

11 **Abstract**

12 Developing food products for children requires their involvement since their needs differ from those of
13 adults. Descriptive methods are helpful in defining product's sensory properties that drive consumer's
14 liking but they are not recommended with children. Consequently, finding new approaches to develop
15 food tailored for children is one of the biggest challenges for food companies and sensory and consumer
16 research scientists. This study has a two-fold aim: 1) to test the suitability of Check-All-That-Apply
17 (CATA) questions to obtain a sensory description of fibre-enriched apple purees by children; 2) to
18 investigate the drivers of liking of these products. 62 children (8-11 years) evaluated the overall liking
19 of 6 apple purees varying in appearance and texture and answered a series of CATA questions. Results
20 showed that children were able to generate appropriate descriptive terms and to discriminate the samples
21 according to the a priori modified sensory modalities using the CATA method. Sweet taste and a smooth
22 texture were positive predictors of apple purees children liking, whereas a granular and crunchy texture
23 were negative predictors.

24

25 **Practical Applications**

26 Check-All-That-Apply questions seem to be an appropriate, child-friendly approach to get insights on
27 how young consumers perceive a food product and identify the most relevant sensory attributes that
28 affect children's perception. Indeed, the use of CATA technique could be useful for food products
29 research and development in order to understand children's drivers of liking and to obtain effective input
30 for products optimization that meet children's sensory expectation, assuring product's success with this
31 specific target of consumers.

32

33 **Keywords:** Sensory profiling; Rapid sensory methods; Food preference; apple puree; dietary fibre;
34 childhood

1. Introduction

The intake of fibre is below the recommended levels in all Western countries due to a modest consumption of fibre-containing foods (Jones, 2014). For this reason, efforts have been made by food companies to develop value-added food products providing higher levels of dietary fibre (Figuerola et al., 2005; Ruspasinghe et al., 2008). The inclusion of fibre in the diet has well-known positive effects on human health (Du et al., 2010; Howarth et al., 2005) resulting in a reduced incidence of chronic diseases, including diabetes, various cancers and coronary heart diseases (Grooms et al., 2013). An appropriate fibre consumption has a beneficial effect on constipation, improves glucose levels and blood lipids profile (Brauchla et al., 2012) and has an important effect on increasing satiety, thus contributing to food intake and body weight control (Clark and Slavin, 2013; Rebello et al., 2016).

Besides being one of the most familiar and palatable fruits for children (Bergamaschi et al., 2016; Laureati et al., 2014; Laureati, Bertoli et al. 2015), whole apples are a good source of fibre with a balanced proportion between soluble and insoluble fraction (Gorinstein et al., 2001). However, during apple processing to purees, a minor part of apple dietary fibre remains in the final product, while the remaining amount is discarded with solid residue (apple pomace), thus decreasing the potential health benefit of apple to children's diet. In fact, on average, dietary fibre contents are approximately 11% and 60% of dry solids in apple pulp and apple pomace, respectively (Lavelli and Kerr, 2012).

Despite having an undeniable positive effect on nutritional quality, it has been reported that fibre might have a negative impact on palatability due to their dark color, bitter flavor and coarse texture (Baixauli et al., 2008; Laureati et al., 2016). Similarly, for fruit purees enriched with fibre, adults' liking ratings were found to depend on the product texture (smooth to rough) and color (Lavelli et al., 2014). Thus, the potential fibre beneficial effect on health is often in conflict with pleasure in eating.

Acceptability and liking are important drivers of food consumption, especially for children for whom the hedonic component is one of the key factors in determining healthy food choice (Taylor et al., 2005). In

59 particular, appearance, sweet taste and texture are reported to play a major role in determining children
60 food preferences and they are mentioned as being the most important reasons of lack in fruit and
61 vegetables consumption (Dovey et al., 2012; Zeinstra et al., 2010). In this context, one of the main
62 challenges of food industry is developing healthy food products that meet children's sensory expectation
63 and liking.

