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A sensory- and consumer based approach to optimize cheese enrichment with grape skin powders

Torri

Summary. A sensory- and consumer based approach to optimize cheese enrichment conditions was proposed. Innovative cheeses developed by adding grape skin powders (GSP) from winemaking process to cow's milk curd were described by cheese taster experts and evaluated by consumers for their acceptability. Even though cheese is not an optimal vehicle for GSP enrichment, the adopted approach clearly identified the effect of the addition of the GSP on the sensory properties of cheese, pointed out which sensory features were detrimental for the product acceptability and allowed to obtain suitable information to optimize the ingredient use and the process conditions.

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11 # SENSORY APPROACH FOR CHEESE OPTIMIZATION

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13 ## A sensory- and consumer based approach to optimize cheese enrichment with grape skin powders

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24 ## ABSTRACT

25 The present study aimed to present a sensory- and consumer based approach to optimize cheese

26 enrichment with grape skin powders (GSP). The combined sensory evaluation approach, involving a

27 descriptive and an affective test respectively, was applied to evaluate the effect of the addition of grape

28 skin powders from two grape varieties (*Barbera* and *Chardonnay*) at different levels (0.8, 1.6 and 2.4% w

29 powder/w curd) on the sensory properties and consumer acceptability of innovative soft cow's milk

30 cheeses. The experimental plan envisaged seven products, six fortified prototypes (B0.8, B1.6, B2.4, C0.8,

31 C1.6, and C2.4) and a control sample, having 1 week ripening. By means of a Free Choice Profile, 21

32 cheese experts described the sensory properties of prototypes. A Central Location Test with 90 consumers

33 was subsequently conducted to assess the acceptability of samples. The GSP enrichment strongly affected

34 the sensory properties of innovative products, mainly considering the appearance and the texture. Fortified

35 samples were typically described with a marbling aspect (violet or brown as function of the grape variety)

36 and with an increased granularity, sourness, saltiness and astringency. The fortification also contributed

certain vegetable sensations perceived at low intensity (grassy, cereal, nuts), and some potential negative sensations (earthy, animal, winy, varnish). The white color, the homogenous dough, the compact and elastic texture and the presence of lactic flavors resulted the positive drivers of preference. On the contrary, the marbling aspect, granularity, sandiness, sourness, saltiness and astringency negatively affected the cheese acceptability for amounts of powder exceeding 0.8% and 1.6% for the *Barbera* and *Chardonnay* prototypes, respectively. Therefore, the amount of powder resulted a critical parameter for liking of fortified cheeses and a discriminant between the two varieties. Reducing the GSP particle size and improving the GSP dispersion in the curd would reduce the impact of powder addition on sensory properties, thereby encouraging the use of these polyphenol-based fortifiers in cheeses. The proposed approach allowed the identification of sensory properties critical for product acceptability by consumers thus helping the optimization of both fortifier characteristics and new cheese production and composition.

Key Words: consumer acceptability, free-choice profile, soft cheese, grape skin powder

INTRODUCTION

Consumers are increasingly aware that food directly contributes to their health (Mollet and Rowland, 2002), and the dairy market plays an active role in health and wellness (Brockman and Beeren, 2011). The use of functional ingredients represents one of the most important trends in diary product technological innovation. Dairy product enrichment can include (1) fortification with micro-ingredients (isolated and purified high-value compounds) to enhance the nutritional value of the food or (2) addition of macro-ingredients (complex ingredients, composed by a mixture of components). Within the first category, several examples are available (Bermúdez-Aguirre and Barbosa-Cánovas, 2011; Rinaldoni et al., 2014; Stratulatet al., 2014). Recently, winery by-products, such as the grape pomace, were added as macro-ingredients to several foods to obtain novel functional food products enriched in terms of polyphenols and dietary fiber (Mildner-Szkudlarz et al., 2013; Yu and Ahmenda, 2013).

Several biological activities are reported for dietary fiber and polyphenols from grape pomace, and advantages from their use in dairy production processes, as well as in product quality, have been envisaged

(Zhuet al., 2014). Environmental sustainability (Augustin et al., 2013) and contributions to managing waste (Fontana et al., 2013) are similarly important factors encouraging the use of non-dairy products as ingredients in the dairy industry. To authors' knowledge, among dairy products grape pomace has been uniquely used to fortify yogurt (Karaaslanet al., 2011; Codaet al., 2012) and salad dressing (Tseng and Zhao, 2013).

Beside the wide literature focusing on the advantages associated to the use of grape pomace as a food ingredient (Zhu et al., 2014; Yu and Ahmedna, 2013), there is a lack of information considering the sensory impact of this ingredient on food prototypes. Generally, the use of ingredients obtained by vegetal by-products to fortify or enrich foods contributes unpleasant sensations, which result detrimental for the overall quality (Braghieri et al., 2014; Ajila et al., 2010) and the acceptability (Rinaldoni et al., 2014; Marti et al., 2014) of food products. A limited number of studies took into account the effect of fortification with grape pomace on product sensory properties (Torri et al., 2015) and on its acceptability by consumers (Sant'Anna et al., 2014; Lavelli et al, 2014).

Health benefit belief from functional foods emerges as the strongest positive determinant of consumer willingness to compromise on taste (Verbeke, 2006). Moreover, considering the appeal of nutrition and health claims, significant interaction effects were found between claim type and the product concept, indicating that consumers differently react to the carrier product, functional ingredient and claims as function of the product concept (Verbeke et al., 2009).

Thus, implementing healthy properties without taking into account taste modifications and consumer response to the new fortified food appears a highly speculative and risky strategic option (Verbeke, 2006). This aspect deserves even more attention in the case of fortification/enrichment of familiar food. In fact, the more a consumer is familiar with the product the more a deviation from the expected sensory properties will negatively affect the consumer's response (Mildner-Szkudlarz et al., 2013). Based on these considerations, and given the importance of developing successful product for the food industry, it seems extremely important to include a consumer-based approach in product innovation and optimization process, in order to investigate the effect of the fortification/enrichment on acceptability and to increase the success probability of new products.

In the present study, a sensory- and consumer based approach to optimize cheese enrichment/fortification conditions was proposed and applied to an innovative cow's milk soft cheese developed by incorporating the grape skin powders (GSP) obtained from two grape varieties (*Barbera*, a red grape variety, and *Chardonnay*, a white grape variety) into the curd. The sensory- and consumer-based approach presented (1) evaluates the effect of enrichment conditions (type and concentration of added ingredient) on cheese sensory properties and (2) identifies the sensory drivers of the acceptability of the enriched soft cheeses developed in this study.

MATERIALS AND METHODS

Products

Grape Skin Powders. Grape pomace from non-fermented white Vitis vinifera cv *Chardonnay* was provided by the Fontanafredda winemaking factory (Serralunga d'Alba, Cuneo, Italy) while that from fermented red Vitis vinifera cv *Barbera* was provided by the Clarea winemaking factory (Chiomonte, Torino, Italy). The skins were mechanically separated, vacuum packaged and stored at -20 °C prior to being dried in an oven (Memmert, UFE 550, Schwabach, Germany) at 54 °C for 48 h and then ground with a Retsch ZM200 grinder (Retsch Gmbh, Haan, Germany) to obtain grape skin powder (GSP) with a particle size of less than 250 μm.

Cheese Samples. Raw cow's milk (protein 3.5%, fat 3.6%, lactose 5.1%) was provided from a local farm, pasteurized at 72°C for 15 sec then added of calcium chloride (0.1% v/v) and mesophilic starter bacteria Lyofast MOSO60D (Clerici-Sacco, Cadorago, CO, I). Coagulation was performed at 38-40 °C with cow rennet (chimosine:pepsine 20:80; Clerici, Milan, Italy). After 30-40 min of resting, the curd was cut two times and left to stand for 10 min at 37°C. Ripening was performed at 6 ± 1°C for 6 days. During ripening, each cheese was manually dry-salted. The obtained soft cheeses were fresh products similar to Robiola and considered as control sample (STD). Six samples of enriched cow's milk soft cheese were developed by incorporating GSP from *Barbera* (B) and *Chardonnay* (C) into the curd during the cheesemaking process. Three different percentages of powders (0.8, 1.6 and 2.4% w powder/w curd) were added directly to the curd before shaping and manually mixed. A preliminary production test showed that it

is not possible to obtain a cheese with a powder percentage higher than 2.5%, since cheeses were not able to maintain their shape. The enriched samples were codified as B0.8, B1.6, B2.4, C0.8, C1.6, and C2.4. In total, the study envisaged seven cheese samples. At the end of ripening, the obtained cheeses (250 ± 10 g) were cut in slices (5 x 3 x 1.5 cm) at room temperature (20 ± 1 °C) approximately 20 minutes prior to each sensory evaluation. Slices were placed in transparent plastic cups (38 ml) and hermetically sealed with a clear plastic lid. Samples were identified with three digit codes, served in randomized and balanced order among subjects and evaluated at room temperature (20 ± 1 °C).

Methods

Free Choice Profile. A group of 21 expert cheese tasters voluntarily participated in one session of the Free Choice Profile. Assessors (M=13, F=8; aged from 24 to 70, mean age=55) were selected from among the tasters of the Italian National Cheese Taster Association (ONAF, Organizzazione Nazionale Assaggiatori Formaggio) and declared a cheese consumption greater than 3 times a week. The session lasted 120 minutes. Sensory analysts briefed the experts on the methodology and the tasting procedure. The Free Choice Profile session was divided in two parts separated by a 15-minute break. In the first part, a vocabulary describing the sensory characteristics of prototypes was developed. The procedure required the assessors to observe, smell and taste samples and describe the sensory characteristics of prototypes considering appearance, odor, taste, flavor, and texture freely using their own terms. Panelists were encouraged to use associative and cognitive terms, rather than quantitative or affective ones (such as good, bad, or intense). Next, the panelists were asked to select from their own list of self-elicited attributes those, which they considered the most discriminative among samples. Each assessor freely selected the number of attributes to use. In the second part, a new set of the same samples was served (with different codes and in a different order) and assessors were asked to taste the samples and rate the intensity of sensations described by the attributes they selected using a 9-point scale (1=extremely weak, 9=extremely intense). Thus, in agreement with literature (Guardia et al., 2010; Vit et al., 2011), assessors tasted each sample twice evaluating the intensity of the descriptors once. The sample codes and presentation order were randomized across assessors in the two parts of the session. Instructions required the assessors to rinse their

mouths with still water before the beginning of the test. After each sample, subjects rinsed their mouths with water, had plain crackers for 30 s and finally rinsed their mouths with water for a further 30 s. Subjects took a 1 min break between sample evaluations.

Consumer Test. A Central Location Test (CLT) with 90 consumers (M=43, F=47; aged from 18 to 70, mean age=43) was performed during the "Cheese 2013" International Cheese Exhibition (Bra, Cuneo, Italy). Consumers voluntarily participated in the sensory test. Demographic information (age: 18-35, 36-55, 56-70; gender: M, F; nationality: Italian, non-Italian), socio-economic information (educational level: primary, high school, college, bachelor, other advanced degrees; occupational status: student, worker, retired, unemployed) and frequency of cheese consumption (once or less a week, 2-3 times a week, 4-5 times a week, once a day, more than once a day) were collected. Participants received individual trays with the seven cheese samples and rinsed their mouths with still water before beginning the evaluation. Participants tasted the samples according to the tray presentation order and in blind conditions, without any information about the innovativeness of the cheeses in order to avoid a potential effect of the information on liking scores. Participants rated their liking for appearance, odor, taste, flavor, texture and overall liking using a 9-point hedonic scale (1=extremely dislike, 9=extremely like) (Peryam and Pilgrim, 1957). Cheese prototypes were served in a randomized and balanced order. The subjects followed the same rinsing procedure adopted in FCP.

Data Analysis

Free Choice Profile. Data collected using the Free Choice Profile were submitted to Generalized Procrustes Analysis (GPA) to obtain a consensus map (Gower, 1975) by using the software Senstools v. 1.2x (OP&P Product Research BV, Utrecht, Netherlands). To estimate the significance of the GPA results, a Permutation Test was carried out (500 permutations were conducted on the raw matrix) and the total accounted variance of first dimensions was considered.

Consumer Test. The effect of the amount of GSP on liking in terms of appearance, odor, taste, flavor, texture and overall liking was assessed using a 2-way ANOVA mixed model with interactions (fixed factor: GSP amount, 3 levels 0.8, 1.6, 2.4%; random factors: subjects). The effect of grape variety on

liking in terms of appearance, odor, taste, flavor, texture and overall liking was assessed using a 2-way ANOVA mixed model with interactions (fixed factor: grape variety, 2 levels *Barbera*, *Chardonnay*; random factors: subjects). A 2-way ANOVA mixed model with interactions was used to estimate the effect of the product on the overall liking and on liking in all sensory modalities (fixed factor: product, 7 levels; random factors: subjects). A Partial Least Square Regression (PLS) was performed for exploratory purposes, considering the sensory data from FCP as the X data set and the overall liking of 90 consumers as the Y data set. To select the most discriminating attributes, those with a loading equal to or greater than 0.7 (absolute value) on the GPA consensus map for the first two principal Dimensions (Dim1 and/or Dim2) were selected to create the matrix. The PLS was performed using The Unscrambler X software, vers. 10.3 (Camo Software AS, Norway). ANOVA analyses were conducted using SYSTAT software, version 13.1 (Systat Software Inc, San José, USA).

