

Minerals and Lactic Acid Contents in Buffalo Milk Cheddar Cheese; a Comparison with Cow

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Abstract The aim of the study was to compare the minerals and lactic acid profile of Cheddar cheese prepared from cow and buffalo milk. Milks standardized at 4% fat level were used to prepare Cheddar cheese. The cheese was prepared and stored for 120 days ripening at 4°C. Chemical composition and minerals contents were determined at one month intervals during ripening. Lactic acid concentration was estimated after 2 and 4 months of ripening. The results revealed that cheese from buffalo milk had significantly higher level of fat, protein, ash, lactose and lactic acid contents as compared to that prepared from cow milk. Sodium, calcium and potassium contents were also considerably higher in the cheese prepared from buffalo milk. During ripening, significant decrease in lactose and pH value, while increase in acidity and lactic acid contents was observed. However, ripening did not influence the minerals profile of the cheese. It was accomplished that buffalo milk Cheddar cheese is nutritionally superior to cow milk cheese.

Keywords: buffalo milk, cow milk, cheddar cheese, minerals, lactic acid

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1. Introduction

Cheddar is a hard type of cheese having high nutritional value owing to the concentration of caseins which contain various levels of all essential amino acids, fat and small amounts of other nutrients like calcium, sodium, potassium, retinol, riboflavin, pyridoxine and cyanocobalamine [1]. Owing to higher concentration of nutrients, it is an important component of balanced diet [2].

Quality of Cheddar cheese depends upon starter cultures, manufacturing technology and composition of milk [3]. Milk composition is influenced by the animal type, individuality, health, feed, weather conditions and lactation stage of producing animal [4]. Cheese is a prepared from milk having dynamically balanced mixture of protein, fat, carbohydrates, vitamins, water, lactose, lactoglobulin, lactalbumin and water-soluble minerals [5].

Worldwide, Cheddar type cheese is produced from cow's milk, but buffalo's milk ranks second in production after cow. About 80% of the world's buffalo milk is produced in India and Pakistan and on account of its composition; it is much appropriate for soft and hard type of cheeses [2,6].

Buffalo's milk is higher in fat, lactose, caseins, calcium, magnesium and inorganic phosphate than cow. Similarly, the capacity of milk to be acidified is better for buffalo's milk as compared to cow [6,7]. This milk is exceptional

for production and manufacturing of various milk products owing to its nutritional composition and buffering capacity [8,9].

During ripening, Cheddar cheese experiences momentous biochemical modifications and transformations because of glycolysis, proteolysis and lipolysis [1,10]. As a result, fresh curd having bland flavour and rubbery texture is converted into a product with attractive flavour and smooth texture [3,11]. The flavours produced in cheese are very multifaceted and comprise of substances including organic acids, which are the metabolites of bacterial cultures [2,12].

A primary function of bacterial culture is to convert the lactose into glucose or galactose, which are then converted into the end product of lactic acid. Lactic acid production is significantly influential on quality of cheese. In addition, the acidification contributes a preservative effect with the result that many pathogenic and spoilage bacteria are inhibited [13].

Lactic acid is the most plenteous organic acid present in cheese varieties. It is the metabolite of glycolysis reaction during cheese ripening [2,14]. Quantitative determination of lactic acid is important because it is an indicator of bacterial activity and contributes to cheese quality by imparting flavour [15,16].

Keeping in view the above facts, the project was designed to compare the composition particularly the minerals and lactic acid contents in Cheddar cheese prepared from buffalo and cow milks.

2. Materials and Methods

2.1. Milk Samples

Cow and buffalo milks were procured from University Farm House, Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad, Pakistan. The milk samples were standardized at 4.0% fat level.

2.2. Cheddar Cheese Manufacturing and Ripening

Cheddar cheese samples were manufactured from cow and buffalo milk using direct in vat (DVS) Mesophilic starter cultures (*Lactococcus lactis*ssp. *cremoris* and *Lactococcus lactis*ssp. *lactis*) of CHR-Hansen, Denmark, following the standard protocol, with some modifications, as described by Murtaza et al [1].

2.3. Cheese Ripening and Quality Evaluation

Cheese samples were stored for ripening at 4°C for a period of 120 days. During ripening, samples were evaluated for various quality parameters.