64 Descriptive methods are helpful in establishing the key sensory properties that drive consumer's liking.
65 However, due to their complexity, descriptive methods are not recommended with young consumers
66 (Laureati, Pagliarini et al., 2015). Children would indeed need to be trained in order to be objective and
67 able to use rating scales correctly. Moreover, they only can focus in few aspects of a product and lack of
68 concentration and attention. In this context, a great support could be supplied by using the check-all-that-
69 apply (CATA) approach, which has been reported to be more intuitive, more consumer friendly and to
70 minimize subject's cognitive processing (Ng et al., 2013). This approach is used to better define which
71 sensory attributes consumers perceive in food products (Ares et al., 2010; Dooley et al., 2010; Ng et al.,
72 2013). Subjects choose, from a list of words or phrases, all the expressions they consider suitable to
73 describe a product, without forcing them to evaluate all attributes on a scale (Ares and Jaeger, 2015). The
74 efficiency of the CATA questions in evaluating adults' sensory perception of a food product has been
75 confirmed by various studies (Ares et al., 2010; Dooley et al., 2010; Ng et al., 2013; Perrin et al., 2008).
76 Moreover, this approach has also been applied with 8-13 years old children to obtain emotion profiles of
77 food (De Pelsmaeker et al., 2013) but it has never been tested as an alternative to descriptive methods in
78 food product development.

79 The aim of this study was to verify the suitability of the CATA method to obtain a sensory description
80 of fiber-enriched apple purees by school-aged children and to investigate the desirable and undesirable
81 sensory properties that affect acceptance of these products in order to find children's drivers of liking.
82 The suitability of the method was evaluated considering children ability to generate appropriate

descriptive terms during the pilot test preceding the CATA assessment and their ability to discriminate the a priori modified products according to the generated descriptors (Laureati, Pagliarini et al., 2015).

2. Materials and methods

2.1 Participants

A total of 62 children (31 boys and 31 girls), aged between 8 and 11 years, from a public school in the metropolitan area of Milan were enrolled in the study. Three classes were involved: one 3rd grade (8-9 years, n=19), one 4th grade (9-10 years, n=17) and one 5th grade (10-11 years, n=26). Although children's sample size was somewhat small, it fulfilled the requirements to perform a sensory characterization of products using the CATA approach (Varela and Ares, 2012) and gather hedonic data (ISO 11136, 2014).

Teachers and parents were informed thoroughly about the aim of the study. Moreover, parents gave written consent and completed a short questionnaire on their child's food allergy and specific diet. Children who suffered from allergies for the study products or followed specific diets were not included in the study. Children's participation was voluntary and school classes received mixed gadgets (e.g., pencils, chalks, highlighters) as a small reward for their participation. The study complied with the principles established by the Declaration of Helsinki and the protocol was approved by the Ethics Committee of the University of Milan.

2.2 Samples

Six different formulations of fibre-enriched apple purees, balanced for dietary fibre and sugar content and energy, were developed by incorporating different sources of apple fibre. Apple skin powder and dried apple in form of powder, small granules or large granules, were selected in order to modify the texture from smooth to particulate and verify what was the most suitable for children.

Apple purees were also varied for color (either red or brownish/yellowish), because authors thought that red color would be more appealing for children and could contribute to increase the liking of the formulation. In order to obtain two sets of purees differing in appearance (3 yellowish/brownish formulations vs 3 red formulations) either an apple puree (100% apple) (Consorzio Melinda S.C.A., Cles, Italy) or a 90:10 mixture of apple puree and blueberry juice (100% blueberry) (Sottobosco Paoli, Trento, Italy) were developed. To increase fibre content, apple skin powder (The Hut Group, Cheshire, UK) was incorporated to all 6 samples. Moreover, dried apple was added to each set of apple puree (both red and yellowish/brownish) in order to obtain three prototypes differing for the particle sizes (\emptyset) of the solid fraction (from smooth to particulate). Two samples (both red and yellowish/brownish) were modified by adding apple powder ($\emptyset \leq 0.5$ mm) (Cooperativa Ortofrutticola Ve.Ba. S.C, Ferrara, Italy). Two samples (both red and yellowish/brownish) were modified by adding dried apple granules ($\emptyset \leq 3$ mm, small granules) (Cooperativa Ortofrutticola Ve.Ba. S.C, Ferrara, Italy). The last two samples (both red and yellowish/brownish) were modified by adding dried apple pieces ($3.5 \text{ mm} \leq \emptyset \leq 4 \text{ mm}$, large granules) (EcorNaturaSi S.P.A., Treviso, Italy). The particles were homogeneously dispersed in the puree. The content of major components and energy values were provided by the producers. Total dietary fibre and soluble carbohydrates contents were also verified by the AOAC procedures (AOAC, 1990) and found to correspond to the declared values. The final dietary fibre content of 3% was achieved, which is higher than that of the conventional puree and whole apple (i.e., 1 and 2%, respectively), and corresponds to “fibre source” according to the EU Regulation 1924/2006. Thus, all the puree prototypes contained 3 g of dietary fibre in 100 g of the final product and were matched for sugar content and energy (corresponding to the sugar content and energy of apple puree). Water was also added to balance the formulations. Preliminary sensory tests were used to screen among various formulations in order to obtain the suitable composition and to select the final 6 prototypes, which were discriminable according to appearance and texture. The composition of the final products is reported in Table 1.

