Scientific Papers. Series D. Animal Science. Vol. LXVI, No. 1, 2023
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

A PRELIMINARY INVESTIGATION INTO THE ENHANCEMENT OF CHEESE WITH GRAPE SKIN POWDER

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Abstract

Improving management and making the food industry more sustainable requires a focus on reducing waste and finding uses for by-products. In the case of grapes, by-products account for approximately 20%. It is worth noting that these by-products contain beneficial phenolic compounds that have anti-allergenic, antibacterial, anti-carcinogenic, anti-inflammatory, antioxidant, and cardioprotective effects. For these reasons, the food industry sector must turn its attention to them and use them as functional ingredients. In this study, grape skin powder (GSP) was added to cheese to increase its antioxidant and bioactive compounds content. The enriched cheese contained significantly higher levels of total phenolic content (TPC) and antioxidant activity compared to the control sample. Adding 2% grape skin powder resulted in an increase of 1.927 mg GAE/g DW (mg gallic acid equivalents (GAE) per gram of dry weight (DW)) of TPC in cheese formulation. The GSP-supplemented cheese also showed greater antioxidant activity than the control. This study demonstrates that grape by-products can effectively transfer beneficial compounds to cheese.

Key words*: by-products, cheese, food, quality.*

INTRODUCTION

One of the most pressing issues that the food industries are grappling with is the alarming amount of waste that they generate (Comunian, et al., 2021). This waste is largely made up of food by-products that are discarded without any regard for their potential value. This problem is not just an isolated issue but is, in fact, a major global challenge that demands our immediate attention. The sheer scale of this problem is staggering, and it represents a inefficient use of our precious natural resources. It is high time that we take this issue seriously and work towards finding sustainable solutions to address this problem (Bedoić et al., 2019).

Agricultural and food by-products can play a role in the production of animal feed and the development of sustainable functional foods (Bedoić et al., 2019).

To achieve this, we must efficiently utilize waste as raw materials and promote strategies that are rooted in green and sustainable technologies. In doing so, we can ensure that we leverage the full potential of these valuable resources while minimizing their environmental impact (Gustavsson et al., 2011).

Grapes are widely regarded as one of the most extensively cultivated fruits across the globe. Specifically, in the continent of Europe, a staggering 3.5 million hectares of land are solely dedicated to the cultivation of this succulent fruit. As a result of this effort, an impressive 27 million tons of grapes are produced annually, highlighting the sheer scale and importance of grape cultivation in this region (FAO, 2019). It has been estimated that each year, some 14.5 million tons of grape by-products are produced. This quantity of waste is primarily composed of grape pomace, which makes up a significant portion (50-65%) of the total by-product volume (Teixeira et al., 2014). Indeed, grape skin is the main constituent of this pomace, underscoring its importance as a source of valuable nutrients and bioactive compounds (Aliaño-González et al., 2022).

These by-products are of utmost importance from an environmental perspective, as they can be utilized as sources of nutrients and various bioactive substances for internal nutrition and feeding (Câmara et al., 2020).

Additionally, when it comes to mineral composition, grape pomace is abundant in Ca, P, Mg, K, and Fe content (Shrikhande, 2000; Galanakis, 2017). Therefore, it is crucial to utilize these by-products to their fullest potential, not only for their nutritional value but also for their positive impact on the environment (Hassan et al., 2020).

The addition of grape by-products to various food items will undoubtedly result in the creation of functional food products, thereby introducing natural functional food ingredients such as dietary fibers and polyphenols into commonly consumed foods. Such practices not only benefit our health but also have a positive impact on the environment.

A significant development in the food industry has been the utilization of grape by-products in various sectors such as the beverage, bakery, and dairy industries (Gaglio et al., 2021). This innovative approach has enabled manufacturers to maximize the potential of grapes, not just for their fruit or juice but also for their by-products. As a result, grape by-products have become an essential ingredient in the food industry, providing a new dimension of flavour and nutritional benefits to a wide range of products (Chouchouli, 2013).

To sum up, after conducting several studies, it has been discovered that grape and wine by-products hold significant importance as a rich source of functional compounds that can be utilized in the production of various dairy products. These dairy products may include fermented milks, yogurts, cheeses, or ice-creams (Dos Santos et al., 2017). It is noteworthy to mention that these by-products have been found to contain a plethora of beneficial nutrients that can enhance the nutritional value of the final products (Pavlou, 2021).

Furthermore, it has been suggested that incorporating grape by-products into dairy products could be a viable method for enhancing their shelf life, as demonstrated in previous research (Tseng et al., 2013). This is due to the fact that grape by-products are known to contain high levels of phenolic compounds and antioxidants, which are not typically found in dairy products (Albu et al., 2018; Kandylis et al., 2021).

