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NUTRITIONAL COMPARISON OF COW AND BUFFALO MILK COTTAGE CHEESE SPREAD WITH THYME AND OREGANO FOR BONE HEALTH

Original Article

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ABSTRACT

Background: Cottage cheese is a soft, cultured dairy product rich in high-quality protein and essential minerals, notably calcium and phosphorus, which are vital for bone development and maintenance. Buffalo milk, due to its superior fat and protein content compared to cow milk, serves as an excellent base for fortified dairy products. Herbs like thyme and oregano, known for their antioxidant, antimicrobial, and mineral-rich properties, have gained attention as functional additives to enhance the nutritional quality of dairy foods and support bone health.

Objective: To develop and evaluate cow and buffalo milk-based cottage cheese spreads enriched with thyme and oregano, focusing on their physicochemical, nutritional, and sensory characteristics with implications for bone health.

Methods: Four formulations were prepared: T0a (100% cow milk), T0b (100% buffalo milk), T1 (95% cow milk + 5% herbs), and T2 (93% buffalo milk + 7% herbs). Proximate analysis (fat, protein, moisture, ash, NFE), acidity, pH, calcium content, and sensory evaluation were conducted. Storage stability was assessed over 30 days at three intervals (day 0, 15, and 30). Data were statistically analyzed using ANOVA ($P<0.05$).

Results: T2 showed the highest fat (5.95%) and protein (4.32%) content, with lower moisture (69.48%) than T1 (72.16%). Ash content peaked in T0b (0.89%), while calcium levels were highest in T2 (mean 38.5 mg). Acidity increased from 0.47% to 0.52% and pH decreased from 5.89 to 5.64 during storage in T2. T0b and T2 received the highest sensory scores. Herb addition improved nutritional value without significantly compromising sensory appeal.

Conclusion: Buffalo milk-based cottage cheese enriched with thyme and oregano enhances nutritional density and supports bone health, offering a functional dairy product with promising sensory and storage stability.

Keywords: Bone Health, Buffalo Milk, Cottage Cheese, Oregano, Proximate Composition, Sensory Analysis, Thyme.

INTRODUCTION

Cottage cheese, a fresh and soft un-ripened milk derivative produced through acid or enzymatic coagulation of whole or skim milk, has long been valued as a nutrient-dense dairy food. Its low-calorie profile coupled with high protein content and abundance of essential minerals like calcium, phosphorus, and potassium supports bone and dental health, rendering it an ideal dietary option across all age groups. A standard 100-gram serving yields approximately 72–103 Kcal, 88 mg of calcium, and 154 mg of phosphorus, contributing significantly to daily mineral requirements (1,2). With global cheese production reaching around 21 million tons in 2019—of which European Commission member states contributed 11.12 million tons—the consumption of cheese-based products continues to grow steadily at an annual rate of 3–5% (3). In addition to its nutritional density, cottage cheese provides bioavailable proteins and essential amino acids that may positively influence cholesterol levels, bone mineral density, and gastrointestinal and immune function (4). These properties enhance its reputation not only as a dietary staple but also as a functional food with broader health implications. In countries like Pakistan, which ranks among the top five milk producers globally, milk production ranges from 57 to 59 million tons annually (5). Among these, buffalo milk holds a significant share, contributing approximately 11% to global milk output. Its superior sensory profile—marked by a mildly sweet, acidic flavor, white color, and spongy texture—makes it particularly favorable for cottage cheese production (6,7). Recent interest in functional foods has sparked exploration into natural enhancements such as the addition of herbs. Oregano and thyme, two culinary herbs with well-documented antioxidant and antimicrobial properties, have demonstrated potential for enhancing both the sensory appeal and health benefits of dairy products.

