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Effect of buffalo milk admixing on textural quality of goat cheese

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Abstract
Goat milk is gaining importance because of its unique chemical and nutritional components and richness in nutraceuticals. However, on technological front variation in protein composition adversely influence product quality specially the textural characteristics of fermented milk products and cheeses. Present investigation was carried out to investigate the admixing of buffalo milk, on quality attributes of cheese; Admixing of buffalo milk in goat milk improved the protein, fat content and rennet coagulation time in cheese milk. Moreover buffalo milk admixing above 40 percent increased the fat recovery in cheese besides enhancing the protein content. Level of buffalo milk and casein to fat (C:F) ratio in cheese milk had a significant ($P<0.05$) effect on textural parameters. Enhancing the level of buffalo milk concentration and C:F ratio significantly improved the primary as well as secondary textural properties. It can be concluded that buffalo milk admixing at or above 40 percent level in goat milk improved the textural properties of resultant cheese.

Keywords: Goat milk, casein fat ratio, texture profile analysis, SDS-page

Introduction
In India, the contribution of minor species including goat, sheep and camel is about 5% in national milk pool. However, demand for milk from non-bovine species is rising day by day. In terms of goat population India has second largest herd in the world (14.6%), after china (17.3%), with an estimated mil, the contribution of minor species production of 4.5 MT, followed by Bangladesh and Pakistan with 2.4 and 0.75 million tons of milk, respectively (FAOSTAT, 2011) [8]. Among the processed dairy products, cheese and other fermented milk products represents the promising segment because of unique health benefits associated with their consumption. Indian consumer’s palate has been adapted to milder variants of cheeses such as processed cheese, cottage, feta, ricotta and other cheese based products. According to an estimate and the current household penetration in terms of cheese consumption is less than 7-8 percent and the per capita consumption of cheese is only 200 gm per year in comparison to the global average of 7 kg per annum (Jain and Sharma, 2014) [13]. Compositional variables of goat milk such as lack of αs_1- casein, predominance of β-casein, richness in medium chain fatty acids (MCFA) and higher levels of calcium & phosphorus, affects the techno-functional properties. Another issue associated with goat milk based products are having intense goaty or meaty flavor that is negatively evaluated by customers. Majority of goat milks are utilized either as fresh liquid milk mixed with cow or buffalo milk for value addition. Products solely based on goat milk suffered with quality defects especially due to lower levels of protein and fat, if compared with bovine milk. Conversion of goat milk into high valued processed products such as cheeses, fermented milks, infant formula etc. could be an attractive option for promoting its processing on commercial level. Recent research findings also indicate that there is potential of utilizing goat milk for the production of novel dairy products and ingredients such as probiotic yoghurt, cheeses, ice-cream and bioactive peptides (da Silva *et al*., 2015; Espejo-Cario *et al*., 2014) [3, 6]. Health benefits of goat milk can be further enhanced by its conversion into fermented products as it leads to better digestibility, higher bioavailability of micronutrients, presence of viable lactic bacteria and production of certain bioactive peptides (Espejo-Carpio *et al*., 2016) [7]. However, it requires technological and formulation interventions to overcome the inherent problems associated with fermented goat milk products. Another, major limiting factor of fermented milks is soft curd or coagulum due to lower fat and SNF content, resulting in poor textural characteristics.

Moreover the fresh or medium ripened cheese varieties have shorter shelf-life even under refrigerated storage due to higher moisture content. Which may causes the greater fat loss in goat milk cheese during cheese making and also accelerated ripening during storage which leads to a sharp flavored cheese with a weaker body and texture. In Austria, mixed cheese varieties are produced either from cows' and ewes' milk or from cows' and goats' milk; in both cases the maximum percentage of cows' milk acceptable is 49%. In addition, some cheeses are manufactured from cows', ewes' and goats' milk, the minimum percentage of each species is10%. The substitution of ewes' and goats' milk for bovine milk improved the quality of cheese (Mayer, Heidler, & Rockenbauer, 1997) [19]. Therefore aim of the present study was to improve the textural characteristic of goat milk cheese by supplementing the cheese milk with buffalo milk and to enhance the fat recovery during the cheese manufacture by altering the casein to fat (C:F) ratio.

