested that apple flavor intensity and sweetness had a greater influence on the overall acceptance of the apple selection compared to the other sensory attributes. The apparent lesser influence of texture may be explained by the high intensity of the texture of the apples pre-selected by the breeding team. As texture is so important to overall sensory quality, the breeding team uses texture to select promising apple selections for sensory testing.
- Flavor and texture groupings were proposed to which trained panelists and consumers assigned apples. These groupings showed promise for providing broad information to both marketers and consumers regarding the taste and texture properties of the apples, particularly important with new selections where the apple name is not recognized.
- The sensory and consumer data on the advanced and elite selections from the WABP provided useful feedback to the breeding team confirming decisions about which selection or selections to take forward for release and commercialization. The differentiation between the individual sensory attributes and the visual presentation of the range of each attribute was particularly helpful in presenting the qualities of each selection to a wider audience.

Future Directions

The future direction of this project is to continue working with the WABP. Because the goal of the breeding program is to commercialize apple selections, sensory evaluation data in the form of trained panel profiles and consumer acceptance data are critical in making decisions regarding which selections to move forward to commercialize. Through the two year involvement of the WSU Sensory Evaluation Facility in the characterization of apple selections developed by the WABP, we feel poised to continue our successful collaboration with the breeding program. We would also like to continue to explore the use of groupings (texture and flavor) to which apples can be assigned based on their intrinsic sensory properties. These groupings may be used to assist in positioning new varieties in the marketplace and as an aid to consumers in making purchase decisions at the point of sale. This is especially important with new apple selections where the name is not familiar to the consumer but the consumer frequently has pre-conceived ideas of how the apple will taste based on its similarity in appearance to well-known varieties for example, all green apples do not taste like ‘Granny Smith’!