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PRELIMINARY STUDIES ON OBTAINING A CHEESE MADE EXCLUSIVELY FROM WHEY ENRICHED WITH PUMPKIN POMACE POWDER

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Abstract

Pumpkin (Cucurbita maxima) is a popular vegetable widely cultivated and consumed due to its rich content in biological active compounds and essential nutrients. Pumpkin pomace (PP) powder, which is a by-product derived from the pumpkin industry, has garnered considerable attention as a potential useful component for enhancing the overall quality of foods.
The study involved the addition of varying amounts (1 and 2%) of pumpkin powder to whey cheese compositions. This study aims to evaluate the effects of PP powder addition on the physical, chemical, color, microbial and sensory characteristics of whey cheese, alongside its impact on the product's nutritional value. PP powder is a good source of phytochemicals such as carotenoids and polyphenols, with remarkable antioxidant capacity. The results indicate that the incorporation of PP powder resulted in enhanced nutritional and colour characteristics of the cheeses. Furthermore, the incorporation of pumpkin powder resulted in a substantial increase in the levels of phytochemicals and antioxidant activity. The resulting supplemented cheeses offer a unique color profile, appealing to health-conscious consumers seeking innovative dairy products. Developing these products has the potential to facilitate sustainable food production and offer consumers a wider range of food options with improved attributes.

Key words*: antioxidant activity, cheese, food ingredients, pigments, pumpkin pomace.*

INTRODUCTION

The food industry has become more interested in utilizing agricultural by-products as potential sources of food ingredients due to the changing consumer preferences for natural and clean-label ingredients. Through specific processing of these by-products, such as fruit and vegetable pomaces, they can be utilized to produce food microstructures that possess desirable functional qualities (Moelants et al., 2014).
Pumpkin, scientifically known as *Cucurbita* L., is a squash fruit vegetable that is part of the *Cucurbitaceae* family, sometimes referred to as the gourd family. It is classified into 130 genera and 800 species. Pumpkins are considered to be economically significant species cultivated on a global scale. They are extensively utilized in the food industry for the commercial manufacturing of various products (pumpkin pie, flour, seed oil, seeds as snacks, bread, cookies, desserts, cereals, ice cream, pumpkin butter, soups, etc.) (Kaur et al., 2020).
A wide variety of shapes, sizes, and colors can be found in pumpkins. There has been an increasing interest in pumpkin fruit and pumpkin-derived products by various industries such as agriculture, food processing, pharmaceuticals, and feed. This interest comes from the nutritional and health-promoting

properties of the phytochemicals, proteins and oil found in pumpkin seeds, as well as the polysaccharides present in pumpkin fruit (Kuchtová et al., 2016). Pumpkin is commonly consumed through several methods, including fresh consumption, cooking, and storage in frozen or canned forms. Pumpkin is a rich source of β-carotene, dietary fibre, pectin, mineral salts, vitamins, and other health-promoting elements (Kundu et al., 2014).

Large amounts of peels, seeds, and pomace are produced as a result of industrial pumpkin processing into puree, juice, and other products (Kampuse et al., 2018). Presently, these by-products are employed as animal feed (Valdez-Arjona and Ramírez-Mella, 2019), representing a relatively low-value application.

These facts could contribute to the development of pumpkin by-products into a diverse range of food products. The utilization of these by-products has been used to supplement cereal flours in bakery foods, soups, sauces, instant noodles, and spices, also as a natural pigment in pasta, dairy products, beverages, snacks and flour blends (Villamil et al., 2023).

Nowadays natural food colorants have established a significant presence in important food applications. Natural colorants, such as carotenoids, have been effectively utilized in various coloring systems, including bakery foods (solid phase) and beverages (liquid phase). Carotenoids are widely recognized for their vibrant orange, and yellow hues, predominantly found in fruits and vegetables, which play a significant role in imparting appealing flavors to many food and beverage products (Rodriguez-Amaya et al., 2019).

