Progress in Nutrition 2018; Vol. 20, Supplement 1: 298-304 DOI: 10.23751/pn.v20i1-S.5415

Original article

Sensory attributes of mineral fortified low fat buffalo milk cheddar cheese

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Summary. Buffalo milk was fortified with different sources of calcium (Ca) and phosphorous (P) to manufacture of cheddar cheese. It was fortified with calcium chloride (CaCl2) and trisodium phosphate (Na3PO4) at level of 10 (T1), 20 (T2) and 30 (T3) mM/ milk. All samples of cheddar cheese (0, 15 and 30 days) were analyzed for moisture, fat, mineral profile such as calcium, sodium, phosphorous and potassium, sensory analysis (hand firmness, chew down degree of breakdown and chew down smoothness). The fat content of Ca and P enriched cheeses exhibited significant differences due to treatments (23.87±0.63to 23.13±0.56%). No obvious significantly effects were observed in moisture fat, mineral profile, ash and organoleptic characteristics on cheddar cheeses during ripening. The salt fortified cheese showed significant effect of mineral with treatments; sodium (612.52±4.17 to 634.47±7.68 mg/100g), potassium (64.76±2.21 to 74.04±2.02mg/100g), calcium (831.58±4.55 to 874.45±2.62mg/100g). Additionally, hedonic response of developed cheeses was significantly affected due to treatments. Decisively, colloidal supramolecular structures of caseins in buffalo milk play a pivotal role in cheese making and other related organoleptic characteristics. Thus, buffalo milk casein along with calcium and phosphorus incorporation for the development of novel cheese formulation is a pragmatic approach in the field of dairy technology.

Key word: mineral profile, organoleptic, buffalo milk, cheese

Introduction

Pakistan is ranked amongst the 4th highest milk producing country with an overall production of about 12.8% out of which 63% accounts for buffalo milk, 35% cow milk and around 2% from other sources (1). Nutritional composition reveals better profiling of buffalo milk like higher solid, fat, casein, lactose and ash content in contrast to cow milk.

Cheese enriched products are unique due to their specific texture and flavorful properties. Generally, cheese is made from milk that ensures numerous healthy ingredients like minerals, mainly calcium & phosphorus and protein. Commonly, it is employed as topping on pizzas, cheese slices in hamburgers & cold sandwiches. Furthermore, cheese formulations are also considered as the vital part of several other products including soups, sauces, filling in crackers, pastry & pies. For instance, cream cheese is an important ingredient in the making of cheese cakes and spreads (2). Globally, 900 varieties of cheeses are available which are classified on the basis of manufacturing methods, ripening period and chemical composition (3).

Cheddar cheese is a hard cheese variety produced by acidification of milk with the help of rennet. It has high nutritional profile due to casein, calcium and essential amino acids (4,5). Later, Upereti and Metzger (6) measured the effect of calcium chloride and phosphorus on textural properties of cheddar cheese. After 30 days of ripening, they noticed different response especially in case of moisture 32.07 to 37.5% and fat content 33 to 36% while protein 24.5 to 26.5% followed the similar pattern. One of the researchers group, Chevanan *et al.* (7) also explicated the similar results of Ca and P enriched cheddar cheese during ripening.

In this scenario, various methods are implemented for the manufacturing of low fat or fat free cheeses nevertheless, it is difficult to attain good hedonic response. This is because of the reason that rheology of low fat cheeses are different from full fat. The major problems include the higher protein content that results in more cross linkages & compact texture hence difficult to chew. Furthermore, the quality of low fat cheeses is also affected by high moisture content which may cause softening during ripening periods (8). The objective of this study was to fortify the calcium and phosphorus in cheddar cheese at different level and check the sensory characteristics.

Materials and methods

Procurement of raw materials

Raw fresh buffalo milk was obtained from the dairy farm of Department of Livestock Management, University of Agriculture Faisalabad. The buffalo milk was skimmed through cream separator in the Dairy Laboratory of National Institute of Food Science and Technology, University at Agriculture, Faisalabad. The Mesophilic starter culture (*Lactococcus lactis* subsp. lactis and *Lactococcus lactis* subsp. *cremoris*) was purchased from CHR-Hansen, Denmark.

