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Research Article

Cholesterol Removal in Goat Milk Cheese and its Chemical, Textural and Sensory Evaluation during Storage

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Abstract

The experiment was conducted in a 2 x 3 x 3 factorial arrangement by having two types (control and cholesterol reduced) goat milk cheeses, which were assigned to three different storage temperatures (-18, 4, and 22°C) and three different storage periods (0, 2, and 4 months). The objectives of this study were to: (1) evaluate cholesterol removal rate of the CR cheese, (2) determine nutrient composition of CC and CR cheeses and (3) compare pH, lipolysis, textural and sensory characteristics of the 2 types of cheeses stored at 3 different temperatures for 3 storage periods. Results showed that mean contents (%) of moisture, fat, ash, protein, and carbohydrate of CC cheeses were: 41.4, 26.9, 3.87, 28.2 and 3.87, and those of CR cheeses were: 41.1, 22.9, 4.84, 35.1, and 3.93, respectively. The fat content of CR cheese was significantly lower than that of CC cheese, indicating that significant part of fat was lost during cream separation of the original cheese milk. Mean cholesterol concentration (mg/100g cheese) of control and cholesterol removed cheese were 115.062 and 81.97 respectively, suggesting that the cholesterol removal rate was only 28.7%, which is substantially lower than previous reports on bovine milk cheese studies. With respect to pH changes in CC and CR cheeses during the 4 month storage at -18, 4 and 22°C temperatures, CC cheese had lower pH than CR cheese. There were no significant differences in pH values for the different temperatures. However, the 2-way interaction effect of cheese type x storage period showed significant ($P < 0.01$) differences in pHs, Concerning textural characteristics of the experimental cheeses, the textural parameters of CC cheese had higher mean values than those of CR cheese for fresh samples. The ADV values of control cheeses were higher than that of CR cheese samples. The 3-way interaction effect of cheese type x temperature x storage period showed highly significant effect on acid degree value in both CC and CR cheeses. The 2-way interaction of storage time x batch effect was also significant ($P < 0.01$ and $P < 001$) for ADV values. The results of sensory evaluation on the CC and CR goat Cheddar cheeses revealed that cooked flavor was not affected by main factors nor by their interactions. However, storage period made greater influence on sweetness, freshness, high acid, coarse, crumbly, sandy and color of the experimental cheese samples. On the other hand, storage temperature had no impact on any of the sensory properties.

Keywords: Cholesterol; Goat Milk Cheese; Storage

Introduction

Goat milk plays an important role in nutrition and socioeconomic wellbeing of rural populations, especially in developing and under-developed countries. Goat milk and its products, such as cheese, yogurt and powder milk, are important for human nutrition and subsistence in goat producing countries. Goat milk serves 3 types of markets around the world, such as (1) home consumption, (2) specialty gourmet interests, and (3) medical needs [1].

Caprine milk is known to have higher digestibility and healthier lipid metabolism than cow milk, as it contains smaller fat globules, higher percent of short and medium chain fatty acids, and softer curd formation of its protein. Although goat milk has some advantages in nutrition compared to other species' milk, some components, such as cholesterol, in goat milk and products may need further scientific investigations [2].

High blood cholesterol is implicated with the incidence of coronary heart disease, hypertension, atherosclerosis, and strokes. Hence, high fat and cholesterol containing foods may not be desirable for those individuals who need healthy diets and medical attention.

Since there is growing interest in production of cholesterol-reduced dairy products, many methods of cholesterol removal in foods have been developed. Physical, chemical and biological methods have been used in reduction of cholesterol, including vegetable oils, extraction by organic solvents, and adsorption with saponin and digitonin to form cholesterol complexes, degradation of cholesterol oxidases, and cholesterol removal by supercritical carbon dioxide. In removal of cholesterol, Kwak., *et al.* [3] showed that the most suitable method is entrapping cholesterol by cross linked β-cyclodextrin, and adipic acid which are most suitable compounds to achieve extracting cholesterol.

β-Cyclodextrin is a cyclic oligosaccharide consisting of seven glucopyranose molecules which are linked together with α-1-4 bonds. It is non-toxic, edible, non-hygroscopic, chemically stable, and is easily separated from complexes. It is effective in removing up to 80% of the cholesterol from various foods.