130

131 2.3 Experimental Design

132 The study consisted of two separate tasks performed on the same day: first children assessed the overall
133 liking of the purees, and then they described the product by means of CATA questions. All children were
134 consumers of apple purees. Tests were administered at school to small groups of 5 children in a quiet
135 room. Children performed all evaluations individually in the presence of an experimenter for each child.
136 Each experimenter was given instructions to be read to the children for all the tests. Prior to the tests, the
137 children received a booklet and the experimenters explained them how to complete it and how to use the
138 hedonic scale. For the liking and CATA tasks, the 6 samples, approximately 30 g of each apple puree,
139 were presented to the children monadically in plastic cups labelled with 3-digit codes. The products
140 presentation order was systematically varied according to William's Latin Square. Mineral water was
141 provided to the children so they could clean their palate between sample trials.

142

143 2.4. Measurements

144 2.4.1. Overall liking assessment

145 Children were asked to taste the products monadically and to express their liking through a 7-point facial
146 hedonic scale, from super good (7) to super bad (1) (Pagliarini, et al., 2003; 2005).

147

148 2.4.2. Check-all-that-apply (CATA) assessment

149 2.4.2.1. Generation of descriptive terms

150 The attributes were selected after a two-step procedure. First, the sensory CATA terms used in the study
151 were generated through a pilot test consisting of a free listing questionnaire carried out with a separate
152 group of 10 children aged 8-11 years old in presence of an experimenter. The children were provided

153 with the 6 apple purees and for each sample, they were asked to pay attention to the appearance, aroma,
154 taste and texture properties. If needed, examples were provided to clarify the task. Children were asked,
155 in a free manner, to write all terms that were related to each of the six samples. They were given a booklet
156 with written instructions and asked to complete the task. The instructions given to the children were:
157 “We would like you to try six samples of apple puree. Please, try each sample and write all the words
158 (appearance, odor, taste, texture) which are suitable for describing this puree”. An open discussion
159 followed the development of lexicon. Children provided a number of terms ranged from 4 to 15. The
160 session lasted approximately 45 min and was performed at school in a quiet room.

161 The second-step procedure was performed by the experimenters in order to finalize the list of terms.
162 When several terms pointed to be a synonymous, the most common word was selected (Jaeger et al.,
163 2015). Only the terms reported by at least 20% of children were included in the final list, which comprised
164 the following 11 sensory attributes: 2 for appearance (red color and brownish color), 3 for taste/flavor
165 (fruit flavor, sweet taste and sour taste), and 6 for texture (sticky, doughy, floury, granular, sandy, and
166 crunchy). This choice is in line with literature data suggesting that the number of words used in the CATA
167 method could affect results reliability (Ares et al., 2013). If a limited number of terms is used, it is likely
168 that respondents have the tendency to select most of them, thus resulting in poor discriminability. On the
169 contrary, if a long list of terms is provided, there is the risk that respondents select the first alternatives,
170 avoiding a careful choice of the terms during the task. Accordingly, it has been suggested that a suitable
171 list of CATA questions would be comprised of 10-40 terms in order to consider consumer heterogeneity
172 but at the meantime avoiding a dilution effect of the responses (Ares and Jaeger, 2015; Jaeger et al.,
173 2015).

174

175 2.4.2.2. Apple purees assessment

176 CATA questions assessment was performed after the overall liking evaluation, after a rest of 5 minutes.

177 Newly coded samples were presented to the children along with a booklet containing the list of 11 sensory
178 descriptors for each sample. The experimenters read CATA questions aloud and children (n=62) were
179 asked whether they knew the meaning of each word. If not, a brief explanation with examples was given.
180 Then, children were asked to taste the products one at the time and select all the words from the list
181 suitable for describing that sample.

