CHEMICAL, FUNCTIONAL AND SENSORY QUALITIES OF MOZZARELLA CHEESE MADE FROM COMBINATIONS OF BUFFALO'S MILK AND RECONSTITUTED SKIM MILK

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ABSTRACT

The effects of partial substitution of whole buffalo's milk with reconstituted skim milk on the chemical, functional and sensory qualities, consumer acceptability, yield and production cost of mozzarella cheese were assessed. Mozzarella cheese from different combinations of buffalo's milk and 12% reconstituted skim milk (RSM) were prepared as follows: 100% buffalo's milk (T1), 80% buffalo's milk and 20% RSM (T2), 70% buffalo's milk and 30% RSM (T3) and 60% buffalo's milk and 40% RSM (T4). The mozzarella cheese produced did not differ significantly among treatments in moisture, protein, salt and calorie contents. Substitution of buffalo's milk with RSM did not influence the meltability of mozzarella but significantly decreased its stretchability. Sensory ratings on appearance, aroma, flavor, after-taste, stretchability and general acceptability did not differ among the different groups. Consumer acceptability ratings for T2, T3 and T4 were consistently higher than T1. Product yields of T2, T3 and T4 were significantly lower than that of T1. Production cost decreased with increased proportion of RSM but the cost of the finished cheese increased. Results indicate that any of the buffalo's milk and 12% RSM combinations can be used in the production of marketable mozzarella cheese.

Keywords: buffalo's milk, mozzarella cheese, sensory quality, skim milk

INTRODUCTION

Mozzarella cheese is a white, unripened cheese with a rubbery texture. It was originally made from water buffalo's milk but due to the high cost of the milk, most of the commercial mozzarella cheese sold locally at present is processed from cow's milk or from cheese analogues. A few local dairy processors in the Philippines are occasionally producing mozzarella cheese from pure buffalo's milk but the popularity of the product remained low. This is due to the extremely firm curd and poor melting quality of the cheese. Filipinos are most familiar with imported mozzarella cheese that easily melts and can be easily stretched when heated.

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Mozzarella cheese from pure buffalo's milk have high fat content but it seems that the sensory acceptability of the cheese among Filipino consumers is not greatly influenced by the creamy flavor imparted by fat but rather by the melting and stretching qualities. Moreover, with the increased health consciousness of Filipinos, there is an increasing preference for healthy food items. This provides a wide avenue for the production of low-fat dairy cheese products. Over the last few decades, dietary awareness and the growing desire for reduced-fat products have increased the market for reduced-fat cheeses (Caro *et al.,* 2011).

The current study focused on the production of low-fat mozzarella cheese by partial substitution of buffalo's milk with reconstituted skim milk (RSM). It was assumed that with the incorporation of RSM in the cheese milk, the functional properties of the low-fat mozzarella would be improved, thereby increasing the consumer acceptability of the product. The study aimed to develop a local technology for the production of low-fat mozzarella cheese. It specifically aimed to characterize the chemical and functional properties and sensory qualities of mozzarella cheese produced from different combinations of buffalo's milk and 12% RSM; determine the effect of age, sex, occupation and type of cheese eaten on consumer acceptability of the product; and compare the processing yield and production cost of the different kinds of mozzarella cheese produced.

MATERIALS AND METHODS

Experimental treatments and design

Four kinds of mozzarella cheeses with different combinations of buffalo's milk and 12% reconstituted skim milk (RSM) powder were prepared. The experimental treatments were as follows: T1 – 100% buffalo's milk (control); T2 – 80% buffalo's milk, 20% of 12% RSM; T3 – 70% buffalo's milk, 30% of 12% RSM; T4 – 60% buffalo's milk, 40% of 12% RSM. The experiment was conducted using a Completely Randomized Design with three replications. Each batch of cheese produced was considered as a replicate.

Milk collection and testing

The fresh buffalo's milk used in the experiment was obtained from the Philippine Carabao Center (PCC) at the University of the Philippines Los Baños (UPLB). The raw milk was sampled and tested for chemical qualities using a milk analyzer (ULTRA Ekomilk milk analyzer, Bulteh 2000 Ltd., Zagora, Bulgaria).