Numerous studies have been conducted on cholesterol removal from cow milk products. However, few studies have been reported on cholesterol removal from goat milk products. Therefore, the objectives of this study were to: (1) develop cholesterol reduced Cheddar-type goat milk cheese, (2) determine the efficiency of cholesterol removal in cholesterol reduced (CR) goat milk cheese compared with control (CC) whole goat milk cheese and (3) evaluate chemical composition of CC and CR cheeses, and (4) assess changes in textural and sensory characteristics of Cheddar type CR and CC goat milk cheeses during 0, 2 and 4 months storage at 4°C, 22°C, and -18°C.

Materials and Methodology

Experimental design

The study was conducted in a 2 x 3 x 3 factorial experiment. The packaged cheese were assigned at three different storage temperatures (4°C, 22°C, and -18°C) and three different storage periods (0, 2, and 4 months). Three batches of two types of cheese [control cheese (CC) and cholesterol removed cheese (CR)] were manufactured. The cheese samples were cut into 3 x 3 x 5-inch sizes and vacuum packaged in plastic pouch (Koch Inc. Kansas City, MO) and placed immediately in respective temperature and storage treatments.

Preparation of goat milk

The experimental goat milk was obtained from the bulk tank milk collected from a mid-lactation milking goat herd of Alpine and Saanen breeds at the Georgia Small Ruminant Research and Extension Center, at Fort Valley State University, Fort Valley, Georgia. Animals were fed one pound of concentrates/head/day, with free access to bermuda grass hay and water. The milk was pasteurized at 62.8°C (145°F) for 30 minutes before manufacture of the experimental Cheddar-type goat milk cheeses.

Cream separation

For cholesterol removal from milk and cream, raw milk was pasteurized and cooled to room temperature. The cream was separated from the pasteurized goat milk using a cream separator (CE Elecrem, Vanves, France), at room temperature in the pilot plant at Fort Valley State University, GA, USA.

Removal of cholesterol

Preparation of cross-linked β-CD

A 7.5g of adipic acid dissolved in 50 mL of distilled water and 50 g of β-CD powder was added in a beaker. The suspension was stirred at 700 RPM at 80°C for 2 hrs using a magnetic stirrer. The pH of the suspension was maintained at 12.0 with 1N NaOH solution. The suspension was stirred at 700 RPM at 60°C for 24h using a magnetic stirrer. The pH of the suspension was maintained at pH 5.0 using 10% HCl solution. The cross-linked product was filtered through Whatman paper No. 2 and washed 3 times with 150 mL of distilled water. The product obtained after filtration was dried at 60°C in an oven for 6 hrs and passed through a 100-mesh sieve to obtain cross-linked β-CD.

Cholesterol removal from milk and cream

The bulk pasteurized milk and cream were stirred with 1% and 10% cross-linked β-CD at 400 at 1400 RPM for 5 minutes and 30 minutes, respectively, with a blender in a temperature-controlled water bath at 10°C and 40°C respectively. The milk and cream were then centrifuged at 10000 RPM at room temperature for 10 minutes to remove cholesterol-cross-linked β-CD complex.

Cholesterol removal from milk and cheese samples was calculated and the efficiency of cross-linked β-CD to remove cholesterol from these samples were determined for an average of 3 batches. The percentage of cholesterol removal was calculated by using the formula shown below:

$$\frac{\text{Cholesterol content in CC cheese–cholesterol content in CR cheese}}{\text{Cholesterol content in CC cheese}} \times 100$$

Manufacture of CC and CR cheeses

Manufacture of control cheese

The control Cheddar goat milk cheeses were manufactured by the procedure of Kosikowski (1997). The processing steps were: (a) milk was pasteurized at 62.8°C (145°F) for 30 min, (b) the lyophilized mesophilic DVS (Direct Vat Set) starter culture was added at the rate of 8.13 mg/gal into the pasteurized milk (Chr. Hansen, Inc. Milwaukee, WI, the U.S.A.) (c) after one hour of continuous slow agitation, 0.079 mL/L of rennet (Chymax; Chr. Hansen, Inc. Milwaukee, WI, U.S.) was added into the milk. The milk was then allowed to set for coagulation of curds for at least 30 min without disturbing the cheese milk, (d) after curd formation, the curds were cut with ¼" x ¼" with knife, (e) then the curds were cooked for 30 min with temp increment by 2°C in every 5 minutes until the temperature rise to 39°C, (f) after completion of cooking, whey was drained with 3 times Cheddaring processes, (g) curds were milled, (h) salting was done at the rate of 0.25% salt in cheese, (i) cheese were hooped with Wilson stainless steel hoops, (j) pressed the cheese at 40 psi at room temperature for overnight in walk-in cooler at 4°C (k) Vacuum packaged using vacuum packager (Kock Co. Kansas City, MO), and (l) cheeses were aged at -18°C, 4°C and 22°C for 0, 2 and 4 months.

