# Sensory acceptability of winery by-products as seasonings for salt replacement

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**Abstract**

High blood pressure is a risk factor for developing cardiovascular diseases. Reduction of dietary salt intake is recommended, particularly for hypertensive subjects. However, most do not adhere to a low-sodium diet as it lacks sensory appeal. The aim of this study was to investigate if low-sodium dishes seasoned with grape pomace (GP) extracts can be sensory acceptable, and feasible to be incorporated into consumer culinary habits. Three sources of GP from red grapes, ecologically red grapes, and white grapes were chemically and sensory studied. While a sensory descriptive analysis of three different base systems (tomato sauce, white sauce, and chicken broth) with no seasoning, salt or GP was performed. The three extracts changed sensory attributes of the base systems, adding wine flavour and astringency. Three culinary recipes (bolognese, risotto, and zucchini puree) seasoned with red GP were developed; consumers (n = 60) were asked to use them and score their liking, ease of use, and saltiness intensity; using a just about right (JAR) scale, and also to answer a Check-All-That-Apply (CATA) question. Despite the sensory changes and selection of the terms *novelty*, *healthy*, and *strange*; consumers liked the bolognese (6.03 ± 2.07) and risotto (6.93 ± 1.99) recipes but liked less zucchini puree (4.83 ± 2.57). Consumers found the preparations easy and salt was not missed in the risotto recipe. This study proves that consumer liking and adherence to low-sodium recipes can be enhanced using GP-derived seasonings, which can also contribute to ameliorate cardiovascular disorders and create a use for winery by-products.

**Keywords:** Sensory acceptability, winery by-products, seasonings, salt replacers, antioxidant

## 1. Introduction

High blood pressure is the principal risk factor involved in developing cardiovascular disease, since it is present in 45% of cardiovascular disorders [1]. One of the worldwide targets to decrease cardiovascular disease and other non-communicable diseases is to reduce salt intake, which could prevent an estimated 2.5 million deaths every year [2]. In fact, only a small reduction of sodium salt (NaCl) leads to a decrease in 4.8 and 2.5 mmHg in systolic BP and in 1.9 and 1.1 mmHg in diastolic BP, in hypertensive and normotensive subjects, respectively [3].

However, to follow a low-sodium diet is difficult, as salt-reduced foods are less appetising to the general population [4], as $Na^+$ is the only non-toxic substance that can produce a saltiness perception [5]. Furthermore, NaCl provides a pleasant saltiness perception and acts as a flavour enhancer while providing texture to foods [4]. NaCl is widely used as a preservative in processed food, inhibiting microbial growth [6]. Because of our current lifestyle, intake of processed food, with high salt content, has been increasing [7], contributing to our sensory development preference for salty food [8].

To promote a low-sodium diet, NaCl alternatives have been proposed; including metallic salts (potassium lactate, KCl), low-sodium blends (NaCl with KCl), salt replacers (KCl with lysine) or flavour enhancers, such yeast extracts [4, 9]. However, these alternatives may negatively affect food texture and flavour. Another proposed salt intake reduction strategy is using herbs and spices that enrich recipes with other flavours that mask the low salt content [10].

Although not use as salt replacer, wine has been employed in many culinary preparations, as its aroma compounds and non-volatile tastants can enhance the flavour of prepared food [11]. Therefore, like using herbs and spices to reduce reducing salt content in culinary preparations, wine could also be a good alternative. In addition, wine production, increasing each year, causes an environmental problem with the generation difficult to manage by-products (25 kg per 100 kg of grapes). These by-products are mainly GP, fundamentally composed by seeds and skins, with, with a considerable amount of bioactive compounds (phenolic compounds and antioxidant dietary fibre) [12]. Considering the low cost of processing of the GP, more products could be developed to use this by-product. In previous studies, different conditions were studied to obtain GP-derived extracts to achieve an adequate antioxidants levels with a yield of 16-20% [13, 14].

Previous studies based on the dietary supplementation with GP-derived extracts in the form of powder or capsules have demonstrated its positive benefits on blood pressure, reducing systolic BP by 5 - 6 mmHg and diastolic BP by 2.5 mmHG [15, 16]. Other studies, without intending to decrease sodium levels, have directly incorporated different GP ingredients into food products; for example in pancakes, noodles, and cereal bars [17]; tomato puree [18]; bread and muffins [19]; and spreadable cheese [20]. Of these studies, consumer acceptability was not altered, until a certain level of GP enrichment.

Therefore, in bibliography there are studies that show the GP extract´s ability to enhance food flavour, further there are studies that show how the polyphenol content of GP extracts can exert beneficial effects on blood pressure mechanisms; however, these two effects have never been investigated and used together. In this study we hypothesized that seasoning foods and recipes with GP extracts could not only be a strategy to reduce sodium salt intake, but also to ameliorate biomarkers of hypertension, and use the winery industry by-products. Additionally, the production of seasonings from GP could be a valuable alternative for the management and revalorisation of this winery by-products.

Therefore, the aim of this study was to investigate for first time if elaborating recipes with low-sodium content and seasoned with GP extracts would be sensory acceptable by consumers, increasing their adherence to a low-sodium salt diet and be feasibly to incorporate this GP into their culinary habits. To achieve this aim, a GP extract with a high polyphenol profile was initially selected. Different base carriers' systems, for developing low salt recipes seasoned with the selected GP extract, were developed using a trained panel. Using a consumer trial, the proposed recipes were tested for liking and feasibility of preparation.

## 2. Materials and methods

### 2.1. GP extracts

Three different GP extracts were initially considered red grape pomace extract (RGPE), ecological red grape pomace extract (ERGPE) (Tempranillo variety), and white grape pomace extract (WGPE) (Verdejo variety). All were manufactured in the industrial facilities of Bodega Matarromera (Valbuena de Duero, Valladolid, Spain), according to previous reported procedures-L3 [13].

### 2.2. Total polyphenols content and phenolic profiling of GP extracts

Total polyphenols content of the three GP extracts was measured by adapting the Folin-Ciocalteu colorimetric method [21] to M96-well plates. Data were obtained in triplicate and expressed as mg of gallic acid equivalent (GAE/mL).

Solutions of each extract at two different concentrations (0.5 and 0.05 mg/mL) were prepared and filtered (0.22 µm) before chromatographic analysis. The internal standard 4-hydroxybenzoic-2,3,5,6-d4 acid solution (Sigma-Aldrich, St. Louis, MO) [1,250 µg/mL in formic acid/acetonitrile (1:200, v/v)] was added to the samples in a proportion 1:5 (v/v). The analysis of targeted phenolic metabolites was conducted by UPLC-ESI–MS/MS following the method described by [22] with modifications. The liquid chromatographic system was a Waters Acquity UPLC (Milford, MA) equipped with a binary pump, an autosampler thermostated at 10 °C, and a heated column compartment (40 °C). The column used was a BEH-C18, 2.1 × 100 mm and 1.7 μm particle size, from Waters (Milford, MA, USA). The mobile phases were 0.1% (v/v) formic acid in water (A) and 0.1% (v/v) formic acid in acetonitrile (B). The gradient programme was: 0 min, 0.1% B; 1.5 min, 0.1% B; 11.17 min, 16.3% B; 11.5 min, 18.4% B; 14 min, 18.4% B; 14.1 min, 99.9% B; 15.5 min, 99.9% B; 15.6 min, 0.1% B. Equilibrium time was 2.4 min resulting in a total run-time of 18 min. The flow rate was set at a constant 0.5 mL/min and the injection volume was 2 μL. The LC effluent was pumped to an Acquity TQD tandem quadrupole mass spectrometer equipped with a Z-spray electrospray ionisation (ESI) source operated in positive polarity mode for anthocyanins and in negative polarity mode for the rest of phenolic compounds. The ESI parameters were: capillary voltage, 3 kV; source temperature, 130 °C; desolvation temperature, 400 °C; desolvation gas ($N_2$) flow rate, 750 L/h; cone gas ($N_2$) flow rate, 60 L/h. For quantification purposes, data were collected in the multiple reaction monitoring (MRM) mode, tracking the transition of parent and product ions specific to each compound. The MS/MS parameters (cone voltage, collision energy, and MRM transition) of the 55 phenolic compounds targeted were reported previously [23]. All metabolites were quantified using the calibration curves of their corresponding standards. Injections were conducted in duplicate (n = 2). Data acquisition and processing were realised with MassLynx 4.1 software.

