

Unlocking export prosperity: USA sensory study on the value of distinctive and superior eating quality

**Roger Harker, Christina Roigard, David Jin, Grace Ryan,
Sok Leang Chheang, Duncan Hedderley, Ann Colonna,
Paul Dalziel**



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Report prepared by:

Dr Roger Harker
Scientist/Researcher, Team
April 2022

Report approved by:

TC Chadderton
Operations Manager – Food Innovation Portfolio
April 2022

For more information contact:

Dr Roger Harker
DDI: +64 9 925 7032
Email: roger.harker@plantandfood.co.nz

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Executive summary

This study demonstrates opportunities that arise from developing foods with distinctive and superior eating quality, using apple as the exemplar product. Stored New Zealand-grown 'Scilate' apples were compared with newly harvested USA-grown 'Gala' and 'Red Delicious' by 122 consumers who resided in Portland, Oregon, USA in November 2021. Nevertheless, it should be noted that New Zealand-grown 'Scilate' are not supplied to the USA at this point in the market window as newly harvested USA-grown 'Scilate' are available. In the current study, the sensory characteristics of the apples were described and the impact of these quality attributes on the way consumers felt about them was assessed using conceptual terms. A Becker-DeGroot-Marschak (BDM) experimental market (auction) was used as a realistic task to determine the relative interest in purchasing the apples.

The 'Scilate' apples were: (a) more liked, (b) described as being sweet with a tropical, floral and pear-like flavor, which was (c) associated with consumers describing the experience with the words 'exciting', 'complex', 'unique', 'happy', 'good', 'intense', 'nourishing', 'invigorating' and 'powerful'.

The sensory properties of the other apples led consumers to be disappointed, uninspired, dissatisfied and bored. The mean \$ bids for the apples were \$1.72, \$0.79, \$0.51 for single 'Scilate', 'Gala' and 'Red Delicious', respectively. The numbers of consumers who indicated that they did not want to purchase apples (by bidding \$0) was: 4, 38 and 52, retrospectively.

The study was extended to consider the importance of sensory and credence attributes using a Best Worst Scaling methodology. When the apples were tasted (as described above) the attribute that dominated consumer choice was '*Grown in a way that is sustainable and does not harm the environment*', however when apples were not tasted (in a twin online study) the dominant attribute was '*Crisp, juicy and sweet*'. Such a result could be explained, in part, by literature that demonstrates that imagined food experiences (as in the online study) can be exaggerations of actual experiences.



Introduction

In a previous report we have reviewed opportunities that arise from New Zealand agribusiness' ability to develop foods with superior eating quality (Harker, 2019). In this study, the focus has been on demonstrating the power of sensory properties of foods to generate value in the export marketplace (in this case the USA). Consumer food research is by its nature product specific and it is necessary to select an exemplar product (in this case apples), although the study has been developed recognising the need to gather data and demonstrate methodologies that might be more broadly applicable. In selecting apples, the study is on a food that is consumed in the marketplace in much the same condition as harvested in New Zealand despite some deterioration in eating quality during refrigerated storage and transport. However, this food differs from those in which sensory properties may change during preparation and cooking in consumers' homes or served as a component in a meal or dish (e.g. meats and vegetables) where condiments, sauces and other food components modify the sensory experience.

The market for fresh fruit is affected by differences in season in the northern and southern hemispheres. New Zealand-grown apples are generally exported to overseas markets to provide fresh produce in the counter season to northern hemisphere producers. A common strategy for New Zealand fruit brands to maintain 12-month supply to retailers (and maintain consumer purchase loyalty) is to grow fruit in both hemispheres.

Consumers often remain somewhat oblivious to seasonal changes in the supply of fruit, unless alerted to this (for example by the media; Woulf 2006). Yet such transitions are of interest because credence attributes (i.e. attributes that cannot be evaluated and verified, even after purchasing and consumption) such as country of origin, freshness and sustainability may be emphasized in consumers' food choices. From a consumer science perspective, these transitions from stored fruit to new season supply offer an opportunity to understand the trade-offs consumers make regarding credence attributes and the importance of sensory properties in these decisions.

Aims and approach



Aims:

The aim was to characterise the sensory properties of apples and determine how this affected:

- Liking
- Willingness to buy (a particular focus was to assess more realistic ways of measuring value)
- Perceptions of freshness and country of origin
- Choices based on complex credence attributes (e.g. sustainability)

This study was undertaken at the Food Innovation Center of Oregon State University, Portland, using experimental approach and design developed at Plant & Food Research Ltd.

The approach involved:

- Comparison of a distinctive superior New Zealand developed apple with USA domestically produced apples – one standard and the second, a traditional and iconic apple.
- Characterisation of the sensory experience using vocabulary that is relevant to consumers (cf. the use of trained panels or experts).
- Understanding the relative interest consumers have in these apples using an experimental market approach.
- Understanding how the sensory experience affected consumer perceptions freshness and bias associated with expectations of country of origin.
- Considering the relative importance of the sensory experience relative to credence attributes in studies where products are tasted in a central location study compared to online data collection.

All apples were presented to consumers without any indication of cultivar or brand.