Oregano contains potent phenolic compounds such as thymol and carvacrol, while thyme is similarly rich in thymol, contributing to their broad therapeutic and antimicrobial activities (8). These herbs are also abundant in minerals like calcium, magnesium, and iron, supporting bone metabolism and offering potential benefits in preventing or mitigating bone-related conditions (9,10). Bone tissue itself is a dynamic organ composed of hydroxyapatite minerals—primarily calcium and phosphorus—alongside collagen, and is constantly remodeled in response to mechanical and hormonal stimuli. Trace elements such as calcium, magnesium, and phosphorus play vital roles in bone metabolism and mechanical integrity (11). Imbalances in these elements often lead to osteoporosis, a condition characterized by fragile bones and heightened fracture risk, highlighting the importance of consistent nutritional support (12). Despite the high production and consumption rates of cottage cheese, limited research has explored the comparative nutritional and functional properties of cow and buffalo milk-based cottage cheese, particularly when enriched with therapeutic herbs like oregano and thyme. Previous studies have not thoroughly addressed their synergistic effects on bone health nor assessed the physicochemical, sensory, and storage attributes of such formulations. There is also a notable lack of research on consumer acceptance and market viability of these enhanced dairy products. Therefore, this study aims to evaluate the nutritional, functional, and sensory properties of herb-enriched cottage cheese prepared from cow and buffalo milk, with a specific focus on bone health promotion and product stability.

METHODS

The present experimental study was conducted to evaluate the nutritional, physicochemical, sensory, and storage characteristics of herb-enriched cottage cheese spreads prepared from cow and buffalo milk. The research was carried out under controlled laboratory conditions, with ethical approval obtained from the institutional review board of the University of Agriculture, Faisalabad. All experimental procedures complied with food safety and ethical guidelines, and no human or animal subjects were involved, thus informed consent was not applicable. Fresh full-cream cow and buffalo milk, along with culinary herbs oregano and thyme, were procured from certified local vendors in Faisalabad to ensure consistency and traceability. The preparation of cottage cheese followed a standardized procedure adapted from a study (13), with minor modifications to accommodate herb incorporation. Briefly, 1600 ml of full-cream milk was homogenized with 400 ml of cream and pasteurized at 72°C for 15 seconds, followed by rapid cooling to 30°C. A commercial mesophilic starter culture was then introduced, and rennet was added to induce curd formation. The mixture was incubated at 30°C for 4.5 hours to allow coagulation. Once firm, the curd was cut and gently heated to promote whey separation. The resulting curd was transferred to a muslin cloth for draining. After complete whey removal, the curd was blended with dried oregano and thyme to produce a smooth, homogenous cheese spread. Four experimental treatments were developed based on milk source and herb concentration. Treatment T0a consisted of 100% cow milk with no herbs; T0b was 100% buffalo milk without herbs; T1 included 95% cow milk with 5% herb mix (oregano + thyme); and T2 comprised 93% buffalo milk with 7% herb mix. These formulations enabled a comparative assessment of both milk types and the added functional herbs.

The proximate composition, including moisture, protein, fat, ash, and nitrogen-free extract (NFE), was analyzed using standardized methods outlined by the Association of Official Analytical Chemists (AOAC, 2016). Physicochemical parameters such as pH and titratable acidity were determined to assess product stability. pH was measured using a calibrated digital pH meter after preparing a slurry of 20g of cheese spread in 12 ml of distilled water. Acidity was determined through acid-base titration using 0.1N NaOH on a cheese-water mixture in a 1:9 ratio. Mineral analysis focused on calcium quantification using an atomic absorption spectrophotometer following AOAC Method 991.25 (2016). For this purpose, approximately 1g of the sample was oven-dried at 100°C, then ashed in a muffle furnace at 525°C. The ash was dissolved in nitric acid and diluted to a standard volume. The absorbance of the sample, in combination with lanthanum chloride ($LaCl_3$) to suppress interference, was measured at a wavelength of 422.7 nm. Calcium concentrations were calculated using a calibration curve derived from known standards (14). To assess consumer appeal, a sensory evaluation was carried out by a panel of trained evaluators using a 9-point hedonic scale, assessing attributes such as color, taste, appearance, spreadability, and overall acceptability. The samples were presented in randomized order under controlled conditions to eliminate bias. Storage stability was analyzed by examining physicochemical and sensory changes on days 1, 15, and 30 of refrigerated storage at 4°C. All measurements were conducted in triplicates to ensure accuracy and reproducibility. Statistical analysis was performed using Analysis of Variance (ANOVA) under a completely randomized factorial design framework, as described by Montgomery (2017). Treatment effects, time intervals, and interaction terms were assessed, with significance levels set at $p<0.05$. Post-hoc comparisons were made where applicable using appropriate statistical software to interpret treatment variability.

