



Penalty analysis based on CATA questions to identify drivers of liking and directions for product reformulation

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Introduction

- During new product development, one of the challenges for Sensory & Consumer Science is to provide actionable information for specific changes in product formulation (Moskowitz & Hartmann, 2008).
- Many strategies have been used in product optimization for identifying drivers of liking and ideal products:
 - Preference mapping based on sensory characterization of the products (van Kleef et al., 2006).
 - Consumer-based sensory characterizations (Dooley et al., 2010; Ares et al., 2010; Varela & Ares, 2012).
 - Consumers' description of the ideal product

◎ Just-about-right scales (JAR)

- Consumers evaluate a set of attributes as deviations from the ideal (Lawless & Heymann, 2010).
- Simple and common approach
- Penalty analysis enables the identification of directions for product reformulation (Xiong & Meullenet, 2006).
- They have raised several concerns regarding their influence on overall liking scores (Epler et al., 1998; Popper et al., 2004).

◎ Ideal profile method

- Consumers rate the intensity of a set of attributes for the samples and their ideal product using scales (Worch et al., 2010; Worch et al., 2012a, 2012b).
- Ideal product descriptions are similar to the most liked products.
- Provides actionable information for product reformulation.

◎ Check-all-that-apply (CATA) questions

- Have gained popularity for sensory characterization of food products with consumers (Adams et al., 2007; Dooley et al., 2010; Ares et al., 2010; Ares et al., 2011).
- Consumers are presented a list of terms and are asked to check all the terms they consider appropriate to describe a sample.
- Quick, simple and easy task for consumers (Adams et al., 2007).
- It has been used to describe consumers' ideal product (Cowden et al., 2009; Ares et al., 2011).
- Penalty/reward analysis for emotional terms (Plaehn, 2012).

Aim of the study

Apply penalty analysis based on consumer responses to a CATA question about a set of samples and their ideal product to identify drivers of liking and directions for product reformulation.

Materials and methods



■ Study 1: Yogurts

- 74 consumers evaluated 8 yogurts formulated following a 2^3 full factorial design for fat content, gelatin and starch.
- They tried the yogurts, rated their texture liking using a 9-point hedonic scale and answered a CATA question composed of 16 texture terms
- They also answered the CATA question for their ideal yogurt.

Smooth	Viscous	Homogeneous	Liquid
Lumpy	Creamy	Sticky	Rough
Gummy	Thick	Gelatinous	Firm
Heterogeneous	Consistent	Runny	Mouth-coating



■ Study 2: Apples

- 119 consumers evaluated 5 commercial apple cultivars.
- They tried the apples, rated their overall liking using a 9-point hedonic scale and answered a CATA question composed of 15 odour, flavour and texture terms
- They also answered the CATA question for their ideal apple.

Firm	Sour	Odourless	Juicy	Crispy
Tasteless	Sweet	Flavoursome	Mealy	Bitter
Coarse	Apple flavour	Apple odour	Soft	Astringent



- Data analysis
 - Overall liking scores
 - ANOVA
 - Cluster analysis on data from Study 2
 - CATA question
 - Frequency of use
 - Cochran's Q test
 - Correspondence analysis
 - Penalty analysis

- Penalty analysis

- Dummy variable approach



Check all the words that apply to describe this apple:

<input checked="" type="checkbox"/> Firm	<input checked="" type="checkbox"/> Sour	<input type="checkbox"/> Odourless
<input type="checkbox"/> Juicy	<input checked="" type="checkbox"/> Crispy	<input type="checkbox"/> Tasteless
<input checked="" type="checkbox"/> Sweet	<input type="checkbox"/> Flavoursome	<input type="checkbox"/> Mealy
<input type="checkbox"/> Bitter	<input type="checkbox"/> Coarse	<input checked="" type="checkbox"/> Apple flavour
<input checked="" type="checkbox"/> Apple odour	<input type="checkbox"/> Soft	<input type="checkbox"/> Astringent

Check all the words that apply to describe your ideal apple:

<input checked="" type="checkbox"/> Firm	<input type="checkbox"/> Sour	<input type="checkbox"/> Odourless
<input checked="" type="checkbox"/> Juicy	<input checked="" type="checkbox"/> Crispy	<input type="checkbox"/> Tasteless
<input checked="" type="checkbox"/> Sweet	<input type="checkbox"/> Flavoursome	<input type="checkbox"/> Mealy
<input type="checkbox"/> Bitter	<input type="checkbox"/> Coarse	<input checked="" type="checkbox"/> Apple flavour
<input checked="" type="checkbox"/> Apple odour	<input type="checkbox"/> Soft	<input type="checkbox"/> Astringent

Consumer	Sample	Firm	Sour	Odourless	Juicy	...	Astringent
1	Crisp Pink	0	1	0	1	...	0
1	...	...	...	...	...	...	...
...
119	Royal gala	...	...	...	...	...	...

0: indicates that the attribute was used to describe the sample as in the ideal product

1: indicates that the attribute was used differently to describe the sample and the ideal product



- Penalty analysis

- The percentage of consumers who used an attribute differently for describing each sample and the ideal product

Threshold: 20% (Xiong & Meullenet, 2006; Plaehn, 2012).

- Mean drop associated with the deviation from the ideal.

