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Relationships between acceptability and sensory attributes of peach nectars using internal preference mapping

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Abstract Eight samples of peach nectars were profiled by a trained panel and assessed for overall liking by a consumer panel. Internal preference mapping was used to derive a multidimensional space of samples based only on acceptance data. The first three preference dimensions showed significant fit for 91.2% of the consumer population. According to the position of these consumers on the maps, four subgroups could be formed. The first dimension was mainly related to sweetness and off-flavour. The second dimension was related to acidity and texture attributes (body, viscosity, sliminess, mouth-coating) and the third dimension was defined by flavour intensity, peach flavour, and artificial and cooked flavours. Based on these results, the preference criteria of each consumer subgroups were established.

Key words Preference mapping · Sensory profile · Acceptability · Peach nectar

Introduction

In order to ascertain the influence of sensory attributes on food acceptance, the descriptive sensory data generated by a trained panel should be related to the hedonic data obtained directly from consumers. Consumers usually differ in the attention paid to sensory attributes when judging the acceptance of a range of products [1, 2]. Hence, the relationships established between the sensory characteristics of foods and mean hedonic values can fail to predict which sensory attributes are important in defining product acceptability. One solution is to establish such relationships with individual hedonic data [2] or with the mean hedonic scores of subgroups of consumers showing similar preference patterns [1].

An alternative approach for investigating hedonic information is to produce a sample space based on the acceptance information alone. Internal preference mapping is a technique that has been developed to fulfil this objective [3–5]. By this technique the major sources of variation within preference data are identified and extracted as preference dimensions. Maps of a predetermined dimensionality can be drawn, in which samples are presented as points and consumers' main preference criteria as vectors. Theoretically, visual inspection of the plots obtained provides valuable information for identifying consumer groups with different preference patterns. Frequently, the consumer vectors are scaled to unit length in each product space defined by two axes [6–9]. Using this approach, information on the preference direction of each consumer but not on the magnitude of preference is obtained. The original ranking of samples with respect to acceptability cannot be recovered by dropping perpendiculars from each consumer vector onto each sample point [10]. Another approach is to consider the cumulative variance accounted for by each subject over all extracted dimensions and represent the length of each consumer vector as proportional to the variance accounted for by the two dimensions of each preference map [5, 6, 11–13]. In addition, internal preference mapping can be used to examine the relationships between preference dimensions and the sensory attributes as evaluated by a trained panel. This can be done by regressing the sensory attributes data on the product coordinates on each preference axis [5, 9].

In a previous paper [8] the acceptability of an optimized formulation of high fruit–low-sugar peach nectar was compared with that of a control sample with normal sucrose content and with those of four commercial regular and two low-calorie nectars. Results indicated that the optimized low-calorie formulation did not differ in acceptability from the control sample with sucrose nor from some commercial samples but

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was less acceptable than a commercial sample manufactured by a market leader company. In addition, observation of the positions of consumer vectors, scaled to unit length, in a two-dimensional internal preference map clearly showed differences in consumer preference patterns.

The aim of this study was to determine which sensory attributes of peach nectars are important in their acceptability. The particular objectives were: (1) to identify consumer groups with different preference criteria for the eight peach nectar samples, using internal preference mapping, and (2) to study the relationships between principal preference axes and sensory attributes of peach nectar samples.

Materials and methods

Samples. Eight peach nectar samples were used. Six of them were commercial peach nectars: two samples contained sugar, two samples contained grape concentrate as sweetener, and two were low-calorie nectars, one formulated with cyclamate and the other formulated with a mixture of cyclamate and saccharine. The other two nectar samples were experimental samples prepared by mixing canned peach puree (60%) with a sucrose solution to provide a 14°Brix nectar (control sample) or with a solution of 0.6 g/l aspartame and 0.6 g/l guar gum, as previously selected by surface response methodology [8]. Table 1 shows the principal characteristics of the eight peach nectar samples.