### 2.3. Sensory Descriptive analysis

#### *Preparations of the base systems*

Three different base systems (tomato sauce, chicken broth, and white sauce) that were later developed to full recipes, were considered. The base systems were not seasoned (Control, C), or were seasoned with salt (0.5 - 0.75%) (Salt, S) or with one extract (1.67% of WGPE, RGPE or ERGPE). Table 1 shows the full composition of each base system.

Tomato samples were prepared in batches of 1,500 g using a kitchen robot (Thermomix, Vorwerk, Spain, M.S.L., Madrid, Spain). All the ingredients except the salt / extracts were added to the kitchen robot and cooked at speed 1 (100 rpm/min) and 100 ºC for 30 min. The white sauce was prepared likewise; all the ingredients except the salt / extracts were added to the kitchen robot and were cooked at speed 4 (400 rpm/min) and 90 ºC for 8 min. Low salt commercial chicken broth was heated at 80 ºC in a water bath for 30 min. The GP extracts were added at the end of the cooking / heating because of the susceptibility of the polyphenols to high temperatures. Samples were prepared fresh every day 1 h in advance to the sensory analysis and were maintained in a water bath at 65 ºC. Samples were served in 20 mL plastic cups.

***Panel training and formal assessment***

Twelve adults, aged between 21 and 30 years old that worked at the institution and were able to attend sessions over a year, took part in this study. They were selected, screened, and recruited following international standards (ISO 8586, 2012). The assessors received no remuneration for participating in the panel. In an initial meeting, the panel, with no previous experience, was introduced in the sensory methodology and given instructions about the procedure (i.e. to not have eaten / smoked 1 h prior the test, not wear strong perfumes, etc).

Over a year, three different studies were performed (one per each base system). In the first session, panellists were presented with three preparations (C, S and, ERGPE) and were asked to describe them. To aid this, they were given a list of possible attributes to describe samples in terms of appearance, odour, taste, mouthfeel, and aftertaste. They were also free to add more attributes; the elicited attributes were discussed in the group. In the second session, the utmost mentioned and agreed attributes were presented again in an open discussion with the same samples for their confirmation. Panellists were then trained to use non-structured scales ranked from 0 to 100 points for each attribute. Series from 9 to 12 training sessions for each base system were required before the final assessment.

For tomato sauce, the following attributes were scored: intensity of darkness, tomato aroma, wine aroma, toasted aroma, tomato flavour, wine flavour, saltiness, bitterness, and astringency. The white sauces' selected attributes were flour aroma, wine aroma, lavender colour, camel colour, while colour, flour taste, wine taste, butter taste, saltiness, bitterness, and astringency. The chicken broths' final attributes were chicken and wine aroma, purple, brown and camel colour, chicken taste, wine taste, bitterness, saltiness, umami taste, and astringency.

After checking that the deviation among panellists was <20.0 in a 100 cm unstructured scale formal assessment, per triplicate, was done. Samples were presented monadically and panellists evaluated each sample in three different sessions across two weeks. Data on both the training and the evaluation were collected using RedJade® Sensory Software Suite (Curion, Deerfield, IL, USA).

### 2.4. Consumer study (in-home test)

Sixty consumers (40 women and 20 men; aged 40 ± 15 years) were invited verbally, by email, and using social media (WhatsApp and Facebook) to take part in a consumer home test.

In a one-to-one session, the study was explained to each participant and the GP extract was given to them. Besides verbally explaining the study, all participants received the instructions (via email) that contained the invitation to the study, general instructions (how to store the GP, temperature of use, and quantity to be used), recipes, and the link for completing an online questionnaire. They were asked to cook (at home) three low salt recipes previously developed in an experimental kitchen (Alice, Alimentation and Science, Sant Fruitós de Bages, Catalonia, Spain) comprising a bolognese sauce, risotto, and zucchini puree, according to the three base systems. Full recipes (ingredients and preparation method) were given to consumers and are included as supplementary material S1.

For each recipe, consumers were instructed to add 1 g per portion of the RGPE. As participants were going to add the extract to three different recipes, at least three zip bags with the pre-weighted extracts were given to the participants. In the case, that they wanted to share the food, or cooked for more people, they were asked to adjust (add more bags) the quantity of GP extracts added by increasing bags used per portions.

The consumers' overall acceptance, liking of the taste, and texture appearance were evaluated using 9-point hedonic scale (9 ¼ like extremely; and 1 ¼ dislike extremely), the ease of use was also asked and evaluated in a nine-point structure scale (being 9 very easy, and 1, very difficult).

In addition, a CATA question with 16 attributes (previously obtained from a group of consumers not further participating in the test (n = 15)) was used to know the hedonics attributes transmitted while cooking with and when tasting GP. CATA attributes were dietary supplement, unpleasant, healthy, colourful, artificial, new, strange, malted cereals, nothing, sweet, astringent, bitter, acid, coffee, chocolate, toasted, and traditional. Finally, the main attributes related to the extracts (saltiness, bitterness, astringency, and wine flavour) were evaluated using JAR 5-point scales.

### 2.5. Statistical analysis

Analysis of variance (one way-ANOVA) was applied to study the differences in the phenolic content among the GP extracts, differences in the perception among bases systems, and differences of consumer perception among recipes. A principal component analysis (PCA) was conducted to find out the relationship between the sensory attributes and the phenolic composition of each extract. The least significant differences were calculated by Tukey's test ($p < 0.05$). The frequency of use of each term in the CATA question was obtained by counting the number of participants who selected each term. Significance differences of frequency selection among words usage were calculated using Cochran's Q test ($\alpha = 0.05$).

From the JAR scale, the percentage of consumers rating saltiness of each recipe by separate on each point scale (five points) was calculated. Secondly, the below and above deviation from point 3 on the scale (JAR) was grouped. Finally, a penalty analysis was used to show the influence of the salt replacement on the overall acceptance. All the data were analysed using the XLSTAT 2019 software (Microsoft, Mountain View, CA).

# 3. Results

## 3.1. Chemical composition and profile of GP extract

As determined by the Folin-Ciocalteu method, the RGPE showed the highest content of total polyphenols (47.96 ± 4.08 mg/g), around 10-fold more than the other extracts, ERGPE (5.66 ± 0.49 mg/g) and WGPE (3.54 ± 0.46 mg/g).

