Haryana Veterinarian (June, 2026) **65(1),** 62-69 ISSN 0033-4359 (P) **Research Article**

HUMECTANT OPTIMIZATION OFFERS A STRATEGIC APPROACH TO ENHANCING THE PHYSICO-CHEMICAL AND SENSORY QUALITY OF GOAT MILK SOFT CHEESE

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ABSTRACT

The present study aimed to evaluate the impact of varying concentrations of two humectants glycerol and sorbitol on the physico-chemical, textural, and sensory characteristics of goat milk soft cheese. Glycerol (G1, G2, G3) and sorbitol (S1, S2, S3) were incorporated at concentrations of 2%, 4%, and 6%, respectively, along with a control sample (C) prepared with 0.75% salt and subjected to a 15-hour incubation. Results from the glycerol-treated samples revealed that increasing glycerol levels significantly ($P<0.05$) reduced pH, moisture, fat-to-dry matter ratio, and water activity, while significantly increasing ($P<0.05$) titratable acidity, total solids, ash content, and Brix values. However, yield, protein, and overall fat content remained unaffected. Textural analysis showed a significant ($P<0.05$) increase in adhesiveness, gumminess, chewiness, and lightness (L*) with higher glycerol levels, although sensory acceptability decreased significantly ($P<0.05$), with G2 (4% glycerol) identified as the most favorable treatment. Similarly, sorbitol-supplemented cheeses showed a significant ($P<0.05$) decline in pH, moisture, fat-to-dry matter ratio, and water activity, accompanied by a significant ($P<0.05$) rise in titratable acidity, total solids, and Brix values. No significant differences were observed in yield, protein, fat, or ash content across sorbitol treatments. Among textural parameters, adhesiveness and gumminess increased significantly ($P<0.05$), while other textural and color traits remained unchanged. Sensory evaluation indicated a significant ($P<0.05$) drop in scores for S3 (6% sorbitol), whereas S2 (4% sorbitol) emerged as the optimal formulation. These findings highlight the potential of humectant optimization to enhance specific quality attributes of goat milk soft cheese.

Keywords: Glycerol, Goat milk, Humectants, Quality attributes, Soft cheese, Sorbitol

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India maintains its position as the leading global producer of milk, contributing approximately 24.76% to global output, according to the Basic Animal Husbandry Statistics (DAHD, 2024). The country produced 239.30 million tonnes of milk in fiscal year 2023-2024, growing at a compound annual growth rate (CAGR) of 5.62% during the previous ten years. Within this dynamic dairy landscape, goat milk has emerged as a significant contributor, with an estimated output of 7.59 million tonnes in 2023, approximately 3.3% of the country's total milk production. This marks a noteworthy year-on-year growth of 9.04%, reflecting a rising demand and growing prominence of goat milk in India's dairy economy. In developed nations, there is an increasing consumer shift towards milk from non-bovine sources, including goat milk, often regarded as a premium and niche product (Haenlein and Wendorff, 2006; Strzałkowska *et al.*, 2009). Goats, sometimes known as the "poor man's cow" because of their low maintenance requirements (Devendra and McLeroy, 1988; Goswami *et al.*, 2017), have long been an important part of smallholder livelihoods, particularly in environments with limited resources. Globally, the value derived from goat farming is distributed among milk (60%), meat (35%), and skin (5%). In many developing regions, goats continue to offer a cost-effective alternative for milk production, especially in areas unsuitable for large-scale bovine dairy systems (Schwarz *et al.*, 2017).

Consumer preference for functional and health-oriented foods has catalyzed a resurgence in goat milk consumption. Known for its digestibility and hypoallergenic properties, goat milk is increasingly recommended for individuals with lactose intolerance or gastrointestinal sensitivities (Mituniewicz *et al.*, 2019). A wide array of goat milk derivatives-ranging from fermented and enriched milk products to curd, frozen yogurt, butter and milk powder is now commercially available (Park, 2007). Among these, goat milk cheese, particularly the soft variety, stands out for its nutritional richness and unique organoleptic characteristics, including its soft texture, white appearance, and vitamin-enhanced flavor profile (Park *et al.*, 2017). Soft goat cheese is believed to be among the earliest forms of cheese consumed by humans, with its origins traceable to ancient Mesopotamia (Kosikowski, 1999). Soft cheese derived from goat milk has gained attention due to its superior digestibility and distinctive flavor, often preferred over cow milk-based cheeses in certain consumer segments (Gänzle, 2015). The market for goat milk-based products, such as cheese, the market for goat milk-based products in India is projected to expand steadily, with an estimated compound annual growth rate (CAGR) of 4.9% between 2024 and 2030. By the end of this period, the sector is anticipated to reach a