Interestingly, cheese in particular may benefit from the addition of grape by-products, as they have been shown to significantly increase the total phenolic content and radical scavenging activity of this popular dairy product (Gaglio et al., 2021). Additionally, studies have evaluated the impact of grape by-products on the microbiological aspects of dairy production, with promising results reported in numerous cases (Barbaccia et al., 2022). Overall, it appears that grape by-products have great potential as a functional ingredient for enhancing the quality and longevity of dairy products.

Furthermore, the addition of grape by-products can reduce the fat content of cheese and increase protein levels since GPP (grape pomace powder) are low in lipid components, including them in cheese led to a reduction in fat while simultaneously increasing protein content (Gaglio et al., 2021). Grape by-products can serve as coagulant in the production of tofu and may change its textural parameters, and even its colour (Zeppa et al., 2021). Therefore, incorporating these by-products into dairy formulations can be a wise and healthy choice, which can also contribute to the sustainability of the food industry (Albu et al., 2018; Baron et al., 2021).

For this reason, the main objective of the present study was to investigate the potential benefits of grape skin powder in terms of providing natural antioxidants and other lipophilic bioactive compounds to the cheese composition of the assorted cheese products. In order to achieve this goal, a thorough examination was conducted on the efficacy of grape skin powder as a viable source of these crucial components. The findings of this research have significant implications for the cheese industry, as the use of natural, plant-based ingredients can enhance the nutritional value and overall quality of the cheese products. Therefore, this study aims to provide valuable insights into the use of grape skin powder as a functional ingredient in the cheese-making process**.**

MATERIALS AND METHODS

30 kg of Feteasca Neagră grapes from USV-Iasi's farm were washed, dried and hand-separated (Figure 1 a). The skin was lab-dried at 40ºC with 1 m/s air speed for the powder preparation (Figure 1 b, c).

a. Pulp removal b. Skin dry c. Powder

Figure 1 Obtaining the powder from the grape skin

The Rediu Iași Research Station, under the University of Life Sciences, supplied 300 L of cow's milk from their 55 Fleckvieh/Simmental cattle.

Extraction of bioactive compounds from grape skin powder (GSP). A quantity of 1 g of dried peels grape powder was utilized for the ultrasound-assisted extraction along with 9 mL of the solvent (80% ethanol) and 1 ml of 1% citric acid. The extractions took place at 40°C for 45 minutes using a sonication water bath (MRC Scientific 193 Instruments, Holon, Israel). In order to obtain extracts rich in anthocyanins, the extraction process was repeated three times. The supernatants were then collected and centrifuged for 10 minutes at 6000 rpm and 4°C. The resultant supernatants were concentrated to dryness at temperature of 40 °C, under reduced pressure (AVC 2-18, Christ, Shropshire, UK), and the obtained extract was dissolved in the extraction solvent and then used for the phytochemical characterization.

Determination of the Total Anthocyanins Content (TAC). A modified pH differential technique was utilized to determine the total monomeric anthocyanins content (TAC) (Lee et al., 2005). Prior to determination, the samples were diluted (1:10) with the extraction solvent. The absorbance of the diluted extracts was then measured at two different wavelengths, 520 nm, and 700 nm (UV-VIS spectrophotometer Libra S22, Biochrom, UK), using 200 µL of vegetable extract and 800 µL of two different buffers solutions (0.025 M potassium chloride buffer at pH 1.0 and 0.4 M sodium acetate buffer at pH 4.5). Results were given in milligrams of cyanidin-3-glucoside (C3G) per gram of dry weight (DW) (mg C3G/g DW).

Determination of the Total Phenolic Compounds (TPC). The total phenolic compounds content (TPC) in the extract was determined by the Folin-Ciocâlteau method (Sant'Anna et al. 2012) using Gallic acid as standard. Briefly, 1 mL of Folin-Ciocâlteu reagent and 15.8 mL distilled water were added to 200 µL of extract, to a final volume of 17 mL. 3 mL of 20% Na_2CO_3 was added after 10 minutes, and the mixture was kept at 25°C in a dark place for 60 minutes. The absorbance of the reaction mixture was measured at a wavelength of 765 nm by UV-VIS spectrophotometer with data analysis software (Libra S22, Biochrom, UK) and the results were expressed as mg gallic acid equivalents (GAE) per gram of dry weight (DW) (mg GAE/g DW).