Kruskal-Wallis test

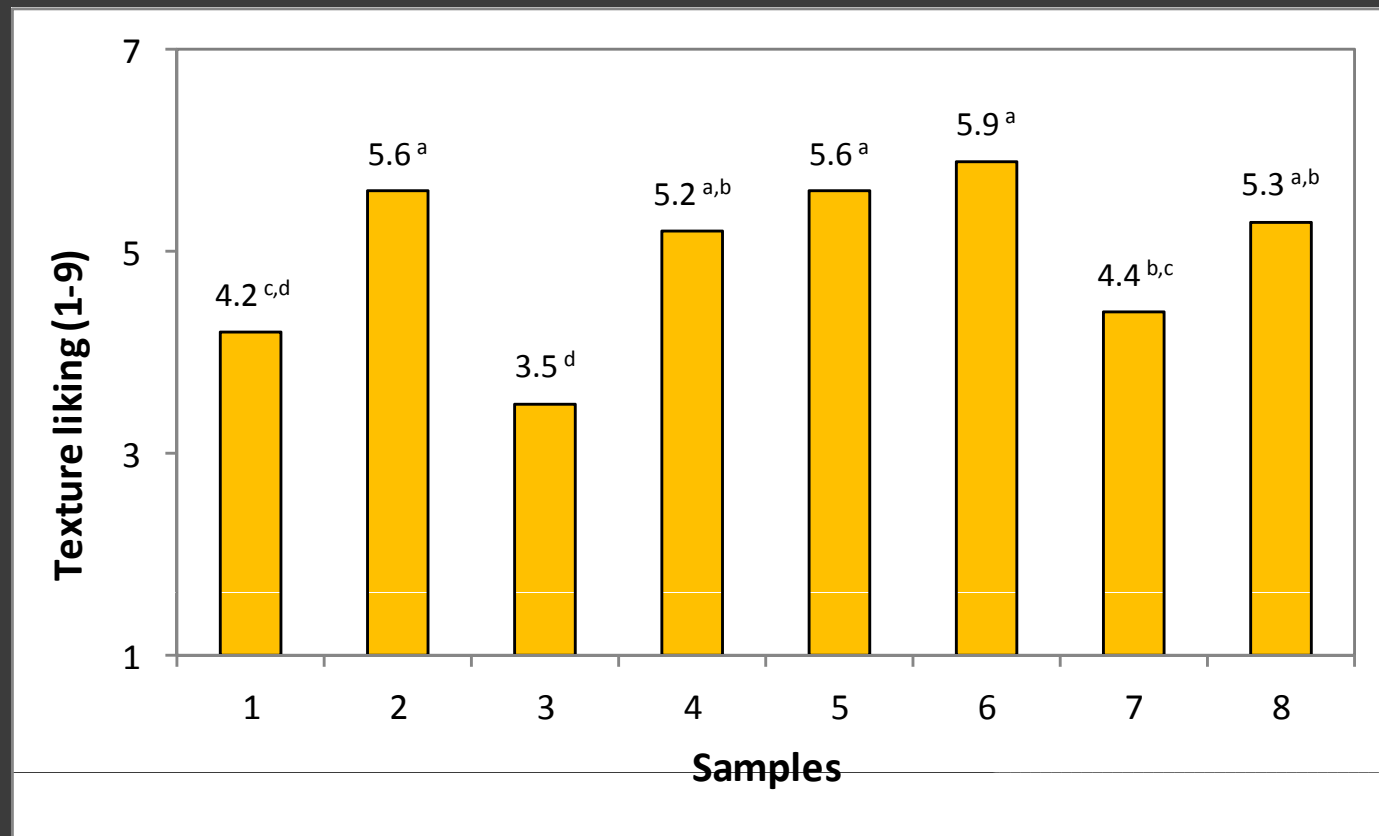
- Partial-least squares (PLS) regression

Overall liking as dependent variable and dummy variables as regressors (Xiong & Meullenet, 2006).

Results

○ Study 1: Yogurts

■ Texture liking scores

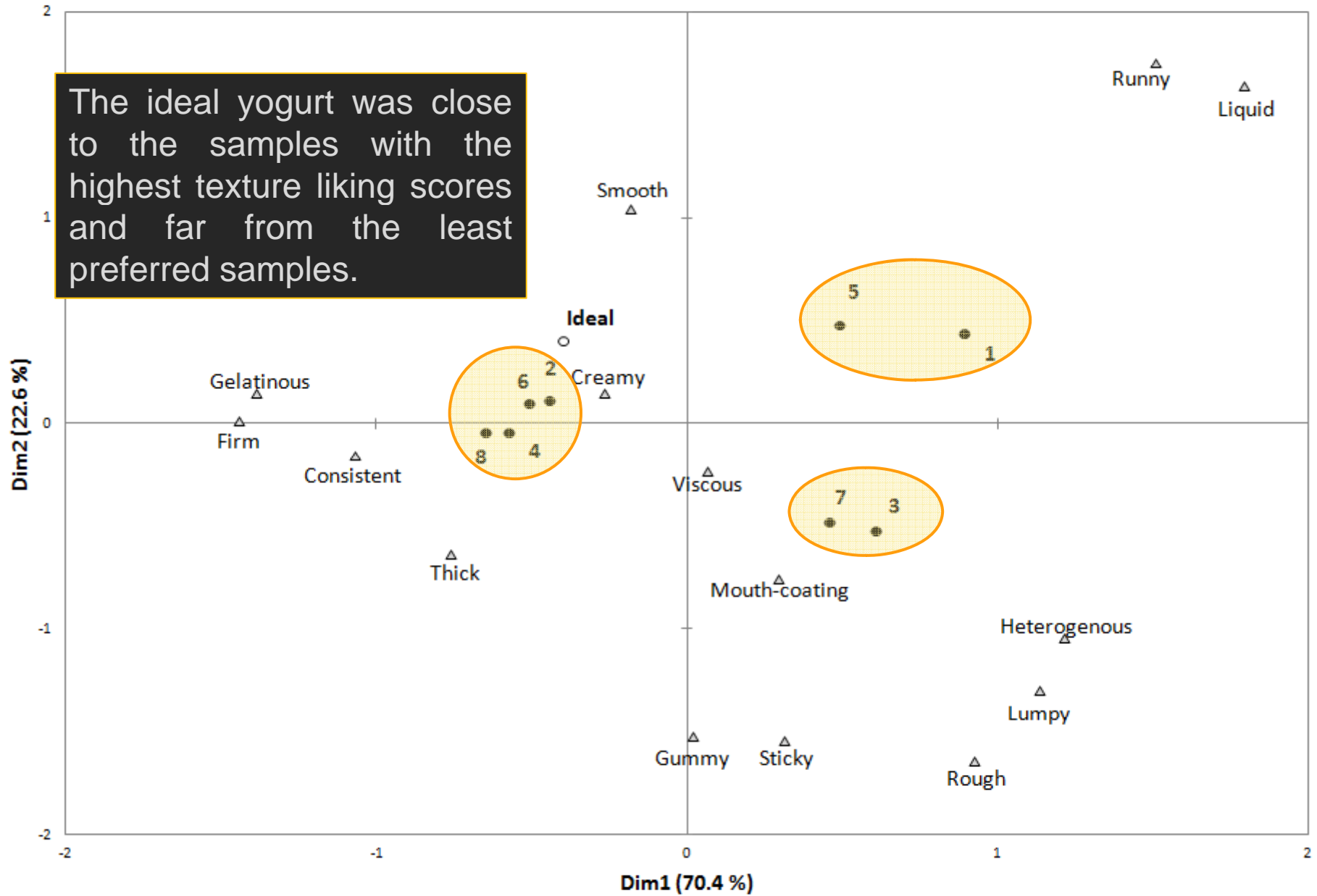


- Frequency of use of the terms (%)