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value of approximately USD 3.68 billion, highlighting growing consumer interest and market potential. However, the production of goat cheese remains constrained by several factors, including technological limitations, the absence of standardized processing protocols, and challenges related to moisture control, textural stability, and shelf life (Bielik *et al.*, 2019). Soft goat cheese, due to its high moisture content, is inherently more perishable than harder cheese variants. Its relatively short shelf life, coupled with a pronounced "goaty" flavor, can limit consumer acceptance despite its nutritional advantages. To mitigate these constraints, the incorporation of humectants such as glycerol and sorbitol has been proposed as a potential strategy to enhance product stability and sensory quality (Aung and Nam, 2024). Glycerol, a triol compound belonging to the sugar alcohol family, is known for its moisture-retention properties and ability to improve the softness and structural integrity of cheese matrices (Haug *et al.*, 2003). Similarly, sorbitol, another polyol, effectively modulates water activity and contributes to favorable textural modifications in dairy formulations (Gänzle *et al.*, 2010). Beyond physicochemical benefits, these humectants may also enhance sensory parameters such as mouthfeel and flavor perception (Ming *et al.*, 2020). While the application of humectants has been explored in various cheese types, comprehensive comparative evaluations of glycerol and sorbitol specifically in goat milk soft cheese remain scarce (O'Neill *et al.*, 2012; Amaral *et al.*, 2022). In light of this knowledge gap, this study was designed to assess the impact of adding glycerol and sorbitol at varying concentrations of 2%, 4% and 6% on the physicochemical properties, texture and sensory qualities of soft cheese made from goat milk. The primary objective of this study was to identify the optimal type and concentration of humectants that can improve the overall quality, shelf life, and consumer acceptance of soft goat cheese while preserving its nutritional profile.

MATERIALS AND METHODS

Location of Study

The experimental work was carried out in the Department of Livestock Products Technology at the College of Veterinary Science and Animal Husbandry, Uttar Pradesh Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), located in Mathura-281001, Uttar Pradesh, India.

Raw Materials

Fresh, clean, and wholesome goat milk was collected from the Department of Veterinary Physiology, DUVASU, Mathura. All ingredients and reagents used in the preparation of goat milk soft cheese, including food-grade glycerol and sorbitol, were sourced from HiMedia Laboratories Pvt. Ltd. Mumbai, a certified supplier. Granular food-grade microbial rennet, sourced from *Mucor pusillus* var. *lindt*, was acquired from Meito Sangyo Co. Ltd., Japan. A starter culture (NCDC-149), containing a mixed strain of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* was obtained from the National Dairy Research Institute (NDRI), Karnal. All cultures and enzymes were stored under recommended conditions until use to ensure viability and efficacy.

Standardization of Processing Conditions

A set of preliminary trials was undertaken to refine the formulation and processing parameters for producing goat milk soft cheese. The preparation followed the methodology outlined by Shabbir *et al.* (2019), with slight adjustments made to suit the objectives of the current study. Key processing parameters, including coagulation time, rennet concentration, pasteurization temperature and curd handling techniques, were standardized to ensure consistent textural characteristics and effective moisture retention in the final product.