The current study aims to investigate the potential of pumpkin (*Cucurbita* sp.) pomace, which is derived from the extraction of carotenoids from pumpkins, as a bioactive ingredient for cheese production.

This study aimed to evaluate the effects of PP powder on the physicochemical properties, phytochemicals, color, microbial and sensory attributes of cheeses enhanced with PP.

MATERIALS AND METHODS

The raw material was represented by 80 liters of whey obtained after processing milk in order to obtain a semi-paste cheese (Rațu et al., 2023).

The cheese was processed in the Milk Processing Workshop at USV Iași.

As for the whey, qualitative determinations were made to determine the content of dry matter, water, fat content, protein, ash, and pH value.

The AOAC method no. 925.23 was utilised to evaluate the total solids (TS) present in whey. Subsequently, the samples underwent dehydration using a Memmert UFE 700 forced air oven manufactured by Memmert GmbH in Schwabach, Germany. The water content (W) was determined by the disparity, as indicated by the equation W (%) = 100% -TS (%) (Rațu et al., 2021).

The acid-butyrometric Gerber method describe by Dick et al. (2001) was utilised to evaluate the fat percentage of whey.

The protein contents were assessed using the Kjeldahl method, which was implemented on a Velp Scientifica DK 6 digestion unit and UDK 7 distillation system (Velp Scientifica, Usmate, Italy), following the established methodology of the International Dairy Federation (IDF) (Usturoi et al., 2017; Simeanu et al., 2015).

The total mineral content of crude ash was evaluated by incinerating it at a temperature of 550ºC in a Super Therm C311 furnace (SuperTherm SRL, Romania) after burning it on a Bunsen funnel. The incineration process continued until the samples stopped smoking, following the standards outlined in AOAC method no. 945.46.

The pH metre (WTW InoLab, Xylem Analytics GmbH, Weilheim, Germany) was calibrated before measuring the pH using a glass electrode and a temperature probe. The pH was tested using buffer solutions with pH values of 4 and 7 (Rațu et al., 2023).

Pumpkin fruits (Golden Nugget variety), were purchased in November 2023 from a market in Iasi County, Romania, when they had reached full maturity. The fruits underwent immediate processing so the pumpkin juice was extracted (Bosch MES3500, Drachten, Holland), yielding the pumpkin pomace. Subsequently, the pomace was freeze-dried for 50 hours at a temperature of -42 °C and a pressure of 0.10 mBar. This process was carried out using BIOBASE BK-FD10T equipment Jinan, China.

In addition, the freeze-dried pomaces were ground into a fine powder using MC 12 machinery (Stephan, Germany) and stored in glass jars at room temperature and in the dark until analysis. The final powder underwent sterilization using a UV lamp to eliminate contaminants.

ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)), gallic acid solution, n-hexane, ethanol, acetone, sodium carbonate, Folin–Ciocalteu reagent, sodium hydroxide, aluminium chloride, sodium carbonate was purchased from Sigma Aldrich (Schnelldorf, Germany).

Extraction of bioactives from PP. The phytochemicals from PP powder were extracted using the ultrasound-assisted extraction approach described by Lima et al., (2019). To extract bioactive compounds, a mixture of 1.0 g of PP powder and 10 mL of n-hexane/acetone solvent mixture (3:1, *v/v*) or 70% ethanol (for total polyphenols and flavonoids) was utilized. The mixture was then subjected to ultrasound treatment for 35 minutes at a temperature of 40°C and a frequency of 37 kHz (Elmasonic S 180 H, Elma, Germany). The obtained crude extract was subsequently subjected to centrifugation for 10 minutes at a speed of 6500 rpm and a temperature of 4°C. After that, the supernatant was examined for total carotenoids, β-carotene, total flavonoids, total polyphenols, and antioxidant activity.

The determination of carotenoids, phenolic compounds and antioxidant activity of PP extract.