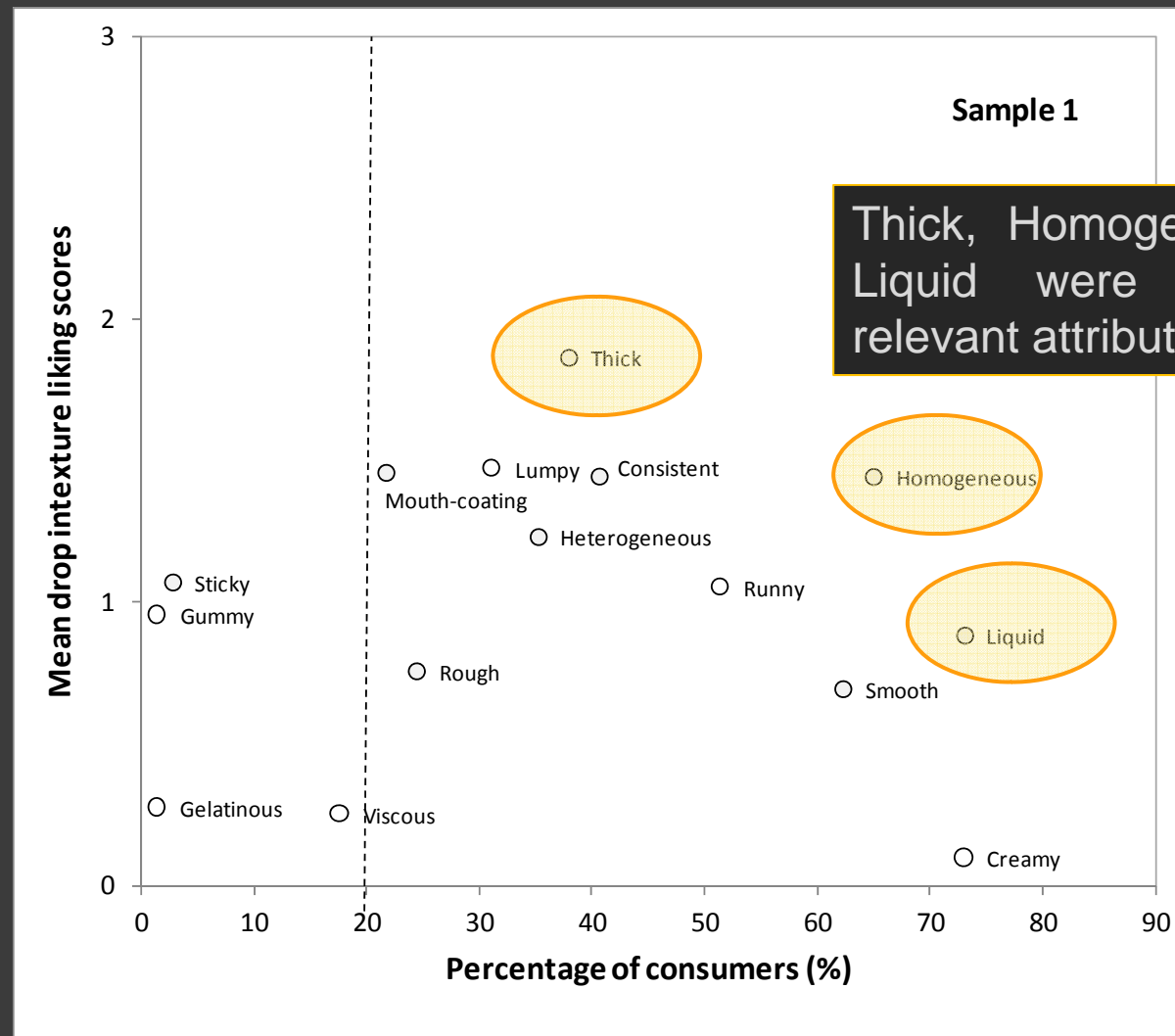
Attribute	Sample								Ideal
	1	2	3	4	5	6	7	8	
Smooth ***	41	53	12	38	62	64	23	45	92
Lumpy ***	32	7	57	11	26	11	61	8	1
Viscous ns	5	8	12	7	11	12	7	15	12
Homogeneous ***	20	39	10	30	33	38	5	43	80
Liquid ***	73	4	10	10	11	12	22	0	3
Thick ***	3	32	10	10	11	12	30	51	38
Gelatinous ***	1	30	10	10	11	12	0	26	0
Firm ***	0	36	10	10	11	12	8	65	20
Sticky *	3	4	10	10	11	12	8	8	0
Creamy **	16	35	10	30	33	38	32	38	86
Rough ***	24	5	46	16	9	7	46	11	0
Consistent ***	0	45	9	57	11	45	20	55	31
Mouth-coating *	15	11	30	16	14	19	24	16	9
Gummy ns	1	0	4	5	1	1	7	5	0
Runny ***	55	11	20	3	47	5	15	0	18
Heterogenous ***	32	19	49	4	18	7	42	0	3

Smoothness, Homogeneity and Creaminess main drivers of texture liking, in agreement with previous studies (Pohjanheimo & Sandell, 2009; Bayarri et al., 2011).

The ideal yogurt was close to the samples with the highest texture liking scores and far from the least preferred samples.