RESULTS

Cheese Sensory Properties

Experts elicited 64 terms in total. The number of elicited attributes per subject ranged from a minimum of four to a maximum of 17 attributes. The average number of attributes elicited by experts was eight, in agreement with findings in the literature (Guàrdia et al., 2010). The initial list of attributes was reduced to achieve a unique list that comprehensively and accurately described the product space; redundant and/or less-cited terms were grouped on a semantic basis and/or eliminated. The final list consisted of 54 descriptors classified according to sensory modality: appearance (7), aroma (11), taste and mouthfeel sensations (6), flavor (17) and texture (13) (Table 1). Analysis of occurrences showed that the most frequently elicited descriptors (cited by at least one third of experts at least 7 times) were: marbling brown, white, odor and flavor of lactic, odor and flavor of yogurt, bitter, sour and gummy.

Appearance resulted a key sensory modality for sample discrimination with a relatively low number of descriptors (7) and a relatively high number of occurrences (31). New prototypes were generally described by using terms related to the marbling aspect (marbling, brown marbling, violet marbling, homogeneous

198 marbling), homogenous dough, white color and by the presence of holes. The control sample was described
199 as having a white color, in contrast to the fortified samples.
200 Taste and mouthfeel were described using four attributes for fundamental tastes (sour, bitter, sweet, salty)
201 and the tactile sensation of astringency with 35 occurrences in total. Sourness was the most used taste,
202 elicited by 11out of 21 judges. Secondly, bitter and salty tastes were elicited seven and six times,
203 respectively, both showing higher intensity scores in the enriched samples compared to the reference
204 standard. Judges elicited astringency only three times. For two assessors this attribute had high loading
205 values on the Dim2, but it was perceived in a contrasting way by judges.
206 Considering the olfactory sensations, judges used a high number of attributes to describe odor and flavor
207 (11 and 17 terms, respectively). Among these descriptors, several terms described vegetable sensations
208 (cereal, grassy, fruity, citric, nuts, vanilla), while other terms were not related to food and tended to have a
209 negative connotation (earthy, varnish, ammonia, acetone, animal, metallic, winy). However, a low number
210 of judges elicited odor and flavor sensations, and most of the sensations in this sensory modality occurred
211 fewer than three times. The odor and flavor of lactic and the odor and flavor of yogurt were the only
212 attributes with a number of occurrences equal to or higher than seven. These two sensations typically
213 characterized the perception of cheese.
214 Texture was extremely important in discriminating among samples, showing the highest number of
215 occurrences (41). Judges mainly used the attributes: gummy, adhesive, elastic and granular, with the last
216 one clearly characterizing the enriched samples. The attributes sandy, creamy and compact had low
217 occurrences but showed high loading values on the consensus map.
218 The experts' individual configurations were submitted to GPA. The Permutation Test indicated a
219 probability of less than 0.05% that the consensus generated in the study could have arisen by chance. The
220 consensus space obtained from GPA and applied to individual configuration is depicted in Fig. 1. The total
221 variance explained by the first two dimensions accounted for 39 and 15% on Dim1 and Dim2, respectively.
222 Samples were clearly discriminated according to the percentage of GSP along theDim1. The reference
223 sample was positively correlated to Dim1 and is highly correlated to white color, homogenous dough,
224 gumminess, sweet, bitter and lactic sensations. Judges also detected an animal flavor in this sample.

Fortified samples tend to move on the left side of Dim1 as a function of their GSP content. In general, sourness, saltiness and bitterness tended to increase as a function of the amount of GSP added, independently from the grape variety.

The grape variety showed a significant effect on sensory properties along theDim2. In particular, all samples containing *Barbera* GSP were on the lower part of the map, while samples with *Chardonnay* GSP spread in the upper quadrant of the map. The grape variety affects the prototype color and marbling descriptors (marbling, marbling violet, marbling brown) along Dim1. In particular, B2.4 and B1.6 were closely associated with intense violet marbling and samples C2.4 and C1.6 had a brown marbling appearance.

Grape variety also influenced the relative differences among samples fortified with increasing amounts of the same GSP. The perceived differences between C1.6 and C2.4 were greater than those detected between B1.6 and B2.4, as shown by the relative distance between samples on the map; specifically, the perceived difference was higher between C1.6 and C2.4 than between B1.6 and B2.4. It is possible to assume that the higher color intensity perceived in cheese prepared with 1.6 and 2.4% of *Barbera* GSP with respect to B0.8 tend to suppress the perception of other sensory differences between this pair of samples. C0.8 and B0.8 were shown to be quite similar in terms of appearance and texture, with B0.8 being associated with granularity and crumbliness sensations, while C0.8 was described as more gummy and having a clearer color. Samples C1.6 and C2.4 were positively correlated to the Dim2 and were primarily described as sandy, creamy, sour, bitter and astringent.

Cheese Liking

Results from the 2-way mixed ANOVA model did not reveal a significant effect ($F=0.921$; $p=0.34$) of the grape variety on the overall liking expressed by all 90 consumers (B=5.0±0.1; C=5.1±0.1). A significant effect of the GSP percentage on the overall liking was found ($F=9.10$; $p<0.01$). In particular, the overall liking significantly decreased with the increase of GSP: prototypes with the lowest percentage of GSP (0.8%) obtained the highest overall liking scores (5.3±0.1), while the prototypes with 2.4% of GSP were the least preferred (4.8±0.1). A significant effect of product ($p<0.001$) was found on liking as expressed by

90 consumers considering the appearance, odor, taste, flavor, texture and overall liking (Table 2). The reference sample was the most liked according to scores relevant to all the sensory modalities. The addition of GSP to the cheese induced a significant decrease in liking ratings ($p<0.05$).

Accordingly to the overall liking ratings, all fortified samples ranged from 4.7 to 5.5 (Tab. 2). In particular, C0.8, B0.8 and C1.6 obtained the highest average scores, C2.4 received the lowest mean value with no significant differences from samples B0.8 and B1.6. C0.8, C1.6 and B0.8 showed the highest mean scores for the appearance. *Barbera* samples fortified with 1.6 and 2.4% of GSP tended to be the least preferred samples in terms of the appearance. Results showed only slight differences among samples in liking for the aroma. Samples containing the lowest and intermediate GSP amount (B0.8, B1.6, C0.8, and C1.6) tended to be preferred than B2.4 and C2.4 in terms of taste and flavor. Considering the texture, C0.8 had the highest score, with the mean rate not significantly different from B0.8 and C1.6. Samples with the highest amount of GSP (B2.4, and C2.4) had the lowest texture ratings, with a mean rate not significantly different from B0.8 and B1.6.

Relationship between Sensory Properties and Hedonic Responses

The map obtained by the PLS regression performed for exploratory purposes shows the relationship between the hedonic responses of 90 consumers and the sensory properties of the samples (Fig. 2). The map indicates consumers' clear preference for the reference sample, as shown by the high concentration of consumers positioned on the right part of the map. The sensory properties characterizing the standard tended to be the positive drivers of the overall liking, particularly the white color, the homogenous dough, the compact and elastic texture and the presence of lactic flavors. On the contrary, all sensations perceived at high intensity in samples with a high amount of GSP appeared to be negative drivers of overall liking, particularly for attributes describing the marbling appearance (violet and brown), the intense sourness and the perception of granularity and sandiness, together with some odors and flavors (varnish, earthy, citric). In general, the analysis of the preferences suggests the importance of reducing the sandiness and granular sensations associated with the less liked cheeses to match consumers' preferences, as well as to reduce the perceived intensity of sourness.

279 Results showed an inverse relationship between the amount of GSP added and the acceptability of
280 prototypes. In general, GSP addition clearly induced lower consumer liking for prototypes. This effect was
281 more evident in B than C samples. In fact, liking strongly decreased as the amount of B GSP increased
282 from 0.8 to 1.6%, whereas only a slight change in liking occurred for the same range of GSP variation in
283 the C samples. Grape variety clearly affects consumer preference for fortified prototypes. In particular, a
284 visual inspection of PLS regression plot shows that consumers tended to be almost equally distributed
285 along the Dim2 between the upper and lower quadrants of the map. This finding suggested the presence of
286 two distinct groups of subjects. One group, composed of the consumers located in the upper right quadrant,
287 preferred the samples prepared with the white grape variety (*Chardonnay*). The other group, located in the
288 lower right quadrant, tended to prefer samples prepared with the red grape variety (*Barbera*). Results
289 confirmed this finding, by computing the mean overall liking ratings of the two separate groups (the first
290 positioned in the right upper quadrant, the second in the lower right quadrant). Both groups preferred the
291 standard sample but among the fortified samples, the former segment preferred samples C1.6 (6.3±0.2) and
292 C0.8 (5.5±0.3), while the latter group preferred the cheese B0.8 (5.7±0.2). .
293
294 **DISCUSSION**
295 ***Effect of the Addition of Grape Skin Powder on Cheese Sensory Properties***
296 Considering the frequency of the occurrence of sensory attributes used in FCP, the most frequent attributes
297 mentioned by experts were related to taste (sourness elicited by 11 out of 21 experts) and appearance,
298 particularly the marbling aspect (16 elicitations in total considering marbling, violet marbling, brown
299 marbling and homogenous marbling). These results confirm the importance of the visual inspection in the
300 description and appreciation of food products (Dinnella et al., 2014). Authors partially explained this result
301 by recalling that generally, visual attributes are easier to describe than the olfactory and gustative
302 sensations because vision and hearing are an inborn mechanism, whereas the other senses rely largely on
303 learning (Köster, 2003).
304 The visual inspection of the consensus map obtained from the GPA clearly showed the strong effect of
305 GSP fortification on the sensory properties of the new developed prototypes. Considering the appearance,

306 the high amount of colored phenol compounds contained in red grape skins from *Barbera* and released
307 from the GSP into the cheese induced a violet and brown marbling, a color that was not present in the
308 reference sample. Other studies showed an analogous effect on food color induced by the use of phenol
309 based winery by-products in biscuits (Mildner-Szkudlarz at al., 2013; Pasqualone et al.,2014). Moreover,
310 the addition of GSP strongly affected the cheese texture. In particular, the granularity sensation perceived
311 in the soft cheese was probably due the particle size of GSP used, which was under 250 μm. This particle
312 size is above the perception threshold, estimated approximately 25 μm (Hintonet al., 1970), and hard and
313 irregular particles can produce gritty sensations, even at the lower size of 10 μm (Utz, 1986). In agreement
314 with our findings, the addition of solid particles in a food matrix increased the sensation of roughness and
315 significantly decreased the ratings of a number of texture attributes, such as smooth, creamy, fatty and
316 slippery (Engelen et al., 2005). Considering soft model systems containing solid particles, larger particle
317 sizes and higher concentrations reduced creaminess (Kilcast and Clegg, 2002). Moreover, both the
318 concentration and the particles size influenced grittiness (Imai et al., 1997), as well as the shape and surface
319 of particles (Tyle, 1993; Engelen et al., 2005). Thus, a finer and rounded-shaped particle size for GSP
320 could help to reduce the perceived sensation of granularity, which was one of sensory properties
321 responsible for decreasing overall liking in the cheese prototypes. In agreement with data from the
322 literature, GSP from both grape varieties contributes a sour taste and peculiar vegetable orto- and retro-
323 olfactory sensations such as grassy, winy, fruity, citric, cereal, nut, toasted, and spicy (Pasqualone et al.,
324 2014).
325
326 ***Effect of the Grape Skin Powder Addition on Consumers' Preference***
327 In studies about food acceptability, a critical question is, "To what extent the variation in perceived sensory
328 characteristics influences consumer response?" (Bayarri et al., 2011). In certain cases, sensory differences
329 among products do not affect the acceptability (Costell et al., 2010), while in other cases, the sensory
330 properties strongly influence liking (Murray and Delahunty, 2000).
331 In the present study, the addition of GSP significantly affected the acceptability of the newly developed
332 samples, inducing a decrease in the liking ratings for all considered sensory modalities ($p < 0.05$). This

result is in complete agreement with Sant'Anna and collaborators (Sant'Anna et al., 2014), who recently reported a decrease in the liking for aroma, aftertaste, flavor and appearance in fettuccine pasta fortified with grape marc powder. Consumers' familiarity with conventional unfortified food (such as commercially available fettuccini pasta or soft cheese) and clear expectations about their sensory properties probably accounts for the low acceptability found for fortified versions of food (Wardle and Cooke, 2008; Sant'Anna et al., 2014). It is noteworthy that the level of familiarity with a food strongly influences its acceptability by consumers,

In agreement with our findings, Rinaldoni and colleagues (2014) also reported that the spreadable cheese-like product supplemented with the lowest degree of soybean proteins had the best hedonic performance in terms of overall liking. These results clearly show that the functionalization of products obtained by the addition of a powdery ingredient (i.e., powder) could negatively affect consumer liking; consequently, the amount of the added material is a crucial parameter when developing new prototypes. Moreover, the amount of powder which can be added without lowering liking below the level of acceptability depended on the considered matrix to which the powder is added. Our study indicated that in soft cow's cheeses, while the small amount of 0.8% was already the critical acceptability threshold in the case of cheeses prepared with *Barbera* GSP, consumers tolerated an amount of 1.6% of *Chardonnay* GSP in cheese without further negative effects on sample acceptability. It could be hypothesized that the violet marbling of *Barbera* samples appeared more unusual to consumers, who then became less inclined to compromise on flavor compared to those consumers who preferred the *Chardonnay* samples enriched at 0.8 and 1.6%.