Cheese Preparation and Incorporation of Humectants

Following standardization, batch trials of goat milk soft cheese were carried out. For each batch, 5 litre fresh and clean goat milk was taken and passed through a double-layer muslin cloth to eliminate any foreign particles or impurities. The milk was thermally processed at 85 °C for 30 minutes, followed by cooling to 37 ± 2 °C. Thereafter, a composite starter culture (NCDC-149) was introduced comprising *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* was added at a rate of 0.2 g/L and allowed to rest for 1-2 minutes before gentle stirring. The culture-inoculated milk was maintained at a temperature of 35-37 °C for a duration of 2 hours to facilitate fermentation. Subsequently microbial rennet was added at a concentration of 0.02 g/L after dissolving in 15 mL of distilled water. The mixture was incubated at 35-37 °C for 15 hours to facilitate Optimal coagulation. The resultant coagulated mass was cut into 5 cm cubes using a sanitized cheese knife and left undisturbed for 15 minutes to allow whey separation. The curd was then transferred to a sterile muslin cloth and hung for 12 hours to achieve optimal whey drainage. The resulting coagulum was kneaded to achieve uniform consistency and manually blended with common salt (0.75%) and humectants. Two food-grade humectants, glycerol and sorbitol were incorporated at three different levels i.e. 2%, 4%, and 6% (w/w, based on the weight of the curd) on the basis of preliminary trials and literature available.

Storage Conditions

The formulated goat milk soft cheese was packaged into pre-sterilized thermo-rigid moulds and stored under refrigeration (4 ± 2 °C) overnight to allow the product to attain the desired consistency and shape. Samples were then analyzed at predetermined intervals to monitor changes in physicochemical, textural and sensory attributes during storage.

Analytical Methods

Physicochemical analyses, including determination of moisture, fat, protein, and ash content, were conducted by standard procedures prescribed by the Association of Official Analytical Chemists (AOAC, 2016). Textural characteristics were evaluated through Texture Profile Analysis (TPA) utilizing a TA. XT plus Texture Analyzer (Stable Micro Systems Ltd., United Kingdom) to assess parameters such as hardness, chewiness, cohesiveness, and springiness, following the protocol of Bourne (1978). Rheological properties were evaluated using a dynamic rheometer (MCR 72, Anton Paar Ltd., Austria) to determine the viscoelastic behavior of cheese samples. *Color parameters* (*L**, *a** and *b**) were determined using a Hunter Lab colorimeter (ColourTech PCM+, Colour Tech Associates Inc., Clinton, NJ, USA) at the Department of Goat Products Technology, Central Institute for Research on Goats (CIRG), Makhdoom, India.

Sensory Evaluation

The sensory characteristics were assessed by a semi-trained group comprising seven individuals, including postgraduate students and faculty members from the College of Veterinary and Animal Sciences, DUVASU, Mathura. Training was imparted to the selected sensory panelists prior to the sensory evaluation related to the type of products, sensory evaluation methods and rules of sensory evaluation. A nine-point hedonic scale (1 = extremely disliked, 9 = extremely liked) was used to assess key sensory attributes assessed included visual characteristics (color and appearance), organoleptic qualities (flavor, odor), perceived acidity, textural consistency, salt perception, and overall sensory acceptability as per the method of Keeton (1983). Total 2 bites of each sample were given to the sensory panelists for evaluation. Plain lukewarm water was provided for palate cleansing between samples. The evaluations were conducted at approximately 4:00 p.m. in a controlled environment, with panelists seated individually and prohibited from communicating.

Statistical Evaluation

All experimental data were subjected to statistical analysis using IBM SPSS Statistics software, version 20.0 (IBM Corp., Armonk, NY, USA) described by Snedecor and Cochran (1995). Each parameter was measured in duplicate across three independent replicates (n = 6). The collected data were analyzed using one-way analysis of variance (ANOVA) and significant differences among treatment means were determined through Duncan's Multiple Range Test (DMRT), with statistical significance set at $P < 0.05$.

