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Enhancement of low-fat spreadable processed cheese with sesame proteins: evaluation of quality and purity characteristics

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Abstract

Objective

Fat is the primary component affecting both the energy content and functional properties of cheese. Consequently, the development of low-fat functional foods continues to attract meaningful interest from researchers and the food industry. However, reducing fat and increasing protein content in processed cheese typically leads to greater brittleness and reduced elasticity, spreadability, and solubility. This investigations examined the effect of incorporating sesame proteins at varying concentrations as fat substitutes in a spreadable low-fat processed cheese mixture, with a centralize on physicochemical, rheological, sensory, and clearance characteristics.

Materials and Methods

Full-fat cheddar cheese combined with full-fat soft cheese served as the positive control, while a blend of full-fat cheddar cheese and low-fat soft cheese served as the negative control. Sesame protein was added as a fat replacer in different proportions (T1, T2, and T3) at concentrations of 1.5%, 3.0%, and 4.5%, respectively. Chemical analyses included determination of moisture, protein, fat, ash, carbohydrate content, total acidity, and pH. Rheological evaluations encompassed hardness, adhesiveness, and flexibility, while sensory analysis and clearance percentage were also evaluated.

Results

Cheese samples with sesame protein exhibited lower moisture content than the negative control, while protein levels were closer to those of the positive control. Carbohydrate, ash, and total acidity levels improved in the replacement treatments, whereas fat content and pH decreased. Texture analyses demonstrated improvements in hardness, adhesion, and flexibility, accompanied by increased sensory attributes and higher clearance percentages relative to both controls. SDS-PAGE analysis affirmed the successful incorporation of sesame proteins (20–50 kDa range), with band intensity increasing in proportion to substitution level, while preserving the structural integrity of milk proteins, containing α-, β-, and κ-caseins.

Conclusion

The incorporation of sesame proteins as fat substitutes improved the physicochemical, rheological, and sensory qualities of low-fat spreadable processed cheese while maintaining protein integrity. These results highlight the potential of sesame proteins as effective fat replacers, proposing a hopeful approach for expanding nutritionally improved and consumer-acceptable low-fat cheese products.

Keywords: clearance percentage, fat substitutes, processed cheese, SDS-PAGE, sesame proteins

Paper Type: Research Paper.

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Introduction

Recent trends in the manufacture of dairy products have increasingly centralized on the use of fat substitutes to improve both nutritional and functional properties. Many fat replacers not only reduce the caloric value of food products but also supply bioactive compounds with potential health benefits. Such compounds have been related to strengthening the immune system, reducing cholesterol levels, and contributing to the development of healthier food options that align with consumer request for functional and low-energy products (Vidigal et al., 2012). Advances in food technology and growing consumer awareness of diet-related health issues have further accelerated the search for functional components and fat substitutes in dairy products. Fat plays a crucial role in cheese, as it largely identifies the energy content, texture, and overall sensory quality of the product. However, the production of low-fat functional foods remains a challenge for both researchers and the food industry. Reducing fat while increasing protein content in processed cheese often leads to undesirable textural alters, like improved brittleness, reduced elasticity, poor spreadability, and decreased solubility (Tamime, 2011). To overcome these limitations, numerous fat replacers have been investigated. For example, starch is broadly applied to improve consistency and density while reducing hardness in spreadable processed cheese. Guar gum has been announced to raise certain textural attributes, whereas carrageenan was found to reduce solubility in cheese spreads (Hazen, 2005). Beyond hydrocolloids and starches, plant-based proteins have also been studied as functional fat substitutes in cheese. Soy protein has been successfully incorporated into a variety of cheese types, containing cheddar, mozzarella, damietta, cream, fresh, and processed cheeses, with varying effects on quality attributes (Hsieh et al., 1990). More recently, the food industry has emphasized the development of sustainable and health-oriented alternatives to animal-derived products, further driving interest in plant proteins (Boukid et al., 2021).

Among plant protein sources, sesame protein has received growing attention. De-oiled sesame seed protein is exclusively notable for its balanced amino acid profile, containing glutamine, arginine, isoleucine, leucine, threonine, and valine (FAO, 2011). Furthermore, sesame protein is rich in sulfur-containing amino acids like methionine and cysteine (Onsaard, 2012), which are often restricted in other plant proteins. This makes sesame protein an excellent candidate for complementing the nutritional profile of food formulations. Additional investigations have highlighted its digestibility, high biological value, and abundance of essential amino acids, containing methionine and tryptophan, which support its use as an ideal plant-based protein component (Achouri et al., 2012; Joshi, et al., 2015; Mousazadeh et al., 2018).

Attending these nutritional and functional advantages, sesame protein shows promise as a fat substitute in cheese manufacturing. However, its effects on the physicochemical, rheological, and sensory properties of low-fat spreadable processed cheese remain insufficiently investigated. Therefore, the current investigations aimed to evaluate the impression of sesame protein incorporation at different concentrations on the quality characteristics and clarification rate of low-fat spreadable processed cheese.