Because the difference between the two grape varieties was evident mainly considering the color of the marbling aspect, the color resulted the main sensory properties discriminating between the two blocks of samples. Similarly, a recent study (Braghieri et al., 2014) on the acceptability of Scamorza cheeses enriched with peptidolytic adjunct showed higher values of overall liking for standard samples compared to enriched samples. In some cases, the fortification of cheese with health related compounds did not play a significant role for the liking of color expressed by consumers (Bermúdez-Aguirre and Barbosa-Cánovas, 2011). However, color influenced consumers' acceptability of low-fat cheeses with added annatto colorant (Wadhwani, and McMahon, 2012). Similarly, in the present study, the deviation from the white color

characterizing the reference sample compared to the marbling aspect of the enriched samples negatively impacted the latter's acceptability. Presumably, consumers perceived the intense violet and brown marbling characterizing samples with the highest amount of GSP (B2.4 and C2.4) as overly strange or not appropriate for a fresh cheese.

CONCLUSIONS

Collecting sensory information allows to develop new fortified/enriched products with an increased probability to meet the consumers' acceptance, factor which could not be neglected especially when dealing with food products very familiar to consumers, such as in the case of cheese. This study showed the feasibility of developing soft cow's milk cheese enriched with grape skin powders (GSP). However, the amount of GSP added to cheeses resulted a critical parameter for the acceptability of innovative prototypes. To obtain satisfactory results in terms of consumers' hedonic responses, no more than 0.8% should be added to samples prepared with the red grape variety *Barbera*, while the threshold for samples prepared with the white grape variety *Chardonnay* should not exceed 1.6%. The fortification with GSP strongly influenced the sensory properties of new prototypes, particularly considering the texture and the appearance. High amounts of GSP were generally associated with an increase in the perceived marbling aspect, granularity, sandiness, sourness, saltiness and astringency. All samples were described as having a lactic flavor, but fortification generally added certain vegetable sensations (grassy, cereal, nuts) in combination with other sensations sometimes perceived as possible defects (earthy, animal, winy, varnish). For the fortification, the amount of GSP added played the main role in modifying the sensory properties of soft cheeses; however, also the grape variety was important for the color modifications, with the *Barbera* and *Chardonnay* samples being described with a violet and brown marbling aspect, respectively. This differentiation of the prototypes based on the grape variety tended to discriminate consumers into two groups with opposite preferences for violet and brown colored cheeses. Therefore, in our study, the grape variety (intended as a modifier of the product appearance, particularly in terms of color) represented an opportunity to differentiate cheeses. In future, a marketing strategy aiming to inform consumers about the addition powder from *Barbera* and *Chardonnay* GSP to cheeses could be developed and represent a good

opportunity to differentiate prototypes suitable to satisfy the needs of different consumer segments with opposing preferences. However, the optimization of the prototype is suitable, however, particularly considering (1) the reduction of the GSP particle size, possibly beyond the perception threshold, and (2) the improvement of the dispersion of GSP in the milk curd.

In conclusion, even probably cheese is not a good vehicle for fortification with GSP, the sensory- and consumer based adopted approach allowed us (1) to identify the effect of the addition of the GSP on the sensory properties of soft cheese, (2) to point out which sensory properties were detrimental for the product acceptability by consumers and (3) to obtain information to optimize the ingredient characteristics and the process conditions.

ACKNOWLEDGMENTS

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REFERENCES

Ajila, C.M., M. Aalami, K. Leelavathi, and U.J.S. Prasada Rao.2010. Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations. *Innov. Food Sci. Emerg. Technol.*11:219–224. doi:10.1016/j.ifset.2009.10.004.

Augustin, M.A., P. Udabage, P. Juliano, and P.T. Clarke. 2013. Towards a more sustainable dairy industry: Integration across the farmfactory interface and the dairy factory of the future. *Int. Dairy J.* 31:2-11.doi:10.1016/j.idairyj.2012.03.009

Bayarri, S., I. Carbonell, E.X. Barrios, and E. Costell. 2011. Impact of sensory differences on consumer acceptability of yoghurt and yoghurt-like products. *Int. Dairy J.* 21:111–118. doi:10.1016/j.idairyj.2010.09.002.

413 Bermúdez-Aguirre, D., and G. V. Barbosa-Cánovas Gustavo. 2011. Quality of selected cheeses fortified
414 with vegetable and animal sources of omega-3. *LWT - Food Sci. Technol.* 44:1577–1584.
415 doi:10.1016/j.lwt.2011.01.023.

416 Braghieri, A., N. Piazzolla, A.Romaniello, F. Paladino, A.Ricciardi, and F. Napolitano. 2014. Effect of
417 adjuncts on sensory properties and consumer liking of Scamorza cheese. *J. Dairy S.* 98:1479–1491.
418 doi: 10.3168/jds.2014-8555.

419 Brockman, C., and C. J. M. Beeren. 2011. Consumer Perceptions of Additives in Dairy Products. In J. W.
420 Fuquay (Ed.), Encyclopedia of Dairy Sciences (Second Edition). pp. 41-48. Cambridge, UK: Elsevier
421 Ltd.

422 Coda, R., A. Lanera, A. Trani, M. Gobbetti, and R. Di Cagno. 2012. Yogurt-like beverages made of a
423 mixture of cereals, soy and grape must: microbiology, texture, nutritional and sensory properties. *Int.*
424 *J. Food Microbiol.* 155:120–7. doi:10.1016/j.ijfoodmicro.2012.01.016.

425 Costell, E., A. Tárrega, and S. Bayarri. 2010. Food acceptance: the role of consumer perception and
426 attitudes. *Chemosens Percept*. 3: 42-50. doi:10.1007/s12078-009-9057-1

427 Dinnella, C., L. Torri, G. Caporale, and E. Monteleone. 2014. An exploratory study of sensory attributes
428 and consumer traits underlying liking for and perceptions of freshness for ready to eat mixed salad
429 leaves in Italy. *Food Res. Int.* 59:108–116.

430 Engelen, L., R. a. De Wijk, A. van der Bilt, J.F. Prinz, A.M. Janssen, and F. Bosman. 2005. Relating
431 particles and texture perception. *Physiol. Behav.* 86:111–7. doi:10.1016/j.physbeh.2005.06.022.

432 Fontana, A.R., A. Antoniolli, and R. Bottini. 2013. Grape pomace as a sustainable source of bioactive
433 compounds: extraction, characterization, and biotechnological applications of phenolics. *J. Agric.*
434 *Food Chem*. 61: 38, 8987-9003.

435 Gower, J.C. 1975. Generalized Procrustes Analysis. *Psychometrika*, 40: 33-51.

436 Guàrdia, M.D., A.P.S. Aguiar, A. Claret, J. Arnau, and L. Guerrero. 2010. Sensory characterization of dry-
437 cured ham using free-choice profiling. *Food Qual. Prefer.* 21:148–155.
438 doi:10.1016/j.foodqual.2009.08.014.

439 Hinton, C.L. 1970. In C. D., Pratt, E. de Vadetsky, K.E. Landwill, K.E. McCloskey and H.W. Schuemann
440 (Eds), *Twenty years of confectionery and chocolate progress* (pp. 111). Westport, USA: Avi
441 Publishing Co.

442 Imai, E., Y. Shimichi, I. Maruyama, A. Inoue, S. Ogawa, K. Hatae, and A. Shimada. 1997. Perception of
443 grittiness in an oil-in-water emulsion. *J. Texture Stud.* 28:257–272. doi:10.1111/j.1745-
444 4603.1997.tb00116.x

445 Karaaslan, M., M.Ozden, H.Vardin,and H. Turkoglu. 2011. Phenolic fortification of yogurt using grape and
446 callus extracts. *LWT - Food Sci. Technol.* 44:1065-1072.doi:10.1016/j.lwt.2010.12.009

447 Kilcast, D., and S. Clegg. 2002. Sensory perception of creaminess and its relationship with food structure.
448 *Food. Qual. Prefer.*13:609–623.doi:10.1016/S0950-3293(02)00074-5

449 Köster, E. P. 2003. The psychology of food choice: Some often encountered fallacies. *Food. Qual. Prefer.*
450 14:359–373.doi:10.1016/S0950-3293(03)00017-X

451 Lavelli, V., P.S.C. Sri Harsha, L. Torri, and G. Zeppa. 2014. Use of winemaking by-products as an
452 ingredient for tomato puree: The effect of particle size on product quality. *Food Chem.* 152:162–168.
453 doi: 10.1016/j.foodchem.2013.11.103

454 Marti, A., L. Torri, M.C. Casiraghi, L. Franzetti,S. Limbo, F. Morandin, L. Quaglia, and M.A. Pagani.
455 (2014). Wheat germ stabilization by heat-treatment or sourdough fermentation: effects on dough
456 rheology and bread properties. *LWT - Food Sci. Technol.* 59:1100-1106.
457 doi:10.1016/j.lwt.2014.06.039

458 Mildner-Szkudlarz, S., J. Bajerska, R. Zawirska-Wojtasiak, and D. Górecka. 2013. White grape pomace as
459 a source of dietary fibre and polyphenols and its effect on physical and nutraceutical characteristics of
460 wheat biscuits. *J. Sci. Food Agric.* 93:389–395.

461 Mollet, B., and I. Rowland. 2002. Functional foods: At the frontier between food and pharma. *Curr Opin*
462 *Biotechnol.*13:483–485.

463 Murray, J., and C.. Delahunty. 2000. Mapping consumer preference for the sensory and packaging
464 attributes of Cheddar cheese. *Food Qual. Prefer.* 11:419–435. doi:10.1016/S0950-3293(00)00017-3.

465 Pasqualone, A., A.M. Bianco, V.M. Paradiso, C. Summo, G. Gambacorta, and F. Caponio. 2014. Physico-
466 chemical, sensory and volatile profiles of biscuits enriched with grape marc extract. *Food Res. Int.*
467 doi:10.1016/j.foodres.2014.07.014.

468 Peryam, D. R., and F.J. Pilgrim. 1957. Hedonic scale method of measuring food preferences. *Food*
469 *Technol.* 11:9-14.

470 Rinaldoni, A.N., D.R. Palatnik, N. Zaritzky, and M.E. Campderrós. 2014. Soft cheese-like product
471 development enriched with soy protein concentrates. *LWT - Food Sci. Technol.* 55:139–147.
472 doi:10.1016/j.lwt.2013.09.003.

473 Sant'Anna, V., F.D.P. Christiano, L.D.F. Marczak, I.C. Tessaro, and R.C.S. Thys. 2014. The effect of the
474 incorporation of grape marc powder in fettuccini pasta properties. *LWT - Food Sci. Technol.* 58:497–
475 501. doi:10.1016/j.lwt.2014.04.008.

476 Stratulat, I., M. Britten, S. Salmieri, P. Fustier, D. St-Gelais, C.P. Champagne, and M. Lacroix. 2014.
477 Enrichment of cheese with bioactive lipophilic compounds. *J. Funct. Foods*. 6:48–59.
478 doi:10.1016/j.jff.2013.11.023.

Torri, L., M. Piochi, V. Lavelli, and E. Monteleone. 2015. Descriptive sensory analysis and consumers' preference for dietary fibre- and polyphenol-enriched tomato purees obtained using winery by-products. *LWT - Food Sci. Technol.* 1–7. doi:10.1016/j.lwt.2014.12.059.

Tseng, A., and Y. Zhao. 2013. Wine grape pomace as antioxidant dietary fibre for enhancing nutritional value and improving storability of yogurt and salad dressing. *Food Chem.* 138:356–365. doi:10.1016/j.foodchem.2012.09.148.

Tyle, P. 1993. Effects of size, shape and hardness of particles in suspension on oral texture and palatability. *Acta Physiol.* 84:111– 8.

Utz, K-H. 1986. The interocclusal tactile fine sensitivity of the natural teeth as studied by aluminium oxide particles. *Dtsch Zahnärztl Z.*41, 313–315.

Verbeke, W. 2006. Functional foods: Consumer willingness to compromise on taste for health? *Food. Qual. Prefe.* 17:126–131. doi:10.1016/j.foodqual.2005.03.003

Verbeke, W., J. Scholderer, and L. Lähteenmäki. 2009. Consumer appeal of nutrition and health claims in three existing product concepts. *Appetite*. 52:684–692. doi:10.1016/j.appet.2009.03.007

Vit, P., Sancho, T., Pascual, A., and R. Deliza. 2011. Sensory perception of tropical pot honeys by Spanish consumers, using free choice profile. *J. ApiProd. ApiMed. Sci.* 3:174-180. doi: 10.3896/IBRA.4.03.4.04

Wadhwani, R., and D. J. McMahon. 2012. Color of low-fat cheese influences flavor perception and consumer liking. *J. Dairy Sci.* 95:2336-2346. doi: 10.3168/jds.2011-5142.

Wardle, J., and L. Cooke. 2008. Genetic and environmental determinants of children's food preferences. *Br. J. Nutr.*99:S15-S21.doi: 10.1017/S000711450889246X.

Yu, J., and M. Ahmedna. 2013. Functional components of grape pomace: their composition, biological properties and potential applications. *Int. J. Food Sci. Technol.* 48:221–237. doi: 10.1111/j.1365-2621.2012.03197.x.

502 Zhu, F., B. Du, L. Zheng, and J. Li. 2014. Advance on the bioactivity and potential applications of dietary
503 fibre from grape pomace. *Food Chem.* doi:10.1016/j.foodchem.2014.07.057.

Table 1. Descriptors used by experts divided on sensory modalities, number of occurrences of each descriptor in the data set and number of occurrences of each construct.