Methods (1)



- Selection of fruit:
 - Apples were purchased in-market and included New Zealand produced and exported ‘Scilate’ apples which had been cold-stored according to industry protocol, the standard (most frequently produced) domestic Washington State apple ‘Gala’ and the iconic Washington State apple ‘Red Delicious’, both of which had been recently harvested and cold-stored according to industry protocol.
- Consumers:
 - 122 consumers who were residents in Portland, Oregon, USA who regularly purchased and ate apples.
 - Consumers attended a central location testing facility with standard individual tasting booths at the Food Innovation Centre.
 - Data collection was using a digital tool CompuSense Cloud.
- Hedonic questions:
 - Data were collected using a 9-category liking scale: 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’.
- Flavour characterisation:
 - Data was collected using a ‘check all that apply’ (CATA) method. This method has the advantage that it uses consumer-familiar descriptors and does not need training of participants or use of experts as in other methods. The frequency with which terms are checked by consumers is related to the intensity of the specific sensory attribute.
- Conceptual CATA:
 - Consumers often struggle to describe flavour, taste and texture in detail and with appropriate subtlety, but find it easy to identify differences in terms of how they feel about the products and situations that they would use them. We often find that conceptual CATA is better at teasing out subtle sensory differences between close-to-each-other products than is achieved using standard flavour descriptors.

Methods (2)



- Willingness to buy:
 - One of the innovations in the study was the application of a less-used method to assess willingness to buy. Often, there are no consequences to consumers for indicating how interested they would be in buying a product in questionnaires, but more realistic tasks that impose consequences on consumers are available. With the constraints imposed by needing to implement the study in a way that is safe in a COVID-19 setting, we decided to use a Becker-DeGroot-Marschak experimental auction in which successful consumers spent some of their money (i.e. incentive payment for attendance) to take an apple home. Before the process started, consumers were physically given an additional \$3 to spend in part or entirely on an apple. They made single bids for each of the three apples. To avoid consumers having to buy all three apples, there was a subsequent draw regarding which of the apples would be sold and then a draw of the price it would be sold for. If any consumer had made a bid with a value higher or equal to the drawn price they got the apple and whatever change was owing from their \$3. If the consumer bid less than the drawn value they did not get an apple and retained the \$3. Consumers were allowed to bid \$0 if they were not interested in purchasing an apple.
- Freshness and Country of origin:
 - This question drew on the typicality methodology proposed by Maitre et al. (2010).
 - Three subsets of consumers (40 consumers each) received questions relating to fresh apples or US apple or New Zealand apples. The questions they were asked was: Imagine you are explaining to a friend the eating quality they should expect from/of fresh apples / US / New Zealand apples they can buy. For each apple presented, please answer the following question: Do you think that this apple is a very good example or a poor example of the eating quality you usually experience with fresh apples / for US apples / for New Zealand apples? Data was collected on a 10 cm line scale anchored at the end with the phrase 0 cm = bad example and 10 cm = good example.
- Sample presentation:
 - The three tasks (hedonic, flavour characterization & conceptual CATA; willingness to buy; freshness and country of origin) used a monadic presentation approach. One apple sample was evenly cut into 3 parts. The participant was asked to taste 1/3 of the same apple and complete the three tasks.

Methods (3)



- Importance of experienced taste relative to credence attributes (e.g. provenance and sustainability):
 - This was investigated in the central location test using the phrase *'tastes like the best of the apples eaten today'*.
 - The other phrases were: *'Grown in New Zealand'*, *'Grown in the Washington State'* (a neighboring State and the predominate source of apples for Portland consumers), *'Available at a discounted price'*, *'Grown in a place far from the effects of pollution'*, *'Grown in a way that is sustainable and does not harm the environment'*, *'Reduced contribution to global warming'*, *'Grown using less chemical sprays'*, and *'Available soon after harvest'*.
 - The study was implemented using Best Worst Scaling methodology in which each consumer received 12 tables containing varying combinations of 6 out of the 9 possible statements in a randomized design. For each table individual consumers indicated the best choice and the worst choice.
 - Analysis of the data used the $\sqrt{(B-W)}$ method described in Jaeger et al. (2021). The relative importance is demonstrated by allocating the most important statement the score of 100 and other statements with scores relative to this.
 - This data was collected on paper forms.
- To investigate how the results from the study above compared to those collected using a remote online approach, a new group of 120 Portland consumers with identical demographic profiles was recruited using the same consumer database:
 - The statement *'tastes like the best of the apples eaten today'* was substituted with a statement drawing on the sensory profile elucidated in the flavour characterization step of the central location test. The statement was: *'Crisp, juicy and sweet'*.
 - This data was collected was using a digital tool Compusense Cloud.

Results: consumer demographics



Demographic	%
Age group	
22 - 30 y. o.	11
31 - 45 y. o.	36
46 - 60 y. o.	33
61 - 76 y. o.	20
Gender	
Woman	56
Man	40
Gender queer / gender non-conforming	2
Transgender	1
Prefer not to disclose	1

Demographic	%
Annual household income (USD)	
Less than \$19,999 /yr	2
\$20,000-\$29,999 /yr	6
\$30,000-\$39,999 /yr	5
\$40,000-\$49,999 /yr	9
\$50,000-\$59,999 /yr	6
\$60,000-\$79,999 /yr	12
\$80,000-\$99,999 /yr	13
\$100,000-\$149,999 /yr	26
\$150,000-\$199,999 /yr	7
\$200,000/yr or more	13

Demographic	%
Household size	
1-2	58
3-4	34
5+	7
Household members	
No-one, I live alone	20
Spouse/partner	66
Child/ren aged under 18	23
Child/ren aged 18 and over	5
Parents	6
Room mates	11
Other	3

Demographic	%
Ethnicity	
American Indian or Alaskan Native	3
Asian	10
Black or African American	0
Latin or Hispanic	2
Middle Eastern or North African	2
Hawaiian Native or Pacific Islander	0
White	88
Other	3

Demographic	mean (SE)	Equivalent Category
Apple liking score*	8.1 (0.8)	Like very much
Apple eating frequency**	2.1 (1.0)	2 or more times each week
Apple purchase frequency**	3.3 (0.9)	About once a week

* Total responses are >100% as participants may select multiple options.
 ** A 9-point hedonic scale was used for apple liking from 1 = 'dislike extremely' to 9 = 'like extremely'. Frequency scale: 1=Everyday or almost everyday; 2=2 or more times a week; 3=About once a week; 4=About 2-3 times a month; 5=About once a month; 6=About once every 2-3 months; 7=About once a year or less; 8=Never.