Table 1: Herb Proportions in Cheese Spread Treatments

Treatment	Cow Milk%	Buffalo Milk%	Herbs (Oregano +Thyme%)
T_{0a}	100	0	0
T_{0b}	0	100	0
T_1	95	0	5
T_2	0	93	7

T_{0a}= Cow Cottage cheese spread, T_{0b}= buffalo cottage cheese spread T_1 = cow cottage cheese spread + oregano and thyme (5%), T_2 = buffalo cottage cheese spread +oregano and thyme (7%)

RESULTS

The comparative analysis of proximate composition among the cheese spread treatments revealed notable nutritional distinctions influenced by milk source and herbal inclusion. Buffalo milk-based spreads (T0b and T2) consistently exhibited higher fat and protein contents than those derived from cow milk, with T0b presenting 5.75±1.12% fat and 4.26±0.04% protein, and T2 showing the highest values at 5.95±1.12% fat and 4.32±0.06% protein. In contrast, cow milk variants T0a and T1 had comparatively lower fat (4.02±1.31% and 4.12±1.35%) and protein contents (3.29±0.05% and 3.35±0.07%, respectively). The inclusion of oregano and thyme led to slight increases in both macronutrients, more evident in buffalo-based samples. Moisture content was inversely related to fat and protein concentration, with cow milk-based cheese exhibiting higher moisture levels (T0a: 73.66±1.32%, T1: 72.16±1.35%) compared to buffalo milk-based cheese (T0b: 70.21±1.11%, T2: 69.48±1.25%). This variation corresponded with the naturally higher total solids in buffalo milk. Herb-enriched treatments displayed marginally lower moisture content, possibly due to water-binding interactions with phytoconstituents in oregano and thyme. Ash content, indicative of mineral composition, was also higher in buffalo milk-based spreads (T0b: 0.89±0.03%, T2: 0.86±0.02%) relative to cow milk variants. The non-fiber extract (NFE) content showed slight increases in herb-enriched treatments, with the highest value recorded in T1 (19.58±0.69%), reflecting the carbohydrate contribution of herbs. Acidity levels increased significantly over the 30-day storage period across all treatments, with herb-enriched variants showing the most prominent rise. At day 30, T2 recorded the highest acidity (0.52±0.02%), followed by T0b (0.51±0.06%), compared to lower values in T0a (0.41±0.04%) and T1 (0.42±0.03%). The mean acidity increase in T2 represented a 29.7% rise compared to T0a, suggesting potential microbial or enzymatic stimulation by herb phytochemicals during storage.

Correspondingly, pH values declined over time. T0a recorded the lowest pH at day 30 (5.65±0.03), while T0b and T2 maintained slightly higher values (5.74±0.02 and 5.64±0.05, respectively), possibly indicating the buffering potential of herbal components. Mean pH for T0a was 5.76±0.04, whereas T0b showed a 1.0% higher mean. T2 had a marginally lower pH than T0a by 0.3%. Calcium analysis demonstrated the highest mineral content in buffalo milk-based and herb-enriched treatments. T2 presented the highest calcium concentration at baseline (40.5±3.22 mg), maintaining stability throughout storage with a mean of 38.5±3.22 mg. T0b followed closely with 37.5±3.17 mg. These treatments showed 12.0% and 14.9% higher calcium levels compared to T0a, underscoring the nutritional enhancement from buffalo milk and herb incorporation. Minimal calcium degradation occurred over time across all groups. Sensory evaluation revealed that taste scores were highest in T1 (7.84±0.43), suggesting a favorable flavor profile with moderate herb concentration. T0a also scored well (7.77±0.03), while T2 demonstrated a slight decline over storage. Color scores were highest for T2 (7.49±0.06) and T0b (7.12±0.05), likely due to the visual appeal imparted by the herbs and buffalo milk's natural richness. T0a and T1 experienced reductions in color appeal over time. Appearance was most appreciated in T0b (7.55±0.05), while T2 remained stable but slightly lower. Spreadability was greatest in T0a and T2 (8.67±0.03 and 8.67±0.06), indicating superior texture and consistency. T0b scored lowest in spreadability (7.48±0.05), potentially due to higher fat content leading to firmer consistency. Overall acceptability was led by T0a (7.55±0.03), followed by T0b (7.37±0.05), while herb-enriched variants T1 and T2 scored slightly lower (7.43 each), possibly due to individualized sensory perceptions of herbal taste.

