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Effect of homogenized recombined milk on functional properties of mozzarella cheese

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Abstract
Effect of homogenization of milk on functional properties of mozzarella cheese was examined to develop mozzarella cheese from recombined milk with desirable textural and melting properties. Recombined milk was homogenized at 1000 psi. When the results of mozzarella cheese manufactured from cheese made from homogenized and unhomogenized recombined milk were compared values for moisture, protein, expressible serum, meltability and fat leakage content were low for cheese made from homogenized milk. Homogenization of recombined milk had no significant effect on stretchability and acidity of cheese.

Keywords: homogenized, recombined milk, functional properties, mozzarella cheese

Introduction
Milk and milk related products account for 17 per cent of India's total expenditure on food. India has emerged as largest milk producing country in the world. The organised cheese market including its variant like processed cheese, mozzarella cheese spreads, flavoured and spiced cheese is valued at around Rs 4.5 billion. Cheese is becoming popular item in the menu of all relatively affluent families. The demand for cheese is projected to grow over Rs 11.00 bn by the terminal year of projection period 2014-15.
Mozzarella cheese belongs to family ''pasta filata'' i.e ability to form strings. Mozzarella cheese is made in many countries from cow milk, buffalo milk and even milk powder. Milk production pattern faces great fluctuation/Variation during course of year. Production of milk is abundant during winters and falls dramatically during summer months. During flush/ glut season milk solids are conserved by processing them into a number of concentrated and dried products so that these can be put into use in the lean period. These milk solids are used for the manufacture of mozzarella cheese having higher shelf-life than normal milk. In the present work, the effect of adding milk powder on cheese making characteristics during manufacture by recombination of mozzarella cheese was studied. The crucial investigation was to determine the cheese making ability of recombined milk in terms of rennet coagulability, cheese stretchability, melting properties and cheese yielding capacity in comparison to fresh milk.

Materials and Methods
Preparation of mozzarella cheese from recombined milk Skim milk powder was recombined by adding water, additional milk and cream adjusting total solids 12, 14 and 16 per cent and casein fat ratio 0.7 per cent. The milk used for cheese making was homogenized at 1000 Mpa at 60^0C. Recombined milk was pasteurized at 72^0C for 15 sec and cooled to 25^0C, pH of the milk was lowered to 5.7 using citric acid solution (5%). The temperature of the milk was then increased to 30^0C and rennet was added with continuous stirring. Curd was allowed to set for 15-20 minutes, the set curd was cut into cubes. After cutting curd was allowed to settle for 5 to 10 min and then was gently agitated gradually. There after citric acid solution was added to further reduce pH to 5.2. The temperature of curd was increased to 40^0C. As soon as desired temperature was attained the water was drained off and curd pressed in cheese press for 5-10 minutes. After removing from the pre-cheese from cheese press, pre-cheese was packaged in polyethylene bags and stored. Stored pre-cheese was stretched in hot water at 75^0C till a breast type structure was obtained.

Rheological properties
Texture profile analysis was performed for; hardness and springiness were determined at 23 to26·C using an Instron Universal Testing Machine (model 4201; Instron, Inc., Canton, MA).

Proximate composition
The moisture content of the samples was measured by the forced-draft oven method and fat content was determined by the Rose-Gotllibe method [1]. These analyses were performed at regular intervals. To determine protein content, total nitrogen content of the cheese was measured by kjeldhal method [1] and a factor of 6.38 was used to convert nitrogen content to protein content.

Meltability
Meltability was determined by the Schreiber test [13] in which samples were cut in the form of discs with 32mm diameter and 7 mm height, discs of equal weights were randomly selected and placed on aluminium plates, covered with a glass petri plates and tempered at room temperature for 30 min. The average weight of the discs was approx 8g. Tempered samples were then heated in oven at 100^0C for 5 min. The meltability of cheese was determined by measuring the final diameter of the cheese discs at 4 different locations after they cooled to room temperature and the average value was reported as meltability of cheese.

Stretchability
Cheese stretch ability was measured by standard [12] method. Grated cheese (10g) was placed on a slice of bread (1x 10 x 10 cm) and heated for 1min in microwave oven and cooled for 1 min. The melted cheese was assessed subjectively for stretching by placing a fork into the cheese layer lifting and measuring the distance the cheese stretched without breaking and ranking as followed over 30cm -5, 20-30cm – 4,10-20 cm –3 ,10cm -2 and below 5 cm- 1.

Melt Time
The modified method of was used to determine the melt time of cheese by recording the time taken in melting 100 g of cheese over water bath at 60^0C [5].