2.4. Composition

Moisture, fat, protein, ash, pH, acidity and salt (Volhard method) were determined following the protocols of AOAC [17] at one month intervals during ripening. Lactose contents were evaluated by Chloramine-T method as given by Kirk and Sawyer [18].

2.5. Minerals Profile

Minerals (sodium, potassium and calcium) contents in Cheddar cheese were determined using Flame Photometer following the method illustrated by Kirk and Sawyer [18] at the intervals of one month.

2.6. Lactic Acid Contents

Lactic acid concentration of cheese during ripening was determined after 2 and 4 months by High Performance Liquid Chromatography (HPLC) following the standard method given by Akalinet al [16].

A SHIMADZU liquid chromatograph (LC-10 AT VP Series, SHIMADZU Corporation, Japan) equipped with a SCL-10AVP system controller injector fitted with a 20 µl

sample loop and a SPD-10AVP UV-VIS detector was used. The detector's wavelength was set at 214 nm.

2.7. Statistical Analysis

Results drawn from the study were statistically analysed using Completely Randomized Design (CRD) and Analysis of Variance (ANOVA) Technique to compare the chemical composition, lactic acid and mineral contents of Cheddar cheese from cow and buffalo milks [19].

3. Results and Discussion

3.1. Composition

The compositional analysis of Cheddar cheese (Table 1) showed that cheese prepared from buffalo milk had significantly ($p < 0.01$) lower moisture ($35.76 \pm 0.24\%$) and higher fat ($31.77 \pm 0.09\%$), protein ($26.41 \pm 0.11\%$), ash ($4.07 \pm 0.006\%$) and lactose ($0.12 \pm 0.004\%$) contents as compared to cow milk. However, salt content, pH value and acidity were non-significantly ($p > 0.05$) influenced by the milk sources.

Table 1. Chemical composition and minerals profile of cow and buffalo milk Cheddar cheese

Ripening days	Cow	Buffalo
Moisture (%)	36.74±0.23a	35.76±0.24b
Fat (%)	30.23±0.096b	31.77±0.091a
Protein (%)	25.22±0.03b	26.41±0.11a
Ash (%)	3.84±0.009b	4.07±0.006a
pH value	5.26±0.012	5.26±0.018
Acidity (%)	0.93±0.005	0.93±0.005
Sodium (mg/100g)	667.55±0.84b	682.68±0.60a
Calcium (mg/100g)	723.68±1.10b	755.00±1.23a
Potassium (mg/100g)	83.07±0.49b	86.43±0.48a

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

The considerable variation in composition of cheese prepared from two different species are because the buffalo milk is richer in milk constituents especially fat, lactose and caseins [6,8] and these significant inter-species differences are reflected in the characteristics of the cheeses produced [20].

During ripening of 120 days (Table 2 and Table 3), moisture, fat, protein, ash and salt contents changed non-significantly ($p > 0.05$). However, lactose decreased significantly ($p < 0.01$) from 0.15 ± 0.005 to $0.06 \pm 0.004\%$ resulting in significant drop of pH and increase in acidity from 5.34 ± 0.021 to 5.19 ± 0.024 and 0.90 ± 0.007 to $0.96 \pm 0.006\%$, respectively.

Table 2. Effect of ripening on moisture, fat, protein and ash contents of Cheddar cheese

Ripening days	Moisture (%)	Fat (%)	Protein (%)	Ash (%)
0	36.99±0.39	31.32±0.22	26.05±0.18	3.93±0.02
30	36.66±0.36	31.18±0.21	26.01±0.18	3.94±0.02
60	36.21±0.36	30.99±0.22	25.80±0.15	3.96±0.03
90	35.78±0.40	30.81±0.21	25.68±0.19	3.97±0.03
120	35.61±0.37	30.67±0.21	25.52±0.16	3.98±0.03

Table 3. Effect of ripening on salt, lactose, pH and acidity of Cheddar cheese

Ripening days	Salt (%)	Lactose (%)	pH	Acidity (%)
0	1.60±0.012	0.15±0.005a	5.34±0.021a	0.90±0.007e
30	1.62±0.007	0.12±0.005b	5.28±0.023b	0.92±0.009d
60	1.62±0.007	0.10±0.006c	5.25±0.022bc	0.93±0.006bc
90	1.63±0.009	0.08±0.005d	5.23±0.023c	0.94±0.007b
120	1.65±0.007	0.06±0.004e	5.19±0.024d	0.96±0.006a

