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

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A sensory- and consumer based approach to optimize cheese enrichment conditions

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 underlined 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 information on how to optimize the ingredient use and the process conditions.
SENSORY APPROACH FOR CHEESE OPTIMIZATION

A sensory- and consumer based approach to optimize cheese enrichment conditions

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ABSTRACT

The present study aimed to present a sensory- and consumer based approach to optimize cheese enrichment conditions. 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 dairy 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; Stratulat et 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, UF550, 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 11 out 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 the Dim1. 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 the Dim2. 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=4.99±0.10; C=5.12±0.10). 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 (5.34±0.12), while the prototypes with 2.4% of GSP were the least preferred (4.76±0.13). 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 to slightly liked (Tab. 2). In particular, C0.8, B0.8 and C1.6 were the most liked samples and C2.4 was the least liked sample with no significant differences from samples B0.8 and B1.6. C0.8, C1.6 and B0.8 showed the highest liking scores for the appearance. Barbera samples fortified with 1.6 and 2.4% of GSP tended to be the least 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 than B2.4 and C2.4 in terms of taste and flavor. Considering the texture, C0.8 had the most liked texture, 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 liked texture, 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 samples C1.6 (6.26±0.22) and C0.8 (5.49±0.27) as slightly pleasant, while the latter group preferred the cheese B0.8 (5.66±0.21).

**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 et 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 (Hinton et 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 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.

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This research was supported by AGER (contract number 2010-2222). The authors thank the Fontanafredda and Clare winemaking factories for providing the grape pomace used in this study and the 21 assessors of the Italian National Cheese Taster Association (ONAF, Organizzazione Nazionale Assaggiatori Formaggio) for their participation in the Free Choice Profile evaluation.

REFERENCES


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.

<table>
<thead>
<tr>
<th>Sensory Modality</th>
<th>Descriptor</th>
<th>Occurrences</th>
<th>O/SM</th>
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<th>Dim2 (15%)</th>
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</table>

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.

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<tr>
<th>Liking</th>
<th>B0.8</th>
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<th>B2.4</th>
<th>C0.8</th>
<th>C1.6</th>
<th>C2.4</th>
<th>STD</th>
<th>SEM</th>
<th>F</th>
<th>P</th>
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<td>appearance</td>
<td>4.93&lt;sup&gt;bc&lt;/sup&gt;d</td>
<td>4.58&lt;sup&gt;bc&lt;/sup&gt;e</td>
<td>4.28&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.06&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>4.82&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>7.10&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>odor</td>
<td>5.46&lt;sup&gt;b&lt;/sup&gt;c</td>
<td>5.36&lt;sup&gt;bc&lt;/sup&gt;c</td>
<td>5.14&lt;sup&gt;bc&lt;/sup&gt;d</td>
<td>5.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.38&lt;sup&gt;bc&lt;/sup&gt;c</td>
<td>5.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.33&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.16</td>
<td>10.32</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>taste</td>
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<td>5.06&lt;sup&gt;bc&lt;/sup&gt;d</td>
<td>4.76&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.44&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.13&lt;sup&gt;bc&lt;/sup&gt;d</td>
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<td>10.98</td>
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<tr>
<td>flavor</td>
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<sup>1</sup>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 = grape skin powders/w curd; STD = control, not fortified.

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.