Processing of mozzarella cheese

Mozzarella cheeses were prepared using the standard processing procedures for Mozzarella cheeses. The cheese milk belonging to five different treatments were prepared: Treatment 1 – 5 l of pure buffalo's milk; Treatment 2 – 4 l of buffalo's milk and 1 l of 12% RSM; Treatment 3 – 3.5 l of buffalo's milk and 1.5 l of 12% RSM; Treatment 4 – 3 l of buffalo's milk and 2 l of 12% RSM. The cheese milk was pasteurized at 72ºC for 15 sec and immediately cooled to 32ºC. When the desired temperature was reached, 1.5% mesophilic bacterial starter was added.

Acidity was allowed to develop for 15 min. Diluted acetic acid (2.5 ml of pure acetic acid in 500 ml of water) was gradually added to 5 l of cheese milk, after which, 0.15 g rennet powder was added and stirred until mixed. The coagulum formed after 7 min was cut into 1/2 in cubes and allowed to settle for 30 min with stirring every 10 min. The optimum acidity of the curd patties (0.6-0.7 % lactic acid) was obtained by titratable acidity test. The curd patties were sliced into portions and were immersed in water heated at about 82ºC. The curd was tumbled until a smooth consistency was obtained, after which, the hot curd was molded to standard size portions. Brining of the cheese was done in 23% cold brine solution for 1 hr. The mozzarella cheeses were packaged and stored at 10ºC.

Product sampling

Approximately 200 g of cheese samples were randomly taken from each treatment of each batch. Cheese samples obtained were used for chemical and functional tests. Samples in each treatment were obtained and were left in the freezer until the complete set was acquired. The remaining cheese samples were used for the experienced panelist evaluation.

Data collection

Fat, moisture and protein were determined using the AOAC methods (AOAC, 2006). Modified Volhard method was used to determine the salt content of the cheese samples (Kosikowski, 1977). Calorie content was obtained using Parr 6200 calorimeter. Meltability and stretchability of cheese samples from different treatment groups were obtained using the modified fork test method (McMahon *et al*., 1999). Produced mozzarella cheeses were baked with a slice of bread in an oven toaster at 193ºC for 3 min. Cheese samples were evaluated by experienced panelists for appearance, flavor, aroma, after-taste, stretchability and general acceptability using a linear scale of 0 to 100 (Mabesa, 1986).

Similar procedures for preparing mozzarella cheese were followed during the consumer acceptability test. A total of 112 consumer panelists consisted of walk-in visitors of PCC at UPLB participated in the test. Consumers rated the acceptability of the cheese samples using the 7-point Hedonic scale with 1 as the least preferred (dislike very much) and 7 as the most preferred (like very much). Percentage yield was obtained at the end of the processing. Production cost of mozzarella cheese for each treatment was computed using the costs incurred to produce the product.

Data analysis

Data gathered on the chemical composition, functional properties and percentage yield of the product were subjected to Analysis of Variance (ANOVA) in a Completely Randomized Design. Sensory quality data were analyzed using ANOVA in a Randomized Complete Block Design with the panel as the blocking factor. Significant differences of the treatments were compared using Bonferroni (Dunn) t-Test. Group comparison of means was done on the data of stretchability. All the data were analyzed using the SAS (Version 9.1). Descriptive statistics was used in the consumer acceptability data.

RESULTS AND DISCUSSION

Chemical composition

Partial substitution of RSM caused a significant difference in the fat content of the cheese samples, particularly between the pure buffalo's milk and the 60% buffalo's milk combined with 40% reconstituted skim milk (Table 1). The results show that the decrease in fat content could be attributed to the addition of RSM. Davide *et al*. (1993) reported that fat and fat-in-dry matter decreased significantly with increasing levels of RSM in mozzarella made from blends of whole cow's milk and 10% RSM. Van Vliet (1991) and Shakeel-Ur-Rehman *et al.*, (2003) reported that increased skimming can produce reduced-fat cheeses. The decrease in fat content could also be attributed to the loss in fat during hot stretching of the curd. With the apparent increase in water content of the cheese milk, there was more melted fat that was left in the whey.

Table 1. Chemical composition of mozzarella cheeses made from different combinations of buffalo's milk (BM) and 12% reconstituted skim milk (RSM).

Components	Treatments (BM:RSM)				%CV
	100:0	80:20	70:30	60:40	
Fat (%)	17.83^{a}	16.67^{ab}	15.67^{ab}	13.50^{b}	8.20
Moisture (%)	45.52	47.40	49.54	51.48	4.53
Protein (%)	19.05	19.37	19.44	19.95	10.19
Salt (%)	1.15	1.29	1.16	1.64	22.93
Calories cal/g)	3945.40	3821.40	3651.30	3426.70	6.94

Means within row having different superscripts are significantly different (P<0.05).