Fat leakage
It was determined by method with the following modification [2]. Discs of 1.8 cm in diameter and 0.5 mm in height were cut weighing approximately 5g; melted on filter paper in the oven at 100^0C for 5 min. The area of oil ring was expressed as fat leakage.

Sensory analysis
Mozzarella cheese samples were evaluated for appearance, body and texture and flavour by a semi- trained panel using 9-point hedonic scale [9].

Statistical analysis
The data collected from the studies was subjected to Completely Randomized Designs (CRD) and Factorial Experiments in CRD using CPCSI software developed by Deptt. Of Maths, Stats and Physics, PAU, Ludhiana.

Results and Discussion
Proximate Composition
Percent of fat, moisture, protein, acidity, yield, stretch ability, meltability, fat leakage of the cheese made from homogenized milk is given in Table 1. Same parameters for cheese made from unhomogenized milk were shown in Table 2. Moisture content of cheese made from homogenized milk was less than the cheese made from unhomogenized milk. Fat content in control mozzarella cheese was 39.46% and for cheese made from recombined milk with 12, 14 and 16% total solid was 32.80, 33.64 and 33.80%. Similarly in cheese made from unhomogenized milk the fat content of cheese varies according to total solids in the milk 33.46 for control, 33.28% from milk having 12% total solids, 33.50 % from milk having 14 % total solid and 33.76% from milk having 16 % total solids. It was observed that cheese made from homogenized milk had higher fat content and yield than cheese made from unhomogenized milk. Scientist reported that the yield increased in the proportion to the homogenization pressure upto a certain homogenization pressure level [6]. The protein content of cheese made from homogenized milk with 12, 14 and 16% total solids was 22.19, 23.52 and 24.05% respectively. Whereas protein content of cheese made from unhomogenized milk with 12, 14 and 16 percent total solids were 23.40, 24.25 and 24.59%. A decrease in the protein content value for the cheese made from homogenized milk as compared to unhomogenized milk was observed. It could be explained by the fact that fat and protein recoveries were significantly higher in the homogenized milk cheese due to reduced losses of fat, protein and total solids in whey or moulding water [6]. A non-significant difference in the acidity values between the cheese made from homogenized and unhomogenized milk was observed.

Table 1: Physico-chemical characteristics of mozzarella cheese from recombined homogenized milk having different total solids

Parameter	Control	Total solids (%)			CD (5%)
		12	14	16	
Moisture (%)	39.15	41.14	40.14	39.23	0.35
Fat (%)	33.46	32.80	33.64	33.80	0.20
Protein (%)	23.72	22.19	23.52	24.05	0.32
Acidity (%)	0.48	0.48	0.48	0.48	NS
Yield (%)	14.48	12.29	15.29	16.89	0.21
Expressible Serum (%)	1.26	1.10	1.27	1.30	0.10
Meltability (cm)	3.98	3.42	3.98	4.79	0.24
Stretchability (score)	4	4	4	4	NS
Melt time (min)	15	18	17	17	0.21
Fat leakage (cm^2)	9.96	7.61	7.89	7.96	0.24

Table 2: Physico-chemical characteristics of mozzarella cheese from unhomogenized recombined milk having different total solids.

Parameters	Control	Total solids (%)			CD (5%)
		12	14	16	
Moisture (%)	39.15	42.03	40.87	39.50	0.29
Fat (%)	33.46	33.28	33.50	33.76	0.31
Protein (%)	23.72	23.40	24.25	24.59	0.25
Titrable acidity (%)	0.48	0.47	0.48	0.48	NS
Yield (%)	14.48	12.02	14.61	15.25	0.17
Renneting time (min)	35	34	34	34	NS
Expressible serum	1.26	1.19	1.29	1.30	0.34
Meltability (cm)	3.98	3.54	4.02	4.98	0.30
Fat leakage (cm^2)	9.96	8.02	8.60	10.48	0.26
Stretchability (score)	4	3	4	3	0.15
Melt time (min)	15	16	15	15	0.18

Meltability and Stretchability

Data regarding meltability and stretchability of Mozzarella cheese is given in the table, it was found that there was a significant difference in the meltability among the samples. Values for meltability in cheese made from homogenized milk having 12, 14 and 16 per cent total solids were 3.42cm. 3.98cm and 4.79 cm respectively where as for unhomogenized cheese meltability ranged from 3.54cm, 4.02 cm, and 4.98 cm for 12,14 and 16% total solids respectively. Results showed that meltability was high in case of cheese made from unhomogenized milk. The results agree with the findings of scientist that homogenization decreases the meltability of Mozzarella cheese because adsorption of casein into the liquid droplets apparently prevents the melted fat from spreading out [10].

