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# Red Grape Pomace Addition Effect on Sensory Properties of Pork Sausages

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The wine industry produces a high amount of co-product known as grape pomace, which consists of grape skins, stems and seeds. This co-product is difficult to dispose of, mainly due to the high concentration of polyphenolic compounds. This could be, however, utilized in other food industries, such as the meat industry, which is currently in pursuit of replacing synthetic antioxidants with natural solutions. In our study, we enhanced pork sausages with grape pomace powder of two different cultivars *Vitis vinifera* L. (Cabernet Franc and Merlot), in the concentration of 5 $g.kg^{-1}$ on the day of preparation and on the last day storage period (21$^{st}$ day). We mechanically determined color by spectrophotometer and TA.XT textural analyzer to observe its effect on sensory parameters. Also, sensory evaluation by a seven-member panel was conducted. The observed parameters were aroma, taste, odor, consistency, and appearance. We proved that grape pomace addition could significantly alter the color of meat products without altering the textural properties such as hardness, chewiness, or resilience. During sensory evaluation on the first day, experimental sausages scored lower in all parameters than control samples. At the end of the storage period samples enhanced with grape pomace powder reached higher levels in aroma parameters and samples with Cabernet Franc had even higher scores in taste parameters than in control groups

**Keywords:** *Vitis vinifera*, meat product, sensory parameters

## Introduction

Grapes (*Vitis vinifera* L.) are highly valued both economically and nutritionally and are consumed worldwide. They are rich in polyphenolic compounds, which have well-known antioxidant properties, antimicrobial effects, and health benefits such as reducing LDL oxidation, decreasing platelet aggregation, and improving coronary blood flow (Spigno et al., 2017). Also, grapes are among the most extensively cultivated fruit crops globally, covering an estimated 7.2 million hectares. In 2023, global wine production from grapes was around 258 million hectoliters, underscoring the robust and essential role of the wine industry worldwide. Italy, France, and Spain lead in wine production, collectively accounting for

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nearly half of global output. Specifically, Italy produced approximately 47.5 million hectoliters in 2023, with France at 42.2 million hectoliters, and Spain at 35.7 million hectoliters (Perra et al., 2022). The winemaking process, however, generates substantial by-products, with grape pomace (GP) being the primary viticultural residue, representing roughly 20–30% of the total grape mass. For instance, processing 1000 kg of grapes typically yields 750 liters of wine and about 130 kg of GP, resulting in an estimated 9 million tons of GP waste annually (Oliveira and Duarte, 2014; Vukušić et al., 2023). However, the industrial processing of grapes produces a significant amount of solid organic waste, which is often discarded by food producers, even though it still contains high levels of polyphenols. Grape skins, seeds, and stalks, therefore, represent a promising source of dietary fiber and phenolic compounds that could be used as innovative, eco-friendly ingredients in the food industry (Baldissera et al., 2022).

In recent years, the accumulation of food waste has raised significant environmental and economic concerns. Across every stage of the supply chain, food waste represents a misuse of resources – including labor, water, and energy – necessitating efforts to recover or compensate for these inputs. As a result, efficient food waste management strategies have gained considerable attention within processing industries (Xiao et al., 2018; De Gorter et al., 2020). In response, international organizations are advocating for sustainable consumption and shifts in production practices, as outlined in the "Sustainable Development Goals" (SDGs). These goals emphasize: reducing food waste; advancing alternative technologies; and transitioning from a linear food model (produce, consume, dispose) to a circular economy model, which promotes more sustainable and efficient resource use (Jamaludin et al., 2022). The potential to repurpose grape pomace for various industrial products is largely due to its complex chemical makeup, which depends on factors like grape variety, environmental conditions, farming practices, and winemaking techniques (Bordiga et al., 2019). GP is particularly rich in nutritional and bioactive compounds, containing carbohydrates (about 12–40%), proteins (around 4–15%), lipids (approximately 2–14%), fibers (17–88%), vitamins and minerals (2–7%), and polyphenols (0.2–9%) (Antonić et al., 2020). Because of this diverse composition, GP could serve as an alternative source of essential nutrients for the food industry, supporting the development of new functional foods that may benefit human health and nutrition (Pereira et al., 2020).