Total carotenoid content. A spectrophotometric study was conducted to quantify and ascertain the quantities of total carotenoids and β-carotene in the extract, following the methodology outlined by Nistor et al. (2022), with minor adjustments. To summarise, 0.2 mL of the extract was dissolved in the extraction solvent combination. It was then placed in the UV quartz cuvette and the absorbance was measured at a wavelength of 450 nm for total carotenoids and 470 nm for β-carotene using a UV-VIS spectrophotometer (Analytik Jena - Specord 210 Plus, Germany). The findings were presented as milligrams per 100 grams of dry weight (d.w.).

Contents (mg/100 g d.w.) = (A x Mw x Df)/ (m x L x Ma),

where A - Absorbance of the sample; Mw - molecular weight; Df - sample dilution rate; m - Mass/weight of extract; L - length of the optical path of the cuvette (1 cm); Ma - molar absorptivity (2500 L/mol/cm for carotenoids, 2590 L/mol/cm for β-carotene).

Total flavonoid content. The content of total flavonoids of PP extract were determined using the aluminium chloride technique (Horincar et al., 2019). Shortly, 250 µL of the PP extract and 75 µL of 5% sodium nitrite ($NaNO_2$) were combined with 2 mL of distilled water. Then after 5 minutes 150 µL of aluminium chloride ($AlCl_3$) was added to the mixture. 0.5 mL of sodium hydroxide (NaOH) 1 M was added to the mixture after 6 minutes. The mixture was then measured using a UV–VIS spectrophotometer (Analytik Jena - Specord 210 Plus, Germany) at 510 nm. As a standard, a calibration curve for catechin was used and the results were expressed as milligrams of catechin equivalents per 100 grams of dry weight (mg CE/100 g d.w.).

Total polyphenolic content. The Folin-Ciocalteu method was used to measure the PP extract total polyphenolic contents (Horincar et al., 2019). In short, 200 µL of the PP extract, 1 mL of the Folin-Ciocalteau reagent, and 15.8 mL of distilled water were combined. After 10 minutes, 3 mL of Na_2CO_3 20% was added to the mixture. The final mixture was measured at 765 nm using a UV-VIS spectrophotometer (Analytik Jena - Specord 210 Plus, Germany) after 60 minutes of dark storage at room temperature. A standard curve for Gallic acid was utilized, and the results were represented as milligrams of Gallic acid equivalents per 100 grams of dry weight (mg GAE/100 g d.w.).

Antioxidant activity (ABTS). The antioxidant activity was determined using the ABTS radical cation decoloring reaction (Mihalcea et al., 2021). To summarise, 0.20 mL of extracts diluted in a mixture of n-hexane and acetone, along with the supernatants obtained from extracting total carotenoids from PP powder, were combined with 1.98 mL of the ABTS+ solution. The mixture was then left to react for 2 hours in the absence of light. The mixture's absorbance (Af) was quantified at a wavelength of 734 nm (Analytik Jena - Specord 210 Plus, Germany).

The blank absorbance was measured at 734 nm using a 1.98 mL ABTS solution (in ethanol) and 0.20 mL ethanol in the absence of the extract (A0). The results were reported as µmol of Trolox equivalents per gram of dry weight (µmol TE/g d.w.).

Also, the inhibition percentage was calculated. % Inhibition = (A0- Af)/A0 x 100.

Preparation and characterization of supplemented whey cheese.

The manufacture of whey cheese was carried out in accordance with industrial production technology, which involves the gradual heating of the whey until it reaches a temperature of 90°C. To improve the yield, we added 20 mL of citric acid to the whey at 70°C to lower its pH value to 5.53. Once the whey reached 85-90°C, we added 150 ml of DAIRSAL+, a pure product based on magnesium chloride and calcium chloride, in accordance with Reg. CE No. 231/212, and stopped the heat at the point of flocculation. The precipitate formed (whey cheese) is collected in baskets and left for 7 hours at a temperature of 18-20°C to cool and drain by self-pressing. After cooling, it was packed in plastic casseroles and stored in a refrigeration system at temperatures between 4-6°C. After cooling the whey cheese, we added powder to the PP-fortified product. Two experimental batches were made, batch CPP1, where an addition of 1% was used, and batch CPP2, where an addition of 2% was used. We kept the experimental groups under the same conditions as the control group. Marketers market whey cheese as fresh cheese and advise against storing it for more than 4-5 days.