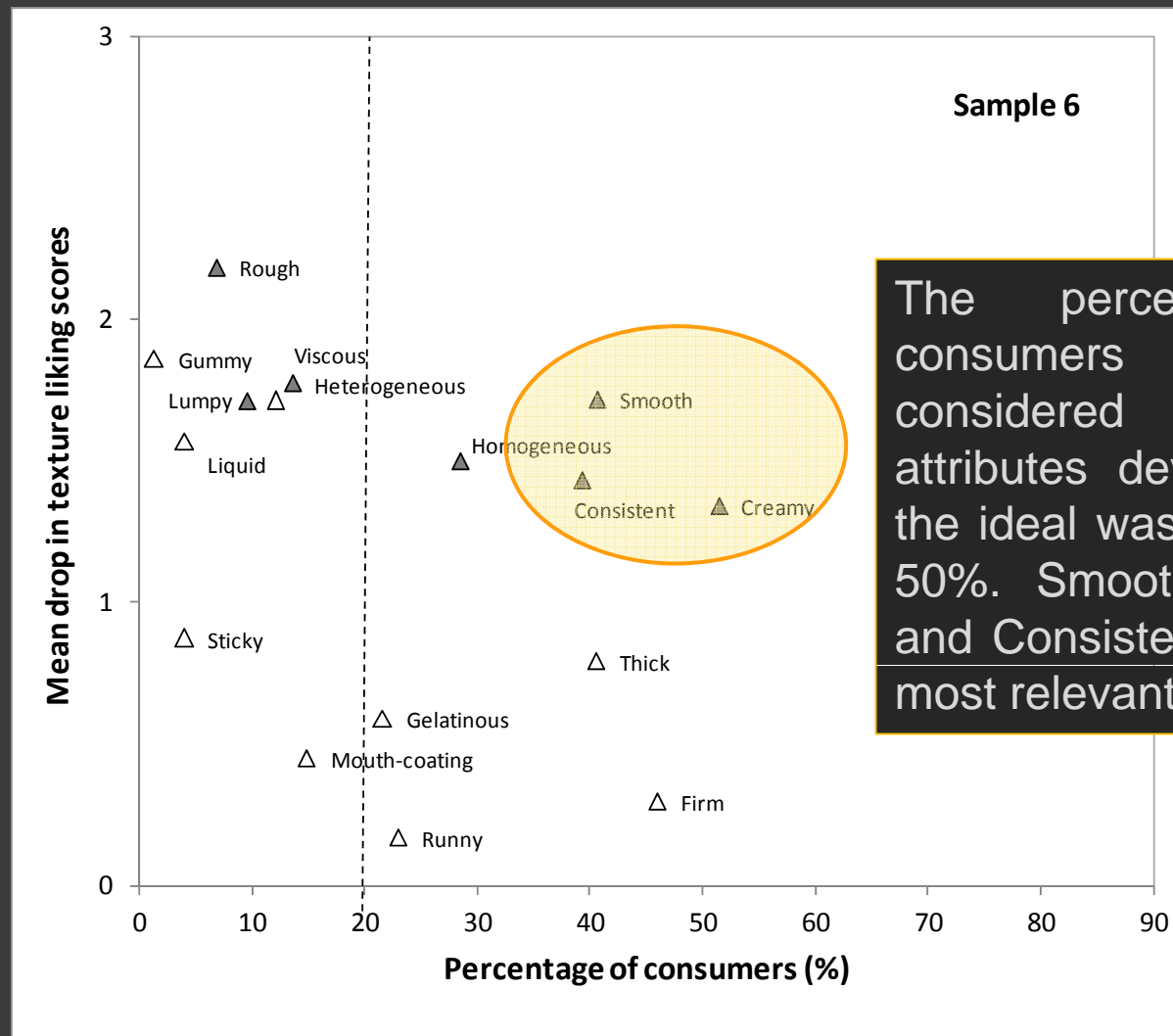
- Penalty analysis



Thick, Homogeneous and Liquid were the most relevant attributes.

Recommended changes:
Increase in Homogeneity and
Thickness

Attribute	Sample								
	1	2	3	4	5	6	7	8	Ideal
Smooth ***	41	53	12	38	62	64	23	45	92
Lumpy ***	32	7	57	11	26	11	61	8	1
Viscous ns	5	8	18	7	14	12	7	15	12
Homogeneous ***	20	39	8	49	26	57	5	43	80
Liquid ***	73	4	23	3	45	1	22	0	3
Thick ***	3	32	23	49	8	43	30	51	38
Gelatinous ***	1	30	4	31	0	22	0	26	0
Firm ***	0	36	1	47	1	45	8	65	20
Sticky *	3	4	14	3	3	4	8	8	0
Creamy **	16	35	18	36	35	38	32	38	86
Rough ***	24	5	46	16	9	7	46	11	0
Consistent ***	0	45	9	57	11	45	20	55	31
Mouth-coating *	15	11	30	16	14	19	24	16	9
Gummy ns	1	0	4	5	1	1	7	5	0
Runny ***	55	11	20	3	47	5	15	0	18
Heterogenous ***	32	19	49	4	18	7	42	0	3



The percentage of consumers who considered that the attributes deviated from the ideal was lower than 50%. Smooth, Creamy, and Consistent were the most relevant attributes.

Recommended changes: an increase in smoothness, and creaminess, and a decrease in consistency.

Attribute	Sample								
	1	2	3	4	5	6	7	8	Ideal
Smooth ***	41	53	12	38	62	64	23	45	92
Lumpy ***	32	7	57	11	26	11	61	8	1
Viscous ^{ns}	5	8	18	7	14	12	7	15	12
Homogeneous ***	20	39	8	49	26	57	5	43	80
Liquid ***	73	4	23	3	45	1	22	0	3
Thick ***	3	32	23	49	8	43	30	51	38
Gelatinous ***	1	30	4	31	0	22	0	26	0
Firm ***	0	36	1	47	1	45	8	65	20
Sticky *	3	4	14	3	3	4	8	8	0
Creamy **	16	35	18	36	35	38	32	38	86
Rough ***	24	5	46	16	9	7	46	11	0
Consistent ***	0	45	9	57	11	45	20	55	31
Mouth-coating *	15	11	30	16	14	19	24	16	9
Gummy ^{ns}	1	0	4	5	1	1	7	5	0
Runny ***	55	11	20	3	47	5	15	0	18
Heterogenous ***	32	19	49	4	18	7	42	0	3

