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Evaluation of rheological and sensory characteristics of Mozzarella cheese prepared from blends of cow and buffalo milk

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Abstract
This research was carried out to find which blend of cow and buffalo milk was more suitable for the preparation of Mozzarella cheese with a good rheological properties and sensory characteristics. In this research Mozzarella cheese was prepared by admixing cow and buffalo milk in different proportions by direct acidification method. Cheese milk was acidified using hydrochloric acid. CHYMAX rennet was used to coagulate the cheese milk. Mozzarella cheese was stretched and molded in 95 °C water. The mean score of meltability of Mozzarella cheese of the treatments T_1, T_2, T_3 and T_4 was 8.75 cm, 9.91 cm, 10.95 cm and 12.22 cm, respectively. The average stretchability of Mozzarella cheese for the treatments T_1, T_2, T_3 and T_4 was 68.50 cm, 73.00 cm, 75.25 cm and 77.75 cm, respectively. The average scores for color and appearance of Mozzarella cheese obtained in this research for the treatments T_1, T_2, T_3 and T_4 are 7.00, 7.75, 8.00 and 7.75, respectively. The scores obtained for the flavour of Mozzarella cheese for the treatments T_1, T_2, T_3 and T_4 are 7.50, 7.75, 7.75 and 8.00, respectively. The mean score of taste of Mozzarella cheese for the treatment T_1, T_2, T_3 and T_4 obtained are 7.25, 7.25, 8.00 and 8.50, respectively. The mean scores obtained for the body and texture of Mozzarella cheese for the treatments T_1, T_2, T_3 and T_4 are 7.25, 7.75, 7.87 and 8.50, respectively. The average scores for the overall acceptability of Mozzarella cheese for the treatments T_1, T_2, T_3 and T_4 are 7.00, 7.25, 8.00 and 8.38, respectively. It was concluded that treatment T_4 which is a blend of 25% cow milk and 75% of buffalo milk produced a superior and more acceptable Mozzarella cheese as compared to the control Mozzarella cheese and other treatments.

Keywords: Mozzarella cheese, buffalo milk, cow milk, direct-acidification, meltability, stretchability

Introduction
Mozzarella cheese is usually round or pear-shaped and when cut open, it has a slightly juicy, milky appearance and a bland, slightly acid flavour and is prized cheese for its stretchability. The name "Mozzarella" originates from the Neapolitan dialect term "mozza" or "mozzare," which means "to cut" or "to sever," reflecting the technique used in its production in Campania, Italy. Differences in levels of fat, and hence protein fat ratio, that occur in milks used for the manufacture of low-fat and full-fat cheeses have marked influences on composition, yield, rheology, flavour, and sensory characteristics of cheese (Guinee *et al*. 2002) [6]. For Mozzarella cheese, buffalo milk is favoured due to its high fat, vitamin A, calcium, and low cholesterol content. Rheological properties (meltability and stretchiness), oil-free production and browning are the chief functional attributes of Mozzarella cheese which are greatly reliant on the basic formation and composition of the cheese Buffalo milk is reported to yield Mozzarella cheese with excellent stretchability, melting characteristics and a piquant aroma (Scott, 1986) [11]. Preparation and quality assessment of Mozzarella cheese from two different milk sources can improve dairy industries to select the milk that may be the best for producing Mozzarella cheese (Bhat *et al.* 2022) [2].

Materials and Methods
Cow milk (3.5% fat) was mixed with buffalo milk (6.0% fat) in different ratios for Mozzarella cheese preparation as given below in Table no: 1.

Table 1: Admixtures of milk for all the treatments

Sr. no.	Cow milk	Buffalo milk
T_1	Cow milk 100% (Control)	Buffalo milk 00%
T_2	Cow milk 75%	Buffalo milk 25%
T_3	Cow milk 50%	Buffalo milk 50%
T_4	Cow milk 25%	Buffalo milk 75%

The cheese milk was acidified by adding 2% hydrochloric acid and heated up to 37 °C followed by addition of rennet (CHY-MAX® EXTRA NB) @ 0.2 grams/ kg milk at 37 °C and left covered for 30 minutes for the setting of curd. The curds were cut into 1inch cubes for the release of whey. The curds were cooked up to 40 °C for 10 minutes while stirring with a ladle due to which the curds became firm and released more whey. The cheese curds were drained in a cheese cloth with the help of a colander. The cheese curds were kept in an incubator at 35 °C for 3 hours to develop acidity and optimum pH required for the stretching of the cheese curds. pH paper was used to measure pH of the curds. Once the cheese curds obtained a pH of 5.4, they were stretched in hot water (95 °C) and moulded into balls and kept in 20% brine solution for 2 hours. The Mozzarella cheese balls were removed from the brine solution and packed in polythene bags, sealed and refrigerated. The Mozzarella cheese balls were further taken for analysis of rheological and sensory characteristics.