Materials and methods

Raw materials: Raw cow's milk was obtained from local dairy farms near Al-Qasim Green University (Iraq). Microbial rennet (chymosin enzyme) was procured from Chr. Hansen A/S (Denmark). Sesame protein was extracted in the laboratories of the College of Food Sciences, Al-Qasim Green University, applying a standardized protein extraction protocol. Emulsifying salts were obtained from the Chinese company CAS.

Preparation of soft cheese: Soft cheese was prepared subsequent the procedure described by Al-Bedrani (2023), with slight modifications. Briefly, raw milk was standardized by adjusting its fat content to 0.5%. The standardized milk was pasteurized at 63 °C for 30 min, followed by cooling to 37 °C. Microbial rennet (Chr. Hansen, Denmark) was then added to induce coagulation. After curd formation, the cheese was processed and stored for further use.

Preparation of processed cheese treatments: Processed cheese was prepared based on the method of Al-Zarfi (2022). For the positive control, full-fat cheddar cheese was blended with full-fat soft cheese. For the negative control, 100 g of full-fat cheddar cheese was mixed with 300 g of low-fat soft cheese. Experimental treatments (T1, T2, and T3) were prepared by mixing 100 g of full-fat cheddar cheese with 300 g of low-fat soft cheese and fortifying with sesame protein at concentrations of 1.5%, 3.0%, and 4.5%, respectively. All mixtures were homogenized, heated, and processed under identical conditions to ensure comparability.

Chemical analyses: Moisture content was identified based on Ling (2008), fat content was calculated subsequent the method of Min and Ellefson (2010), and pH was estimated as described by Ling (2008). Total protein, ash, carbohydrate content, and titratable acidity were also calculated subsequent standard AOAC procedures to supply a complete chemical profile of the cheese samples.

Texture profile analysis: Textural properties of the cheese samples were analyzed applying a texture analyzer (CT3, Brookfield Engineering Labs, USA) equipped with a 5 kg load cell. Measurements of hardness, adhesiveness, and flexibility were obtained based on the method of Joon (2017), with three replicates per sample to ensure statistical reliability.

Sensory evaluation: Sensory evaluation was managed by a trained panel of ten faculty members from the College of Food Sciences, Al-Qasim Green University. The panelists evaluated appearance, flavor, texture, spreadability, and overall acceptability applying a structured evaluation form expanded by Afnor (1993). Evaluations were carried out under controlled conditions to minimize bias.

Protein profile analysis (SDS-PAGE): Protein patterns of cheese samples (controls and treatments) and sesame protein extracts were analyzed by sodium dodecyl sulfate–polyacrylamide gel electrophoresis (SDS-PAGE) based on Laemmli (1970). Samples were prepared by homogenizing 2 g of cheese with 10 mL of sample buffer (0.125 M Tris-HCl, pH 6.8, 4% SDS, 20% glycerol, 10% β-mercaptoethanol, and 0.01% bromophenol blue) and heating at 95 °C for 5 min. Electrophoresis was carried out on 12% resolving gels with 5% stacking gels applying a vertical electrophoresis apparatus at 120 V. Gels were stained with Coomassie Brilliant Blue R-250 and destained with a methanol–acetic acid solution. Molecular weight markers (10–200 kDa) were applied to estimate band sizes. Electrophoretic profiles were compared to assess protein conformation, stability, and interactions between sesame proteins and milk proteins in the processed cheese formulations.

Statistical analysis: Data were analyzed applying the Statistical Analysis System (SAS, version 2018). Outcomes were expressed as mean ± standard deviation. Analysis of variance (ANOVA) was carried out to assess differences among treatments, and meaningful differences were identified at $p < 0.05$ applying Duncan's multiple range test.

Results and discussion

Chemical composition of low-fat processed cheese with partial replacement by sesame proteins: The proximate composition of the control and experimental cheese treatments is showed in Table 1. The moisture content of the positive control (C+) was 63.8%, which aligns with the results of Chatziantoniou (2015), who announced 63.35% for processed cheese, and with El-Aidie (2023), who announced 62.53%. These outcomes are also in line with Al-Zorfi (2022), who indicated that the moisture content of full-fat cooked cheese was almost 64%. The improve in moisture generally occurs at the expense of fat reduction, a trend also announced by Al-Badrani (2019). Statistical analysis showed no meaningful differences ($p \leq 0.05$) between the positive control and the negative control (C−). Similarly, no meaningful differences were observed between C+ and the sesame protein treatments (T1, T2, T3), although T3 showed a meaningful difference compared to C−. The protein content of C+ was 13.28%, whereas C− exhibited a higher level (17.87%). This improve is in line with El-Assar et al. (2019), who announced higher protein levels in cheese where fat was replaced with inulin. Kumar (2012) also highlighted that low-fat dairy products typically contain higher protein percentages, as protein becomes the dominant solid fraction in the absence of fat. This trend was further supported by Rahi et al. (2023), who demonstrated that the addition of vegetable proteins improved total protein levels in processed cheese. In the current investigations, treatments enriched with sesame protein showed progressive improves in protein content (19.07%, 20.35%, and 21.45% for T1, T2, and T3, respectively), with meaningful differences compared to the controls ($p \leq 0.05$). Fat content decreased markedly in the low-fat formulations. The fat level of C+ was 17.5%, which aligns with El-Shibiny et al. (2007), who announced 13.71% for processed cheese. By contrast, C− contained only 5.75% fat.

