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The effect of temperature and cutting time on curd yield and quality made from goat, buffalo and cow milk

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For the present study, two species of lactating animals, that is, Bubalusbubalis (Buffalo) and Bosindicus (Cow) was selected. In both types of milk, highest curd yield at 34°C was obtained at 60 min of cutting time after the addition of rennet followed by 39°C at 60 min of cutting time while at 28°C and 60 min of cutting time the yield was low and cutting times. This may be due to the improper rearrangements of casein network and the minimum curd fat retention level. The % total solids of curd were maximum at 28°C and at 60 min of cutting time may be due to the lower fat losses in whey and %TS were lower at 34°C when the cutting time was 90 min after the rennet addition because of the higher moisture content retention in the casein network due to the elongation in the protein network rearrangement time. The whey fat losses and curd fat retention values were minimized and maximized, respectively, between 28 and 39°C. The whey fat losses (*WFL)* and curd fat retention (*CFR)* were minimum at 28°C and maximum at 39°C. Increasing cutting time at 28°C results in firm gel with a good capability of fat retention and will decrease fat losses in whey. However, at temperature more than 30°C, coarsening of the milk gel occurs more rapidly, permeability of the gel is greater and the microsyneresis can occur at longer aging times. All these factors decreased the ability of the curd to retain fat. These results showed that the retention of fat is dependent on relative rigidity and structure of network at cutting. Below 28°C, there will be less gel firmness before cutting, therefore, increase in temperature will increase the rate of curd firming at best gel will be formed at 35°C. Above 35°C, the network becomes more rigid, rapid coarsening occur and the gel is more porous and all these assists the release of fat in whey and also the fat has high mobility at higher temperature which results in increase fat losses.

Key word: Gelation temperature, optimum cutting time, curd yield and quality.

INTRODUCTION

The ratio of fat and protein is higher up to 40 to 60% in buffalo and goat milk as compared to cows' milk. The ash percentage was also found to be greater in buffalo and goat milk. It may be due to the high concentration of calcium bound to casein protein and different buffering capacity of both milk types. Due to the composition of

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buffalo and goat milk (higher solids), it is expected that they would give a higher curd yield than cows' milk (Hussain et al., 2011). The goat milk are higher in some free amino acids contents like taurine which is upto 9 mg/100 ml and plays an important role in cerebral, vision, cardiac function, detoxification and fatty acids accumulation . The calcium, phosphorus and magnesium content between soluble and colloidal phases of goat, cow and sheep milks are similar. It is considered that iron bioavailability is higher in goat milk than cows' milk due to the higher nucleotide content which contributes to better absorption in the intestines. Extensive studies have been carried out on cows' milk due to higher commercial production. The current increase in consumers and the importance of dairy products from goats and buffalo milk have resulted in further more research on goat and buffalo milk processing and further value addition of milk products.

The development of controlled instability in milk leads to the formation of curd by destabilizing the protein especially the casein and is mainly done by two process, that is, by traditional method, in which selected strains of lactic acid bacteria are used which reduce the pH and cause the precipitation of casein around their isoelectric point and the other method in which rennet/chymosin are used which are proteolytic enzymes and produce coagulum in the presence of calcium, both methods development of instability leading to coagulum/curd formation. The proteinase enzymes like chymosin/rennet are the major coagulating enzymes which act on the active side of the casein micelles called Κ-casein which lies on the outer surface of casein and causes instability in the casein structure and the inner reactive regions to calcium appears and causes the proteins particles to aggregate and as the aggregation proceeds, three dimensional macroscopic network of casein micelles forms throughout the milk which convert the milk physically to a semi firm viscoelastic gel called curd. After a predetermined time the curd is cut into small pieces which promote the expulsion of the containing water, lactose, small ion and some whey soluble proteins by the rearrangements of proteins called syneresis. Curd is cut after a specific period of time of enzymatic reaction which depends on operator judgment and on immanent assessment of textural and visual properties of curd. Delaying in cutting time results in higher moisture content in cheese due to higher firmness and retarded syneresis and too early cutting will result in low yield of final cheese product due to the losses of fat and curd particles in whey (Payne et al., 1998). These causes suggest the grandness of an objective method for best possible cutting time determination in cheese making. Determination of the most favorable cutting time is more important for the small and less automated cheese plants usual for goat cheese production, because of the large integrative variation between milk batches and the large variation in coagulation process.

