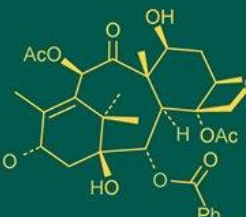
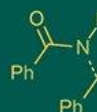
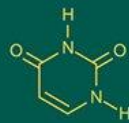


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Effect of optimized humectant treatments on the quality characteristics of goat milk soft cheese: A comparative study

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Abstract

This present study was conducted to compare the quality characteristics of goat milk soft cheese prepared with pre optimized humectant treatments in earlier trials. Several preliminary trials were conducted to optimize different levels of glycerol and sorbitol as humectant *i.e.* 2%, 4%, and 6%, under different sub experiments, where two treatments with 4% glycerol (G2) and 4% sorbitol (S2) were selected on the basis of sensory evaluation. The selected treatments were further compared with control (C) to select the best treatments as well as accepted Goat Milk Soft Cheese in terms of physico-chemical and sensory properties. The pH, moisture content, fat on dry matter basis, and water activity were significantly ($P<0.05$) higher in the control (C), whereas titratable acidity and °Brix values were significantly ($P<0.05$) higher in G2 and S2. Total solids were significantly ($P<0.05$) higher in S2. Humectant incorporation significantly ($P<0.05$) increased adhesiveness, gumminess, and chewiness, while springiness, cohesiveness, resilience, and most colour attributes remained unaffected. Sensory evaluation showed significantly ($P<0.05$) higher flavor, body and texture, and overall acceptability scores for S2. Therefore, it was concluded that addition of 4% sorbitol improved the texture and moisture retention in product. It also improved the sensory properties of goat milk soft cheese in terms of flavour, mouth feel and overall acceptability. This makes sorbitol a reliable option as a humectant in the process of making goat milk soft cheese for significant market appeal and commercial producers.

Keywords: Goat milk soft cheese, humectant, glycerol, sorbitol, texture profile, sensory properties

Introduction

Goat milk soft cheese has drawn growing interest for its digestibility, distinct flavor, and nutritional edge over cheese made from cow's milk. Smaller fat globules, a higher share of medium-chain fatty acids, and a comparatively weak protein matrix all make goat milk easier to digest and well suited to soft cheese production (Park et al., 2007; Clark and Mora García, 2017)^[4, 18]. Beyond its processing advantages, goat milk itself carries recognized dietary value, including easier tolerance among individuals sensitive to cow milk proteins (Goswami et al., 2017)^[12]. The trade-off is moisture: soft cheese holds a lot of water, which leaves it prone to textural breakdown, syneresis, spoilage, and a short shelf life. Controlling moisture and water activity is therefore central to keeping the product safe, stable, and acceptable to consumers (Fennema, 2008)^[7].

Much of that moisture instability traces back to syneresis, the contraction of the casein network after coagulation that squeezes whey out of the curd. Dejmeek and Walstra (2004)^[5] reported that the rate and extent of syneresis in rennet-induced curd are primarily governed by the microstructure and surface characteristics of casein micelles. Following gel formation, moisture retention is largely determined by the rearrangement and contraction of the protein matrix rather than by subsequent processing interventions. Consequently, humectants provide an effective approach for modulating moisture retention in soft cheese, as they influence the water phase after curd formation without altering the coagulation mechanism or the overall cheese-making process. According to Rahman (2007)^[19], foods with a water activity ranging from approximately 0.60 to 0.85 are classified as intermediate-moisture foods. The microbial stability of these products is achieved through

the incorporation of humectants or other water-binding solutes, which lower water activity without requiring extensive dehydration or continuous refrigeration.