Determination of the Total Flavonoids Compounds (TFC). The aluminium chloride colourimetric method was used for the determination of the total flavonoids compounds (Dewanto et al., 2002). For TFC content the assay involved the mixing of 0.25 mL of extract sample with 1.25 mL of distilled water and 0.075 mL of 5% sodium nitrite solution. A volume of 0.150 mL of 10% aluminium chloride solution was added and allowed to react for 6 min at room temperature after the initial 5 min of reaction. In addition, 0.750 mL of distilled water and 0.5 mL of 1M sodium hydroxide were added, and the

mixtures' absorbance was then measured instantly at 510 nm by UV-VIS spectrophotometer with data analysis software (Libra S22, Biochrom, UK). The TFC content was expressed in mg catechin equivalents (CE) per g dry weight (mg CE/g DW), based on the catechin standard curve.

Determination of antioxidant activity (DPPH). The antioxidant activity was determined by DPPH (2,2-diphenyl-1-picryl-hydrazyl-hydrate) assay. The capacity to inhibit the DPPH radical derived from the fact that the purple colour of DPPH turns yellow when the full quantity of free radicals is blocked by the antioxidants. The DPPH scavenging activity was measured by using the method described by Turturică et al. (2015). Briefly, a mixture was obtained by adding 3.9 mL of 0.1 M DPPH solution and 200 µL extract. The mixture was stored at 25°C for 90 minutes in a dark area. The mixture absorbance was determined at a 515 nm wavelength by UV-VIS spectrophotometer with data analysis software (Libra S22, Biochrom, UK). Also, a control was made by mixing 3.9 mL DPPH solution 0.1 M and 200 µL methanol. The absorbance mixture was then measured.

The results obtained were expressed as mM Trolox/ g DW.

The DPPH Inhibition (%) was calculated using the following formula:

$$\% \text{ Inhibition} = (A_{blank} - A_{sample}/A_{blank}) \times 100,$$

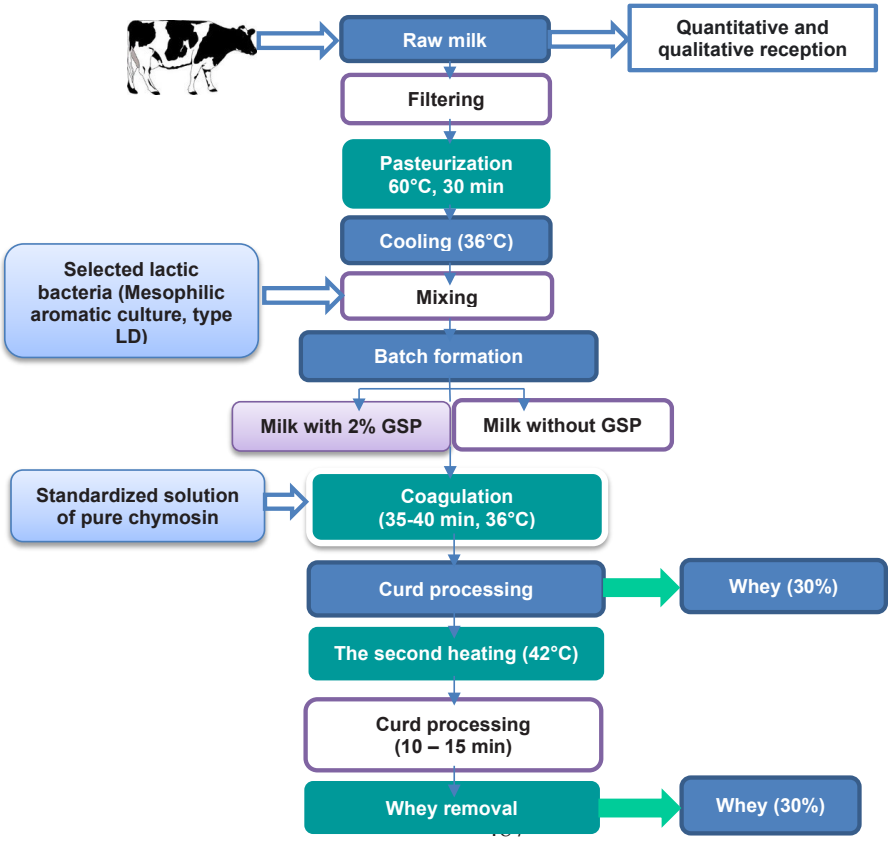
A_{blank} - absorbance of the control sample;

A_{sample} - absorbance of the sample.

Cheese making. 300 L of milk were taken from the farm's storage tank and delivered to the University of Life Sciences for processing. The milk was kept at 5°C in a storage tank. Five samples were taken from the reservoir in sterile containers weighing 300 ml each. The samples were transported in a separate box with ice packs and refrigerated at 4°C for 24 hours.

The milk was homogenized and analysed in the laboratory with five replications per trait/method. Physicochemical parameters of milk samples were analysed using AOAC, 1990 methods to determine moisture, solid non-fat, fat, protein, ash and pH.