The gelation/incubation temperature is an important parameter and has a great effect on the yield and quality of curd. Chymosin activity is highly dependent and sensitive to temperature. More proteolysis and super imposition of thermal effects occur at higher gelation temperatures. The curd moisture is affected by temperature, fat and protein percentage. Gelation temperature affects the contraction of gel matrix and the yield of curd. The yield, quality, curd moisture, and whey fat losses are affected by cutting times and lengthen the cutting time produces an overly firmness in curd, in which the network fails to rearrange, which thus increases curd moisture content and shattering of resultant curd will increase and cause more losses of fat and protein in whey (Castilloa et al., 2006).

The objectives of this study is to determine the upshot of different gelation/incubation temperatures and cutting times at constant pH on curd yield and quality and to conclude curd moisture, fat losses in whey and fat retention capability of curd at different incubation temperatures and cutting times.

MATERIALS AND METHODS

Animal selection

For the present study, three species of lactating animals, that is, Bubalusbubalis (Buffalo), Bosindicus (Cow) were selected in Dairy Training and Research Center and Capra hircus (Goat) was selected in Small Ruminant Training and Research Center, University of Veterinary and Animal Sciences Lahore, Ravi campus, Pattoki. The animals were free from disease indicating healthy conditions. Fresh milk samples from each animal were collected in plastic bottles after complete milking and proper mixing at morning time and transported to post graduate laboratory, Department of Dairy Technology, Ravi Campus Pattoki, UVAS.

Experimental design

The research experiment consisted of three phases, that is, phase-1, phase-2 and phase-3. All the experiments were performed in triplicate.

Phase-1

In Phase-1, milk normal composition was analyzed by Milkoscane, (WTO/Admin/DSR/04) present in the Quality Operational Laboratory, University of Veterinary and Animal Science Lahore. Milk samples from each milk type were transported in falcon tubes in thermo-flask containing ice pieces to the Quality Operational Laboratory. Each sample was analyzed in triplicate to avoid the chances of error. The Milkoscane results consisted of fat%, SNF%, density kg/m^3, lactose%, ash%, protein% and pH of milk. The samples were also analyzed by manual method for fat% and total solids.

Fat determination: Fat was determined by Gerber method, in which 10 ml 98% pure sulfuric acid is taken in butyrometer and 10.94 ml of milk sample is added at an angle so that the milk do not touch the sulfuric acid directly. Then 1 ml amyl alcohl is added to it. The sulfuric acid dissolves all the components other than fat. The amyl alcohol is used for the phase separation. After proper mixing of

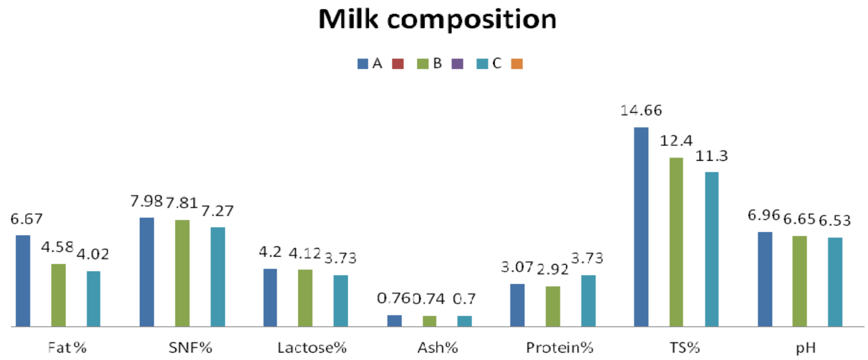

Figure 1. Comparison of three types of milk. A Buffalo milk; B, cows' milk; C, goat milk.

Table 1. Treatment phase

Sample No.	Sample weight (g)	Temperature (°C)	Chymosin (g)	Cutting time minutes
S. 1 (W)	300	28	0.06	30
S. 2 (X)	300	28	0.06	45
S. 3 (Y)	300	28	0.06	60
S. 4 (Z)	300	28	0.06	95

these reagents, centrifugation is done for five minutes at 1100 rpm. The fat is calculated in percentage.