Table 2: Proximate Composition (%) in Cow and Buffalo Cottage Cheese Spread

Treatment	Fat %	Protein%	Moisture%	Ash %	NFE %
T_{0a}	4.02±1.31^{a}	3.29±0.05^{a}	73.66±1.32^{b}	0.77±0.02^{a}	18.26±0.67^{a}
T_{0b}	5.75±1.12^{b}	4.26±0.04^{b}	70.21±1.11^{ab}	0.89±0.03^{b}	18.89±0.57^{ab}
T_1	4.12±1.35^{a}	3.35±0.07^{a}	72.16±1.35^{b}	0.79±0.01^{ab}	19.58±0.69^{b}
T_2	5.95±1.12^{b}	4.32±0.06^{b}	69.48±1.25^{a}	0.86±0.02^{b}	19.39±0.61^{b}

T_{0a}= Cow Cottage cheese spread, T_{0b}= buffalo cottage cheese spread T_1 = cow cottage cheese spread + oregano and thyme (5%), T_2 = buffalo cottage cheese spread +oregano and thyme (7%)

Table 3 Impact of Treatment and Storage on Acidity (%) and pH of Cow and Buffalo Cottage Cheese Spread

Parameter	T_{oa}	T_{ob}	T_1	T_2	Overall mean
Acidity					
0 day	0.36±0.06^{c}	0.45±0.08^{abc}	0.37±0.05^{bc}	0.37±0.05^{abc}	0.41±0.23^{b}
15 day	0.38±0.05^{abc}	0.48±0.07^{abc}	0.39±0.04^{abc}	0.49±0.03^{abc}	0.43±0.19^{ab}
30 day	0.41±0.04^{abc}	0.51±0.06^{ab}	0.42±0.03^{abc}	0.52±0.02^{a}	0.46±0.15^{a}
Mean	0.38±0.05^{b}	0.48±0.07^{a}	0.39±0.04^{b}	0.49±0.03^{a}	
pH					
0 day	5.86±0.04^{abc}	5.94±0.06^{a}	5.84±0.02^{abc}	5.89±0.07^{ab}	5.76±0.05^{b}
15 day	5.79±0.05^{bc}	5.84±0.05^{abc}	5.75±0.04^{cd}	5.76±0.06^{bcd}	5.78±0.05^{b}
30 day	5.65±0.03^{d}	5.74±0.02^{cd}	5.63±0.03^{d}	5.64±0.05^{d}	5.66±0.03^{c}
Mean	5.76±0.04^{b}	5.84±0.04^{b}	5.74±0.03^{b}	5.76±0.05^{b}	

T_{0a}= Cow Cottage cheese spread, T_{0b}= buffalo cottage cheese spread T_1 = cow cottage cheese spread + oregano and thyme (5%), T_2 = buffalo cottage cheese spread +oregano and thyme (7%)

Table 4: Impact of Storage and Treatment on Calcium (mg) in Cow and Buffalo Cottage Cheese Spread