Meat is a complex material that is highly prone to oxidation. Because of its composition and the interactions between natural pro-oxidant agents and processing methods, meat is vulnerable to reactions that degrade its lipids and proteins. This oxidative stress can reduce the sensory and nutritional quality of meat, which impacts its appeal to consumers (Estévez, 2021). To address this, the meat industry is working on methods to maintain product quality by using agents that slow down these deterioration processes. Additionally, the growing interest in healthier food options has led to research focused on finding bioactive and functional molecules from natural sources (Silva et al., 2022). In this context, plant extracts high in phenolic compounds are promising for use in meat products. The antioxidants in these compounds help extend shelf life and offer health benefits to consumers (Lorenzo et al., 2017). The chemical and nutritional composition of the grapes is directly influenced by climatic variations, forms of cultivation, variety, sanitary conditions, and maturation stage. The processing methods interfere with the sensory characteristics of grape products and the chemical components that remain retained in bagasse (Chikwanha et al., 2018).

In our study, we incorporated red grape pomace into raw cooked meat products to determine the possible changes on sensory quality of such products. Valorization of current wine-making co-products would help to reduce the agricultural waste produced and at the same time enhance the meat product oxidation stability due to high polyphenol concentration of grape pomace. However, sensory quality and of such products is crucial for the customers and their acceptance of those novelty products.

## Materials and methodology

### Plant material

Grape pomace from cultivars Cabernet Franc and Merlot was sourced from the Tajna winery in Slovakia. All samples originated from a single location in the municipality of Tajná within Slovakia's Nitra wine region. Samples were dried at 50 °C over four days in a Memmert SF 110 drying oven (Memmert GmbH, Schwabach, Germany) and then homogenized for 60 seconds at 25,000 rpm using an IKA A10 batch mill (IKA-Werke GmbH & Co. KG, Staufen, Germany).

### Pork sausage preparation

The meat product formulation included water, pork meat, nutmeg, black pepper, sweet and spicy paprika, and a curing mix containing 0.3% sodium nitrite. Pork loin and shoulder, sourced from a local butcher, were ground, blended with spices, and thoroughly homogenized. The resulting meat batter was divided into three following groups: Control – without antioxidants; Cab. Franc – with 5 g.kg-1 Cabernet Franc powder; and Merlot – with 5 g.kg-1 Merlot powder.

### Color measurement

A portable spectrophotometer (CR 400, Konica Minolta, Japan) was used to measure the color of sausage samples. with the setting Specular Component Included (SCI). The D65 light source and a 10° observer, with a port 8 mm in diameter were used. Three color attributes—lightness (L*), redness (a*), and yellowness (b*)—were recorded.

### Textural analysis

The texture profile analysis (TPA) test using the TA.XTplus Texture Analyzer was used to analyze textural properties. TPA consists of applying two deformation cycles that affect the sample. Between these two compression cycles, the sample rests for a certain period. This test monitored 5 parameters, namely: hardness, fracturability, springiness, cohesiveness, gumminess, chewiness, and resilience.

### Sensory evaluation

Sensory evaluations were conducted on days 1 and 21 of storage. A five-point scale was employed to assess five key parameters – Color, Aroma, Taste, Consistency, and Surface Appearance – following the guidelines set by the Decree of the Ministry of Agriculture and Rural Development of the Slovak Republic No. 83/2016 Coll. on meat products. The sensory panel comprised seven trained evaluators of both genders, aged between 25 and 55.

### Statistical analysis

In our study, we performed an analysis of variance (ANOVA) deploying Duncan's test to determine the statistical differences among samples at significance level α = 0.05 and Pearson correlation test using XLSTAT® software (version 2018.5.52280, Addinsoft, New York).

## Results and discussions

### Color measurement results

On the first day, the Control group consistently showed higher values across all color parameters, with the most consistent differences observed in the a*(D65) parameter where all group comparisons were significantly different. The b*(D65) and L*(D65) parameters showed more selective differences between specific group pairs. At the end of the storage period Control samples appear to be significantly different from samples containing Merlot pomace powder across all measurements, while experimental sausage groups are more similar to each other.

The effect on color coordinates of meat products enhanced with grape pomace in various forms is well documented. Garrido et al. (2011) reported the darkening of beef patties after the addition of various grape pomace extracts, and also significant changes during 6-day storage. Ryu et al. (2014) conducted a study with various concentrations of grape pomace powder and reported a continuous decrease of all color parameters with the increment of powder concentration. Significant changes were also proven in pork loin samples marinated with grape pomace-enhanced marinade (Lee et al., 2017). The strong coloring potential of grape pomace was further underscored by Turcu et al. (2020) in which authors reported color changes in chicken thigh meat of broilers consumed grape pomace powder-enhanced feed. Change of color is not necessarily a bad marker, the final say will always have a customer and his acceptance of experimental product.