Total solids determination: For total solids determination by manual method, empty, clean and dry crucible is weighed and then upto 5 gm sample is taken and kept at 102°C for overnight. The crucible is weight along with sample and the total solids are determined by the following formula:

% TS= (S+C) /Sample weight * 100
(S+C) = sample plus crucible weight after drying,
Sample weight= sample weight before drying

Phase-2 (Treatment phase)

Milk samples each of 300 ml were weight and pasteurized at 65°C for 30 min in a control water bath and then allowed to cool to 28°C. Each milk sample was treated separately, that is, first buffalo, then cows' and in the last goat milk was treated and analyzed. The milk samples were placed at gelation temperature of 28, 34 and 39°C in a temperature control water bath for 30, 45, 60 and 90 min. Chymosin/Rennet at 0.02% was added to the milk samples and the samples were thoroughly mixed and incubated as shown in Table 1.
The same procedure was repeated for 34 and 39°C. After the calculated time of chymosin addition, the curd was cut into10 to 12 mm or 1cm size pieces, using a specially designed laboratory scale curd cutter. Curd sample was healed at similar Gelation temperature for 10 min and then the samples were centrifuged by a centrifuge (Agilent series 1100) present in the Quality Operational Laboratory, University of Veterinary and Animal Sciences Lahore, to separate whey and curd and weight on electric balanc e and stored at freezing temperature for further analysis.

Phase-3 (Post treatment)

In phase-3, the physico-chemical parameters like fat, protein and total solids of curd and rennet whey were determined by manual methods and also by Milkoscane. The curd fat level was measured by Gerber method and the protein was determined by the formal titration method. Total solids were measured by taking accurately weighed up to 5 gm from each sample of different gelation temperatures in a clean dry crucible and were placed in hot air oven at 102°C over night. The curd was analyzed for yield on wet and dry bases, total whey fat losses and total fat retention by the formulas as follow:

Total whey fat losses in grams, WFL= (M-C) / 100 * F_w
Curd Yield on wet basis, % CY_{wb} = C / M *100
Curd yield on dry basis, % CY_{db}= (C*TS_c/ M*TS_m) *100
Curd fat retention, % CFR= (M*F_m –W*F_w) / M*F_m *100

C= Curd weight in grams, M=Milk weight in grams, W=Whey weight in grams, F_m=% milk fat, F_w= % whey fat, TS_c=curd % total solids, TS_m= Milk % total solids, *=Multiplication.

Statistical analysis

Data was statistically analyzed by applying two way analysis of variance (ANOVA) at a significant level of P<0. 05. The effect of different gelation temperatures and cutting times on curd yield, curd moisture, whey fat losses and casein fractions of the curd made from three different milk types and the mean will be calculated by Duncan Multiple Range Test (DMR).

RESULTS AND DISCUSSION

The curd was prepared from buffalo, cows' and goat milk. The milk samples were analyzed for its chemical composition such as total protein, fat, lactose, ash, total solids and pH before using for curd preparation. The milk curd was analyzed for physicochemical composition like

Table 2. Curd total solids, curd moisture, curd ash, whey total solids and whey ash of three experiments of Buffalo milk.

Samples	Curd %TS	Curd %moisture	Curd %Ash	Whey %TS	Whey %Ash
WA	54.46^{a}±2.69	45.54^{a}±2.69	3.08^{a}±0.08	8.03^{a}±0.24	0.74^{a}±0.01
XA	50.7^{b}±0.67	49.30^{b}±0.66	3.68^{c}±0.12	7.18^{b}±0.03	0.59^{b}±0.01
YA	69.08^{c}±2.22	30.92^{c}±2.22	3.22^{b}±0.05	7.59^{c}±0.046	0.68^{a}±0.02
ZA	54.55^{a}±1.13	45.45^{a}±1.12	3.6^{c}±0.15	7.23^{b}±0.65	0.7^{a}±0.005
WB	59.94^{d}±0.55	40.06^{d}±0.55	3.60^{c}±0.02	7.55^{c}±0.11	0.66^{a}±0.01
XB	58.80^{d}±0.64	41.20^{d}±0.64	3.50^{d}±0.01	7.56^{c}±0.01	0.76^{a}±0.02
YB	56.95^{a}±1.79	43.05^{a}±1.79	4.02^{e}±0.05	7.54^{c}±0.6	0.65^{a}±0.01
ZB	60.44^{d}±0.67	39.56^{d}±0.67	3.45^{d}±0.04	7.75^{c}±0.15	0.65^{a}±0.01
WC	60.04^{d}±0.55	39.96^{d}±0.55	4.50^{d}±0.04	7.21^{b}±0.46	0.59^{b}±0.02
XC	58.80^{d}±0.2	41.57^{d}±0.2	4.0^{e}7±0.03	6.65^{c}±0.06	0.6^{b}±0.01
YC	63.79^{e}±0.65	36.21^{e}±0.66	3.45^{d}±0.05	6.51^{c}±0.42	0.61^{b}±0.02
ZC	61.87^{e}±0.69	38.13^{e}±0.69	4.53^{d}±0.04	7.04^{b}±0.07	0.61^{b}±0.03