Manufacture of cholesterol reduced cheeses:

The CR cheeses were made with the cholesterol reduced milk after cream separation and cholesterol removal by β-CD from the whole milk. The cholesterol removed creams were put back into the skim milk, and then the CR cheeses were manufactured using the exactly same procedure used for CC cheeses.

Analysis of basic nutrients

Moisture

Moisture content of all cheese samples was determined in triplicate by the oven drying method at 105°C keeping overnight using AOAC [4] procedure.

Ash

Ash content was determined by ashing the cheese samples in a muffle furnace at 550°C for 24 hour [4].

Protein

Total protein content was determined by using the Fast trac CEM analyzer (SB1550, CEM Corporation, Matthews, NC, USA).

Fat

The fat content was determined by using the Fast trac CEM analyzer (SB1550, CEM Corporation, Matthews, NC, USA).

Carbohydrate

Carbohydrate content was calculated by subtracting the sum of fat, protein, and ash from total solids content, which was analyzed by oven drying 24h at 105°C [4].

Chemical analysis

pH

A 10g cheese sample and 20 mL double deionized water was homogenized in a Waring blender (Waring Products, Inc., New Hartford CT). The pH of the cheeses was determined by an Accumet pH meter Fisher Scientific (No. 910; Pittsburgh, PA).

ADV

Acid degree value (ADV) is the quantitative index of hydrolytic lipolysis in dairy products and measures the amount of free fatty acids present in a fat sample. ADV was determined according to Richardson (1985). A 10 g cheese sample was shredded, ground, and placed into the Babcock bottles. The extracted fat was collected from the Babcock bottle and transferred to an Erlenmeyer flask using a 1 mL syringe. The fat was dissolved in 5 mL of fat solvent and 5 drops of 1% phenolphthalein was added to it. One blank titration was made on fat solvent using 5 drops of the same indicator. The fat was titrated to the first faint but definite color change with the standardized 0.02 N. alcohol KOH solution using a 5 mL microburette. The following formula was used to calculate ADV,

$$\text{ADV} = \frac{\text{(mL of KOH for sample – mL of KOH for blank) x N}}{\text{Fat weight}} \times 100$$

Where, N=normality of KOH solution in methanol.

Analysis of cholesterol

Extraction of fat

A 0.2-g sample of well-ground cheese was accurately weighed into as ample preparation tube to which 5 ml of methanolic KOH solution were also added. The tube was capped tightly, and its contents were vortexed for 15s. The lower half of the tube was then immersed in a 80°C bath and kept there for 15 minutes, removing the tube every 5 minutes to vortex for 10s. Following heating, the tube was cooled with tap water, 1 ml of water and 5 ml of hexane were added, and the contents were vortexed vigorously for 1 min and then centrifuged for 1 minute at 2000 × g. An aliquot of the upper phase was transferred into the autosampler vial pending GC analysis.

Cholesterol analysis

Concentration of cholesterol was determined using a GC 2010 Plus (Shimadzu Scientific Instruments Inc., Canby, Oregon, US) equipped with a fused silica capillary column (HP-5, 30 m long x 0.32 mm internal diameter x 0.25 µm film thickness) and autosampler (AOC-20i, Shimadzu Scientific Instruments Inc., Canby, Oregon, US). The injector and detector temperatures were set at 270°C and 300°C, respectively. The oven temperatures was programmed for temperature ramping program to increase from 200 to 300°C at 10°C/minute, and then held for 20 minutes at 300°C. Helium was used as a carrier gas at a flow rate of 2 mL/minute and the sample was injected with a split ratio of 1:50.