Sensory Modality	Descriptor	Occurrences	O/SM[1]	Dim1 (39%)		Dim2 (15%)	
				+	-	+	-
Appearance	holes	5		0	0	0	0
	homogeneous_dough	2		1	0	0	0
	homogeneous_marbling	2		0	2	0	0
	marbling	3	31	0	3	0	0
	marbling_brown	7		0	6	0	0
	marbling_violet	4		0	2	0	0
	white	8		5	0	0	0
Odor	o-cereal	2		0	0	0	0
	o-citric	1		0	1	0	0
	o-cream	1		0	1	0	0
	o-earthy	1		0	1	0	0
	o-fruity	2		0	0	0	0
	o-grassy	1	30	0	0	0	0
	o-lactic	7		1	1	0	0
	o-nuts	2		0	0	0	0
	o-varnish	1		0	1	0	0
	o-winy	4		0	0	0	0
	o-yogurt	8		0	1	0	0
Taste and mouthfeel	bitter	7		1	1	1	0
	salty	6		0	3	0	0
	sour	11	36	0	5	1	0
	spicy	3		0	0	0	0
	sweet	5		2	1	0	0
	astringent	3		0	0	1	1
Flavor	f-acetic	1		0	0	0	0
	f-acetone	1		0	0	0	0
	f-ammonia	1		0	0	0	0
	f-animal	1		1	0	0	0
	f-citric	2		0	1	0	0
	f-cream	3		0	0	0	0
	f-earthy	1		0	1	0	0
	f-grassy	1		0	0	0	0
	f-lactic	8	35	1	0	0	0
	f-floury	2		0	0	0	0
	f-metallic	1		0	0	0	0
	f-nuts	2		0	1	0	0
	f-toasted	2		0	0	0	0
	f-vanilla	1		0	0	0	0
	f-winy	1		0	0	0	0
	f-yogurt	7		0	0	1	0
	f-overall intensity	1		0	0	0	0
Texture	adhesive	5		1	0	0	0
	compact	3		1	0	1	0
	creamy	2		0	0	2	0
	crumbly	1		0	0	0	1
	doughy	4		0	1	0	0
	elastic	5		1	0	0	0
	granular	5	41	0	2	0	1
	gummy	8		2	0	0	0
	sandy	3		0	0	2	0
	soft	1		0	1	0	0
	soluble	2		0	1	0	0
	sticky	1		0	0	0	0
	watery	1		0	0	0	0
Total	54	173	173	17	37	9	3

[1]O/SM = number of occurrences per sensory modality.

Descriptors with a vector loading ≤ 0.7 or ≥ 0.7 on the first two dimensions (Dim) of GPA have been included.

A descriptor can have a loading on more than one axis.

Table 2. Overall liking and liking for appearance, odor, taste, flavor and texture of the cheese samples expressed by 90 consumers.

	Samples[1]									
Liking	B0.8	B1.6	B2.4	C0.8	C1.6	C2.4	STD	SEM	F	P
appearance	4.9^{bcd}	4.6^{de}	4.3^{e}	5.3^{b}	5.1^{bc}	4.8^{cd}	7.1^{a}	0.18	36.34	<0.001
odor	5.5^{b}	5.4^{bc}	5.1^{bc}	5.4^{b}	5.4^{bc}	5.0^{c}	6.3^{a}	0.16	10.32	<0.001
taste	5.4^{bc}	5.1^{bcd}	4.8^{d}	5.4^{b}	5.1^{bcd}	5.0^{cd}	6.3^{a}	0.17	10.98	<0.001
flavor	5.3^{bc}	5.1^{bc}	5.0^{c}	5.4^{b}	5.1^{bc}	4.9^{c}	6.4^{a}	0.17	13.32	<0.001
texture	5.3^{bcd}	5.2^{cd}	5.0^{d}	5.6^{b}	5.6^{bc}	5.2^{cd}	6.5^{a}	0.17	12.85	<0.001
overall	5.2^{bc}	5.0^{cde}	4.8^{de}	5.5^{b}	5.2^{bcd}	4.7^{e}	6.4^{a}	0.17	3.97	<0.001

[1]Samples: B = *Barbera* grape variety, C = *Chardonnay* grape variety; 0.8 = 0.8 w grape skin powders/w curd, 1.6 = 1.6 w grape skin powders/w curd, 2.4 w grape skin powders/w curd; STD = control, not fortified.

SEM: standard error of the mean

Table shows results from 2-way mixed ANOVA models (fixed factor: product; random factor: subject, interaction product/subject).

Different letters within a row indicate significant differences ($p<0.05$) between mean values. Fisher's Least Significance Difference post hoc test was conducted on the data set of 90 subjects.

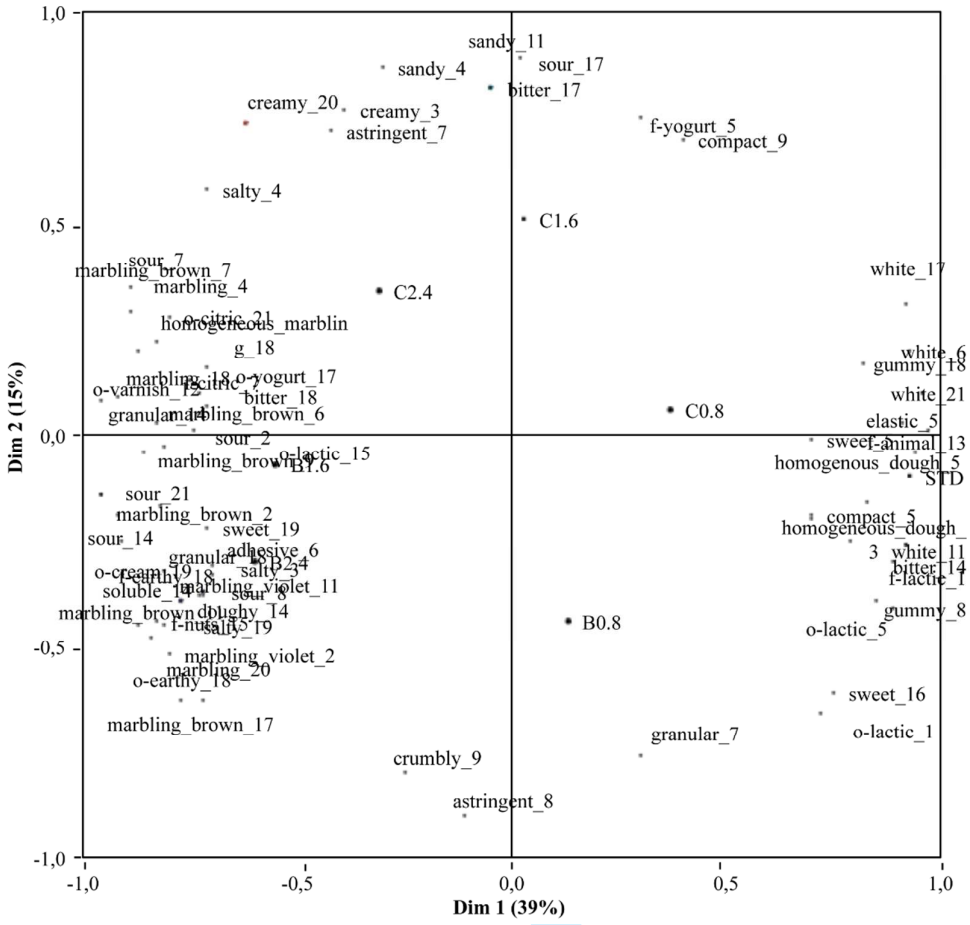
527 **Figure captions**

528

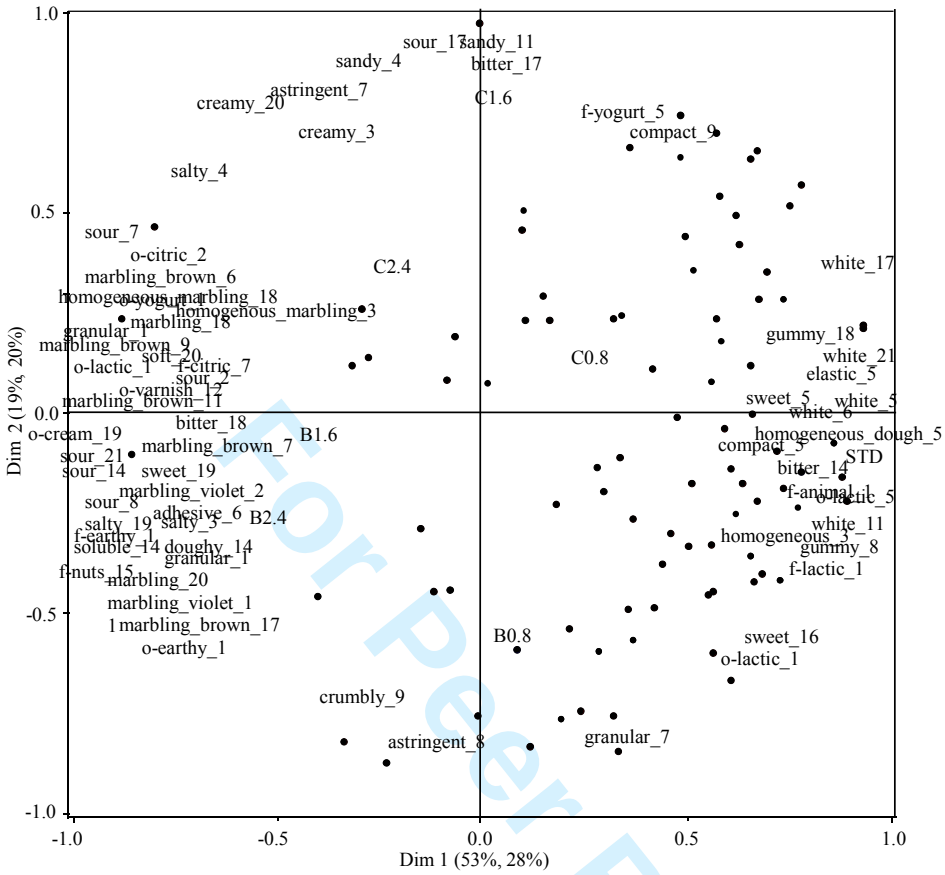
529 Fig. 1. Consensus maps obtained from General Procrustes Analysis (GPA) applied on the Free-
530 Choice Profile data conducted with 21 experts. Individual configurations and sample's
531 positioning are depicted. Descriptors with a vector loading ≤ 0.7 or ≥ 0.7 on the first two
532 dimensions (Dim) are shown.
533 Individual attributes are indicated by the name of the attribute itself and the number of judge who
534 used the descriptor.
535 Letters o- and f- : odor and flavor.
536 Samples: B = *Barbera* grape variety, C= *Chardonnay* grape variety, 0.8 = 0.8 w grape skin
537 powders/w curd, 1.6 = 1.6 w grape skin powders/w curd, 2.4 w grape skin powders/w curd.
538

539 Fig. 2. Map obtained from Partial Least Square Regression (PLS) performed considering as X data
540 set the sensory data from Free-Choice Profile and as Y data set the overall liking of 90 consumers.
541 The first and the second percentage on each axis express the variability explained by the X and Y
542 data set, respectively.
543 Descriptors with a vector loading ≤ 0.7 or ≥ 0.7 on the first two dimensions (Dim) of GPA have
544 been included.
545 Individual attributes are indicated by the name of the attribute itself and the number of judge who
546 used the descriptor.
547 Letters o- and f- : odor and flavor.
548 ● = Consumers
549 Samples: B = *Barbera* grape variety, C= *Chardonnay* grape variety, 0.8 = 0.8 w grape skin
550 powders/w curd, 1.6 = 1.6 w grape skin powders/w curd, 2.4 w grape skin powders/w curd.

Torri Figure 1



569 Torri Figure 2



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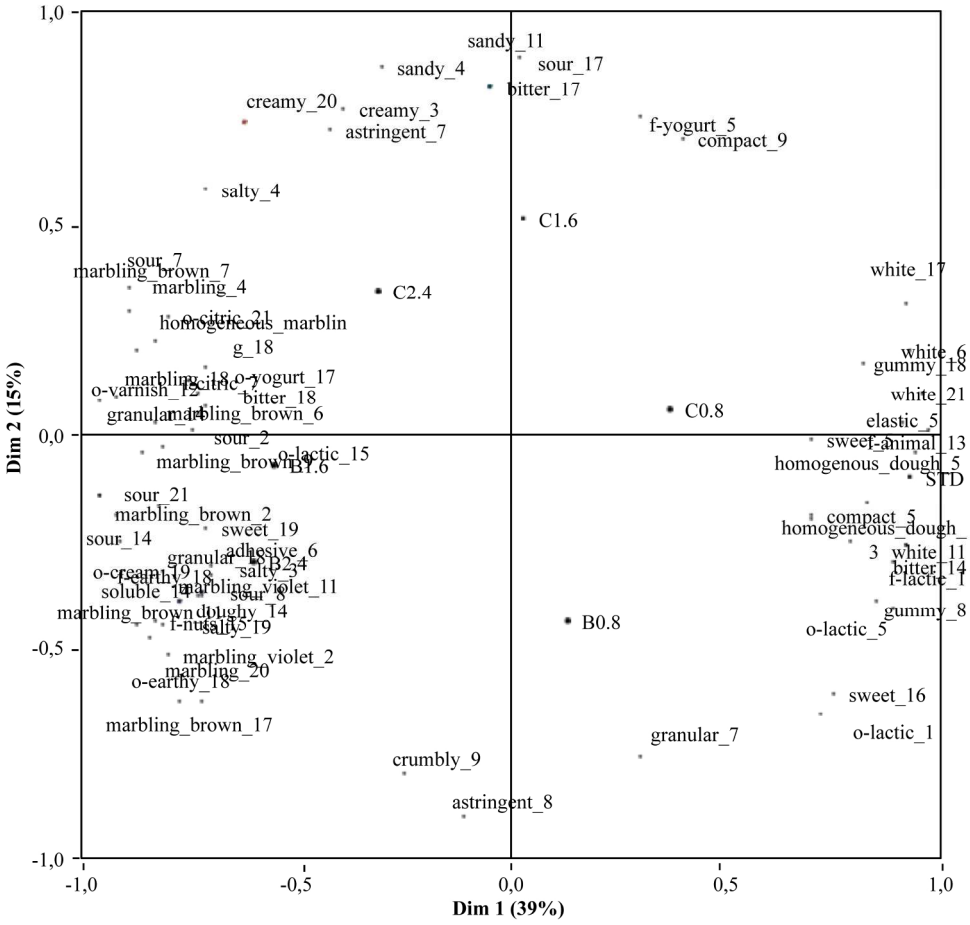