Means with different letter in a column are statistically different (P<0.05); **A, B, C**: 28, 34 and 39°C, respectively.

Table 3. Overall whey analysis buffalo milk.

Samples	%Fat	%SNF	%Lactose	%Ash	%protein	pH
WA	0.01^{a}±0.001	8.01^{a}±0.02	4.28^{a}±0.01	0.73^{a}±0.01	2.97^{a}±0.01	4.89^{a}±0.02
XA	0.06^{a}±0.01	4.15^{b}±0.05	2.2^{b}±0.01	0.36^{b}±0..02	1.56^{b}±0.03	4.92^{a}±0.03
YA	0.03^{a}±0.001	7.45^{a}±0.03	3.99^{a}±0.02	0.68^{a}±0.03	2.76^{a}±0.04	7.05^{b}±0.05
ZA	0.05^{a}±0.01	7.80^{a}±0.03	4.16^{a}±0.03	0.72^{a}±0.03	2.88^{a}±0.03	4.79^{a}±0.01
WB	0.14^{b}±0.01	5.56^{b}±2.86	3.84^{a}±0.03	0.65^{a}±0.01	2.66^{a}±0.01	5.42^{c}±0.03
XB	0.19^{b}±0.01	7.21^{a}±0.02	3.88^{a}±0.01	0.66^{a}±0.01	2.66^{a}±0.02	5.26^{c}±0.04
YB	0.25^{b}±0.02	7.21^{a}±0.02	3.84^{a}±0.01	0.66^{a}±0.01	2.65^{a}±0.02	5.15^{c}±0.05
ZB	0.26^{b}±0.01	7.19^{a}±0.01	3.82^{a}±0.01	0.65^{a}±0.01	2.66^{a}±0.03	5.8^{c}±0.03
XC	0.29^{b}±0.01	6.45^{c}±0.01	3.45^{a}±0.01	0.59^{a}±0.02	3.4^{a}±0.01	5.08^{a}±0.05
WC	0.15^{b}±0.02	6.47^{c}±0.03	3.44^{a}±0.01	0.61^{a}±0.02	2.4^{a}±0.01	5.05^{a}±0.07
YC	0.25^{b}±0.02	7.21^{a}±0.02	3.49^{a}±0.02	0.6^{a}±0.01	2.44^{a}±0.02	5.14^{a}±0.01
ZC	0.55^{c}±0.03	6.58^{c}±0.02	3.49^{a}±0.01	0.6^{a}±0.01	2.4^{a}±0.02	5.13^{a}±0.04

Means with different letter in a column are statistically different (P<0.05); A: B: C: 28, 34 and 39°C, respectively. W: X: Y: Z: Sample No. 1, 2, 3 and 4, respectively.

curd yield, whey yield, curd total solids, curd ash, and the physic-chemical composition such as protein, fat, lactose, ash, total solids and pH of whey was analyzed. The results of normal composition of milk and curd formation from three types of milk are discussed in detail in the study.

Physicochemical composition of milk

The composition of milk is not absolute as many factors influence the end product. These variations in milk composition can be related to genetics, environment, milk production, stage of lactation, species, disease, season, locality and age of the animal. Milk components, that is, protein and fat are the primary factors influencing the product quality and yield of the cheese, composition and characteristics. Fresh cows' and buffalo milk samples were procured from disease free animals for curd production. The results regarding the chemical composition of milk samples were shown in Table 2 to 4. The total solids content of buffalo milk were found to be higher when compared with cows' milk. This finding is fully agreement with the results of Hussain et al. (2011). The total protein, fat, and ash contents were found to be higher and significantly different than cows' milk. While fat and lactose contents were observed non-significantly different in both types of milk. The pH of all buffalo and cows' milk samples were found in the range of 6.63- 6.93 and 6.63 to 6.70 respectively (Table 2). These results were agreement with the previous studies of Hussain et al. (2011) and Ahmad et al. (2010).