Twenty phenolic compounds were detected by UPLC-MS in the GP extracts (data not shown). To better compare, compounds were grouped into main classes: phenolic acids, flavonols, flavan-3-ols, and anthocyanins (only for red GP extracts) (Figure 1). The RGPE had a higher content of phenolic acids (1.84 mg/g) than the ERGPE (0.85 mg/g) and the WGPE (1.21 mg/g). However, it was the ERGPE which had the greatest flavanol and flavan-3-ol content. Concerning flavanols, both kaempferol and quercetin-3-*O*-glucoside were found in the RGPE (0.073 mg/g) and ERGPE (0.087 mg/g) but were absent in the WGPE. For flavan-3-ols, (+)-catechin and (-)-epicatechin appeared in the tree extracts counting for 0.29 mg/g in the WGPE, 0.28 mg/g in the RGPE, and 0.68 mg/g in the ERGPE, along with epicatechin gallate, also detected in the ERGPE. The ERGPE was the only extract with anthocyanins detected, with malvidin-3-*O*-glucoside (820 µg/g), petunidin-3-*O*-glucoside (245 µg/g), and delphinidin-3-*O*-glucoside (202 µg/g).

[FIGURE 1 HERE]

## 3.2. Sensory profile of the base recipes

Sensory descriptive analysis of the three different base systems (tomato sauce, white sauce, and chicken broth) with no seasoning (Control, C), and salt (S) or GP extract (RGPE, ERGPE or WGPE) addition are shown in Figure 2.

[FIGURE 2 HERE]

In the tomato sauce system, red grape extracts (RGPE and ERGPE) decreased the tomato aroma (only smelling) and flavour (when tasting), but increased the wine taste, wine flavour, bitterness, and astringency (Figure 2a); both red grape extracts conferred a darker colour. No significant differences between the control (no added seasoning) and the salted samples were found in the perception of aromas, flavours, dark colour, and bitterness. WGPE was significantly greater in wine flavour for the control and salted samples. Regarding saltiness, salted samples were different from the other four samples (Figure 2a).

In the white sauce system, GP-derived seasonings provided a lavender and camel colour to the white sauce, especially RGPE and ERGPE (Figure 2b). The typical white sauce flavour and taste (flour and butter taste) decreases when any GP is added, wine flavour and taste is also present in comparison with control and salted samples. As occurred with the tomato sauce, samples seasoned with GP had significantly higher bitterness and astringency than control and salted samples. Regarding the saltiness, salted samples were significantly higher, followed by samples with RGPE greater than ERGPE, and WGPE that is not significantly different from the control sample (Figure 2b).

In the chicken broth system, the addition RGPE and ERGPE reduced the intensity of chicken aroma and chicken flavour while increasing wine aroma and taste, especially the ERGPE (Figure 2c). The three extracts also provided a change of colour in the chicken broth, with greater purple tone intensity when ERGPE was added, brown colour when RGPE is added, and more camel colour when WGPE is added. The three extracts gave greater astringency to the broth. Umami flavour, in comparison with the control and salted samples, decreased for the RGPE and ERGPE, but not for WGPE. The perceived salt intensity was higher for the salted sample, followed by samples seasoned with red grape extracts and lower in the control and WGPE-seasoned samples (Figure 2c).

### 3.3. Relationship between phenolic composition and sensory profile

Principal component analysis including the phenolic composition and sensory attributes of the three base systems (Figure 3) are shown in Figure 3. PCA explained the 93.15%, 89.29%, and 92.46% of variance for the tomato sauce, chicken broth, and white sauce systems, respectively. The first component separated preparations without GP extract (control and control with salt) and WGPE preparations, from ERGPE and RGPE preparation. Control system and control with were related with the typical tomato, chicken, and flour tastes and aromas; RGPE and ERGPE preparations, were related with the wine flavour, astringency, and bitterness attributes.

[FIGURE 3 HERE]

For the tomato sauce, the components ethyl gallate, quercetin-3-*O*-glucoside, and gallic acid were related with RGPE and the attributes bitterness, wine flavour, wine aroma, darkness, astringency, and tomato aroma. Other components, (+)-catechin, (-)-epicatechin, (-)-epicatechin gallate, peonidin-3-*O*-glucoside, kaempferol, petunidin-3-*O*-glucoside, 3,5-dihydroxybenzoic acid, delphinidin-3-*O*-glucoside, and malvidin-3-*O*-glucoside did not relate with any of the sensory attributes (Figure 3a).

In the white sauce comparable results were observed. The first component explained 61.87% of the variance, while the second component explained 30.59%. Like the tomato sauce, many of the sensory attributes and phenolic compounds were correlated with PC1 while other polyphenols with the PC2. That relationship resulted in a similar ordination of the samples in the PCA of the white sauce. On the right side of the PCA, the RGPE was located and was related with the camel colour, close to the ethyl gallate, quercetin-3-*O*-glucosdie, gallic acid, total polyphenols content, and bitterness. Other sensory attributes such as astringency and wine taste were also related with RGPE and ERGPE, catechin, protocatechuic, and epicatechin; the latter also relates with wine aroma. As with the tomato sauce, other components (epicatechin gallate, peonidin glucoside, kaempferol, petunidin glucoside, 3,5-dihydroxybenzoic acid, delphinidin glucoside, and malvidin glucoside) were not linked to sensory-specific attributes (Figure 3b).

In the chicken broth both the two principal components explained the 61.39% and 27.89% of the total variance. The relationship between components and the measured variables exhibited a similar pattern to both the previous sauces and an identical dispersion of the samples. Here, the variable colour allowed for a deeper differentiation of the GP extracts, connecting the camel colour with the WGPE, brown with the RGPE, and lavender with the ERGPE. Camel colour in the chicken broth was the only attribute correlated with the WGPE among the three sauces. The two red grape extracts showed a strong correlation between phenolic composition and attributes associated with the GP extracts, like bitterness, astringency, and wine taste. According to the relationship between phenolic compounds and the attributes; protocatechuic acid, flavan-3-ols, and kaempferol were correlated with bitterness and astringency, explaining why the ERGPE had the highest scores for both parameters (Figure 3c).

### 3.4. In-home test: consumer's opinion of recipes seasoned with GP extracts

The acceptance of a new functional food ingredient is one of the principal parameters related to its success, along with potential biological activities and production costs. Based on the highest concentration in polyphenols, RGPE was chosen for the consumer acceptability study. As it can be observed in Table 2, when GP is added to the three different recipes (bolognese sauce, risotto, and zucchini puree), the overall acceptability, the taste, and aroma significantly increased in the risotto and the bolognese but not in the zucchini puree. When asking about the facility of use of the extract in a home context, consumers found the recipes and the use of the extract easy.

[TABLE 2. HERE]

Figure 4 shows the frequencies of the most selected terms for each recipe; only those with a selection frequency over 10% are represented. The attributes with the highest ordered frequencies were *novelty*, *healthy*, *strange*, *colourful*, *toasted*, *nutritional supplement*, *sweet*, *bitter*, and *astringency*. In contrast with *novelty* and *strange*, around a 10% of participants selected *traditional* as a term to describe the samples.

[FIGURE 4 HERE]

The adequacy of the intensity of the attributes saltiness, bitterness, wine flavour, and astringency of the recipes with the RGPE are shown in Figure 5. As it was mentioned in the materials and methods, all the recipes were low in salt. Most of the participants perceived salt intensity as too little for the bolognese sauce (72%) and the zucchini puree (77%), however, was considered just about right (53%) for the risotto. Furthermore, penalty analysis showed that containing not enough salt results in a mean drop of liking of 1.81 points for the bolognese recipe and 1.80 for the zucchini puree.