Parameter	T_{oa}	T_{ob}	T_1	T_2	Overall mean
Calcium 0 day	34.5±3.15[a]	38.5±3.21[a]	35.5±3.25[a]	40.5±3.22[a]	37.2±3.20[a]
15 day	33.5±3.11[a]	37.5±3.16[a]	34.5±3.21[a]	38.5±3.23[a]	36.0±3.17[a]
30 day	32.5±3.09[a]	36.5±3.14[a]	33.5±3.19[a]	36.5±3.22[a]	34.7±3.16[a]
Mean	33.5±3.11[b]	37.5±3.17[ab]	34.5±3.21[ab]	38.5±3.22[a]	

$T_{0a=}$ Cow Cottage cheese spread, $T_{0b=}$ buffalo cottage cheese spread $T_{1\ =}$ cow cottage cheese spread + oregano and thyme (5%), T_2 = buffalo cottage cheese spread +oregano and thyme (7%)

Table 5: Impact of Storage and Treatment on Taste, Color, Spreadability and Overall Acceptability of Cow and Buffalo Cottage Cheese Spread

Parameter	Treatment	0 Day	15 Day	30 Day	Mean
Taste	T_{0a}	8.24±0.03[a]	7.96±0.02[b]	7.13±0.05[e]	7.77±0.03[a]
	T_{0b}	7.95±0.04[b]	7.73±0.06[c]	6.96±0.06[f]	7.54±0.05[b]
	T_1	8.12±0.05[a]	7.95±0.02[b]	7.45±0.06[d]	7.84±0.43[a]
	T_2	7.87±0.08[bc]	7.56±0.07[d]	7.06±0.05[ef]	7.49±0.06[b]
	Overall mean	8.04±0.05[a]	7.80±0.04[b]	7.15±0.05[c]	
Color	T_{0a}	7.15±0.03[c]	6.65±0.02[e]	6.25±0.05[f]	6.68±0.03[c]
	T_{0b}	7.96±0.04[a]	7.56±0.06[b]	7.15±0.06[c]	7.12±0.05[a]
	T_1	7.12±0.05[c]	6.85±0.02[d]	6.16±0.06[f]	6.71±0.43[c]
	T_2	7.45±0.08[b]	7.05±0.07[c]	6.86±0.05[d]	7.49±0.06[b]
	Overall mean	7.42±0.05[a]	7.02±0.04[b]	6.60±0.05[c]	
Appearance	T_{0a}	8.06±0.03[a]	7.84±0.02[b]	7.43±0.05[c]	6.68±0.03[c]
	T_{0b}	7.83±0.04[b]	7.36±0.06[c]	6.95±0.06[d]	7.55±0.05[a]
	T_1	7.35±0.05[c]	6.96±0.02[d]	6.45±0.06[f]	6.71±0.43[c]
	T_2	7.45±0.08[c]	7.03±0.07[d]	6.75±0.05[e]	7.12±0.06[b]
	Overall mean	7.42±0.05[a]	7.02±0.04[b]	6.60±0.05[c]	
Spreadability	T_{0a}	8.95±0.03[a]	8.69±0.02[b]	8.38±0.05[c]	8.67±0.03[a]
	T_{0b}	7.85±0.04[f]	7.45±0.06[g]	7.14±0.06[h]	7.48±0.05[d]
	T_1	8.06±0.05[de]	7.85±0.02[f]	7.46±0.06[g]	7.79±0.43[c]
	T_2	8.65±0.08[b]	8.15±0.07[g]	7.95±0.05[h]	8.67±0.06[b]
	Overall mean	7.42±0.05[a]	7.02±0.04[b]	6.60±0.05[c]	
Overall Acceptability	T_{0a}	7.65±0.03[a]	7.54±0.02[ab]	7.46±0.05[bc]	7.55±0.03[a]
	T_{0b}	7.66±0.04[a]	7.35±0.06[cd]	7.12±0.06[e]	7.37±0.05[b]
	T_1	7.55±0.05[ab]	7.47±0.02[cd]	7.27±0.06[de]	7.43±0.43[b]
	T_2	7.52±0.08[ab]	7.46±0.07[bc]	7.32±0.05[cd]	7.43±0.06[b]
	Overall mean	7.50±0.05[a]	7.45±0.04[b]	7.72±0.05[c]	