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

The fermentation of lactose resulted in fall of pH and rise in acidity because various metabolic reactions and transformations including glycolysis occur during cheese ripening [1,10]. Among these reactions, the conversion of lactose into lactate and other metabolic products by lactic acid producing bacteria is imperative and manipulate the concentration and production rate of acidification [20]. Onget al [21]also reported that during ripening, the lasting lactose content predominantly converted and transformed into L-lactate and ultimately the lactic acid.

3.2. Minerals Profile

Table 4. Effect of ripening on minerals profileof Cheddar cheese

Ripening days	Sodium (mg/100g)	Calcium (mg/100g)	Potassium (mg/100g)
0	671.17±2.25	736.17±3.66	80.67±0.62
30	673.25±1.82	736.96±3.61	82.29±0.69
60	675.38±1.67	738.58±3.69	85.33±0.65
90	677.00±1.81	741.71±3.82	87.08±0.52
120	678.79±1.82	743.29±3.81	88.38±0.50

Minerals contents increased non-significantly ($p>0.05$) during ripening. The slight increase might be result of non-significant decrease in moisture content during 120 days. Since minerals are not engaged in any microbiological, biochemical or metabolic process occurring during ripening thus minerals contents are influenced non-significantly [22].

3.3. Lactic Acid

The concentration of lactic acid produced in Cheddar cheese during ripening showed that buffalo milk cheese contained significantly higher lactic acid than cow (Figure 1). The considerable difference between cow and buffalo milk cheeses may be due to the significant differences in the composition of both types of milk as the milk from buffalo is more affluent in casein, lactose and fat contents than cow [7,8] and moreover, along with these differences, the capacity of milk to be acidified is higher for buffalo than cow [2,6].

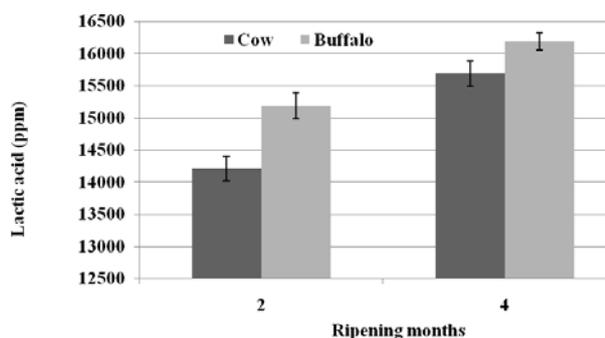


Figure 1. Lactic acid contents of cow and buffalo milk Cheddar cheese

After 4 months of cheese ripening, significant increase in lactic acid concentration was observed as compared to 2 months (Figure 1). This increase may be due to the metabolic transformations of remaining lactose and related compounds during ripening. At the start of ripening, lactose is quickly metabolized into lactate. This lactate is an imperative precursor for the production of lactic acid through a series of metabolic reactions and transformations including microbial processes, oxidation-reduction reactions and racemisation [10,23]. Murtaza et al [2] also found the increase in lactic acid concentration in

Minerals analysis of Cheddar cheese (Table 4) revealed that cheese prepared from buffalo milk contained significantly ($p<0.01$) higher sodium (682.68 ± 0.60 mg/100 g), calcium (755.00 ± 1.23 mg/100 g) and potassium (86.43 ± 0.48 mg/100 g) as compared to cow with mean values of 667.55 ± 0.84 mg/100 g, 723.68 ± 1.10 mg/100 g and 83.07 ± 0.49 mg/100 g, respectively. The significant differences in minerals profile of cheese are found because as compared to cow, buffalo milk contains considerably higher minerals contents especially calcium [7,8].

Cheddar cheese during the first few weeks of ripening owing to the use of residual lactose trapped in the curd.

4. Conclusion

Hence, it was concluded that buffalo milk cheese is nutritionally superior to cow as it contains better compositional profile especially the minerals and lactic acid contents. Moreover, during ripening the concentration of lactic acid increased significantly, while minerals profile was influenced non-significantly.

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