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ORIGINAL ARTICLE

EFFECT OF SKIMMED MILK POWDER ADDITION ON SELECTED QUALITY PROPERTIES OF FRESH CHEESES AND NATURAL YOGURTS

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Ethical considerations: When reporting experiments on animals Observation of the ARRIVE guidelines 2.0: Updated guidelines for reporting animal research, published on July 14, 2020 (DOI: 10.1371/journal.pbio.3000410), is applied. The authors ensure that all procedures were performed in compliance with the guidelines for animal care of their institutions or with national/international guidelines.

ABSTRACT

Fermented dairy products, due to their nutritional properties, are suitable matrices for further enrichment. This work examined the effect of skimmed milk powder (SMP) addition (0, 3, 6, and 9%) on selected physicochemical, rheological, and organoleptic properties of fresh cheeses and natural yogurts. With increasing SMP content, protein content increased in both products, while fat content decreased. In cheeses, this trend was reflected in increased hardness. In yogurts, higher protein and total solids content led to a significant increase in viscosity (from 1.070 to 3.714 mPa·s). A strong correlation was observed between total solids and viscosity. SMP affected the acidity of both products and the colour of the cheeses, especially yellowness. Sensory evaluation showed that the addition of SMP significantly affected the organoleptic properties (consistency and taste) of both products. Optimal consumer acceptance was achieved at 3–6% in cheeses and 6–9% in yogurts. Further research could focus on the impact of SMP on shelf-life, specific textural characteristics, and consumer acceptance across a broader range of formulations.

Keywords: chemical composition; fresh cheeses; organoleptic properties; protein enrichment; skimmed milk powder; texture; viscosity; yogurts

INTRODUCTION

Milk and dairy products are important components of a balanced diet because they provide essential nutrients. Low consumption of these products during childhood and adolescence can lead to insufficient intake of calcium, magnesium, and iodine, which may negatively affect physical development and bone strength [1–3]. Moreover, fermented dairy products (yogurts, various fermented milks, and cheeses) are an excellent source of probiotics, prebiotics, and bioactive compounds. They offer additional health benefits, such as modulating the gut microbiota, improving intestinal health, and increasing lactose tolerance [4, 5].

This group of foods is also suitable for fortification with other nutritionally desirable components [6, 7]. These components (e.g., vitamin D and antioxidants), which are

often insufficient in the typical consumer diet, play an important role in the proper functioning of the body and enhance the attractiveness of enriched products [4, 8, 9].

The typical way to enrich dairy products is to increase their protein content. Proteins are fundamental nutrients and are important building blocks of cells and muscle tissue [10, 11]. Milk proteins, such as casein and whey proteins, are characterized by high biological value and a complete profile of essential amino acids [10, 12, 13].

In cheeses, increasing the protein content can be achieved by various methods, such as heating milk (above 75 °C), membrane processes (e.g., ultrafiltration), treatment with high hydrostatic pressure (e.g., 400 MPa for 30 min, which can denature up to 90% of whey proteins), ultra-high pressure homogenization (above 100 MPa), or the addition of milk protein concentrates, including skimmed milk powder (SMP), casein concentrates, and whey proteins, as well as buttermilk and its derivatives [14–17].

The protein content of yogurt can be increased prior to fermentation by the addition of dairy powders, evaporation, or membrane filtration. It can also be enhanced after fermentation through straining, mechanical separation, or membrane filtration [7, 10, 12, 18].

Although SMP is commonly used to increase the protein content and improve the texture of fermented dairy products, particularly yogurts [7, 19, 20], limited information is available on the effects of different levels of SMP addition on selected product properties. The optimal level of SMP addition that enhances the nutritional value of both fresh cheeses and natural yogurts while maintaining desirable technological and sensory characteristics has not yet been clearly established. Therefore, the aim of this study was to produce fresh cheeses and natural yogurts with varying SMP levels and to evaluate their physicochemical, technological, and sensory properties.

MATERIALS AND METHODS

Preparation of milk, cheese, and yogurt samples

In two experiments, fresh cheeses and natural yogurts were prepared from cow's milk enriched with different levels of SMP under laboratory conditions. The chemical composition of the SMP was analysed by the supplying dairy company and was as follows: fat, 0.30%; protein, 34.30%; lactose, 50.0%; moisture, 3.53%; and pH, 6.54.

Raw milk (12 l) was pasteurized in the mini pasteurizer FJ 16 (Milky, Farmland, Janschitz GmbH, St. Marienkirchen bei Schärding, Austria) at 72 °C for 20 s, then cooled and enriched with 3, 6, and 9% SMP. The control sample without SMP addition was also prepared. The composition of the raw milk and pasteurized milk samples is given in Table 1.