Results: fruit quality



Chemical and physical properties of apples (means of 20 fruit)

	Flesh firmness (kgf)	Soluble solids concentration (%)	Titrateable acidity (%)
NZ 'Scilate'	7.8	13.9	0.19
USA 'Gala'	7.6	11.3	0.31
USA 'Red Del.'	6.8	12.3	0.20

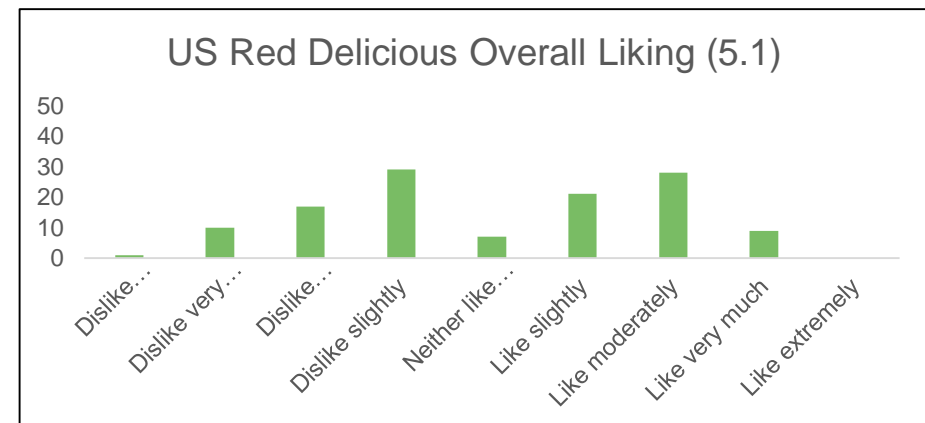
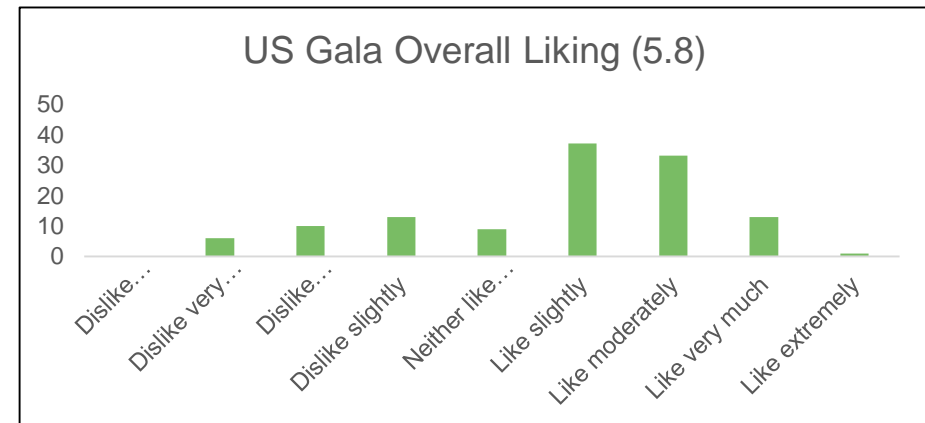
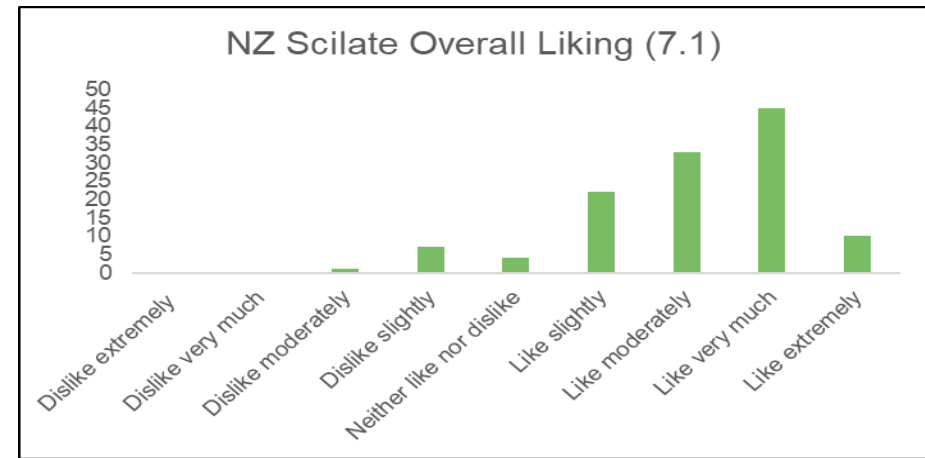


Consumer liking for apples

Cultivar	Mean \pm SE
NZ 'Scilate'	7.1 ^{a*} \pm 0.1
USA 'Gala'	5.8 ^b \pm 0.2
USA 'Red Delicious'	5.1 ^c \pm 0.2

*letters indicate treatments are statistically different (F = 75.4 on 2 and 240 df, p < 0.001)

- Average scores of consumer liking for the apples was statistically different.
- As anticipated consumers expressed higher liking for the elite apple 'Scilate' (~liked moderately) over 'Gala' (~like slightly) and 'Red Delicious' (~neither like nor dislike).
- The iconic and traditional cultivar, 'Red Delicious' evoked a bimodal response from consumers – such that some consumers liked this apple, while others disliked it.