RESULTS AND DISCUSSION

Effect of glycerol on quality characteristics of goat milk soft cheese

Table 1 presents the effects of different glycerol levels on pH, titratable acidity, moisture content, total solids, fat, protein, ash, water activity, and Brix values. The pH values exhibited a statistically significant decline ($P < 0.05$) with the incremental addition of glycerol, while titratable acidity demonstrated a corresponding significant increase ($P<0.05$). However, no significant variation was noted between the control group (C) and the G1 treatment. Significant reductions ($P < 0.05$) were observed in moisture content, fat-to-dry matter ratio and water activity across treatments, although the moisture content of C and G1 remained statistically comparable. Similarly, the fat/dry matter ratio and water activity levels in G1 and G2 did not significantly differ from those recorded in both C and G3. These findings align with the observations of Chen *et al.* (2014), who reported decreased moisture levels in various jerky products with the incorporation of glycerol or sorbitol. There were no statistically significant differences ($P > 0.05$) in yield percentage, protein concentration, or total fat content across the treatment groups. In contrast, total solids, ash content, and Brix values showed a significant increase ($P < 0.05$). However, the total solid content between G1 and G2 and the ash content between C and G1 did not differ significantly. The elevated Brix readings may be attributed to the water-binding properties of glycerol, which potentially reduce the amount of unbound water, thus lowering moisture levels in the final cheese matrix. Similar trends were reported by Torrico *et al.* (2019), who established a positive association between sugar alcohol addition and Brix values, reflecting enhanced thickness and viscosity in flavored yogurt formulations.

Texture Profile Analysis (TPA) for goat milk soft cheese formulated with varying concentrations of glycerol showed statistically significant enhancement ($P<0.05$) in adhesiveness, gumminess and chewiness was recorded as

Table 1. Physico-chemical properties (Mean±SE) of goat milk soft cheese prepared with different levels of glycerol percentage

Parameters	C	G1	G2	G3	Treatment mean
pH	5.99^{a} ± 0.09	5.95^{a} ± 0.07	5.81^{b} ± 0.15	5.74^{c} ± 0.09	5.87 ± 0.15
Titratable acidity	0.50^{c} ± 0.01	0.53^{c} ± 0.03	0.58^{b} ± 0.02	0.64^{a} ± 0.02	0.56 ± 0.01
Total Solid (%)	37.64^{c} ± 0.66	41.52^{b} ± 0.31	42.51^{b} ± 0.47	45.34^{a} ± 0.29	41.75 ± 0.44
Yield (%)	21.88 ± 0.20	22.09 ± 0.14	21.29 ± 0.26	21.59 ± 0.22	21.69 ± 0.16
Moisture (%)	62.25^{a} ± 1.06	60.48^{a} ± 0.31	58.48^{b} ± 0.47	54.65^{c} ± 0.29	58.96 ± 0.43
Protein (%)	19.81 ± 0.26	19.24 ± 0.39	19.04 ± 0.40	18.65 ± 0.39	19.18 ± 0.21
Fat (%)	19.65 ± 0.29	19.64 ± 0.26	20.11 ± 1.21	20.09 ± 0.25	19.87 ± 0.18
Fat/Dry Matter (%)	52.14^{a} ± 1.32	47.29^{ab} ± 1.43	47.30^{ab} ± 2.74	44.28^{b} ± 1.78	47.75 ± 1.07
Ash (%)	1.73^{c} ± 0.05	1.75^{c} ± 0.08	1.84^{b} ± 0.09	1.93^{a} ± 0.08	1.81 ± 0.06
Water activity	0.95^{a} ± 0.01	0.94^{ab} ± 0.03	0.94^{ab} ± 0.02	0.93^{b} ± 0.04	0.94 ± 0.02
Brix value	23.27^{d} ± 0.17	30.16^{c} ± 0.21	30.80^{b} ± 0.18	32.28^{a} ± 0.34	29.12 ± 0.72

Overall means bearing different superscripts in a row (a, b, c, d) differ significantly (P<0.05)

Table 2. Texture profile analysis (Mean±SE) of goat milk soft cheese with different levels of glycerol percentage