Despite the significant differences on fat content of the experimental mozzarella cheeses, the calorie content of the product did not differ significantly. The moisture, protein and salt contents did not differ significantly among treatments. Similar salt contents of the mozzarella were expected since the cheeses were subjected to similar brining conditions.

Functional properties

There were no significant differences on the melting ability of the mozzarella produced from different combinations of buffalo's milk and 12% RSM (Table 2). It was observed, however, that mozzarella from the 80:20, 70:30, and 60:40 treatment groups had higher meltability values. No statistical difference was detected probably due to the high variability of observations as evidenced by the high coefficient of variation (CV). The higher melting ability of the mozzarella with RSM could be due to the softer curd of the cheese and lower total solids of the cheese milk.

Stretchability of mozzarella from buffalo's milk combined with different levels of RSM was significantly lower than those from pure buffalo's milk. A similar trend

Table 2. Functional properties of mozzarella cheeses made from different combinations of buffalo's milk (BM) and 12% reconstituted skim milk (RSM).

Properties	Treatments (BM:RSM)				%CV
	100:0	80:20	70:30	60:40	
Meltability (%)	23.73	41.82	41.81	41.52	32.24
Stretchability (%)	805.41[a]	619.01[ab]	514.03[b]	517.25[b]	14.56

Means within rows with different superscripts are different (P<0.05)

was noted on the rating for stretchability by sensory panelists (Table 3). This could be attributed to the lower fat content of the mozzarella with RSM. Similar observations were reported by Rudan *et al*. (1999). This could be due to the melted fats in heated mozzarella acting as a lubricant in the curd for the cheese to be stretched. The decrease fat content of the mozzarella cheese lessened lubrication in the heated curd, thus, the stretchability was decreased.

Table 3. Sensory qualities of mozzarella cheeses made from different combinations of buffalo's milk (BM) and 12% reconstituted skim milk (RSM).

Qualities	Treatments (BM:RSM)				%CV
	100:0	80:20	70:30	60:40	
Appearance[ns]	76.83	77.22	76.31	76.83	18.01
Aroma[ns]	73.58	75.75	75.56	75.33	20.81
Flavor[ns]	66.36	69.31	69.39	71.25	26.58
Aftertaste[ns]	66.11	60.94	62.53	68.08	41.31
Stretchability[ns]	65.69	62.44	57.14	58.11	36.99
General Acceptabilty[ns]	66.56	70.69	65.72	70.42	23.37

ns: no significant differences

Appearance = 0 (extremely undesirable) to 100 (extremely desirable); Aroma = 0 (extremely undesirable aroma) to 100 (extremely desirable aroma); Flavor = 0 (extremely weak flavor) to 100 (extremely rich and full flavor); After-taste = 0 (extremely undesirable after-taste) to 100 (extremely desirable after-taste); Stretchability = 0 (extremely unstretchable) to 100 (extremely stretchable); General Acceptability = 0 (extremely unacceptable) to 100 (extremely acceptable).

The results of the current study are contrary to the findings of Davide *et al*. (1993). Meltability decreased with increasing levels of substitution (40 to 70%) of 10% RSM to whole cow's milk. Stretchability of mozzarella increased with substitution of whole cow's milk with RSM; however, the cheese became more tenacious.

Sensory qualities

No significant differences were found on the sensory ratings for the mozzarella cheese's appearance, aroma, flavor, after-taste, stretchability and general acceptability of the cheese samples (Table 3). The results imply that the sensory properties of mozzarella were not affected by the partial substitution of buffalo's milk with 20, 30, and 40% of 12% RSM. Mozzarella cheese with good sensory qualities could be produced from different combinations of buffalo's milk and 12% RSM.

Consumer acceptability

Table 4 shows the acceptability rating of consumers on the experimental mozzarella cheeses. Mozzarella cheese with varying levels of RSM had higher acceptability scores than with the cheese produced from pure buffalo's milk. The preference of the consumers for the product was not influenced by age, sex, occupation or type of cheese consumed. The results imply that buffalo's milk with 20, 30 and 40% of 12% RSM could be used to produce a highly marketable mozzarella cheese.

Table 4. Consumer acceptability of mozzarella cheeses made from different combinations of buffalo's milk (BM) and 12% reconstituted skim milk (RSM).

