A conjoint study on apple acceptability: sensory characteristics and nutritional information

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Abstract

The main objective of this work was to study whether the intensity of intrinsic sensory attributes and different information about fibre and antioxidant content (extrinsic attributes) provided immediately before tasting could affect the acceptability of four apple varieties characterised by two levels of crunchiness and sweetness. The tested products (Fuji, Golden Delicious, Granny Smith, and Reinette du Canada) were selected on the basis of the results of the quantitative descriptive analysis performed on 21 commercially available varieties.
A panel of 346 consumers was asked to rate the overall liking of the selected cultivars, which were presented in duplicate with different information about fibres and antioxidants content using a fractional factorial design. A preliminary test was performed on 226 consumers to measure the acceptability without the effect of such information. Demographic data, fruit consumption data, and the importance of health aspects in nutrition were also collected by means of a questionnaire. Significant effects were found for the sensory factors: overall liking was positively influenced by high levels of crunchiness and sweetness. Information about the nutritional content affected apple acceptance only for some consumer groups depending on their attitudes towards healthy food. This work demonstrates the effectiveness of conjoint analysis integrated with tasting in the case of fresh unprocessed product. Moreover, the proposed approach provides to Italian apple producers/distributors a better understanding of the relative importance consumers give to sensory attributes and nutritional information in order to support consumer-led breeding selections.

Keywords: apple acceptability; conjoint analysis; sensory characteristics; external information; consumers' segmentation.

1. Introduction

In the last years, the number of publications investigating the basis of consumer choice evaluating simultaneously intrinsic and extrinsic product attributes by means of rating or choice-based conjoint experiments has increased (see among others De Pelsmaeker, Dewettinck, & Gellynck, 2013; Green, Krieger, &Wind, 2001). Consumer choice is based on a complex trade-off between external information such as price, packaging, labelling, and other psychosocial and individual aspects, including personal sensory preferences and attitudes. In order to develop new products or to improve those already on the market, most of these studies have focused on the effect of a combination of important characteristics such as functional and nutritional properties on liking or willingness to pay (e.g. see Gadioli et al., 2013), product origin (e.g. see Herseleth, Næs, Rødbotten, Videke, & Monteleone, 2012), and production method (e.g. see Lee, Shimizu, Kniffin, & Wansink, 2013). However, these effects also depend on the type of food product analysed.

1.1. Conjoint analysis for fresh unprocessed products

For fresh fruit, conjoint studies have shown that liking is influenced by intrinsic attributes such as size, shape, and colour (Gamble, Jaeger, & Harker, 2006; Jaeger et al., 2011; Skreli & Imami, 2012). For apples, in particular, few authors have observed the effect of external information about pesticide use, certification, percentage of fruit damage, origin, and method of production (Baker, 1999; Baker & Crosbie, 1993; Novotorova & Mazzocco, 2008; Wang, Sun, & Parsons, 2010). In general, the findings of these works show that consumers have a broad preference for locally grown apples. Price, despite being one of the most important factors, may play a minor role for consumers, who appear instead to be more sensitive to a reduced pesticide use, a minor percentage of fruit damage, or an organic production. Far fewer studies investigated the taste as a factor in a conjoint framework. Cerda, Garcia, Ortega-Farias, and Ubilla (2012) have evaluated the effect of the information on fruit taste (mostly sweet or mostly sour) varying at the same time different levels of price, production method, and variety. Del Carmen and colleagues (2013) have interestingly investigated the degree of fruit sweetness set up by a sensory panel on three levels: very sweet (>12°Brix), just right (10–12°Brix), or not sweet (<9°Brix) together with other factors such as absence of damage, degree of ripeness (percentage of yellow of peel colour), and price. Both these studies showed that fruit taste, especially sweetness, play an important role in consumer preferences. Nevertheless, the cited studies evaluated consumer responses to a set of hypothetical fruit profiles, but when the sensory variation is considered as a factor in the conjoint study, the tasting of real products should be included. Important examples of studies incorporating tasting in a conjoint framework are those described by Helgesen, Solheim, and Næs (1998) for sausages, by Rødbotten et al. (2009) and Enneking, Neumann, and Henneberg (2007) for juices, by Solheim and Lawless (1996), Haddad et al. (2007) and Johansen, Næs, Øyaas, and Hersleth (2010) for dairy products.When real products are investigated, it is important to focus on specific sensory attributes and to base the choice of samples to be tested on a sensory profile which measures the actual variability of the available products (Johansen et al., 2010). In addition, an effective experimental design is necessary for this type of study (De Pelsmaeker et al., 2013; Green & Srinivasan, 1978). Processed products are best suited for sensory studies because they are modifiable according to a specific design. In the case of unprocessed products, one option would be to use instrumental methods for estimating different levels of a specific sensory attribute (e.g. using dry matter or soluble solid content as a proxy of sweetness). Nardozza et al. (2010) have demonstrated for kiwifruit that fruits with high dry matter have a high soluble solid content and are perceived as sweeter than low-dry matter fruits by a sensory panel. A strong relation between dry matter and soluble solid content is also known in apples (Palmer, Harker, Tustin, & Johnston, 2010). However, it remains to prove their relation with the perceived sweetness for which interactions with other attributes are involved (Corollaro et al., 2014; Harker et al., 2002). Literature provides only a few examples of non-processed product tasting where the effects on liking of different dry matter

categories were measured (Gamble et al., 2010; Jaeger et al., 2011). Furthermore, there are no conjoint studies examining the effects of combining taste and texture with information about health benefits while considering unprocessed food products. This means that product taste and texture have not been manipulated in respect to controlling the variation within the sensory attributes. Here, for the first time a conjoint study including tasting was carried out on unprocessed food, apple in particular, measuring the effect on liking of sweetness and texture evaluated by a sensory panel.

1.2. Objective of the study

To enter the shortlist of marketed apples, any new cultivar should have a comparable or superior eating quality than those already available. Being eating quality difficult to measure, it often happens that new varieties never achieve commercial success (Hampson et al., 2000). The extensive consumer acceptability of successful apples such as Fuji, Braeburn, and Gala is attributed to their superior eating quality (Stebbins, Duncan, Compton, & Duncan, 1992), strictly correlated with freshness and thus, texture attributes (Péneau, Hoehn, Roth, Escher, & Nuessli, 2006). Harker, Gunson, and Jaeger (2003) have confirmed the importance for consumer acceptability of texture properties but acceptability is generally based on a combination between texture and taste attributes (Gatti, Di Virgilio, Magli, & Predieri, 2011). It is also known that nutrition and health claims have a role in consumers' perception influencing food choices. Purchases of food with health and nutritional properties are increasing, especially in health conscious consumers (Mai & Hoffmann, 2012). The health benefits from antioxidant and fibre content are information widely used in the marketing of different products and quite clear concepts to the consumer (see among others Bravo, 1998; Yang, Wang, Zhou, & Xu, 2012). The presence of these substances with beneficial properties in apples is well known so that in few studies apples are used to enrich the nutritional value of other products such as drinks and biscuits (Kayacier, Yuksel, & Karaman, 2014; Laguna, Sanz, Sahi, & Fiszman, 2014; Sun-Waterhouse, Bekkour, Wadhwa, & Waterhouse, 2014).
Aiming at optimally match taste and nutrition, this work studied consumer acceptability of apples focussing on intrinsic sensory properties (such as sweetness and crunchiness) and on additional information (on fibre and antioxidant content) given just before tasting. These issues were addressed by combining a consumer acceptability test with a rating-based conjoint analysis on fresh unprocessed products such as apples. The approach to the experimental design was mainly focused on sensory attributes and their variability in the samples. Samples were not prepared but just selected on the basis of a wide descriptive sensory analysis previously conducted on 21 cultivars (Corollaro et al., 2013). Analysis of conjoint data was performed using the standard mixed model ANOVA methodology with all the factors involved providing the estimates of the relative importance on acceptability of intrinsic and extrinsic attributes and their interactions. Consumer demographics and food attitudes relevant to the provided nutritional information were also identified on the basis of data provided by a questionnaire filled just after tasting. Therefore, the objective of this work is two fold: (a) to propose a conjoint approach to study fresh unprocessed product; (b) to help apple producers by gaining a better understanding of the relative importance consumers give to sensory attributes and nutritional information for successful breeding selections and for activating successful strategies to promote the consumption of healthy food.