Parameters	C	G1	G2	G3	Treatment mean
Adhesiveness (g/sec)	-21.89^{d} ± 0.31	-22.89^{c} ± 0.28	-24.66^{b} ± 0.37	-26.32^{a} ± 0.27	-23.94 ± 0.21
Springiness(cm/mm)	0.42 ± 0.02	0.43 ± 0.04	0.42 ± 0.01	0.41 ± 0.04	0.42 ± 0.03
Cohesiveness (Ratio)	0.61 ± 0.05	0.62 ± 0.03	0.63 ± 0.01	0.64 ± 0.05	0.62 ± 0.03
Gumminess (N/cm2)	2.54^{d} ± 0.31	2.93^{c} ± 0.33	3.24b ± 0.50	3.88^{a} ± 0.80	3.14 ± 0.30
Chewiness (N/cm)	0.36^{d} ± 0.02	0.40^{c} ± 0.01	0.42b ± 0.03	0.45^{a} ± 0.02	0.40 ± 0.02
Resilience (Ratio)	0.14 ± 0.05	0.13 ± 0.02	0.12 ± 0.05	0.15 ± 0.01	0.13 ± 0.03

Overall means bearing different superscripts in a row (a, b, c, d) differ significantly (P<0.05)

Table 3. Color values (Mean±SE) of goat milk soft cheese with different levels of glycerol percentage

Parameters	C	G1	G2	G3	Treatment mean
Lightness (L^*)	81.09^{b} ± 0.11	81.26^{b} ± 0.19	81.94^{b} ± 0.27	83.81^{a} ± 0.33	82.02 ± 0.25
Redness (a^*)	0.75 ± 0.09	0.81 ± 0.50	0.88 ± 0.29	0.91 ± 0.28	0.83 ± 0.16
Yellowness (b^*)	13.76 ± 0.22	13.42 ± 0.30	13.99 ± 0.33	13.40 ± 0.69	13.64 ± 0.21

Overall means bearing different superscripts in a row (a, b) differ significantly (P<0.05)

Table 4. Sensory scores (Mean±SE) of goat milk soft cheese with different levels of glycerol percentage

Parameters	C	G1	G2	G3	Treatment mean
Color and appearance	7.92^{a} ± 0.05	7.62^{b} ± 0.03	7.56^{b} ± 0.06	6.76^{c} ± 0.04	7.46 ± 0.06
Acidity	7.84^{a} ± 0.14	7.77^{b} ± 0.03	7.70^{b} ± 0.03	5.92^{c} ± 0.11	7.30 ± 0.09
Flavor	7.82^{a} ± 0.08	7.73^{b} ± 0.02	7.67^{b} ± 0.48	5.62^{c} ± 0.74	7.21 ± 0.10
Body and texture	7.65^{a} ± 0.14	7.77^{b} ± 0.02	7.71^{b} ± 0.48	6.69^{c} ± 0.07	7.45 ± 0.10
Saltiness	7.61^{a} ± 0.07	7.48^{b} ± 0.07	7.43^{b} ± 0.07	6.55^{c} ± 0.07	7.26 ± 0.08
Overall acceptability	7.79^{a} ± 0.08	7.75^{b} ± 0.02	7.66^{b} ± 0.43	6.70^{c} ± 0.89	7.47 ± 0.83

Overall means bearing different superscripts in a row (a, b, c) differ significantly (P<0.05)

glycerol concentration increased (Table 2). This enhancement in textural attributes may be attributed to glycerol's hygroscopic nature and water-binding capacity, which likely contributed to a more viscous and firmer matrix in the cheese. These findings align with the study conducted by Swain *et al.* (2014), which demonstrated that sugar alcohols exert a favorable impact on the growth of *Lactobacillus* species in fermented dairy systems, potentially through mechanisms involving cytoplasmic dehydration and triggering external osmotic efflux mechanisms. ultimately leading to a firmer and more compact product texture. However, no statistically significant differences (P > 0.05) were detected in springiness, cohesiveness, and resilience among the control and treatment groups, which suggests that glycerol incorporation had a limited effect on these specific parameters.