182

183 2.5 Data Analysis

184 A mixed ANOVA model was carried out on overall liking data considering *Children* as a random factor
185 and *Samples* (the 6 apple purees) as fixed factor. Post hoc comparison (Least Significant Difference,
186 LSD) was used to compare the samples means.

187 For the CATA questions, the frequency of mention for each term was determined by counting the number
188 of children that used that term to describe each sample. Cochran's Q test was performed for each of the
189 11 terms to evaluate significant differences among apple purees.

190 Different statistical approaches are found in the literature in order to relate hedonic data and CATA
191 questions to find drivers of liking. One of this approach is the penalty-lift analysis (Arés, Dauber et al.,
192 2014) in which consumers are asked to score overall liking for a set of samples and an ideal product and
193 to describe them by CATA questions. Penalty analysis provides a graphical representation of the
194 relationship between liking data and the deviation from the ideal product, which is, however, not the aim
195 of the present study.

196 An alternative approach is to use multiple factor analysis (MFA), which allows giving the same weight
197 to variables so that perceptual map is not dominated by only a few attributes (Meyners et al., 2013). MFA
198 has been largely used in previous studies to relate CATA questions to hedonic data (Arés et al., 2010;
199 Parente et al., 2011; Choi et al., 2015; Tarancón et al., 2015).

200 Another common approach to study the relationship between sensory attributes and hedonic data is the

Partial Least Square (PLS) regression (Wold et al., 2001). This method formally requires scale data, but it is easily performed using CATA data (Meyners et al., 2013).

In the present study, both Partial Least Square Regression (PLSR) analysis and MFA were performed to study the relationship between CATA questions and liking data. MFA was performed on the frequency table containing responses to the CATA questions, considering children overall liking scores as supplementary variable (Bécue-Bertaut and Pagès, 2008).

PLSR was performed considering CATA questions as X matrix (sensory profiling data) and liking scores as Y matrix (hedonic data). Data were autoscaled and cross validation was chosen as validation method. Correlation loadings was calculated to find significant variables (>50% explained variance) (Westad et al., 2003).

Since similar conclusions could be drawn by both PLSR and MFA analyses, in the present paper, the authors decided to show the PLSR approach, because of its predictive nature and because this analysis is more appropriate when the aim is to predict liking based on a series of descriptive attributes (Wold et al., 2001).

ANOVA was performed using the SAS software version 9.3 (SAS Institute SAS Institute Inc. 2012 SAS® 9.3. Cary, NC: SAS Institute Inc.). PLSR was performed using The Unscrambler X version 10.3 (CAMO, Oslo, Norway). $p < 0.05$ was chosen as the threshold for statistical significance.

3. Results

3.1 Overall liking assessment

The mean hedonic scores by samples are depicted in Figure 1. The main factor *Samples* was found to have a significant effect on liking ($F_{(5,305)}=4.98$, $p<0.001$). Overall, the six apple purees were well accepted, with mean overall liking scores well above the middle of the scale (range 5.0-5.7).

The samples added with apple powder (both red and brownish/yellowish, R_SM and B_SM) and the

225 brown sample with small pieces of dried apple (B_SP) obtained the highest liking scores and were
226 statistically comparable. The red sample added with small pieces of dried apple (R_SP) was comparable
227 to the B_SP and B_SM but was significantly less liked than the R_SM sample. At the same time, the
228 R_SP sample was comparable with the samples added with large pieces of dried apple (both red and
229 brownish/yellowish, R_LP and B_LP), which were comparable between them and significantly less liked
230 than the remaining samples.

231

232 3.2. Check-all-that-apply assessment

233 The frequency table of terms checked by children to describe the 6 different apple purees is reported in
234 Table 2. Significant differences were found in the frequency mention for 8 out of 11 terms. Children
235 were able to distinguish correctly the samples according to their appearance (red and brownish colors
236 both $p < 0.0001$), texture (crunchy $p < 0.0001$, granular $p < 0.0001$, sandy $p < 0.01$, doughy $p < 0.05$ and floury
237 $p < 0.05$) and taste (sour taste $p < 0.05$). The descriptors that were not discriminated were the sweet taste,
238 fruity flavor and sticky.