Materials and Methods

Raw materials

Goat and buffalo milk was obtained from the Livestock Research Centre (ICAR-National Dairy Research Institute, Karnal) for manufacturing cheese. Direct vat set starter CHN 11 Culture (*Lactococcus lactis* Subsp. *Cremoris, Leuconostoc, Lactococcus lactis* subsp. *lactis, Lactococcus lactis subsp. lactis biovar diacetylactis)* was procured from CHR HANSEN (INDIA) PVT LTD. For manufacturing of cheese Meito rennet from *Mucor pusillus* var. *lindt,* was supplied by Meigo Sangyo Co. Ltd., Japan was used at the rate of 1.5 g/100 liters of milk. Salt of M/S Tata chemicals, Mumbai, India.

Analysis of milk

Fat content of milk was determined by the Gerber method as detailed in IS: 1224: 18(part 1), 1977 [11]. Casein content of milk was analyzed according to the Walker-Formol method.

Rennet coagulation time (RCT)

For the determination of RCT 10ml each of goat milk, buffalo milk, mixture of goat and buffalo (G:B) milk ratios (70:30), (60:40), (50:50), (40:60) in a test tube, was taken and its temperature was raised to 31ºC. 1ml of 1% rennet solution was added slowly into it and tubes were monitored for the appearance of clots/flakes on the surface of the test tube. Time taken for the appearance of the flakes after rennet addition is recorded as rennet coagulation time.

Preparation of cheese

Goat milk, buffalo milk and mixture of goat and buffalo (G:B) milk in four different ratios (70:30), (60:40), (50:50), (40:60) were standardized separately to three different levels of casein to fat ratio i.e. 0.7, 0.75 and 0.8, and pasteurized at 63°C for 30 minutes, cooled to 31°C, inoculated with DVS (CHN 11) starter culture (2gm/100lts) for 30 minutes at 31±2°C. Rennet was added @1.5g/100 lit of milk and mixed thoroughly. The curd obtained was then cut with stainless steel knives, left undisturbed for 5 min. to facilitate whey expulsion and finally cooking process was initiated by scalding method. Whey was drained carefully; curd particles were washed with sterilized water and then left for matting. Milling and salting of curds was done for further whey expulsion, dressed and pressed overnight and stored after surface drying at 4ºC.

Analysis of cheese

Cheese samples were analyzed for compositional parameters, textural properties and electrophoretic behavior. Moisture, fat and ash content of cheese was determined gravimetrically using as per the method described in IS: SP: 18(part XI, 1981) [12]. Total protein and titratable acidity was determined by the method described by AOAC (1984) [1] and the pH of the cheese was measured by pH meter (Eutech Instruments, Cyberscan pH2100 U.K.).

SDS-PAGE

SDS-PAGE was conducted according to the procedure suggested by Fling and Gregerson (1986) [9] using 5% (wt/vol) stackingand 12.5%(w/v) resolving gel. Electrophoresis was performed using Bio-Rad Mini-PROTEAN® TetraCell, a vertical slab gel electrophoresis unit. For SDS-electrophoresis, the cheese proteins were extracted according to the method described by Kalit *et al*., (2005) [16]. Approximately 1.2g of previously grounded cheese was extracted with continuous shaking in15mL of buffer (0.055M Tris-HCl, pH 6.8, 2% (w/v) SDS, 7 % (v/v) glycerol, 5 % β-mercaptoethanol (v/v)) for 30 minutes at 40°C. The obtained suspension was centrifuged for 15 minutes at 2.600g (Sigma, 2-16K, Germeny). The clear solution beneath the upper layer was carefully taken and diluted with sample buffer (0.055 M Tris-HCl, pH 6.8, 2% (w/v) SDS, 7% (v/v) glycerol, 4.3% (v/v) β-mercaptoethanol, 0.0025% (w/v) bromophenol blue). Extract to sample buffer ratio was 1:3 and then frozen. Prior to electrophoresis, samples were heated at 90°C for 5min and cooled down to the room temperature. 25 µL of each sample intended for the SDS-PAGE were loaded per well. The gels were run at 30 mA per gel for 4 hours to completion. Gels were fixed, stained with 0.23% (w/v) Coomassie Blue R-250 [dissolved in 3.9% (w/v) Trichloro acetic acid (TCA), 6% (v/v) acetic acid, and 17% (v/v) methanol] for 45 min and destained with 8 % acetic acid and 18 % (v/v) ethanol. Molecular weights of the polypeptides were estimated by using the low molecular weight markers (Sigma-Aldrich, USA).