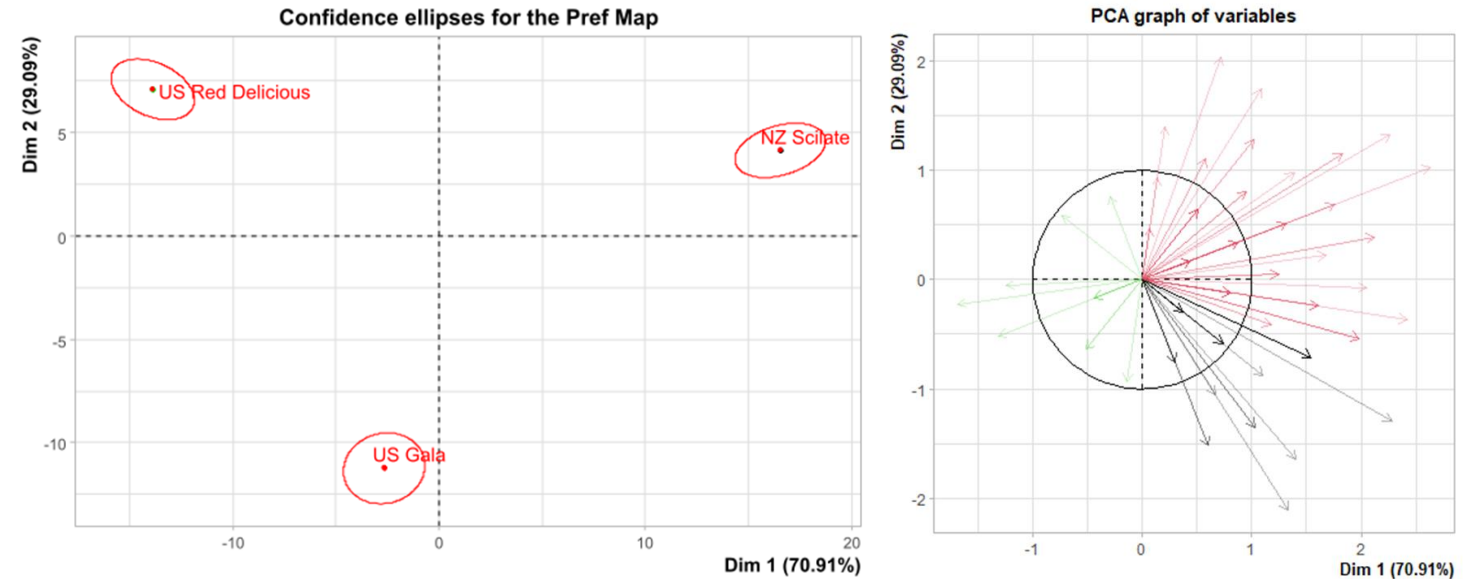
Consumer segments (Cluster analysis)



A more precise analysis of consumer liking identified three groups of consumers each of which was homogenous in response:

- 76 consumers who liked 'Scilate' and were neutral regarding 'Gala' and 'Red Del'.
- 32 consumers who liked 'Scilate' and 'Gala' to a similar extent, but disliked 'Red Del'.
- 14 consumers who liked 'Red Del.' and 'Gala' more than they liked 'Scilate'.

There were too few consumers in Cluster 3 for further consideration. It is presented here because it is not unusual to discover small groups of consumers whose preferences contradict the majority.



Principal components analysis on the hedonics provided the above preference map (arrows indicate directions of increasing liking for individuals). Ward D2 cluster function was used to identify 3 clusters of consumers: red, green and black arrows.

Cultivar	Cluster 1 (Black) (mean ± SE)	Cluster 2 (Red) (mean ± SE)	Cluster 3 (Green) (mean ± SE)
Number of consumers	32	76	14
Liking for NZ 'Scilate'	7.0 ± 0.2	7.4 ± 0.1	5.5 ± 0.4
Liking for USA 'Gala'	7.1 ± 0.2	5.1 ± 0.2	6.6 ± 0.3
Liking for USA 'Red Del.'	4.4 ± 0.3	5.0 ± 0.2	6.8 ± 0.3