239

240 3.3. Relating sensory profiling (CATA) with liking

241 The purpose of this calculation was to establish which sensory attributes are mainly related to the overall
242 liking of the samples and to obtain a perceptual map of the products based on both liking and sensory
243 profiling obtained by children through the CATA method.

244 Since univariate tests, such as ANOVA, might not be the best way to assess significance for multivariate
245 models, we performed the PLSR analysis including all the sensory descriptors and then we used
246 correlation loadings to select significant variables (Westad et al., 2003).

247 The relation between sensory terms and overall liking of the six samples is depicted in Figure 2 (a-b).

248 The first factor explains respectively the 43% and 62% of the variation in X and Y, while the second

249 factor accounts for 10% and 31%. As inferred from the Scores plot (Figure 2a), the PLSR analysis
250 provided a better discrimination of the samples than the ANOVA. Samples were clearly discriminated
251 according to their texture, with factor 1 distinguishing the samples added with dried apple powder (R_SM
252 and B_SM, right side of the map) from the rest of the samples and factor 2 separating the samples with
253 the small apple pieces (R_SP and B_SP, upper side of the map) from the other apple purees.
254 Comparing figures 2 a and b, it is possible to see that children liking was oriented toward apple purees
255 on the right side of the map (R_SM and B_SM), which were mainly associated with the sensory
256 descriptors Sweet taste, Sandy and Floury texture. Liking was opposed to the sensory terms Fruity flavor,
257 Granular and Crunchy texture, which correctly described the samples added with small and large pieces
258 of dried apple. This outcome is probably due to the presence of the apple pieces, which enhanced the
259 perception of the texture attributes as well as of the Fruity flavor and Sour taste. This is reflected by the
260 increased perception of sweet taste characterizing samples without pieces.
261 According to the correlation loadings plot (Figure 2b), the descriptors Brown and Red colors, Sour taste,
262 Doughy and Sticky texture accounted for less than 50% explained variance, indicating that they play a
263 marginal role in predicting liking of the apple purees.

264

265 **4. Discussion**

266 This study investigated children drivers of liking of six apple purees differing in appearance and texture
267 in order to develop a healthy, fibre-enriched product for children. A further purpose of the study was to
268 investigate the appropriateness of the CATA method as a tool to obtain sensory description of food by
269 young consumers.

270 From a methodological point of view, the findings of the present study indicate that CATA questions
271 may represent a valid, rapid, and child-friendly method for the description of the sensory properties of
272 food. Different criteria can be used to establish the appropriateness of a method. One principle can be

performing experiments in which comparative data are collected. This can be translated, for instance, in using different approaches or comparing children results to those of a group of adults (Laureati, Pagliarini et al., 2015). However, in food product sensory characterization with children both principles might have drawbacks. In fact, comparing CATA questions with another approach, such as descriptive methods, does not seem a suitable way to pursue, since these methods are too complex and rating scales are not recommended with children. Moreover, comparing children self-reported assessment with that of adults might be problematic as well, since adults may have a different sensory perception and expectation of the product (Liem and Mennella, 2003; Liem et al., 2004; Lukasewycz and Mennella, 2012; Zeinstra et al., 2010). Thus, if differences arise, it is difficult to ascribe them to a different perception between children and adults or rather to a different understanding of the task. A clear discrimination of an a priori modified variable (e.g., texture) is another suitable way to establish that a methodology is appropriate for data collection from young consumers (Guinard, 2001; Laureati, Pagliarini et al., 2015). Based on this last assumption, in the present study we established the suitability of the CATA method considering children ability to generate appropriate descriptive terms and to discriminate the products according to the generated descriptors. In this sense, significant differences among apple purees for most of the descriptors were found. More importantly, the differences were coherent with the a priori modified sensory modalities, with samples added with small or large pieces of dried apple perceived as more crunchy and granular and the samples added with powdered dried apple being more doughy, sandy and floury. Sour was also perceived as different among samples. Actually, apple purees were not formulated to vary in sour taste, but it might well be that the addition of dried apple pieces or blueberry juice- the latter added in order to provide a red color, which was supposed to be more appealing for children - increased the perception of sourness.