Humectants are food-grade compounds that bind water and lower water activity without removing much moisture from the food itself. Researchers have looked at them as a way to improve texture, control moisture movement, and extend shelf stability (Khanam et al., 2017) ^[16]. Glycerol and sorbitol, both polyhydric alcohols, are common choices because their hydrophilic groups form hydrogen bonds with water and limit how much of it stays free (Grembecka, 2015) ^[13]. Earlier work has shown that adding humectants changes the physicochemical makeup, texture, and sensory profile of intermediate-moisture foods (Gliemmo et al., 2006; Chen et al., 2014) ^[3, 10]: they bind free water and, in doing so, shift moisture distribution, texture, and microbial stability, which together affect overall quality. Their use in goat milk soft cheese specifically has not been studied much and still needs systematic optimization. Humectants have been studied fairly widely for food preservation, but goat milk soft cheese remains a gap. Few studies have looked closely at optimized glycerol and sorbitol levels in this product, particularly how the two compare on physicochemical properties, texture, colour, and sensory acceptance under the same formulation conditions (Livesey, 2003) ^[17].

The present study was aimed to evaluate and compare the quality characteristics of goat milk soft cheese prepared using the pre-optimized humectant treatments, selected through

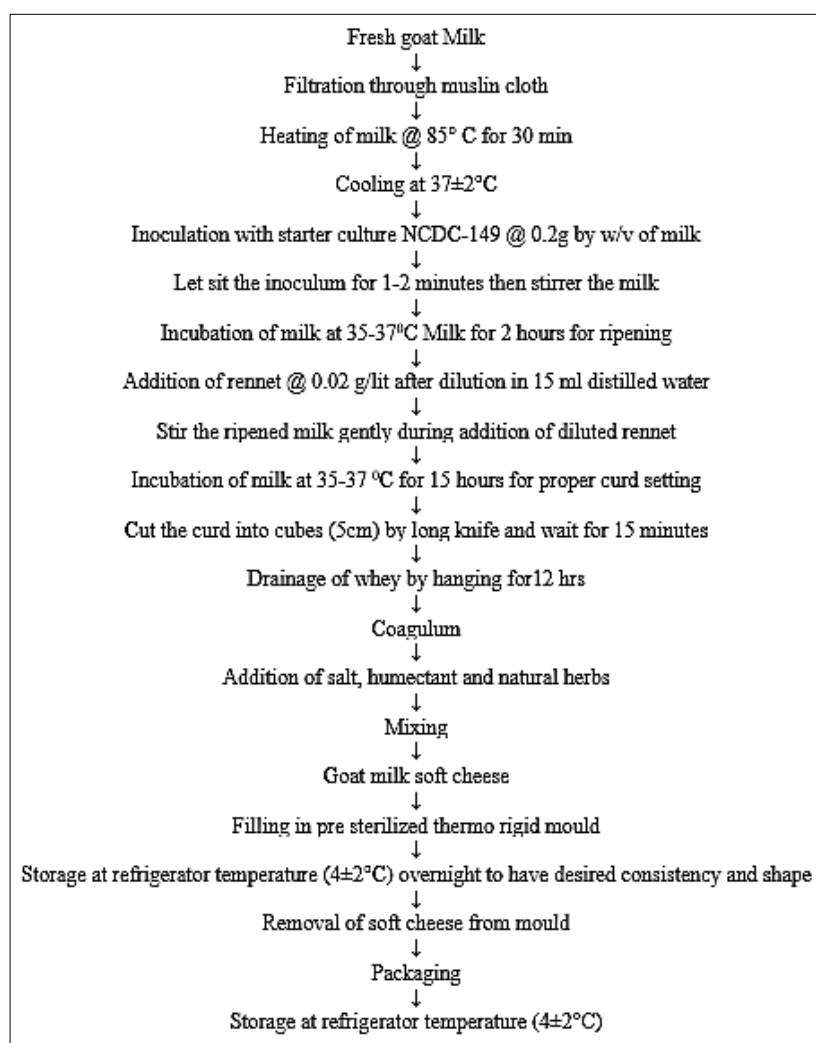
preliminary optimization trials based on sensory acceptability. Additionally, the study sought to determine the relative effectiveness of humectants in improving moisture regulation and product stability, thereby contributing to the development of high-quality intermediate-moisture goat milk soft cheese.