Regression coefficients from PLS model

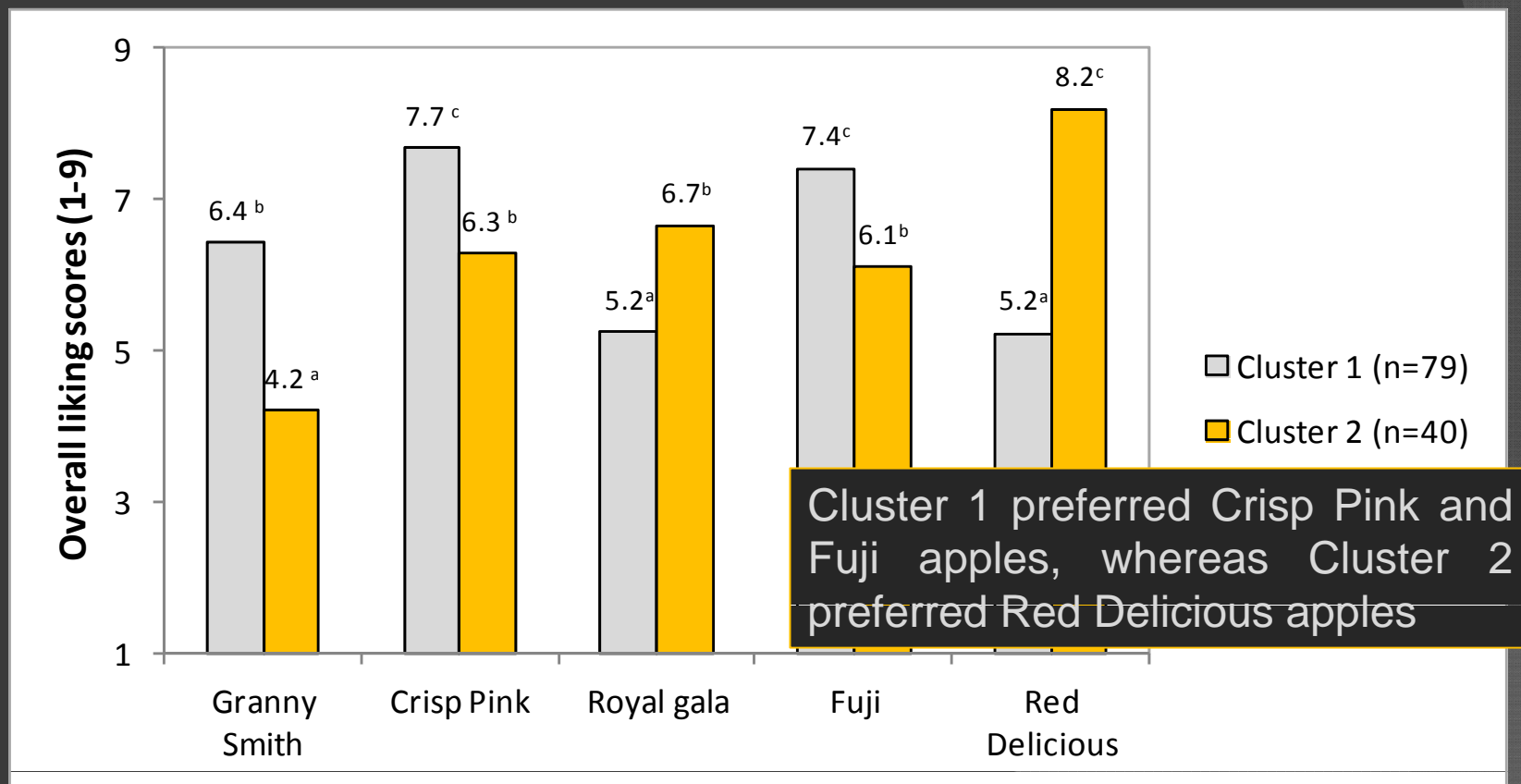
Term	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5		Sample 6		Sample 7		Sample 8	
	%	RC	%	RC	%	RC	%	RC	%	RC	%	RC	%	RC	%	RC
Smooth	62	-0.15	50	-0.24	82	-0.17	59	-0.21	41	-0.16	41	-0.20	77	-0.14	53	-0.14
Lumpy	31	-0.31	8	-	55	-0.10	12	-	27	-0.15	12	-	59	ns	9	-
Viscous	18	-	12	-	16	-	14	-	20	ns	14	-	16	-	22	-0.15
Homogeneous	65	-0.13	49	-0.18	77	-0.08	39	-0.17	59	ns	28	-0.16	74	-0.10	36	ns
Liquid	73	-0.14	4	-	26	-0.09	5	-	45	-0.18	4	-	24	ns	3	-
Thick	38	ns	32	ns	34	ns	46	ns	35	ns	41	ns	32	ns	43	ns
Gelatinous	1	-	30	ns	4	-	31	ns	0	-	22	ns	0	-	26	ns
Firm	20	ns	41	ns	22	ns	41	ns	19	-	46	ns	26	-0.14	55	-0.15
Sticky	3	-	4	-	14	ns	3	-	3	-	4	-	8	ns	8	-
Creamy	73	ns	57	-0.18	69	-0.10	58	-0.32	59	ns	51	-0.16	57	-0.19	57	-0.35
Rough	24	-0.17	5	-	46	-0.09	16	-	9	-	7	-	46	-0.14	11	-
Consistent	41	ns	45	ns	39	ns	41	ns	38	ns	39	-0.17	39	ns	45	-0.18
Mouth-coating	22	-0.13	12	-	34	-0.10	20	ns	18	-	15	-	28	-0.11	18	-
Gummy	1	-	0	-	4	-	5	-	1	-	1	-	7	-	5	-
Runny	51	ns	23	ns	30	-0.09	18	-	35	-0.13	23	ns	27	-0.11	18	-
Heterogenous	35	-0.15	22	ns	49	-0.12	7	-	18	-	9	-	45	-0.20	3	-
Intercept	7.2		7.2		6.3		7.0		6.9		7.3		7.3		7.4	
Mean drop (*)	3.0		1.8		2.8		1.8		1.0		1.4		2.9		2.1	