In Figure 2 is the technological flow of cheese manufacturing (Caciotta cheese).



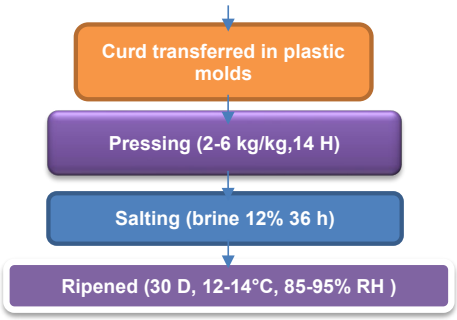


Figure 2. Technological flow of cheese manufacturing

In this case, the milk used in the technological process was not normalized (full-fat milk was used). The milk was pasteurized at 60°C for 30 minutes, after which it was cooled to 36°C degrees, at which point selected lactic bacteria were added. After homogenization, the two batches (CC and CGSP) were created. Coagulation, coagulum processing and molding (putting the coagulum into forms) was done separately for each batch.

Regarding the part of the qualitative analysis carried out to establish the qualitative parameters of both the product with the addition (Cheese with grapes skin powder - CGSP) and the control product (CC), sensory, physical (pH, colour and texture) and chemical analysis were performed (water, dry matter, F/DM (fat reported on dry matter content), protein, ash and salt content).

Sensory session. The samples were evaluated descriptively through the use of standard terminology and references. Two separate samples were examined during the sensory session for each of the qualities, with each sample being divided into three replicates for each of the assessors. Muir et al., (1996), describe an experimental strategy utilized to remove carryover and order of tasting bias is detailed in depth. 16 characteristics for the tested cheeses were chosen and carefully defined for profiling using the QDA (Qualitative Data Analysis) approach (Table 1).

Table 1. Attribute list used in QDA analysis

Descriptor	Characteristics
Colour	visual intensity measurement
Creamy odour	market-cream odour (30%)
Acid odour	A characteristic flavour of fermented milk products like yoghurt
Buttery	flavour connected to butter
Flowers/fruits	the fragrant fusion of several fruity flavours, including red berries, juicy apples, and pineapple. Additionally, it might contain the aromas connected to sweetened cultured dairy products such fruit yoghurts.
Salty	sodium chloride's characteristic basic flavour when diluted in water (0.2%)
Sweet	basic taste experience that sucrose often has
Acid	fermented milk products' flavour
Bitter	flavour, basic caffeine taste in water (0.5%)
Aftertaste	aftertaste that persisted after the sample was taken away
Hardness*	the amount of force required by the jaws to tear the sample in half
Chewiness	length and frequency of chewing the substance before swallowing
Rubbery	the sample's capacity to reshape itself after pulling
Dryness (moisture)	moisture in the sample, mouthfeel after four or five chews
Grainy	the sample's capacity to splinter into parts
Overall quality	general impression based on what people like and dislike

These characteristics included colour, scent (creamy, acid, buttery, fruits), taste (salty, acid, sweet, bitter, aftertaste), and texture (hardness, chewiness, rubbery, dryness, grainy). Continuous unstructured graphical scales were used to rate the attribute intensities. The scales

were 10 cm long with verbal anchors at either end, with the left side representing the attribute's lowest intensity (value 0) and the right side representing its highest intensity (value 10). The
same type of scale as described above, which is anchored at both ends, was used to evaluate the overall quality of cheeses: unlinking (0)-extremely linking (10).

Physical parameters. pH was determined by potentiometric analysis, with the electrode being inserted directly into the cheese wheel.

The colour characteristics were measured using the MINOLTA Chroma Meter model CR-410 (Konica Minolta, Osaka, Japan) with a CIE Lab scale. The Chroma parameters were read using A* (red (> 0) to green (< 0) colour), b* (yellow (> 0) to blue (<0) colour), and L* (black: L* = 0 and white: L* = 100). The results were expressed in triplicate, following equipment calibration against a white plate. The colour was described by hue angle (Hue angle = arctan(b*/a*) for quadrant I (+a*, +b*), where 0° or 360° indicated red colour, 90° indicated yellow colour, 180° indicated green colour, and 270° indicated blue colour. The purity or saturation of colour, also known as chroma, was also determined (Chroma = $\sqrt{(a^*)^2 + (b^*)^2}$)(Dag et al., 2017).

The statistical analysis was performed using the SPSS program (ver. 19), which has a multi-function utility with regard to the experimental design. comparisons were performed using single factor ANOVA in according with Pallant, (2016).