Texture evaluation

Texture analysis of the experimental cheeses was performed using a TA-XT2i texture analyzer (Texture Technologies Corp., Scarsdale, New York, USA) according to the manufacturer instructions. The basic characteristics of the texture profile determined were hardness, adhesiveness, resilience, cohesiveness, springiness, gumminess, and chewiness. The point of highest force during the first compression was the hardness. The extent to which the sample returns to its original shape between the first and second compressions was the elasticity. The ratio of the area under the second compression curve was cohesiveness. Gumminess and chewiness were calculated as hardness x cohesiveness, and gumminess x elasticity, respectively.

Sensory evaluation

An eight members of untrained sensory panel consisting of faculty and graduate students from College of Agriculture, Family Sciences and Technology at Fort Valley State University performed the sensory evaluation of the goat milk cheese. The panelist were trained for sensory scoring practice of cheese for 4 times prior to the sensory experiment and also at the time of the experiment (0, 2, and 4 months storage). The lexicon was made up first-bite firmness, first-bite fracturability, chewdown degree of breakdown, chewdown cohesiveness, chewdown adhesiveness, chewdown smoothness of mass, and residual smoothness of mouth coating. The panelist were provided with 8 cubes (1.27 cm^3) of each cheese samples at room temperature, to be used throughout testing at the discretion of the panelist in 118 mL plastic cups labeled with 3-digit codes. Panelists were given deionized water to clean their palates between each sample and reference cheese was made available for each session. Each panelist evaluated each sample in duplicate according to the previous procedures.

Statistical analysis

All collected experimental data were analyzed using the GLM procedure of SAS program (2000) (SAS package Ver. 9.3). Mean separation was conducted by least significant difference (LSD). For analysis of variance, correlation coefficients, least square mean difference, and Duncan's multiple mean comparisons between treatments were also analyzed using the methods of Steel and Torrie [5].

Results and Discussion

Nutrient composition of the control (CC) and cholesterol removed (CR) cheeses

The previous reports have shown that the typical Cheddar cheese contains moisture 37%, protein 25%, fat 33%, carbohydrate 1%, and ash 4%. These results indicated that the present study of control cheese has higher moisture, carbohydrate and protein content but lower values of ash and fat content than the reported values. Cholesterol reduced cheese showed similar levels on moisture, and protein content but lower for fat, carbohydrate and ash contents Cheddar cheese has legal limit of moisture content of 37%, while the present study on goat milk Cheddar contained 41%

moisture, indicating goat cheese had significantly higher moisture than cow counterpart. This results suggest that goat milk tends to have soft curd formation [2] leading to higher moisture retention in the cheeses. In addition the higher values of moisture are attributed to the insufficient drainage of whey during manufacturing process and also different goat milk samples being analyzed after their storage at respective time and temperature.

The fat content of CR cheese was significantly lower than that of control cheese. This may have been caused by some part of cream being extracted from the milk during cream separation of the milk during preparation of CR cheese. Similar result was reported by Kwak., *et al.* [6], where they postulated that Cheddar cheese made by β-CD treated cream showed a lower fat content due to the smaller size of fat globule resulting from stirring. The protein content of CR cheese was expected to be lower than that of control cheese as observed by Kwak., *et al.* [6] in cow milk. Due to the differences in milk composition that was being used for manufacturing cheese, the protein value was higher for CR cheese in the present study. Similarly, Ha., *et al.* [7] observed that there was a minimal effect on lactose content by cholesterol reduction process. Hence the carbohydrate content in the present study revealed similar trend as the previous studies.

Parameters	Moisture		Ash		Protein		Fat		Carbohydrate	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	41.4[a]	0.53	3.87[a]	0.15	28.[b]2	0.24	26.9[a]	0.29	3.87[a]	0.27
CR	41.1[a]	0.53	4.84[a]	0.15	35.1[a]	0.24	22.9[b]	0.29	3.93[a]	0.27

Table 1: Basic nutrient (%) analysis of the original fresh control and cholesterol reduced goat milk Cheddar cheese.

CR: Cholesterol Reduced; SD: Standard Deviation

[a,b]: Mean with different superscript within a same column are different ($P < 0.05$).

Effect of cholesterol removal on pH of CC and CR cheeses

Effects of the main factors, cheese type, storage period, and storage temperature on pH of CC and CR cheeses were evaluated. There were no significant differences in pH between storage temperatures, while differences between cheese type was highly significant. The pHs of Control cheese were similar to the cholesterol removed cheese across temperature treatments.