**Table 1** Color measurement results

| Sample | Day 1 | | | Day 21 | | |
|---|---|---|---|---|---|---|
| | L*(D65) | a*(D65) | b*(D65) | L*(D65) | a*(D65) | b*(D65) |
| **Control** | 68.61 ±0.63$^{a}$ | 13.34 ±0.26$^{a}$ | 19.60 ±0.25$^{a}$ | 67.32 ±0.51$^{a}$ | 13.23 ±0.67$^{a}$ | 19.94 ±0.35$^{a}$ |
| **Cab. Franc** | 65.53 ±1.10$^{ab}$ | 10.50 ±0.47$^{b}$ | 16.16 ±0.78$^{b}$ | 65.10 ±1.07$^{ab}$ | 10.96 ±0.41$^{b}$ | 16.17 ±0.5$^{6b}$ |
| **Merlot** | 64.18 ±1.27$^{b}$ | 9.50 ±0.05$^{c}$ | 14.66 ±0.30$^{b}$ | 63.84 ±0.64$^{b}$ | 9.75 ±0.29$^{b}$ | 14.99 ±0.37$^{b}$ |

Note: Results are expressed as x̄ ± S.D.; a, b, c as upper index indicate significant differences among groups in a collum

**Table 2** Results of textural analysis on the 1st and 21st day of storage

| Parameter | Day 1 | | | Day 21 | | |
|---|---|---|---|---|---|---|
| | Control | Cab. Franc | Merlot | Control | Cab. Franc | Merlot |
| **Hardness** | 5.10 ±2.01 | 6.54 ±0.82 | 5.03 ±1.05 | 7.50 ±0.57 | 8.23 ±0.76 | 7.54 ±0.72 |
| **Fracturability** | 6.34 ±1.41 | 6.10 ±1.29 | 5.40 ±0.47 | 7.99 ±0.44 | 6.84 ±2.15 | 8.19 ±0.52 |
| **Springiness** | 0.88 ±0.02 | 0.86 ±0.02 | 0.88 ±0.03 | 0.89 ±0.03 | 0.81 ±0.11 | 0.88 ±0.01 |
| **Cohesiveness** | 0.57 ±0.08 | 0.53 ±0.10 | 0.56 ±0.04 | 0.62 ±0.08 | 0.70 ±0.08 | 0.53 ±0.16 |
| **Gumminess** | 4.30 ±0.36 | 4.01 ±0.42 | 4.02 ±0.57 | 4.70 ±0.93 | 5.80 ±1.12 | 3.96 ±1.23 |
| **Chewiness** | 3.92 ±0.40 | 4.61 ±0.30 | 4.82 ±0.43 | 4.21 ±0.97 | 4.66 ±0.85 | 3.48 ±1.10 |
| **Resilience** | 0.21 ±0.04 | 0.23 ±0.03 | 0.27 ±0.03 | 0.31 ±0.04 | 0.36 ±0.05 | 0.26 ±0.10 |