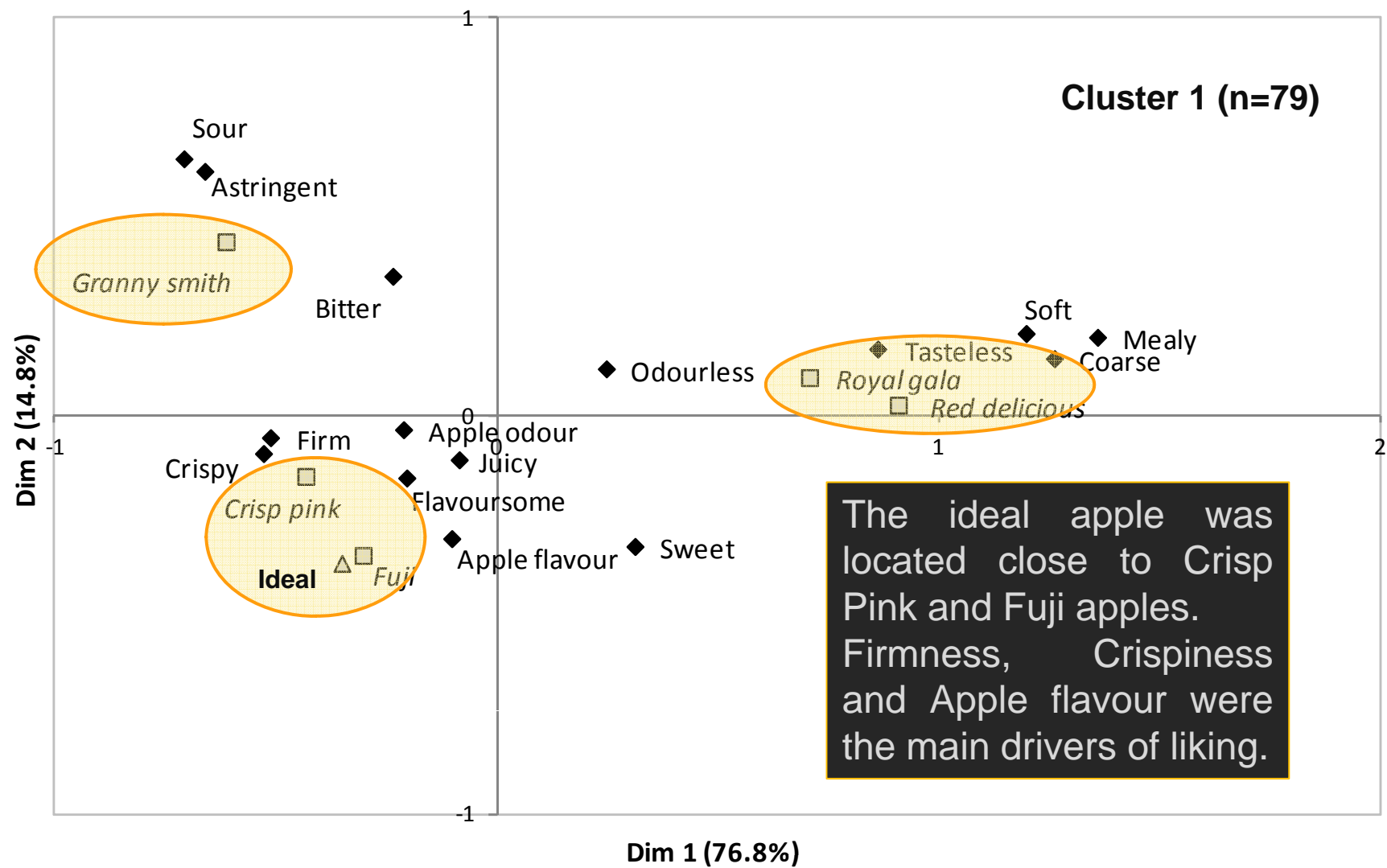
○ Study 2

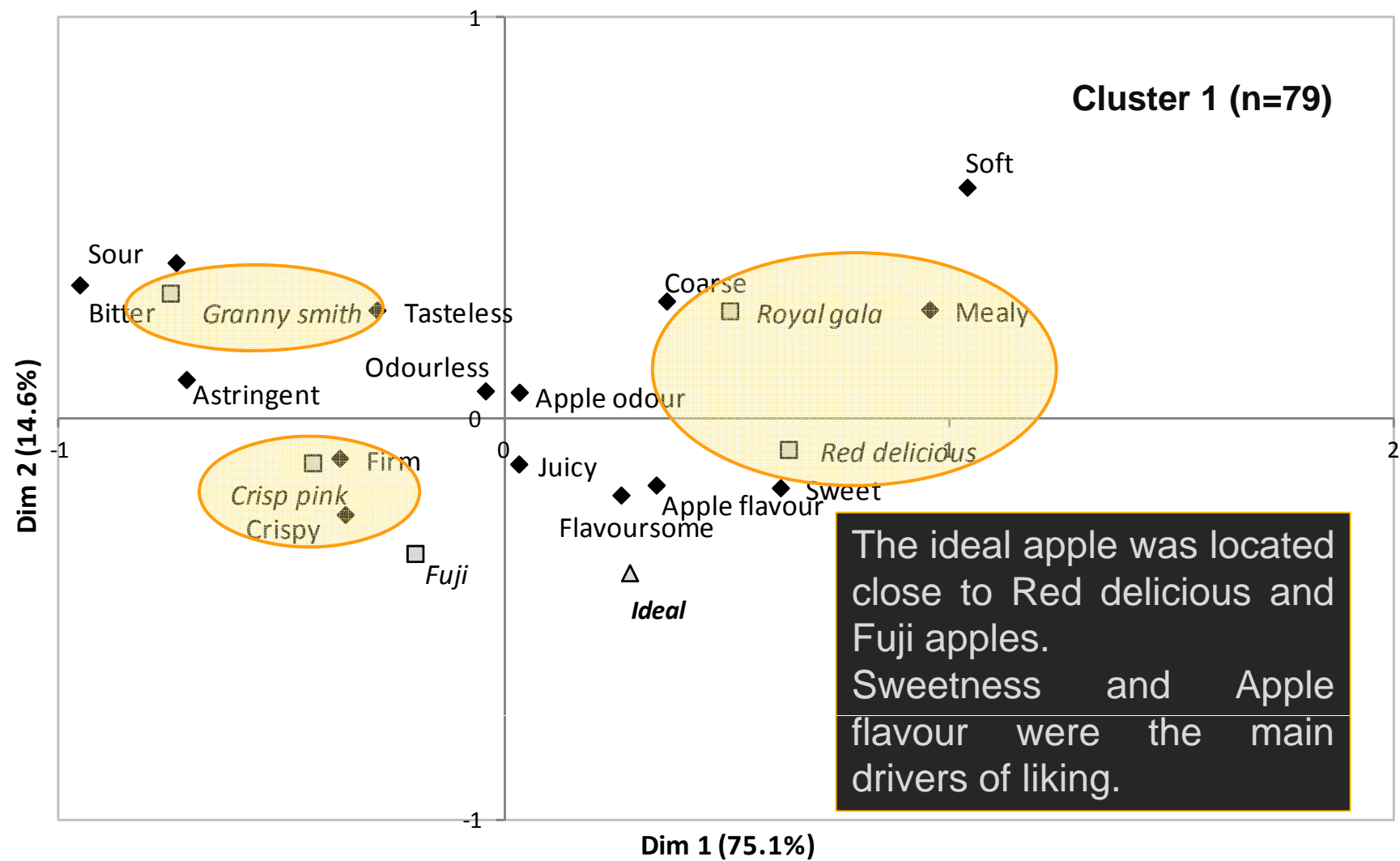
- Frequency of use of the terms (%) for the whole consumer sample