No significant difference was observed between the cheese samples made from homogenized milk with total solids of 12, 14 and 16% total solids. Whereas stretchability among the cheese samples made from unhomogenized milk vary significantly ($p<0.05$). When the stretchability of cheese samples made from homogenized and unhomogenized samples were compared. It was concluded that the stretchability scores of cheese made from homogenized and unhomogenized milk did not vary significantly.

Melt time

It was observed that there was a significant difference in the melt time of samples made from homogenized milk. Melt time was 18, 14 and 17 minute for 12 14 and 16%. Melt time vary among the cheese samples made from homogenized milk. Similarly in case of unhomogenized milk a significant ($p<0.05$) difference in melt time among samples was observed i.e melt time was 16 minute for 12% total solid and 15 minute for 14 and 16%. It was observed that the time taken by the cheese samples for melting was high in case of cheese made from homogenized milk than from unhomogenized milk. The melt time may depends on the presence of casein at the water-fat droplet interface, which causes fat droplets to be cross-linked in protein matrix.

Fat leakage

Data obtained from table shows that a significant difference was observed between cheese samples made from homogenised milk with different total solids (12, 14 and 16%). Fat leakage in case of cheese samples with 12 and 14 and 16% total solids were 7.61(cm^2) and 7.89 (cm^2) and 7.96 (cm^2) respectively. Fat leakage increases with increase in the total solids of milk used for making mozzarella cheese. In case of unhomogenized milk cheese, it was observed that fat leakage increasesd significantly with increasing total solids. Fat leakage was 8.02(cm^2) and 8.60 (cm^2) for 12 and 14 % total solids respectively, and for cheese made from recombined milk with 16 per cent total solids was 10.48 (cm^2).

In comparison, fat leakage of the cheese that was prepared from homogenized milk was lower than the unhomogenized milk. The results obtained were in accordance with Scientist reported that homogenised milk contains smaller sized milk fat globules partially coated with caseins to stabilize the expanded fat globule surface area [15]. This may be responsible for reduction in free-oil and increase in apparent viscosity where cheese milk was homogenized. The caseins adsorbed onto the fat globule surface after homogenization may be able to form protein – protein bonds with cheese casein matrix [3] thus increasing the rigidity of cheese protein matrix. Scientists reported that homogenization of milk prior to the manufacture of cream cheese allows the fat globules to interact with casein matrix and produce a more elastic cheese with less free-oil formation [4].

Expressible serum

The expressible serum values for recombined milk having 12, 14 and 16% total solids were 1.19, 1.27 and 1.32% respectively in case of homogenized milk. The results obtained for unhomogenized milk cheese samples were also same i.e. the expressible serum varied significantly for the cheese made from milk having 12 per cent total solids it was 1.10%which increased to 1.30% for 16%. It was noticed that expressible serum for samples made from homogenized milk was higher than those compared with unhomogenized milk.

Level of expressible serum has been used as indirect method of water holding capacity (WHC) of the cheese with low levels indicating high water holding capacity. The increased WHC of the cheese was considered important as it affects the ability to stretch flow and remain succulent during heating [7, 8].

Texture properties

A hardness and springiness value depends on the fat content of the cheese. It was observed that there was significant decrease ($p<0.05$) in the values for hardness and springiness in the cheese made from homogenized and unhomogenized milk having 12, 14 and 16 % total solids. Hardness was 0.774 for the cheese made from recombined milk with 12% total solid and decreased to 0.770 at 16% total solid in case of cheese made from homogenized milk. Springiness values also decreases in case of cheese made from homogenized milk from 8.46 at 12% total solid to 8.40 at 16% total solid. Similar trend was observed in case of cheese made from unhomogenized milk. Hardness values decreases from 0.772 at 12% total solid to 0.764 at 16% in case of cheese made from unhomogenized milk. Springiness values decreases from 8.45 to 8.39 in cheese made from unhomogenized milk with 12 and 16% total solid. With increase in total solid, decreases in hardness values may be due to increase in fat content. Whereas the no significant difference in the values for hardness and springiness among the cheese made from homogenized and unhomogenized milk was observed.

Sensory analysis

As indicated in the Table 3 the highest scores for appearance were obtained from the cheese made from milk containing 14 per cent total solids 8.50, followed by control 7.33. Appearance score for cheese made from milk with 16 per cent total solids were 6.17 which reduced to 6.00 for cheese made from 12% total solids. Same results were found in case of body and texture parameter of the cheese made from homogenized milk with varying total solids. A significant difference ($p<0.05$) was observed in the values obtained for body texture. For cheese made from 14 per cent total solids the score was 8.83, followed by control was 7.27, body and texture scores were low for cheese made from milk having 12 and 16% total solids. It was observed that highest scores for body texture was for the sample made from milk containing 14% total solids. Likewise the score for flavor of the cheese samples, highest scores were obtained for the cheese made from 14 per cent i.e. 8.67. At the end the overall acceptability score for the cheese sample made from milk containing 14 per cent total solid was highest 8.67. A significant difference among all the parameters was observed and on the basis of

sensory score of cheese made from milk containing 14 per cent total solids was best selected for further experimentation.