Table 5. Physico-chemical properties (Mean±SE) of goat milk soft cheese prepared with different levels of sorbitol percentage

Parameters	C	S1	S2	S3	Treatment mean
pH	$6.01^{a}\pm0.10$	$5.91^{b}\pm0.07$	$5.74^{c}\pm0.15$	$5.62^{d}\pm0.09$	5.82 ± 0.05
Titratable acidity	$0.51^{d}\pm0.01$	$0.53^{c}\pm0.02$	$0.57^{b}\pm0.02$	$0.61^{a}\pm0.01$	0.55 ± 0.01
Total Solid (%)	$37.64^{c}\pm1.06$	$42.65^{b}\pm0.83$	$43.44^{b}\pm0.63$	$45.14^{a}\pm0.66$	42.21 ± 0.72
Yield (%)	21.91 ± 0.20	22.01 ± 0.22	22.29 ± 0.42	22.59 ± 0.44	22.20 ± 0.16
Moisture (%)	$62.15^{a}\pm0.26$	$58.34^{b}\pm0.23$	$57.23^{b}\pm0.35$	$55.39^{c}\pm0.58$	58.27 ± 0.71
Protein (%)	19.86 ± 0.26	19.34 ± 0.39	19.14 ± 0.40	18.83 ± 0.39	19.29 ± 0.21
Fat (%)	19.66 ± 0.29	19.84 ± 0.66	20.31 ± 1.20	20.11 ± 0.85	19.98 ± 0.39
Fat/Dry Matter (%)	$52.23^{a}\pm0.32$	$46.51^{b}\pm0.43$	$46.75^{b}\pm0.24$	$44.55^{c}\pm0.38$	47.51 ± 0.17
Ash (%)	1.82 ± 0.15	1.82 ± 0.10	1.89 ± 0.24	1.96 ± 0.21	1.87 ± 0.24
Water activity	$0.96^{a}\pm0.06$	$0.95^{b}\pm0.04$	$0.94^{b}\pm0.05$	$0.92b\pm0.03$	0.94 ± 0.06
Brix value	$23.30^{b}\pm0.17$	$31.07^{a}\pm0.34$	$31.80^{a}\pm0.28$	$32.89^{a}\pm0.36$	29.76 ± 0.28

Overall means bearing different superscripts in a row (a, b, c, d) differ significantly (P<0.05)

Table 6. Texture profile analysis (Mean±SE) of goat milk soft cheese with different levels of sorbitol percentage

Parameters	C	S1	S2	S3	Treatment mean
Adhesiveness (g/sec)	$-21.92^{d}\pm0.11$	$-22.64^{c}\pm0.05$	$-24.22^{b}\pm0.07$	$-26.12^{a}\pm0.02$	-23.72 ± 0.07
Springiness(cm/mm)	0.41 ± 0.02	0.44 ± 0.04	0.43 ± 0.02	0.41 ± 0.04	0.422 ± 0.00
Cohesiveness (Ratio)	0.65 ± 0.05	0.66 ± 0.04	0.67 ± 0.01	0.68 ± 0.05	0.66 ± 0.00
Gumminess (N/cm^2)	$2.63^{d}\pm0.21$	$2.66^{c}\pm0.12$	$2.85^{b}\pm0.60$	$3.62^{a}\pm0.20$	2.94 ± 0.22
Chewiness (N/cm)	0.38 ± 0.03	0.42 ± 0.04	0.43 ± 0.02	0.44 ± 0.03	0.41 ± 0.00
Resilience (Ratio)	0.15 ± 0.01	0.14 ± 0.01	0.15 ± 0.02	0.16 ± 0.04	0.15 ± 0.00

Overall means bearing different superscripts in a row (a, b, c, d) differ significantly (P<0.05)

Table 7. Color values (Mean±SE) of goat milk soft cheese with different levels of sorbitol percentage

Parameters	C	S1	S2	S3	Treatment mean
Lightness (L^*)	81.12 ± 0.18	81.47 ± 0.20	81.96 ± 0.27	83.87 ± 0.34	82.10 ± 0.30
Redness (a^*)	0.74 ± 0.17	0.88 ± 0.84	0.89 ± 0.27	0.92 ± 0.29	0.85 ± 0.21
Yellowness (b^*)	13.82 ± 0.27	13.51 ± 0.32	13.92 ± 0.36	13.96 ± 0.69	13.80 ± 0.21

Table 8. Sensory scores (Mean±SE) of goat milk soft cheese with different levels of sorbitol percentage