Buffalo milk curd analysis

In buffalo milk, highest curd yield at 34°C was obtained at

Table 4. Buffalo milk curd and whey composition analysis.

Samples	WFL (g)	%CY_{wb}	%CY_{db}	%CFR
WA	0.025	15.837	61.596	99.8
XA	0.17	16.53	59.86	99
YA	0.73	18.83	92.91	99.5
ZA	0.13	20.3	79.11	99.2
WB	0.14	16.94	67.93	99.8
XB	0.46	18.70	73.53	97.93
YB	0.16	19.66	74.68	96.36
ZB	0.64	18.35	74.17	96.15
WC	0.38	17.39	77.79	97.69
XC	0.72	17.95	78.14	95.55
YC	1.36	18.31	74.17	96.15
ZC	1.4	16.18	75.61	91.5

WFL, Whey fat losses; CY_{wb}, Curd yield on wet bases; CY_{db}, curd yield on dry bases; CFR, Curd fat retention; A: B: C, 28, 34 and 39°C, respectively; W: X: Y: Z, Sample No. 1, 2, 3 and 4, respectively.

60 min of cutting time after the addition of rennet followed by 39°C at 60 min of cutting time while at 28°C and 60 min of cutting time the yield was lower as compared to the above two temperatures and cutting times. This is possible because `beyond 35°C, the fat boils and losses occur in whey, so the yield will be decreased. The lowest yield was obtained at 34°C when the cutting time was 45 min after the rennet addition. This may be due to the improper rearrangements of casein network and the minimum curd fat retention level. The %total solids of curd were maximum at 28°C and at 60 min of cutting time may be due to the lower fat losses in whey and %TS were lower at 34°C when the cutting time was 90 min after the rennet addition. This is because of the higher moisture content retention in the casein network due to the elongation in the protein network rearrangement time. These result correlated with the studies of Hussain et al. (2011) which shows that dynamic moduli of the curd is directly related with the gelation temperatures and at 28°C the curd yield was lower than 34 and 39°C. Their results also show that at 34°C curd has better moisture retention and less structural breakage. The whey fat losses and curd fat retention values were minimized and maximized, respectively, between 28 and 39°C which were selected for the research study.

This study shows that the best temperature for the formation of Mozzarella type cheese and other type cheese made from cow milk is 34°C which is better for the gel firmness, curd fat retention, optimum moisture content and final product yield and quality.

The whey fat losses *WFL* and curd fat retention *CFR* were minimum at 28°C and maximum at 39°C. At temperature below 28°C, the gel will be weak when cut. Therefore, increasing cutting time at 28°C results in firm gel with a good capability of fat retention and will decrease fat losses in whey. However, at temperature more than 30°C, coarsening of the milk gel occurs more rapidly, permeability of the gel is greater and the microsyneresis can occur at longer aging times. All these factors decrease the ability of the curd to retain fat. These results were broad supported by the studies of Fagan et al. (2007). Their results show that the retention of fat is dependent on relative rigidity and structure of network at cutting. At temperature below 28°C, there will be less gel firmness before cutting, therefore, increase in temperature will increase the rate of curd firming at best gel will be formed at 35°C. Above 35°C, the network becomes more rigid, rapid coarsening occur and the gel is more porous and all these assists the release of fat in whey and also the fat has high mobility at higher temperature which results in increase fat losses.

Cow milk curd analysis

The cow milk analysis show less difference as compared to buffalo milk. It may be due to the little difference in the total solids contents of both milks. The highest yield at gelation temperature of 28°C was obtained after 60 min of cutting the curd when the chymosin was added. This may be due to the proper rearrangements of casein matrix and the proper fat retention in the curd. At 34°C of gelation temperature, the yield was highest and at 39°C of gelation temperature the curd was also high at 60minutes of cutting time. These results show that the best cutting time for high yield of curd is 60 min after the addition of chymosin. The best yield was obtained at gelation temperature of 34°C. These results correlate with the results of Husain et al. (2011). The percent total solids were higher at 28°C and 90 min of temperature and time combination, followed by 34°C and 60 min and the lower at 39°C and 45 min of temperature and time combination, respectively. The whey fat losses were lower at 28, 34 and 39°C with the time relation of 30, 60

Table 5. Overall analysis of curd total solids, curd moisture, curd ash, whey total solids and whey ash of cow milk experiments.