For chemical analysis, about 100 g of cheese was taken from various parts of the cheese mass. We determined the water and dry matter content in accordance with the Association of Official Analytical Chemists (AOAC, 2005). The fat content was determined according to Van Gulik (IDF, 2008), protein contents were assessed using the Kjeldahl method (AOAC 2003), and ash was obtained by dry ashing at 550°C (AOAC 935.42).

The crude fibre was determined using the methodology outlined by Gavril (Rațu et al., 2024). The part that remained after undergoing digestion with standard sulfuric acid and sodium hydroxide was detected. Essentially, 2.0 g of the substance underwent hydrolysis in 299 mL of 1.25% sulfuric acid, followed by a 30-minute heating process. The mixture underwent vacuum filtration, followed by three rinses with hot distilled water. Subsequently, it was subjected to an additional 30-minute heating process using 200 mL of 1.25% sodium hydroxide. Finally, the combination was subjected to another round of vacuum filtration. After initial neutralisation with hydrochloric acid, the digested sample underwent three rinses using hot distilled water. The residual substance was transferred into a crucible, subjected to a drying process lasting 2 hours at a temperature of 100ºC within an oven, and subsequently chilled in a desiccator prior to being measured in terms of weight. The sample in the crucible was subjected to a temperature of 500ºC for a duration of 5 hours in order to fully eliminate all carbonaceous substances. Subsequently, the crucible holding ash was subjected to desiccation, followed by cooling and subsequent weighing.

% crude fiber = [loss in weight (g) after ignition)/(weight of the original sample (g)] × 100.

Colour analysis. The colour parameters of the samples were evaluated using a MINOLTA Chroma Metre model CR-410 (Konica Minolta, Osaka, Japan) equipped with a CIE Lab scale. The outcomes of the colour measurements were denoted as L*, representing the degree of lightness (where L* = 0 for black and L* = 100 for white), a*, encompassing a spectrum from red to green, and b*, encompassing a spectrum from yellow to blue. After calibrating the device using a white plate, the CIELAB colour parameters were measured three times.

The hue angle-colour appearance (Hue angle = 180 + arctan(b*/a*) for quadrant II (−a*,+b*); Hue angle = arctan (b*/a*) for quadrant I (+a*,+b*) and Chroma-colour intensity $[\sqrt{(a^*)^2 + (b^*)^2}]$ were also calculated (Dag et al., 2017).

Sensorial analysis. A group of twenty individuals, ranging in age from 24 to 65, with an equal distribution of 60% women and 40% males, evaluated the sensory attributes of fortified cheese samples. The panel members were provided with information regarding the overarching objective of the study, as well as the requisite protocols for managing personal data. The panel members were instructed to

examine a total of 9 descriptors, encompassing appearance, section appearance, odor, aroma, texture, color, taste, aftertaste, and the overall evaluation. The analysis was conducted in compliance with the requirements outlined in ISO 13299 (2016). Faccia et al. (2012) reported that the assessors used a seven-point hedonic scale (1 = extremely low; 7 = extremely high) to award a score for each quality.