Rheological properties of Mozzarella cheese

The two important rheological properties of Mozzarella cheese viz; stretchability and meltability were evaluated.

Meltability

Meltability was evaluated by the Schreiber's test (Muthukumarappan *et al.*, 1999) [9]. Cheese sample was cut in a circular shape with 5 cm diameter and placed on a baking tray and baked at 230 °C in a microwave oven for 5 minutes until the cheese melts. The final length of the melted cheese on baking tray was measured in centimeters as meltability of the cheese sample.

Stretchability

The stretchability of cheese was measured by the fork test (Dharaiya *et al.*, 2019) [3]. 100 grams of shredded Mozzarella cheese sample was placed in a petri plate and baked in a microwave oven at 230 °C for 5 minutes. As soon as the petri plate was taken out from the oven, a fork was pierced in the centre of the melted cheese sample and big mass from the centre was pulled out. The length of the stretched cheese was measured in centimeters as the stretchability of cheese.

Evaluation of sensory properties of Mozzarella cheese

The sensory properties like colour and appearance, flavour, taste, body and texture and overall acceptability were evaluated on a 9-point hedonic scale by a panel of five semi-trained judges. The experimental Mozzarella cheese samples were weighed up to 100 grams and shredded by a cheese grater. Handmade Pizza base was prepared by mixing 500 grams of refined flour, 50 grams sugar, 20 grams dried yeast powder, 10 grams of common salt and 50 ml of refined oil. A smooth dough was hand kneaded, covered and kept for fermentation for 2 hours until the size of dough gets double. 15-centimetre sized Pizza base was prepared from the dough and was smeared with 50 grams of Pizza sauce. It was topped with shredded Mozzarella cheese samples and baked at 230 °C for 8-10 minutes in an OTG (Oven Toaster and Griller) until the cheese completely melted. Hot Pizza was sliced and served to the sensory evaluators who evaluated the Pizza on a 9-point hedonic scale to determine the suitability of the experimental Mozzarella cheese on Pizza.

Results and Discussion

The term meltability refers to the degree to which melted cheese flows and spreads when heated (Kuo *et al.*, 2001; Abbas *et al.*, 2014) [8, 1]. The highest meltability was observed in treatment T_4 (12.22 cm). The meltability among all the treatments differed significantly with the control treatment (T_1) having the lowest meltability (8.75 cm). The observed result is in accordance to the results obtained by Fasle *et al.*, 2017 [5] where the cheese which had higher concentration of buffalo milk exhibited higher meltability.

Table 2: Meltability of Mozzarella cheese

Treatments	Replications				Mean
	R1	R2	R3	R4	
T_1	8.75	9	8.5	8.75	8.75^d
T_2	9.95	9.95	9.85	9.9	9.91^c
T_3	10.85	10.9	10.95	11.1	10.95^b
T_4	12.1	12.21	12.35	12.3	12.22^a
SEM	± 0.0650				
CD (5%)	0.200				

The values with different superscripts differ significantly (p<0.05)

El-Tahra (2008) [4], noted that a reduction in calcium content leads to enhanced interaction between protein and moisture. This results in the expansion of the protein matrix, making it more hydrated and increasing its meltability. It was found that the Mozzarella cheese prepared from the milk blend containing higher levels of fat and protein had a superior meltability.

Stretchability of experimental Mozzarella cheese

Table 3: Stretchability of Mozzarella cheese

Treatments	Replications				Mean
	R1	R2	R3	R4	
T_1	68.00	66.00	69.00	71.00	68.50^d
T_2	72.00	73.00	74.00	73.00	73.00^c
T_3	74.00	76.00	75.00	76.00	75.25^b
T_4	78.00	77.00	78.00	78.00	77.75^a
SEM	± 0.6208				
CD (5%)	1.912				

The values with different superscripts differ significantly (p<0.05)

The stretchability of Mozzarella cheese was calculated using the fork test and the results obtained are given in Table no: 3. All the treatments differ significantly among themselves with treatment T_4 showing a higher stretchability of 77.75 cm. The control treatment had a lowest stretchability of 68.50 cm. It is observed that the stretchability of the experimental cheese samples increased as the proportion of buffalo milk increased in the cheese milk.