[FIGURE 5 HERE]

## 4. Discussion

To help reduce the amount of salt in culinary preparations (recipes) this work investigated the use of GP extracts. Three different GP extracts were chemically and sensory studied; as expected, red grape extracts contained higher amounts of polyphenols than the white grape extracts. These results agree with previous studies where the concentrations of polyphenols were 10 - 69 mg GAE/g for GP extracts from red Tempranillo variety [24-27] and 8 mg GAE/g for WGPE [28].

Comparable to other authors phenolic profiling of the extracts show similar amounts of flavan-3-ols, although extracts with a high concentration of gallic acid and procyanidins have not been detected [27, 29]. Furthermore, there was also a difference between the two red grape extracts, as ERGPE was the only one to contain quantifiable amounts of anthocyanins (malvidin glucoside, petunidin glucoside, and delphinidin glucoside).

The sensory profile of the extracts added to different base systems showed that the three extracts significantly change all the attributes related to appearance and flavour. These attributes were replaced by wine taste while adding astringency. In a previous study, although the extracts were added to a food product and not to a culinary preparation, it was shown that the sensory profile when adding GP to chicken patties, primosale cheese, spreadable cheese [20, 30, 31], and tomato puree [18] provided bitterness and, slight saltiness. Here, the risotto salt level was about right, but was not enough for bolognese and zucchini puree. This discrepancy may be for the different sauces and GP causing the release of the compounds related to the flavour perception to occur at different degrees in the function of the water and lipidic contents [32]. As observed by Torri, Piochi [18] the particle size of the grape extracts is enough to generate differences between products.

Astringency is strongly related to the polyphenol content; this is the reason the red grape extracts exerted more intensity than the white extract, as previously reported by Costa and Lucera, Costa [20] in primosale cheese and spreadable cheese, respectively. Among the different compounds, procyanidins have been proposed as the major contributors to the astringency intensity [33]; these compounds were not detected in our extracts. Still, authors have remarked the great influence of flavan-3-ols on astringency and the monomeric fraction of the procyanidins [34, 35]. That can offer an explanation of why ERGPE, whose content of (+)-catechin and (-)-epicatechin is higher than the other extracts, presented a higher intensity for the astringency parameter. Kallithraka, Kim [36] also reported a positive relationship between total flavanols and perceived astringency, but neither monomeric nor polymeric procyanidins were correlated to astringency intensity in their studies. Moreover, since Torri, Piochi [18] showed tomato puree which contained bigger GP particle size of presented less astringency, we believe the granularity may play a key role through liberation of polyphenols and proteins and their interaction.

The aim of this study was to use GP to decrease the salt addition in food preparation. Looking at the consumer results, the addition of GP extracts clearly changes the sensory characteristics of the base systems included in the full recipe, with the level of saltiness was considered just about right for the risotto recipe. Besides, the sensory changes were well accepted by consumers, and they perceived the GP ingredient as a novel solution for high blood pressure, probably because they were explained and understood the benefits and costs of using this novel ingredient.

Although not aiming to decrease salt content, several previous studies obtained high acceptability results by incorporating grape by-products to different foods. Tseng and Zhao [37] produced yoghurt and salad dressing (Italian and Thousand island) with added RGPE, 1 – 3% and 0.5 – 1% respectively, which gave positive results on overall acceptance, despite a small reduction of taste. The high fibre content of GP has been purposed as an alternative to flour derivatives, as shown by Maner, Sharma [38] in their study carried out with bread, muffins, and brownies without altering the sensory characteristics of the base products and with good acceptance. They also evaluated using JAR scales observing and improvement in the mouthfeel of the bread and without changes in sweetness. Moreover, the employment of crescent amounts of red and white grape seed flour allowed [17] reduce successfully the amounts of flour in the elaboration of cereal snack bars. However, they obtained bad scores in pancakes and noodles due to the astringency and bitter taste. The sensory benefits of the GP have been also observed in fish since Solari-Godiño, Pérez-Jiménez [39] employed it in the elaboration of a paste made from anchovy mince. The extract improved the acceptance of the product through the reduction of the strong fish flavour. In summary, incorporation of GP in different food matrices are generally well accepted, this study is the first to systematically address the sensory and consumer evaluation of their suitability for the preparation of different recipes.

## 5. Conclusions

Within the framework to reduce salt intake, this study provided a new solution by developing an innovative culinary preparation using GP; beneficial also to sustainability and health. In a first step it was elucidated that sensory profiles of base systems change when adding the GP extracts when replacing totally the added salt; GP extracts contributed to wine flavour and astringency but were considered acceptable by consumers when adding RGPE, except for the zucchini puree. Total salt replacement success, using RGPE, depended on the recipe; RGPE hid the lack of salt in the risotto recipe, but not in the bolognese or zucchini puree. Consumers found using GP, with a recipe, easy at home, which might help the implementation of GP as a salt replacer in daily cooking.

This study proves that consumer liking, and further adherence, to low-sodium recipes can be enhanced by using GP-derived seasonings, which can also help to ameliorate cardiovascular disorders and offer a sustainable use of winery by-products.

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**Table 1.** Ingredients used for the three different base systems.

| Tomato sauce | | | | White sauce | | | | Chicken broth | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ingredients (%) | C | S | RGPE/ERGPE/WGPE | Ingredients (%) | C | S | RGPE/ERGPE/WGPE | Ingredients (%) | C | S | RGPE/ERGPE/WGPE |
| Crushed tomato | 95.98 | 95.5 | 94.31 | Butter (without salt) | 5.61 | 5.61 | 5.61 | Commercial chicken broth (low salt) | 99.85 | 99.25 | 98.18 |
| White sugar | 1 | 1 | 1 | Milk | 88.68 | 85.98 | 84.76 | | | | |
| Olive oil | 3 | 3 | 3 | Olive oil | 1.12 | 1.12 | 1.12 | | | | |
| | | | | Flour | 6.74 | 6.74 | 6.74 | | | | |
| Salt | 0.02 | 0.5 | 0.02 | Salt | 0.1 | 0.55 | 0.1 | | 0.15 | 0.75 | 0.15 |
| GP | - | - | 1.67 | GP | - | - | 1.67 | | - | - | 1.67 |

C: Control; S: Salt added; RGPE: Red grape pomace extract added; ERGPE: Ecological red grape pomace extract added; WGPE: White grape pomace extract added

**Table 2.** Consumer's opinion when using the GP seasoning at home.

| Matrix | Overall acceptability | Taste | Appearance | Aroma | Facility of use |
|---|---|---|---|---|---|
| **Bolognese** | 6.03* ± 2.07ab | 6.13 ± 2.17a | 6.18 ± 1.80a | 6.12 ± 1.94a | 7.75 ± 2.01a |
| **Risotto** | 6.93 ± 1.99a | 6.72 ± 2.10a | 5.85 ± 2.07a | 6.26 ± 1.92a | 7.37 ± 2.48a |
| **Zucchini cream** | 4.83 ± 2.57b | 4.65 ± 2.50b | 4.42 ± 2.21b | 4.75 ± 2.13b | 7.61 ± 2.08a |

*Mean ± standard desviation

[a,b,c] Different letters indicate statistically significant differences ($P < 0.05$)