Texture profile analysis

The textural characteristics of fresh cheeses were evaluated, using Texture analyzer (Stable Micro Systems, model TA.XT Plus, Surrey, England) equipped with a cell charge of 25 kg. Cylindrical samples, with diameters and heights equal to 20 mm, were removed from random points in the cheese, in order to get uniform and homogeneous samples, and kept at room temperature (20°C). The texture profile was generated by a double compression test of the cheese samples, at room temperature, using a cylindrical compression probe with a 75 mm diameter (P75). Compression was performed at a constant speed of 3.0 mms^{-1} (pre-test),1.0 mms^{-1} (test), and 3.0 mms^{-1} (post-test), with contact strength equal to 5 g until the sample height was reduced to 4 mm (that means 80% of the initial height).

Cutting strength (Warner–Bratzler shear test)

This test measures the force (Newtons) necessary to shear a piece of cheese. The test cell consisted of a 3 mm-thick steel blade (Warner-Bratzler blade), and was fitted through a 4-mm wide slit in a small table. Assay parameters were pre-test speed: 3.0 mms^{-1}, test speed: 1.0 mms^{-1}, post-test speed: 3.0 mms^{-1}.

Statistical analysis

Two way ANOVA was carried out using SAS 9.3, for evaluating the effect of goat-buffalo milk ratio and casein fat ratio on the physico-chemical properties and textural behavior of cheese analogue.

Results and Discussion

Buffalo milk was having highest concentration of casein and fat, goat milk admixing with buffalo milk in different ratios the casein and fat content decreased significantly ($p<0.05$). It was expected that increasing the proportion of goat milk decreased the fat content and lowest was observed for the blend having 70% goat milk and 30% buffalo milk. Casein content also decreased with increasing the level of goat milk. There was no significant difference in the cheese milks having 40% or 50% of goat milk, but with further increase in goat milk proportion, the casein content decreased ($p<0.05$) significantly (Table 1). Admixing of milk not only altered the overall composition of the blends but influence the techno-functional properties such as viscosity, rennet coagulation time (RCT) and heat coagulation time (HCT). Enhancing the level of goat milk in cheese milk blend led to lowering in rennet coagulation time (RCT), this was statistically significant except for the blend which had 40 and 50% goat milk (Figure 1). Variation in coagulation properties is mainly related to the difference in casein profile and α_{s1}-casein play a major role in coagulum formation. RCT is negatively correlated with β-casein and positively with α_s/β-casein ratio of goat milk (Storry *et al.*, 1983) [23]. Rennet coagulation require hydrolysis of k-casein and about 97% k-casein must be hydrolyzed for curd formation since k-casein content is less in goat milk (Sabharwal, 1966) [22], the completion of its hydrolysis is achieved earlier, resulting in shorter coagulation time. The larger casein micelle size in goat milk contributes to its faster coagulation and greater water holding capacity with a fragile texture (Jenness, 1980) [14].

Table 1: Changes in casein and fat content in cheese milks with rennet coagulation time.

Ratios	Fat (%)	Casein (%)
B100	7.38±0.29^a	2.91±0.07^a
G:B 40:60	6.50±0.10^b	2.61±0.10^a
G:B 50:50	6.18±0.15^c	2.46±0.07^a
G:B 60:40	5.83±0.20^d	2.35±0.10^b
G:B 70:30	5.56±0.13^e	2.11±0.17^c
G100	4.05±0.17^f	2.05±0.10^d

Data are presented as means ± SEM (n=6).

$^{a-f}$ Means within rows with different lowercase superscript are significantly ($p<0.05$) different from each other.