Chemical parameters. The quantification of the fat content was accomplished through the Soxhlet extraction technique (Wojciechowski et al., 2016), a widely recognized and accepted analytical technique. In tandem, the protein content was assessed using the Kjeldahl method, another established and precise method for measuring this nutritional component (Barbano & Clark, 1990; Lynch & Barbano, 2006). Additionally, the determination of water, dry matter and F/DM content were conducted in strict accordance with the AOAC's 2012 guidelines, a well-respected and rigorously researched set of protocols. Titration with $AgNO_3$ (International Standard FIL-IDF 88/A: 1988) was used to determine the concentration of sodium chloride (salt content).

RESULTS AND DISCUSSIONS

Characterization of the GSP extract. In the current study, the extraction process was performed using the ultrasound-assisted extraction method, with ethanol 80% and citric acid (1%) as a solvent. The biologically active compounds content and antioxidant activity of the GSP extract were evaluated and the results are presented in Table 2.

Table 2. Phytochemical content and antioxidant activity of the GSP extract

Sample	TAC[1] (mg C3G/g DW)	TFC[2] (mg CE/g DW)	TPC[3] (mg GAE/g DW)	DPPH[4] (mM Trolox /g DW)	Inhibition %
GSP[5]	1.242±0.019	10.175±0.128	22.357±0.535	20.591±0.093	78.587 ±0.355

[1] - Total Anthocyanins Content
[2] - Total Flavonoids Compounds
[3] - Total Phenolic Compounds
[4] - Antioxidant Activity (DPPH)
[5] - Grape Skin Powder

The extract's TAC was 1.242±0.019 mg C3G/g DW, and its TFC and TPC values were 10.175 ± 0.128 mg CE/g DW, and 22.357 ± 0.535 mg GAE/g DW, respectively. The GSP extract's radical-scavenging activity was 20.591 ± 0.093 mM Trolox/g DW, with 78.587 ± 0.355% inhibition of DPPH radical.

Therefore, Serea et al., 2021 reported similar values for anthocyanins (1.36 ± 0.14 mg C3G/g DW), polyphenols (16.51 ± 3.20 mg GAE/g DW), flavonoids contents (10.61 ± 0.82 mg CE/g DW), and for antioxidant activity (15.20 ± 0.70 mM Trolox/g DW) in ultrasound-assisted extracts of *Băbească neagră* red grapes skins using 96% ethanol at 25ºC for 55 minutes.

Additionally, Constantin et al., 2015 extracted the biologically active compounds from *Feteasca neagră* red grapes skins using a conventional method (at 28ºC for 2 hours) and

reported anthocyanins of 18.54 ± 0.34 mg C3G/g DW, flavonoids of 2.27 ± 0.20 mg CE/g DW, polyphenols of 7.42 ± 0.06 mg GAE/g DW, and antioxidant activity of 4.89 ± 0.02 µM Trolox/g DW (by ABTS assay). Li et al., 2019 utilized the following extraction parameters after model validation: 49% ethanol, at 51°C and 15 minutes; to achieve an antioxidant activity of 41.78 ± 1.13 mg Trolox/g DW, the total phenolic content of 15.24 ± 0.73 mg GAE/g DW), and total anthocyanins content of 346.68 ± 9.10 mg C3G/100 g DW. Similar results for grape skin extract flavonoids were achieved by Ivanova et al., 2010, who reported a value of 6.90±0.42 mg CE/g DW following extraction with 80% ethanol. A lower concentration of TPC of 33.3±0.3 mg GAE/100 g DW skin of red grapes was reported by Negro et al., 2003 by extracting the compounds with 80% ethanol and acetic acid. On the other hand, Manconi et al., 2016 stated a higher amount of phenolic compounds of 126 ± 30 mg GAE/g DW from grape pomace and a lower radical scavenging activity by using a DPPH• assay of 0.91 ± 0.17 mM Trolox/g DW compared with the current results. De Andrade et al., 2021 reported similar findings and found that the skin of *Syrah* grapes cultivar contained 3.25 ± 0.03 mg malvidin-3-O-glucoside/g DW of anthocyanins. According to Mendoza et al., 2013, the concentration of anthocyanins in different grape pomace cultivars ranged between 20.74 ± 0.02 and 70.86 ± 5.71 mg malvidin-3-O-glucoside/100 g DW in a considerably lower amount compared with our results. In contrast, Tan et al., 2020 reported that the anthocyanins content of the grape skin extract via ultrasound-assisted enzymatic extraction was 3.01±0.04 mg C3G/g DW, obtained under an extraction temperature of 50°C, ultrasonic power of 400 W, pectinase dosage of 0.16%, and extraction time of 28 minutes.

However, the phytochemical composition of GSP extracts can vary with different origins of raw materials, cultivar (i.e., genetic and environmental features), agronomic practices, different extraction conditions (type of solvent, pH, temperature), and methods, and the measurements method applied.