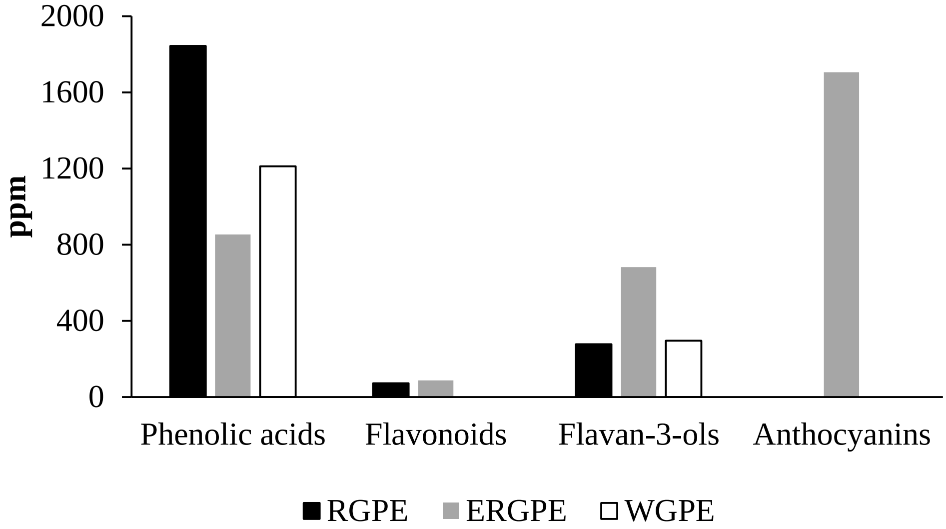
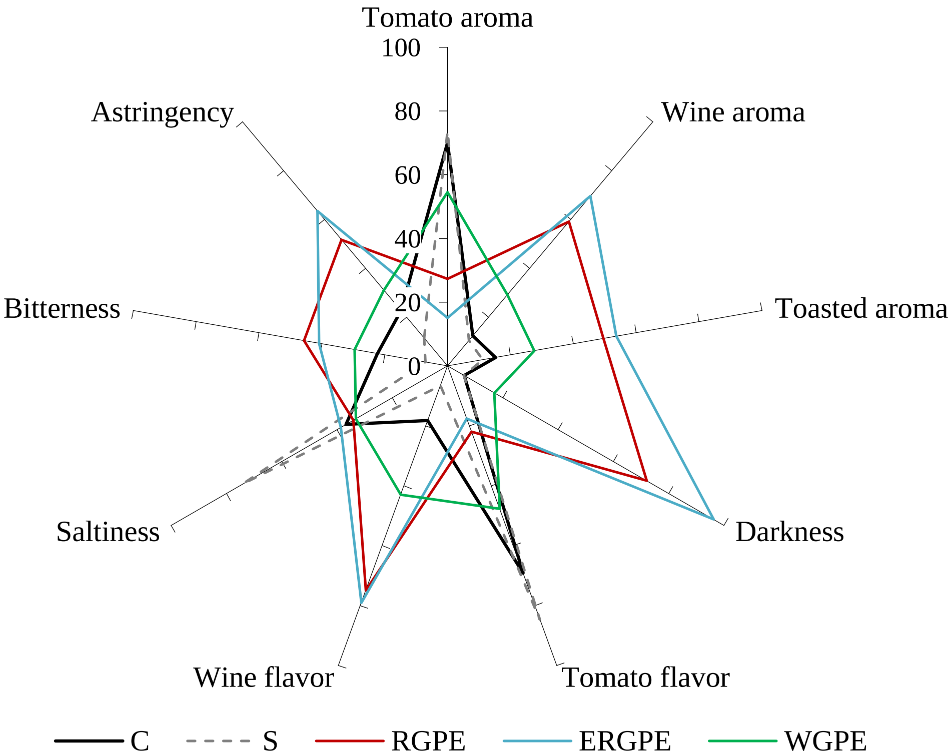
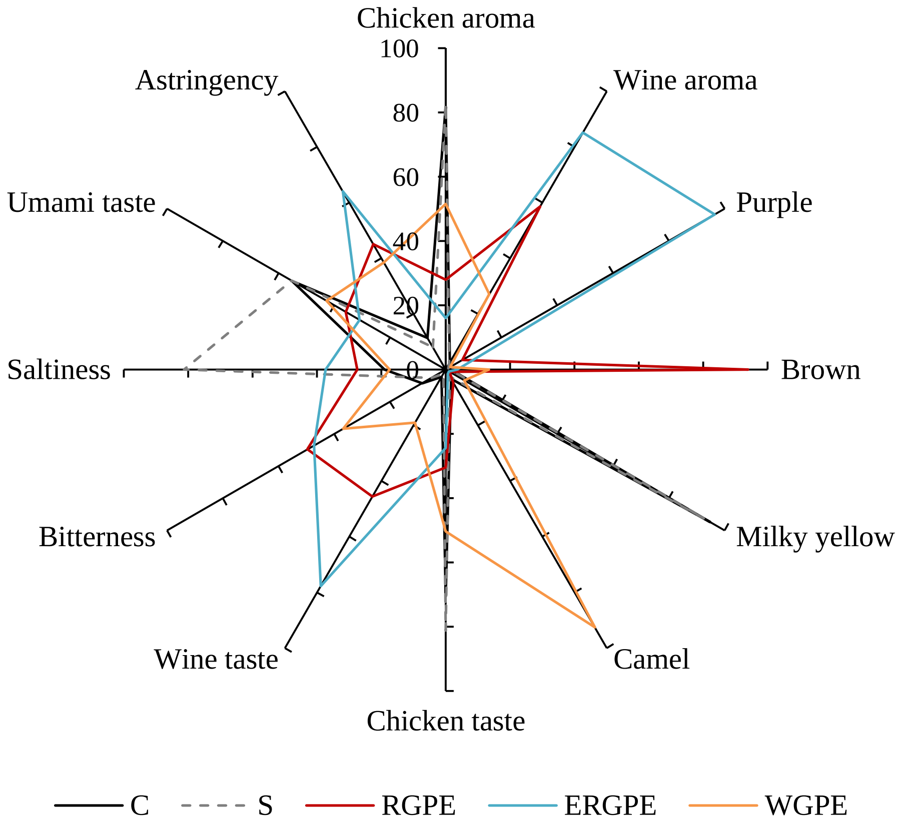



**Figure 1.** Main classes of phenolic compounds present in the different grape pomace extracts. RGPE: red grape pomace extract; ERGPE: ecological red grape pomace extract; WGPE: white grape pomace extract.

a)


Tomato aroma
100
80
60
40
20
0
Wine aroma
Toasted aroma
Darkness
Tomato flavor
Wine flavor
Saltiness
Bitterness
Astringency
C
S
RGPE
ERGPE
WGPE

b)


Chicken aroma
100
80
60
40
20
0
Wine aroma
Purple
Brown
Milky yellow
Camel
Chicken taste
Wine taste
Bitterness
Saltiness
Umami taste
Astringency
C
S
RGPE
ERGPE
WGPE

c)