Manufacturing of cheddar cheese

The Ca and P enriched cheddar cheeses were prepared by adopting the protocol of Banville *et al.* (9) with some modification. For the preparation of hard cheeses, milk was standardized at 1.5% fat level followed by pasteurization with continues stirring at 65 °C for 30 min. Mesophilic culture composed of *Lactococcus Lactis* spp *lactis; lactococcus lactis* spp *cremoris* was added to the milk at 31°C and incubated for 45 min. Afterwards, 0.07 mL/Kg rennet was added to the milk and kept at 31°C for 45 min till the curd was firm enough to break cleanly over an inserted rod. Moreover, $CaCl_2$ and Na_3PO_4 (10, 20 and 30 mM) were added and curd was cut both ways with knives to a size of 3-5 mm and then uncut curd was stirred into the centre. Gentle stirring was done until the curd floated in the whey and scalded at 1°C for 5 min until final temperature of 40°C. The curd was floated to one end of the vat to assist whey removal at pH 6.2. The compact curd was cut into blocks and piled up after every 10-15 min and repeated this cheddaring process for 90 min. Further, curd was milled to finger size pieces. The milled curd was aerated and cooled and 2% salt was sprinkled on the curd. The salted curd was then molded and pressed for 10-12 hr by gradual rise in pressure for complete removal of whey.

Cheese ripening

The cheese samples were stored for ripening at 4°C and 30 days.

Composition and mineral profile

Moisture, fat and mineral profile was determined by following the protocol of AOAC, (10). Purposely, calcium, phosphorus, iron and zinc were determined through Atomic Absorption Spectrophotometer (Varian AA240, Australia). Nevertheless, sodium and potassium were measured by Flame Photometer-410 (Sherwood Scientific Ltd., Cambridge).

Organoleptic properties

During sensory profiling, descriptive analysis was carried out by using the protocols of Rogers *et al.* (11) and Yates and Drake (12). The analysis was conducted through experienced texture panel. Each panelist used descriptive texture analysis for cheeses utilizing the hedonic scale with a product-specific, established cheese texture language. This lexicon was made up of texture terms: hand firmness, chew down degree of breakdown and chew down smoothness of mass. The panelists were provided with respective cheese samples at room temperature. The cheeses were given to judges in plastic cups labeled with random three digit codes to maintain the anonymity. Panelists were given deionized water to cleanse their palates between each sample.

Statistical design

The resulting data were subjected to statistical analysis using complete randomized design. The effect of treatments on tested parameters was determined by analysis of variance (ANOVA) using Statistical 8.1 soft ware version. One way ANOVA at 5% significant level ($\alpha = 0.05$) was carried out to assess various treatments resulted in statistically significant differences in the variables evaluated.

Results and discussion

Compositional analysis

The moisture contents of Ca and P enriched cheddar cheese affected significantly ($p \leq 0.05$) due to treatments and ripening time. The moisture content for cheddar cheeses were 35.90±1.79, 37.06±1.44 and 39.65±1.46%, T_1, T_2 and T_3 correspondingly at 0 day (Table 1). During 30 days trial a progressive decrease in moisture content of cheddar cheese was observed as 31.31±1.25 (T_1), 32.99±1.20 (T_2) and 35.66±1.26 (T_3).

The mean squares for fat content of Ca and P enriched cheeses exhibited significant ($p \leq 0.05$) differences due to treatments.The means for fat content of respective treatments were 23.87±0.63 (T_1), 23.56±0.66 (T_2) and 23.13±0.56% (T_3) as showed in Table 2. Mean squares for ash showed significant ($p \leq 0.05$) effect within the treatments whilst, non-momentous differences due to storage The means for ash content in treatments *i.e.* T_1, T_2 and T_3 were 2.89±0.28, 3.18±0.28 and 3.43±0.51%, respectively (Table 3).