Consumer descriptions of sensory differences



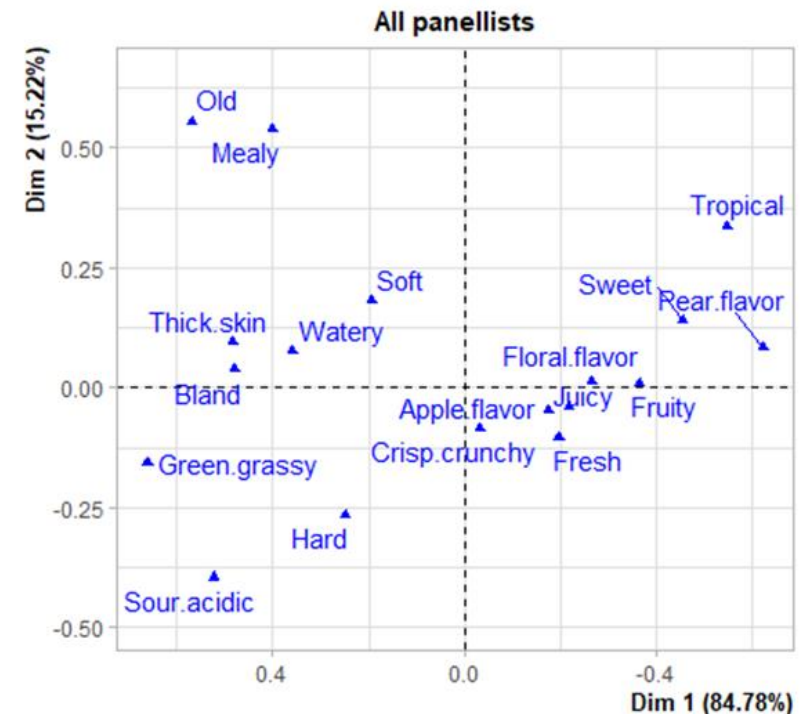
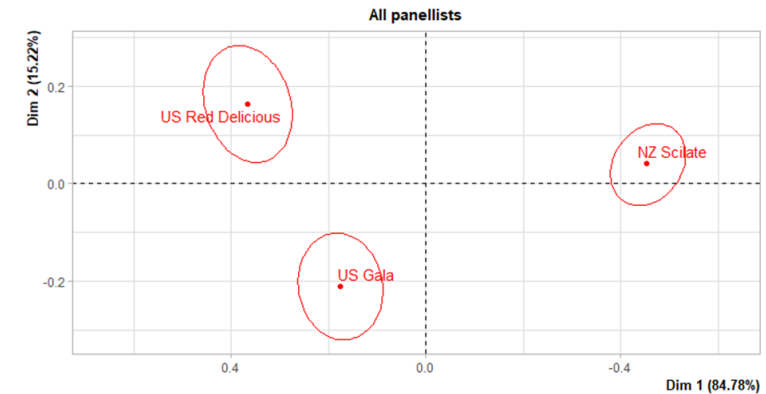
The figures on the right relate the attributes (in blue) that consumers use to describe each apple (in red) using correspondence analysis. The ellipses represent 95% confidence limits for the average location of the apples – when these don't overlap we can be certain the apples were different in sensory properties.

85% of the variability in descriptions was associated with Dimension 1 (x-axis) and 15% with Dimension 2 (y-axis).

Attributes that are closer to an apple are more frequently used to describe it.

Hence:

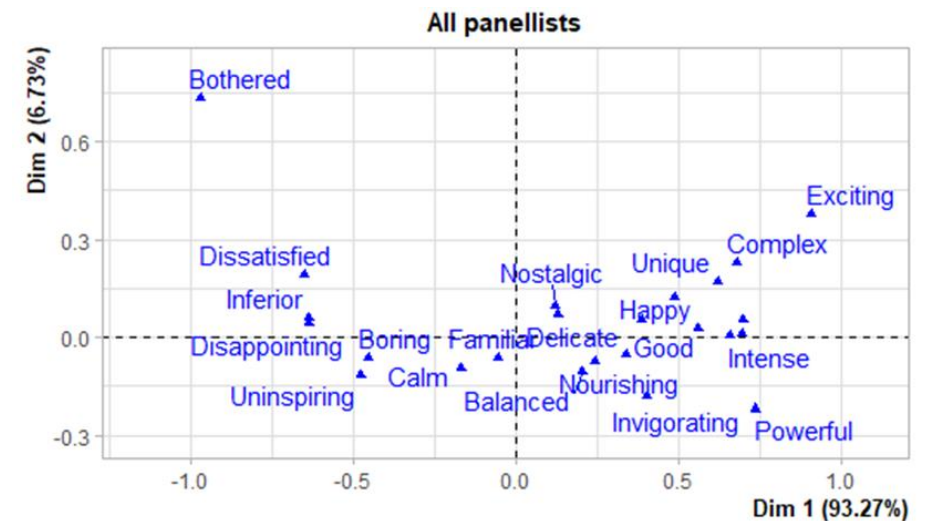
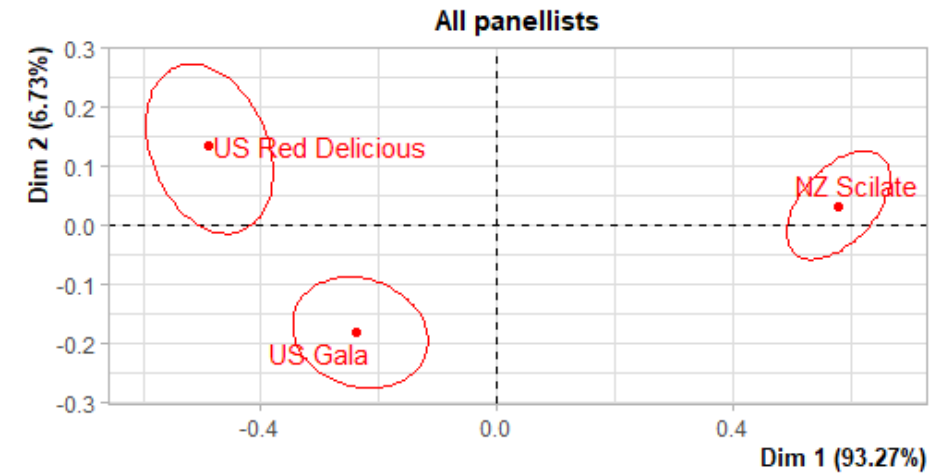
- 'Scilate' was differentiated because it was sweet with a tropical, floral and pear-like flavour as well as being juicy and fresh.
- 'Gala' was hard, sour-acidic with an apple and green-grassy flavour.
- 'Red Delicious' was differentiated by the use of attributes: old, mealy, thick skin, soft, watery and bland.