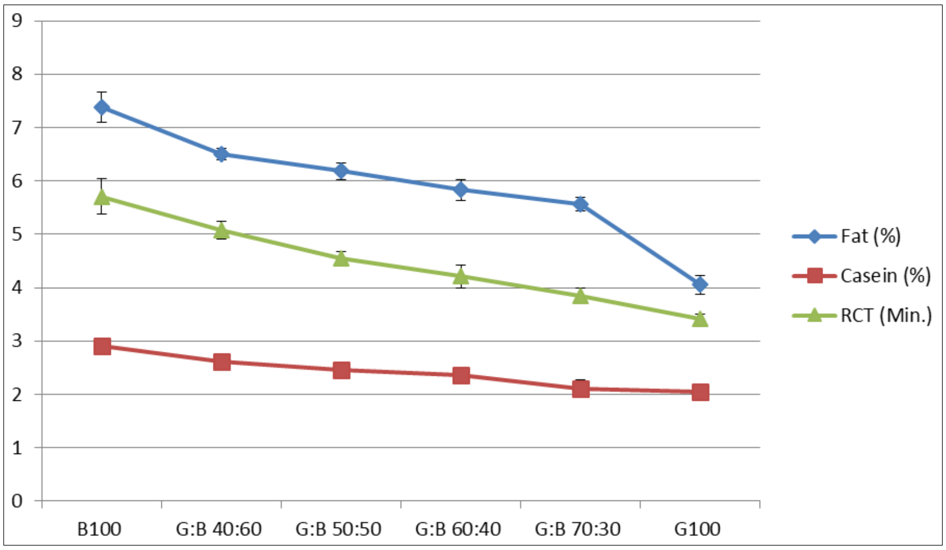

Fig 1: Changes in casein and fat content in cheese milks with rennet coagulation time

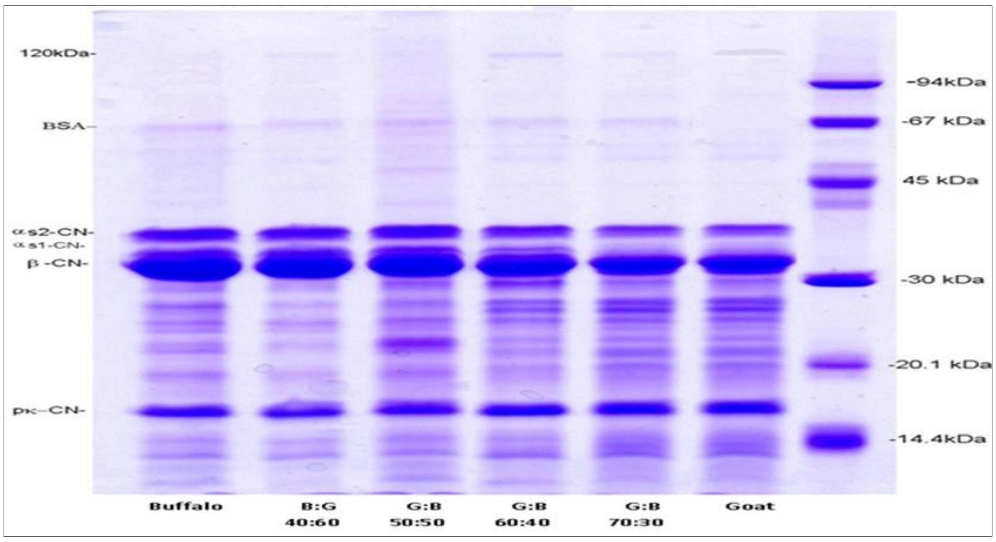

Fig 2: Electrophoretic pattern of goat milk cheeses mixed with buffalo milk at different levels.