Parameters	C	S1	S2	S3	Treatment mean
Color and appearance	$7.92^{a}\pm0.08$	$7.87^{a}\pm0.03$	$7.86^{a}\pm0.06$	$7.07^{b}\pm0.08$	7.68 ± 0.05
Acidity	$7.81^{a}\pm0.14$	$7.78^{a}\pm0.03$	$7.75^{a}\pm0.03$	$6.92^{b}\pm0.10$	7.5 ± 0.09
Flavor	$7.78^{a}\pm0.14$	$7.81^{a}\pm0.08$	$7.89^{a}\pm0.06$	$6.65^{b}\pm0.09$	7.53 ± 0.08
Body and texture	$7.66^{a}\pm0.10$	$7.68^{a}\pm0.01$	$7.79^{a}\pm0.04$	$7.18^{b}\pm0.04$	7.57 ± 0.04
Saltiness	$7.81^{a}\pm0.11$	$7.83^{a}\pm0.07$	$7.94^{a}\pm0.07$	$6.86^{b}\pm0.06$	7.61 ± 0.08
Overall acceptability	$7.75^{a}\pm0.11$	$7.72^{a}\pm0.02$	$7.78^{a}\pm0.04$	$7.08^{b}\pm0.08$	7.58 ± 0.08

Overall means bearing different superscripts in a row (a, b) differ significantly (P<0.05)

Non-significant variations (P > 0.05) were detected in the redness (a*) and yellowness (b*) parameters among the control and glycerol-enriched cheese samples (Table 3), indicating that the incorporation of glycerol exerted a negligible effect on the intrinsic color characteristics of goat milk soft cheese. These findings are consistent with those reported by Sofyan *et al.* (2013), who observed comparable results in shrikhand fortified with white crystallized sugar syrup, indicating similar effects on the product's compositional or sensory characteristics. However, the lightness (L*) values exhibited a significant (P<0.05) increase with higher glycerol concentrations, indicating a perceptible enhancement in the brightness of the cheese matrix.

As the concentration of glycerol increased, all sensory attributes, namely color and appearance, acidity, flavor, body and texture, saltiness and overall acceptability declined significantly (P<0.05), as shown in Table 4.

However, no significant differences were observed between the G1 and G2 treatments for any of the sensory parameters. The decline in sensory scores at higher glycerol levels may be attributed to its ability to mask the natural acidic flavor of goat milk soft cheese by imparting a mildly sweet aroma. Additionally, the lower texture scores recorded for G3 could be associated with increased stickiness and dryness, likely due to reduced moisture content. These findings are consistent with the observations of Khanam (2017), who reported a decline in sensory acceptability with the incremental addition of glycerol (0.5% to 1.5%) in chicken spread formulations.

Effect of sorbitol on quality characteristics of goat milk soft cheese

Table 5 outlines the physico-chemical properties of goat milk soft cheese developed using different concentrations of sorbitol. The pH of goat milk soft cheese declined significantly (P<0.05) with increasing concentrations of sorbitol, while titratable acidity and total solids exhibited a significant rise (P<0.05). Nonetheless, total solids did not differ significantly between the S1 and S2 treatments. Moisture content and fat content on a dry matter basis also decreased notably (P<0.05) with higher sorbitol levels, though the reduction between S1 and S2 was not statistically meaningful. No significant variations were observed across treatments in yield percentage, protein, fat or ash content. These findings align with those of Rai *et al.* (2017), who reported stable proximate composition in Rabri formulated with 4%, 6%, and 8% sugar alcohols in cow, buffalo, and mixed milk. Water activity decreased significantly (P<0.05), whereas Brix values increased (P<0.05) as sorbitol concentration rose; however, differences among S1, S2, and S3 were not statistically significant for either parameter. Comparable patterns have been observed by Syed and Babar (2018) in sheerqurma, as well as by Anurag and Chawla (2016) in studies involving milk-based sweets formulated with bottle gourd where sugar alcohols enhanced sweetness and moisture regulation without markedly altering basic composition.