The sesame protein treatments showed even lower fat values (5.85%, 4.5%, and 4.3% for T1, T2, and T3, respectively). These reductions are in line with Abd El-Salam (2015), who demonstrated that incorporating fat substitutes in milk intended for cheese production effectively reduces fat levels in the final product.

Table 1. Chemical composition, pH values, and total acidity of low-fat processed cheese with different levels of sesame protein

Treatment	Moisture (%)	Protein (%)	Fat (%)	Carbohydrates (%)	Ash (%)	Acidity (% lactic acid)	pH
C+	63.8	13.28	17.5	3.52	1.90	1.24	5.90
C−	66.33	17.87	5.75	7.49	2.56	1.25	5.88
T1 (1.5%)	65.00	19.07	5.85	7.38	2.70	1.26	5.85
T2 (3.0%)	64.66	20.35	4.50	7.49	3.00	1.75	5.83
T3 (4.5%)	63.20	21.45	4.30	7.55	3.50	1.87	5.79
LSD (0.05)	3.017*	3.405*	3.256*	2.065*	1.027*	0.419*	0.308^{NS}

*** Indicates significant differences at $p \leq 0.05$; NS = not significant**

Carbohydrate content also varied among treatments. The C+ sample had 3.52%, comparable to the results of Al-Badrani (2019), while C− had 7.49%. Sesame protein treatments showed slightly higher values (7.38–7.55%), with meaningful differences observed between C− and C+. Ash content improved in the sesame protein treatments compared to controls. While C+ contained 1.90%, the negative control (C−) reached 2.56%. T1, T2, and T3 had 2.70%, 3.00%, and 3.50%, respectively. The improve in ash may be attributed to the mineral-rich nature of sesame proteins, which contribute to the total inorganic content of the cheese. Similar results were announced by El-Baz (2013), and Joshi et al. (2004), who indicated that high-protein cheeses often exhibit higher ash levels alongside reduced fat contents. The pH values varied between 5.79 and 5.90 across all treatments, with C+ at 5.90 and C− at 5.88, closely matching outcomes announced by Al-Badrani et al. (2019). Sesame protein treatments showed slightly lower pH values (5.85, 5.83, and 5.79 for T1, T2, and T3, respectively). The lower pH may be explained by the addition of emulsifying salts, which are known to reduce pH through processing. Pinto et al. (2007) announced similar acidity levels in processed cheeses. Acidity improved progressively with sesame protein addition, ranging from 1.24% in C+ to 1.87% in T3, denoting that fat replacement may impression lactic acid retention and buffering capacity.

Rheological properties: Hardness is defined as the force needed to compress or deform a cheese sample (Brown et al., 2003; Nateghi et al., 2012). Figure 1 shows the hardness values for C+, C−, and sesame protein treatments. C+ exhibited a hardness of 26.7 g, whereas C− reached 41.5 g. Treatments fortified with sesame protein showed much higher hardness values (81.8, 88.0, and 91.0 g for T1, T2, and T3, respectively).