Chemical composition of cheese

Cheese made with different blends of goat and cow milk and having adjusted to three casein to fat ratio were analyzed for proximate composition. There was reduction in moisture content of cheese with increasing level of buffalo milk in the proportion of goat milk (Table 2). 100% goat milk based cheese was having maximum moisture content, while those made with 100% buffalo milk were contained lowest moisture. The statistical significant variation was noticed in cheese made with a blend of goat and buffalo milk (60:40) adjusted to 0.8 C:F ratio. As the proportion of buffalo milk increased the variation become more apparent in all compositional parameters and it was more evident in cheeses prepared with admixture where buffalo milk was added 40 percent or above. Raising the C:F ratio of cheese milk resulted in decreased moisture but increase in other compositional parameters significantly. Buffalo milk addition and increasing C:F ratio improved the fat and protein content in cheese because of incorporation of αs1-casein and larger fat globules in cheese curd. Increasing protein content in cheese milk led to improvement in fat binding capacity in curd and better recovery as compared to lower protein levels in 100% goat milk cheese. On the other hand bovine milks are having higher creaming ability, where clustering ability of fat globules induced by agglutinin. In caprine milk lack of agglutinin and smaller fat globules makes fat globule membranes of caprine milk more fragile (Kalantzopoulos, 1993) and lesser amount of αs1- casein leads to the lesser amount of casein content which makes the composition of goats' milk, especially the various casein fractions, is different from cows' milk (Chandan *et al.*, 1992; Park, 2001) [2, 21].

Table 2: Changes in chemical constituents due to different casein fat ratio of cheese milk

Milk	C/F Ratio	Moisture (%)	Fat (%)	Protein (%)	Ash	Acidity
G100	0.7	57.22±0.40^{a}	18.32±0.52^{a}	18.51±0.60^{a}	1.86± 0.08^{a}	0.44±0.01^{a}
	0.75	56.44±0.48^{a}	19.09±0.55^{a}	19.84±0.49^{a}	1.97± 0.03^{a}	0.44±0.01^{a}
	0.8	54.97±0.01^{a}	20.03±0.07^{a}	21.15±0.06^{a}	2.06± 0.01^{a}	0.45±0.03^{a}
G:B 70:30	0.7	56.86±0.54^{a}	19.93±0.63^{a}	20.51±0.86^{a}	1.88± 0.04^{a}	0.44±0.01^{a}
	0.75	55.61±0.80^{a}	20.90±0.25^{b}	21.81±1.02^{a}	1.97± 0.02^{a}	0.44±0.03^{a}
	0.8	53.92±0.02^{a}	21.76±0.07^{c}	23.26±0.08^{b}	2.09± 0.09^{a}	0.43±0.08^{a}
G:B 60:40	0.7	55.16±1.01^{a}	21.37±0.33^{d}	21.06±1.03^{a}	1.85± 0.05^{a}	0.43±0.02^{a}
	0.75	54.79±0.62^{a}	22.56±0.72^{e}	22.31±0.74^{c}	2.01± 0.11^{a}	0.44±0.02^{a}
	0.8	53.02±0.03^{b}	23.73±0.08^{f}	24.00±0.06^{d}	2.10± 0.08^{a}	0.44±0.04^{a}
G:B 50:50	0.7	54.65±0.49^{a}	23.48±0.64^{g}	21.76±1.51^{a}	1.86± 0.03^{a}	0.46±0.04^{a}
	0.75	53.28±1.13^{c}	24.61±0.45^{h}	23.69±0.27^{e}	1.91± 0.15^{a}	0.45±0.03^{a}
	0.8	52.41±0.02^{d}	25.61±0.11^{i}	24.53±0.07^{f}	2.11± 0.06^{a}	0.46±0.04^{a}
G:B 40:60	0.7	54.30±0.67^{a}	25.21±0.93^{j}	22.13±0.53^{g}	1.92± 0.10^{a}	0.47±0.02^{a}
	0.75	52.98±0.85^{e}	26.51±0.69^{k}	23.39±0.49^{h}	2.05± 0.06^{a}	0.48±0.02^{a}
	0.8	51.83±0.03^{f}	27.63±0.11^{l}	24.75±0.07^{i}	2.15± 0.04^{a}	0.48±0.03^{a}
B100	0.7	49.86±0.88^{g}	34.78±0.84^{m}	22.71±0.87^{j}	2.17± 0.27^{a}	0.46±0.01^{a}
	0.75	48.53±1.38^{h}	35.97±0.42^{n}	24.34±0.59^{k}	2.35± 0.26^{a}	0.48±0.03^{a}
	0.8	47.91±0.01^{i}	37.11±0.04^{o}	26.16±0.08^{l}	2.46± 0.05^{b}	0.48±0.03^{a}

Data are presented as mean s± SEM (n=6).