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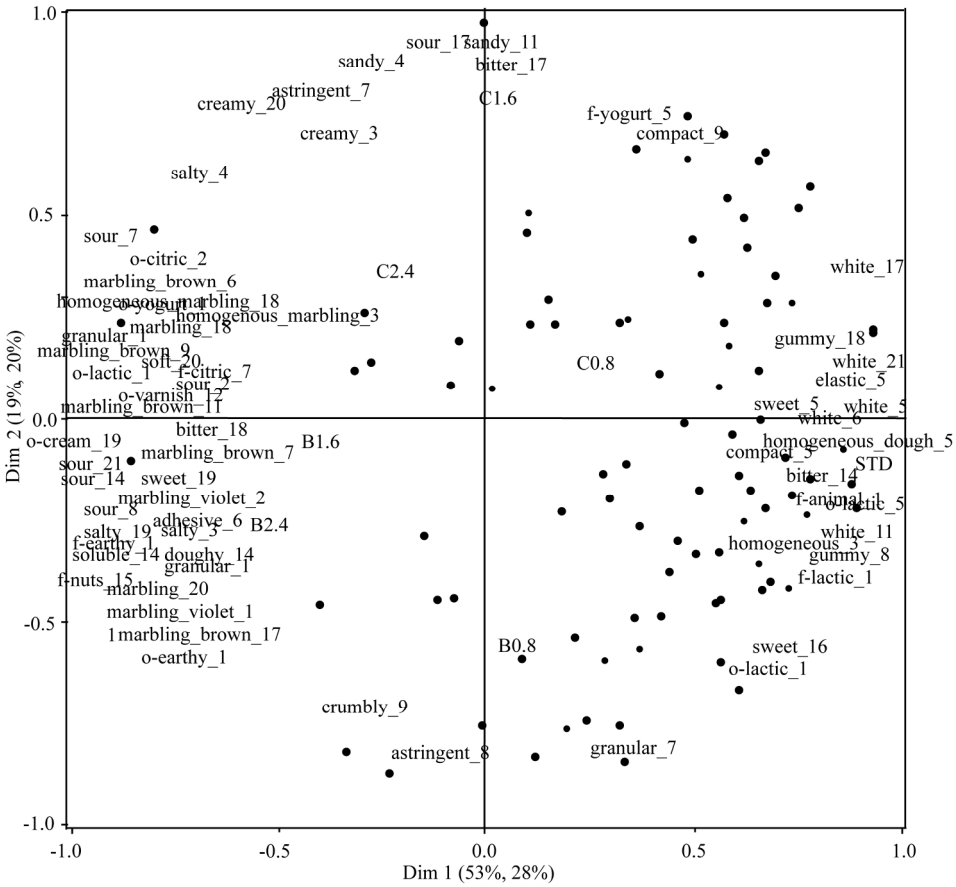

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A sensory- and consumer based approach to optimize cheese enrichment ~~conditions~~with grape skin powders

Torri

Summary. A sensory- and consumer based approach to optimize cheese enrichment conditions was proposed. Innovative cheeses developed by adding grape skin powders (GSP) from winemaking process to cow's milk curd were described by cheese taster experts and evaluated by consumers for their acceptability. Even though cheese is not an optimal vehicle for GSP enrichment, the adopted approach clearly ~~clearly underlined~~identified the effect of the addition of the GSP on the sensory properties of cheese, ~~it~~ pointed out which sensory features were detrimental for the product acceptability and ~~it~~ allowed to obtain suitable information ~~on how~~ to optimize the ingredient use and the process conditions.

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SENSORY APPROACH FOR CHEESE OPTIMIZATION

A sensory- and consumer based approach to optimize cheese enrichment with grape skin powders

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ABSTRACT

The present study aimed to present a sensory- and consumer based approach to optimize cheese enrichment ~~conditions~~with grape skin powders (GSP). The combined sensory evaluation approach, involving a descriptive and an affective test respectively, was applied to evaluate the effect of the addition of grape skin powders ~~(GSP)~~ from two grape varieties (*Barbera* and *Chardonnay*) at different levels (0.8, 1.6 and 2.4% w powder/w curd) on the sensory properties and consumer acceptability of innovative soft cow's milk cheeses. The experimental plan envisaged seven products, six fortified prototypes (B0.8, B1.6, B2.4, C0.8, C1.6, and C2.4) and a control sample, having 1 week ripening. By means of a Free Choice Profile, 21 cheese experts described the sensory properties of prototypes. A Central Location Test with 90 consumers was subsequently conducted to assess the acceptability of samples. The GSP enrichment strongly affected the sensory properties of innovative products, mainly considering the appearance and the texture. Fortified samples were typically described with a marbling aspect (violet or brown as function of the grape variety) and with an increased granularity, sourness, saltiness and astringency. The fortification

also contributed certain vegetable sensations perceived at low intensity (grassy, cereal, nuts), and some potential negative sensations (earthy, animal, winy, varnish). The white color, the homogenous dough, the compact and elastic texture and the presence of lactic flavors resulted the positive drivers of preference. On the contrary, the marbling aspect, granularity, sandiness, sourness, saltiness and astringency negatively affected the cheese acceptability for amounts of powder exceeding 0.8% and 1.6% for the *Barbera* and *Chardonnay* prototypes, respectively. Therefore, the amount of powder resulted a critical parameter for liking of fortified cheeses and a discriminant between the two varieties. Reducing the GSP particle size and improving the GSP dispersion in the curd would reduce the impact of powder addition on sensory properties, thereby encouraging the use of these polyphenol-based fortifiers in cheeses. The proposed approach allowed the identification of sensory properties critical for product acceptability by consumers thus helping the optimization of both fortifier characteristics and new cheese production and composition.

Key Words: consumer acceptability, free-choice profile, soft cheese, grape skin powder

INTRODUCTION

Consumers are increasingly aware that food directly contributes to their health (Mollet and Rowland, 2002), and the dairy market plays an active role in health and wellness (Brockman and Beeren, 2011). The use of functional ingredients represents one of the most important trends in diary product technological innovation. Dairy product enrichment can include (1) fortification with micro-ingredients (isolated and purified high-value compounds) to enhance the nutritional value of the food or (2) addition of macro-ingredients (complex ingredients, composed by a mixture of components). Within the first category, several examples are available (Bermúdez-Aguirre and Barbosa-Cánovas, 2011; Rinaldoni et al., 2014; Stratulatet al., 2014). Recently, winery by-products, such as the grape pomace, were added as macro-ingredients to several foods to obtain novel functional food products enriched in terms of polyphenols and dietary fiber (Mildner-Szkudlarz et al., 2013; Yu and Ahmenda, 2013).

Several biological activities are reported for dietary fiber and polyphenols from grape pomace, and advantages from their use in dairy production processes, as well as in product quality, have been envisaged

(Zhuet al., 2014). Environmental sustainability (Augustin et al., 2013) and contributions to managing waste (Fontana et al., 2013) are similarly important factors encouraging the use of non-dairy products as ingredients in the dairy industry. To authors' knowledge, among dairy products grape pomace has been uniquely used to fortify yogurt (Karaaslanet al., 2011; Codaet al., 2012) and salad dressing (Tseng and Zhao, 2013).

Beside the wide literature focusing on the advantages associated to the use of grape pomace as a food ingredient (Zhu et al., 2014; Yu and Ahmedna, 2013), there is a lack of information considering the sensory impact of this ingredient on food prototypes. Generally, the use of ingredients obtained by vegetal by-products to fortify or enrich foods contributes unpleasant sensations, which result detrimental for the overall quality (Braghieri et al., 2014; Ajila et al., 2010) and the acceptability (Rinaldoni et al., 2014; Marti et al., 2014) of food products. A limited number of studies took into account the effect of fortification with grape pomace on product sensory properties (Torri et al., 2015) and on its acceptability by consumers (Sant'Anna et al., 2014; Lavelli et al, 2014).

Health benefit belief from functional foods emerges as the strongest positive determinant of consumer willingness to compromise on taste (Verbeke, 2006). Moreover, considering the appeal of nutrition and health claims, significant interaction effects were found between claim type and the product concept, indicating that consumers differently react to the carrier product, functional ingredient and claims as function of the product concept (Verbeke et al., 2009).

Thus, implementing healthy properties without taking into account taste modifications and consumer response to the new fortified food appears a highly speculative and risky strategic option (Verbeke, 2006). This aspect deserves even more attention in the case of fortification/enrichment of familiar food. In fact, the more a consumer is familiar with the product the more a deviation from the expected sensory properties will negatively affect the consumer's response (Mildner-Szkudlarz et al., 2013). Based on these considerations, and given the importance of developing successful product for the food industry, it seems extremely important to include a consumer-based approach in product innovation and optimization process, in order to investigate the effect of the fortification/enrichment on acceptability and to increase the success probability of new products.

In the present study, a sensory- and consumer based approach to optimize cheese enrichment/fortification conditions was proposed and applied to an innovative cow's milk soft cheese developed by incorporating the grape skin powders (GSP) obtained from two grape varieties (*Barbera*, a red grape variety, and *Chardonnay*, a white grape variety) into the curd. The sensory- and consumer-based approach presented (1) evaluates the effect of enrichment conditions (type and concentration of added ingredient) on cheese sensory properties and (2) identifies the sensory drivers of the acceptability of the enriched soft cheeses developed in this study.

MATERIALS AND METHODS

Products

Grape Skin Powders. Grape pomace from non-fermented white Vitis vinifera cv *Chardonnay* was provided by the Fontanafredda winemaking factory (Serralunga d'Alba, Cuneo, Italy) while that from fermented red Vitis vinifera cv *Barbera* was provided by the Clarea winemaking factory (Chiomonte, Torino, Italy). The skins were mechanically separated, vacuum packaged and stored at -20 °C prior to being dried in an oven (Memmert, UFE 550, Schwabach, Germany) at 54 °C for 48 h and then ground with a Retsch ZM200 grinder (Retsch Gmbh, Haan, Germany) to obtain grape skin powder (GSP) with a particle size of less than 250 μm.

Cheese Samples. Raw cow's milk (protein 3.5%, fat 3.6%, lactose 5.1%) was provided from a local farm, pasteurized at 72°C for 15 sec then added of calcium chloride (0.1% v/v) and mesophilic starter bacteria Lyofast MOSO60D (Clerici-Sacco, Cadorago, CO, I). Coagulation was performed at 38-40 °C with cow rennet (chimosine:pepsine 20:80; Clerici, Milan, Italy). After 30-40 min of resting, the curd was cut two times and left to stand for 10 min at 37°C. Ripening was performed at 6 ± 1°C for 6 days. During ripening, each cheese was manually dry-salted. The obtained soft cheeses were fresh products similar to Robiola and considered as control sample (STD). Six samples of enriched cow's milk soft cheese were developed by incorporating GSP from *Barbera* (B) and *Chardonnay* (C) into the curd during the cheesemaking process. Three different percentages of powders (0.8, 1.6 and 2.4% w powder/w curd) were added directly to the curd before shaping and manually mixed. A preliminary production test showed that it

is not possible to obtain a cheese with a powder percentage higher than 2.5%, since cheeses were not able to maintain their shape. The enriched samples were codified as B0.8, B1.6, B2.4, C0.8, C1.6, and C2.4. In total, the study envisaged seven cheese samples. At the end of ripening, the obtained cheeses (250 ± 10 g) were cut in slices (5 x 3 x 1.5 cm) at room temperature (20 ± 1 °C) approximately 20 minutes prior to each sensory evaluation. Slices were placed in transparent plastic cups (38 ml) and hermetically sealed with a clear plastic lid. Samples were identified with three digit codes, served in randomized and balanced order among subjects and evaluated at room temperature (20 ± 1 °C).

Methods

Free Choice Profile. A group of 21 expert cheese tasters voluntarily participated in one session of the Free Choice Profile. Assessors (M=13, F=8; aged from 24 to 70, mean age=55) were selected from among the tasters of the Italian National Cheese Taster Association (ONAF, Organizzazione Nazionale Assaggiatori Formaggio) and declared a cheese consumption greater than 3 times a week. The session lasted 120 minutes. Sensory analysts briefed the experts on the methodology and the tasting procedure. The Free Choice Profile session was divided in two parts separated by a 15-minute break. In the first part, a vocabulary describing the sensory characteristics of prototypes was developed. The procedure required the assessors to observe, smell and taste samples and describe the sensory characteristics of prototypes considering appearance, odor, taste, flavor, and texture freely using their own terms. Panelists were encouraged to use associative and cognitive terms, rather than quantitative or affective ones (such as good, bad, or intense). Next, the panelists were asked to select from their own list of self-elicited attributes those, which they considered the most discriminative among samples. Each assessor freely selected the number of attributes to use. In the second part, a new set of the same samples was served (with different codes and in a different order) and assessors were asked to taste the samples and rate the intensity of sensations described by the attributes they selected using a 9-point scale (1=extremely weak, 9=extremely intense). Thus, in agreement with literature (Guardia et al., 2010; Vit et al., 2011), assessors tasted each sample twice evaluating the intensity of the descriptors once. The sample codes and presentation order were randomized across assessors in the two parts of the session. Instructions required the assessors to rinse their

mouths with still water before the beginning of the test. After each sample, subjects rinsed their mouths with water, had plain crackers for 30 s and finally rinsed their mouths with water for a further 30 s. Subjects took a 1 min break between sample evaluations.