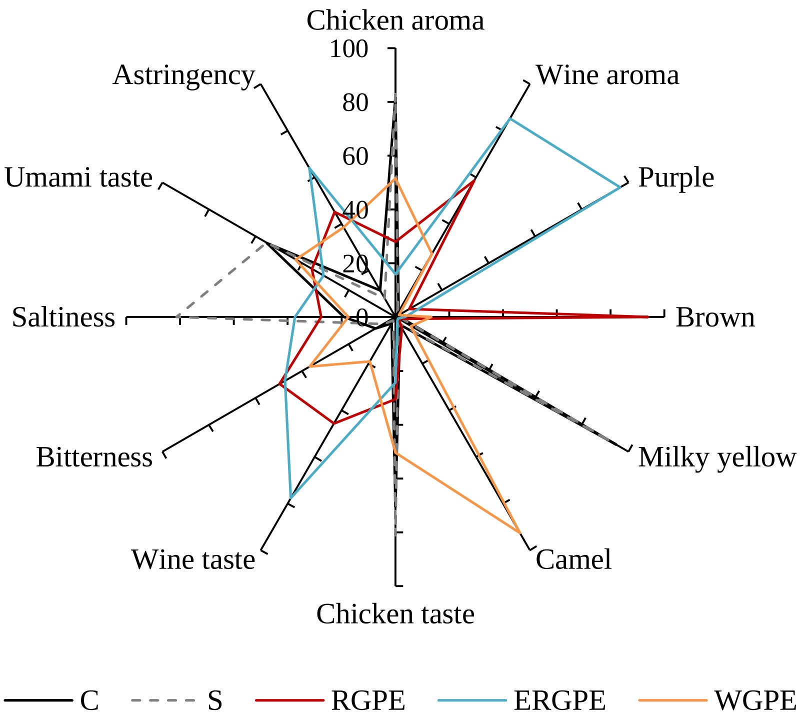
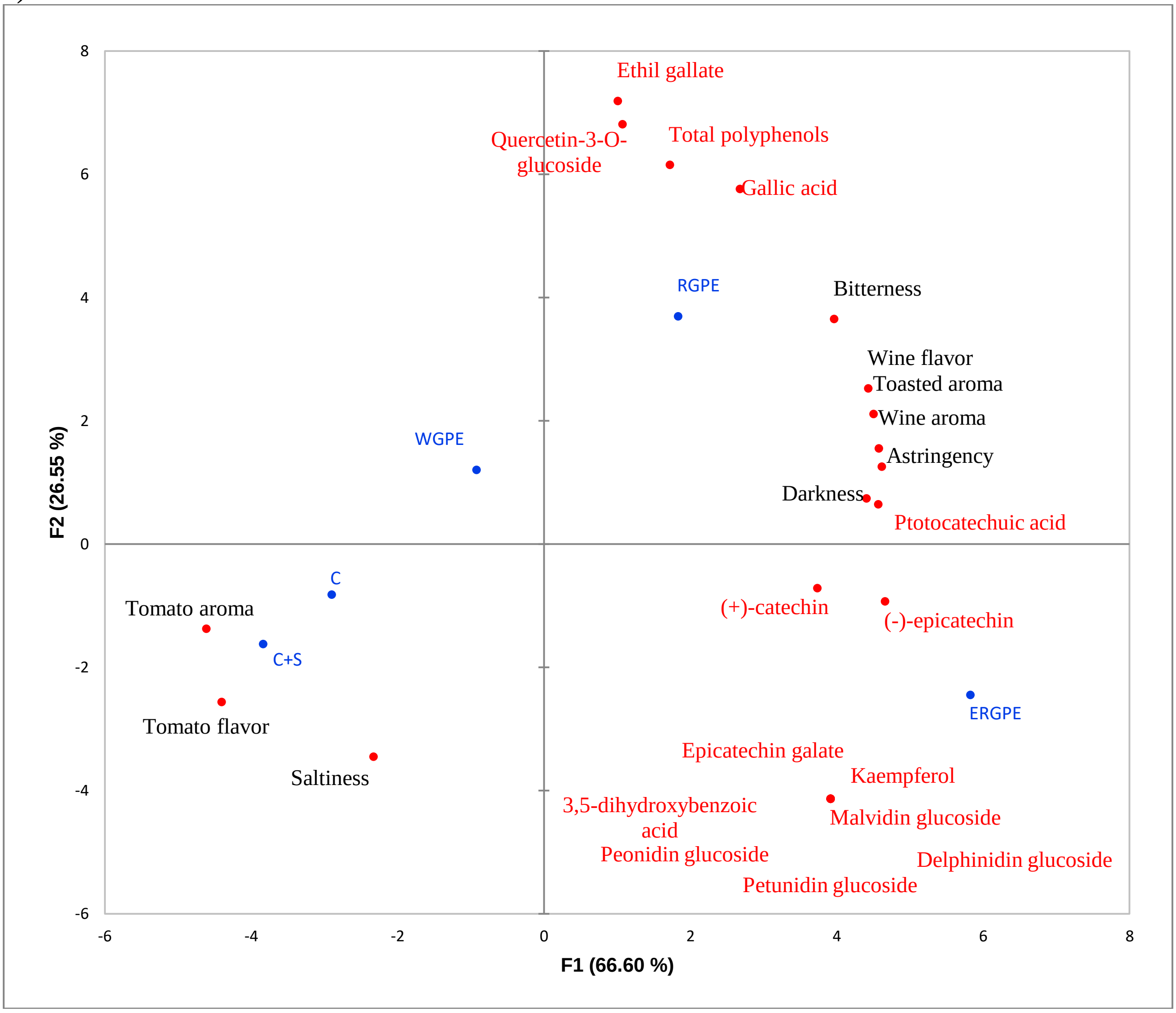
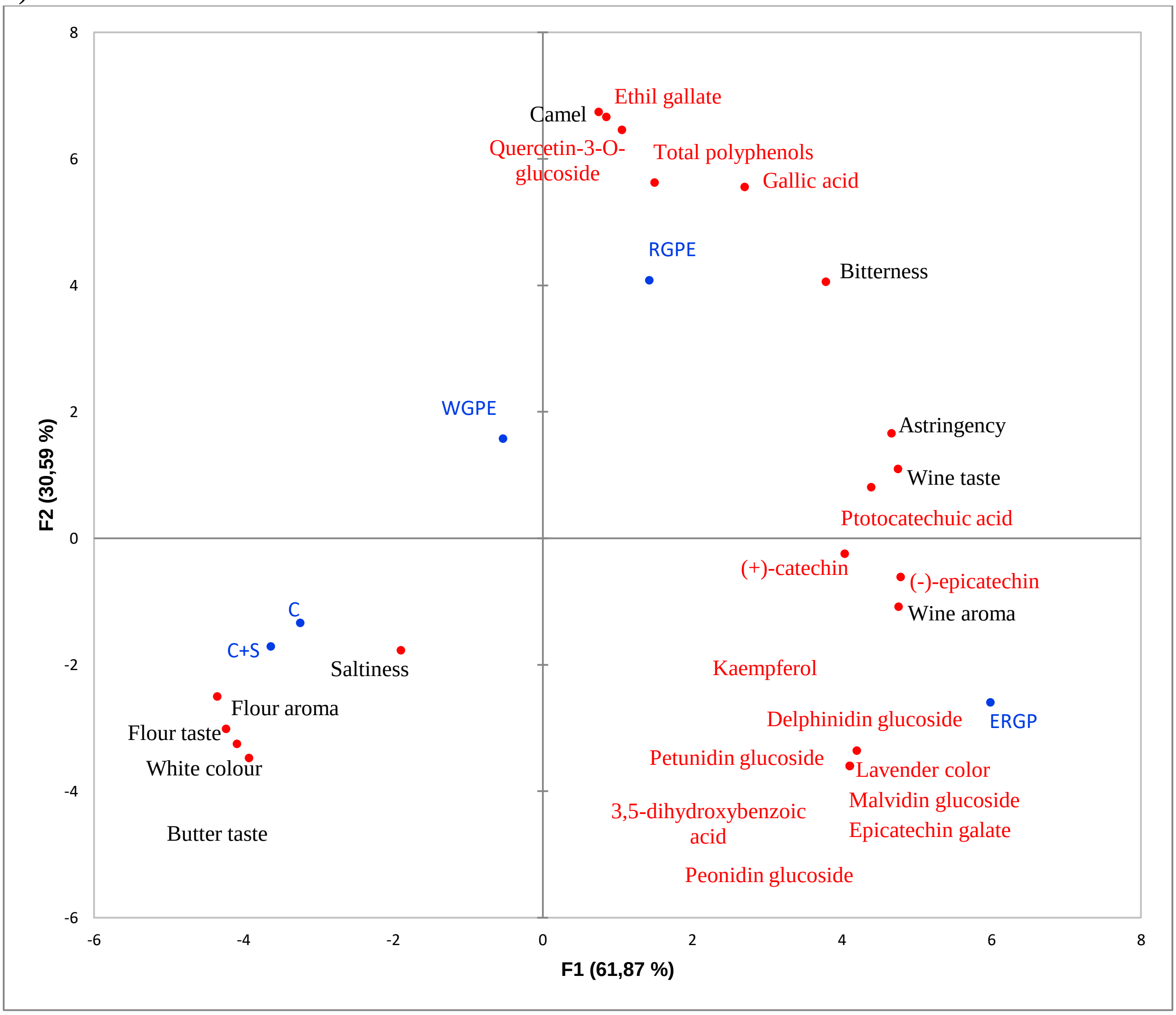