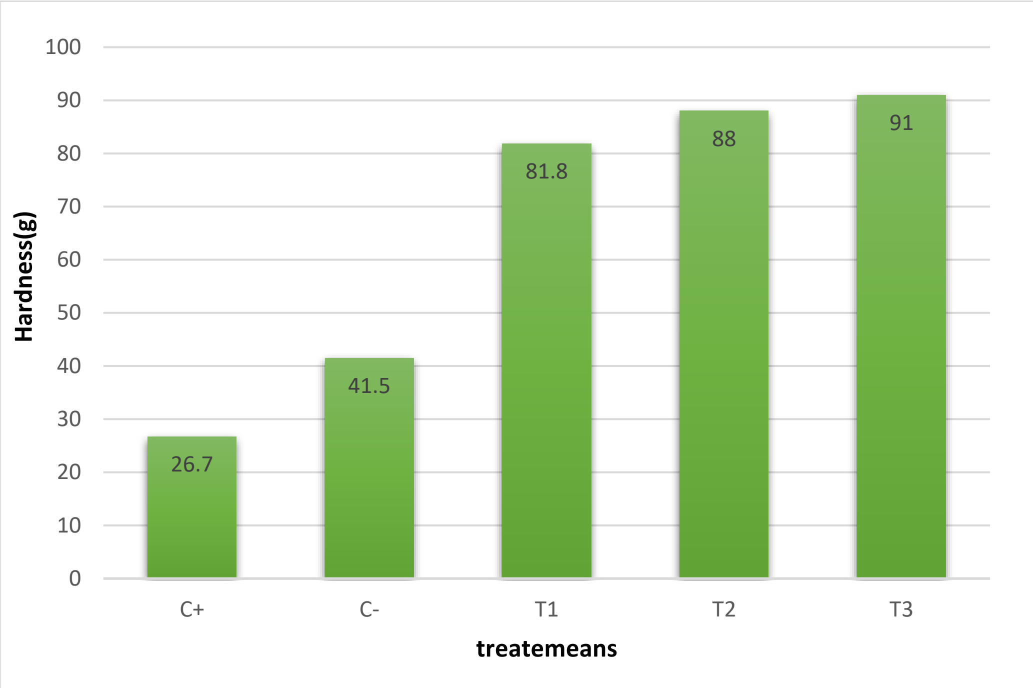

Figure 1. Hardness values of processed cheese treatments (C+ = full-fat control; C− = low-fat control; T1, T2, T3 = 1.5%, 3.0%, and 4.5% sesame protein). LSD = 9.38 ($p \leq 0.05$)

The progressive improve in hardness with higher levels of sesame protein proposes that fat replacement intensifies protein dominance in the cheese matrix, leading to a denser protein network. Since fat typically imparts softness and elasticity, its reduction outcomes in firmer and less elastic textures. Similar trends were announced by Rogers et al. (2010), who showed that reducing fat improves protein concentration, thereby enhancing protein-protein interactions and producing a more rigid cheese structure.

Cohesion: The outcomes showed in Figure 2 show the cohesion values of the positive control (C+), negative control (C−), and the cheese samples fortified with sesame proteins (T1, T2, T3). The cohesion value of C+ was 0.95, while C− exhibited a slightly lower value of 0.94. The sesame protein treatments demonstrated values of 0.95, 0.97, and 1.02 for T1, T2, and T3, respectively. These outcomes indicate that the replacement treatments exhibited higher cohesion than the negative control and values comparable to the positive control. This proposes that the addition of sesame proteins raises the structural integrity of the cheese matrix by reinforcing protein–protein interactions, thus improving cohesion. Similar results were announced by Lucey et al. (2014), who observed that protein enrichment in reduced-fat cheeses improves network stability and consistency.

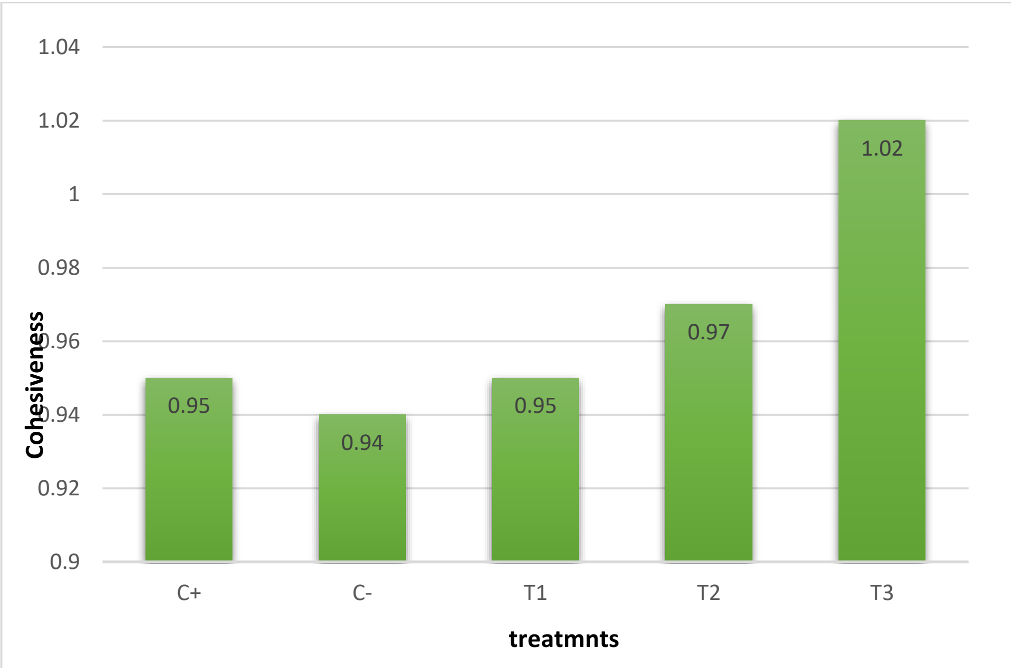

Figure 2. Cohesion values for treatments of full-fat processed cheese (C+), low-fat control (C−), and processed low-fat cheese supplemented with sesame proteins at 1.5%, 3.0%, and 4.5%. LSD = 1.7 ($p \leq 0.05$)