Consumer Test. A Central Location Test (CLT) with 90 consumers (M=43, F=47; aged from 18 to 70, mean age=43) was performed during the "Cheese 2013" International Cheese Exhibition (Bra, Cuneo, Italy). Consumers voluntarily participated in the sensory test. Demographic information (age: 18-35, 36-55, 56-70; gender: M, F; nationality: Italian, non-Italian), socio-economic information (educational level: primary, high school, college, bachelor, other advanced degrees; occupational status: student, worker, retired, unemployed) and frequency of cheese consumption (once or less a week, 2-3 times a week, 4-5 times a week, once a day, more than once a day) were collected. Participants received individual trays with the seven cheese samples and rinsed their mouths with still water before beginning the evaluation. Participants tasted the samples according to the tray presentation order and in blind conditions, without any information about the innovativeness of the cheeses in order to avoid a potential effect of the information on liking scores. Participants rated their liking for appearance, odor, taste, flavor, texture and overall liking using a 9-point hedonic scale (1=extremely dislike, 9=extremely like) (Peryam and Pilgrim, 1957). Cheese prototypes were served in a randomized and balanced order. The subjects followed the same rinsing procedure adopted in FCP.

Data Analysis

Free Choice Profile. Data collected using the Free Choice Profile were submitted to Generalized Procrustes Analysis (GPA) to obtain a consensus map (Gower, 1975) by using the software Senstools v. 1.2x (OP&P Product Research BV, Utrecht, Netherlands). To estimate the significance of the GPA results, a Permutation Test was carried out (500 permutations were conducted on the raw matrix) and the total accounted variance of first dimensions was considered.

Consumer Test. The effect of the amount of GSP on liking in terms of appearance, odor, taste, flavor, texture and overall liking was assessed using a 2-way ANOVA mixed model with interactions (fixed factor: GSP amount, 3 levels 0.8, 1.6, 2.4%; random factors: subjects). The effect of grape variety on

liking in terms of appearance, odor, taste, flavor, texture and overall liking was assessed using a 2-way ANOVA mixed model with interactions (fixed factor: grape variety, 2 levels *Barbera*, *Chardonnay*; random factors: subjects). A 2-way ANOVA mixed model with interactions was used to estimate the effect of the product on the overall liking and on liking in all sensory modalities (fixed factor: product, 7 levels; random factors: subjects). A Partial Least Square Regression (PLS) was performed for exploratory purposes, considering the sensory data from FCP as the X data set and the overall liking of 90 consumers as the Y data set. To select the most discriminating attributes, those with a loading equal to or greater than 0.7 (absolute value) on the GPA consensus map for the first two principal Dimensions (Dim1 and/or Dim2) were selected to create the matrix. The PLS was performed using The Unscrambler X software, vers. 10.3 (Camo Software AS, Norway). ANOVA analyses were conducted using SYSTAT software, version 13.1 (Systat Software Inc, San José, USA).

RESULTS

Cheese Sensory Properties

Experts elicited 64 terms in total. The number of elicited attributes per subject ranged from a minimum of four to a maximum of 17 attributes. The average number of attributes elicited by experts was eight, in agreement with findings in the literature (Guàrdia et al., 2010). The initial list of attributes was reduced to achieve a unique list that comprehensively and accurately described the product space; redundant and/or less-cited terms were grouped on a semantic basis and/or eliminated. The final list consisted of 54 descriptors classified according to sensory modality: appearance (7), aroma (11), taste and mouthfeel sensations (6), flavor (17) and texture (13) (Table 1). Analysis of occurrences showed that the most frequently elicited descriptors (cited by at least one third of experts at least 7 times) were: marbling brown, white, odor and flavor of lactic, odor and flavor of yogurt, bitter, sour and gummy.

Appearance resulted a key sensory modality for sample discrimination with a relatively low number of descriptors (7) and a relatively high number of occurrences (31). New prototypes were generally described by using terms related to the marbling aspect (marbling, brown marbling, violet marbling, homogeneous

marbling), homogenous dough, white color and by the presence of holes. The control sample was described as having a white color, in contrast to the fortified samples.

Taste and mouthfeel were described using four attributes for fundamental tastes (sour, bitter, sweet, salty) and the tactile sensation of astringency with 35 occurrences in total. Sourness was the most used taste, elicited by 11out of 21 judges. Secondly, bitter and salty tastes were elicited seven and six times, respectively, both showing higher intensity scores in the enriched samples compared to the reference standard. Judges elicited astringency only three times. For two assessors this attribute had high loading values on the Dim2, but it was perceived in a contrasting way by judges.

Considering the olfactory sensations, judges used a high number of attributes to describe odor and flavor (11 and 17 terms, respectively). Among these descriptors, several terms described vegetable sensations (cereal, grassy, fruity, citric, nuts, vanilla), while other terms were not related to food and tended to have a negative connotation (earthy, varnish, ammonia, acetone, animal, metallic, winy). However, a low number of judges elicited odor and flavor sensations, and most of the sensations in this sensory modality occurred fewer than three times. The odor and flavor of lactic and the odor and flavor of yogurt were the only attributes with a number of occurrences equal to or higher than seven. These two sensations typically characterized the perception of cheese.

Texture was extremely important in discriminating among samples, showing the highest number of occurrences (41). Judges mainly used the attributes: gummy, adhesive, elastic and granular, with the last one clearly characterizing the enriched samples. The attributes sandy, creamy and compact had low occurrences but showed high loading values on the consensus map.

The experts' individual configurations were submitted to GPA. The Permutation Test indicated a probability of less than 0.05% that the consensus generated in the study could have arisen by chance. The consensus space obtained from GPA and applied to individual configuration is depicted in Fig. 1. The total variance explained by the first two dimensions accounted for 39 and 15% on Dim1 and Dim2, respectively. Samples were clearly discriminated according to the percentage of GSP along theDim1. The reference sample was positively correlated to Dim1 and is highly correlated to white color, homogenous dough, gumminess, sweet, bitter and lactic sensations. Judges also detected an animal flavor in this sample.

Fortified samples tend to move on the left side of Dim1 as a function of their GSP content. In general, sourness, saltiness and bitterness tended to increase as a function of the amount of GSP added, independently from the grape variety.

The grape variety showed a significant effect on sensory properties along theDim2. In particular, all samples containing *Barbera* GSP were on the lower part of the map, while samples with *Chardonnay* GSP spread in the upper quadrant of the map. The grape variety affects the prototype color and marbling descriptors (marbling, marbling violet, marbling brown) along Dim1. In particular, B2.4 and B1.6 were closely associated with intense violet marbling and samples C2.4 and C1.6 had a brown marbling appearance.

Grape variety also influenced the relative differences among samples fortified with increasing amounts of the same GSP. The perceived differences between C1.6 and C2.4 were greater than those detected between B1.6 and B2.4, as shown by the relative distance between samples on the map; specifically, the perceived difference was higher between C1.6 and C2.4 than between B1.6 and B2.4. It is possible to assume that the higher color intensity perceived in cheese prepared with 1.6 and 2.4% of *Barbera* GSP with respect to B0.8 tend to suppress the perception of other sensory differences between this pair of samples. C0.8 and B0.8 were shown to be quite similar in terms of appearance and texture, with B0.8 being associated with granularity and crumbliness sensations, while C0.8 was described as more gummy and having a clearer color. Samples C1.6 and C2.4 were positively correlated to the Dim2 and were primarily described as sandy, creamy, sour, bitter and astringent.

Cheese Liking

Results from the 2-way mixed ANOVA model did not reveal a significant effect (F=0.921; p=0.34) of the grape variety on the overall liking expressed by all 90 consumers (B=5.0~~4.99~~±0.1~~0~~; C=5.1~~2~~±0.1~~0~~). A significant effect of the GSP percentage on the overall liking was found (F=9.10; p<0.01). In particular, the overall liking significantly decreased with the increase of GSP: prototypes with the lowest percentage of GSP (0.8%) obtained the highest overall liking scores (5.3~~4~~±0.1~~2~~), while the prototypes with 2.4% of GSP were the least preferred (4.~~76~~8±0.1~~3~~). A significant effect of product (p<0.001) was found on liking as

expressed by 90 consumers considering the appearance, odor, taste, flavor, texture and overall liking (Table 2). The reference sample was the most liked according to scores relevant to all the sensory modalities. The addition of GSP to the cheese induced a significant decrease in liking ratings ($p<0.05$).

Accordingly to the overall liking ratings, all fortified samples ranged from ~~slightly disliked~~4.7 to ~~slightly liked~~5.5 (Tab. 2). In particular, C0.8, B0.8 and C1.6 ~~were~~ obtained the ~~most~~ highest ~~lik~~averaged~~ed~~ ~~samples~~ scores, ~~and~~ C2.4 ~~was~~ received the ~~least liked sample~~lowest mean value with no significant differences from samples B0.8 and B1.6. C0.8, C1.6 and B0.8 showed the highest ~~liking~~ mean scores for the appearance. *Barbera* samples fortified with 1.6 and 2.4% of GSP tended to be the least preferred~~liked~~ samples in terms of the appearance. Results showed only slight differences among samples in liking for the aroma. Samples containing the lowest and intermediate GSP amount (B0.8, B1.6, C0.8, and C1.6) tended to be ~~more liked~~preferred than B2.4 and C2.4 in terms of taste and flavor. Considering the texture, C0.8 had the ~~most liked texture~~highest score, with the mean rate not significantly different from B0.8 and C1.6. Samples with the highest amount of GSP (B2.4, and C2.4) had the ~~least~~ lowest ~~liked~~ texture ratings, with a mean rate not significantly different from B0.8 and B1.6.

Relationship between Sensory Properties and Hedonic Responses

The map obtained by the PLS regression performed for exploratory purposes shows the relationship between the hedonic responses of 90 consumers and the sensory properties of the samples (Fig. 2). The map indicates consumers' clear preference for the reference sample, as shown by the high concentration of consumers positioned on the right part of the map. The sensory properties characterizing the standard tended to be the positive drivers of the overall liking, particularly the white color, the homogenous dough, the compact and elastic texture and the presence of lactic flavors. On the contrary, all sensations perceived at high intensity in samples with a high amount of GSP appeared to be negative drivers of overall liking, particularly for attributes describing the marbling appearance (violet and brown), the intense sourness and the perception of granularity and sandiness, together with some odors and flavors (varnish, earthy, citric). In general, the analysis of the preferences suggests the importance of reducing the sandiness and granular

sensations associated with the less liked cheeses to match consumers' preferences, as well as to reduce the perceived intensity of sourness.

Results showed an inverse relationship between the amount of GSP added and the acceptability of prototypes. In general, GSP addition clearly induced lower consumer liking for prototypes. This effect was more evident in B than C samples. In fact, liking strongly decreased as the amount of B GSP increased from 0.8 to 1.6%, whereas only a slight change in liking occurred for the same range of GSP variation in the C samples. Grape variety clearly affects consumer preference for fortified prototypes. In particular, a visual inspection of PLS regression plot shows that consumers tended to be almost equally distributed along the Dim2 between the upper and lower quadrants of the map. This finding suggested the presence of two distinct groups of subjects. One group, composed of the consumers located in the upper right quadrant, preferred the samples prepared with the white grape variety (*Chardonnay*). The other group, located in the lower right quadrant, tended to prefer samples prepared with the red grape variety (*Barbera*). Results confirmed this finding, by computing the mean overall liking ratings of the two separate groups (the first positioned in the right upper quadrant, the second in the lower right quadrant). Both groups preferred the standard sample but among the fortified samples, the former segment ~~rated as~~preferred samples C1.6 (6.3~~26~~±0.2~~2~~) and C0.8 (5.~~49~~5±0.~~27~~3) ~~as slightly pleasant~~, while the latter group preferred the cheese B0.8 (5.~~66~~7±0.2~~1~~). .

DISCUSSION

Effect of the Addition of Grape Skin Powder on Cheese Sensory Properties

Considering the frequency of the occurrence of sensory attributes used in FCP, the most frequent attributes mentioned by experts were related to taste (sourness elicited by 11 out of 21 experts) and appearance, particularly the marbling aspect (16 elicitations in total considering marbling, violet marbling, brown marbling and homogenous marbling). These results confirm the importance of the visual inspection in the description and appreciation of food products (Dinnella et al., 2014). Authors partially explained this result by recalling that generally, visual attributes are easier to describe than the olfactory and gustative

sensations because vision and hearing are an inborn mechanism, whereas the other senses rely largely on learning (Köster, 2003).