$^{a-o}$ Means within rows with different lowercase superscript are significantly (p<0.05) different from 100% goat milk cheese with made from 0.7 casein fat ratio.

Table 3: ANOVA table for the physico-chemical properties of cheese

	Source	DF	Type III SS	Mean Square	F Value	Pr > F	CD value
Moisture	Milk	5	620.8900185	124.1780037	45.58	<.0001	1.92
	Cfratio	2	97.9317630	48.9658815	17.97	<.0001	2.78
	Milk*Cfratio	10	5.0009037	0.5000904	0.18	0.9971	1.72
Fat	Milk	5	3233.623363	646.724673	422.18	<.0001	1.43
	Cfratio	2	81.898541	40.949270	26.73	<.0001	2.08
	Milk*Cfratio	10	1.385859	0.138586	0.09	0.9999	1.29
Protein	Milk	5	228.2181407	45.6436281	16.87	<.0001	1.91
	Cfratio	2	147.1549574	73.5774787	27.20	<.0001	2.77
	Milk*Cfratio	10	2.8797426	0.2879743	0.11	0.9997	1.72
Ash	Milk	5	1.81921574	0.36384315	5.11	0.0004	0.31
	Cfratio	2	1.02245185	0.51122593	7.19	0.0013	0.44
	Milk*Cfratio	10	0.05829259	0.00582926	0.08	0.9999	0.27
Acidity	Milk	5	0.02605278	0.00521056	1.94	0.0004	0.095
	Cfratio	2	0.00087222	0.00043611	0.16	0.0013	0.850
	Milk*Cfratio	10	0.00315000	0.00031500	0.12	0.9999	0.999

Texture profile analysis of cheese

Hardness of cheese samples increased significantly (P<0.05) within the increase casein fat ratio and also with the increase in buffalo milk concentration. In this case factors like milk and C/F ratio and their interaction, all of them are affected the hardness significantly (P<.0001) as shown in table 4 and 5. The joint action of protein and fat reduction, caused by the goat milk, kept the cheese's hardness low. In this case, lower values of hardness, produced by the lower concentration of proteins, possibly were balanced by the lower amount of fat that caused higher resistance to deformation, an antagonistic effect (Lobato *et al.*, 1998) [17]. Goat milk also having a lower amount of αs_1-casein which gives a softer texture in cheese so increase in casein content might improve the hardness of cheese. There might be the small fat globules in goat milk, bringing a homogenization effect on curd tension which gives a softer textured cheese with lower hardness (Devendra, 1980) [4]. Adhesiveness also increased significantly ($P<0.05$), when casein fat ratio of cheese milk increased and also buffalo milk concentration effected positively towards the adhesiveness of the cheese, all the other parameters like cohesiveness, springiness, gumminess increased in a significant manner and the factors milk, C/F ratio and interaction of them affected significantly, interaction factor did not affected adhesiveness and springiness. The results are indicating that the increase in this properties happened may be due to the interaction casein micelles of buffalo milk with goat milk casein and also the increase in casein fat ratio improved this typical cheese characteristics. Chewiness of the cheese improved quite extraordinarily, where all the factors contributed significantly. Chewiness may be increased with decreasing moisture content. Increased moisture allows for more flexibility of the protein matrix (Luyten, 1988) [18]. Cutting strength also improved for the contribution of both factors C/F ratio and goat -buffalo milk proportion. For each variety of cheese milk cutting strength improved significantly but interaction factor was not affected the cutting strength of cheese. That phenomenon might be happened due to decrease in moisture content of the cheese and increase in casein/fat ratio. Also the interaction of buffalo milk casein with goat milk casein gave it a firm structure and improved the cutting strength, a visible smooth cut has also been observed in the cheeses.