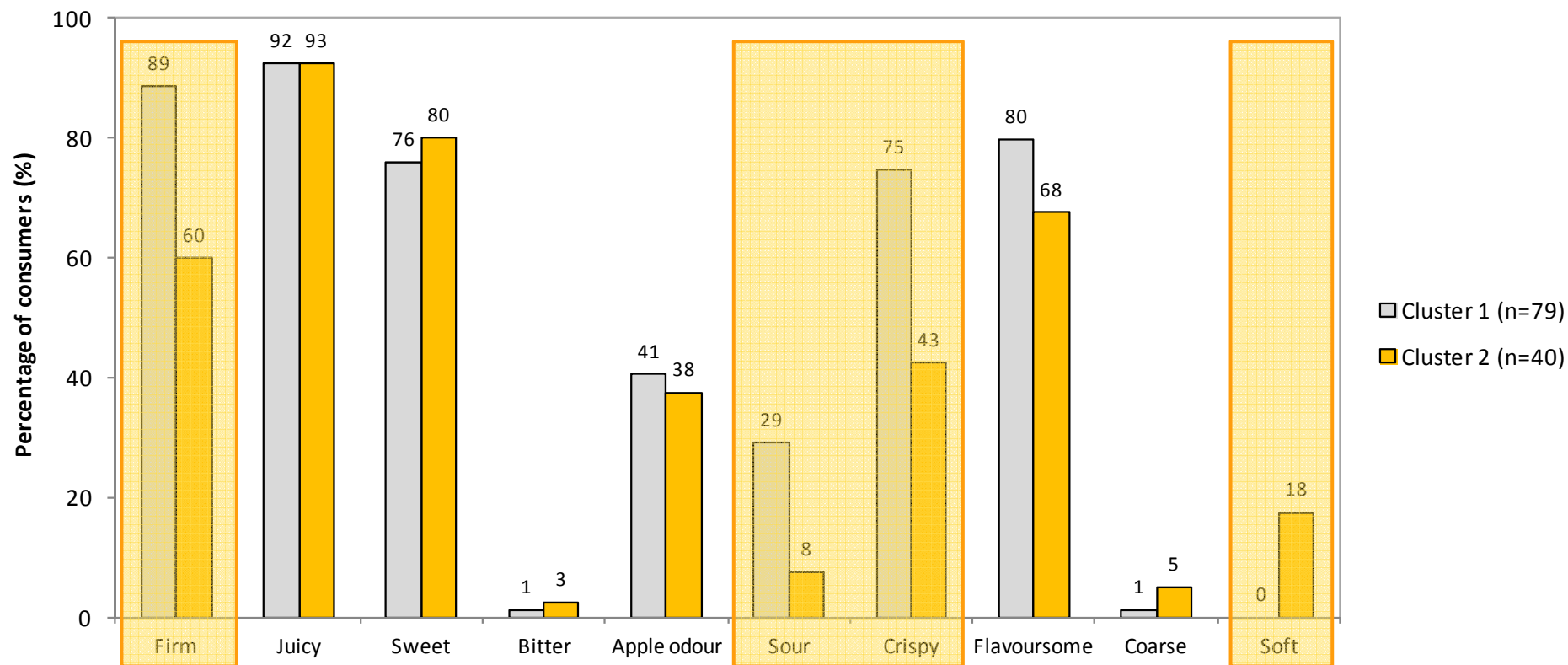
Attribute	Sample					
	Crisp pink	Fuji	Granny smith	Royal gala	Red delicious	Ideal
Firm ***	68	70	66	19	18	79
Juicy ***	63	76	49	51	48	92
Sweet ***	32	39	5	31	61	77
Bitter ***	5	10	Firmness, Juiciness, Sweetness, Crispiness and Apple flavour were the main drivers of liking.			2
Apple odour ***	13	8				39
Sour ***	52	12				22
Crispy ***	66	55				64
Flavoursome ***	43	44	25	25	31	76
Coarse ***	3	1	2	15	24	3
Soft ***	1	2	2	49	45	6
Odourless ***	13	14	14	22	14	1
Tasteless ***	4	9	8	31	10	0
Mealy ***	1	0	1	36	58	5
Apple flavour ***	45	40	14	25	37	69
Astringent ***	8	7	16	3	1	7

- Overall liking scores



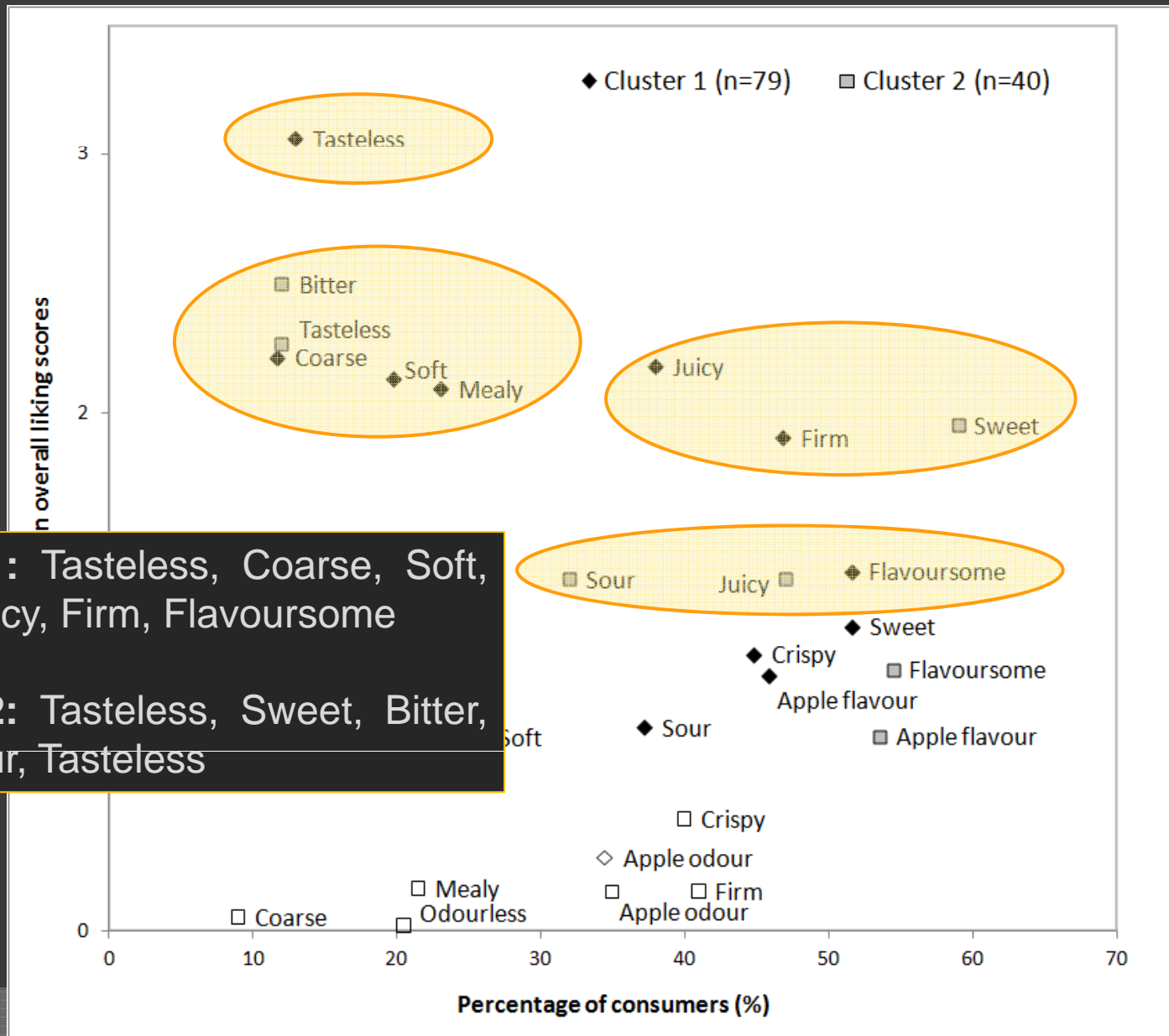






The clusters differed in their description of the ideal apple, particularly in the frequency of mention of the terms Firm, Sour, Crispy and Soft