The instant results are in agreement with the work of Lopez *et al.* (13), they found that the fat content in cheddar cheese was not increased during ripening period. Afterwards, Johnson *et al.* (14) observed a significant increase in cheese moisture and yield by increasing the coagulum firmness. However, fat lost in the form of whey during manufacturing leads to the rigidity and structure of casein aggregates. Milling of curd has associated with increased surface area of cheddar curd hence more fat is released. It has also been observed that a porous and softer curd is associated with additional expulsion of fat, serum and whey upon subsequent pressing.

One of the scientists groups, Banville *et al.* (9) noticed non-significant changes in ash content during ripening period that supported the current results. One of their peers, Yasin and Shalaby (15) determined the ash content in fat free cottage cheese as 1.78%. They concluded that the increase of ash content in

Table 1. Effect of treatments and ripening on moisture (%) of various developed cheddar cheese

Treatments	Ripening days			Means
	0	15	30	
T1	35.90±1.79c	33.64±2.01fc	31.31±1.25ab	33.61±1.68b
T2	37.06±1.44b	34.99±1.31c	32.99±1.20b	34.99±1.31b
T3	39.65±1.46a	37.15±1.68a	35.66±1.26a	37.15±1.46a
Means	37.53±1.12b	35.26±1.92b	33.32±1.77b	

Different letters in columns indicate significantly different values at p ≤ 0.05

Table 2. Effect of treatments and ripening on fat (%) of various developed cheddar cheese

Treatments	Ripening days			Means
	0	15	30	
T1	24.1±0.95	23.84±0.63	23.70±0.33	23.87±0.63a
T2	23.75±0.92	23.53±0.55	23.41± 0.52	23.56±0.66a
T3	23.30±0.80	23.15±0.41	22.93±0.48	23.13±0.56ab
Means	22.72±0.74	22.51±0.57	22.31±0.48	

Different letters in columns indicate significantly different values at p ≤ 0.05

Table 3. Effect of treatments and ripening on ash (%) of various developed cheddar cheese

Treatments	Ripening days			Means
	0	15	30	
T1	2.86±0.34	2.89±0.23	2.92±0.28	2.89±0.28d
T2	3.15±0.28	3.18±0.27	3.21±0.38	3.18±0.28c
T3	3.41±0.53	3.43±0.54	3.46±0.46	3.43±0.51b
Means	3.14±0.33	3.16±0.31	3.19±0.29	

Different letters in columns indicate significantly different values at p ≤ 0.05

cheddar cheese was due to addition of calcium and trisodium phosphate during cheese manufacturing. Likewise, Khan and Pal (16) analyzed the effect of calcium phosphate in paneer cheese and reported higher ash content with the increment in calcium phosphate, might be due to the fortification of inorganic salt like Ca and P.

Mineral profile

Sodium and potassium contents were significantly affected due to treatments. However, storage and interaction differed non-significantly.The means for sodium contents were; T_1 612.52±4.17, T_2 623.44±3.84 and T_3 634.47±7.68 mg/100g. Nonetheless, non-significant ($p \leq 0.05$) differences were observed during ripening period and the recorded values for sodium were 625.48±3.61 to 621.59±5.77mg/100g at 0 to 30 days respectively (Table 4).

Similarly, significant increase in potassium content were noticed within treatments as 64.76±2.21 (T_1), 68.25±2.70 (T_2) and 74.04±2.02 (T_3) mg/100g, respectively (Table 5). During storage, non-momentous decrease was observed in potassium content from 69.73±1.53at initiation to 68.86±1.00 mg/100g at termination of the study.

The treatments affected significantly on the calcium and phosphorus contents of resultant cheeses while, storage and their interactions behaved non-momentously.The means for calcium content of minerals enriched semi-skimmed cheeses were T_1 (831.58±4.55), T_2 (842.11±3.26) and T_3 (874.45±2.62) mg/100g, respectively (Table 6).