Table 4: Changes in textural properties due to different casein fat ratio of cheese milk

Milk	CF Ratio	Hardness (N)	Adhesiveness	Springiness (mm)	Cohesiveness	Gumminess (N)	Chewiness (N. mm)	Cutting Strength (N)
G100	0.7	34.07± 0.17^{a}	-1.04± 0.01^{a}	10.32± 0.21^{a}	0.14± 0.03^{a}	5.09± 0.13^{a}	52.43± 1.06^{a}	1.18± 0.01^{a}
	0.75	40.13± 0.39^{b}	-1.13± 0.01^{a}	12.74± 0.25^{b}	0.16± 0.02^{a}	6.75± 0.11^{a}	86.05± 1.76^{a}	1.35± 0.08^{b}
	0.8	45.41± 0.18^{c}	-1.35± 0.01^{a}	14.91± 0.01^{c}	0.31± 0.09^{b}	14.42± 0.40^{b}	215.15± 6.19^{b}	1.57± 0.02^{c}
GB7030	0.7	40.60± 0.49^{a}	-1.21± 0.04^{a}	11.14± 0.54^{a}	0.18± 0.01^{a}	7.43± 0.60^{a}	83.18± 8.18^{a}	1.32± 0.02^{a}
	0.75	46.95± 0.60^{b}	-1.57± 0.12^{a}	13.38± 0.77^{b}	0.36± 0.03^{b}	17.10± 1.57^{b}	230.80± 24.50^{b}	1.53± 0.02^{b}
	0.8	54.73± 0.09^{c}	-1.83± 0.01^{b}	16.18± 0.06^{c}	0.46± 0.07^{c}	25.32± 0.41^{c}	409.93± 6.65^{c}	1.76± 0.01^{c}
GB6040	0.7	45.00± 0.71^{a}	-1.70± 0.08^{a}	12.02± 0.46^{a}	0.25± 0.02^{a}	11.61± 1.05^{a}	139.08± 12.48^{a}	1.40± 0.03^{a}
	0.75	51.39± 0.48^{b}	-2.28± 0.19^{b}	14.59± 0.39^{b}	0.47± 0.03^{b}	24.33± 1.88^{b}	355.01± 31.11^{b}	1.59± 0.02^{b}
	0.8	58.80± 0.15^{c}	-2.45± 0.05^{c}	16.55± 0.02^{c}	0.55± 0.05^{c}	32.46± 0.30^{c}	537.47± 4.98^{c}	1.77± 0.02^{c}
GB5050	0.7	51.89± 0.88^{a}	-2.10± 0.10^{a}	12.91± 0.40^{a}	0.36± 0.01^{a}	18.71± 0.87^{a}	242.74± 15.65^{a}	1.53± 0.03^{a}
	0.75	54.02± 0.68^{a}	-2.49± 0.18^{a}	14.18± 0.37^{a}	0.49± 0.03^{b}	26.58± 2.00^{b}	377.60± 29.73^{b}	1.71± 0.03^{b}
	0.8	59.90± 0.48^{b}	-2.82± 0.02^{b}	16.88± 0.01^{b}	0.63± 0.09^{c}	38.25± 0.68^{c}	645.87± 11.61^{c}	1.89± 0.01^{c}
GB4060	0.7	54.30± 0.62^{a}	-2.48± 0.17^{a}	13.21± 0.46^{a}	0.41± 0.02^{a}	22.33± 1.44^{a}	299.21± 27.55^{a}	1.65± 0.02^{a}
	0.75	57.26± 0.62^{b}	-2.51± 0.17^{a}	16.12± 0.89^{b}	0.54± 0.02^{b}	31.26± 1.25^{b}	504.68± 32.43^{b}	1.82± 0.02^{b}
	0.8	61.95± 0.05^{c}	-2.85± 0.01^{a}	17.05± 0.02^{c}	0.69± 0.08^{c}	42.91± 0.54^{c}	731.76± 9.43^{c}	1.98± 0.01^{c}
B100	0.7	60.31± 0.67^{a}	-2.56± 0.19^{a}	14.12± 0.59^{a}	0.65± 0.02^{a}	39.41± 1.74^{a}	558.03± 35.51^{a}	1.85± 0.03^{a}
	0.75	64.12± 0.40^{b}	-2.75± 0.05^{a}	16.02± 0.68^{b}	0.81± 0.03^{b}	52.12± 2.41^{b}	835.79± 56.81^{b}	2.05± 0.03^{b}
	0.8	67.76± 0.73^{c}	-3.34± 0.04^{b}	18.97± 0.09^{c}	0.93± 0.01^{c}	60.65± 1.26^{c}	1150.68± 23.27^{c}	2.22± 0.01^{c}

Data are presented as means ± SEM (n=6).