Flexibility (Elasticity): Textural attributes of cheese, containing elasticity, are identified by the interactions between the protein matrix and fat globules dispersed within it (Lobato-Calleros et al., 2007). The reduction or removal of fat disrupts this balance and typically outcomes in undesirable alters in texture, like improved hardness and reduced elasticity, chewiness, and overall palatability (Drake et al., 1999; Awad et al., 2005). Therefore, the use of fat substitutes that mimic the functional role of fat is critical for maintaining consumer acceptability of low-fat cheese. The elasticity values of the different treatments are shown in Figure 3. The positive control (C+) exhibited the highest elasticity (5.6 mm), while the negative control (C−) demonstrated a markedly reduced value (2.9 mm). Treatments fortified with sesame protein demonstrated intermediate values of 5.3 mm (T1), 4.8 mm (T2), and 3.8 mm (T3). These results clearly show that sesame protein addition improved elasticity relative to the negative control, though elasticity decreased as the substitution level improved. This behavior may be attributed to the dual effect of protein enrichment: at moderate levels (1.5–3%), sesame proteins may raise the viscoelastic properties of the matrix by integrating into the protein network, but at higher concentrations (4.5%), the denser protein structure may restrict flexibility.

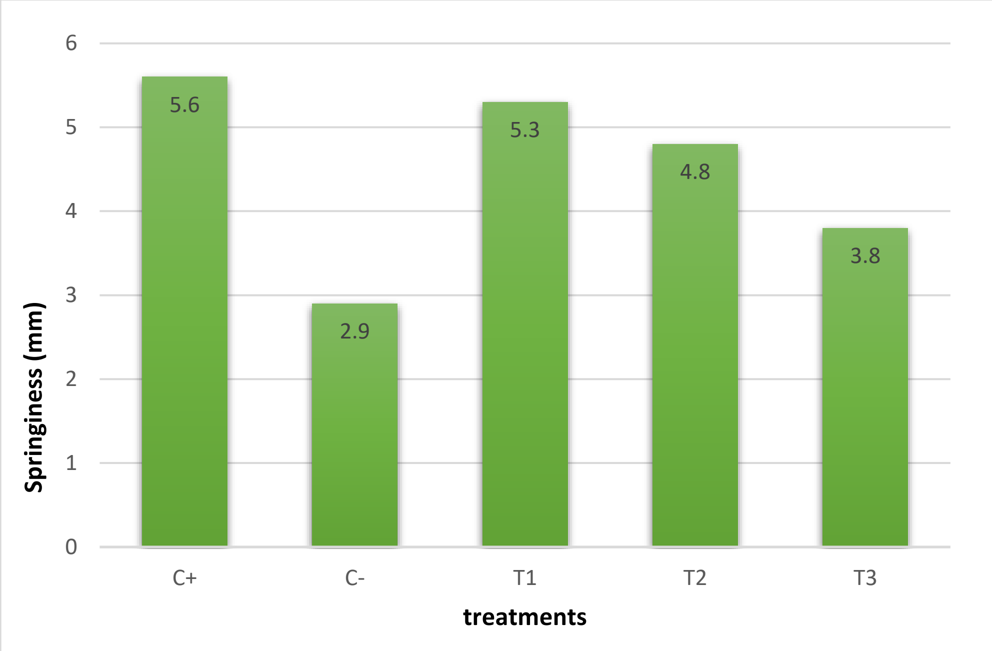

Figure 3. Elasticity values for treatments of full-fat processed cheese (C+), low-fat control (C−), and processed low-fat cheese supplemented with sesame proteins at 1.5%, 3.0%, and 4.5%. LSD = 1.84 ($p \leq 0.05$)

These observations are in agreement with Koca and Metin (2004), who announced that low-fat cheeses exhibit reduced elasticity compared to their full-fat counterparts. Similarly, Korish and Abeer (2012) demonstrated that the addition of plant proteins can improve flexibility in reduced-fat cheese formulations by partially compensating for the absence of fat. In the current investigations, the sesame protein-enriched cheeses showed greater elasticity than C−, affirming that sesame proteins act as functional fat replacers capable of restoring some of the desirable textural properties lost with fat reduction.

Sensory evaluation: The sensory evaluation outcomes for the processed cheese samples are showed in Table 2. The evaluation included the positive control (C+), negative control (C−), and the experimental treatments supplemented with sesame proteins at levels of 1.5% (T1), 3.0% (T2), and 4.5% (T3). Overall, the panel scores indicated that the control samples (C+ and C−) were superior to the sesame protein-enriched cheeses in most sensory attributes, containing appearance, texture, flavor, cohesiveness, and overall acceptability.