2. Design and methods

2.1. Descriptive sensory analysis

The first step consisted in investigating the realistic and relevant variability of the sensory attributes in apples. This was achieved analysing a wide number of apple varieties (21 in total) by means of sensory profiling. A trained panel of 13 assessors from FEM (Fondazione Edmund Mach, a non-

profit organisation in Italy involved in education, research, services, and technology transfer in the fields of environment, agriculture, and nutrition) performed the sensory profile of apples according to quantitative descriptive analysis (Stone and Sidel, 2004) in a sensory laboratory compliant to the ISO standards 8589 (ISO, 1988). The assessors were selected and trained over 9 sessions according to ISO standards 13299 (ISO, 2010) during which they agreed on a 15-attribute list describing flesh appearance (2), texture (7), tastes (4, including astringency), and overall odour intensity perceived by both ortho- and retro-nasal evaluation (2). All attributes were evaluated on a 100-point linear scale labelled 50 (mid-point), 0 and 100 (end-points). For each of the six samples randomly presented in a test session, eight apple cylinders (1.8 cm diameter, 1.2 cm high each) were cut, dipped in an antioxidant solution, and served in a plastic cup labelled with three-digit numbers and presented in a balanced order over the panel. Two replicates were performed for each variety. For further details about the selection of the panel, its performance, lexicon development, and sensory test procedures refer to Corollaro et al. (2013).

2.2. Apple selection for the consumer study

Once obtained, sensory data were submitted to PCA and the correlation loading plot (Figure 1) of the significant sensory attributes of the 21 apple varieties was created following Martens and Martens (2001) suggestions. The first two components accounted for 90% of the variation (79% and 11%) while the third component accounted for 3%, thus two components were used for the selection of samples.

The selection of the varieties to be submitted to the consumer test was obtained by following the approach suggested by Johansen and colleagues (2010), that is by choosing them according to a geometric structure similar to a rectangle in the two-dimensional space generated by the first two principal components. The corners of the rectangle were selected in such a way that the rectangle represents the whole space of variability and that the two rectangular directions correspond as much as possible to the two most important sensory dimensions, in this case texture (crunchiness, crispness, hardness, fibrousness, graininess, and flouriness) and taste (sweetness, sourness, and astringency). They corresponded well to the first two principal components. Moreover, the apple varieties were chosen among the most common on the local market. The corners of the rectangle are represented by four apple cultivars with high and low levels of sweetness and crunchiness: Granny Smith, Reinette du Canada, Fuji, and Golden Delicious (Figure 2).

2.3. Experimental design

The two levels of the two sensory attributes represented by the corners of the rectangle are combined with two information related variables. To keep the design as simple as possible, two levels for each information related variable were chosen by a focus group involving 10 researchers with different skills in food science (food technologists, chemists, statisticians, nutritionists, psychologists, physicists). Thus, a basic fractional factorial design with two levels of each factor was used. The study was thus based on a design with essentially four two-level factors, two intrinsic factors and two extrinsic factors. Since eight combinations for each consumer were considered the maximum number here, the experimental design chosen was a $2^{(4-1)}$ fractional factorial design of resolution IV. This means that none of the two-factor interactions are confounded with the main effects, but two-factor interactions are confounded with each other. The design is given in Table 1.

2.4. Consumer study

The consumer study was performed at FEM and consisted of two phases organised with a one-week break in between: a pre-test, where sample acceptability was evaluated 'blind' (without any external information) on a subset of consumers (226, 73% of male, age M=21, DS=11), and a main

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experiment, combining conjoint analysis with tasting (259 consumers, 82% of them attended both experiments). In order to extend these results outside of the Trentino region (Northern Italy) the conjoint test was repeated following the same protocol on 87 students and staff of the University of Gastronomic Sciences in Pollenzo (Piedmont, north-west of Italy). Note that the results of the conjoint experiment include the data of the consumers of both regions (346 consumers, 66% of male, age M=23, DS=10). All subjects declared to like apples and voluntarily joined the sensory evaluations. Subjects were not paid, however upon completion of the task, they were thanked with a buffet.

2.4.1. Sample preparation

The fruits were harvested from commercial orchards located in the Trentino region and for each test a crate for each variety was bought from local retailers (about 60 fruits of homogeneous size and without any visible external damage). All samples were stored at room temperature (18 ± 1 °C) for 24 h prior to analysis. To avoid any expectation effect due to the sight sense, all apples were presented peeled. They were then cut using an apple-slicer-corer (after cutting away the stem cavity and calyx depression to standardise the slice size among the different varieties), dipped in an antioxidant solution, and one slice per sample was served in plastic cups labelled with three-digit random codes.

2.4.2. Blind testing

The blind testing was done in order to compare conjoint results (informed testing) with blind testing (no information). This test consisted of a hedonic evaluation of the four apple varieties without any information. Each consumer received four apple slices, one for each variety, presented in a random order using a balanced design.
Consumers rated their degree of overall liking on a 9-point scale (1 = dislike extremely; 9 = like extremely).

2.4.3. Conjoint testing

The following week, the conjoint test was conducted. Apple samples were prepared following the same procedure briefly described in sections 2.4.1 and 2.4.2. Each consumer received eight apple slices according to the fractional factorial design. Information about fibre and antioxidant content was submitted to consumers on the computer screen (Figure 3) while they were tasting the samples. They rated the overall liking of the eight combinations on a 9-point scale from "dislike extremely" to "like extremely". No verbal instructions were given to the consumers prior to testing: the consumers were told to pay attention and carefully read all the instructions provided during the test. The chosen information and the way to communicate it to the consumers was a decision taken by the focus group. Consumers generally have little knowledge and consciousness about the actual content of antioxidants and fibres in apples, so it was chosen to submit the information in two phases: in one of the first slides, consumers were informed about the average amount of fibre and antioxidant content in one apple in general (Figure 3a). Then just before tasting, a bar-plot was shown indicating the fibre and the antioxidant content of the sample under evaluation compared with the average content (Figure 3b).