Fresh cheese samples. Pasteurized milk samples (0, 3, 6, and 9% SMP) were heated to the coagulation temperature (32 °C). A starter culture (10% mesophilic culture; Laktoflora®, MILCOM a.s., Czech Republic) was added to the milk. After 15 min, 0.01% calcium chloride (36%) and 0.01% rennet (NATUREN®, Christian Hansen, NOVONESIS, Lyngby, Denmark) were added. Coagulation was carried out at 32 °C for 45 min. The developed curd was cut into cubes approximately 1 × 1 cm. Then, the curd

Table 1. Composition of raw and pasteurized milk samples enriched by different levels of skimmed milk powder (SMP)*

Parameters[1]	Raw milk	Pasteurized milk				P-value
		0% SMP	3% SMP	6% SMP	9% SMP	
Fat (%)	3.35±0.14	3.34±0.18	3.24±0.19	3.11±0.20	2.99±0.17	ns
Protein (%)	3.26±0.05	3.28±0.06	4.26±0.06	5.27±0.08	6.28±0.12	***
Casein (%)	2.62±0.03	2.64±0.06	3.80±0.06	5.00±0.11	6.18±0.18	***
Lactose (%)	5.00±0.09	5.03±0.06	6.61±0.09	8.24±0.09	9.89±0.10	***
SNF (%)	9.02±0.12	9.05±0.10	11.7±0.10	14.5±0.13	17.2±0.09	***
Total solids (%)	12.4±0.13	12.4±0.22	15.0±0.17	17.6±0.18	20.2±0.11	***
SCC (×10^3 cells/ml)	272±73.2	281±74.6	313±78.1	336±80.7	358±93.3	ns
FPD (°C × -1 000)	532±9.87	530±7.94	695±12.6	859±12.2	1018±12.7	***

* Values are presented as the mean ± standard deviation; * – $P < 0.05$; ** – $P < 0.01$; *** – $P < 0.001$; ns – not significant;
[1] SNF – solids-not-fat; SCC – somatic cell count; FPD – freezing point depression

grains were stirred manually for approximately 25 min and subsequently transferred into conical plastic molds (top ∅ 95 mm, bottom ∅ 75 mm, height 70 mm). From each group (0, 3, 6, and 9% SMP), four cheese samples were prepared. Fermentation proceeded at room temperature (21 °C) until the following day (approximately 18 h), during which the cheese samples were turned twice.

Natural yogurt samples. Pasteurized milk samples (0, 3, 6, and 9% SMP) were heated to the fermentation temperature (42 °C), inoculated with a starter culture (5% yogurt culture; YC-380, Christian Hansen, NOVONESIS, Lyngby, Denmark), and thoroughly mixed. From each group (0, 3, 6, and 9% SMP), four yogurt samples were prepared. Fermentation was carried out at 42 °C for 4 h. The process was terminated at the specified time in accordance with ON 57 0534 [21] to ensure identical conditions for all samples.

Both cheese and yogurt samples were subsequently stored at 4 ± 1 °C until analyses. All analyses were performed within 24 h after the completion of cheese and yogurt preparation.

Analysis of milk, cheese, and yogurt samples

Milk samples (n = 2). The chemical composition (fat, protein, casein, lactose, and solids-not-fat contents (%)), somatic cell counts ($\times 10^3$ cells/ml), and freezing point depression (°C × -1 000) were determined using Fourier transform mid-infrared spectroscopy. The analyses were performed using a Combi Foss™ FT 6000 instrument (Foss Electric, Denmark), comprising a MilkoScan 6000 analyzer and a Fossomatic™ 5000 flow cytometer.

Cheese and yogurt samples (n = 4). The chemical composition (fat, protein, lactose, and total solids contents; %) was determined using near-infrared spectroscopy with Fourier transformation (NIR MasterTM N500; Büchi, Switzerland) and NIRWare version 1.5, according to the manufacturer's instructions. Approximately 30 g of homogenized sample was placed in a Petri dish and analysed.

Active acidity was measured using a pH meter equipped with a combined electrode (Fisher Scientific) and reported in pH units. Titratable acidity was determined according to the Soxhlet-Henkel method and expressed in SH units (ml of 0.25 M NaOH required to titrate 100 g of cheese or yogurt to a standard pink colour) as well as in mmol/l according to the equation: titratable acidity (mmol/l) = SH × 2.5, where SH = SH units and 2.5 = coefficient.

The colour of cheese and whey samples was measured using a ColorEye XTH spectrophotometer (Gretag Macbeth, New Windsor, NY, USA). Measurements were performed on 50 g portions of the sample. The results were expressed as L* (lightness), a* (red–green axis), and b* (yellow–blue axis) values.