The visual inspection of the consensus map obtained from the GPA clearly showed the strong effect of GSP fortification on the sensory properties of the new developed prototypes. Considering the appearance, the high amount of colored phenol compounds contained in red grape skins from *Barbera* and released from the GSP into the cheese induced a violet and brown marbling, a color that was not present in the reference sample. Other studies showed an analogous effect on food color induced by the use of phenol based winery by-products in biscuits (Mildner-Szkudlarz at al., 2013; Pasqualone et al.,2014). Moreover, the addition of GSP strongly affected the cheese texture. In particular, the granularity sensation perceived in the soft cheese was probably due the particle size of GSP used, which was under 250 μm. This particle size is above the perception threshold, estimated approximately 25 μm (Hintonet al., 1970), and hard and irregular particles can produce gritty sensations, even at the lower size of 10 μm (Utz, 1986). In agreement with our findings, the addition of solid particles in a food matrix increased the sensation of roughness and significantly decreased the ratings of a number of texture attributes, such as smooth, creamy, fatty and slippery (Engelen et al., 2005). Considering soft model systems containing solid particles, larger particle sizes and higher concentrations reduced creaminess (Kilcast and Clegg, 2002). Moreover, both the concentration and the particles size influenced grittiness (Imai et al., 1997), as well as the shape and surface of particles (Tyle, 1993; Engelen et al., 2005). Thus, a finer and rounded-shaped particle size for GSP could help to reduce the perceived sensation of granularity, which was one of sensory properties responsible for decreasing overall liking in the cheese prototypes. In agreement with data from the literature, GSP from both grape varieties contributes a sour taste and peculiar vegetable orto- and retro-olfactory sensations such as grassy, winy, fruity, citric, cereal, nut, toasted, and spicy (Pasqualone et al., 2014).

Effect of the Grape Skin Powder Addition on Consumers' Preference

In studies about food acceptability, a critical question is, "To what extent the variation in perceived sensory characteristics influences consumer response?" (Bayarri et al., 2011). In certain cases, sensory differences

among products do not affect the acceptability (Costell et al., 2010), while in other cases, the sensory properties strongly influence liking (Murray and Delahunty, 2000).

In the present study, the addition of GSP significantly affected the acceptability of the newly developed samples, inducing a decrease in the liking ratings for all considered sensory modalities ($p < 0.05$). This result is in complete agreement with Sant'Anna and collaborators (Sant'Anna et al., 2014), who recently reported a decrease in the liking for aroma, aftertaste, flavor and appearance in fettuccine pasta fortified with grape marc powder. Consumers' familiarity with conventional unfortified food (such as commercially available fettuccini pasta or soft cheese) and clear expectations about their sensory properties probably accounts for the low acceptability found for fortified versions of food (Wardle and Cooke, 2008; Sant'Anna et al., 2014). It is noteworthy that the level of familiarity with a food strongly influences its acceptability by consumers,

In agreement with our findings, Rinaldoni and colleagues (2014) also reported that the spreadable cheese-like product supplemented with the lowest degree of soybean proteins had the best hedonic performance in terms of overall liking. These results clearly show that the functionalization of products obtained by the addition of a powdery ingredient (i.e., powder) could negatively affect consumer liking; consequently, the amount of the added material is a crucial parameter when developing new prototypes. Moreover, the amount of powder which can be added without lowering liking below the level of acceptability depended on the considered matrix to which the powder is added. Our study indicated that in soft cow's cheeses, while the small amount of 0.8% was already the critical acceptability threshold in the case of cheeses prepared with *Barbera* GSP, consumers tolerated an amount of 1.6% of *Chardonnay* GSP in cheese without further negative effects on sample acceptability. It could be hypothesized that the violet marbling of *Barbera* samples appeared more unusual to consumers, who then became less inclined to compromise on flavor compared to those consumers who preferred the *Chardonnay* samples enriched at 0.8 and 1.6%.

Because the difference between the two grape varieties was evident mainly considering the color of the marbling aspect, the color resulted the main sensory properties discriminating between the two blocks of samples. Similarly, a recent study (Braghieri et al., 2014) on the acceptability of Scamorza cheeses enriched with peptidolytic adjunct showed higher values of overall liking for standard samples compared to

enriched samples. In some cases, the fortification of cheese with health related compounds did not play a significant role for the liking of color expressed by consumers (Bermúdez-Aguirre and Barbosa-Cánovas, 2011). However, color influenced consumers' acceptability of low-fat cheeses with added annatto colorant (Wadhwani, and McMahon, 2012). Similarly, in the present study, the deviation from the white color characterizing the reference sample compared to the marbling aspect of the enriched samples negatively impacted the latter's acceptability. Presumably, consumers perceived the intense violet and brown marbling characterizing samples with the highest amount of GSP (B2.4 and C2.4) as overly strange or not appropriate for a fresh cheese.

CONCLUSIONS

Collecting sensory information allows to develop new fortified/enriched products with an increased probability to meet the consumers' acceptance, factor which could not be neglected especially when dealing with food products very familiar to consumers, such as in the case of cheese. This study showed the feasibility of developing soft cow's milk cheese enriched with grape skin powders (GSP). However, the amount of GSP added to cheeses resulted a critical parameter for the acceptability of innovative prototypes. To obtain satisfactory results in terms of consumers' hedonic responses, no more than 0.8% should be added to samples prepared with the red grape variety *Barbera*, while the threshold for samples prepared with the white grape variety *Chardonnay* should not exceed 1.6%. The fortification with GSP strongly influenced the sensory properties of new prototypes, particularly considering the texture and the appearance. High amounts of GSP were generally associated with an increase in the perceived marbling aspect, granularity, sandiness, sourness, saltiness and astringency. All samples were described as having a lactic flavor, but fortification generally added certain vegetable sensations (grassy, cereal, nuts) in combination with other sensations sometimes perceived as possible defects (earthy, animal, winy, varnish). For the fortification, the amount of GSP added played the main role in modifying the sensory properties of soft cheeses; however, also the grape variety was important for the color modifications, with the *Barbera* and *Chardonnay* samples being described with a violet and brown marbling aspect, respectively. This differentiation of the prototypes based on the grape variety tended to discriminate consumers into two

388 groups with opposite preferences for violet and brown colored cheeses. Therefore, in our study, the grape
389 variety (intended as a modifier of the product appearance, particularly in terms of color) represented an
390 opportunity to differentiate cheeses. In future, a marketing strategy aiming to inform consumers about the
391 addition powder from *Barbera* and *Chardonnay* GSP to cheeses could be developed and represent a good
392 opportunity to differentiate prototypes suitable to satisfy the needs of different consumer segments with
393 opposing preferences. However, the optimization of the prototype is suitable, however, particularly
394 considering (1) the reduction of the GSP particle size, possibly beyond the perception threshold, and (2) the
395 improvement of the dispersion of GSP in the milk curd.
396 In conclusion, even probably cheese is not a good vehicle for fortification with GSP, the sensory- and
397 consumer based adopted approach allowed us (1) to identify the effect of the addition of the GSP on the
398 sensory properties of soft cheese, (2) to point out which sensory properties were detrimental for the product
399 acceptability by consumers and (3) to obtain information to optimize the ingredient characteristics and the
400 process conditions.
401

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408 **REFERENCES**

409 Ajila, C.M., M. Aalami, K. Leelavathi, and U.J.S. Prasada Rao.2010. Mango peel powder: A potential
410 source of antioxidant and dietary fiber in macaroni preparations. *Innov. Food Sci. Emerg.*
411 *Technol.*11:219–224. doi:10.1016/j.ifset.2009.10.004.
412 Augustin, M.A., P. Udabage, P. Juliano, and P.T. Clarke. 2013. Towards a more sustainable dairy industry:
413 Integration across the farmfactory interface and the dairy factory of the future. *Int. Dairy J.* 31:2-
414 11.doi:10.1016/j.idairyj.2012.03.009

Bayarri, S., I. Carbonell, E.X. Barrios, and E. Costell. 2011. Impact of sensory differences on consumer acceptability of yoghurt and yoghurt-like products. *Int. Dairy J.* 21:111–118. doi:10.1016/j.idairyj.2010.09.002.

Bermúdez-Aguirre, D., and G. V. Barbosa-Cánovas Gustavo. 2011. Quality of selected cheeses fortified with vegetable and animal sources of omega-3. *LWT - Food Sci. Technol.* 44:1577–1584. doi:10.1016/j.lwt.2011.01.023.

Braghieri, A., N. Piazzolla, A.Romaniello, F. Paladino, A.Ricciardi, and F. Napolitano. 2014. Effect of adjuncts on sensory properties and consumer liking of Scamorza cheese. *J. Dairy S.* 98:1479–1491. doi: 10.3168/jds.2014-8555.

Brockman, C., and C. J. M. Beeren. 2011. Consumer Perceptions of Additives in Dairy Products. In J. W. Fuquay (Ed.), Encyclopedia of Dairy Sciences (Second Edition). pp. 41-48. Cambridge, UK: Elsevier Ltd.

Coda, R., A. Lanera, A. Trani, M. Gobbetti, and R. Di Cagno. 2012. Yogurt-like beverages made of a mixture of cereals, soy and grape must: microbiology, texture, nutritional and sensory properties. *Int. J. Food Microbiol.* 155:120–7. doi:10.1016/j.ijfoodmicro.2012.01.016.

Costell, E., A. Tárrega, and S. Bayarri. 2010. Food acceptance: the role of consumer perception and attitudes. *Chemosens Percept.* 3: 42-50. doi:10.1007/s12078-009-9057-1

Dinnella, C., L. Torri, G. Caporale, and E. Monteleone. 2014. An exploratory study of sensory attributes and consumer traits underlying liking for and perceptions of freshness for ready to eat mixed salad leaves in Italy. *Food Res. Int.* 59:108–116.

Engelen, L., R. a. De Wijk, A. van der Bilt, J.F. Prinz, A.M. Janssen, and F. Bosman. 2005. Relating particles and texture perception. *Physiol. Behav.* 86:111–7. doi:10.1016/j.physbeh.2005.06.022.

Fontana, A.R., A. Antoniolli, and R. Bottini. 2013. Grape pomace as a sustainable source of bioactive compounds: extraction, characterization, and biotechnological applications of phenolics. *J. Agric. Food Chem.* 61: 38, 8987-9003.

Gower, J.C. 1975. Generalized Procrustes Analysis. *Psychometrika*, 40: 33-51.

Guàrdia, M.D., A.P.S. Aguiar, A. Claret, J. Arnau, and L. Guerrero. 2010. Sensory characterization of dry-cured ham using free-choice profiling. *Food Qual. Prefer.* 21:148–155. doi:10.1016/j.foodqual.2009.08.014.

Hinton, C.L. 1970. In C. D., Pratt, E. de Vadetsky, K.E. Landwill, K.E. McCloskey and H.W. Schuemann (Eds), *Twenty years of confectionery and chocolate progress* (pp. 111). Westport, USA: Avi Publishing Co.

Imai, E., Y. Shimichi, I. Maruyama, A. Inoue, S. Ogawa, K. Hatae, and A. Shimada. 1997. Perception of grittiness in an oil-in-water emulsion. *J. Texture Stud.* 28:257–272. doi:10.1111/j.1745-4603.1997.tb00116.x

Karaaslan, M., M.Ozden, H.Vardin,and H. Turkoglu. 2011. Phenolic fortification of yogurt using grape and callus extracts. *LWT - Food Sci. Technol.* 44:1065-1072.doi:10.1016/j.lwt.2010.12.009

Kilcast, D., and S. Clegg. 2002. Sensory perception of creaminess and its relationship with food structure. *Food. Qual. Prefer.*13:609–623.doi:10.1016/S0950-3293(02)00074-5

Köster, E. P. 2003. The psychology of food choice: Some often encountered fallacies. *Food. Qual. Prefer.* 14:359–373.doi:10.1016/S0950-3293(03)00017-X

Lavelli, V., P.S.C. Sri Harsha, L. Torri, and G. Zeppa. 2014. Use of winemaking by-products as an ingredient for tomato puree: The effect of particle size on product quality. *Food Chem.* 152:162–168. doi: 10.1016/j.foodchem.2013.11.103

Marti, A., L. Torri, M.C. Casiraghi, L. Franzetti,S. Limbo, F. Morandin, L. Quaglia, and M.A. Pagani. (2014). Wheat germ stabilization by heat-treatment or sourdough fermentation: effects on dough

rheology and bread properties. *LWT - Food Sci. Technol.* 59:1100-1106. doi:10.1016/j.lwt.2014.06.039

Mildner-Szkudlarz, S., J. Bajerska, R. Zawirska-Wojtasiak, and D. Górecka. 2013. White grape pomace as a source of dietary fibre and polyphenols and its effect on physical and nutraceutical characteristics of wheat biscuits. *J. Sci. Food Agric.* 93:389–395.

Mollet, B., and I. Rowland. 2002. Functional foods: At the frontier between food and pharma. *Curr Opin Biotechnol.*13:483–485.

Murray, J., and C.. Delahunty. 2000. Mapping consumer preference for the sensory and packaging attributes of Cheddar cheese. *Food Qual. Prefer.* 11:419–435. doi:10.1016/S0950-3293(00)00017-3.

Pasqualone, A., A.M. Bianco, V.M. Paradiso, C. Summo, G. Gambacorta, and F. Caponio. 2014. Physico-chemical, sensory and volatile profiles of biscuits enriched with grape marc extract. *Food Res. Int.* doi:10.1016/j.foodres.2014.07.014.

Peryam, D. R., and F.J. Pilgrim. 1957. Hedonic scale method of measuring food preferences. *Food Technol.* 11:9-14.

Rinaldoni, A.N., D.R. Palatnik, N. Zaritzky, and M.E. Campderrós. 2014. Soft cheese-like product development enriched with soy protein concentrates. *LWT - Food Sci. Technol.* 55:139–147. doi:10.1016/j.lwt.2013.09.003.