2.4.4 Questionnaire

The consumer panel was predominantly composed of men younger than 23 years of age (49%), with 95% of them being childless, and 82% living with their parents. Seventy percent of all the participants were non-smokers but just 26% did sports more than twice a week. In addition to socio-

demographic data, participants provided information about their fruit consumption, in particular about apples and their preferred varieties among seven suggested (Golden Delicious, Fuji, Gala, Stark Delicious, Granny Smith, Reinette du Canada, Pink Lady) rated on a 9-point hedonic scale. Attitudes towards healthy food (in general and towards light and natural food) and consumer relation with food (cravings, food as a reward, and pleasure) were also recorded according to Roininen, Lahteenmaki, and Tuorila (1999). Participants rated their degree of agreement with a series of positive and negative statements conveniently translated in Italian. In the present study a 9-point scale (1 = totally disagree; 9 = totally agree) rather than the original 7-point scale was used, in order to be consistent with other questionnaires usually used in the laboratory. Furthermore, the consumers were asked to rate their agreement on a 9-point scale with ten true statements (five about fibres and five about antioxidants; Table 2). These statements were previously developed by the focus group of researchers mentioned in section 2.3. with the goal to measure consumer knowledge.

2.5. Analyses

Data analysis was performed by STATISTICA v. 9.1 (StatSoft, Inc. 2010).

2.5.1. Analysis of questionnaire data

To compare the translated version of the Roininen et al. (1999) attitude scales to the original ones, for each scale, the internal reliability was tested using Cronbach's alpha (Carmines, and Zeller, 1979). Subsequently for each participant and each attitude scale, a sum score was obtained by summing the raw scores according to the procedure described by Roininen et al. (1999). Based on these scores, the participants were classified in three groups (low, moderate, and high) according to the 33rd and 66th percentile points (Table 3a). Internal validity of the developed scale on consumer knowledge about fibre and antioxidants were also tested using Cronbach's alpha. Participants were also classified into three groups according to their knowledge on fibres and antioxidants and to the complexity of these concepts according to the 33rd and 66th percentile points (Table 3b). A two-way analysis of variance was used to test how gender and age affected scores of attitude and health knowledge scales.

2.6.2. Analysis of consumer data

The liking data obtained from the blind testing were analysed using the following model with main effects and two-factor interactions for the design variables plus random effect of consumer and its first order interaction with the design variables:

$$y_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + C_k + \alpha C_{ik} + \beta C_{jk} + \varepsilon_{ijk}, \quad i=1,..,I, \; j=1,...,J, \; k=1,..,K \tag{1}$$

Where y_{ijk} is the $(ijk)^{th}$ observation, μ is the general mean, α_i and β_j are the main effects of the two conjoint factors sweetness and texture, and $\alpha\beta_{ij}$ is their interaction effects. C_k represents the main effects of consumers, αC_{ik} and βC_{jk} the interactions between consumers and conjoint design variables, and ε_{ijk} is the independent random noise. These are all random effects which are assumed to be independent and homoscedastic.

The liking data obtained in the conjoint testing were analysed using the following model with main effects and two-factor interactions for the design variables plus random effect of consumer:

$$y_{ijklm} = \mu + \alpha_i + \beta_j + \gamma_l + \delta_m + \alpha\beta_{ij} + \alpha\gamma_{il} + \alpha\delta_{im} + \beta\gamma_{jl} + \beta\delta_{jm} + \gamma\delta_{lm}C_k + \varepsilon_{ijklm},$$
$$i=1,..,I, \; j=1,...,J, \; k=1,..,K, \; l=1,...,L, \; m=1,...,M, \tag{2}$$

Here, y_{ijklm} is the $(ijklm)^{th}$ observation, μ is the general mean, α_i, β_j, γ_l, and δ_m are the main effects of the four conjoint factors sweetness, texture and information about fibres and antioxidants, respectively. $\alpha\beta_{ij}$, $\alpha\gamma_{il}$, *etc.* are the fixed interaction effects. Note that due to confounding, it is possible to estimate only some interactions. C_k represents the main effects of consumers and conjoint design variables, and ε_{ijk} is the independent random noise.

In order to identify which groups of people were more sensitive to healthy knowledge, the same ANOVA model (2) was recalculated in specific subgroups of consumers identified by age (G1 = 162 consumers over 20 years of age), by knowledge about antioxidants (G2 = 120 consumers with an established knowledge on antioxidants) and by attitude towards food as a reward (G3 = 128 consumers who use food as a reward).

3. Results

3.1. Consumer panel profile

Although in the European Food Information Council review (Eufic, 2012) Italy exceeds the recommended fruit and vegetable intake per person with 452 grams per day, the information gathered in this work showed that consumers who participated in this study do not have a very high fruit consumption. Seventy-four percent of consumers stated that they eat no more than two portions of fruit daily and only 2% regularly eat five or more. Fresh fruit is usually eaten after main meals and occasionally consumed as a snack food. Half of the panel consumes apples all year long, while the others eat them only during the production season. Fifty-six percent of participants report to eat at least one apple per day: most of them prefer to eat it with the skin and just occasionally in a fruit salad or cooked, almost never pureed. The 346 consumers stated that they like on average all the seven apple varieties investigated, especially Golden Delicious (M = 7.12, SD = 1.64) and Fuji (M = 6.82, SD = 1.73). Reinette du Canada (M = 5.73, SD = 2.25) was the least appreciated whereas Pink Lady was the one with a higher percentage of people who has never tasted it (34%). Before classifying the consumers according to the attitude scales, the reliability of each scale was verified comparing the Cronbach's alphas with those obtained by the attitude scale creators (Roininen et al., 1999; Table 3). Except for the attitude scale related to the importance of obtaining pleasure from food that revealed a low internal validity (Cronbach's alfa = 0.33), the results of the other scales appear to be similar to those originally described by Roininen and colleagues, thus supporting the comparability between them. Consistently with the scale creators, we found some associations with gender and age: women ($p < 0.001$) and respondents older than 20 years of age ($p < 0.01$) rated higher general health interest than did men or younger respondents (< 20 years of age). Same results were obtained in natural products interest ($p < 0.01$ for both woman and older consumers). Cravings for sweet foods were rated higher by women than men ($p < 0.001$).

The descriptive statistics of the health knowledge scales on consumer knowledge about fibres and antioxidants were calculated and are shown in Table 3b. Both scales are reliable showing Cronbach's alfas higher than 0.7. Additionally, more established knowledge are shown by women ($p = 0.005$ and $p = 0.024$ for fibres and antioxidants, respectively) and consumers older than 20 years of age ($p < 0.0001$ for both).