The hardness of the cheese samples was analysed using the TA.XT Plus texture analyser (Stable Micro-Systems, Godalming, UK). First, the shape of the cheese samples was standardised (blocks of 75 × 40 × 25 mm). The analyser was equipped with a knife probe that cut the samples in half, and the maximum force (kg) required for cutting was recorded. The following settings of the texture analyser were used: pre-test speed: 3 mm/s; test speed: 2 mm/s; and post-test speed: 10 mm/s. A knife probe used for cutting force analysis was a common approach in food measurement and processing, e.g., as generally described by Brown et al. [22]. Moreover, it was one of the described approaches recommended by the manufacturer of the texture analyser.

The viscosity in mPa·s of yogurt samples was measured with a HAAKE Viscotester 6L/R plus viscometer (Thermo Electron (Karlsruhe) GmbH, Karlsruhe, Germany) with an R5 spindle at 50 rpm and a sample temperature of 20 ± 2 °C (R4 for a sample containing 0 and 3% SMP). Enumeration of lactic acid bacteria in yogurt samples was performed using the standard plate method [23]. A ten-fold series dilution was prepared using 10 g of the sample and 0.9% sterile saline solution. For bacterial enumeration, 1 ml of an aliquot was inoculated on MRS agar for *Lactobacillus delbrueckii* subsp. *bulgaricus* (incubated anaerobically at 37 °C for 48 hours) and on M17 agar for *Streptococcus salivarius* subsp. *thermophilus* (incubated aerobically at 37 °C for 48 hours). The results were expressed as the logarithm of colony-forming units per gram of sample (log CFU/g).

Sensory analysis

The sensory evaluation of both products was conducted by a panel of 10 assessors with a mean age of 42.7±10.8 years (range: 29–57). The panel consisted of 50% men (mean age, 46.4±10.5 years) and 50% women (mean age, 39.0±10.9 years). The evaluation was carried out in accordance with the requirements and principles of sensory analysis [24, 25]. The intensity of individual descriptors (colour, aroma, consistency, acceptability, sour and sweet

taste intensity) for each sample was recorded on a 100-mm unstructured line scale.

Statistical analysis

Statistical analysis was performed using Statistica 12 software (StatSoft CR s.r.o.). The dataset was first tested to verify the assumptions for parametric methods (normality of data and homogeneity of variances). The effect of SMP addition was evaluated using one-way analysis of variance. Relationships among variables were assessed using correlation and regression analyses. Post hoc pairwise comparisons were performed using Tukey's HSD test, and Pearson's correlation coefficient (r) was used in the correlation analysis. Statistical significance was determined at the usual levels of significance (0.05, 0.01, 0.001).

RESULTS AND DISCUSSION

Properties of cheese samples

Table 2 shows the effect of SMP addition on the chemical composition, acidity, hardness, and colour of the cheeses. A clear trend was observed in protein and fat content: with increasing SMP levels, protein content increased (from 15.6 to 16.9%), while fat content decreased significantly (from 19.2 to 9.92%; $P < 0.001$). This trend corresponds to the well-known phenomenon whereby an increase in protein content leads to a relative decrease in fat content and changes in the protein-to-fat ratio in cheese [26].

Rogers et al. [27] reported that such compositional changes affect cheese microstructure. Although cheeses with reduced fat content align with current nutritional trends, fat remains a key component that substantially influences the rheological properties of cheese. According to Sharafi et al. [28], decreasing fat content results in increased hardness and springiness, while adhesiveness and cohesiveness decrease, which may be undesirable from a sensory perspective.

These findings were also confirmed in the present study. With increasing SMP content, the force required to cut the samples increased significantly from 2.52 kg to 5.41 kg ($P < 0.001$), indicating an increase in cheese hardness. This relationship was further supported by a positive correlation between hardness and protein content (Figure 1), with a moderate coefficient ($r = 0.5787$; $P < 0.05$). This correlation suggests that compositional changes are among the primary factors influencing the rheological properties of the products [26].

Table 2. Selected parameters of fresh cheese samples enriched with 0, 3, 6, and 9% skimmed milk powder*