To our knowledge there is only one example of application of CATA questions involving children. De Pelsmaecker, Schouteten, and Gellynck (2013) recently investigated whether 8–13-year-old children

297 associate different emotions with different brands of flavored milk using the CATA method. Results
298 revealed that children associated positive emotions with the leader brands and negative emotions with
299 less known products, thus suggesting they understood the task. Unfortunately, there is no systematic
300 research on methodologies that can be applied to get insights on sensory properties that children may
301 consider desirable or undesirable in food.

302 In this context, combining the sensory profiling obtained with CATA to liking seem to be useful to find
303 children's drivers of liking. Since acceptability drives food preference and food choice in children,
304 understanding the drivers of liking of healthy food is an important task for food industry as it may help
305 resolving the conflict between pleasure in eating and consumption of healthy food. The six samples were
306 well-appreciated by the children, as they all obtained hedonic responses well above the middle value of
307 the scale, even in the case of the least favorite sample. It should be pointed out that the formulations were
308 developed in order to obtain samples that were appreciated by children with the overall aim of increasing
309 the intake of such a healthy food. Indeed, it is well known that low liking is one of the main determinants
310 of reduced intake of fibre-enriched products (Laureati et al., 2016), especially among children. Moreover,
311 fibre-enriched apple puree could be more easily offered to children as a convenient snack during mid-
312 morning break than a raw fruit, which may need to be peeled. In fact, a study on children preference for
313 fresh apples has revealed that skin toughness was negatively related to taste preference (Birka et al.,
314 2001).

315 The sensory modalities that guided children's liking were sweet taste and texture. Several lines of
316 evidence show that the sensory pleasantness derived from tasting something sweet has an innate basis
317 and plays a major role in children food acceptance (Pepino et al., 2006).

318 Regarding texture, consistent with previous studies on children (Lukasewycz and Mennella, 2012;
319 Werthmann et al., 2015), our sample of young consumers was less likely to prefer foods with particles.
320 In fact, a smooth and uniform texture were positive predictors of apple purees liking. On the contrary, a

granular and lumpy texture with pieces predicted liking negatively. One explanation of children's preference for a uniform texture is that children more typically consume these versions of food (Lukasewycz and Mennella, 2012; Werthmann et al., 2015). Moreover, people, and especially children, like to be in full control of the food placed in their mouth (Szczesniak, 2002). Food with a granular texture or containing unexpected lumps or hard particles may indicate a less homogeneous product, which could be rejected for fear of gagging. In this respect, rejection of a more complex texture has been linked to neophobic attitude (Lukasewycz and Mennella, 2012), which is known to be high in childhood (Laureati, Bergamaschi et al., 2015).

Contrary to our expectation, color did not seem to be of any importance for children liking. Previous research on children found that food appearance, especially color, is an important factor for food preference and selection (Tesini et al., 2015). The discrepancy with our findings may be explained by the fact that in the study by Tesini et al. (2015) color was found to affect the visual liking of fresh cheese provided to children during an educational laboratory. Thus, children choose their favorite colored cheese without actually tasting it. It might well be that at a first glance, color is an important property for food selection, but then, when the product is chewed and swallowed, other sensory characteristics prevail. This assumption seems to be corroborated by the findings of Werthmann et al., (2015), indicating that food texture but not taste or color modification affected food acceptance and intake of a well-liked yoghurt.

In conclusion, the application of CATA questions enabled the identification of differences in children perception of six fibre-enriched apple purees varying in appearance and texture. This study suggests that this methodology could be an interesting approach to get an insight on how young consumers perceive food product and identify the most relevant sensory attributes that affect children's perception. Indeed, the use of CATA technique could be useful for food products research and development in order to understand children's drivers of liking and to obtain effective input for products optimization assuring

345 their success with this specific target of consumers.

346 Future perspectives of study should be addressed toward a deeper investigation of the suitability of the

347 CATA method in consumer testing with children. One hypothesis could be trying to compare the output

348 with other potentially child-friendly methods, such as projective mapping or Napping®. It is also

349 advisable to consider a wider children age range in order to investigate age-related differences in the

350 understanding of the task. Finally, it is recommended to extend the number of children included in the

351 experiment in order to obtain more robust and generalizable outcome.