3.2. Blind testing

The results of the ANOVA mixed model showed significant main effects on liking and interactions with a p-value lower than 0.0001 (except for the random interaction effects; consumer*texture $p = 0.01$ and consumer*sweetness $p = 0.02$). The degree of sweetness had the strongest effect ($MS = 740.18$), followed by texture ($MS = 94.32$) and their interaction ($MS = 59.54$). Both sweetness and texture increased liking even if an increase in texture had a minor influence for the sweetest apples and a major influence for the least sweet. This result can also be seen looking at the average likings

for the four samples: apple varieties with highest degree of sweetness got the highest scores by consumers (Fuji: $M = 7.11$, $DS = 1.53$; Golden: $M = 6.97$, $DS = 1.52$; Granny: $M = 5.81$, $DS = 2.09$; Reinette: $M = 4.65$, $DS = 2.13$).

3.3. Conjoint testing

The results of the ANOVA mixed model for liking with all the experimental factors are shown in Table 4. Significant main effects of the degree of sweetness ($p < 0.001$) and texture ($p < 0.001$) and significant effect of their interaction on liking ($p < 0.001$) were observed. The findings of the blind testing were confirmed: the degree of sweetness has the strongest effect ($MS = 1931.12$), followed by that of texture ($MS = 328.80$) and of their interaction ($MS = 61.92$), with high levels of sweetness and texture increasing liking. The effect of consumers ($MS = 9.30$) and the effects of information about fibres ($MS = 8.35$) and antioxidants ($MS = 10.94$) were also important, although the latter two were not significant ($p = 0.093$ and $p = 0.055$ respectively). The remaining variables had instead a smaller component of variance in comparison. The significant interaction effect found here was confounded. Taking into account the blind test results and the insignificant effect of nutritional information, it is very likely that this effect was due to the interaction between sweetness and texture and should be interpreted as reported above.
Although slightly lower than those obtained previously, the liking averages of the varieties of apple confirmed the ranking found in the blind test. (Fuji: $M = 6.78$, $DS = 1.70$; Golden: $M = 6.39$, $DS = 1.72$; Granny: $M = 5.41$, $DS = 2.13$; Reinette: $M = 4.42$, $DS = 2.14$).

The results of the ANOVA model (2) recalculated for specific subgroups of consumers identified by age (G1), knowledge on antioxidants (G2) and attitude towards food as reward (G3) are reported in Table 4. Findings concerning each subgroup confirmed those observed for the complete panel of consumers (Table 4). Additionally, there were significant effects on liking of the external information about fibres and antioxidant content which varied depending on the subgroup: the information about the content of antioxidants caused a significant increase in liking for participants with more than 20 years of age and with consolidated notions about antioxidants (G1 and G2 in Figure 4). The information about the fibre content produced a significant increase in liking for participants who use food as a reward (G3 in Figure 4).

4. Discussion

4.1. Proposed approach

In the present paper, an approach to study the variation of sensory attributes independently of apple variety was proposed. This approach is probably in the same time the strength and weakness of the study. As far as the authors know, this is the first work that studied sensory attributes of unprocessed products by conjoint analysis, opening up new research possibilities. The key point is how to select the sample products so that they vary for different levels of the identified sensory attributes, without modifying them. This point has been solved by using the approach proposed by Johansen et al. (2010) that provides the advantage of maximising the sensory space identified using a previous extensive sensory characterisation. It is clear that is not possible to vary only the factors under study while keeping unchanged the other sensory parameters due to the type of product used and this is probably the major weakness of the proposed approach. It is however possible to verify a posteriori if the choice made on a previous characterisation is confirmed by a sensory descriptive profile performed on the same batch of apples used in the consumer test. Herein this work, the descriptive analysis on the same batch of apples used in the consumer test confirmed the choices made in the preliminary phase (data not shown). Another limitation is the high intrinsic variability, which is generally present in fruit and vegetable products, and it remains an experimental problem

important to keep it under control as much as possible. One possibility is to group fruits into categories using non-destructive measurements of texture and taste (Harker et al., 2008). Our future research is going in that direction exploring novel non-destructive instrumental measurements of texture and testing different food technology approaches to modify one sensory attribute at time in unprocessed product. It should also be mentioned that sensory factors under study are correlated with other sensory attributes that should be taken into account before drawing final conclusions.

4.2. Effects of sweetness and texture

Although previous works evaluated consumer liking for different apple varieties or new selections (Harker, Kupfermanb, Marinc, Gunsona, & Triggs, 2008; Kelly, Hyde, Travis, & Crassweller, 2010; Varela, Salvador, & Fiszman, 2005; Gatti et al., 2011), literature results are difficult to use as a reference because the degree of acceptability depends on the set of products evaluated in the same test and on the kind of consumer who evaluated the products. Moreover several cross-cultural studies demonstrated that different countries have different consumer expectations (Bonany et al., 2013; Bonany et al., 2014; Galmarini, Symoneaux, Chollet, & Zamora, 2013; Gamble, Jaeger, & Harker, 2006). For this reason, it was decided to perform a blind test to explore the acceptability of apples under study when no external information was given. With this blind test, the importance of sensory attributes on consumer liking was confirmed in accordance with the findings of several authors, who demonstrated the positive correlation between crispness, hardness, juiciness, and liking (Péneau, Brockhoff, Hoehn, Escher, & Nuessli, 2006; Hampson et al., 2000; Harker et al., 2008). In agreement with our findings, Symoneaux and colleagues (2012) reported that crunchiness and sweetness are the main sensory preference key drivers. We also found that an increase in some texture parameters has a minor influence for the sweetest apples and a major influence for the least sweet. This result may be related to a more dominant effect of sweetness on the texture that induces the consumer to seek at least firmer apples when they are not sweet. Tomala and colleagues (2009), who studied the acceptability of scab-resistant apples against conventional cultivars, characterised consumer groups that had preference patterns in accordance with this finding. Except for the first cluster of consumers who liked indiscriminately all tested apples, the authors have identified a second group of consumers who preferred firm, juicy, and quite acid apples, and a third group who liked sweeter but less firm apples. It is obvious that the results depend strongly on the variety of apples included in the study, and thus the selection of samples plays a fundamental role.
The results obtained for the sensory factors in the conjoint experiment confirmed those obtained in the blind test, except that by including extrinsic factors we then considered a fractional factorial design where the interactions are confounded. The effect of the significant interaction is confounded between two possible interactions: Texture * Sweetness or Information about fibres * Information about antioxidants. As in the blind test, the interaction between sweetness and texture was significant while the main effects for extrinsic factors in the conjoint experiment were not. It is likely that this effect could be due to the interaction between sweetness and texture. However, a more thorough investigation is needed to confirm this assumption.

4.3. Effects of nutritional information

Considering the total mean data, apple acceptance was not influenced by giving information about fibre and antioxidant content which affects instead acceptance for only some consumer groups depending on their interest. The literature shows several papers where the effect of healthy claims has been studied. Recently, Dean et al. (2012) studied the effect on the consumer of different claims: a) the benefit claim, which gives information about health-related effect; b) the risk reduction claim, which gives information about the functional ingredient; c) the function and the long term risk reduction of disease as health outcome; d) the nutritional claim which is the kind we used (like 'it contains antioxidants'). These authors (see also Van Kleef et al., 2005; Verbecke,

2005) demonstrated that people tend to prefer risk reduction claims to more general nutritional claims. The lack of significant effect of the nutrition information on total mean liking in our study could be due to the fact that consumers are not all homogeneously aware of the link between the nutrition information and the specific risk or disease, or the level of information given in the nutrition claim is not sufficient, as suggested by Dean and colleges (2012). Other researchers (Williams, Ridges, Batterham, Ripper, & Hung, 2008; Miele, Di Monaco, Cavella, & Masi, 2010) found that health claim effectiveness depends also on the type of product, especially for healthier or functional foods. Here, the problem is perhaps the contrary: apple is commonly associated to the concept of health and maybe the consumer does not understand the advantage of making a healthy food, healthier.