Parameters		Levels of skimmed milk powder				P-value
		0%	3%	6%	9%	
Acidity	active (pH)	$4.61^{a}\pm0.13$	$4.64^{ab}\pm0.15$	$4.77^{bc}\pm0.11$	$4.81^{c}\pm0.11$	**0.0020**
	titratable (SH)	88.6±7.58	95.5±6.49	96.3±7.91	97.0±5.10	0.3262
Hardness (kg)		$2.52^{a}\pm0.51$	$3.41^{a}\pm0.94$	$4.55^{b}\pm1.17$	$5.41^{b}\pm0.98$	**<0.001**
Cheese colour	L*	89.8±7.17	89.2±7.59	89.2±6.09	88.7±5.83	0.9864
	a*	$-0.56^{b}\pm0.31$	$-0.60^{b}\pm0.62$	$-1.06^{ab}\pm0.35$	$-1.30^{a}\pm0.37$	**0.0008**
	b*	$9.52^{a}\pm0.82$	$10.0^{ab}\pm0.38$	$10.3^{ab}\pm0.63$	$10.7^{b}\pm0.88$	**0.0036**
Whey colour	L*	35.2±5.72	35.5±5.99	33.3±2.12	35.5±4.18	0.7390
	a*	-0.46±0.29	-0.69±0.36	-0.67±0.11	-0.74±0.15	0.1115
	b*	$-1.70^{b}\pm0.47$	$-2.21^{ab}\pm0.68$	$-2.73^{a}\pm0.41$	$-2.63^{a}\pm0.56$	**0.0011**
Lactose (%)		$2.17^{a}\pm0.38$	$2.82^{b}\pm0.30$	$3.12^{b}\pm0.42$	$3.31^{b}\pm0.41$	**<0.001**
Fat (%)		$19.2^{c}\pm2.53$	$14.8^{b}\pm0.29$	$12.0^{ab}\pm0.25$	$9.92^{a}\pm0.52$	**0.0001**
Protein (%)		15.6±1.31	16.0±0.71	17.2±0.16	16.9±0.59	0.0584
Total solids (%)		36.5±1.58	33.1±5.07	35.9±1.56	34.5±2.20	0.1817

* Values are presented as the mean ± standard deviation
^{a,b,c} Means with different superscripts in a row differ ($P < 0.05$)

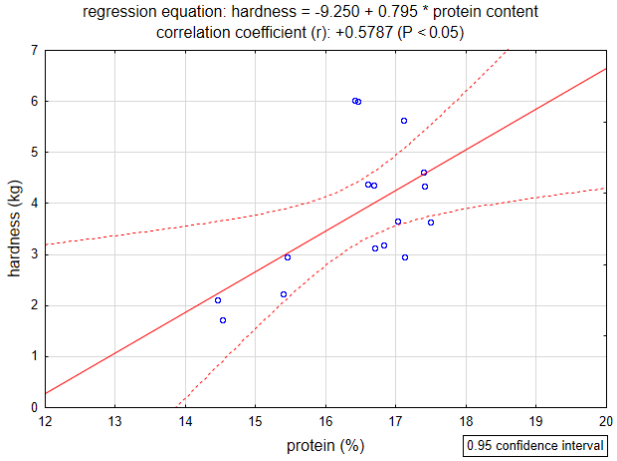


Fig. 1. The relationship between protein content and the hardness of fresh cheese samples

At the same time, a significant increase in lactose content was observed with increasing SMP levels (from 2.17 to 3.31%; $P < 0.001$). In contrast, SMP addition had no significant effect on total solids content. This may indicate that changes in individual components (protein, fat, lactose) partially compensated for each other, resulting in a relatively stable total solids content.

Regarding acid–base properties, increasing SMP levels led to a statistically significant increase in the cheeses' active acidity (from 4.61 to 4.81; $P < 0.01$). This trend is mainly associated with a higher lactose content, which serves as the primary substrate for lactic acid bacteria and thus significantly influences the acidification [29].

Colour measurements of cheese samples showed statistically significant differences in the a* ($P < 0.001$) and b* ($P < 0.01$) coordinates. For the b* coordinate, which describes the transition from yellow (positive values) to blue (negative values), a clear trend was observed: increasing SMP addition led to higher yellow colour intensity in the cheeses. A significant effect was also found for the b* coordinate of whey, where increasing SMP addition resulted in reduced yellow colour ($P < 0.01$). Results reported by Milovanovic et al. [30] further indicate that L* and b* values increase in milk powder.

Properties of yogurt samples

As in fresh cheeses, a similar trend in the fat and protein content was observed in yogurts (Table 3). With increasing SMP content, a significant increase in protein content was detected (from 3.50 to 6.08%; $P < 0.001$), accompanied by a significant decrease in fat content (from 3.58 to 2.96%; $P < 0.01$). In contrast to cheeses, yogurts with higher SMP levels also exhibited a significant increase in total solids content (from 11.6 to 19.7%; $P < 0.001$).