Descriptive analysis. A panel of 11 trained assessors evaluated 11 sensory attributes: seven flavour attributes (flavour intensity, peach flavour, sweetness, acidity, artificial flavour, cooked flavour, off-flavour) and four texture attributes (body, viscosity, sliminess, mouth-coating). Generation and selection of descriptors, and selection and training of assessors were described previously [14]. The intensities of attributes were rated on semi-structured scales (100 mm), anchored on the left side as "weak" and on the right side as "strong". Descriptive analysis of the eight samples was carried out in triplicate over eight sessions and each assessor evaluated three samples per session. The order of presentation of samples was randomized across sessions but was balanced across assessors within each session.

Tests were carried out in separate booths, in a standardized test room [15] at about 22 °C, under normal white fluorescent illumination in morning sessions (11:00–13:00), every other day. Samples of nectars (50 ml) were presented at room temperature in brown glasses coded with three-digit numbers. The assessors were allowed to swallow the samples and rinsed their mouths with mineral water between samples to avoid residual flavour effects.

Table 1 Composition of both commercial and experimental samples of peach nectars[a]

Sample	Sweetener	Fruit (%)	pH	Soluble Solids (° Brix)	Acidity (g/l tartaric acid)
A[b]	Sucrose	45[b]	3.67 (0.07)	13.7 (0.1)	4.89 (0.01)
B[b]	Sucrose	45[b]	3.65 (0.03)	13.3 (0.1)	3.88 (0.01)
C[b]	Grape concentrate	50[b]	3.75 (0.06)	11.3 (0.1)	6.24 (0.01)
D[b]	Grape concentrate	–	3.82 (0.09)	12.5 (0.3)	3.88 (0.01)
E[b]	Cyclamate	50[b]	3.36 (0.09)	6.3 (0.1)	6.04 (0.05)
F[b]	Cyclamate +saccharine	40[b]	3.87 (0.08)	5.1 (0.3)	4.35 (0.05)
G[c]	Sucrose	60[c]	3.48 (0.08)	14.0 (0.1)	5.20 (0.05)
H[c]	Aspartame	60[c]	3.53 (0.08)	7.2 (0.1)	5.14 (0.01)

[a] Average value of three replicates. Standard deviation within parentheses
[b] Commercial samples, declared fruit content
[c] Experimental samples, real fruit content

Consumer tests. Consumers were recruited according to their responses to a brief screening questionnaire about sex, age, product usage and available time to perform the test, sent by mail by a local consumer association. A group of 60 consumers, aged between 25 and 60, were selected but only 57 of them (43 women and 14 men) completed all sessions. All of them consumed fruit nectars once a week or more often. Each consumer evaluated the acceptability of each one of the eight nectar samples, using a semi-structured 100 mm line scale with ends labelled "I dislike very much" and "I like very much". Testing was performed over three sessions and each assessor evaluated three samples per session in the first two sessions and two samples in the last one. The order of presentation of samples was randomized across sessions but was balanced across consumers within each session. Evaluation was conducted under the same conditions as for the descriptive test.

Chemical analysis. Soluble solids were determined by a digital refractometer ATAGO RX-100 and expressed as degrees Brix(°B). pH was measured by a digital pH meter CRISON 2001. Acidity was determined by titration with NaOH [16] and expressed as g/l tartaric acid.

Data analysis. Two-way analysis of variance (ANOVA) was applied to the descriptive and acceptability data. Sources of variation were samples, assessors and their interactions in the ANOVA for each sensory attribute score, and samples and assessors in the ANOVA for the hedonic scores. Minimum significant differences were calculated by Tukey's test for descriptive data and by Fisher's test for hedonic data ($\alpha \leq 0.05$).

An internal preference map was obtained by using the MDPREF program and the sample ratings of each sensory attribute were related to sample scores on the dimensions of the internal preference map by multiple regression analysis using the PROFIT program. Only consumers who were significantly fitted on the preference dimensions of each plot ($R^2 > 0.70$) were considered. These analyses were performed using the PC-MDS Multidimensional Statistic Package [17].