Nevertheless, health information could catch more on specific groups of consumers who might be more aware of these aspects than both the average population and people younger than 20 years (who represented 73% of our consumer sample).

The information about antioxidant content increased the acceptance of apples for the group of older consumers and for those more educated on the benefits of eating food rich in antioxidants. These results are in accordance with the literature, which reports that older people are more positive toward functional food and more receptive to health claims (Herath, Cranfield, & Hunson, 2008; Ares, Gimenez, & Gambaro, 2009; Lalor, Madden, McKanzi, & Wall, 2011). Furthermore, several authors also reported that respondents having knowledge about nutrition reported a higher satisfaction, willingness to try, and attitude toward a functional food (Bech-Larsen, & Grunert, 2003; Žeželj, Milošević, Stojanivić, & Ognjanov, 2012; Ares, Gimènez, & Gàmbaro, 2008).

The information about the fibre content produces a significant increase in liking for participants who use food as a reward, a typical behaviour of restrained eaters who modify their diet for fear of gaining weight. Restrained eaters have a more positive implicit attitude towards palatable food (Papies, Stroebe, & Aarts, 2009). Therefore, by enhancing a food they like (apples, in our case) with a nutritional information in accordance with a low-calorie diet, a double satisfaction was perceived by these consumers: sensory and psychological.

No effect was shown for the interactions Sweetness * Information about fibres (or Texture * Information about antioxidants) and Sweetness * Information about antioxidants (or Texture * Information about fibres) for the whole consumer panel as well as in the specific consumer groups identified (G1, G2, and G3). This means that consumers did react to the information about antioxidants (or fibres) and that it was independent of the level of sweetness (or texture parameters) and thus the expectations created by the information gave the same liking score regardless of product performance. This finding provides useful marketing insights ecause it demonstrates that external information if provided to the ''right'' consumers has an effect of primary importance on liking.

5. Conclusion

This study showed that a methodological approach which combines the measure of acceptability with a conjoint design based on selecting samples from sensory data is suitable to identify the effects of intrinsic and extrinsic factors of fresh unprocessed products. Significant effects were found for intrinsic factors while extrinsic factors affected apple preference only for some groups of consumers depending on their sensitivity to the information given. In particular, overall liking was positively influenced by high levels of crunchiness and sweetness. This result confirms the importance of sensory characteristics in consumer acceptability, whereas it suggests that information about the amount of nutritional components are less relevant in general but can be important for certain group of consumers which might be more aware of these aspects. This latter effect could be more important in the case of products that are not considered as healthy as apple. The work presented here is an example of how consumer science can support apple breeding to

meet the consumers' needs and activate successful strategies based on perceived and nutritional quality to promote the consumption of healthy food.

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References

Ares, G., Gimènez, A., & Gàmbaro, A. (2008). Influence of nutritional knowledge on perceived healthiness and willingness to try functional foods. *Appetite*, 51, 663-668.

Ares, G., Gimenez, A., & Gambaro, A. (2009). Consumer perceived healthiness and willingness to try functional milk desserts. Influence of ingredient, ingredient name and health claim. *Food Quality and Preference*, 20, 50-56.

Baker, G.A., & Crosbie, P.J. (1993). Measuring food safety preferences: Identifying consumer segments. *Journal of Agricultural and Resources Economics*, 18(2), 277-287.

Baker, G. (1999). Consumer preferences for food safety attributes in fresh apples: market segments, consumer characteristics, and marketing opportunities. *Journal of Agricultural and Resources Economics*, 24(1), 80-97.

Bech-Larsen, T., & Grunert, K.G. (2003). The perceived healthiness of functional foods. A conjoint study of Danish, Finnish and American consumers'perception of functional foods. *Appetite*, 40, 9-14.

Bernstein, A.M., Titgemeier, B., Kirkpatrick, K., Golubic, M., & Roizen, M.F. (2013). Major cereal grain fibers and psyllium in relation to cardiovascular health. *Nutrients*, 5, 1471-87.

Bonany, J., Buehler, A., Carbó, J., Codarin, S., Donati, F., Echeverria, G., et al. (2013).Consumer eating quality acceptance of new apple varieties in different European countries. *Food Quality and Preference*, 30, 250–259.

Bonany, J., Brugger, C., Buehler, A., Carbó, J., Codarin, S., Donati, F., et al. (2014). Preference mapping of apple varieties in Europe. *Food Quality and Preference*, 30(2), 317–329.

Bravo, L. (1998). Polyphenols: Chemistry, Dietary Sources, Metabolism, and Nutritional Significance. *Nutrition Reviews*, 56, 317-333.

Brownawell, A.M., Caers, W., Gibson, G.R., Kendall, C.W.C., Lewis, K.D., Ringel, Y., & Slavin, J.L. (2012). Prebiotics and the Health Benefits of Fiber: Current Regulatory Status, Future Research, and Goals. *The Journal of Nutrition*, 142, 962-974.

Carmines, E.G., & Zeller, R.A. (1979) *Reliability and validity assessment*. Sage, Thousand Oaks

Cerda, A.A., Garcia, L.Y., Ortega-Farias, S., & Ubilla, A.M. (2012). Consumer preferences and willingness topay for organic apples. *Ciencia e Investigacion Agraria*, 39(1), 47-59.

Claret, A., Guerrero, L., Aguirre, E., Rincon, L., Hernandez, M.D., Martinez, I., Peleteiro, J.B., Grau, A., & Rodríguez-Rodríguez, C. (2012). Consumer preferences for sea fish using conjoint analysis: Exploratory study of the importance of country of origin, obtaining method, storage conditions and purchasing price. *Food Quality and Preference*, 26, 259-266.

Corollaro, M.L., Endrizzi, I., Bertolini, A., Aprea, E., Demattè, M.L., Costa, F., Biasioli, F., & Gasperi, F. (2013). Sensory profiling of apple: Methodological aspects, cultivar characterisation and postharvest changes. *Postharvest Biology and Technology*, 77, 111-120.

Corollaro, M.L., Aprea, E., Endrizzi, I., Betta, E., Demattè, M.L., Charles, M., Bergamaschi, M., Costa, F., Biasioli, F., Corelli Grappatelli, L., & Gasperi, F. (2014). A combined sensory-instrumental tool for apple quality evaluation. *Postharvest Biology and Technology*, in press (10.1016/j.postharvbio.2014.05.016).