Sant'Anna, V., F.D.P. Christiano, L.D.F. Marczak, I.C. Tessaro, and R.C.S. Thys. 2014. The effect of the incorporation of grape marc powder in fettuccini pasta properties. *LWT - Food Sci. Technol.* 58:497–501. doi:10.1016/j.lwt.2014.04.008.

Stratulat, I., M. Britten, S. Salmieri, P. Fustier, D. St-Gelais, C.P. Champagne, and M. Lacroix. 2014. Enrichment of cheese with bioactive lipophilic compounds. *J. Funct. Foods*. 6:48–59. doi:10.1016/j.jff.2013.11.023.

Torri, L., M. Piochi, V. Lavelli, and E. Monteleone. 2015. Descriptive sensory analysis and consumers' preference for dietary fibre- and polyphenol-enriched tomato purees obtained using winery by-products. *LWT - Food Sci. Technol.* 1–7. doi:10.1016/j.lwt.2014.12.059.

Tseng, A., and Y. Zhao. 2013. Wine grape pomace as antioxidant dietary fibre for enhancing nutritional value and improving storability of yogurt and salad dressing. *Food Chem.* 138:356–365. doi:10.1016/j.foodchem.2012.09.148.

Tyle, P. 1993. Effects of size, shape and hardness of particles in suspension on oral texture and palatability. *Acta Physiol.* 84:111– 8.

Utz, K-H. 1986. The interocclusal tactile fine sensitivity of the natural teeth as studied by aluminium oxide particles. *Dtsch Zahnärztl Z.*41, 313–315.

Verbeke, W. 2006. Functional foods: Consumer willingness to compromise on taste for health? *Food. Qual. Prefe.* 17:126–131. doi:10.1016/j.foodqual.2005.03.003

Verbeke, W., J. Scholderer, and L. Lähteenmäki. 2009. Consumer appeal of nutrition and health claims in three existing product concepts. *Appetite*. 52:684–692. doi:10.1016/j.appet.2009.03.007

Vit, P., Sancho, T., Pascual, A., and R. Deliza. 2011. Sensory perception of tropical pot honeys by Spanish consumers, using free choice profile. *J. ApiProd. ApiMed. Sci.* 3:174-180. doi: 10.3896/IBRA.4.03.4.04

Wadhwani, R., and D. J. McMahon. 2012. Color of low-fat cheese influences flavor perception and consumer liking. *J. Dairy Sci.* 95:2336-2346. doi: 10.3168/jds.2011-5142.

Wardle, J., and L. Cooke. 2008. Genetic and environmental determinants of children's food preferences. *Br. J. Nutr.*99:S15-S21.doi: 10.1017/S000711450889246X.

Yu, J., and M. Ahmedna. 2013. Functional components of grape pomace: their composition, biological properties and potential applications. *Int. J. Food Sci. Technol.* 48:221–237. doi: 10.1111/j.1365-2621.2012.03197.x.

507 Zhu, F., B. Du, L. Zheng, and J. Li. 2014. Advance on the bioactivity and potential applications of dietary
508 fibre from grape pomace. *Food Chem.* doi:10.1016/j.foodchem.2014.07.057.

509 **Table 1.**Descriptors used by experts divided on sensory modalities, number of occurrences of each
510 descriptor in the data set and number of occurrences of each construct.

Sensory Modality	Descriptor	Occurrences	O/SM[1]	Dim1 (39%)		Dim2 (15%)	
				+	-	+	-
Appearance	holes	5		0	0	0	0
	homogeneous_dough	2		1	0	0	0
	homogeneous_marbling	2		0	2	0	0
	marbling	3	31	0	3	0	0
	marbling_brown	7		0	6	0	0
	marbling_violet	4		0	2	0	0
	white	8		5	0	0	0
Odor	o-cereal	2		0	0	0	0
	o-citric	1		0	1	0	0
	o-cream	1		0	1	0	0
	o-earthy	1		0	1	0	0
	o-fruity	2		0	0	0	0
	o-grassy	1	30	0	0	0	0
	o-lactic	7		1	1	0	0
	o-nuts	2		0	0	0	0
	o-varnish	1		0	1	0	0
	o-winy	4		0	0	0	0
	o-yogurt	8		0	1	0	0
Taste and mouthfeel	bitter	7		1	1	1	0
	salty	6		0	3	0	0
	sour	11		0	5	1	0
	spicy	3	36	0	0	0	0
	sweet	5		2	1	0	0
	astringent	3		0	0	1	1
Flavor	f-acetic	1		0	0	0	0
	f-acetone	1		0	0	0	0
	f-ammonia	1		0	0	0	0
	f-animal	1		1	0	0	0
	f-citric	2		0	1	0	0
	f-cream	3		0	0	0	0
	f-earthy	1		0	1	0	0
	f-grassy	1		0	0	0	0
	f-lactic	8	35	1	0	0	0
	f-floury	2		0	0	0	0
	f-metallic	1		0	0	0	0
	f-nuts	2		0	1	0	0
	f-toasted	2		0	0	0	0
	f-vanilla	1		0	0	0	0
	f-winy	1		0	0	0	0
	f-yogurt	7		0	0	1	0
	f-overall intensity	1		0	0	0	0
Texture	adhesive	5		1	0	0	0
	compact	3		1	0	1	0
	creamy	2		0	0	2	0
	crumbly	1		0	0	0	1
	doughy	4		0	1	0	0
	elastic	5		1	0	0	0
	granular	5	41	0	2	0	1
	gummy	8		2	0	0	0
	sandy	3		0	0	2	0
	soft	1		0	1	0	0
	soluble	2		0	1	0	0
	sticky	1		0	0	0	0
	watery	1		0	0	0	0
Total	54	173	173	17	37	9	3

511
512 [1]O/SM = number of occurrences per sensory modality.
513 Descriptors with a vector loading ≤ 0.7 or ≥ 0.7 on the first two dimensions (Dim) of GPA have been
514 included.
515 A descriptor can have a loading on more than one axis.

Table 2. Overall liking and liking for appearance, odor, taste, flavor and texture of the cheese samples expressed by 90 consumers.

	Samples[1]									
Liking	B0.8	B1.6	B2.4	C0.8	C1.6	C2.4	STD	SEM	F	P
appearance	4.93^{bcd}	4.586^{de}	4.283^{e}	5.283^{b}	5.061^{bc}	4.82^{cd}	7.10^{a}	0.18	36.34	<0.001
odor	5.465^{b}	5.364^{bc}	5.14^{bc}	5.43^{b}	5.384^{bc}	5.00^{c}	6.33^{a}	0.16	10.32	<0.001
taste	5.374^{bc}	5.061^{bcd}	4.768^{d}	5.44^{b}	5.13^{bcd}	4.985.0^{cd}	6.293^{a}	0.17	10.98	<0.001
flavor	5.263^{bc}	5.091^{bc}	5.00^{c}	5.42^{b}	5.061^{bc}	4.91^{c}	6.44^{a}	0.17	13.32	<0.001
texture	5.34^{bcd}	5.21^{cd}	5.04.96^{d}	5.62^{b}	5.56^{bc}	5.172^{cd}	6.52^{a}	0.17	12.85	<0.001
overall	5.20^{bc}	4.995.0^{cde}	4.787^{de}	5.475^{b}	5.152^{bcd}	4.74^{e}	6.394^{a}	0.17	3.97	<0.001

[1]Samples: B = *Barbera* grape variety, C = *Chardonnay* grape variety; 0.8 = 0.8 w grape skin powders/w curd, 1.6 = 1.6 w grape skin powders/w curd, 2.4 w grape skin powders/w curd; STD = control, not fortified.

SEM: standard error of the mean

Table shows results from 2-way mixed ANOVA models (fixed factor: product; random factor: subject, interaction product/subject).

Different letters within a row indicate significant differences ($p<0.05$) between mean values. Fisher's Least Significance Difference post hoc test was conducted on the data set of 90 subjects.

Figure captions

Fig. 1. Consensus maps obtained from General Procrustes Analysis (GPA) applied on the Free-Choice Profile data conducted with 21 experts. Individual configurations and sample's positioning are depicted. Descriptors with a vector loading ≤ 0.7 or ≥ 0.7 on the first two dimensions (Dim) are shown.

Individual attributes are indicated by the name of the attribute itself and the number of judge who used the descriptor.

Letters o- and f- : odor and flavor.

Samples: B = *Barbera* grape variety, C= *Chardonnay* grape variety, 0.8 = 0.8 w grape skin powders/w curd, 1.6 = 1.6 w grape skin powders/w curd, 2.4 w grape skin powders/w curd.

Fig. 2. Map obtained from Partial Least Square Regression (PLS) performed considering as X data set the sensory data from Free-Choice Profile and as Y data set the overall liking of 90 consumers. The first and the second percentage on each axis express the variability explained by the X and Y data set, respectively.

Descriptors with a vector loading ≤ 0.7 or ≥ 0.7 on the first two dimensions (Dim) of GPA have been included.

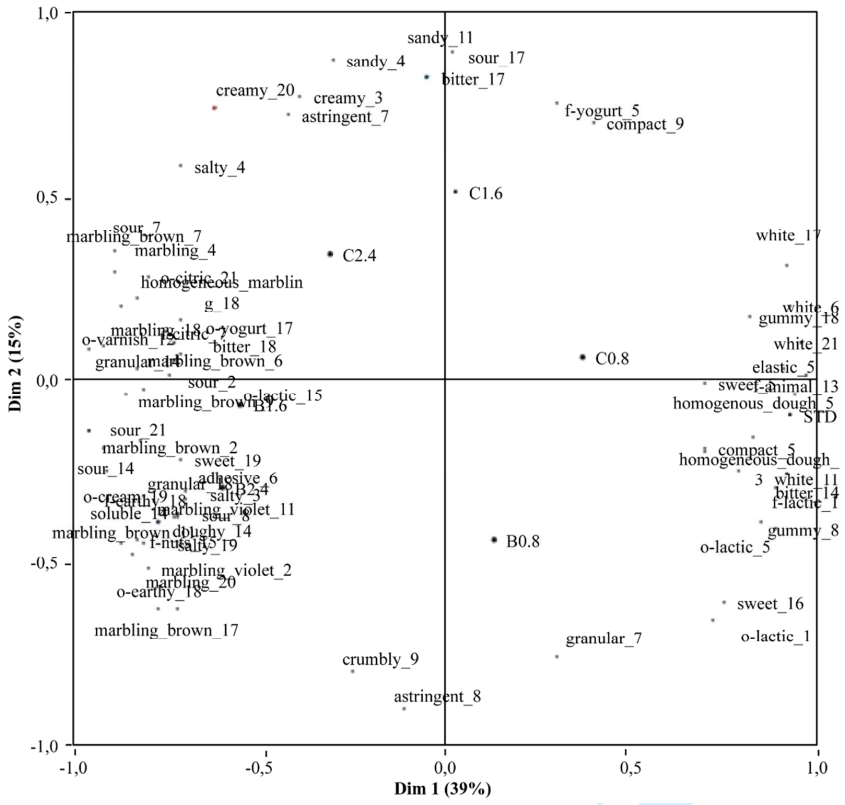
Individual attributes are indicated by the name of the attribute itself and the number of judge who used the descriptor.

Letters o- and f- : odor and flavor.

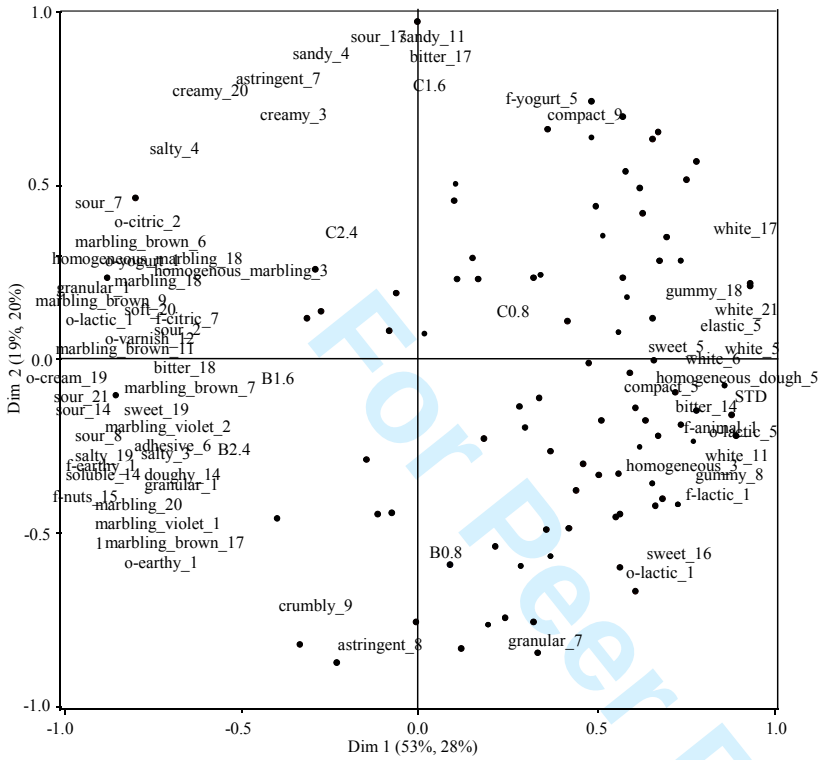
● = Consumers

Samples: B = *Barbera* grape variety, C= *Chardonnay* grape variety, 0.8 = 0.8 w grape skin powders/w curd, 1.6 = 1.6 w grape skin powders/w curd, 2.4 w grape skin powders/w curd.

Torri Figure 1



574 Torri Figure 2



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