There were no significant differences in pH values for the different temperatures. However, the interaction between cheese type x storage period showed significant differences in pH values suggesting that the decreased pH might be due to increased lipolysis. The result showed that pH for CC cheese was decreased up to 2 months for all storage temperature treatments, while pHs of 4 month were increased due to increased. Similar trend was there in cholesterol reduced cheese. Fresh CC cheese had lower pH compared to CR cheese since removal of fat and cholesterol may have decreased the free fatty acids resulting in slightly higher in pH values.

Comparison of ADV (lipolysis) between CC and CR cheeses

The acid degree values of fresh CC and CR cheese samples for 0, 2, and 4 months were compared (Table 6). The analysis showed that the interaction between cheese type x temperature on acid degree value were significantly different. This might be due to the fact that temperature has significant impact on lipolysis of cheese. Similarly, storage time also had significant differences in acid degree value, which can be explained on the fact that with the storage advances more lipolysis is expected to occur in cheese samples. There were increase in ADV values from month 2 to month 4. Only data available are 22°C temp treatment, where the ADV values were increased by storage time of 0, 2, 4 months for both CC and CR cheeses.

Cheese type		0 month		2 month		4 month	
		Mean	SD	Mean	SD	Mean	SD
Control	-18	-	-	0.69	0.04	0.85	0.031
	4	-	-	0.75	0.03	0.76	0.02
	22	0.54	0.02	0.58	0.05	0.87	0.04
CR	-18	-	-	0.76	0.03	0.81	0.02
	4	-	-	0.76	0.02	0.85	0.03
	22	0.51	0.10	0.58	0.03	0.87	0.04

Table 2: Mean and standard deviation values for the effect of temperature on ADV.

CR: Cholesterol Reduced; SD: Standard Deviation

-: Missing data.

Source	DF	Mean square	F-value	Pr > F
Batch	2	0.00223364	1.89	0.1632
Cheese type	1	0.00001071	0.00001071*	0.01
Storage	2	0.29587847	250.80***	< .0001
Temp	2	0.35267123	0.17633562	149.47
Cheese type x batch	2	0.00542438	4.60*	0.0156
Cheese type x Storage	2	0.00280069	2.37	0.1055
Cheese type x Temp	2	0.01083750	9.19**	0.0005
Temp x storage	2	0.06394306	54.20***	< .0001
Temp x batch	4	0.00147917	1.25	0.3032
Storage x batch	4	0.00396181	3.36	0.0179
Cheese type x Temp x batch	4	0.00272917	2.31	0.0732
Temp x storage x batch	4	0.00195556	1.66	0.1779
Cheese type x Temp x storage x batch	4	0.00285833	2.42	0.0631

Table 3: Statistical summary of the interaction among cheese type, batch, month, temperature on ADV.

Significant at P < 0.05, ** Significant at P < 0.01,*** Significant at P < 0.001.

DF= Degrees of freedom

Textural properties of CC and CR cheeses

Textural properties of cheese including hardness, adhesiveness, resilience, cohesiveness, springiness, gumminess and chewiness revealed that the CC cheese had higher mean values of all textural parameters except adhesiveness than those of CR cheese for fresh samples at 0 month storage.

There were significant differences in hardness among batches, temperature, storage, and 2-wayand 3-way interactions among batch, month, and temperature and cheese type. The hardness of the CC and CR cheeses was in an increasing trend for all the storage period during ripening. The changes in texture profiles were expected because of the differences in moisture content between CC and CR cheeses, and also due to less fat content in cholesterol reduced cheese Van Hekken., *et al*. (2004) studying rheological and proteolytic properties of Monterey Jack goat milk cheese during 26 weeks aging at 4°C, concluded that β-caesins levels decreased with corresponding increase in peptide levels. Hydrolysis of protein matrix resulted in more flexible and softer cheese. The results of present study are in agreement with the decreasing hardness during 4 month storage in both CC and CR cheeses).

All the textural properties had highly significant differences among cheese type. There was no significant differences in batch effect except for hardness. The hardness, resilience, cohesiveness, gumminess and chewiness were also highly significant for the storage temperature except adhesiveness and springiness. With storage period there were significant differences for hardness, adhesiveness, resilience, cohesiveness, springiness and gumminess. The interaction effect of cheese type x temperature were also significant for hardness, resilience, cohesiveness, gumminess and chewiness. There were highly significant differences in hardness, adhesiveness, resilience, cohesiveness, springiness, and chewiness for interaction effect of cheese type x storage. Also all the textural properties were significantly different for temperature x storage period. For batch x storage, only the gumminess parameter was highly significant. For 4-way interaction of batch x storage period x temperature x cheese type, all the textural properties showed significant difference.