Samples	Curd %TS	Curd %moisture	Curd %Ash	Whey %TS	Whey %Ash
WA	$61.05^a±0.68$	$38.95^a±0.68$	$3.4^a±0.01$	$7.36^a±0.12$	$0.65^a±0.01$
XA	$63.17^a±0.52$	$36.83^a±0.52$	$2.64^b±0.05$	$7.38^a±0.01$	$0.51^b±0.01$
YA	$66.28^b±0.85$	$33.71^b±0.85$	$3.04^c±0.05$	$7.31^a±0.04$	$0.6^a±0.02$
ZA	$66.90^b±0.03$	$33.10^b±0.03$	$3.11^a±0.04$	$7.41^a±0.03$	$0.49^b±0.01$
WB	$46.85^c±0.71$	$53.13^c±0.73$	$3.24^a±0.04$	$7.42^a±0.06$	$0.65^a±0.01$
XB	$48.52^d±0.55$	$51.48^d±0.56$	$2.69^b±0.03$	$7.47^a±0.04$	$0.65^a±0.02$
YB	$64.7^a±0.88$	$35.3^a±0.88$	$2.62^b±0.03$	$7.47^a±0.05$	$0.63^a±0.01$
ZB	$63.51^a±0.76$	$36.49^a±0.76$	$2.77^b±0.06$	$7.56^a±0.15$	$0.33^c±0.01$
WC	$61.4^a±1.22$	$38.58^a±1.22$	$3.19^a±0.45$	$6.84^b±0.02$	$0.58^a±0.01$
XC	$63.52^a±0.71$	$36.48^a±0.71$	$4.05^d±0.63$	$6.81^b±0.12$	$0.57^a±0.02$
YC	$62.2^a±0.42$	$37.79^a±0.42$	$4.04^d±0.05$	$7.06^c±0.1$	$0.59^a±0.01$
ZC	$61.36^a±0.28$	$38.64^a±0.28$	$4.71^d±0.16$	$7.25^a±0.05$	$0.59^a±0.01$

Means with different letter in a column are statistically different (P<0.05); A: B: C, 28, 34 and 39°C, respectively; W: X: Y: Z, Sample No. 1, 2, 3 and 4, respectively.

Table 6. Whey Analysis of three experiments of cow milk.

Samples	%Fat	%SNF	%Lactose	%Ash	%protein	pH
WA	$0.05^a±0.05$	$7.05^a±0.02$	$3.74^a±0.04$	$0.64^a±0.01$	$2.05^a±0.04$	$6.75^a±0.05$
XA	$0.12^b±0.02$	$5.64^b±0.03$	$3.01^b±0.03$	$0.52^b±0.02$	$2.07^a±0.01$	$6.71^a±0.02$
YA	$0.08^a±0.02$	$6.58^c±0.02$	$3.37^a±0.31$	$0.60^a±0.02$	$2.61^b±0.02$	$6.70^a±0.04$
ZA	$0.15^b±0.02$	$5.36^b±0.03$	$2.83^b±0.03$	$0.50^b±0.03$	$2.00^a±0.03$	$6.69^a±0.01$
WB	$0.03^a±0.04$	$7.08^a±0.02$	$3.77^a±0.02$	$0.66^a±0.01$	$2.64^b±0.03$	$6.68^a±0.02$
XB	$0.06^a±0.03$	$6.98^a±0.03$	$3.67^a±0.04$	$0.63^a±0.02$	$2.58^b±0.02$	$6.70^a±0.03$
YB	$0.01^a±0.01$	$6.90^a±0.02$	$3.66^a±0.01$	$0.64^a±0.02$	$2.54^b±0.02$	$6.70^a±0.01$
ZB	$0.21^c±0.02$	$3.49^d±0.02$	$1.85^c±0.02$	$0.32^c±0.01$	$1.30^c±0.01$	$6.81^a±0.04$
WC	$0.15^b±0.02$	$6.40^a±0.02$	$3.40^a±0.01$	$0.58^a±0.01$	$2.36^b±0.01$	$6.62^a±0.04$
XC	$0.01^a±0.02$	$6.20^a±0.02$	$3.29^a±0.01$	$0.56^b±0.01$	$2.90^d±0.2$	$6.70^a±0.01$
YC	$0.37^d±0.04$	$6.45^a±0.02$	$3.39^a±0.02$	$0.59^a±0.02$	$2.38^b±0.02$	$6.69^a±0.02$
ZC	$0.48^e±-.02$	$6.40^a±0.01$	$3.41^a±0.01$	$0.59^a±0.01$	$2.36^b±0.01$	$6.70^a±0.01$