Results and discussion

Descriptive analysis

Results of ANOVAs of the sensory attribute scores across the eight peach samples for 11 assessors are given in Table 2. For all sensory attributes, the analysis of variance showed significant sample main effects but assessors were also a significant source of variation in all cases ($\alpha \leq 0.05$). Considering that individual differences between assessors are always present, some variation among assessors is considered acceptable in sensory profile analysis [18–20]. The important thing to be aware of is whether these variations may have consequences in the estimation of sample differences [21]. The assessors × sample interaction pro-

Table 2 Two-way analysis of variance of sensory attribute ratings of peach nectars. *F*-ratios when assessors are treated as fixed effect (A) and when assessors are treated as random effect (B). ns = not significant

Attribute	Assessor	Sample (A)[a]	Assessor × Sample	Sample (B)[b,c]
Flavour intensity	6.62*	6.99*	2.08*	3.36*
Peach flavour	7.76*	15.31*	1.39^{ns}	–
Sweetness	14.16*	45.85*	1.80*	25.53*
Acidity	10.48*	52.16*	2.16*	24.13*
Artificial flavour	16.48*	7.22*	1.77*	4.08*
Cooked flavour	23.22*	27.85*	1.93*	14.44*
Off-flavour	8.10*	19.48*	1.71*	11.42*
Body	10.17*	44.01*	1.27^{ns}	–
Viscosity	16.80*	40.62*	0.98^{ns}	–
Sliminess	13.24*	22.72*	2.75*	8.26*
Mouth-coating	24.59*	27.78*	1.72*	16.13*

[a] The error term was used as the denominator for the *F* test
[b] The interaction term was used as the denominator for the *F* test
[c] Dashes correspond to attributes with no significant interaction
* Significant at $\alpha \leq 0.05$

vided information about consistency among judges. It was not significant for three of the attributes, but it was for the remaining eight. In spite of this, the main sample effect for these eight attributes remained significant when tested against the assessors–sample interaction term (column B in Table 2). Mean attribute scores for each peach nectar are given in Table 3.

Table 4 Mean hedonic scores for overall consumers and for subgroups segmented by internal preference mapping for the eight nectar samples [a,b,c]

Sample	Overall consumers ($n = 57$)	Subgroup I ($n = 17$)	Subgroup II ($n = 11$)	Subgroup III ($n = 7$)	Subgroup IV ($n = 11$)
A	**6.5a**	**6.7a**	4.4b	**6.5a**	**6.7a**
B	4.1c	4.0b	3.1b	4.9ab	3.5cd
C	4.9bc	4.5b	2.8b	**6.3a**	1.9d
D	4.1c	**6.2a**	2.8b	**7.1a**	4.0cd
E	4.8bc	3.2b	4.3b	**6.2a**	**6.6a**
F	5.2b	**7.0a**	4.3b	**6.6a**	5.6ab
G	5.3b	**6.1a**	**6.4a**	3.3b	5.3ab
H	5.3b	**6.5a**	**7.9a**	2.8b	3.8c

[a] Composition of samples given in Table 1
[b] Within a column, means sharing letters are not significantly different (Fisher's test, $\alpha \leq 0.05$)
[c] Within a column, bold figures correspond to significantly preferred samples

Table 5 Percentage of variability explained and percentage of consumers related to each dimension obtained by internal preference map

Dimension	Variability (%)	Cumulative variability (%)	Consumers (%)
1	25.54	–	45.6
2	18.19	43.73	24.6
3	16.72	60.45	21.0
4	12.23	72.68	5.2
5	11.02	83.70	3.5

Analysis of acceptability data by internal preference mapping: segmentation of consumers

Acceptability data from all consumers were analysed by ANOVA and significance of differences established by Fisher's test (Table 4). As previously stated [8], results indicated that the optimized low-calorie formulation (H) did not differ in acceptability from the control sample with sucrose added (G) nor from some commercial samples (C, E, F) but was less acceptable than sample A, sweetened with sucrose and manufactured by a leading firm in the market.