Cox, D.N., Evans, G., & Lease, H.J. (2011). The influence of product attributes, consumer attitudes and characteristics on the acceptance of: (1) Novel bread and milk, and dietary supplements and (2) fish and novel meats as dietary vehicles of long chain omega 3 fatty acids. *Food Quality and Preference*, 22, 205-212.

De Pelsmaeker, S., Dewettinck, K., & Gellynck, X. (2013). The possibility of using tasting as a presentation method for sensory stimuli in conjoint analysis. *Trends in Food Science & Technology*, 29, 108-115.

Dean, M., Lampila, P., Shphrd, R., Arvola, A., Saba, A, Vassallo, M., Claipein, E., Winkelmann, M., & Lähtemmäki, L. (2012). Perceived relevance and foods with health-related claims. *Food Quality and Preference*, 24, 129-135.

Del Carmen, D.R., Esguerra, E.B., Absulio, W.L., Maunahan, M.V., Masilungan, G.D., Collins, R., & Sun, T. (2013). Understanding consumers preferences for fresh table-ripe papaya using survey and conjoint methods of analyses. In Abdullah, H.; Latifah, M.N. (Eds.), Proceedings of the 7th International Postharvest Symposium, *Acta Horticulturae*, 1012, 1379-1385.

Enneking, U., Neumann, C., & Henneberg, S. (2007). How important intrinsic and extrinsic product attributes affect purchase decision. *Food Quality and Preference*, 18(1), 133-138.

Eufic (2012). Fruit and vegetables consumption in Europe – do Europeans get enough? http://www.eufic.org/article/en/page/RARCHIVE/expid/Fruit-vegetable-consumption-Europe/.

Frankel, E.N., Kanner, J., German, J.B., Parks, E., & Kinsella, J.E. (1993). Inhibition of oxidation of human low-density lipoprotein by phenolic substances in red wine. *The Lancet*, 341, 454-457.

Fuhrman, B., Lavy, A., & Aviram, M. (1995). Consumption of red wine with meals reduces the susceptibility of human plasma and LDL to lipid peroxidation. *The American Journal of Clinical Nutrition*, 61, 549-54.

Fukomoto, L.R., & Mazza, G. (2000). Assessing antioxidant and prooxidant activities of phenolic compounds. *Journal of the Agriculture and Food Chemistry*, 48, 3597-3604.

Gadioli, I.L., Pineli, L.D.D., Rodrigues, J.D.Q., Campos, A.B., Gerolim, I.Q., & Chiarello, M.D. (2013). Evaluation of packaging attributes of orange juice on consumers' intention to purchase by conjoint analysis and consumer attitudes expectation. *Journal of Sensory Studies*, 28(1), 57-65.

Galmarini, M.V., Symoneaux, R., Chollet, S., & Zamora, M.C. (2013). Understanding apple consumers' expectations in terms of likes and dislikes. Use of comment analysis in a cross-cultural study. *Appetite*, 62, 27–36.

Gamble, J., Jaeger, S.R., & Harker, R. (2006). Preferences in pear appearance and response to novelty among Australian and New Zealand consumers. *Postharvest Biology and Technology*, 41, 38-47.

Gamble, J., Harker, F.R, Jaeger, S.R., White, A., Bava, C., Beresford, M., Stubbings, B., Wohlers, M., Hofman, P.J., Marques, R., Woolf, A. (2010). The impact of dry matter, ripeness and internal defects on consumer perceptions of avocado quality and intentions to purchase. *Postharvest Biology and Technology,* 57, 35-43.

Gatti, E., Di Virgilio, N., Magli, M., & Predieri, S. (2011). Integrating sensory analysis and hedonic evaluation for apple quality assessment. *Journal of Food Quality*, 34, 126-132.

Grau, A., Rodriguez-Rodriguez, C. (2012). Consumer preferences for sea fish using conjoint analysis: Exploratory study of the importance of country of origin, obtaining method, storage conditions and purchasing price. *Food Quality and Preference*, 26(2), 259-266.

Green, P.E., & Srinivasan, V. (1978). Conjoint analysis in consumer research: Issues and outlook. *Journal of Consumer Research*, 5(2), 103-123.

Green, P.E., Krieger, A.M., & Wind, Y. (2001). Thirty years of conjoint analysis: reflection and prospects. *Interfaces*, 31(3), S56-S73.

Haddad, Y., Haddad, J., Olabi, A., Shuayto, N., Haddad, T., & Toufeili, I. (2007). Mapping determinants of purchase intent of concentrated yogurt (Labneh) by conjoint analysis. *Food Quality and Preference*, 18(5), 795-802.

Hampson, C.R., Quamme, H.A., Hall, J.W., Mac Donald R.A., King, M.C., & Cliff, M.A. (2000). Sensory evaluation as selection tool in apple breeding. *Euphytica*, 111, 79-90.

Harker, F.R., Marsh, K.B., Young, H., Murray, S.H., Gunson, F.A., & Walker, S.B. (2002). Sensory interpretation of instrumental measurements 2: sweet and acid taste of apple fruit. *Postharvest Biology and Technology,* 24, 241–250.

Harker, F.R., Gunson, F.A., & Jaeger, S.R. (2003). The case of fruit quality: an interpretative review of consumer attitudes, and preferences for apples. *Food Quality and Preference*, 11(5), 405-417.

Harker, R.F., Kupfermanb, E.M., Marinc, A.B., Gunsona, F.A., & Triggs, C.M. (2008). Eating quality standards for apples based on consumer preferences. *Postharvest Biology and Technology*, 50, 70-78.

Helgesen, H., Solheim, R., & Næs, T. (1998). Consumer purchase probability of dry fermented lamb sausages. *Food Quality and Preference*, 9(5), 295-301.

Herath, D., Cranfield, J., & Henson, S. (2008). Who consumes functional foods and nutraceuticals in Canada? Results of cluster analysis of the 2006 survey of Canadians' Demand for Food Products Supporting Health and Wellness. *Appetite*, 51, 256-265.

Herseleth, M., Næs, T., Rødbotten, M., Videke, L., & Monteleone, E. (2012). Lamb meat - Importance of origin and grazing system for Italian and Norwegian consumers. *Meat Science*, 90(4), 899-907.

ISO (1988). International standard 8589. Sensory analysis – General guidance for the design of test rooms. Genève: International organisation of standardisation.

ISO (2010). International standard 13299. Sensory analysis – Methodology - General guidance for establishing a sensory profile. Brussels: CEN.

Jaeger, S.R., Harker, R., Trigg, C.M., Gunson, A., Campbell, R.L., Jackmam, R., & Requejo-Jackman, C. (2011). Determining consumer purchase intensions: The importance of dry matter, size, and price of kiwifruit. *Journal of Food Science*, 76(3), 177-184.

Johansen, S.B., Næs, T., Øyaas, J., & Hersleth, M. (2010). Acceptance of calorie-reduced yoghurt: Effects of sensory characteristics and product information. *Food Quality and Preference*, 21, 13-21.

Johansson, E.V., Nilsson, A.C., Östman, E.M., & Björck, I.M.E. (2013). Effects of indigestible carbohydrates in barley on glucose metabolism, appetite and voluntary food intake over 16 h in healthy adults. *Nutrition Journal*, 12, 46.