Physicochemical parameters of milk samples. Table 3 presents the chemical composition results of the cow's milk samples used as the raw material for cheese production.

Table 3 Chemical composition (%) of raw cow's milk samples (n = 5)

Parameters	Mean	±Sx	Interval	Variance
Water (%)	86.88	0.128	86.40-87.15	0.330
Total solids (%) (TS)	13.12	0.128	12.85-13.60	2.182
Fat (%)	4.00	0.027	3.95-4.10	1.534
Solid-non fat (SNF) (%)	9.12	0.129	8.88-9.59	0.014
Protein (%)	3.32	0.014	3.29-3.36	0.976
Ash (%)	0.50	0.007	0.48-0.52	3.162
pH	6.58	0.009	6.55-6.60	0.292

In terms of its composition, the milk sample had an average water content of 86.88 ± 0.128% and a total solids content of 13.12 ± 0.128%. Water plays a crucial role as the medium in which all other components of milk are dissolved or suspended. The average fat content was 4.00 ± 0.027%, resulting in an average solid-non fat (SNF) content of 9.12±0.129%. The protein level was recorded at an average value of 3.32 ± 0.014%, while the ash content was found to be 0.50 ± 0.007%, with variation limits between 0.48% and 0.52%. These findings were consistent with those reported by Amitot et al., 2002. The pH value of the milk ranged between 6.55 and 6.60, with an average value of 6.58 ± 0.009, which was similar to the results reported by Danthine et al., 2000.

Phytochemical profile of value-added cheese. The value-added Caciotta cheese sample was obtained by enrichment with 2% amounts of grape skin powder. Bioactive compounds

content were measured in control and experimental cheese samples to assess the impact of adding GSP to cheese. The obtained Caciotta cheese's phytochemical content and antioxidant activity are shown in Table 4.

Table 4 Phytochemical profile of value-added Caciotta cheese

Sample	TAC, mg C3G/100 g DW	TFC, mg CE/g DW	TPC, mg GAE/g DW	Antioxidant activity, mM Trolox/g DW
CC	-	0.313 ± 0.005^{a}	2.264 ± 0.029^{a}	1.574 ± 0.057^{a}
CGSP (2%)	4.661 ± 0.031	0.517 ± 0.004^{b}	4.191 ± 0.039^{b}	2.425 ± 0.091^{b}

Values with different letters in the same column are significantly different ($p<0.05$).

Statistically significant differences ($p<0.05$) were discovered among cheeses. As anticipated, the control cheese (CC) had lower amounts of bioactive compounds than the corresponding CGSP-enriched cheeses.

The anthocyanins were not detected in sample CC, and flavonoid content had a low level (0.313 ± 0.005 mg CE/g DW). The contents of the bioactive compounds were found to increase when GSP (2%) was added to the cheese formulation. Moreover, the sample obtained had considerably higher levels of bioactive compounds in comparison to the control sample, exhibiting functional characteristics (total phenolic content and antioxidant activity). In particular, the addition of 2% (*w/w*) of GSP resulted in an increase of 1.927 mg GAE/g DW of TPC in Caciotta cheese formulation.

Furthermore, the GSP-supplemented cheese sample showed greater antioxidant activity than the control due to the increased concentrations of bioactive compounds in the GSP.

These findings supported the hypothesis that the addition of GSP to dairy products causes an increase in the phytochemical contents especially TPC (Barbaccia et al., 2022; Marchiani et al., 2016a; Marchiani et al., 2016b; Aiello et al. 2020). In order to study the effect of green tea catechins on antioxidant characteristics, Rashidinejad et al., (2016) added green tea extract to full-fat cheeses. As a result, authors noticed a considerable increase in TPC and antioxidant activity at all levels.

Additionally, Costa et al. (2018) showed that Primosale cheese samples enriched with red wine grape pomace (enriched to 50 g/kg) have higher contents of bioactive compounds (polyphenols 6.92 ± 0.38 mg GAE/g DW; flavonoids 1.15 ± 0.24 mg quercetin equivalents/g DW) and significant antioxidant activity (ABTS) (8.44 ± 0.11 mM Trolox/g DW) compared to cheese without grape pomace (control), demonstrating added value.

The literature has reported a wide range of phenolic content for various types of cheese, including up to 11.3 mg GAE/g DW, flavonoids up to 0.9 mg of quercetin equivalent/g DW, and antioxidant activities up to 4.00 mg of Trolox/g DW or 31.14 mM Trolox/g DW (Da Silva et al., 2015; Han et al., 2011; Lucera et al., 2018).