How sensory differences effect conceptual and emotional terms



- Using a similar approach as used for sensory descriptions, it is possible to associate conceptual and emotional words (in blue) with apples (in red).
- In this case, 93% of the variability in concepts/emotions was associated with Dimension 1 (x-axis) and 7% with Dimension 2 (y-axis).
- Hence:
 - ‘Scilate’ is perceived as exciting, complex, unique, happy, good, intense, nourishing, invigorating and powerful experience.
 - Both ‘Gala’ and ‘Red Delicious’ are perceived as a disappointing, uninspiring, boring experience that left consumers dissatisfied.
 - ‘Red Delicious’ was separated from ‘Gala’ along Dimension 2 in that it was more likely to be described using the word ‘bothered’ and less frequently described as ‘calm’(ing) or uninspiring.

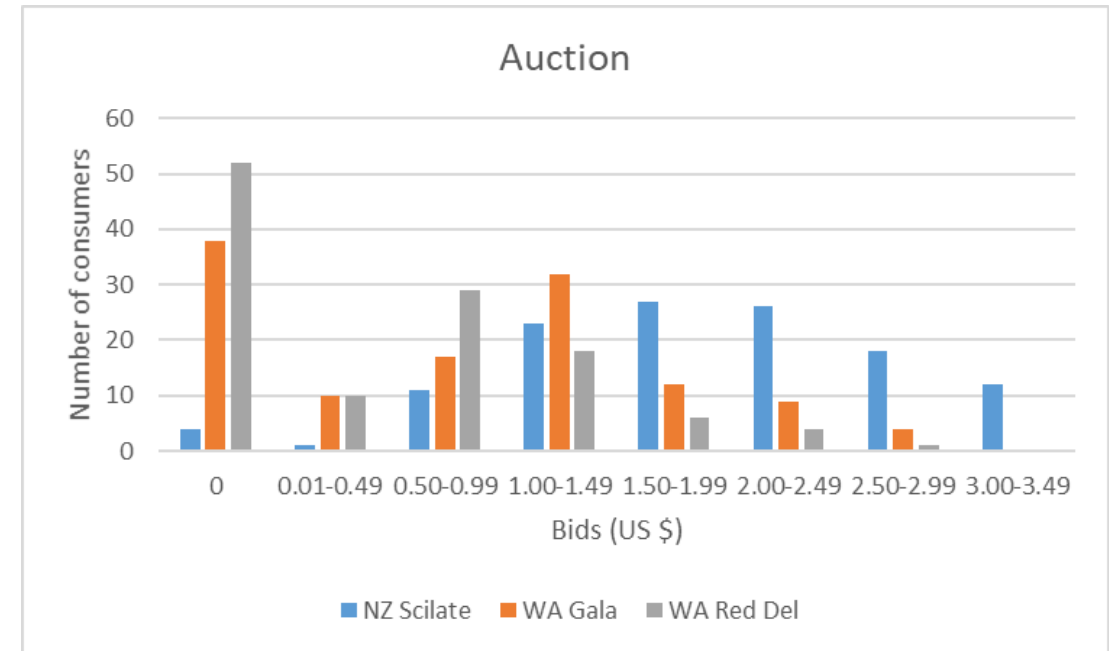


Principal components analysis on the hedonics provided the above preference.

Willingness to buy (BDM experimental auction)



- Willingness to pay was assessed using a realistic task in which consumers, if they ‘won’ in the bidding process, had to pay and take the apples away (see method section).
- We promote these values (bids) as powerful indicators of interest (and relative interest) in the products, rather than realistic price in a real-world market.
- If consumers were not interested in purchasing the apple, they were instructed to bid \$0.
- The willingness to pay (bids) reflected the liking scores, as well as sensory and conceptual descriptors:
 - ‘Scilate’ attracted the highest mean bid and the least number of \$0 bids.
 - ‘Gala’ attracted the middle mean bid and 31% of consumers bid \$0.
 - ‘Red Delicious’ attracted the lowest mean bid and 43% of consumers bid \$0.



Cultivar	Bid value (mean ± SE)	Number bidding \$0
NZ ‘Scilate’	\$1.72 ^a ± 0.07	4
US ‘Gala’	\$0.79 ^b ± 0.07	38
US ‘Red Del.’	\$0.51 ^c ± 0.06	52

*letters indicate treatments are statistically different (F = 129.9 on 2 and 242 df, p < 0.001)

Influence of eating quality on perceptions of freshness and country of origin



Cultivar	Perceived Freshness (mean \pm se)	Is this a good example of USA apples? (mean \pm se)	Is this a good example of NZ apples (mean \pm se)
NZ 'Scilate'	7.34 ^{a*} \pm 0.29	6.99 ^a \pm 0.38	7.08 ^a \pm 0.38
USA 'Gala'	4.13 ^b \pm 0.37	4.66 ^b \pm 0.44	4.93 ^b \pm 0.44
USA 'Red Del.'	3.99 ^b \pm 0.45	3.90 ^b \pm 0.37	4.25 ^b \pm 0.45

*letters indicate treatments (within and between columns) are statistically different (F = 60.8 on 2 and 236 df, p < 0.001)

Freshness:

- Recall that 'Scilate' had been grown in the counter season and stored while 'Gala' and 'Red Delicious' were recently harvested.
- No information on cultivar or country of origin was provided to consumers.
- In these conditions, consumers assessed freshness on the basis of eating quality, such that 'Scilate' was significantly fresher than either 'Gala' or 'Red Delicious', which were not different from each other