Kähkönen, M.J., Hopia, A.I., Vuorela, H.J., Rauha J., Pihlaja, K., Kujala, T.S., & Heinonen, M. (1999). Antioxidant activity of plant extracts containing phenolic compounds. *Journal of the Agriculture and Food Chemistry*, 47, 3954-3962.

Kanner, J., Frankel, E., Granit, R., German, B., & Kinsella, J.E. (1994). Natural antioxidants in grapes and wines. *Journal of Agricultural and Food Chemistry*, 42, 64-69.

Kayacier, A., Yuksel, F., & Karaman, S. (2014). Response surface methodology study for optimization of effects of fibre level, frying temperature, and frying time on some physicochemical, textural, and sensory properties of wheat chips enriched with apple fiber. *Food and Bioprocess Technology*, 7, 133-147.

Kelly, K., Hyde, J., Travis, J., & Crassweller, R. (2010). Assessing Consumer Preferences of Scab-resistant Apples: A Sensory Evaluation. *Hortechnologie*, 20, 885-891.

Kim, S.-J., Min, S.C., Shin, H.-J., Lee, Y.-J., Cho, A.R., Kim, S.Y., & Han, J. (2013). Evaluation of the antioxidant activities and nutritional properties of ten edible plant extracts and their application to fresh ground beef. *Meat Science*, 93, 715-722.

Laguna, L., Sanz, T., Sahi, S., & Fiszman, S.M. (2014). Role of fibre morphology in some quality features of fibre-enriched biscuits. *International Journal of Food Properties*, 17, 163-178.

Lalor, F., Madden, C., McKenzie, K., & Wall, P.G. (2011). Health claims on foodstuffs: A focus group study of consumer attitudes. *Journal of Functional Foods*, 3, 56-59.

Lee, W.J., Shimizu, M., Kniffin, K.M., & Wansink, B. (2013). You taste what you see: Do organic labels bias taste perceptions? *Food Quality and Preference*, 29, 33-39.

Martens, H., & Martens, M. (2001). *Multivariate analysis of quality. An introduction*. Chichester: John Wiley & Sons.

Miele, N.A., Di Monaco, R., Cavella, S., & Masi, P. (2010) Effect of meal accompaniments on the acceptability of a walnut oil-enrichedn mayonnaise with and without a health claim. *Food Quality and Preference,* 21, 470-477.

Miyake, S., Takahashi, N., Sasaki, M., Kobayashi, S., Tsubota, K., & Ozawa, Y. (2012). Vision preservation during retinal inflammation by anthocyanin-rich bilberry extract: cellular and molecular mechanism. *Laboratory Investigation*, 92, 102-109.

Nardozza, S., Gamble, J., Axten, L.G., Wohlers, M.W., Cleaewater, M.J., Feng, J., & Harker, F.R. (2010). Dry matter content and fruit size affect flavour and texture of novel Actinidia deliciosa genotypes. *Journal of the Science of Food and Agriculture*, 91, 742-748.

Novotorova, N.K., & Mazzocco, M.A. (2008). Consumer preferences and trade-offs for locally grown and genetically modified apples: a conjoint analysis approach. *International Food and Agribusiness Management Review*, 11(4), 31-53.

Olsen, N.V., Menichelli, E., Grunert, K.G., Sonne, A.M., Szabò, E., Banati, D, & Næs, T. (2011). Choice probability for apple juice based on novel processing techniques: Investigating the choice relevance of mean-end-chains. *Food Quality and Preference*, 22, 48-59.

Palmer, J.W., Harker, F.R., Tustin, D.S., & Johnston, J. (2010). Fruit dry matter concentration: a new quality metric for apples. *Journal of the Science of Food and Agriculture*, 90, 2586-2594.

Papies, E.K., Stroebe, W., & Aarts, H. (2009). Who likes it more? Restrained eaters' implicit attitudes towards food, *Appetite*, 53, 279-287.

Péneau, S., Brockhoff, P.B., Hoehn, E., Escher, F., &, Nuessli, J. (2006). Relating consumer evaluation of apple freshness to sensory and physico-chemical measurements. *Journal of Sensory Studies*, 22, 313-335.

Péneau, S., Hoehn, E., Roth, H.R., Escher, F., &, Nuessli, J. (2006). Importance and consumer perception of freshness of apples. *Food Quality and Preference*, 17, 9-19.

Rødbotten, M., Martinsen, B.K., Borge, G.I., Mortvedt, H.S., Knutsen, S.H., Lea, P., & Næs, T. (2009). A cross-cultural study of preference for apple juice with different sugar and acid contents. *Food Quality and Preference*, 20, 277-284.

Roininen, K., Lahteenmaki, L., & Tuorila, H. (1999). Quantification of consumer attitudes to health and hedonic characteristics of foods. *Appetite*, 33(1), 71-88.

Selvendran, R.R. (1984). The plant cell wall as a source of dietary fiber: chemistry and structure. *The American Journal of Clinical Nutrition*, 39, 320-337.

Serafini, M., Ghiselli, A., & Ferro-Luzzi, A. (1994). Red wine, tea and antioxidants. *The Lancet*, 344, 626.

Skreli, E., & Imami, D. (2012). Analyzing consumers' preferences for apple attributes in Tirana, Albania. *International Food and Agribusiness Management Review*, 15(4), 137-156.

Slavin, J. (2013). Fiber and Prebiotics: Mechanisms and Health Benefits. *Nutrients*, 5, 1417-1435.

Sofi, F., Macchi, C., Abbate, R., Gensini, G.F., & Casini, A. (2013). Mediterranean diet and health. *Biofactors*, 39, 335-342.

Solheim, R., & Lewless, H.T. (1996). Consumer purchase probability affected by attitude towards low-fat foods, liking, private body consciousness and information on fat and price. *Food Quality and Preference*, 7(2), 137-143.

Stebbins, R.L., Duncan, A.A., Compton, O.C., & Duncan, D. (1992). New apple varieties with grater consumer appeal. *Compact Fruit Tree*, 25, 76-83.

Stefek, M. & Karasu, C. (2011). Eye Lens in Aging and Diabetes: Effect of Quercetin. *Rejuvenation Research*, 14, 525-534.

Stojković, D., Petrović, J., Soković, M., Glamočlija, J., Kukić-Marković, J., & Petrović, S. (2013). In situ antioxidant and antimicrobial activities of naturally occurring caffeic acid, p-coumaric acid and rutin, using food systems. *Journal of the Science of Food and Agriculture*, 93, 3205-3208.

Stone, H., & Sidel, J.L. (2004). *Sensory Evaluation Practices.* 3rd ed. San Diego, CA: Elsevier Academic Press.

Sun-Waterhouse, D., Bekkour, K., Wadhwa, S.S., & Waterhouse, G.I.N. (2014). Rheological and chemical characterization of smoothie beverages containing high concentrations of fibre and polyphenols from apple. *Food and Bioprocess Technology*, 7, 409-423.