Sensory characteristics of CC and CR cheeses

There were no significant differences in cooked, whey, fluffy and soggy flavor affected by main factors and their interactions effects of cheese type, batch, storage time and temperature. Storage time had significant effect on most of sensory characters except freshness, rancid, oxidized, fluffy, gummy, soggy, weak body and color traits. Rancid flavor was highly significant for the cheese type. This may be due to the reason that cholesterol reduced cheese contained some of the flavor of β-cyclodextrin compound during manufacturing process of cheese. Cheese type was significant for rancid and sandy flavors. Coarse flavor of the cheese was highly significantly affected by storage time and 4-way interaction of batch x storage x temperature x cheese type effect. The flavors of CC and CR cheeses were influenced by lipolysis of chesses during storage as well as degradation of fat which resulted in rancidity flavor of the products.

Cheese type		Cholesterol reduced							Control cheese						
Parameters	Time (month)	0	2			4			0	2			4		
	Temp °C	22	-18	4	22	-18	4	22	22	-18	4	22	-18	4	22
Hardness	Mean	4175.97	4166.4	3978.5	10961.9	5293.4	3696.5	3448.8	5454.6	5170.1	5222.7	5453.5	5441.5	5363.5	5333.1
	SD	2178.8	1943.0	2153.6	2524.8	361.2	881.6	935.8	21.7	25.4	108.3	26.6	53.2	21.7	94.1
Adhesiveness	Mean	-3.36	-75.8	-45.7	-37.2	-7.33	-37.4	-80.1	-7.35	-4.78	-4.97	-6.23	-5.81	-4.44	-5.0
	SD	5.73	43.5	24.3	9.35	1.47	40.6	63.2	0.84	0.87	1.40	2.04	2.26	1.16	1.08
Resilience	Mean	12.4	5.82	5.65	9.67	74.8	22.0	6.14	78.4	79.6	78.3	72.6	78.3	72.6	73.6
	SD	4.25	1.69	1.71	1.79	3.68	28.6	2.69	2.84	25.4	3.05	0.18	3.11	0.13	2.66
Cohesiveness	Mean	0.35	0.20	0.20	0.24	1.48	0.37	0.19	0.74	0.74	0.74	0.75	0.66	0.54	0.57
	SD	0.09	0.04	0.04	0.04	0.01	0.21	0.02	0.02	0.03	0.02	0.02	0.19	0.03	0.07
Springiness	Mean	77.9	41.7	45.9	62.0	87.4	64.6	53.7	87.9	87.012	87.9	88.0	88.1	88.5	88.2
	SD	7.76	4.54	10.1	7.54	1.81	19.8	15.7	0.77	1.63	1.25	0.58	0.89	0.55	1.25
Gumminess	Mean	1560.9	937.1	867.1	2862.9	3296.3	1408.9	678.9	2880.0	2747.2	2883.2	3548.1	3645.8	3550.5	3411.6
	SD	732.9	668.5	592.5	981.2	409.7	876.5	223.0	344.0	8.74	325.4	23.7	319.5	9.1	325.4
Chewiness	Mean	1085.7	394.4	422.1	1773.8	4216.9	1237.8	357.7	3853.7	3670.1	3866.9	4776.5	3645.8	3471.7	3514.1
	SD	497.0	304.9	335.4	663.7	589.8	1321.7	147.2	460.7	12.7	445.2	4.62	144.0	15.8	69.6

Table 4: Mean values of the textural properties of CC and CR cheeses among storage period and temperature.

The study results indicate that storage period has greater influence on sweetness, freshness, high acid, coarse, crumbly, sandy and color of the experimental cheese samples. On the other hand, it was observed that storage temperature had no impact on any of the sensory properties.