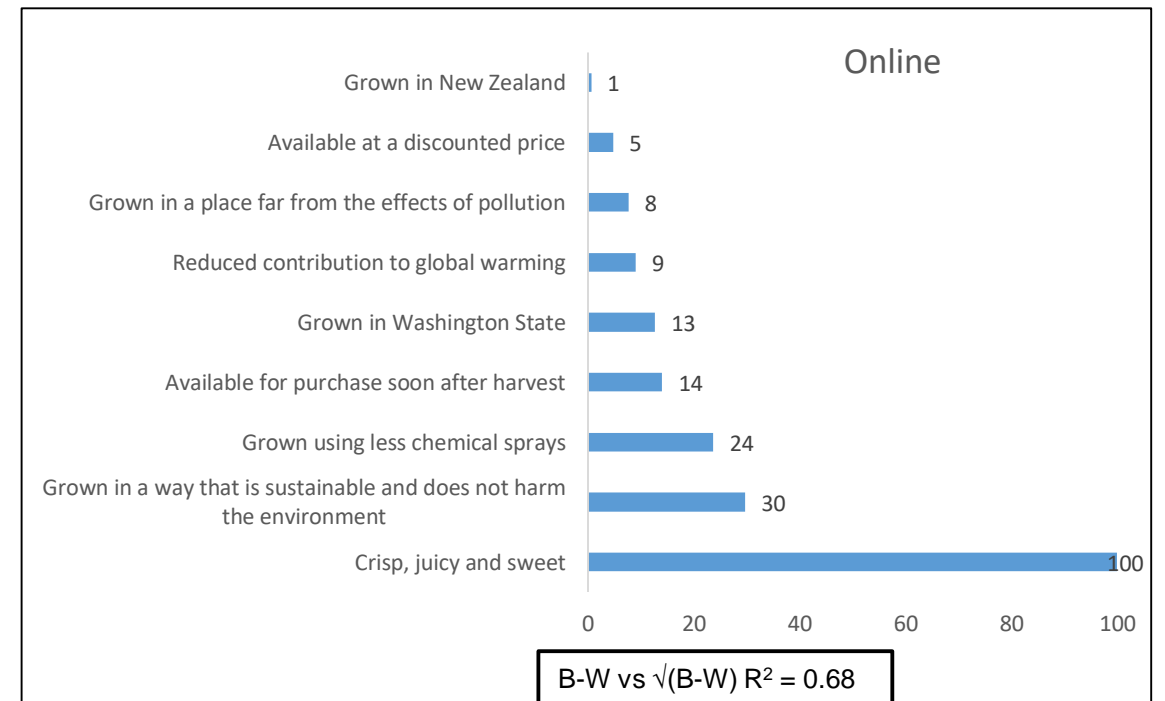
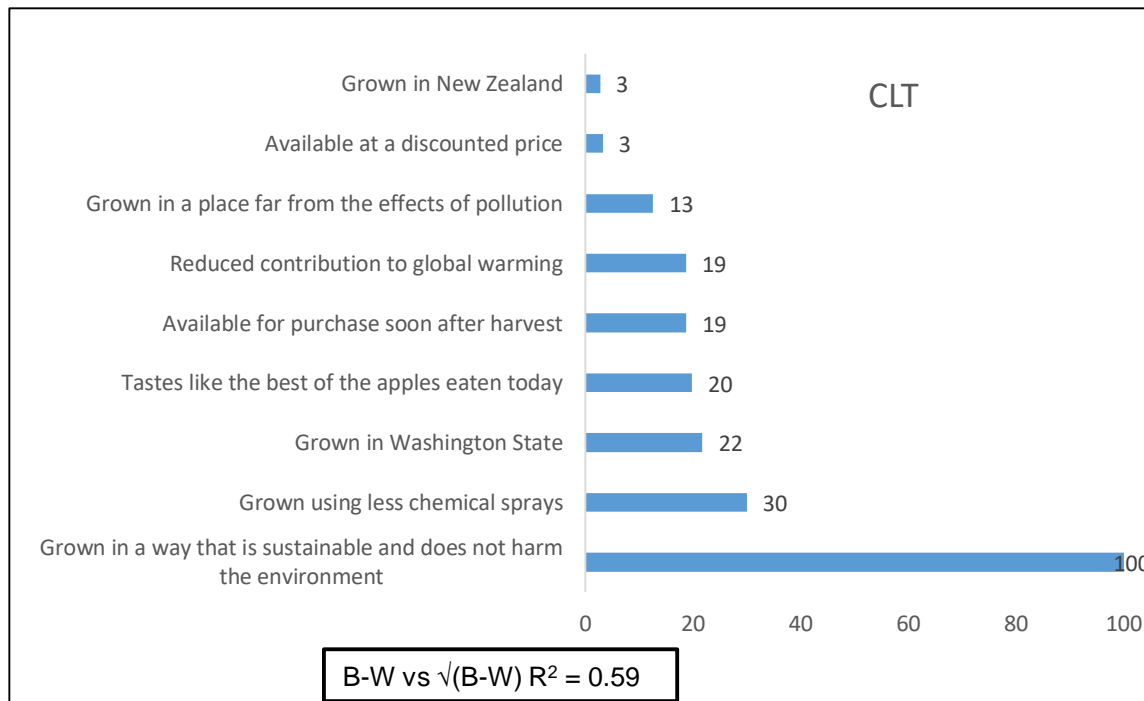
Typicality:

- We hypothesised that USA consumer-bias would lead to better quality apples being perceived as more typical of apples grown in the USA than NZ.
- This hypothesis was rejected as consumers rated the apples with the same levels of typicality immaterial of the suggested origin of the fruit.
- This suggests there is no cognitive bias regarding the country of origin (USA vs NZ) but rather see the treatments as good or bad example of apple in general.