$^{a-c}$ Means within rows with different lowercase superscript are significantly ($p<0.05$) different from 0.7 casein fat ratio for each variety of milk

Table 5: ANOVA table for the texture profile analysis of cheese

	Source	DF	Type III SS	Mean Square	F Value	Pr > F	CD value
Hardness	Milk	5	10665.52625	2133.10525	758.92	<.0001	1.95
	Cfratio	2	3255.96741	1627.98370	579.21	<.0001	2.82
	Milk*Cfratio	10	262.71003	26.27100	9.35	<.0001	1.75
Adhesiveness	Milk	5	65.62370400	13.12474080	109.84	<.0001	0.40
	Cfratio	2	10.45272363	5.22636182	43.74	<.0001	0.58
	Milk*Cfratio	10	1.73310457	0.17331046	1.45	0.1628	0.36
Springiness	Milk	5	261.2487954	52.2497591	26.65	<.0001	1.62
	Cfratio	2	599.1741780	299.5870890	152.78	<.0001	2.36
	Milk*Cfratio	10	18.7933935	1.8793394	0.96	0.4819	1.46
Cohesiveness	Milk	5	6.06643187	1.21328637	244.31	<.0001	0.081
	Cfratio	2	2.08768170	1.04384085	210.19	<.0001	0.118
	Milk*Cfratio	10	0.12734543	0.01273454	2.56	0.0066	0.073
Gumminess	Milk	5	31417.65048	6283.53010	408.49	<.0001	4.56
	Cfratio	2	9979.85751	4989.92875	324.39	<.0001	6.61
	Milk*Cfratio	10	675.80119	67.58012	4.39	<.0001	4.10
Chewiness	Milk	5	9617355.611	1923471.122	342.85	<.0001	87.13
	Cfratio	2	4493305.418	2246652.709	400.46	<.0001	126.27
	Milk*Cfratio	10	522215.288	52221.529	9.31	<.0001	78.35
Cutting strength	Milk	5	8.27379333	1.65475867	230.86	<.0001	0.098
	Cfratio	2	4.23091000	2.11545500	295.13	<.0001	0.142
	Milk*Cfratio	10	0.04493667	0.00449367	0.63	0.7893	0.088

SDS PAGE analysis of electrophoretic behavior of fresh cheese due to incorporation of buffalo milk in goat milk

In cheese this technique is applied for the resolution of proteins and peptides that are present native form and also the behavior of peptides during ripening. PAGE is widely used to monitor primary proteolysis in cheese and is mostly related to the activities of residual coagulant and plasmin. αs_1-casein is hydrolyzed faster than β-casein in cheese by all commercial coagulants (McSweeny *et al*., 1993) [20].

The SDS PAGE electrophoresis pattern obtained for goat, buffalo and mixed milk cheese with a casein fat ratio of 0.8 showed the presence of lesser amount of αs_1-casein in goat

milk. It indicated that goat milk was having negligible amount of αs_1-casein and it remained same upto 30% buffalo milk addition. At 40% buffalo milk addition resolution of αs_1-casein band became more prominent. It can be correlated with significant increase in protein content in cheese milk and therefore improvement in hardness, cutting strength, chewiness and other textural parameters; β-casein bands are more prominent in cheese samples containing buffalo milk at higher concentration if compared to pure goat milk cheese. At 67 kDa bovine serum albumin (BSA) bands are also present though with lower resolution in cheese containing 40% or above buffalo milk.
(Plate 1)

Conclusion
Quality of cheese made from goat milk was improved by substituting it with buffalo milk in cheese milk. The textural properties of the resultant cheese were improved significantly. With the increase in casein to fat ratio of cheese milk the fat and protein recovery of cheeses were improved significantly. Adjusting casein to fat ratio at 0.8 in cheese milk was observed to have better textural and compositional properties in terms of fat recovery and protein content. Electrophoretic pattern of cheeses were also confirmed that with the increase in buffalo milk concentration the proportion of αs1-casein also increased, which exhibited better coagulation and gelation properties in during renneting and other unit operations involved in cheese manufacture. Improvement in textural and composiotional parameters were more pronounced above 40% buffalo milk addition.

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