Table 2. Sensory evaluation of positive and negative control samples and processed cheese with sesame proteins added at 1.5, 3.0, and 4.5%. Each value represents the mean of three replicates

Treatment	Total (80)	Cohesiveness (10)	Appearance (10)	Bitterness (10)	Texture (10)	Fat separation (10)	Flavor (10)	Body (10)	Color (10)
C+	75.7	9.5	9.4	10.0	9.0	9.8	9.5	9.0	9.5
C−	71.2	8.7	9.1	9.4	8.5	9.0	8.8	8.5	9.2
T1	66.8	8.4	8.0	9.0	7.8	8.6	8.4	8.0	8.6
T2	61.8	7.8	7.8	8.3	7.5	7.8	7.4	7.0	8.2
T3	61.6	8.0	7.6	7.8	7.5	7.8	7.2	7.7	8.0
LSD ($p \leq 0.05$)	7.85	1.24	1.38	1.53	1.29	1.22	1.27	1.19	1.25

Interestingly, the color attribute was not negatively affected by sesame protein addition, proposing that protein enrichment does not alter the visual quality of the final product. In contrast, the flavor attribute was somewhat impressd, exclusively in terms of bitterness. However, panelists still rated the bitterness as acceptable, and the scores were comparable to those of the control samples. Statistical analysis disclosed no meaningful differences ($p \leq 0.05$) in color and bitterness among treatments, but meaningful differences were observed in attributes related to texture, body, and overall acceptability. These results affirm that while the addition of sesame proteins modifies some sensory characteristics, it does not compromise fundamental attributes like color or flavor beyond consumer acceptability thresholds. Similar trends have been announced by Korish and Abeer (2012), who showed that partial substitution with plant proteins can reduce creaminess and flavor intensity in cheese but does not necessarily reduce overall consumer acceptance.

Liquefaction ratio: The liquefaction ratio (or clearance percentage) of the cheese samples is shown in Figure 4. Differences were observed among treatments, primarily impressed by the composition of the milk and the type of fat replacer applied. The positive control (C+) exhibited the highest liquefaction ratio at 62%, while the negative control (C−) demonstrated a lower value of 58.3%. Sesame protein-fortified cheeses showed intermediate values depending on the level of addition (1.5%, 3.0%, and 4.5%).

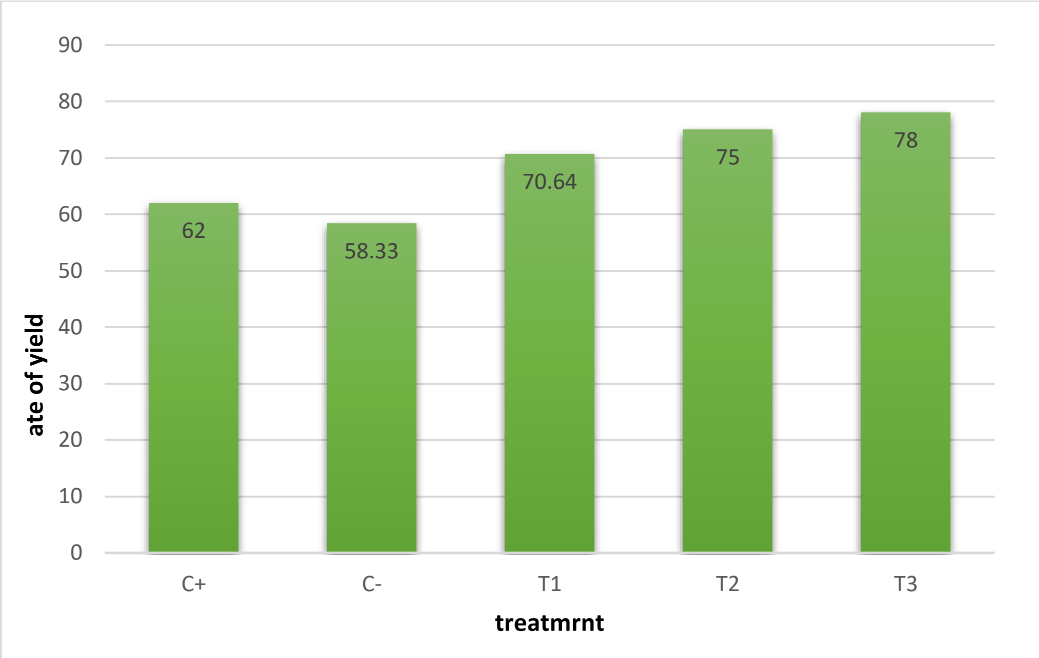

Figure 4. Liquefaction ratio (%) of processed cheese treatments: positive control (C+), negative control (C−), and low-fat processed cheese supplemented with sesame proteins (1.5%, 3.0%, and 4.5%)

The lower liquefaction ratio in the C− sample can be explained by the use of skimmed milk, which contains less fat and therefore generates cheese with reduced meltability and flow. This observation is in line with Rowney et al. (2004), who announced that cheeses made from skimmed or low-fat milk typically display reduced liquefaction due to their lower fat content and denser protein matrix. The incorporation of sesame proteins further modifies this property, with higher protein levels likely reinforcing the protein network and thus reducing liquefaction. From a technological standpoint, the goal of applying fat replacers like proteins or carbohydrates is to raise the texture, softness, and functionality of reduced-fat cheese. By mimicking the physical and functional roles of fat, such replacers can help generate products with desirable melting and sensory properties while lowering caloric content (Drake et al., 1999). The current outcomes affirm that sesame proteins, when applied at appropriate levels, can contribute positively to these properties without excessively compromising meltability.