An increase in total solids content is positively associated with improved yogurt texture. Janoušek Honesová et al. [20] observed a positive effect of 10% SMP addition compared to 5%. Damin et al. [7] reported beneficial effects within the range of 12–14% total solids, while Tamime and Robinson [31] identified the most pronounced effects at 12–20%. The improvement in textural properties, together

Table 3. Selected parameters of natural yogurt samples enriched with 0, 3, 6, and 9% skimmed milk powder*

Parameters[1]		Levels of skimmed milk powder				P-value
		0%	3%	6%	9%	
Acidity	active (pH)	4.47±0.36	4.43±0.21	4.39±0.11	4.49±0.14	0.8948
	titratable (SH)	40.7^{a}±4.69	51.2^{b}±4.10	60.1^{c}±2.80	68.4^{d}±3.65	**<0.001**
Lactose (%)		3.13±0.94	2.40±1.01	3.22±1.71	3.13±1.60	0.7627
Fat (%)		3.58^{b}±0.02	3.54^{b}±0.13	3.03^{a}±0.39	2.96^{a}±0.19	**0.0026**
Protein (%)		3.50^{a}±0.05	4.33^{a}±0.46	5.56^{b}±0.11	6.08^{b}±0.92	**0.0001**
Total solids (%)		11.6^{a}±1.55	14.5^{ab}±1.75	16.4^{b}±1.77	19.7^{c}±1.38	**<0.001**
Viscosity (mPa·s)		1070^{a}±554	2174^{ab}±1087	3120^{b}±667	3714^{b}±1060	**0.0027**
ST (log CFU/mL)		8.51±0.36	8.60±0.13	8.64±0.30	8.84±0.07	0.2310
LB (log CFU/mL)		8.38±0.48	8.32±0.22	8.49±0.08	8.41±0.09	0.8058

* Values are presented as the mean ± standard deviation

^{a,b,c} Means with different superscripts in a row differ ($P < 0.05$)

[1] ST – *Streptococcus salivarius* subsp. *thermophilus*; LB – *Lactobacillus delbrueckii* subsp. *bulgaricus*; CFU – colony-forming units

with increased protein and total solids content, is attributed to a denser protein network and reduced pore size, resulting in higher viscosity. For example, Damin et al. [7] showed that yogurts enriched with SMP exhibited a higher proportion of smaller pores within the gel structure. A strong influence of SMP addition on the rheological properties of yogurt has also been reported by Yu et al. [32].

A similar trend was confirmed in the present study: the viscosity of yogurt samples without SMP addition was 1.070 mPa·s, whereas the addition of 9% SMP increased the viscosity to 3.714 mPa·s. This increase can be attributed to the higher total solids and protein content provided by SMP, which improved water-binding capacity and promoted the formation of a stronger gel network [7, 12]. The strong relationship between total solids content and yogurt viscosity is further illustrated in Figure 2, which shows a high correlation coefficient ($r = 0.8634$; $P < 0.001$).

Active acidity did not differ significantly among the yogurt samples. Körzendörf and Hinrichs [33] reported that the optimal pH of high-protein yogurts ranges from 4.7 to 4.9, with higher pH values promoting greater viscosity and a more homogeneous structure, whereas lower pH values result in a more granular texture. In contrast, a significant effect of SMP addition on the titratable acidity of the yogurts was observed, with values increasing from 40.7 to 68.4 SH at higher levels of addition ($P < 0.001$).

The different trends in active and titratable acidity were also confirmed by other authors [7, 19, 20]. The discrepancy between pH and titratable acidity can be attributed to the buffering capacity of milk components, particularly proteins and minerals, which stabilizes the concentration of free hydrogen ions. Consequently, the total acid content may increase significantly without a proportional decrease in pH, leading to higher titratable acidity values despite a relatively constant pH.

Sensory evaluation of yogurt and cheeses

The study also included an evaluation of organoleptic properties (Figure 3). As expected, the most pronounced differences were observed in consistency for both cheeses and yogurts (both $P < 0.001$). Among the cheeses, the sample with 9% SMP addition received the highest scores for consistency and colour, but the lowest score for taste. This sample also exhibited the lowest perceived sour taste intensity, whereas the cheese without SMP addition (0%) showed the highest. These findings suggest that sour taste intensity plays a key role in consumer preference, as cheeses with 0% and 9% SMP were rated lowest in taste, while those with 3% and 6% SMP were rated most favourably.

In contrast, yogurt samples containing 6% and 9% SMP achieved the highest ratings for both taste and consistency. Unlike cheeses, the higher sour taste intensity in these samples was positively perceived. Additionally, these samples showed the lowest sweet taste intensity while receiving the highest taste scores, indicating that a combination of higher sour and lower sweet intensities may be preferred by consumers in natural yogurts.

The influence of protein enrichment on organoleptic properties and consumer preferences has also been reported in previous studies for cheese [34, 35] and yogurt [7, 20, 32], which demonstrate that the incorporation of milk proteins improves texture, viscosity, and overall sensory quality, key factors determining consumer acceptance.