Materials and Methods

Experimental Design

The work was carried out at the Department of Livestock Products Technology, DUVASU, Mathura, India. Treatments identified as optimal in preliminary trials were carried forward for detailed evaluation, with the goal of understanding how optimized glycerol and sorbitol incorporation affects the quality of goat milk soft cheese. Goat milk soft cheese was prepared from standardized goat milk under controlled laboratory conditions. Two preliminary sub-experiments were undertaken to improve the quality of developed product incorporating two humectants *i.e.* glycerol and sorbitol separately at 2%, 4%, and 6%, in which 4% glycerol (G2) and 4% sorbitol (S2) were selected on the basis of sensory evaluation. The selected treatments were further compared with control (C) to select the best treatment to have well accepted goat milk soft cheese with desirable characteristics. The method of goat milk soft cheese preparation has been given in flow diagram 1.

Flow diagram 1: Preparation of goat milk soft cheese



Product analysis

Cheese samples were tested for pH, titratable acidity, total solids, moisture, protein, fat, fat on a dry matter basis, and ash content, following the standard procedures of AOAC International (2016) [1]. Water activity was measured in triplicate with a calibrated water activity meter (AquaLab 3TE, Decagon Devices Inc., Pullman, WA, USA). Yield and °Brix values were measured with a digital refractometer (Atago RX-5000i, Japan) following standard analytical procedures. All determinations were run in triplicate, and results are reported as mean $\pm$ standard error. Texture profile analysis (TPA) measured adhesiveness, springiness, cohesiveness, gumminess, chewiness, and resilience using a texture analyzer (TA.HD Plus, Stable Micro Systems, UK) under standardized test conditions. Samples went through double compression cycles, and textural parameters were calculated from the resulting force-time curves. Lightness (L^*), redness (a^*), and yellowness (b^*) were measured with a Hunter colorimeter (Colour Tech PCM+, Colour Tec Associates Inc., Clinton, NJ, USA). The instrument was calibrated against standard white and black tiles before each session. A semi-trained panel of seven postgraduate students and faculty from the Veterinary College, DUVASU, Mathura, evaluated the samples. Panelists scored colour and appearance, flavor/odor, body and texture, acidity, saltiness, and overall acceptability on a 9-point hedonic scale (1 = extremely disliked; 9 = extremely liked), following Keeton (1983) [15]. Evaluation sessions ran in the late afternoon, around 4:00 p.m., under controlled conditions. Panelists worked without interacting with one another, and lukewarm water was provided between samples to cleanse the palate.

Statistical Analysis

Data were analyzed in SPSS (version 20.0) using a completely randomized design, with triplicate experiments and duplicate observations for each parameter ($n = 6$ per treatment; 21 observations overall). One-way analysis of variance (ANOVA) was applied, and means were separated using Duncan's Multiple Range Test (DMRT) at $P < 0.05$, following the procedures described by Snedecor and Cochran (1995) [20].

Results and Discussion

Physico-chemical Properties: The physico-chemical characteristics of goat milk soft cheese prepared with incorporation of humectants are presented in table 1. The pH, moisture content, fat on dry matter basis content and water activity values of C were significantly ($P < 0.05$) higher whereas titratable acidity and brix values of C were significantly ($P < 0.05$) lower than G2 and S2, however there was no significant difference between G2 and S2 for both the parameters. The lower moisture content observed in G2 and S2 likely reflected additional syneresis induced by the humectants themselves, in addition to the whey loss that occurred during the initial curd formation. As described by Dejmeek and Walstra (2004) [5] for rennet curd systems, once the casein network was established, any factor that altered the distribution of water between the protein matrix and the surrounding serum, including the addition of solutes with a strong affinity for water, could promote further contraction of the protein network. As per Chen et al. (2014) [3], water exists in three general forms in food matrix (1) free, unbound water; (2) free, immobilized water; (3) chemically bound water. Humectants attract water to themselves in meat products by chemical bonds, so they potentially reduce the moisture content of products due to underestimation of water content. They are believed to reduce aw of a product due to the presence of hydrophilic group such as hydroxyl groups, which have affinity to form hydrogen bonds with molecules of water, thus decreasing the availability of free water (Gliemmo et al., 2006) [11]. The reduction in water activity observed in G2 and S2 was attributed to the strong water-binding capacity of glycerol and sorbitol, which converted free water into a bound form, thereby limiting water availability to microorganisms and contributing to product stabilization. Total solid content of S2 was significantly ($P < 0.05$) higher than C and G2 indicating that sorbitol did a better job of regulating moisture than glycerol. Badola et al. (2017) [2], while evaluating several humectants in a model khoa system, reported that sorbitol produced the greatest reduction in water activity among the compounds tested, supporting the notion that the water-binding capacity of sorbitol was not specific to a single dairy matrix but was applicable across different milk-based products. There was no significant difference in yield%, protein, fat and ash content between control and treatments.