- Penalty analysis at the aggregate level



Regression coefficients from PLS model

Term	Crisp pink				Fuji				Red delicious			
	Cluster 1		Cluster 2		Cluster 1		Cluster 2		Cluster 1		Cluster 2	
	%	RC	%	RC	%	RC	%	RC	%	RC	%	RC
Firm	42	-0.13	35	ns	38	ns	30	ns	84	-0.09	53	ns
Juicy	45	-0.31	53	-0.23	37	-0.16	35	ns	65	-0.14	38	ns
Sweet	59	-0.16	70	-0.23	50	-0.13	70	-0.19	59	-0.09	23	-0.36
Bitter	23	ns	10	-	27	-0.18	10	-	26	ns	3	-
Apple odour	47	ns	40	ns	48	ns	33	ns	49	ns	30	ns
Sour	49	ns	65	-0.17	43	ns	15	-	43	ns	10	-
Crispy	36	ns	40	ns	49	-0.13	40	-0.19	75	ns	33	ns
Flavoursome	49	ns	53	-0.14	54	ns	58	-0.22	70	-0.08	55	ns
Coarse	23	ns	5	-	23	ns	5	-	46	-0.15	18	-
Soft	22	ns	18	ns	23	ns	18	-	60	ns	30	-0.43
Odourless	30	ns	20	ns	30	ns	18	-	31	-0.09	20	ns
Tasteless	22	ns	10	-	27	-0.29	13	-	31	-0.12	5	-
Mealy	24	ns	10	-	24	ns	8	-	71	-0.15	48	ns
Apple flavour	48	ns	55	ns	51	-0.11	50	ns	58	-0.11	43	ns
Astringent	26	ns	13	-	30	ns	13	-	29	ns	3	-
Intercept	9.0		8.2		7.6		8.2		7.8		8.8	
Mean drop	1.3		1.9		0.2		2.1		2.6		0.6	

Discussion and Conclusions

- The methodology was able to identify the sensory characteristics of the ideal product, which were similar to those of the most liked products.
- Simple and flexible add-on to usual CATA ballots.
- Provides information for the identification of drivers of liking, even for consumers with different preference patterns, and recommendations for product reformulation.
- Does not provide a measure of the degree of difference between the product and the ideal.

References

- Ares, G., Barreiro, C., Deliza, R., Giménez, A., & Gámbaro, A. (2010). Application of a check-all-that-apply question to the development of chocolate milk desserts. *Journal of Sensory Studies*, 25, 67–86.
- Ares, G., Varela, P., Rado, G., & Giménez, A. (2011). Identifying ideal products using three different consumer profiling methodologies. Comparison with external preference mapping. *Food Quality and Preference*, 22, 581-591.
- Bayarri, S., Carbonell, I., Barrios, E.X., & Costell, E. (2011). Impact of sensory differences on consumer acceptability of yoghurt and yoghurt-like products. *International Dairy Journal*, 21, 111-118.
- Bayarri, S., Carbonell, I., Barrios, E.X., & Costell, E. (2011). Impact of sensory differences on consumer acceptability of yoghurt and yoghurt-like products. *International Dairy Journal*, 21, 111-118.
- Costa, A.I.A., & Jongen, W.M.F. (2006). New insights into consumer-led food product development. *Trends in Food Science & Technology*, 17, 457-465.
- Cowden, J., Moore, K., & Vanluer, K. (2009). Application of check-all-that-apply response to identify and optimize attributes important to consumer's ideal product. In 8th Pangborn Sensory Science Symposium, 26-30 July 2009, Florence, Italy.
- Dooley, L., Lee, Y.S., & Meullenet, J.F. (2010). The application of check-all-that-apply (CATA) consumer profiling to preference mapping of vanilla ice cream and its comparison to classical external preference mapping. *Food Quality and Preference*, 21, 394–401.
- Epler, S., Chambers, E., IV., & Kemp, K.E. (1998). Hedonic scales are better predictors than just-about-right scales of optimal sweetness in lemonade. *Journal of Sensory Studies*, 13, 191–197.
- Lawless, H. T., & Heymann, H. (2010). *Sensory Evaluation of Food. Principles and practices*. Second Edition. (pp. 227-253). New York: Springer.

References

- Moskowitz, H.R., & Hartmann, J. (2008). Consumer research: creating a solid base for innovative strategies. *Trends in Food Science & Technology*, 19, 581-589.
- Plaehn, D. (2012). CATA penalty/reward. *Food Quality and Preference*, 24, 141-152.
- Pohjanheimo, T., & Sandell, M. (2009). Explaining the liking for drinking yoghurt: the role of sensory quality, food choice motives, health concern and product information. *International Dairy Journal*, 19, 459-466.
- Popper, R., Rosentock, W., Schraidt, M., & Kroll, B.J. (2004). The effect of attribute questions on overall liking ratings. *Food Quality and Preference*, 15, 853-858
- van Kleef, E., van Trijp, H.C.M., & Luning, P. (2006). Internal versus external preference analysis: An exploratory study on end-user evaluation. *Food Quality and Preference*, 17, 387-399.
- Varela, P., & Ares, G. (2012). Sensory profiling, the blurred line between sensory and consumer science. A review of novel methods for product characterization. *Food Research International*, In press.
- Worch, T., Dooley, L., Meullenet, J.F., Punter, P.H. (2010). Comparison of PLS dummy variables and Fishbone method to determine optimal product characteristics from ideal profiles. *Food Quality and Preference*, 21, 1077-1087.
- Worch, T., Lê, S., Punter, P., & Pagès, J. (2012a). Extension of the consistency of the data obtained by the Ideal Profile Method: Would the ideal products be more liked than the tested products? *Food Quality and Preference*, 26, 74-80.
- Worch, T., Lê, S., Punter, P., & Pagès, J. (2012b). Assessment of the consistency of ideal profiles according to non-ideal data for IPM. *Food Quality and Preference*, 24, 99-110.
- Xiong, R., & Meullenet, J. F. (2006). A PLS dummy variable approach to assess the impact of JAR attributes on liking. *Food Quality and Preference*, 17, 188-198.



**Thank you very much
for your kind attention!**

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