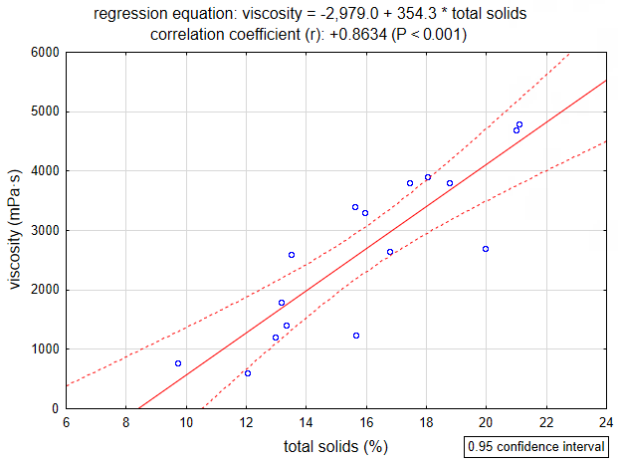


Fig. 2. The relationship between total solids content and the viscosity of natural yogurt samples

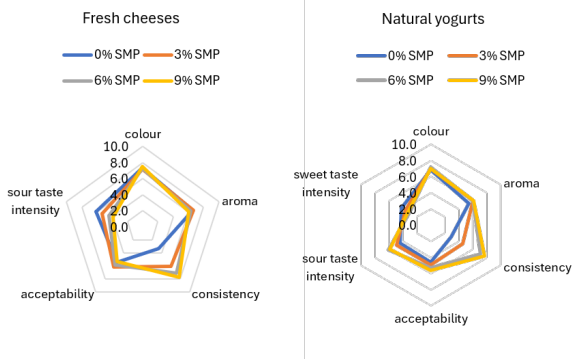


Fig. 3. Sensory profile of fresh cheese samples and natural yogurt samples enriched with 0, 3, 6, and 9% skimmed milk powder (SMP)

CONCLUSION

The study demonstrated a significant effect of SMP addition on the physicochemical and organoleptic properties of the evaluated dairy products. However, the optimal level of SMP addition differed between fresh cheeses and yogurts.

With increasing SMP content, both fresh cheeses and natural yogurts showed increased protein content accompanied by a relative reduction in fat content. In fresh cheeses, this trend was reflected in increased hardness, whereas in yogurts it resulted in increased viscosity.

Sensory evaluation confirmed that SMP addition affects the organoleptic properties of fermented dairy products. In fresh cheeses, samples containing 3% and 6% SMP were rated as the most acceptable, while those with 0% and 9% SMP showed lower consumer preference. In contrast, yogurt samples with higher levels of SMP addition (6% and 9%) were evaluated more favourably.

Based on these findings, it can be concluded that SMP addition is an effective approach to enhance the nutritional value, technological, and sensory properties of fermented dairy products. However, the optimal level of SMP addition should be adjusted based on consumer preferences associated with specific characteristics of each dairy product.

Data Availability Statement

The raw data supporting the findings of this study are available from the authors upon reasonable request.

Ethical Statement

Ethical approval was not required for this study.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Generative AI Statement

No generative AI or AI-assisted technologies were used in the preparation of this manuscript.

Authors' Contributions

Simona Janoušek Honesová: writing – original draft, resources, conceptualization, writing – review & editing. **Eva Samková:** writing – original draft, writing – review & editing, methodology, investigation, conceptualization, funding acquisition, supervision. **Lucie Hasoňová:** methodology, investigation, conceptualization, writing – original draft, data curation. **Kristina Hradilová:** methodology, investigation, writing – original draft. **Tereza Janů:** writing – review & editing, resources. **Lada Švecová:** writing – review & editing, resources. **Eva Baldíková:** writing – review & editing, resources. **Jan Bedrníček:** methodology, investigation, conceptualization, writing – original draft, data curation.

REFERENCES

1. **Black, R. E., Williams, S. M., Jones, I. E., Goulding, A., 2002:** Children who avoid drinking cow milk have low dietary calcium intakes and poor bone health. *Am. J. Clin. Nutr.*, 76, 3, 675–680. DOI: 10.1093/ajcn/76.3.675
2. **Gahruie, H. H., Eskandari, M. H., Mesbahi, G., Hanifpour, M. A., 2015:** Scientific and technical aspects of yogurt fortification: A review. *Food Sci. Hum. Well.*, 4, 1, 1–8. DOI: 10.1016/j.fshw.2015.03.002
3. **Rizzoli, R., 2014:** Dairy products, yogurts, and bone health. *Am. J. Clin. Nutr.*, 99, 5, 1256S–1262S. DOI: 10.3945/ajcn.113.073056
4. **García-Burgos, M., Moreno-Fernández, J., Alférez, M. J. M., Díaz-Castro, J., López-Aliaga, I., 2020:** New perspectives in fermented dairy products and their health relevance. *J. Funct. Foods*, 72, 104059. DOI: 10.1016/j.jff.2020.104059
5. **Sarkar, S., 2019:** Potentiality of probiotic yoghurt as a functional food – A review. *Nutr. Food Sci.*, 49, 2, 182–202. DOI: 10.1108/Nfs-05-2018-0139
6. **Abdi-Moghadam, Z., Darroudi, M., Mahmoudzadeh, M., Mohtashami, M., Jamal, A. M., Shamloo, E., Rezaei, Z., 2023:** Functional yogurt, enriched and probiotic: A fo-