Table 1: Physico-chemical properties (Mean $\pm$ SE) of goat milk soft cheese prepared with different humectants

Parameters	C	G2	S2	Treatment mean
pH	5.98 ^a $\pm$ 0.19	5.71 ^b $\pm$ 0.13	5.71 ^b $\pm$ 0.08	5.8 $\pm$ 0.09
Titratable acidity	0.52 ^b $\pm$ 0.01	0.57 ^a $\pm$ 0.02	0.58 ^a $\pm$ 0.04	0.55 $\pm$ 0.01
Total Solid (%)	37.64 ^c $\pm$ 0.16	42.32 ^b $\pm$ 0.38	45.44 ^a $\pm$ 0.26	41.80 $\pm$ 0.28
Yield (%)	21.96 $\pm$ 0.20	21.26 $\pm$ 0.32	21.38 $\pm$ 0.42	21.67 $\pm$ 0.20
Moisture (%)	62.36 ^a $\pm$ 1.06	57.48 ^b $\pm$ 0.47	55.33 ^b $\pm$ 0.65	58.38 $\pm$ 0.83
Protein (%)	19.88 $\pm$ 0.21	18.99 $\pm$ 0.40	18.94 $\pm$ 0.40	19.27 $\pm$ 0.54
Fat (%)	19.64 $\pm$ 0.29	20.14 $\pm$ 0.32	20.11 $\pm$ 0.33	19.96 $\pm$ 0.22
Fat/Dry Matter (%)	52.17 ^a $\pm$ 0.32	47.35 ^b $\pm$ 0.74	45.68 ^b $\pm$ 0.53	48.40 $\pm$ 0.27
Ash (%)	1.86 $\pm$ 0.15	1.78 $\pm$ 0.06	1.82 $\pm$ 0.24	1.82 $\pm$ 0.14
Water activity	0.95 ^a $\pm$ 0.01	0.94 ^b $\pm$ 0.01	0.94 ^b $\pm$ 0.05	0.94 $\pm$ 0.02
Brix value	23.42 ^b $\pm$ 0.17	29.16 ^a $\pm$ 0.21	30.24 ^a $\pm$ 0.28	27.60 $\pm$ 0.24

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

Texture Profile Analysis

The texture profile analysis values of goat milk soft cheese prepared with incorporation of humectants are presented in table 2. The adhesiveness, gumminess and chewiness values of G2 and S2 were significantly higher ($P < 0.05$) than C; however there was no significant between G2 and S2 for these parameters. Higher textural values of treatments might

be due to water binding capacity of humectants resulting into low moisture content and more viscous product. The lower moisture content and increased binding of free water likely contributed to this effect; with reduced availability of free water, protein-protein interactions were strengthened, resulting in a denser protein network. Fox et al. (2017) and Walstra et al. (2006) [10, 22] reported similar relationships