**Figure 2.** Sensory profile of the base systems not seasoned (Control, C), and seasoned with salt (Salt, S) or with GP extract (RGPE, ERGPE or WGPE). a) Tomato sauce, b) White sauce, c) Chicken broth. RGPE: red grape pomace extract; ERGPE: ecological red grape pomace extract; WGPE: white grape pomace extract.

a)


Ethil gallate
Quercetin-3-O-glucoside
Total polyphenols
Gallic acid
RGPE
Bitterness
Wine flavor
Toasted aroma
Wine aroma
Astringency
Darkness
Ptotocatechuic acid
WGPE
C
Tomato aroma
C+S
Tomato flavor
Saltiness
(+)-catechin
(-)-epicatechin
ERGPE
Epicatechin galate
Kaempferol
3,5-dihydroxybenzoic acid
Malvidin glucoside
Peonidin glucoside
Delphinidin glucoside
Petunidin glucoside
F2 (26.55 %)
F1 (66.60 %)
8
6
4
2
0
-2
-4
-6
-6
-4
-2
0
2
4
6
8

b)



Ethil gallate
Camel
Quercetin-3-O-glucoside
Total polyphenols
Gallic acid
RGPE
Bitterness
WGPE
Astringency
Wine taste
Ptotocatechuic acid
(+)-catechin
(-)-epicatechin
Wine aroma
C
C+S
Saltiness
Kaempferol
Flour aroma
Flour taste
Delphinidin glucoside
ERGP
Petunidin glucoside
White colour
Lavender color
Malvidin glucoside
3,5-dihydroxybenzoic acid
Epicatechin galate
Butter taste
Peonidin glucoside
F2 (30,59 %)
F1 (61,87 %)
8
6
4
2
0
-2
-4
-6

c)

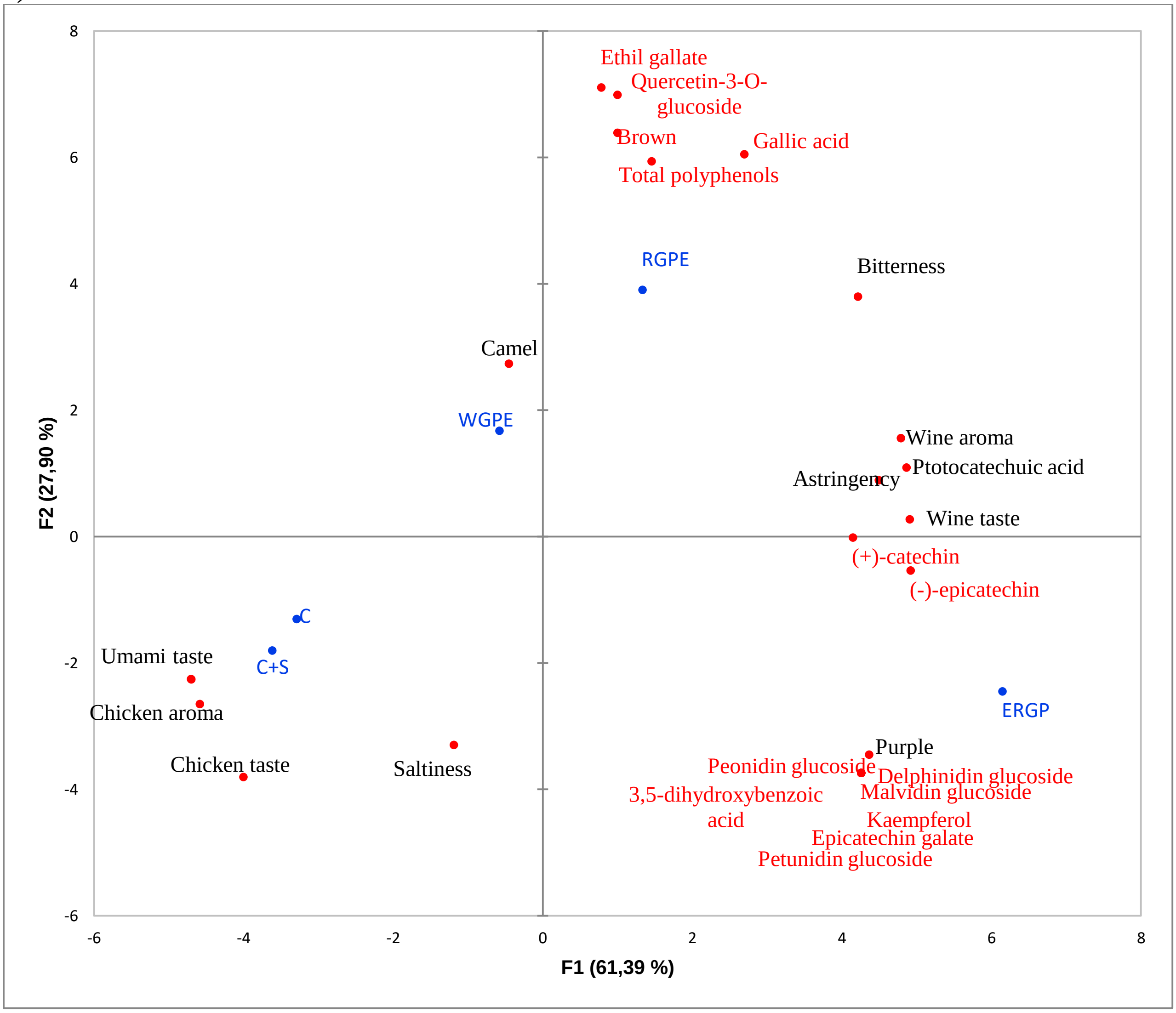
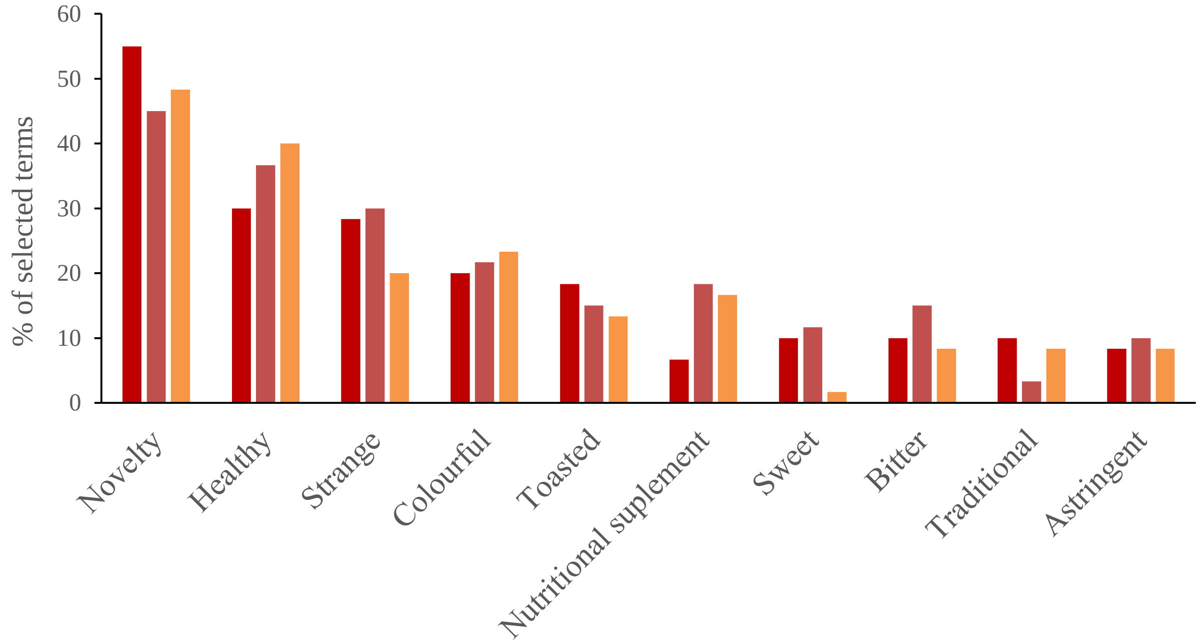
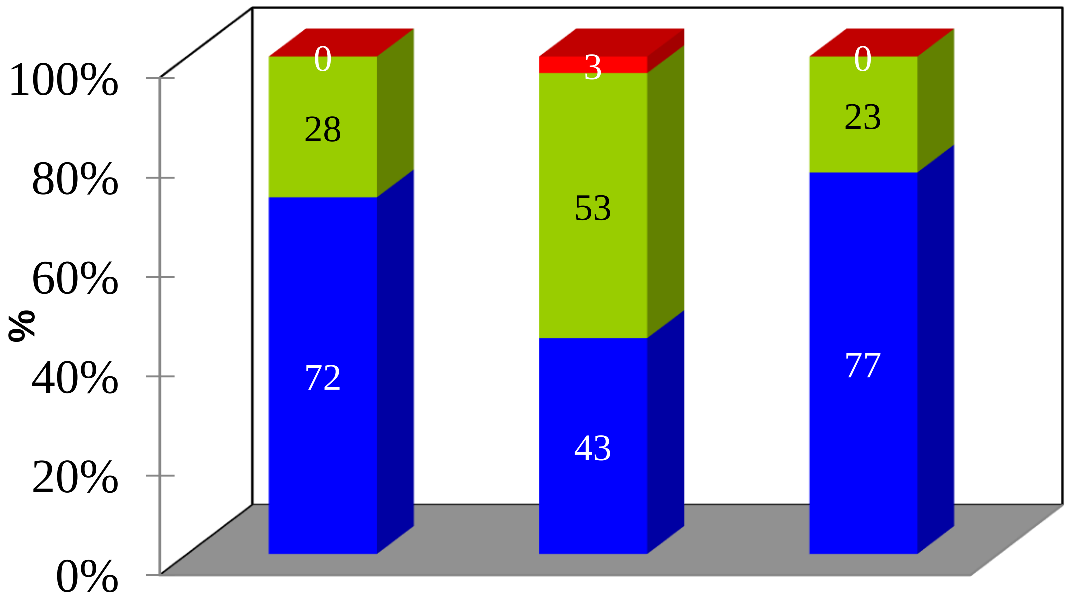