Means with different letter in a column are statistically different (P<0.05); A: B: C, 28, 34 and 39°C, respectively. W: X: Y: Z: Sample No. 1, 2, 3 and 4, respectively.

and 45 min, respectively, after the cutting of curd while the fat losses were higher at 28, 34 and 39°C at 90 min after the cutting of curd. These results coincide with the results of Fagan et al. (2007) (Tables 5 to 7).

Goat milk curd analysis

The goat milk shows different results as compared to buffalo milk. It is because of the total solids content difference of both milks. The highest yield was obtained at 28°C at 45 min of cutting time, at 34°C the highest yield was at 90 min and at 39°C the highest yield was also at 90 min of cutting time. The whey fat losses at 28°C were higher and the yield was lower at this time and temperature combination while at 28°C and 45 min of cutting time the whey fat %age was lower and the curd yield was highest at this combination. At 34°C and 90 min of cutting time, the whey fat losses were lower and the curd yield was higher while at 39°C and 90 min of cutting time. The total solids percentage was higher at 28°C and 90 min of cutting time followed by 34°C and 90 min and in the last at 39°C at 90 min. It is possible that at 28°C, the curd moisture retention was lower so the total solids were higher, followed by 34°C and the highest moisture retention was at 39°C at 90 min of cutting time (Tables 9 to 10).

Conflict of Interest

The authors have not declared any conflict of interest.

Table 7. Cows' milk curd and whey composition analysis.

Samples	WFL (gm)	%CY_{wb}	%CY_{db}	%CFR
WA	0.13	15.43	69.72	99.13
XA	0.13	15.79	73.85	98.28
YA	0.20	16.95	83.17	98.64
ZA	0.38	16.19	80.16	97.43
WB	0.08	9.60	31.84	99.45
XB	0.16	13.58	46.52	98.95
YB	0.02	21.16	99.37	99.84
ZB	0.51	20.60	92.33	99.61
WC	0.38	16.07	81.63	96.94
XC	0.03	17.29	90.84	99.94
YC	0.95	15.60	80.27	92.40
ZC	1.23	15.36	77.97	90.12

WFL, Whey fat losses; CY_{wb}, Curd yield on wet bases; CY_{db}, curd yield on dry bases; CFR, Curd fat retention A: B: C, 28, 34 and 39°C, respectively; W: X: Y: Z, Sample No. 1, 2, 3 and 4, respectively.

Table 8. Curd total solids, curd moisture, curd ash, whey total solids and whey ash analysis of three goat milk experiments.

Samples	Curd %TS	Curd %moisture	Curd %Ash	Whey %TS	Whey %Ash
WA	62.53^{a}±0.27	37.47^{a}±0.26	4.95^{a}±0.22	6.34^{a}±0.05	0.57^{a}±0.02
XA	62.12^{a}±0.1	37.87^{a}±0.1	4.67^{b}±0.1	6.57^{a}±0.02	0.57^{a}±0.01
YA	61.86^{a}±0.54	38.13^{a}±0.54	5.52^{c}±0.06	6.5^{a}±0.08	0.59^{a}±0.01
ZA	66.77^{b}±0.76	33.22^{b}±0.77	4.95^{a}±0.18	6.66^{a}±0.06	0.50^{b}±0.01
WB	57.73^{c}±0.44	42.34^{c}±0.44	3.75^{d}±0.07	7.42^{b}±0.67	0.67^{c}±0.02
XB	54.86^{d}±0.33	45.14^{d}±0.3	3.95^{d}±0.06	7.68^{b}±0.04	0.63^{c}±0.01
YB	56.4^{c}±0.19	43.6^{c}±0.19	3.49^{d}±0.4	7.97^{c}±0.01	0.69^{c}±1.32
ZB	58.99^{c}±0.8	40.01^{c}±0.8	3.63^{d}±0.14	8.06^{c}±0.1	0.65^{c}±0.01
WC	54.98^{d}±0.83	45.01^{d}±0.83	3.81^{d}±0.07	7.60^{b}±0.2	0.41^{d}±0.02
XC	54.65^{d}±0.24	45.36^{d}±0.24	3.88^{d}±0.06	8.35^{d}±0.19	0.63^{c}±0.01
YC	56.67^{c}±1.32	45.33^{c}±4.15	7.71e±0.12	8.03^{d}±0.07	0.65^{c}±0.02
ZC	57.12^{c}±0.76	42.88^{c}±0.77	4.09^{d}±0.21	8.21^{d}±0.19	0.65^{c}±0.01