between moisture content and firmness in other dairy matrices. The increased gumminess and chewiness exhibited by the treated samples were attributable to their higher total solids content, as these textural parameters are indicative of the resistance of the cheese matrix to deformation and the energy required during mastication. The reduction in moisture content facilitated closer packing of casein micelles, leading to enhanced rigidity and structural integrity of the protein network. This inverse relationship between moisture content and textural firmness has been extensively reported in intermediate-moisture foods (Fennema, 2008) [7]. There was no significant difference in springiness, cohesiveness and resilience values between control and treatments suggesting the cheese's viscoelastic balance held steady regardless of humectant. In other words, the humectants affected firmness without touching the network's elastic recovery, a finding in

line with Gunasekaran and Ak (2003) [14], who found that moderate compositional shifts do not necessarily change the elastic behavior of soft cheese. The relationship between reduced moisture content and increased firmness has been well documented in cheese science literature. Foegeding and Drake (2007) [9], in their review of the sensory and mechanical properties of cheese texture, reported that increased structural compactness and chewiness were associated with the progressive tightening of the protein network around a diminished pool of free water. A similar mechanism likely accounted for the increased firmness, gumminess, and chewiness observed in G2 and S2 compared with the control (C), where reduced moisture content promoted the formation of a more compact and rigid protein matrix.

Table 2: Texture profile analysis (Mean $\pm$ SE) of goat milk soft cheese prepared with different humectants

Parameters	C	G2	S2	Treatment mean
Adhesiveness (g/sec)	-21.91 ^b $\pm$ 0.21	-23.96 ^a $\pm$ 0.13	-24.02 ^a $\pm$ 0.16	-23.29 ^b $\pm$ 0.08
Springiness (cm/mm)	0.47 $\pm$ 0.04	0.44 $\pm$ 0.01	0.45 $\pm$ 0.03	0.45 $\pm$ 0.02
Cohesiveness (Ratio)	0.62 $\pm$ 0.07	0.62 $\pm$ 0.01	0.63 $\pm$ 0.01	0.62 $\pm$ 0.20
Gumminess (N/cm ²)	2.53 ^b $\pm$ 0.11	3.27 ^a $\pm$ 0.32	2.88 ^b $\pm$ 0.38	2.89 $\pm$ 0.25
Chewiness (N/cm)	0.34 ^b $\pm$ 0.12	0.44 ^a $\pm$ 0.05	0.44 ^a $\pm$ 0.01	0.40 $\pm$ 0.04
Resilience (Ratio)	0.15 $\pm$ 0.07	0.11 $\pm$ 0.02	0.13 $\pm$ 0.04	0.13 $\pm$ 0.05

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

Instrumental color analysis

The instrumental color values of goat milk soft cheese prepared with incorporation of humectants are presented in table 3. There was no significant difference in lightness and yellowness values between control and treatments, however redness values of G2 and S2 were significantly ($P < 0.05$) higher than C. Generally, humectants attract water resulting in low moisture levels and helps to prevent intermediate

moisture in products from drying out, leading to increasing light-scattering and producing lighten finish product, however it depends on nature of humectants (Fernandez-Lopez et al., 2003). It might be the possible reason for the higher redness values of G2 and S2 than C. Sorapukdee et al. (2016) [21] also observed significantly ($P < 0.05$) higher redness (a^*) values of spent hen meat jerky incorporated with glycerol at 10 and 15% level than control.

Table 3: Color values (Mean $\pm$ SE) of goat milk soft cheese prepared with different humectants

Parameter	C	G2	S2	Treatment mean
Lightness (L^*)	81.06 $\pm$ 0.18	81.34 $\pm$ 0.13	81.56 $\pm$ 0.27	81.32 $\pm$ 0.16
Redness (a^*)	0.74 ^b $\pm$ 0.11	0.91 ^a $\pm$ 0.11	0.88 ^a $\pm$ 0.29	0.84 $\pm$ 0.15
Yellowness (b^*)	13.73 $\pm$ 0.31	13.87 $\pm$ 0.09	13.94 $\pm$ 0.35	13.84 $\pm$ 0.18