352

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358

359 **Conflict of Interest**

360 None

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 501

502 **Table 1.** Formulation of the fibre-enriched apple puree prototypes balanced for fibre content, sugar content and energy.¹

Samples	Color	Texture	Apple Skin Powder g/100g	Apple Powder g/100g	Dried Apple Small Pieces g/100g	Dried Apple Large Pieces g/100g	Blueberry Juice g/100g	Apple Puree g/100g	Sugars g/100g	Total fibre g/100g	Energy kcal/100g
B_SM	Brownish/yellowish	Smooth	2.9	4.3	-	-	-	71	11.5	3.05	69.4
B_SP	Brownish/yellowish	Small Pieces	2.9	-	3.6	-	-	72	11.1	3.05	68.4
B_LP	Brownish/yellowish	Large Pieces	2.0	-	-	5.9	-	51	10.0	3.09	63.2
R_SM	Red	Smooth	2.9	4.3	-	-	7.2	64	11.1	3.05	66.7
R_SP	Red	Small Pieces	2.9	-	3.6	-	7.2	65	10.8	3.05	65.7
R_LP	Red	Large Pieces	2.0	-	-	5.9	5.1	46	9.7	3.08	61.3

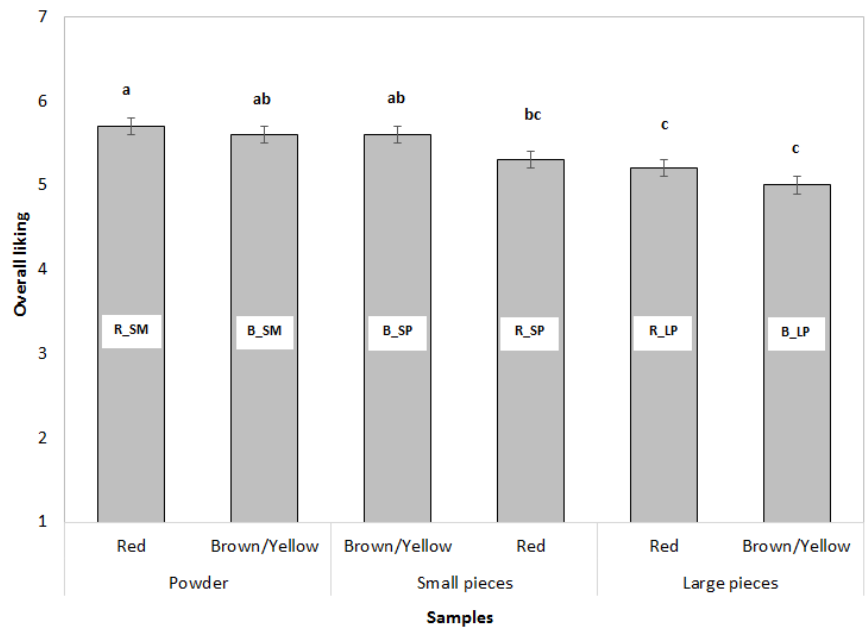
503 ¹The ingredients were combined to have a final fiber content of 3 g in 100 g and the same sugar content and energy of apple puree. Water
504 was added to balance the formulations.

505 **Table 2.**

506 Number of sensory attributes associated with each product by children (n=62). For each term, the Italian translation is provided between
507 brackets.

Sensory modality	Sensory attribute	Frequency of mention (n)					
		Samples					
		B_LP	B_SP	B_SM	R_LP	R_SP	R_SM
Appearance	Red color (colore rosso)***	0	0	0	61	61	62
	Brownish color (colore marrone)***	34	34	38	0	0	0
Taste/Flavour	Fruity flavor (gusto fruttato) n.s.	41	42	39	38	43	36
	Sweet taste (gusto dolce) n.s.	41	37	45	43	41	49
	Sour taste (gusto acido)*	13	12	8	10	18	14
Texture	Sticky (appiccicoso) n.s.	9	14	13	11	8	9
	Doughy (pastoso)*	15	18	23	11	15	16
	Floury (farinoso)*	5	7	10	8	9	13
	Granular (granuloso)***	37	31	11	37	34	8
	Sandy (sabbioso)**	12	10	19	6	11	20
	Crunchy (croccante)***	13	9	2	16	9	1

508 * p<0.05, ** p< 0.01, *** p <0.001, n.s. non-significant differences according to Cochran's Q test.