cus on human health. *Clin. Nutr. Espen*, 57, 575–586. DOI: 10.1016/j.clnesp.2023.08.005

7. **Damin, M. R., Alcântara, M. R., Nunes, A. P., Oliveira, M. N., 2009:** Effects of milk supplementation with skim milk powder, whey protein concentrate and sodium caseinate on acidification kinetics, rheological properties and structure of nonfat stirred yogurt. *LWT-Food Sci. Technol.*, 42, 10, 1744–1750. DOI: 10.1016/j.lwt.2009.03.019
8. **Olson, R., Gavin-Smith, B., Ferraboschi, C., Kraemer, K., 2021:** Food fortification: The advantages, disadvantages and lessons from sight and life programs. *Nutrients*, 13, 4, 1118. DOI: 10.3390/nu13041118
9. **Wajs, J., Brodziak, A., Król, J., 2023:** Shaping the physicochemical, functional, microbiological and sensory properties of yoghurts using plant additives. *Foods*, 12, 6, 1275. DOI: 10.3390/foods12061275
10. **Gomaa, M. A. E., Allam, M. G., Haridi, A. A. I. M., Eliwa, A. M., Darwish, A. M. G., 2021:** High-protein concentrated pro-yogurt (Pro-WPI) enriched with whey protein isolate improved athletic anemia and performance in a placebo-controlled study. *Front. Nutr.*, 8, 788446. DOI: 10.3389/fnut.2021.788446
11. **Keršienė, M., Jasutienė, I., Eisinaitė, V., Pukalskienė, M., Venskutonis, P. R., Damulevičienė, G., et al., 2020:** Development of a high-protein yoghurt-type product enriched with bioactive compounds for the elderly. *LWT-Food Sci. Technol.*, 131, 109820. DOI: 10.1016/j.lwt.2020.109820
12. **Jorgensen, C. E., Abrahamsen, R. K., Rukke, E.-O., Hoffmann, T. K., Johansen, A.-G., Skeie, S. B., 2019:** Processing of high-protein yoghurt – A review. *Int. Dairy J.*, 88, 42–59. DOI: 10.1016/j.idairyj.2018.08.002
13. **Khan, I. T., Nadeem, M., Imran, M., Ullah, R., Ajmal, M., Jaspal, M. H., 2019:** Antioxidant properties of milk and dairy products: a comprehensive review of the current knowledge. *Lipids Health Dis.*, 18, 41. DOI: 10.1186/s12944-019-0969-8
14. **Giroux, H. J., Dupont, F., Villeneuve, G., Britten, M., 2020:** Effect of heating milk on whey protein denaturation and cheese-making properties. *Int. Dairy J.*, 111, 104831. DOI: 10.1016/j.idairyj.2020.104831
15. **Jiránková, H., 2015:** Membrane processes in the food and dairy industry. In *Membrane Processes in the Food Industry*. The Czech Membrane Platform, o.s., Stráž pod Ralskem, pp. 4–11. [In Czech].
16. **Kelly, A. L., Huppertz, T., Sheehan, J. J., 2008:** Pre-treatment of cheese milk: principles and developments. *Dairy Sci. Technol.*, 88, 549–572. DOI: 10.1051/dst:2008017
17. **Masotti, F., Cattaneo, S., Stuknytė, M., De Noni, I., 2017:** Technological tools to include whey proteins in cheese: Current status and perspectives. *Trends Food Sci. Tech.*, 64, 102–114. DOI: 10.1016/j.tifs.2017.04.007
18. **Ibrahim, A. S., Saad, M. F., Hafiz, N. M., 2021:** Safety and quality aspects of whole and skimmed milk powders. *Acta Sci. Polon.–Techn.*, 20, 2, 165–177. DOI: 10.17306/J.Afs.2021.0874
19. **de Souza, W. F. C., do Amaral, C. R. S., Bernardino, P. D. L. D., 2021:** The addition of skim milk powder and dairy cream influences the physicochemical properties and the sensory acceptance of concentrated Greek-style yogurt. *Int. J. Gastron. Food Sci.*, 24, 100349. DOI: 10.1016/j.ijgfs.2021.100349
20. **Janoušek Honesová, S., Samková, E., Dadáková, E., Hasoňová, L., Jarošová, M., Reindl, K., Bárta, J., 2024:** Effect of skimmed milk powder and fruit jams addition on the physicochemical characteristics of yogurt. *Fermentation-Basel*, 10, 9, 462. DOI: 10.3390/fermentation10090462
21. **ON 57 0534, 1986:** Milk fermentationability determination. Standard of Milk Industry: Prague. [In Czech]
22. **Brown, T., James, S. J., Purnell, G. L., 2005:** Cutting forces in foods: experimental measurements. *J. Food Eng.*, 70, 2, 165–170. DOI: 10.1016/j.jfoodeng.2004.09.022
23. **ČSN ISO 7889 (571420), 2003:** Yogurt Enumeration of Characteristic Microorganisms—Colony-Count Technique at 37 °C. Czech Office for Standards, Metrology and Testing: Prague. [In Czech]
24. **ČSN ISO 11035 (560061), 2003:** Sensory analysis – Identification and selection of descriptors for establishing a sensory profile by a multidimensional approach. Czech Office for Standards, Metrology and Testing: Prague. [In Czech]
25. **ČSN ISO 4121 (560052), 2009:** Sensory analysis – Guidelines for the use of quantitative response scales. Czech Office for Standards, Metrology and Testing: Prague. [In Czech]
26. **Lepesioti, S., Zoidou, E., Lioliou, D., Moschopoulou, E., Moatsou, G., 2021:** Quark-type cheese: Effect of fat content, homogenization, and heat treatment of cheese milk. *Foods*, 10, 1, 184. DOI: 10.3390/foods10010184
27. **Rogers, N. R., McMahon, D. J., Daubert, C. R., Berry, T. K., Foegeding, E. A., 2010:** Rheological properties and microstructure of Cheddar cheese made with different fat contents. *J. Dairy Sci.*, 93, 10, 4565–4576. DOI: 10.3168/jds.2010-3494
28. **Sharafi, S., Nateghi, L., Eyvazzade, O., Ebrahimi, M. T. A., 2020:** The physicochemical, texture hardness and senso-