The matrix of individual acceptability scores across the eight nectar samples was analysed by internal preference mapping. The total amount of variance explained by the first five dimensions was 83.7%, but the preference criteria of most consumers (91.2%) could be adequately interpreted with only the first three dimensions, which explained 60.4% of the total variance (Table 5).

Table 3 Mean sensory attribute scores ($n = 11 \times 3$ replicates) and corresponding Tukey's honestly significant difference (*HSD*) at $\alpha \leq 0.05$ for the eight nectar samples [a, b]

Sample	Flavour intensity	Peach flavour	Sweetness	Acidity	Artificial flavour	Cooked flavour	Off-flavour	Body	Viscosity	Sliminess	Mouth-coating
A	7.4ab	5.3a	6.3b	3.4bc	2.4c	0.7c	1.7d	5.4ab	4.9a	1.1b	4.0ab
B	6.7abc	3.3bc	4.5cd	3.0bc	4.8a	1.1bc	4.7b	4.3bc	3.5b	1.0b	3.1 bc
C	6.5bc	1.6d	3.9de	2.7cd	4.6ab	4.6a	6.7a	6.5a	5.9a	2.4a	4.6a
D	5.9c	3.0bcd	4.5 cd	2.3 cd	3.2bc	2.2b	3.3bcd	1.5d	1.3d	0.4b	1.0e
E	7.8a	3.0bcd	3.1e	8.2a	3.9abc	1.3bc	3.8b	2.0d	1.6 cd	0.4b	1.5de
F	7.6ab	3.8bc	8.2a	1.5d	3.7abc	2.2b	3.6bc	6.3a	5.9a	2.2a	4.3a
G	7.6ab	4.5ab	6.0b	4.1b	2.8c	0.7c	2.0 cd	3.2c	2.6bc	0.6b	2.2 cd
H	7.5ab	4.3a bc	7.6a	2.6 cd	3.3abc	0.5c	2.0 cd	3.7c	3.4b	0.7b	2.6c
HSD	1.2	1.5	1.2	1.3	1.6	1.2	1.7	1.2	1.3	0.8	1.1

[a] A, B, C, D, E, F were commercial samples; G, H were experimental samples; composition of samples given in Table 1
[b] Within a column, means sharing letters are not significantly different

The preference spaces defined by dimensions 1 and 2 and by dimensions 1 and 3 are shown in Fig. 1a, b, respectively. In these spaces the consensus configuration of the eight samples based on the acceptability data are represented. Each point represents the end of each consumer's acceptance vector and each vector can be visualized by drawing a line from the centre to the point, the length of vectors indicating how much of the variance of the acceptability scores of consumers is explained by the dimensions of each plot. In Fig. 1a, only consumers who were significantly fitted on preference dimensions 1 and 2 were included in the plot. In Fig. 1b, for simplicity, only consumers who were significantly fitted on preference dimension 3 were included.

Points showing the preference direction for each consumer were mainly concentrated in the region of negative scores on dimension 1 (Fig. 1a). However, considering vector positions with respect to dimension 2, additional conclusions can be drawn. Segmenting the consumers by similarity of preference using the quadrants defined by the first two dimensions (Fig. 1a), it can be observed that the major group of consumers (17), referred to as subgroup I, is in the top left quadrant. This group preferred sample F and the range of mean scores, from 2.9 (sample E) to 6.6 (sample F), was wider than the range of scores for the whole population (Table 4). The second group of 11 consumers (subgroup II) is in the bottom left quadrant, they preferred the experimental samples (H and G). This group showed a wide range of mean scores from 3.0 (sample D) to 7.9 (sample H) (Table 4). The third group of seven consumers (subgroup III), which represented only 12% of the total population, is in the top right quadrant and their preferences were opposed to that of subgroup II, their mean scores ranging from 2.8 (sample H) to 7.1 (sample D) (Table 4). The group of consumers in the bottom right, with preferences criteria opposed to those of subgroup I, represented less than 10% of all consumers. When representing the space defined by axes 1 and 3 (Fig. 1b), only the end point of the consumer acceptance vectors that were significantly fitted to the third axis were considered. Clearly, the majority of these consumers were negatively correlated with axis 3. For this group of 11 consumers (subgroup IV) the most preferred samples were samples A and E, i.e. the regular and the low-calorie peach samples manufactured by a leading commercial firm, respectively, and the least preferred one was sample C (Table 4).