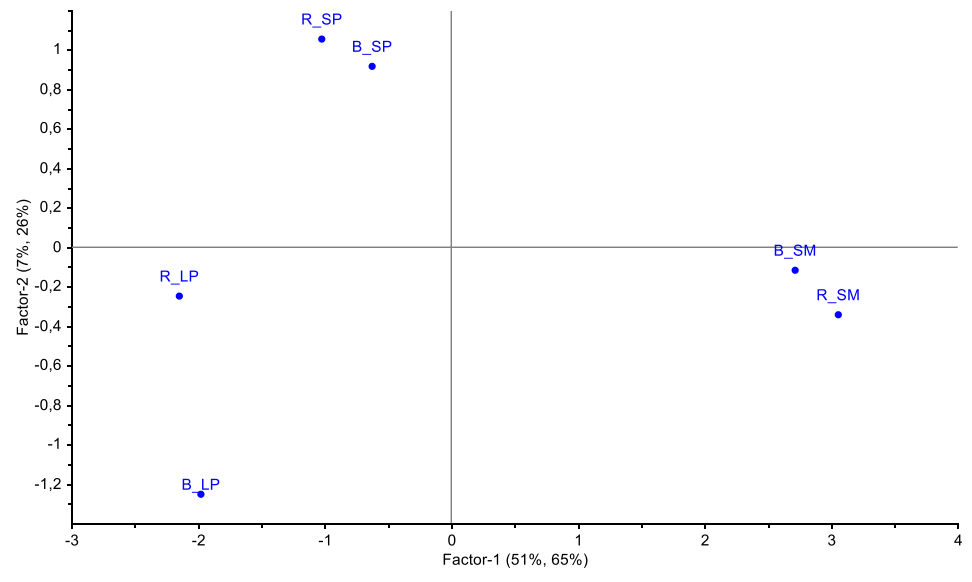


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511 **Figure 1.** Mean liking scores and standard error of the mean (SEM) by samples. Different letters indicate
 512 significant differences according to post hoc test.

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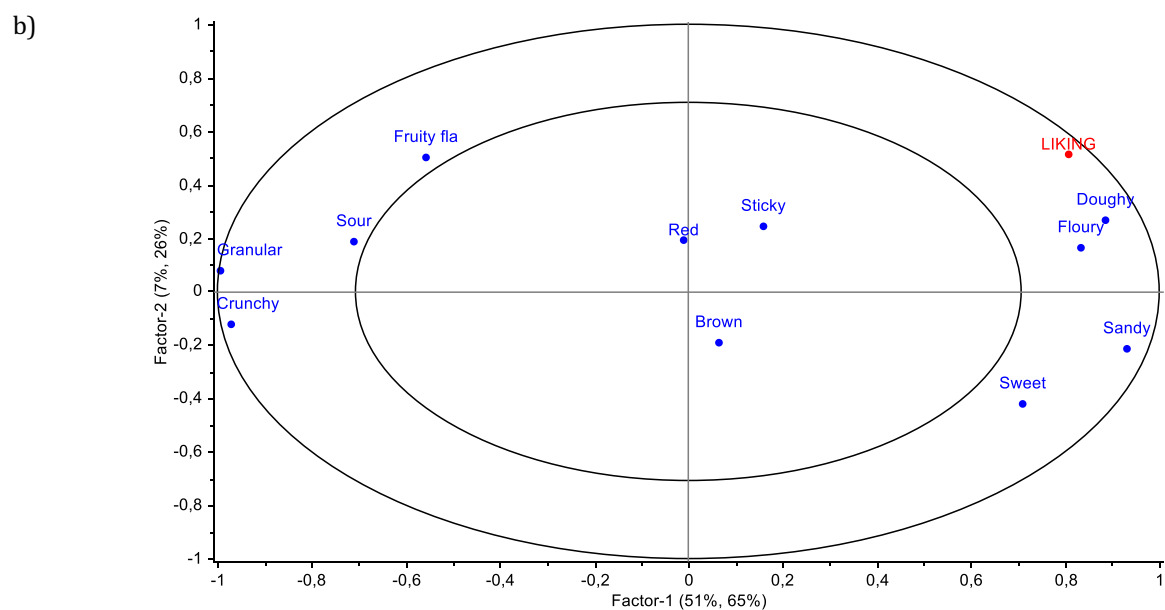
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523 **Figure 2 (a-b).** Scores Plot (a) and Correlation Loadings Plot (b) obtained by the PLSR model of the six
 524 apple purees based on CATA questions and hedonic data.