Sensory evaluation of cheese. To evaluate the sensory aspects of the product, we employed the quantitative descriptive analysis (QDA) method, which is commonly used in studies of various products, including cheese (Stone & Sidel 2017; Lawless & Heymann 2010). Table 5 outlines the mean intensity ratings of descriptive attributes and the analysis of variance. Our ANOVA results indicate that there were significant ($P < 0.05$) differences in the intensity of various attributes, including colour, creamy odour, flavour, salty taste, sweet taste, acid taste, bitter taste, aftertaste, hardness, chewiness, rubbery, dryness, grainy, and overall quality.

Table 5. Quantitative descriptive analysis of CC and CGSP cheeses

Specification	**Type of cheese**	
	CC	**CGSP**
Colour	5.7^{a}	6.13^{b}
Creamy odour	5.9^{a}	4.1^{b}
Acid odour	4.3^{a}	4.7^{a}
Buttery	$6,2^{a}$	$5,1^{b}$
Flouers/fruits	1.3	6.7^{b}
Salty taste	3.7^{a}	3.4^{a}

Sweet taste	4.1[a]	6.4[b]
Acid taste	2.7[a]	1.5[b]
Bitter taste	1.6[a]	2.3[b]
Aftertaste	3.3[a]	6.9[b]
Hardness	6.5[a]	3.9[b]
Chewiness	6.6[a]	4.5[b]
Rubbery	6.5[a]	5.1[b]
Dryness (moisture)	3.1[a]	2.8[a]
Grainy	5.8[a]	4.1[b]
Overall quality	5.7[a]	6.8[b]

Letters describe a comparison between each variety of cheese; means marked with the same letters in each row do not show significant differences (ANOVA test, $P < 0.05$).

In Figure 3, it is evident that the inclusion of GSP had a noteworthy impact on the colour of the product. However, this particular attribute was highly valued by consumers, as indicated by the fact that CGSP received a higher score in comparison to CC.

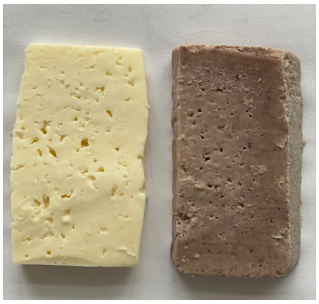


Figure 3. CC and CGSP cheese

It is important to note that this outcome may be attributed to the unique properties of GSP, which contributed to the enhanced colour of the final product. Overall, these findings suggest that the addition of GSP can lead to a favorable sensory experience for consumers, particularly in terms of colour perception (Table 4). These findings serve as a validation of the critical role that visual assessment plays in accurately depicting and valuing food items, as established by Dinnella et al. (2014) study.

When considering the visual aspects, it was observed that the red grape skins from Fetească Neagră contain a significant amount of coloured phenol compounds. These compounds were then released from the grape skins into the cheese, resulting in a unique violet and brown marbling effect that was not present in the reference sample. Similar effects have been observed in other studies that have utilized phenol-based winery by-products in the production of biscuits (Mildner-Szkudlarz et al., 2013; Pasqualone et al., 2014). Additionally, the addition of grape skin powder (GSP) had a substantial impact on the texture of the cheese.

According to the obtained results, it was observed that the inclusion of solid particles within the food matrix led to an increase in the perceived sensation of roughness, while simultaneously causing a significant reduction in the ratings attributed to a number of texture-related characteristics, including hardness, chewiness, rubbery consistency, dryness and graininess. These findings were also reported by Engelen et al. (2005).

Physical parameters. Table 6 details how cheese supplemented with GSP changes in colour. The non-added product (CC) had a distinctively yellow tint.

Table 6. Colour traits and pH of CC and CGSP cheeses

Specification	Type **of cheese**	
	CC	**CGSP**
L*	68.31±0.04[a]	53.33±0.09[b]
a*	-1.22±0.27[a]	8.31±0.06[b]
b*	11.59±0.05[a]	6.46±0.08[b]
C*	11.66±0.05[a]	10.53±0.10[b]
h°	-1.47±0.02[a]	0.66±0.033[b]
pH	5.21±0.01[a]	5.14±0.004[b]

L* value is the lightness coefficient; b* value indicates the position on the blue (−) to yellow (+) axis; C* (chroma); h◦ (hue angle). Letters describe a comparison between each variety of cheese; means marked with the same letters in each row do not show significant differences (ANOVA test, $P < 0.05$)