$T_{0a=}$ Cow Cottage cheese spread, $T_{0b=}$ buffalo cottage cheese spread $T_{1\ =}$ cow cottage cheese spread + oregano and thyme (5%), T_2 = buffalo cottage cheese spread +oregano and thyme (7%)

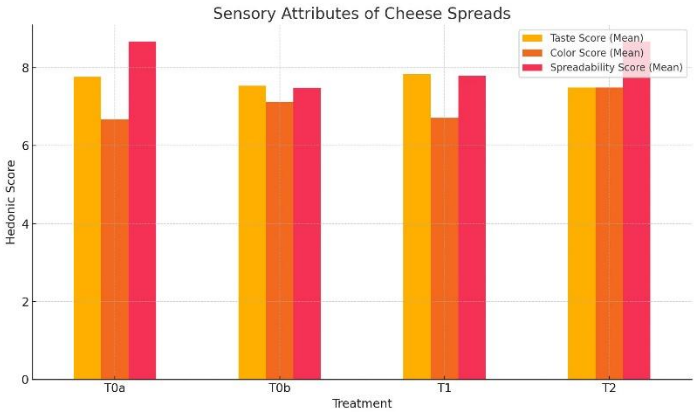

Figure 1 Sensory Attributes of Cheese Spreads

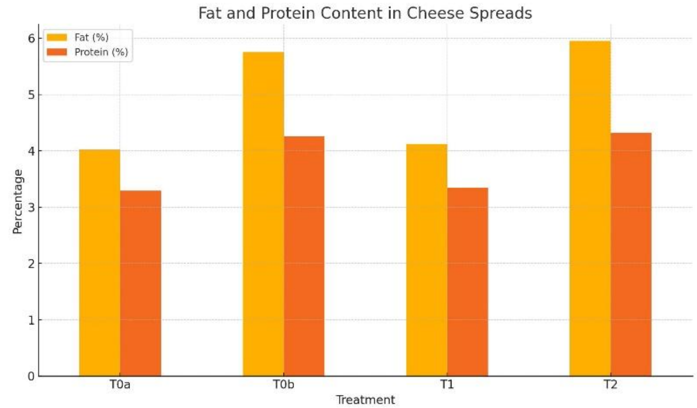

Figure 2 Fat and Protein Content in Cheese Spreads

DISCUSSION

The observed differences in moisture content between buffalo and cow milk-based cottage cheese spreads were consistent with the intrinsic compositional differences in the milk types. Buffalo milk, known for its higher total solids, naturally led to a lower moisture content in the final product due to reduced water retention during curd formation. These findings were consistent with previously reported trends in similar dairy formulations, where buffalo milk cheese was shown to retain less moisture owing to its dense composition. The additional reduction in moisture levels following herb incorporation likely resulted from the hygroscopic nature of oregano and thyme, which may have promoted moisture evaporation or hindered water binding during processing and storage (15-17). A consistently higher ash content in buffalo milk-based cheese supported the understanding of buffalo milk's rich mineral composition, particularly calcium and phosphorus. This elevated ash percentage reinforced its nutritional superiority in terms of mineral delivery. The inclusion of herbs, while beneficial in flavor and texture, did not substantially alter ash content, suggesting that their mineral contributions were either minimal or not bioavailable in the matrix of the cheese spread (18). This aligns with literature documenting the stable mineral profile in dairy matrices despite the addition of dried herbs or spices during formulation. Fat content demonstrated modest yet notable variations, especially in herb-enriched buffalo cheese, where a slight increase was evident (19). Although these differences were not statistically significant, the improved fat retention could be attributed to the mild emulsifying properties of the herbal compounds. These phytochemicals may have interacted with milk fat globules, enhancing retention during curdling and blending. This interaction has previously been associated with improved texture and mouthfeel in herb-fortified dairy products, validating the current observations (20).