SDS-PAGE protein profile analysis: Sodium Dodecyl Sulfate–Polyacrylamide Gel Electrophoresis (SDS-PAGE) was employed to evaluate the protein profiles of control cheese samples (+C, −C) and treatments (T1, T2, T3) enriched with sesame proteins. Separate bands corresponding to major milk proteins, containing caseins (α-, β-, and κ-casein) and whey proteins (β-lactoglobulin and α-lactalbumin), were observed in all samples (Figure 5). Additional bands appeared in the sesame protein treatments (T1–T3) within the 20–50 kDa range, affirming the successful incorporation of sesame proteins. The intensity of these bands improved with higher substitution levels, subsequent the order T3 > T2 > T1, denoting dose-dependent enrichment. Importantly, no major degradation of milk proteins was observed, proposing that sesame proteins are compatible with the cheese protein matrix (Table 3).

Table 3. Protein profiles of control and sesame protein-enriched cheese samples

Sample	Major Milk Protein Bands (kDa)	Sesame Protein Bands (kDa)	Observation
C+ (Positive control)	25, 37, 66	–	Normal cheese protein profile
C− (Negative control)	25, 37, 66	–	Reduced intensity of casein bands
T1 (1.5%)	25, 37, 66	20, 45	Weak sesame protein bands
T2 (3.0%)	25, 37, 66	20, 32, 45	Clear sesame protein incorporation
T3 (4.5%)	25, 37, 66	20, 32, 45, 50	Strong sesame protein bands

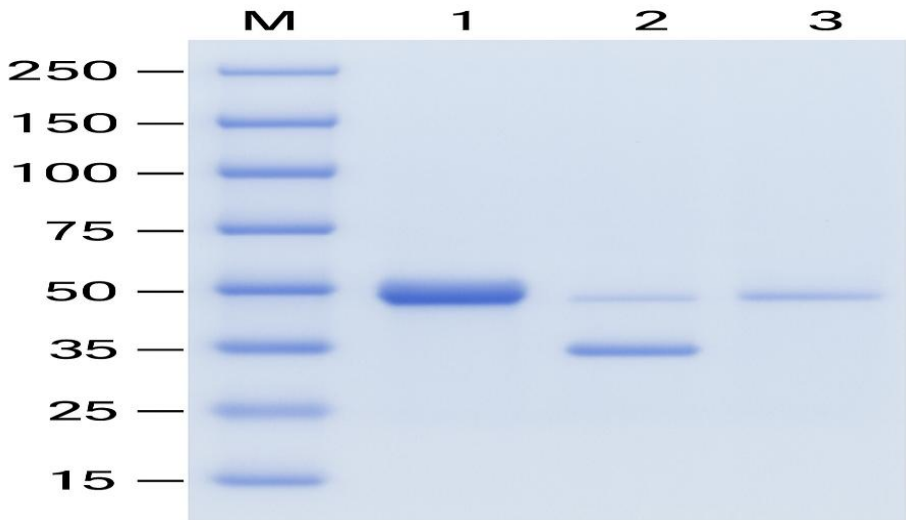

Figure 5. SDS-PAGE electrophoretic pattern of control and sesame protein-enriched cheese samples

The SDS-PAGE analysis demonstrates that sesame protein incorporation did not disrupt the primary milk protein structure, as α-, β-, and κ-casein bands remained intact across all treatments. The emergence of discrete sesame protein bands further affirms that these plant proteins are stably integrated into the cheese matrix. This result is in line with previous investigations denoting that plant proteins can be incorporated into dairy matrices without creating proteolysis or unexpected fragmentation, and that their presence can be quantified applying SDS-PAGE (Joshi et al., 2025;

Lu et al., 2010). Overall, the electrophoretic data support the hypothesis that sesame protein supplementation raises the nutritional and functional properties of low-fat spreadable processed cheese while maintaining the structural integrity of the milk proteins. These outcomes reinforce the utility of SDS-PAGE as a reliable tool for validating plant protein incorporation into dairy systems and for monitoring protein–protein interactions in complex food matrices.