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

Sensory Evaluation

The sensory scores of goat milk soft cheese prepared with incorporation of humectants are presented in table 4. There was no significant difference in color and appearance scores between control and treatments, as also supported by instrumental colour values and suggesting the cheese's visual appeal held steady regardless of treatment. Flavor as well as body and texture scores of S2 were significantly ($P < 0.05$) higher than C and G2, where no significant difference was observed between C and G2. The mild sweetness and balanced acidity that sorbitol brought likely explained the stronger flavor and aroma scores, and the improved body and texture ratings lined up with S2's higher total solids and more even moisture distribution. Lower sensory scores of G2 might be due to thick gel formation and stickiness of product as compared to S2, again addition of glycerol masked the mild acidic flavor of goat milk soft cheese. The comparatively lower sensory acceptance of G2 might also be due to the highly hygroscopic nature of glycerol, which could have imparted a slightly viscous or syrupy mouthfeel. Similar

effects of polyols on mouthfeel characteristics have been reported in other dairy and intermediate-moisture food systems (Fennema, 2008; Gunasekaran and Ak, 2003) [7, 14]. Acidity, saltiness and overall acceptability scores of C and S2 were significantly ($P < 0.05$) higher than G2, however there was no significant difference between C and S2. Higher sensory scores of S2 might be due to slight sweetish-acidic flavor and aroma provided by sorbitol which was much liked by sensory panelists. The pattern of stronger discrimination for flavor and overall acceptability than for appearance also matches general observations on dairy sensory testing. Drake (2007) [6], reviewing sensory analysis methods for dairy foods, noted that flavor and texture attributes usually drive consumer acceptability more than visual appearance, since appearance differences tend to be too subtle for a panel to reliably distinguish unless a formulation change is fairly severe. Therefore, S2- goat milk soft cheese with 4% sorbitol as humectant was selected as the best treatment and used as control in next experiment.

Table 4: Sensory scores of (Mean $\pm$ SE) of goat milk soft cheese prepared with different humectants

Attributes	C	G2	S2	Treatment mean
Color and appearance	7.80 $\pm$ 0.08	7.74 $\pm$ 0.06	7.76 $\pm$ 0.06	7.76 $\pm$ 0.06
Acidity	7.74 ^a $\pm$ 0.14	7.45 ^b $\pm$ 0.03	7.80 ^a $\pm$ 0.03	7.66 $\pm$ 0.05
Flavor	7.68 ^b $\pm$ 0.14	7.61 ^b $\pm$ 0.04	7.91 ^a $\pm$ 0.04	7.73 $\pm$ 0.05
Body and texture	7.75 ^b $\pm$ 0.10	7.72 ^b $\pm$ 0.04	7.91 ^a $\pm$ 0.04	7.79 $\pm$ 0.05
Saltiness	7.71 ^a $\pm$ 0.11	7.38 ^b $\pm$ 0.07	7.74 ^a $\pm$ 0.07	7.61 $\pm$ 0.08
Overall acceptability	7.80 ^a $\pm$ 0.11	7.56 ^b $\pm$ 0.43	7.79 ^a $\pm$ 0.04	7.71 $\pm$ 0.06

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

Conclusion

Incorporation of humectants improved the overall quality characteristics of goat milk soft cheese, with sorbitol proving to be more effective than glycerol. The addition of 4% sorbitol produced cheese with desirable physico-chemical and textural attributes, characterized by lower water activity, higher total solids, and improved body and texture, while maintaining acceptable colour characteristics. Furthermore, the sorbitol-treated cheese received the highest sensory scores for flavour, mouthfeel, and overall acceptability, indicating its suitability for consumer preferences. The use of sorbitol as a humectant offers a practical approach for developing value-added goat milk products with enhanced quality and marketability. Commercial adoption of this technology could contribute to better utilization of goat milk, diversification of dairy products, and increased income opportunities for goat farmers and small-scale dairy processors, thereby supporting rural livelihoods and promoting the sustainable growth of the goat dairy sector.

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