Source Parameter (F-value)	Cheese type	Batch	Storage time	Temp	Storage time x temp	Storage time x cheese type	Batch x storage	Temp x cheese type	Batch x storage x temp x cheese type
DF	1	2	2	1	1	3	4	1	15
Cooked	0.05	0.62	0.9	0.01	0.05	0.05	0.55	0.01	0.52
Sweetness	3.18	3.9*	10.9**	3.56	0.22	3.13	1.05	2.35	2.32*
Freshness	0.90	1.74	9.24**	0.07	0.16	1.12	0.93	0.16	1.14
Rancid	0***	0.59	0.17	0.11	0.06	0.17	0.98	0.11	0.57
Whey	0.55	1.01	0.17	3.07	0.38	0.52	1.61	2.08	1.28
High acid	0.07	2.67	4.54*	0.09	0.21	1.14	0.93	0.02	2.43*
Oxidized	2.18	2.97	2.56	1.87	0.18	1.46	0.86	2.32	1.73*
Coarse	0.24	2.78	10.3**	0.73	0.93	0.93	5.05***	0.56	1.96*
Crumbly	1.20	2.24	5.60*	0.54	0.33	0.81	0.88	0.17	1.05
Fluffy	0.55	0.65	0.14	2.4	0.05	0.66	0.76	2.40	1.41
Gummy	0.98	0.02	4.01	2.52	0.39	1.72	0.45	2.52	1.92*
Sandy	0.02*	1.14	3.87*	0.01	0.27	0.17	0.64	0.01	0.96
Soggy	0.29	0.3	1.02	0.14	0.02	0.06	0.49	0.02	0.95
Weak body	0.84	1.99	1.76	2.63	0.78	1.76	2.46*	2.63	1.67
color	1.24	1.49	6.81*	1.98	0.16	1.98	2.15	3.27	1.46

Table 5: Statistical analysis on the sensory properties of CC and CR Cheddar cheeses.

*: Significant at $P < 0.05$. **: Significant at $P < 0.01$. ***: Significant at $P < 0.001$.

DF: Degree of Freedom.

Efficiency of cholesterol removal

The cholesterol removal efficiency was found to be 28.7%, which was much lower compared to a previous study by Kwak., *et al*. [8], where they were able to remove above 90% cholesterol. The lower efficiency of cholesterol removal in this study might be due to analytical error during different steps of cholesterol removal process. In addition, because goat milk has lower creaming ability due to natural homogenization of milk [9], the efficiency of cholesterol extraction by β-CD could be impeded. As far as the effect of storage period goes), 0 month storage had higher cholesterol content than 2 and 4 month period. This reduction in cholesterol may be attributed to the oxidation of cholesterol in the cheeses during storage [2]. There were significant ($P < 0.001$) differences between cheese types in cholesterol content. In addition, temperature effect, had also significant ($P < 0.001$) effect on cholesterol contents among 3 temperature treatment group.

Parameters	22°C		4°C		-18°C	
	Mean	SD	Mean	SD	Mean	SD
Control	116.7[a]	4.81	116.5[a].0	6.6	109.6[a]	4.70
Cholesterol reduced	87.43[b]	4.12	81.1[b]	4.62	68.1[b]	3.92

Table 6: Cholesterol contents between CC and CR cheese, as compared among three different storage temperature treatments.

SD: Standard Deviation

[a,b]: Mean with different superscript within a same column are different.

Summary and Conclusions

Average basic nutrient contents (%) of moisture, fat, ash, protein, and carbohydrate were: 41.4, 26.9, 3.87, 28.2, 3.87 for control and 41.1, 22.9, 4.84, 35.1 and 3.93 for cholesterol-reduced cheese. There were significant ($P < 0.01$) differences in fat content between the experimental cheeses. Control cheese had lower pH as compared to the cholesterol removed cheese. The ADV values of CC cheese were higher than those of CR cheese samples All textural properties of CC (control) cheese had higher values than those of cholesterol reduced (CR) cheese for fresh samples and highly significant ($P < 0.01$) different among cheese type. The fresh cheese samples had higher values of sensory characteristics as compared to stored cheeses. The cholesterol removal rate in this study was 28.7%, which was substantially low compared to the previous studies with cow milk cheeses. Further studies are necessary to clarify the causes of the substantially lower cholesterol removal rate in this caprine cheese study, compared to cow milk counterparts. Future studies needed to determine if the cholesterol extraction procedure used for cow milk cheeses can be directly applicable to the goat milk cheese counterparts, with respect to the unfavorable conditions of low cream ability of goat milk characteristics [10-54].

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