Because of the presence of anthocyanins, the addition of powder to milk entirely altered the product's hue. The introduction of GSP, resulted in a significantly lower brightness (L*) value in the CGSP sample ($P < 0.05$). In the instance of the CGSP product, an increase in the parameter a* was clearly seen as expected ($P < 0.05$). This is a result of the anthocyanins that were added, which are in charge of giving GSP its red hue. Eventually, the parameter b* in the GSP-enriched product significantly decreased ($P < 0.05$). Regarding the results for Chroma, the average was 11.66 ± 0.05 for CC

and 10.53 ± 0.10 3 for CGSP. The differences were similarly very significant (P < 0.05).
The mean values for the Hue angle parameter were -1.47 ± 0.02 for CC and 0.66 ± 0.033 for CGSP, with a very significant difference (P < 0.05) between the two.
In terms of pH value, differences were also found (P < 0.05). When GSP was added to cheese, the pH dropped from 5.21 ± 0.01 in the control batch (CC) to 5.14 ± 0.004 in the CGSP batch (P < 0.05). Mohamed et al., (2014) also observed a similar pattern in their yoghurt consumption data. Decomposition of the emulsifying salts and/or their interaction with protein during storage likely led to a gradual reduction in pH values across all treatments (Chamber and Daurelles, 2000).
Similar to our research on colour, it has also been carried out on bakery and pastry products. According to Hayta et al. (2014) and Nakov et al. (2020), GPP inclusion caused a significant reduction in brightness (L*) in samples of breeds and cakes.
Demirkol et al. (2018) in a study made on yogurt observed that the L and b* values decreased (P < 0.05) but the a* value increased (P <0.05).
A decrease in the pH of products that have been supplemented with grape skin powder or grape pomace powder has been demonstrated in several products, not just in dairy products (Shirahigue et al., 2010; Rosales Soto et al., 2012; Frumento et al., 2013).
Chemical parameters. Differences (P < 0.05) were found for every parameter in the examination of the chemical quality parameters carried out on the two types of cheese (CC and CGSP), with the exception of fat (Table 6).

Table 6 Chemical composition (%) of CC and CGSP cheeses (n = 5)

Parameters	Type of cheese	Mean	±Sx	Interval	Variance
Water (%)	CC	37.93[a]	0.08	37.63-38.13	0.49
	CGSP	35.97[b]	0.33	34.99-36.82	2.05
Dry matter (%) (DM)	CC	62.07[a]	0.08	61.87-63.37	0.30
	CGSP	64.03[b]	0.33	63.18-65.01	1.15
Fat (%)	CC	33.95[a]	0.09	33.61-34.12	0.59
	CGSP	34.13[a]	0.10	33.86-34.47	0.66
Fat in dry matter (FDM) (%)	CC	57.70[a]	0.16	54.17-55.05	0.66
	CGSP	53.31[b]	0.39	52.33-54.33	1.62
Protein (%)	CC	24.21[a]	0.08	23.98-24.44	0.73
	CGSP	26.06[b]	0.12	24.66-25.41	1.08
Ash (%)	CC	3.87[a]	0.18	4.42	10.12
	CGSP	4.82[b]	0.38	3.85 – 5.60	17.68

Values with different letters in the same column are significantly different (P < 0.05).

According to expectations, the addition of powder made from grape skins increased the amount of dry matter; the average value was 64,03% for the product with addition (CGSP) compared to 62,07% for the control product (CC).
However, the improvement of the chemical composition of dairy products to which powder obtained from the skin of grapes or grape pomace powder was added was also reported by Han et al. (2011a, b) who observed that dairy products with grapes and their derivatives introduce to their matrix a large number of phenolic compounds, which have the ability to associate with proteins and carbohydrates. Marchiani et al. (2016a) investigated the addition of red and white Chardonnay and Barbera grape pomaces, both before and after distillation, to Cheddar and Toma-like cheeses. They noted variations in moisture content in the cheeses that were produced as well as between grape pomaces. Arunkumar (2014) also noted a decrease in moisture content, which is explicable given the rise in total solids brought on by the addition of grape pomace flour during cheese manufacture.

CONCLUSIONS

The findings of the study shed light on an interesting fact - grape by-products extracts (GSP) contain a significant amount of total phenolic compounds, total flavonoids, and antioxidant activity that can be effectively transferred to cheeses. This discovery presents a promising avenue for reducing the environmental impact of winemaking across the globe, while also creating new possibilities for the dairy industry to develop innovative dairy products with enhanced functional properties. This is especially relevant today, as consumers are increasingly concerned about the environment and actively seek out healthier food options.

However, it is important to note that while the use of grapes and their derivatives in dairy products offers numerous benefits, it is crucial to pay close attention to their impact on acidity and sensory characteristics. This will ensure that the final product not only boasts functional properties but also meets consumers' expectations in terms of flavour and texture. By carefully balancing these factors, the dairy industry can capitalize on this exciting new opportunity to create products that are both healthy and delicious.

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