Table 3: Effect of homogenisation and non-homgenisation on hardness and springiness of mozzarella chesse.

Total solids	Homogenized cheese		Unhomogenized cheese	
	Hardness (g)	Springiness	Hardness	Springiness
12%	0.774	8.46	0.772	8.45
14%	0.770	8.43	0.771	8.43
16%	0.762	8.40	0.764	8.39
CD (P<0.05)	0.28	0.44	0.28	0. .39

Effect of total solids (12%, 14% and 16%) on the sensory scores of mozzarella cheese prepared from recombined unhomogenized milk

As indicated in the Table 4 the appearance scores differed significantly (p<0.05) for different total solids. Cheese made from milk containing 14 per cent total solids obtained higher appearance score i.e 7.17, body texture 8.83 and flavour 8.67. The overall acceptability score was highest for sample made from milk containing 14 per cent total solids. Among the samples cheese made from unhomogenized milk containing 14 per cent total solid was selected for further studies.

Table 4: Sensory scores for mozzarella cheese from recombined homogenized milk with different total solids (12%, 14% and 16%)

Treatments	Appearance	Body texture	Flavour	Overall acceptability
Control	7.33	7.27	7.33	7.31
12%	6.00	6.07	6.47	6.18
14%	8.50	8.83	8.67	8.67
16%	6.17	6.27	6.50	6.31
CD (5%)	0.61	0.810	0.904	0.328

Comparative sensory scores of mozzarella cheese prepared from homogenised and unhomogenized recombined milk having 14% total solids

As indicated in the Table 5 the appearance scores differed significantly ($p < 0.05$) among the samples. Maximum score for appearance was found in homogenized (8.33), followed by unhomogenized (7.17) and control (7.00). The colour of cheese is affected by the amount of intact casein micelles, therefore higher amount of intact casein micelle leads to more scattering of light resulting in whiter appearance.

Table 5: Sensory scores for mozzarella cheese from recombined unhomogenized milk with different total solids (12%, 14% and 16%).

Treatments	Appearance	Body texture	Flavour	Overall acceptability
Control	7.00	6.50	7.00	6.83
12%	6.50	6.70	6.00	6.40
14%	7.17	7.00	7.33	7.17
16%	6.00	6.00	6.50	6.17
CD (5%)	0.15	0.14	0.16	0.25

Same results were found for body and texture the scores significantly ($p < 0.05$). Homogenized samples obtained highest scores (8.83) followed by control (7.33) and unhomogenized (7.00) for body and texture. Homogenized cheese samples were soft and showed less oozing of fat as compared to control and unhomogenized cheese samples.

The flavour scores also differed significantly ($p < 0.05$). The homogenized cheese samples gave a richer and smoother flavour as compared to control cheese and unhomogenized mozzarella cheese. The flavour score was lowest for unhomogenized cheese (7.33). The overall acceptability scores also differed significantly ($p < 0.05$). The overall acceptability scores were highest for homogenized mozzarella cheese sample than control and unhomogenized mozzarella cheese.

Table 6: Comparative sensory scores for mozzarella cheese from homogenised and unhomogenized recombined milk

Treatments	Appearance	Body texture	Flavour	Overall acceptability
Control	7.00	7.33	7.67	7.33
Homogenized*	8.33	8.83	8.70	8.62
Un homogenized*	7.17	7.00	7.33	7.17
CD (5%)	0.16	0.21	0.29	0.31

* 14 per cent Total solids

Conclusions

It is summarized that processing parameters for recombined milk used for making pre cheese and mozzarella cheese were optimized. The casein: fat ratio used was 0.7 per cent adjusting 12, 14 and 16 per cent total solids in the milk. Cheese made from homogenized milk had lower moisture, protein, meltability, expressible serum, fat leakage values than cheese made from unhomogenized milk. Homogenization of milk prior to the manufacture of cream cheese allows the fat globules to interact with the casein matrix and produce a more elastic cheese with less free oil formation. In addition, use of homogenized milk for cheese-making will produce higher yields since more moisture will ultimately be retained in the protein network. The difference in the hardness and springiness values for the cheese made from homogenized and unhomogenized milk depends on the fat content of the cheese. Based on the sensory evaluation scores it was concluded that cheese made from homogenized milk having 14 per cent total solids have higher acceptability than cheese from unhomogenized milk.

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