Means with different letter in a column are statistically different ($P<0.05$); **A: B: C**, 28, 34 and 39°C, respectively; **W: X: Y: Z**, sample No. 1, 2, 3 and 4, respectively.

Table 9. Whey analysis of experiment of goat milk.

Samples	%Fat	%SNF	%Lactose	%Ash	%protein	pH
WA	0.34^{a}±0.01	6.21^{a}±0.01	3.29^{a}±0.01	0.59^{a}±0.02	2.3^{a}±0.01	6.68^{a}±0.03
XA	0.24^{b}±0.01	6.2^{a}±0.01	3.3^{a}±0.02	0.57^{a}±0.03	2.29^{a}±0.02	6.72^{a}±0.08
YA	0.30^{a}±0.01	6.27^{a}±0.04	3.31^{a}±0.01	0.58^{a}±0.01	2.31^{a}±0.02	6.7^{a}±0.01
ZA	0.30^{a}±0.03	5.45^{b}±0.06	2.9^{b}±0.01	0.51^{b}±0.02	2.04^{a}±0.05	6.71^{a}±0.02
WB	0.12^{c}±0.01	7.29^{c}±0.01	3.9^{c}±0.01	0.67^{c}±0.02	2.7^{b}±0.02	6.29^{b}±0.04
XB	0.4^{d}±0.02	6.76^{a}±0.03	3.64^{a}±0.04	0.61^{a}±0.02	2.49^{c}±0.01	6.69^{a}±0.01
YB	0.27^{b}±0.01	7.45^{c}±0.03	3.98^{c}±0.02	0.69^{c}±0.01	2.76^{b}±0.01	6.69^{a}±0.01
ZB	0.35^{a}±0.02	7.19^{c}±0.02	3.84^{c}±0.02	0.66^{c}±0.02	2.66^{b}±0.02	6.71^{a}±0.01
WC	0.59e±0.02	4.41^{d}±0.02	2.4^{b}±0.02	0.4^{d}±0.01	1.62^{d}±0.02	6.67^{a}±0.03
XC	0.7f±0.02	6.83^{a}±0.02	3.65^{a}±0.01	0.64^{c}±0.01	2.53^{c}±0.02	6.69^{a}±0.01
YC	0.61g±0.03	7.02^{c}±0.05	3.71^{a}±0.05	0.68^{c}±0.03	2.76^{b}±0.01	6.69^{a}±0.01
ZC	0.83h±0.02	7.0^{c}±0.05	3.73^{a}±0.03	0.65^{c}±0.05	2.61^{b}±0.02	6.6^{a}±0.03

Means with different letter in a column are statistically different ($P<0.05$); **A: B: C**, 28, 34 and 39°C, respectively; **W: X: Y: Z**, Sample No. 1, 2, 3 and 4, respectively.

Table 10. Goat milk curd and whey composition analysis.

Samples	WFL (gm)	$\%CY_{wb}$	$\%CY_{db}$	%CFR
WA	0.90	12.38	63.75	92.26
XA	0.60	17.11	87.56	94.83
YA	0.80	12.41	63.25	93.17
ZA	0.77	15.50	85.24	93.42
WB	0.30	18.54	76.39	97.54
XB	1.01	16.81	65.70	91.70
YB	0.68	17.40	69.96	94.44
ZB	1.03	21.27	90.97	91.55
WC	1.46	18.44	71.99	88.15
XC	1.75	17.57	68.20	85.79
YC	1.50	18.97	76.34	87.83
ZC	2.01	20.30	82.37	83.71

WFL, Whey fat losses; CY_{wb}, Curd yield on wet bases; CY_{db}, curd yield on dry bases; CFR, Curd fat retention; A: B: C, 28, 34 and 39°C, respectively;W: X: Y: Z, Sample No. 1, 2, 3 and 4, respectively.

Conflict of Interest

The authors have not declared any conflict of interest.

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