rial properties of ultrafiltrated low-fat cheese containing galactomannan and novagel gum. *Acta Sci. Polon.–Techn.*, 19, 1, 83–100. DOI: 10.17306/j.Afs.0685

29. **Nicosia, F. D., Pino, A., Maciel, G. L. R., Sanfilippo, R. R., Caggia, C., de Carvalho, A. F., Randazzo, C. L., 2023:** Technological characterization of lactic acid bacteria strains for potential use in cheese manufacture. *Foods*, 12, 6, 1154. DOI: 10.3390/foods12061154
30. **Milovanovic, B., Djekic, I., Miocinovic, J., Djordjevic, V., Lorenzo, J. M., Barba, F. J., et al., 2020:** What is the color of milk and dairy products and how is it measured? *Foods*, 9, 11, 1629. DOI: 10.3390/foods9111629
31. **Tamime, A. Y., Robinson, R. K., 2007:** *Tamime and Robinson's Yoghurt.* Woodhead Publishing, Sawston, Cambridge, England, pp. 808.
32. **Yu, H. Y., Wang, L., McCarthy, K. L., 2016:** Characterization of yogurts made with milk solids nonfat by rheological behavior and nuclear magnetic resonance spectroscopy. *J. Food Drug Anal.*, 24, 4, 804–812. DOI: 10.1016/j.jfda.2016.04.002
33. **Körzendörfer, A., Hinrichs, J., 2019:** Manufacture of high-protein yogurt without generating acid whey – Impact of the final pH and the application of power ultrasound on texture properties. *Int. Dairy J.*, 99, 104541. DOI: 10.1016/j.idairyj.2019.104541
34. **Alsaleem, K. A., Hamouda, M. E. A., Alayouni, R. R., Elfaruk, M. S., Hammam, A. R. A., 2023:** Effect of skim milk powder and whey protein concentrate addition on the manufacture of probiotic Mozzarella cheese. *Fermentation*, 9, 11, 948. DOI: 10.3390/fermentation9110948
35. **Giménez, P., Peralta, G. H., Batistela, M. E., Cuffia, F., Ale, E. C., Wolf, I. V., et al., 2023:** Impact of the use of skim milk powder and adjunct cultures on the levels of organic acid and carbohydrates, volatile compounds and sensory properties of Cremoso cheese. *Int. Dairy J.*, 140, 105594. DOI: 10.1016/j.idairyj.2023.105594