Table 4. Effect of treatments and ripening on sodium (m/100g) of various developed cheddar cheese

Treatments	**Ripening days**			**Means**
	0	**15**	**30**	
T1	614.46±4.13	612.52±6.00	610.58±4.52	612.52±4.17c
T2	625.32±5.09	623.36±7.25	621.41±5.54	623.44±3.84ab
T3	636.67±3.52	634.72±5.00	632.78±7.52	634.47±7.68a
Means	625.48±3.61	623.53±5.25	621.59±5.77	

Different letters in columns indicate significantly different values at p ≤ 0.05

Table 5. Effect of treatments and ripening on potassium (mg/100g) of various developed cheddar cheese

Treatments	**Ripening days**			**Means**
	0	**15**	**30**	
T1	66.35±4.32	64.43±2.12	63.51±2.51	64.76±2.21d
T2	69.18±3.60	67.26±2.02	68.32±2.50	68.25±2.70b
T3	73.66±2.51	73.70±2.50	74.76±1.06	74.04±2.02a
Means	69.73±1.53	68.46±1.19	68.86±1.00	

Different letters in columns indicate significantly different values at p ≤ 0.05

Table 6. Effect of treatments and ripening on calcium (m/100g) of various developed cheddar cheese

Treatments	Ripening days			Means
	0	15	30	
T1	830.14±4.58	833.26±4.44	831.34±4.65	831.58±4.55d
T2	840.67±3.30	843.78±3.25	841.90±3.25	842.11±3.26c
T3	873.35±2.64	876.47±2.60	874.55±2.63	874.45±2.62a
Means	848.05±2.93	851.17±3.70	849.26±3.86	

Different letters in columns indicate significantly different values at $p \leq 0.05$

Table 7. Effect of treatments and ripening on phosphorous (m/100g) of various developed cheddar cheese

Treatments	Ripening days			Means
	0	15	30	
T1	440.80±4.98	442.93±4.05	443.97±5.26	442.92±7.09b
T2	455.93±5.31	457.99±5.31	459.03±4.32	457.98±5.31a
T3	464.98±6.25	467.03±6.25	468.08±9.25	467.03±8.25a
Means	453.90±5.09	455.90±5.65	457.02±5.76	

Different letters in columns indicate significantly different values at $p \leq 0.05$

The calcium contents showed non-momentous increase from 848.05±2.93 mg/100g (initiation) to 849.26±3.86 mg/100g (termination). Likewise, means for phosphorus content of various developed cheeses were 442.92±7.09 (T_1), 457.98±5.31 (T_2) and 467.03±8.25 (T_3) mg/100g, correspondingly. The phosphorus content was observed as 453.90±5.09mg/100g at 0 day and 457.03±5.76 mg/100g at 30th day of ripening periods (Table 7).

The estimated values of calcium and phosphorus for developed cheeses are in accordance with the findings of Chevanan and Muthukumarappan (18). They observed increased level of calcium and phosphorus content by their supplementation from 510 to 690 mg/100g and 380 to 480 mg/100g, respectively. The present findings are also similar to the investigation of Joshi *et al.* (19). Later, Hassan *et al.* (19) did not report any increase in calcium content during storage. Although, insoluble Ca showed linkages with casein particles of cheese thus responsible for textural effect during cheese moulding. Likewise, phosphorus is also vital in the formation of rennet coagulated milk and provides structure during cheese making (20).

Hedonic response

The highest score for hand firmness in cheddar cheese was observed as 8.38±0.42 (T_3) trailed by 7.64±0.25 (T_1) and 7.53±0.28 (T_2). The results demonstrated that maximum scores for chew down smoothness of cheddar cheese were for T_3 followed by 7.46±0.32 (T_1) and 7.14±0.26 (T_1) as showed in Figure 1.