These results indicate that the consumer population was highly segmented and irregularly distributed around several sectors of the preference space defined by the first three dimensions. The first two segmented subgroups accounted for about 50% of the total number of consumers, the third one represented only around 12% and the fourth one around 20%. Differences in average acceptability scores of the eight nectar samples for the four major consumer subgroups showed their different preference patterns (Table 4). The rest of the consumers, around 9%, were randomly distributed and could not be grouped under any common sensory preference criterion.

Relationships between acceptability and sensory attributes

A way of interpreting the preference spaces obtained using internal preference mapping is to identify product attributes that are related to the different axes. Sensory attributes data generated by the trained panel (Table 3) were regressed on to the product coordinates on each preference axis (Figs. 1a, b). As stated by Greenhoff and MacFie [5], if there are several sensory attributes associated with a preference axis, one should not automatically assume that they are all of equal importance in explaining consumer preference. However, it is true that attributes that are not related to the preference space are unlikely to play a major role in determining consumer preference. In any case, this technique has a limitation in that only linear regressions between attributes and preference dimensions are considered. This may not be sufficient to adequately explain the dimensionality, and attribute interactions and quadratic effects may also need to be taken into account.

In this case, the attributes more positively associated with peach nectar acceptance were sweetness and peach flavour (negative part of dimension 1) whereas off-flavour (positive part of dimension 1) was a negative characteristic (Fig. 1a). However, this is only part of the interpretation, since individual consumers showed considerable variation in position with respect to axes 2 and 3. Consumers with preference vectors clustered in the top left quadrant (subgroup I) preferred sweet peach nectars with a clear peach flavour and with some degree of viscosity and body. They appeared to be tolerant to sliminess and cooked flavour but critical of acidity or perception of artificial flavour. Consumers in subgroup II also preferred nectars with peach flavour but were less affected by differences in sweetness and acidity. Instead, they were looking for nectars with high flavour intensity, less viscosity and less body. This group is critical of sliminess and cooked flavour. The small group of consumers with vectors in the upper right quadrant (subgroup III) could be considered as the opposite of consumers in subgroup II. They preferred nectars with less flavour intensity and were clearly tolerant of the presence of cooked flavour. Finally, the consumers with preference vectors clustered around the negative part of axis 3 seemed to prefer nectars with high flavour intensity, high peach flavour and high acidity and appeared to be less affected by differences in sweetness and texture-related attributes (viscosity, body, sliminess, mouth-coating). They were more critical of the presence of cooked, artificial and off-flavours.