Among texture profile analysis (TPA) a statistically significant (P<0.05) increase in adhesiveness and gumminess was observed with the progressive addition of sorbitol (Table 6), likely attributable to the higher solute content, which may enhance the viscosity and structural firmness of the cheese matrix. A moderate increase in adhesiveness and gumminess is generally desirable in soft cheeses because it contributes to a creamier, smoother mouthfeel and better spreadability-attributes typically preferred by consumers (Cai *et al.*, 2024).

Similar findings were documented by Nurhartadi *et al.* (2017), who reported increased textural integrity and viscosity in cheese whey yogurt when supplemented with sugar alcohol syrups at levels of 8%, 10%, and 12%. Soukoulis *et al.* (2007) also suggested that increased acidity throughout the fermentation can strengthen casein-calcium ion interactions, thereby promoting gel firmness and viscosity. In contrast, other parameters such as springiness, cohesiveness, chewiness and resilience did not exhibit significant variation across treatment and control groups, suggesting that these textural traits were not substantially affected by sorbitol addition.

As shown in Table 7, the chromatic parameters of goat milk soft cheese, including lightness (L*), redness (a*), and yellowness (b*), did not exhibit any statistically significant differences (P>0.05) between the control group and the samples supplemented with sorbitol. This observed stability in color can likely be attributed to the chemically inert and thermally stable nature of sorbitol, which does not undergo degradation or participate in Maillard browning reactions under typical processing conditions. Nezzal (2000) similarly noted the resistance of sugar alcohols like sorbitol to thermal decomposition and non-enzymatic browning pathways. Conversely, Broyart *et al.* (1998) identified a significant (P<0.05) correlation between lower sugar content and higher lightness in baked goods, where Maillard reaction was the key driver of color formation. Additionally, Bates *et al.* (1998) emphasized that changes in pH can influence color dynamics in dairy products through non-enzymatic browning, often leading to decreased hue angles and a shift from yellow to reddish tones. In contrast, such color transitions were not evident in the present study, suggesting that sorbitol inclusion had minimal impact on the visual quality of goat milk soft cheese.

The sensory attribute scores, including color and appearance, acidity, flavor, body and texture, saltiness and overall acceptability, declined significantly (P<0.05) with increasing sorbitol concentration (Table 8), particularly in the S3 treatment (6% sorbitol). However, no significant differences (P>0.05) were observed among the control (C), S1 (2% sorbitol) and S2 (4% sorbitol) across any sensory parameter, including overall acceptability. These results align with the findings of Manalo and Benedicto (2014), who noted that sorbitol incorporation had a limited impact on the sensory properties of ready-to-eat tocino, indicating that sugar alcohols may preserve product palatability without markedly altering consumer perception. Furthermore, the enhanced spreadability and overall acceptability identified in the current study resonate with the findings of Prajapati *et al.* (1991), who documented improvements in the organoleptic characteristics of low-fat cheese spreads following the incorporation of sugar alcohols. Among the evaluated formulations, the S2 variant exhibited the highest overall acceptability score, likely due to its balanced sweet–acidic flavor profile and desirable firmness. As a result, the goat milk soft cheese containing 0.75% salt and 4% sorbitol (S2) was identified as the most suitable formulation in this study based on comprehensive sensory evaluation.

CONCLUSION

This study assessed the effects of glycerol and sorbitol, used as humectants, on the physicochemical, textural, and sensory characteristics of goat milk soft cheese. The findings revealed that both additives significantly influenced the overall quality profile of the cheese. Among the glycerol-enriched formulations, the sample containing 4% glycerol (G2) demonstrated improved physicochemical and textural parameters. However, its sensory attributes particularly flavor and overall acceptability, were comparatively lower than those observed in the sorbitol-enriched variants. In contrast, the incorporation of sorbitol at a 4% concentration (S2) produced the most favorable outcomes, enhancing not only texture and flavor but also overall consumer acceptability. The sweet–acidic balance and pleasant aroma introduced by sorbitol were especially well-received by the sensory panel, without detracting from key quality parameters such as appearance or acidity. Collectively, these results indicated that incorporating 4% sorbitol into goat milk soft cheese is a promising approach for optimizing product quality. It effectively enhances organoleptic appeal while maintaining desirable structural and compositional attributes, thereby presenting a viable formulation strategy for improved consumer satisfaction.

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