Microbiological analyses. Every analytical step involved in counting the microbiological load of whey cheese was carried out in a sterile setting using three duplicates for every lab sample. Using a laboratory blender (Seward, West Sussex, UK) set to run at 250 rpm for five minutes, 10 g of cheese were homogenized with 90 mL of buffered peptone water (Bio-Rad, Marnes-la-Coquette, France) in preparation for microbiological tests. The serial dilutions were created by combining 1 mL of the prior dilution with 9 mL of buffered peptone water in test tubes. The spread and pour plate techniques separated the bacteria, yeast, and molds from the dilutions (Suler et al., 2021a; Najgebauer-Lejko et al., 2022). The non-selective Plate Count Agar (PCA) supplemented with 1 g/L skimmed milk powder and Potato Dextrose Agar (PDA; Scharlau, Barcelona, Spain) along with the selective chromogenic agar Rapid *E. coli* 2 (RE) and Rapid Staph (RS; Bio-Rad, Marnes-la-Coquette, France) were the microbiological media used for plating after inoculation with 1 mL of sample. In compliance with ISO 7218 (2016), total aerobic bacteria were counted following a 72-hour incubation period at 30°C on injected PCA plates. Following five days of incubation at 28ºC on PDA plates, the number of yeast and molds was counted. Following a 24-hour incubation period at 37°C, colonies of *Escherichia coli* and other coliforms were identified on RE media under ISO 16140 (2021). Additionally, all samples were grown on RS medium, which ensures that coagulase-positive staphylococci (*Staphylococcus aureus*) will be found and counted in 24 hours at 37°C. Following incubation, the automated colony counter Scan 1200 (Interscience, Saint-Nom-la-Bretèche, France) was used to count the microorganisms in the cheese samples. The results were represented as logarithmic colony forming units per gram (log CFU g^{-1}) (Suler et al., 2021b).

Statistical Analysis. The data presented in this study consist of mean values, with a standard deviation of the mean. These values represent the means obtained from triplicate analyses. The Data Analysis Toolkit in Microsoft Excel program was utilized to do statistical data analysis. The quantification of significant differences between samples was conducted using a one-way analysis of variance (ANOVA), following the assessment of normality and equality of variances. A post hoc analysis using Tukey's test was conducted at a significance level of 5% ($p < 0.05$) using Minitab Inc., State College, PA, USA.

RESULTS AND DISCUSSIONS

Table 1 present the results of phytochemical, physicochemical contents and the ABTS radical scavenging activity of the PP extract.

Table 1. Phytochemical and physicochemical analysis of PP powder

Parameters	PP powder
Total carotenoids (mg/100 g d.w.)	31.02±0.15
β-caroten (mg/100 g d.w.)	28.04±0.11
Total flavonoids (mg CE/100 g d.w.)	42.11±0.28
Total polyphenols (mg GAE/100 g d.w.)	109.02± 0.55
ABTS (µmol TE/g d.w.)	1264.20±10.23
Inhibition (ABTS) %	77.53± 0.57
L*	74.89±0.12
a*	7.82±0.08
b*	41.58±0.06

Therefore, the PP extract had a notable carotenoids content of 31.02±0.15 mg/100 g d.w. and a remarkable antioxidant activity of 1264.20±10.23 µmol TE/g d.w., with an inhibition of 77.53 ± 0.57%. In their research, Hussain et al. (2021) examined the peel, pulp, and seeds of *C. maxima* pumpkins, focusing on the identification of diverse nutritional components that contribute to a range of health benefits. Therefore, the authors reported a total carotenoid value of 35.2 ± 0.49 mg/100 g powder, a total polyphenolic content of 134.59 ± 1.24 mg GAE/100 g powder, and a total flavonoid content of 77.11 ± 0.63 mg CE/100 g powder for the pumpkin pulp.

Pinna et al. (2023) reported a total carotenoid value of 1006.00 ± 78.72 µg β-carotene/g d.w. and an antioxidant activity of 1490.77 ± 69.74 µg TE/g d.w. (ABTS) for pomace of Delica vanity variety.

These variations could be caused by the origin material's phytochemical variability and the kind of solvent combination utilized during the extraction process.

The estimated values for L*, a*, and b* were determined to be 74.89, 7.82, and 41.58, respectively, based on the colour parameters. b* parameter that represents blue-to-yellow intensity, indicates a trend towards yellow shades in PP powder due to the high carotenoid content. Pinna et al. (2023) reported the CIELab param ± 1.15 for L*, 10.00 ± 1.00 for a*, and 27.33 ± 0.58 for b*. Based on the colour indices, it was determined that the PP powder was situated within quadrant I (+a*, +b*).