Conclusions: The current investigations demonstrates that sesame proteins can be effectively incorporated as fat substitutes in low-fat spreadable processed cheese without compromising key quality attributes. Partial replacement of fat with sesame proteins meaningfully improved protein and ash content while reducing fat levels, resulting in a nutritionally increased product. Rheological analysis disclosed that the addition of sesame proteins improved hardness, cohesion, and elasticity relative to the low-fat control, denoting that sesame proteins contribute to the structural integrity of the cheese matrix. Sensory evaluation showed that although control cheeses (C+ and C−) scored slightly higher in overall acceptability, the sesame protein-fortified cheeses remained acceptable to the panelists, with minimal effects on color, flavor, and bitterness. SDS-PAGE analysis affirmed the successful incorporation of sesame proteins into the cheese protein network without creating proteolytic degradation of milk proteins, emphasizing their compatibility with dairy matrices. Overall, these results indicate that sesame proteins are a hopeful functional component for producing low-fat processed cheese with improved nutritional and textural properties. The use of sesame proteins permits the development of healthier cheese products with reduced calories while maintaining acceptable sensory and structural qualities, supporting their potential application in the functional dairy product industry.

Author contributions

Conceptualization, methodology, software, and validation by SHA and formal analysis, investigation, and resources by DIJA; both authors have read and agreed to the published version of the manuscript

Data availability statement

The datasets generated via and/or analyzed in the current investigation are available from the corresponding author on reasonable request.

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Ethical considerations

Not applicable

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Conflict of interest

There is no conflict of interest.

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چکیده

هدف: چربی اصلی‌ترین جزء تعیین‌کننده در میزان انرژی و ویژگی‌های عملکردی پنیر است. از این‌رو، توسعه مواد غذایی کم‌چرب عملکردی همچنان مورد توجه جدی پژوهشگران و صنعت غذا قرار دارد. با این حال، کاهش چربی و افزایش پروتئین در پنیر فرآوری‌شده معمولاً موجب شکنندگی بیشتر و کاهش خاصیت کشسانی، قابلیت پخش و حلالیت می‌شود. در این پژوهش، اثر افزودن پروتئین‌های کنجد در غلظت‌های مختلف به‌عنوان جایگزین چربی در پنیر فرآوری‌شده کم‌چرب قابل‌پخش، با تمرکز بر ویژگی‌های فیزیکوشیمیایی، رئولوژیکی، حسی و شاخص خلوص مورد بررسی قرار گرفت.

مواد و روش‌ها: پنیر چدار پرچرب به همراه پنیر نرم پرچرب به‌عنوان شاهد مثبت و ترکیب پنیر چدار پرچرب با پنیر نرم کم‌چرب به‌عنوان شاهد منفی استفاده شد. پروتئین کنجد در مقادیر مختلف (T1 ، T2و T3) با غلظت‌های ۱.۵٪، ۳.۰٪ و ۴.۵٪ به‌عنوان جایگزین چربی افزوده شد. آنالیزهای شیمیایی شامل تعیین رطوبت، پروتئین، چربی، خاکستر، کربوهیدرات، اسیدیته کل و pH بود. ارزیابی‌های رئولوژیکی شامل سختی، چسبندگی و انعطاف‌پذیری و همچنین آزمون حسی و درصد خلوص انجام گرفت.

نتایج: نمونه‌های پنیر حاوی پروتئین کنجد نسبت به شاهد منفی رطوبت کمتری داشتند، در حالی که میزان پروتئین آن‌ها نزدیک‌تر به شاهد مثبت بود. میزان کربوهیدرات، خاکستر و اسیدیته کل در تیمارهای جایگزین افزایش یافت، در حالی که مقدار چربی و pH کاهش یافت. تجزیه بافتی نشان‌دهنده بهبود در سختی، چسبندگی و انعطاف‌پذیری بود که با ارتقای ویژگی‌های حسی و درصد

خلوص بالاتر در مقایسه با هر دو شاهد همراه شد. آزمون SDS-PAGE ادغام موفق پروتئین‌های کنجد (در محدوده ۲۰-۵۰ کیلو دالتون) را تأیید کرد؛ شدت باندها متناسب با سطح جایگزینی افزایش یافت و در عین حال یکپارچگی پروتئین‌های شیر از جمله α- ، β- و κ- کازئین‌ها حفظ شد.

نتیجه‌گیری: افزودن پروتئین‌های کنجد به‌عنوان جایگزین چربی موجب بهبود ویژگی‌های فیزیکوشیمیایی، رئولوژیکی و حسی پنیر فرآوری‌شده کم‌چرب قابل‌پخش شد، در حالی که یکپارچگی پروتئینی حفظ گردید. این یافته‌ها پتانسیل پروتئین‌های کنجد را به‌عنوان جایگزین مؤثر چربی نشان داده و راهکاری نویدبخش برای تولید محصولات پنیر کم‌چرب با ارزش تغذیه‌ای بالاتر و پذیرش مطلوب مصرف‌کننده ارائه می‌دهد.

کلیدواژه‌ها: پروتئین‌های کنجد، پنیر فرآوری‌شده، جایگزین‌های چربی، درصد خلوص، SDS-PAGE

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