Protein levels remained predictably higher in buffalo milk-based cheese due to the naturally elevated protein content in buffalo milk. The lack of significant variation following herb addition indicated that the structural protein network remained stable and that herbs neither promoted protein degradation nor interfered with casein micelle formation during coagulation. The findings were in line with prior studies on fortified dairy products, where protein concentrations were largely preserved despite additive inclusion, ensuring that the nutritional integrity of the protein fraction was maintained (21-23). Acidity increased progressively across the storage timeline, particularly in herb-enriched treatments, suggesting an interaction between herbs and microbial metabolic activity. The phenolic compounds in thyme and oregano may have influenced bacterial growth dynamics, leading to enhanced lactic acid production. This was particularly evident in T2, which demonstrated the highest acidity, corroborating previous reports that linked herbal bioactives with stimulation of microbial acidification. Such acidification plays a dual role in flavor development and shelf-life extension but may also alter textural stability over prolonged storage (24). The pH values across all treatments followed a decreasing trend, consistent with the natural fermentation process. However, the slightly higher and more stable pH observed in herb-containing treatments indicated a potential buffering effect imparted by the herbs. This may be attributed to the basic nature of some phytochemicals present in oregano and thyme, which can offset pH decline to a limited extent. Although pH values were generally higher than those traditionally observed in fermented cheeses, they remained within acceptable safety and sensory limits.

Sensory characteristics showed a multifaceted response to both treatment and storage. Taste and spreadability declined steadily over the 30-day period, with herb-enriched cow milk cheese maintaining the most favorable sensory profile. The decline was likely associated with oxidative changes and the breakdown of volatile flavor compounds, particularly in high-fat matrices. Buffalo milk-based spreads, despite scoring slightly lower in taste, demonstrated superior color and appearance, likely due to higher protein and fat contents contributing to visual appeal and structural integrity. The stabilizing effect of herbs on sensory attributes was moderate, offering benefits in masking off-flavors and enhancing aroma without significantly improving long-term acceptability (25). The overall acceptability of all treatments showed a downward trend with time, underscoring the inherent limitations of storage stability in soft cheese products. The presence of herbs offered a partial protective effect by maintaining acceptable sensory thresholds but could not fully counteract the natural degradation processes. This study's strengths included its comprehensive assessment of nutritional, physicochemical, and sensory parameters across multiple storage intervals, and its incorporation of locally sourced raw materials, making the findings contextually relevant. However, limitations were evident in the lack of microbial profiling, which could have substantiated the acidity and pH changes with specific bacterial activity. Additionally, the absence of advanced instrumental texture analysis and volatile compound profiling limited the understanding of structural and flavor dynamics. The sensory panel, though methodologically sound, relied on trained evaluators only, thereby restricting the generalizability of consumer acceptability data. Future research should explore the incorporation of natural antimicrobials or stabilizers alongside herbs to prolong shelf life and sensory quality. Integrating microbiological assessments and employing broader demographic panels for sensory analysis would also enhance the translational impact of such studies. Furthermore, exploring the synergistic effects of other herb combinations or encapsulated plant extracts may provide novel avenues for developing functional, stable, and consumer-acceptable cottage cheese spreads.

CONCLUSION

This study concluded that cottage cheese formulated from buffalo milk, when enriched with thyme and oregano, offers enhanced nutritional benefits that may contribute positively to bone health. The naturally higher levels of essential nutrients in buffalo milk, combined with the bioactive properties of the added herbs, suggest a promising functional food formulation, particularly beneficial for individuals at risk of osteoporosis or osteopenia. These findings emphasize the critical role of milk type and herbal incorporation in improving the nutritional quality of dairy products and point toward the potential for developing targeted dietary interventions to support skeletal health.

AUTHOR CONTRIBUTION

Author	Contribution
Nawal Waheed*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Saadia Manzoor	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Nosheen Naz	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Virsha Shahzad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Saira Mukhtar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Fatima Mukhtar	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Faisal Mukhtar	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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