Symoneaux, R., Galmarini, M.V., & Mehinagic, E. (2012). Comment analysis of consumer's likes and dislikes as an alternative tool to preference mapping. A case study on apples. *Food Quality and Preference*, 24, 59-66.

Tomala, K., Baryłko-Pikielna, N., Jankowski, P., Jezioreka, K., & Wasiak-Zysb, G. (2009). Acceptability of scab-resistant versus conventional apple cultivars by Polish adult and young consumers. *Journal of the Science of Food and Agriculture*, 89, 1035-1045.

van Kleef, W., van Trijp, H.C.M., & Luning, P. (2005). Funtional foods: Health claim-food product compatibility and the impact of health framing on consumer evaluation. *Appetite*, 44, 299-308.

Varela, P., Salvador, A., & Fiszman, S. (2005). Shelf-life estimation of 'Fuji' apples: Sensory characteristics and consumer acceptability. *Postharvest Biology and Technology*, 38, 18-24.

Verbecke, W. (2005). Consumer acceptance of functional foods: Socio-demographic, cognitive and attitudinal determinants. *Food Quality and Preference*, 16, 45-57.

Vrhovsek, U., Rigo, A., Tonon, D., & Mattivi, F. (2004). Quantification of polyphenols in different apple varieties. *Journal of Agricultural and Food Chemistry*, 52, 6532-6538.

Vuksan, V., Jenkins, A.L., Jenkins, D.J.A., Rogovik, A.L., Sievenpiper, J.L., & Jovanovski, E. (2008). Using cereal to increase dietary fiber intake to the recommended level and the effect of fiber on bowel function in healthy persons consuming North American diets. *The American Journal of Clinical Nutrition*, 88, 1256-1262.

Wang, H., Cao, G., & Prior, R.L. (1996). Total antioxidant capacity of fruits. *Journal of Agriculture and Food Chemistry*, 44, 701-705.

Wang, Q., Sun, J., & Parsons, R. (2010). Consumer preferences and willingness to pay for locally grown organic apples: evidence from a conjoint study. *Horticultural Science*, 45(3), 376-381.

Williams, P., Ridges, L., Batterham, M., Ripper, B., & Hung, M.C. (2008) Australian consumer attitudes to health claim – food product compatibility for functional foods. *Food Policy*, 33, 640-643.

Yang, J., Wang, H-P., Zhou, L., Xu, C.-F. (2012). Effect of dietary fiber on constipation: A meta analysis. *World Journal of Gastroenterology*, 18, 7378-7383.

Žeželj, I., Milošević, J., Stojanivić, Ž., & Ognjanov, G. (2012). The motivational and informational basis of attitudes toward foods with health claims. *Appetite*, 59, 960-967.

Tables

Table 1 – Fractional factorial design $2^{(4-1)}$ used in the conjoint experiment.

Product profile	Texture	Sweetness	Fibre Info	Antioxidant Info	Cultivars
1	Low	High	Low	Low	Golden
2	High	High	Low	High	Fuji
3	Low	Low	Low	High	Reinette
4	High	Low	Low	Low	Granny
5	Low	High	High	High	Golden
6	High	High	High	Low	Fuji
7	Low	Low	High	Low	Reinette
8	High	Low	High	High	Granny

Table 2 – The list of statements about fibres (a) and antioxidants (b) of the health knowledge scales with the relative references in parentheses. Asterisks indicate the most widely known concepts.

Fibre knowledge scale (a)

*1**	Fibres help to stay in shape (Johansson et al., 2013; Sofi et al., 2013)
*2**	Fibres promote bowel regularity (Yang et al., 2012; Vuksan et al., 2008)
*3**	Fibres are found in the bran of cereals (Selvendran, 1984)
4	Fibres may have prebiotic effects (Slavin, 2013; Brownawell et al., 2012)
5	Fibres slow the rise in blood glucose after meals (Bernstein et al., 2013)

Antioxidant knowledge scale (b)

*1**	Antioxidants abound in red fruit (Wang et al., 1996; Kähkönen et al., 1999; Fukomoto & Mazza, 2000)
*2**	Antioxidants fight free radicals (Bravo, 1998)
3	Antioxidants prevent the oxidation of LDL cholesterol (Fuhrman et al., 1995; Kanner et al., 1994; Frankel et al., 1993; Serafini et al., 1994)
4	Antioxidants help to better preserve foods (Stojković et al., 2013; Kima et al., 2013)
5	Antioxidants protect eyesight (Miyake et al., 2012; Stefek & Karasu, 2011)

Table 3 – Descriptive statistics of attitude scales toward healthfulness and taste of food (a) and of health knowledge scales (b) and their percentile cut-points used for dividing respondents in groups.

Attitude scale (a)	Mean	SD	33rd	66th	Cronbach's α	Cronbach's α *
General health interest	43.9	12.3	39	50	0.80	0.89
Light product interest	24.9	9.4	21	30	0.78	0.82
Natural product interest	32.2	9.5	28	36	0.70	0.76
Craving for sweet foods	42.2	10.4	39	48	0.86	0.87
Using food as reward	32.5	10.6	28	37	0.79	0.79
Pleasure	32.4	6.8	30	35	0.33	0.67
Health knowledge scales (b)						
Fibres	31.3	6.1	29	34	0.71	--
Antioxidants	30.5	6.7	27	33	0.71	--

* value obtained by Roininen et al. (1999)

Table 4 – Results of ANOVA mixed model on the effects of the conjoint factors on liking performed on All = 346 consumers, on G1 = 162 consumers over 20 years of age, on G2 = 120 consumers with an established knowledge on antioxidants and on G3 = 128 consumers who use food as reward. *P*-values written in bold are significant.

Effect	All	G1	G2	G3
Consumer (Random)	**≤ 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Sweetness	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Texture	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
FibreInfo	0.093	0.090	0.325	**0.011**
AntioxInfo	0.055	**0.006**	**0.018**	0.416
*Sweetness * Texture or FibreInfo * AntioxInfo*	**< 0.001**	**< 0.001**	**0.007**	**0.006**
*Sweetness * FibreInfo or Texture * AntioxInfo*	0.409	0.369	0.168	0.579
*Sweetness * AntioxInfo or Texture * FibreInfo*	0.439	0.816	0.928	0.236

Figure captions

Figure 1 – Apple varieties sensory map: Correlation loading plot from PCA of sensory attributes related to taste and texture evaluated on the 21 varieties. The four apple varieties selected for the conjoint testing are written in bold and connected by a dashed grey line (Granny, Reinette, Fuji and Golden).

Figure 2 – Spider plot for the sensory attributes related to taste and texture of the four selected varieties.

Figure 3 – Examples of screen used in the conjoint study: a) the introductory slide on the average content of fibres and antioxidants in one apple; b) the information about the fibre and antioxidant content in the proposed sample were given simultaneously by a bar-plot.

Figure 4 – Bonferroni intervals of information factors for acceptability in All = 346 consumers, in G1 = 162 consumers over 20 years of age, in G2 = 120 consumers with an established knowledge on antioxidants, and in G3 = 128 consumers who use food as reward (within the same effect and group, mean values with different letters are significantly different; $p < 0.05$)