During storage non-significant increase were observed in chew down smoothness from 7.30±0.27 initiation to 7.40±0.34 at the termination of study (Figure 2). The highest score for chew down breakdown of

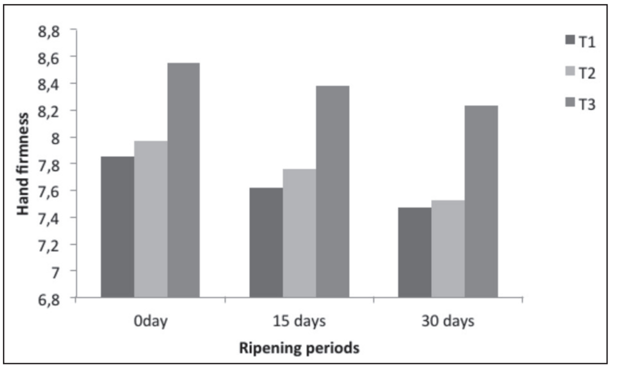

Figure 1. Effect of treatments and ripening on hand firmness of various developed cheddar cheese

cheddar cheese was noticed in 8.15±0.33 T_3 followed by 7.15±0.28 T_2 and 6.65±0.32 T_1. During storage a non-significant increase was observed in chew down breakdown from 7.21±0.27 to 7.61±0.22 as presented in Figure 3.

The instant results are in agreement with the work of Sameen *et al.* (21) observed that chew down smoothness and break down were increased that ranged from 4.98 to 7.44 and 4.04 to 7.90, scores, respectively. The smoothness of all cheese types were raised non substantialy with ripening period due to change in average size, distance and variations of fat globules that associated with casein curd. Similar findings were elaborated by Brown *et al.,* (22), they recorded an increase in chew down smoothness and breakdown of mozzarella cheese from 3.36 to 4.91 and 3.68 to 5.41 scores, respectively throughout the ripening duration.

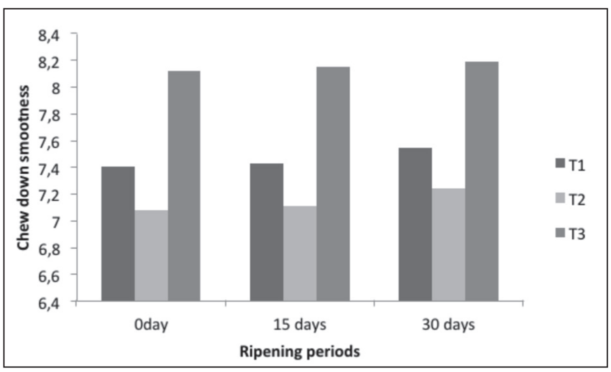

Figure 2. Effect of treatments and ripening on chew down smoothness of various developed cheddar cheese

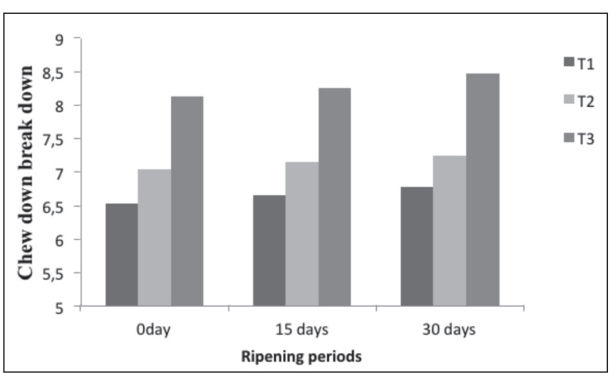

Figure 3. Effect of treatments and ripening on chew down break down of various developed cheddar cheese

Conclusions

Moreover, it is deduced that treatment T_3 (30 mM $CaCl_2$ and Na_3PO_4 enriched semi-skimmed cheddar cheese) were more acceptable as compared to rest of the treatments. For fortification purpose, calcium chloride and trisodium phosphate were added in low fat milk for increasing the elasticity of casein curd by the formation of colloidal calcium phosphate that possessed similar effect like milk fat entrapped in casein curd. Moreover, added calcium exerted positive impact on the physical parameters of the low fat developed cheeses. In the nut shell, minerals enriched cheese with low fat content has potential to eradicate micronutrients deficiencies by supplying ample amounts of Ca and P thus improves human health.

Acknowledgment

The authors are thankful to Higher Education Commission for providing funds to conduct this project. The corresponding author would like to thank Dr Sarfraz Ahmad (Late) for his valuable suggestions during the research period.

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