This is in agreement with the findings of Hayam *et al.* (2014) [7], who reported that cheese exhibits low stretchability as the proportion of cow milk increases in the cheese milk. Similar results were obtained in a study conducted by Fasle *et al.* (2017) [5], where cheese sample which was made with a higher proportion of buffalo milk had higher stretchability values.

Table 4: Meltability and stretchability of experimental Mozzarella cheese

Treatments	Meltability	Stretchability
T_1	8.75	68.50
T_2	9.91	73.00
T_3	10.95	75.25
T_4	12.22	77.75
SEM	0.0650	0.6208
CD (5%)	0.200	1.912

Sensory analysis of Mozzarella cheese prepared from blends of cow and buffalo milk

The sensory evaluation was done by a semi-trained panel of 5 judges using a 9-point hedonic scale. The scores obtained by from the judges were statistically analysed by using Completely Randomized Design.

Colour and appearance of experimental Mozzarella cheese

The mean scores obtained for all the treatments during the analysis of colour and appearance of Mozzarella cheese are given in Table no: 5. The results from table indicate that the treatments exhibited a non-significant difference in colour and appearance of the experimental cheese sample. The treatment T_3 had a higher score for colour and appearance as compared to control treatment which is 8.00 and 7.00, respectively. This result is similar to the results obtained by Narayana and Palliyaguru (2022) [10], where the cheese milk blend which had equal proportion of cow and buffalo milk had higher scores for colour and appearance.

Table 5: Colour and appearance of Mozzarella cheese

Treatments	Replications				Mean
	R1	R2	R3	R4	
T_1	7.00	7.00	7.00	7.00	7.00
T_2	8.00	8.00	7.00	8.00	7.75
T_3	8.00	8.00	9.00	7.00	8.00
T_4	7.00	6.00	9.00	9.00	7.75
SEM	± 0.4448				
CD (5%)	1.370				

The values differ non-significantly (p>0.05)

Flavour of experimental Mozzarella cheese

Table 6: Flavour of Mozzarella cheese

Treatments	Replication				Mean
	R1	R2	R3	R4	
T_1	8.00	7.00	7.00	8.00	7.50
T_2	7.00	8.00	8.00	8.00	7.75
T_3	8.00	7.00	9.00	7.00	7.75
T_4	9.00	6.00	8.00	9.00	8.00
SEM	± 0.4677				
CD (5%)	1.441				

The values differ non-significantly (p>0.05)

The mean scores for flavour of experimental Mozzarella cheese are given in the Table no: 6. The results from the table indicate that the scores for flavour of experimental Mozzarella cheese differ non-significantly. The highest score was recorded for treatment T_4 which had higher concentration of buffalo milk while the lowest score for flavour was obtained by the control treatment. Treatment T_2 and T_3 had a similar score for flavour (7.75).

The obtained results are similar to the findings of Fasle *et al.* (2017) [5], where higher score for flavour was obtained for the cheese made from the cheese milk which had higher proportion of buffalo milk. The higher fat content of the buffalo milk is also responsible for the rich and nutty flavour of the Mozzarella cheese. Fat plays an important role in imparting a rich flavour to almost all the dairy products.

Taste of experimental Mozzarella cheese

The mean scores for the taste of experimental Mozzarella cheese are given in Table no: 7. The mean scores for taste of experimental Mozzarella cheese samples for control and treatment T_2, T_3 and T_4 are 7.25, 7.25, 8.00 and 8.50, respectively. Treatments T_1 and T_2 had the same score for taste whereas treatment T_3 and T_4 had higher scores for taste. The treatments differ non-significantly for taste in experimental Mozzarella cheese. The results found are similar to the results obtained by Fasle *et al.*, 2017 [5] where the score for taste of Mozzarella cheese decreased with an increase in the proportion of cow milk in the cheese milk. Similar observations were made by Upadhyay *et al.*, (2006) [12].