**Figure 3.** PCA of the phenolic composition and sensory attributes of the three base systems not seasoned (Control, C), and seasoned with salt (Salt, S) or with GP extract (RGPE, ERGPE or WGPE). a) Tomato sauce, b) White sauce, c) Chicken broth. RGPE: red grape pomace extract; ERGPE: ecological red grape pomace extract; WGPE: white grape pomace extract.




644
645 **Figure 4.** Percentage (%) of selected terms by consumers when testing the RGPE extract at home
646 with three different recipes (red: bolognese sauce, orange: risotto,r green: zucchini puree).




647
648 **Figure 5.** Percentage (%) of consumers' just about right ratings for the three recipes and the
649 saltiness attribute.

**Supplementary material**

**S1.** Recipes given to participants.

### a) Bolognese Sauce

**Ingredients:**

- 50g minced beef
- 50g minced pork
- 30g carrot
- 30g celery
- 30g white onion
- 20g concentrated tomato paste
- 50g tomato sauce
- 1g RGPE
- ½ clove
- 1 pinch of cinnamon
- 10g olive oil

**Method:**

1. Chop the celery, onion, and carrot. Put them in a pan together with the oil over low heat and cook for about 20 minutes.
2. Add the minced meat and cook over high heat until light brown.
3. Mix in tomato paste, cloves, and cinnamon. Cover the mixture with hot water.
4. Cook for 30 minutes over low heat until the water has evaporated and forms a consistent sauce.
5. Remove the heat, mix in the extract with the tomato sauce and add it to the saucepan. Mix well and serve.

### b) Risotto

**Ingredients:**

- 70g rice
- 80g mushrooms
- 3 asparagus
- 40g onion
- White wine
- 10g parmesan
- 250g vegetable stock
- 1g Vinesenti Vinius
- 1 knob of butter

**Method:**

1. Reserve 20g of broth and dissolve the extract in it.
2. In a saucepan, cook the chopped onion over low heat for 5 minutes. Add ¾ of the chopped mushrooms and cook them until they lose some water.

3. Add the rice, stir, and cook a couple of minutes. Add a splash of white wine and reduce the alcohol. Cook it approximately 2-3 minutes.

4. Next add the hot broth little by little and at intervals as it is absorbed while you are stirring the risotto with a spoon.

5. After about 12 minutes, add the grated Parmesan and stir until it dissolves.

6. Remove the saucepan from the heat and add the diluted extract and butter. Stir until it dissolves and takes on a creamy consistency.

7. In a pan with a few drops of oil, sauté the remaining mushrooms and the tips of the asparagus.

8. Serve the risotto with the mushrooms and sautéed asparagus on top.

**c) Zucchini Cream**

**Ingredients:**

- 350g zucchini
- 40g small onion
- Pepper
- Pinch of Nutmeg (2 g approx.)
- 25g cream
- 1g Vinesenti Vinius
- Virgin olive oil

**Method:**

1. Peel the zucchini, chop it and cook it in a saucepan with plenty of water for 20-30 minutes until it is tender. Drain and reserve the water.

2. Chop the onion and sauté for a few minutes in a pan with a few drops of oil.

3. Dissolve the extract in the cream.

4. Blend together the sautéed onion, zucchini, cream, and a little water from the cooking stock to form a cream.

5. Rectify the consistency if it is very thick.

6. Add pepper and nutmeg to taste and serve