**Note:** Results are expressed as $\bar{x} \pm$ S.D.

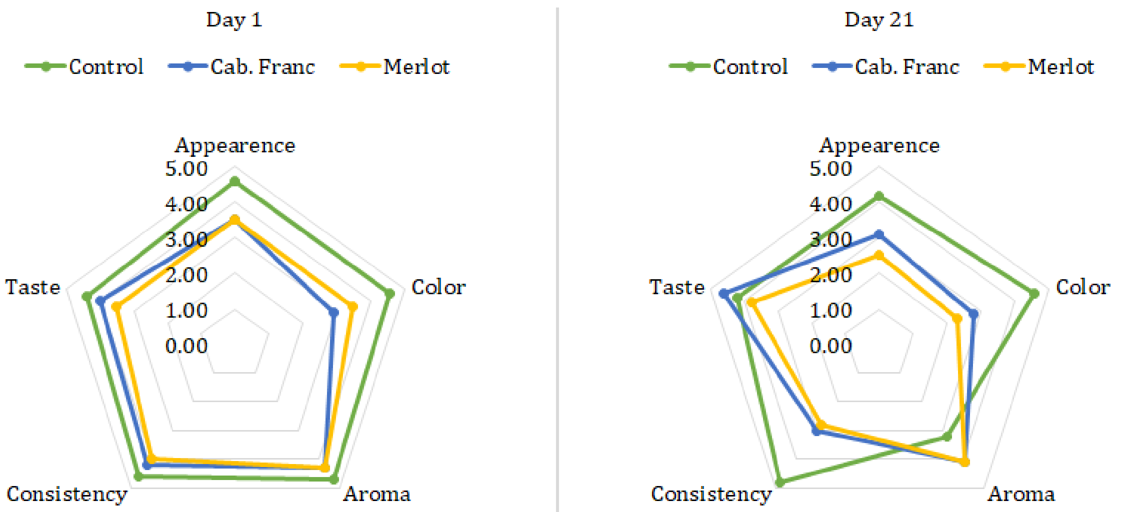


**Figure 1** Graphic expression of sensory evaluation conducted on the 1st and 21st day

## Textural analysis results

During our analysis, we observed seven textural parameters, namely hardness, fracturability, springiness, cohesiveness, gumminess, chewiness, and resilience. The whole analysis was carried out with fresh meat products, on day 1, and at the end of the storage period (day 21). On both, the 1st and 21st day, we did not observe any statistically significant ($p \geq 0.05$) differences among pork sausage groups at any of the observed parameters. However, we observed an increase, most notably, in hardness and resilience of samples after storage. This could be explained by possible water loss of samples during storage and an increase in firmness as a consequence.

Pereira et al. (2022) tried to enhance beef patties with a 2 and 4% addition of grape pomace powder and observed an increase in hardness, springiness, gumminess, and chewiness. This difference could be caused by notably higher enhancement than in our work, 2 and 4% compared to 0.5%. Including dietary fibers in food products affects their stability and texture, depending on the fiber's solubility and the processing methods used (Adıbelli and Serdaroglu, 2017). Grape pomace, which consists of 80% dietary fiber in its dry matter, can enhance the hardness and shear force of pomace-enhanced meat products. Studies have shown that adding fiber typically increases the firmness and binding properties of burgers while also reducing their fat content (López-Vargas et al., 2014; Pietrasik et al., 2020). Dietary fiber and phenolic compounds can enhance the shelf life, freshness, and texture of food products. High-fiber foods are also recognized for their health benefits to humans (Pathania and Kaur, 2021). The same results, the hardening of meat products was reported in low-fat chicken meatballs with 2.4 and 6.0% addition of grape pomace powder (Santhi et al., 2022). On the other hand, Yıldız et al. (2024) reported no significant differences in Turkish traditional fermented meat product, sucuk, in hardness, cohesiveness, gumminess, or chewiness after up to 3% addition of grape pomace powder. Those findings suggest that changes in meat products after grape pomace addition depend on the concentration of grape pomace addition and the type of meat product as well.

**Sensory evaluation**

Sensory evaluation was carried out at 1 and 21 days of storage. During the evaluation, statistically significant differences ($p \leq 0.05$) between individual samples were detected. On the first day of evaluation, the control sample achieved the best score in all monitored parameters. The experimental samples achieved the lowest scores in the appearance and color parameters due to the addition of Cabernet Franc and Merlot powder. On the other hand, at the end of the storage period (21 days), the control sample achieved the best evaluation in appearance, color, and consistency. The sample with the addition of Cabernet Franc. powder achieved the highest score in the parameters of aroma and taste. From the sensory point of view of the comparison of experimental groups, the addition of powder from the Cabernet Franc variety appears to be a more suitable addition to pork sausages.

Sensory dissatisfaction is one of the factors that limit the use of wine pomace in meat products. Selani et al. (2011) observed a significant effect of two grape varieties on the quality of chicken meat. They observed color and flavor changes in the samples with the addition of grapes, similar to our study. Brannan (2009) also observed significant color changes in samples with the addition of grape seed extract. Similar conclusions were reached by the authors Aquilani et al. (2018), who stated that the most significant changes were related to the color of the products. Özvural and Vural (2011) observed an overall decrease in the acceptability of sausages after the addition of grape seed flour even though products made with concentrations lower than 0.05% resulted in scores similar to the control. Riazi et al. (2016) reported that the application of grape pomace improved the sensory properties (especially taste) of the produced beef sausages compared to control and blank preparations. Pereira et al. (2022) observed no significant difference between control and Merlot beef burger patties in flavor, juiciness, and color, whereas lower sensory attributes were observed for texture, taste, and overall acceptability.

## Conclusions

During our experiment, we proved the significant effect of red grape pomace powder addition on the mechanically measured color of pork sausage samples. Also, the significant difference among groups was observed by a sensory panel, mainly in color, appearance, and consistency. On the other hand, all textural parameters measured by TPA were not affected by red grape pomace powder addition on the first, or the last day of storage period. Overall, the addition of red grape pomace did not enhance the properties of pork sausage and was not accepted by evaluators of sensory panels. Questions about further utilization of grape pomace are still current and its integration into meat products is still possible. However, it is necessary to find different forms, such as extract, or experiment with different meat products.

**Conflict of interest**

The authors declare no conflict of interest.

**Ethical statement**

This article does not include any studies necessitating an ethical statement.

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