Table 7: Taste of Mozzarella cheese

Treatments	Replications				Mean
	R1	R2	R3	R4	
T_1	8.00	7.00	7.00	7.00	7.25
T_2	7.00	6.00	8.00	8.00	7.25
T_3	7.00	8.00	9.00	8.00	8.00
T_4	9.00	7.00	9.00	9.00	8.50
SEM	± 0.4208				
CD (5%)	1.296				

The values differ non-significantly (p>0.05)

Body and texture of experimental Mozzarella cheese

The mean scores for body and texture of Mozzarella cheese are given in Table no: 8. The result indicates a non-significant difference among the treatments for the body and texture of experimental Mozzarella cheese. It can be observed that the body and texture scores of the experimental Mozzarella cheese improved as the concentration of buffalo milk increased in the cheese milk. The highest score for body and texture was obtained by the treatment number T_4 and the lowest by the control treatment which was 8.50 and 7.25, respectively.

Table 8: Body and texture of Mozzarella cheese

Treatments	Replications				Mean
	R1	R2	R3	R4	
T_1	7.00	7.00	7.00	8.00	7.25
T_2	8.00	8.00	7.00	8.00	7.75
T_3	7.50	8.00	7.75	8.25	7.87
T_4	9.00	7.00	9.00	9.00	8.50
SEM	± 0.3166				
CD (5%)	0.975				

The values differ non-significantly (p>0.05)

The obtained results are similar to the findings of Narayana and Palliyaguru (2022) [10] and Fasle *et al.* (2017) [5], where the cheese samples exhibited improved body and texture when mixed milk was used (cow and buffalo milk) or when the concentration of buffalo milk was higher in the cheese milk. The improved body and texture in the experimental Mozzarella cheese is attributed to the increase in fat content of the milk blend as the proportion of the buffalo milk is increased.

Overall acceptability of experimental Mozzarella cheese

The mean scores of the overall acceptability of the experimental Mozzarella cheese are given in Table no: 9. The result depicts a non-significant difference of overall acceptability among the treatments. Treatment T_4 scored the highest number for overall acceptability (8.38) whereas the control treatment scored the lowest overall acceptability number (7.00). The above results are similar to the results of Fasle *et al.* (2017) [5], which showed a similar increase in the scores of overall acceptability as the buffalo milk concentration was increased in the cheese milk. These findings implied that buffalo milk tends to produced Mozzarella cheese of higher overall acceptability which was liked by the sensory judges.

Table 9: Overall acceptability of Mozzarella cheese

Treatments	Replications				Mean
	R1	R2	R3	R4	
T_1	7.00	7.00	7.00	7.00	7.00
T_2	8.00	6.00	7.00	8.00	7.25
T_3	8.00	8.00	9.00	7.00	8.00
T_4	9.00	7.00	8.50	9.00	8.38
SEM	± 0.3936				
CD (5%)	1.212				

The values differ non-significantly (p>0.05)

Table 10: Sensory Scores

Treatments	Colour and appearance	Flavour	Taste	Body and texture	Overall acceptability
T_1	7	7.50	7.25	7.25	7
T_2	7.75	7.75	7.25	7.75	7.25
T_3	8	7.75	8	7.87	8
T_4	7.75	8	8.50	8.50	8.38
CD (5%)	1.370	1.441	1.296	0.975	1.212
SEM	0.448	0.4677	0.4208	0.3166	0.3936

Conclusions

Rheological characteristics

The meltability scores of Mozzarella cheese increased as the concentration of buffalo milk in the cheese milk blend increased. It was found that milk blend containing higher levels of fat and protein will produce Mozzarella cheese with a good meltability. The treatment T_4 recorded the highest stretch length of 77.75 cm as it had higher proportion of buffalo milk in the cheese milk blend whereas the control treatment T_1 had the lowest stretch length as it was prepared from 100% cow milk as cheese milk.

Sensory characteristics

The Mozzarella cheese prepared from higher proportion of buffalo milk in the cheese milk blend had higher sensory value for attributes like flavour, taste, body and texture and overall acceptability whereas the Mozzarella cheese prepared from equal proportions of cow and buffalo milk had a superior color and appearance value compared to other treatments.

Hence, it was concluded that milk blend of 25% cow milk and 75% buffalo milk was considered best for manufacturing Mozzarella cheese with enhanced meltability, stretchability and superior sensory qualities.

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