The influence of sensory task on the relative importance of sustainability, use of chemicals, country of origin, and taste



- Recall that just after the first tasting task, consumers were asked to complete a choice task in which different statements were presented regarding sustainability, use of chemicals, country of origin and taste. We used a Best Worst Scaling method (see method) and the taste statement was: '*tastes like the best of the apples eaten today*'.
- The same task was repeated later with a similar group of consumers, but as an online task and replacing the taste statement with the phrase: '*Crisp, juicy and sweet*' (these terms were the most frequently used sensory descriptors earlier in the study).
- The results below are scaled such that most important attribute is given a value of 100 and other attributes scaled relative to this (Jaeger et al. 2021).



The importance of taste



Interpretation:

- Results were similar between the two consumer tasks, with one major difference.
- The consumers responding to the on-line task reported that the most important consideration by some distance was '*Crisp, juicy and sweet*'. The consumers at the tasting session placed much less weight on '*Tastes like the best of the apples eaten today*'.
- This result may appear counterintuitive, since the consumers in the taste test expressed high liking and willingness to pay for 'Scilate', but in the choice task indicated that environment (score = 100) was more important than taste (score = 20). Whereas, the consumers who didn't taste apples, '*Crisp, juicy and sweet*' was more important (score = 100) than the environment (score = 42).
- Nevertheless, this outcome is consistent with literature suggesting that imagined food experiences can be exaggerations of actual experiences (Cardello and Maller, 1982; Cardello et al., 2012). In the current study, the on-line consumers may have imagined the counterfactual to '*Crisp, juicy and sweet*' was an apple that was terrible to taste, whereas when consumers tasted the apples, they knew that all the apples were of a high taste standard.
- This interpretation is consistent with one of the key assumptions of this research programme, which is that physical attributes such as flavour, texture, appearance, odour/aroma and convenience are essential elements of quality in the consumer's judgement of willingness to pay a premium (Saunders et al, 2017, pp. 5-6).
- Profiling credence attributes such as sustainability can enhance a product's perceived quality, but it cannot replace the fundamental importance of outstanding taste and other physical characteristics.

General learnings for the agri-food and fruit export sectors



- Imported New Zealand foods (e.g. 'Scilate' apples) were differentiated from standard (e.g. 'Gala') and iconic (e.g. 'Red Delicious') local foods on the basis of superior and distinctive sensory characteristics (texture, taste and flavour) that were attractive to consumers and achieved premium prices in experimental markets.
- The distinctive nature of these foods was captured using consumer-relevant sensory vocabularies (e.g. crisp, floral, sweet).
- The superior nature of these foods was captured in the same way as sensory characteristics, but using conceptual terms such as uninspiring, inferior, nourishing, unique, complex.
- The BDM experimental auction was a simple and easily implemented method to assess consumer interest in foods that importantly meant there was a real consequence to consumers for the decisions they made. We advocate that these bids should be considered as an indication of consumer interest rather than real prices in the market.
- What seemed to be a relatively small change in mean liking scores (2 units out of 9, i.e. from 'neither like nor dislike' to 'like moderately' translated to a more than three-fold increase in interest in the product (mean bids increased from \$0.51 to \$1.72).
- The interaction and relative importance of experienced attributes (e.g. taste) and credence attributes (i.e. attributes that cannot be evaluated and verified, even after purchasing and consumption) is complex and difficult to assess experimentally. In this study, the importance of taste dominated importance for consumers answering questions on-line, but was less important for consumers who had tasted the three types of apple in the test.
- This result illustrates the importance of quality physical attributes (such as taste) for purchase decisions, but also illustrates how credence attributes (such as sustainability) can contribute to consumer perceptions of a premium product.



Additional learnings for the export fruit sector

- The current study found that apple sensory quality in itself was contributing majorly to perceptions of freshness and there was no specific bias associated with associating freshness with New Zealand or USA production (noting that all testing was blind to country of origin or harvest dates). Furthermore, 'available soon after harvest' was of moderate importance in the BWS choice tasks, with either taste (in the online study) or environmental sustainability (central location study) being the dominant factors. In both consumer choice studies, it was found that apples having been grown in Washington State was a more important positive determinant of choice than grown in New Zealand.
- 'Grown using less sprays' was 2nd (central location test) or 3rd (online study) option in terms of importance in the BWS choice task.

Conclusion



This study has demonstrated that sensory characteristics that enhance eating quality are of great interest and monetary value to consumers. In respect to the latter, the Becker-DeGroot-Marschak experimental market (auction) was a simple and highly successful approach to determine willingness to buy, or perhaps more accurately the relative interest in products. Furthermore, this method could be implemented safely in a COVID-19 environment.

One topic of interest in the broader programme of research is the way 'experienced' and 'credence' attributes are traded against each other when consumers make food choices. Here, we have found that from an experimental perspective, the importance of 'eating quality' and 'sustainability' differ according to whether or not the trade-offs are made in studies that involve tasting or not. This observation is supported by studies that have previously demonstrated that imagined eating quality is an exaggeration of real experiences.

Overall, this result argues: (1) that there is a continuing need to understand the influence of data collection-conditions on consumer responses and (2) without this knowledge, businesses should be cautious in interpreting data at face value.

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Thank you

roger.harker@plantandfood.co.nz

plantandfood.co.nz     

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