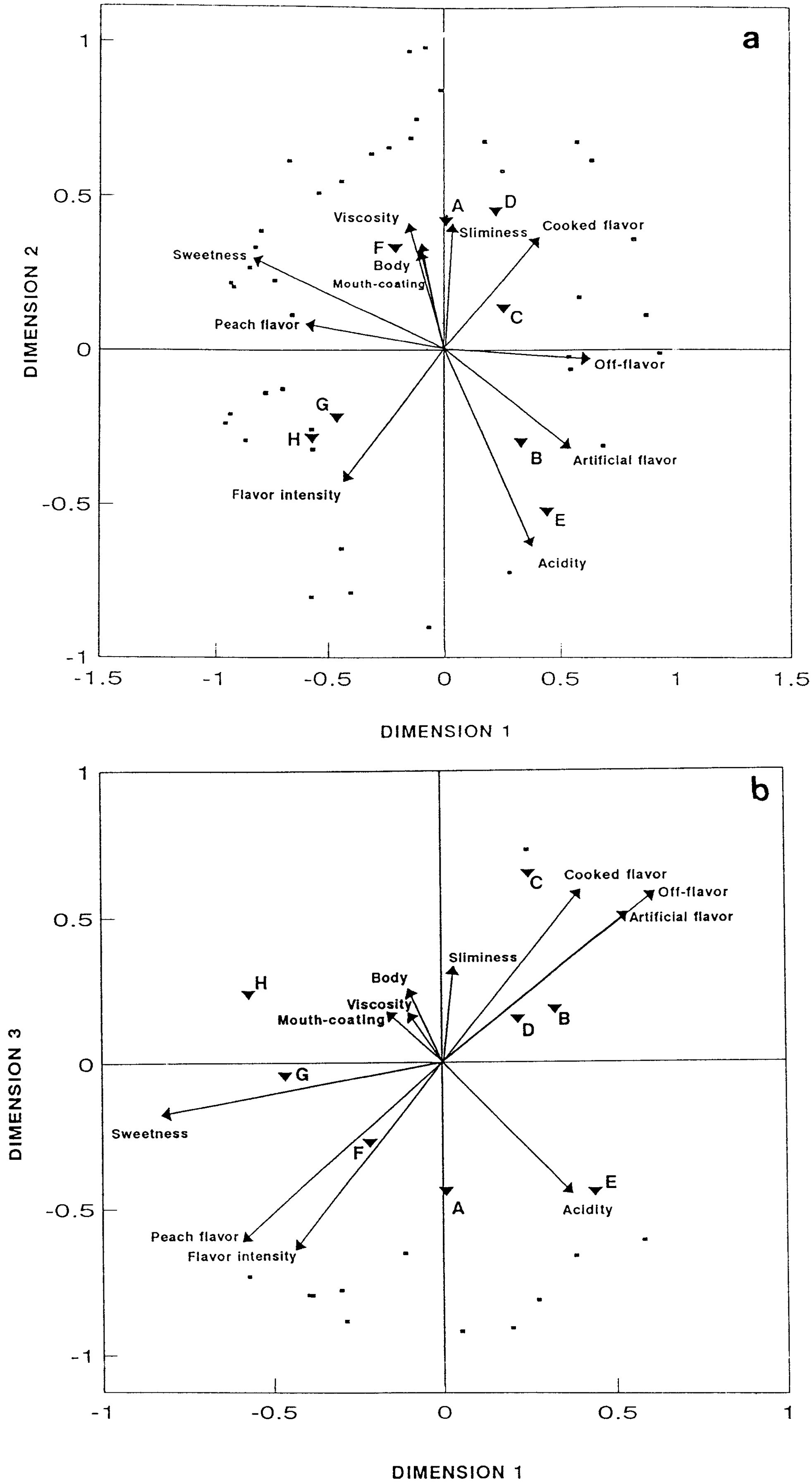

Fig. 1 Internal preference map showing the position of the eight peach nectar samples (samples as identified in Table 1) with consumers (points) close to their preferred samples and correlation between preference axes and sensory attributes (vectors). **a** Dimensions 1 and 2: only consumers who were significantly fitted on preference dimensions 1 and 2 are included. **b** Dimensions 1 and 3: only consumers who were significantly fitted on preference dimension 3 are included

Conclusions

Internal preference mapping can be a valuable tool for detecting subgroups of consumers with different preference patterns. Relationships between preference axes and sensory attributes ratings generated by a trained panel inform about which sensory attributes are important for each subgroup of consumers. In this work, the first two segmented subgroups, accounting for about 50% of the total number of consumers, preferred sweet peach nectars with a clear peach flavour. The consumers in the third subgroup, representing only around 12%, preferred nectars with less flavour intensity and were clearly tolerant of the presence of cooked flavour. Those in the fourth subgroup, around 20% of consumers, seemed to prefer nectars with high flavour intensity, high peach flavour and high acidity.

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