The phytochemical profile and antioxidant activity by the use of the ABTS method of the control and supplemented cheeses are presented in Table 2. Consistent with expectations, there is a notable rise in the levels of carotenoids and antioxidant activity as the concentration of PP powder increases. Thus, the cheese variants exhibited a total carotenoids content with values between 21.22 ± 0.611 mg/100 g d.w and 32.65 ± 0.86 mg/100 g d.w. Regarding the antioxidant activity, there has been an observed rise from 379.82 ± 3.45 µmol TE/g d.w. for CPP1 to 426.38 ± 3.86 µmol TE/g d.w. for CPP2. Extracts from the fruit of Sea buckthorn (*Hippophae rhamnoides* L.) were also tested as colourants for cream cheese (Ghendov-Mosanu et al., 2020).

Eters for pomace of the Delica vanity variety as follows: 29.33

Table 2. Phytochemical characterization of PP-incorporated cheeses

Parameters	**Type of cheeses**		
	CC	CPP1	CPP2
Total carotenoids (mg/100 g d.w.)	-	21.22±0.61^{b}	32.65±0.86^{a}
Total flavonoids (mg CE/100 g d.w.)	3.85±1.63^{c}	11.02±1.99^{b}	20.01±2.14^{a}
Total polyphenols (mg GAE/100 g d.w.)	8.52±3.59^{c}	24.63±1.96^{b}	37.13±2.17^{a}
ABTS (µmol TE/g d.w.)	162.29±3.22^{c}	379.82±3.45^{b}	426.38±3.86^{a}
Inhibition (ABTS) %	11.59±0.49^{c}	26.84±0.71^{b}	39.11±0.67^{a}

Means with the same letter in each row are not significantly different ($p > 0.05$).

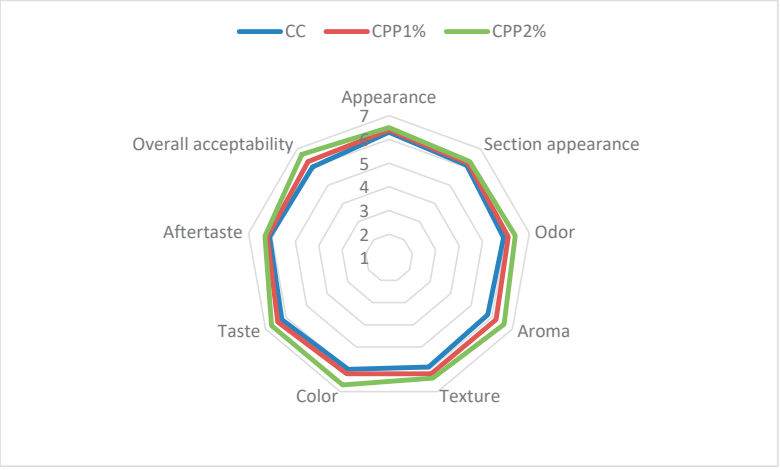

Figure 1. Sensory evaluation scores of controls (CC) and supplemented cheeses (CPP1, CPP2)

Table 3. Physicochemical properties of PP-incorporated cheeses

Parameters	Type of cheeses		
	CC	CPP1	CPP2
Moisture (%)	79.44±0.51[a]	77.62±0.16[b]	75.11±0.15[c]
Total solid (%)	20.56±0.50[c]	22.38±0.16[b]	24.89±0.19[a]
Fat (%)	4.09±0.10[b]	4.41±0.10[a]	4.52±0.11[a]
Protein (%)	9.97±0.10[c]	10.15±0.06[b]	10.97±0.07[a]
Ash (%)	0.98±0.03[c]	1.18±0.03[b]	2.15±0.08[a]
Crude fibre (%)	0.00±0.00[c]	2.42 ±0.11[b]	4.11±0.09[a]

Means with the same letter in each row are not significantly different ($p > 0.05$).