Groups	Treatments (BM:RSM)			
	100:0	80:20	70:30	60:40
	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Overall	4.79±1.55	5.22±1.47	5.33±1.40	5.03±1.35
Age				
11- 30	4.67±1.57	5.15±1.42	5.37±1.34	4.94±1.40
31-50	4.76±1.55	5.43±1.47	5.24±1.70	5.33±1.24
51-70	5.90±0.88	5.40±1.96	5.20±1.40	5.10±1.20
Sex				
Male	4.79±1.60	5.14±1.39	5.38±1.31	5.12±1.30
Female	4.79±1.51	5.31±1.55	5.28±1.51	4.93±1.41
Occupation				
Working	5.32±1.36	5.08±1.57	5.16±1.55	5.27±1.17
Non-working	4.53±1.58	5.29±1.42	5.41±1.33	4.91±1.43
Type of cheese				
Traditional cheese	4.86±1.52	5.08±1.55	5.40±1.30	5.10±1.30
Processed cheese	4.77±1.55	5.18±1.47	5.41±1.32	5.02±1.35
Imported cheese	4.84±1.52	5.15±1.47	5.40±1.30	5.05±1.32

Product yield and production cost

The percentage yield has been used to determine the efficiency of the production. The percentage yields of the mozzarella cheeses belonging to different

combinations of buffalo's milk and RSM are presented in Table 5. Product yield of mozzarella from the 60:40 buffalo's milk and RSM combination was significantly lower than the other treatment groups. The substitution of buffalo's milk with 40% of 12% RSM increased the water content of the cheese milk, thus, during processing there were more proteins, fats and other solid components that got dissolved in the whey. As the process continued, more components of the curd were lost in the whey during hot stretching and the subsequent brining. Moreover, the increased substitution with 12% RSM decreased the total solids of the cheese milk; therefore, curd recovery during processing was lower. If instead of 12% RSM, a higher concentration of RSM was used, then maybe product yield would not be significantly decreased. Lower yields were similarly observed by Davide *et al*. (1993) in mozzarella manufactured from different blends of cow's milk and 10% RSM. Cheese yield of 21.84% from the 100% buffalo's milk in the present study is higher than the 19.83% yield of mozzarella from pure buffalo's milk that was reported by Emata and Almazan (1998). This could be attributed to differences in milk composition and differences in processing methods used in the experiments.

Table 5. Product yield and income over production cost of mozzarella cheeses with different combinations of buffalo's milk (BM) and 12% reconstituted skim milk RSM).

Items	Treatments (BM:RSM)			
	100:0	80:20	70:30	60:40
Product yield, %	21.84[a]	17.91[ab]	16.78[ab]	13.97[b]
Ingredient cost	261.12	239.32	228.42	217.52
Operating cost	246.66	237.97	234.16	229.29
Total production cost	507.77	477.29	462.58	446.81
Actual cost of cheese	461.61	530.32	544.21	638.30
Income from sales *	925.00	740.00	740.00	555.00
Profit	417.23	262.71	277.42	108.19

*Means within row having different superscripts are different (P<0.01).
Computations based on 5 kg milk.
Actual cost of cheese = Total Production Cost / Product Yield.
**Selling price x No. of packs (Selling Price of Mozzarella Cheese = P185.00 per 200g).
T1-Mozzarella cheeses from 100% buffalo's milk; Product yield =1.1kg = 5 packs of 200g cheese.
T2-Mozzarella cheeses from 80% buffalo's milk and 20% reconstituted skim milk; Product yield =0.9kg = 4 packs of 200g cheese.
T3- Mozzarella cheeses from 70% buffalo's milk and 30% reconstituted skim milk; Product yield =0.85kg= 4 packs of 200g cheese.
T4-Mozzarella cheeses from 60% buffalo's milk and 40% reconstituted skim milk; Product yield =0.7kg= 3 packs of 200g cheese.

The cost analysis showed that total expenses incurred differ among treatments. The total production cost decreased as buffalo's milk was substituted with 12% RSM. This was caused by the decrease in buffalo's milk and the increase in RSM per treatment, thereby lowering the cost of ingredients and operating cost. The actual cost of cheese, however, increased with increased proportion of 12% RSM due to the significant decrease in product yield. The projected profit from the sales of the product decreased when computed based on similar selling prices. This indicates that higher selling prices should be used in marketing mozzarella made from buffalo's milk with 12% RSM. This would not be a problem since it has comparable sensory properties with those from pure buffalo's milk. It could also be marketed as a reduced-fat cheese which is highly in demand in recent years.

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