Table 4. Colour parameters of PP-incorporated cheeses

Parameters	Type of cheeses		
	CC	CPP1	CPP2
L*	93.94±0.34[a]	87.82±0.41[b]	86.26±0.35[c]
a*	-1.72±0.13[a]	0.88±0.03[b]	1.32±0.10[c]
b*	10.79±0.42[a]	15.71±0.48[b]	19.61±0.22[c]
Chroma	10.93±0.41[a]	15.73±0.48[b]	19.66±0.21[c]
Hue angle	178.59±0.02[a]	1.51±0.01[b]	1.49±0.01[c]

For each type of cheese, letters indicate a comparison across colour parameters; Means with the same letter in each row are not significantly different ($p > 0.05$).

Table 5. Microbial quality of PP-incorporated cheeses

Parameters	Type of cheeses		
	CC	CPP1	CPP2
TAB	7.51 ± 0.48[a]	7.92 ± 0.12[a]	8.11 ± 0.25[a]
Yeast	0.90 ± 0.11[a]	1.44 ± 0.41[a]	1.55 ± 0.32[a]
Molds	0.46 ± 0.09[a]	1.94 ± 0.23[a]	2.21 ± 0.30[a]
Coliforms	2.48 ± 0.24[a]	2.61 ± 0.17[a]	2.67 ± 0.26[a]
Escherichia coli	Not detected	Not detected	Not detected
Coagulase-positive staphylococci	Not detected	Not detected	Not detected

TAB - total aerobic bacteria count. Means with the same letter in each row are not significantly different ($p > 0.05$).

The primary measured pigments and polyphenols from the extracts of the fruits were carotenoids (8.27 mg/L total carotenoids) and polyphenols (1842.86 mg/100 g d.w., respectively. In terms of sensory evaluation, the addition of Sea buckthorn extract increased with 2.04% the average organoleptic score compared with tartrazine-supplemented cheeses.

The findings displayed in Table 2 support the enhanced nutritional value of cheeses incorporating pumpkin pomace powder, as evidenced by the observed increase in total carotenoids and antioxidant activity.

Chemical composition of control and supplemented cheeses (CPP1, CPP2). The results of chemical composition of analysed samples are presented in Table 4.

The chemical composition data of three types of whey cheese, namely plain (CC), and those enriched with 1% (CPP1) and 2% (CPP2) powder (PP), demonstrates notable nutritional improvements. It is worth mentioning that there is a clear correlation between the concentration of PP and the moisture content, indicating a higher density of the product. Additionally, the total solids, fat, protein, and ash contents gradually increase, suggesting an enhanced nutrient profile. CPP2 has the most elevated concentrations of total solids and protein, suggesting an enhanced nutritional density resulting from the incorporation of PP. In addition, the ash content, which serves as an indicator of mineral content, experiences a substantial increase, especially in CPP2, indicating a higher intake of minerals. Notably, the PP worts had a significantly greater crude fibre content. Specifically, CPP2 contains more than four times the fibre compared to CC, highlighting the potential for enhanced digestive health benefits. The addition of PP to the whey cheese enhances its nutritional qualities, indicating its potential for developing healthier and more nutritious goods.

In another study, the utilization of saffron (*Crocus sativus* L.) as a pigment for newly produced ovine cheese involved the incorporation of a concentrated extract (1000 mg/L) into 2 L of pasteurized ovine milk.

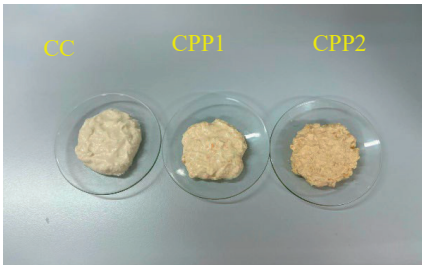

Figure 2. Personal images of the cheese without PP, control (CC); cheese with 1% PP (CPP1); cheese with 2% PP (CPP2)

The incorporation of saffron did not have any significant impact on the levels of moisture, total protein, salt, and lipids. However, these cheese samples exhibited the greatest antioxidant capacity values (up to 25.97% radical scavenging activity). The cheese samples containing the lowest amount of saffron (50 mg/L) exhibited comparable sensory scores to the control cheeses (Aktypis et al., 2018).

Colour evaluation of supplemented cheeses samples. Table 5 displays the CIELAB parameter values for the supplemented cheeses. The enriched cheeses have a high level of yellowness, which is characteristic of carotenoid compounds, as indicated by the b* values.

Luminosity was influenced by the PP powder concentration, the L* values decrease with powder addition, while a* and b* values increased together with powder concentration. Similar results were found by Durmaz et al. (2020) in ice creams enriched with microalga powder as coloring agent.

The cheeses with higher PP powder concentrations also showed higher Chroma values, which measure the intensity of color. The results mentioned are linked to the visual characteristics of the sample and the detection of carotenoids. The hue angle was positioned in the first quadrant in the color solid for enriched cheeses, indicating the yellowness of all samples.

Microbial Quality. The summary of the microbiological examination for the prevailing samples (CC, CPP1, CPP2) is presented in Table 5, which indicates that the product can be considered safe for eating. Both *Escherichia coli* and coagulase-positive staphylococci (*Staphylococcus aureus*) were not detected in any of the samples. All cheese samples exhibited the presence of coliforms; however, their occurrence did not reach statistical significance when compared to the control sample. The 2% PP fortified cheese sample exhibited the highest viable microbial counts, including total aerobic bacteria, yeast, moulds, and total coliforms, in comparison to the control cheese sample. However, it is important to note that the recorded data falls within the permissible limits as stipulated by European Regulation 2073/2005.

Sensory evaluation of supplemented cheeses.

Consumers preferences for taste, aroma, colour, and overall quality were determined through sensory evaluations.

The sensory qualities and general acceptability of the cheeses, which were supplemented with varying concentrations of PP powder, were evaluated (Figure 2). The attributes evaluated were appearance, section appearance, color, aroma, texture, taste, odor, aftertaste, and overall acceptability. The findings of sensory evaluations are presented in Figure 1. The panellists provided positive evaluations for all evaluated products. The acceptability of the cheeses supplemented with PP powder was assessed based on their taste, aftertaste, and odor. The cheeses with pumpkin powder were evaluated as having an acceptable odor, aroma, and appearance. Furthermore, the cheeses were appreciated for their soft, fine, and crumbly texture. The addition of PP to cheese resulted in a visually appealing yellow hue, which can be attributed to the enrichment of pumpkin pigments.

The results of the sensory assessments point to the 2% PP powder-added cheese as having the highest “general acceptability” value. In a study by Ghendov-Mosanu et al. (2020) the authors prepared a cheese by combining sea buckthorn powder with sunflower oil. The sensory panel results of cheese manufactured with extract were shown to be superior to those of tetrazine-supplemented cheese, mostly attributed to the

presence of chlorophylls, carotenoids, and total phenolic content in the extract.

CONCLUSIONS

The research emphasises the possibility of using pumpkin pomace as a sustainable and nutrient-dense food ingredient, which has the ability to enhance the health appeal of conventional dairy products such as whey cheese. This development addresses the increasing consumer need for functional foods that offer beneficial effects on health.

The incorporation of PP powder into the cheeses resulted in an enhancement of both the carotenoid content and antioxidant activity.

Cheese prepared with PP powder showed better results in the sensory panel due to the carotenoids, and total phenolic content of powder as compared to control sample. Sensorial analysis revealed that panelists appreciated the improved color of the enriched cheeses. The results indicated that the incorporation of carotenoids as an colorant in food products not only satisfies consumer preferences but also improves sensory characteristics.

This study presents novel opportunities for the use of by-products from food processing and for the production of innovative dairy products that are enhanced with nutritional value.

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