Buffalo Milk Cheeses - Characterization and Value Addition

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Introduction

India produces about 100 million tons of milk a year, of which about 55.0% comes from the country's 40 million buffalo, according to the Animal Production and Health Commission for Asia and the Pacific. India is home to more than 40 million water buffaloes, which help to produce more than 100 million tons of milk each year. Most of the buffalo milk is turned into butter and ghee (clarified butter). Cheese, however, has yet to gain wide appeal. Nutritionally, water buffalo milk is higher in fat, calcium, iron, and phosphorus than cow's milk, and it contains about 11% more protein than cows' milk. Buffalo milk has slightly nuttier, more acidic notes when compared with cows' milk.

Buffalo milk cheeses are becoming increasingly popular throughout the world; buffalo's milk is the preferred commodity in preparing many cheese varieties, namely soft, semi, hard cheeses and certain pickled cheeses. Buffalo milk cheeses display typical body and textural characteristics which are unique in nature. Another area where buffalo milk has made strong inroads is in the preparation of cheese spreads. Such products are popular for their mild flavour and ease of use. Haryana is the homeland of the Murrah buffalo famed for the fattiness of its high-yielding milk. China and Bulgaria imported them in the 1950s and 1960s to improve their domestic stock.

Value addition to dairy products has been one direction for the dairy industry. Cheese lends itself for potential value addition. Value addition has been applied to cheese through use of probiotic cultures, enhancing the conjugated linoleic acid (CLA) content of product, pre-treatment to cheese milk (i.e. homogenization, membrane processing, high pressure processing, etc.), or by manipulating its functional property (i.e. melt, stretch on pizza pie)

Cheeses made from buffalo milk

In Southern Italy, fresh buffalo milk cheeses like Mozzarella and Stracciatella are most popular and beloved to the consumers. Blu di Bufala is an Italian blue-veined cheese made from full-fat pasteurized buffalo milk in Bergamo, Italy. It is a cube-shaped cheese with a perfect balance of milky sweetness, punchy blue veining, crumby texture and a creamy mouth feel.

Table 1 summarizes some of the buffalo cheese

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varieties with their country of origin. **Table 2** shows the proximate composition of few cheese varieties prepared from buffalo milk. Apart from these, several cheese varieties have been manufactured from buffalo milk which are conventionally made from bovine milk.

Fresh and pickled buffaloes milk white cheeses with high solids and protein had improved appearance and texture due to more stability resulting from protein fat interlacing and calcium links to casein (Hofi *et al*, 1992).

Yield of cheese

The yield of Domiati, Kariech, Feta, Cheddar, Swiss, Cottage, Mozzarella and other types of cheeses is higher when prepared from buffalo milk as compared to when made using cow milk. The cheese processors therefore appreciate the value of buffalo milk. One of the advantages derived from the increased yield is the lower cost for the manufacture of cheese.

Cheese ripening and flavour

Cheddar cheese prepared from buffalo milk utilizing indigenous cultures and ripened at higher temperature (i.e. 12°C) received higher descriptive sensory scores compared with those of commercial cultures and ripened at lower temperature (i.e. 6°C). Milk sources markedly affect the 'creamy' and 'sour' traits of odor; the 'creamy', 'smoky', and 'soapy' flavors; and all the texture attributes except 'maturity' (Murtaza *et al*, 2013).

Mozzarella cheese

Mozzarella cheese manufactured from buffalo milk has a white color, characteristic texture and aroma and results in higher yield as compared to its cows' milk counterpart (Jana and Mandal, 2011). Cheeses from buffaloes' milk obtained higher yield and greater fat content than using cows' milk. The titratable acidity, moisture, protein and soluble nitrogen of buffalo Mozzarella cheese were least, while the ash content and pH value were highest when compared to cheeses made from cows' milk or blend of cow and buffalo milks (Bonassi *et al*, 1982). The industry can achieve about 20.0 to 22.0 kg of mozzarella from the processing of 100 liters of milk, an almost 50% higher yield than that for bovine milk (Citro, 2010). For cheeses where chewing and stringy properties are desired, buffalo milk is more desirable than cows' milk, as in the case of Mozzarella cheese.

Table 1: Major cheese varieties made from buffalo milk

Cheese	Country of origin
Mozzarella	Italy
Paneer	India
Domiati	Egypt
Queso Blanco	South and Central America
White Brined and Pickled	Balkan countries

The majority of mozzarella cheese produced must have functional properties that are suitable for pizza production. Mozzarella cheese should exhibit good shredding, melting and stretching properties and should be free of off-flavours or textural defects for pizza production. Buffalo milk was preferred over ultrafiltered (UF) cows' milk having the same chemical composition for making Mozzarella cheese due to the unique characteristics of the former (Hussain *et al*, 2013).

The fat levels in milk used for Mozzarella cheese making significantly affected the concentration of lactic and citric acids, but formic and pyruvic acid content remained unaffected. The free oil formation and flowability

Table 2: Composition of some buffalo milk cheeses

Constituents	Cheese variety		
	Soft pickled	Mozzarella	Cheddar
Moisture (%wt)	53.30	50.28	38.65
Fat (%wt)	21.60	23.11	32.45
Protein (%wt)	14.40	20.13	20.50
Ash (%wt)	2.70	3.17	4.40
pH	-	5.60	4.76

Source: Shaheinet al. (2014); Pagthinathan and Nafees (2016); Fasale et al (2017)

of cheese increased during ripening period. The stretchability of cheese initially increased up to 40 days; a decrease was noted at 60th day of storage (Sameen *et al*, 2008).

Low-fat Mozzarella cheese: There is demand for low-fat cheeses owing to greater incidence of obesity and other diseases amongst the people. Lowering the fat content compromises the overall texture and functionality of cheese. The ratio of moisture to protein is reduced, creating harder cheeses. The reduced fat content does not allow for adequate free oil release and hinders the pizza bake performance. Strains of exopolysaccharide (EPS) producing lactic acid bacteria have been used successfully to manufacture low-fat Mozzarella cheeses (LFMC) with improved moisture retention and functional properties (Petersen *et al*, 2000). LFMC containing 6% fat have been made by pre-acidification of milk, pre-acidification combined with EPS producing starter, used independently or as a co-culture with non-EPS starter. Use of EPS helped in reducing the hardness, springiness and chewiness of low-fat cheeses and such cheeses exhibited increased cohesiveness and meltability (Zisu and Shah, 2005). LFMC in baked condition exhibited similar melting and browning characteristics to those of the full-fat variety. This was achieved by coating cheese shreds with a hydrophobic material before baking to prevent surface dehydration and subsequent skin formation (Rudan and Barbano, 1998).

Domiati cheese

Domiati cheese is one of the most popular, soft, white-pickled varieties of Middle Eastern cheeses. It is made chiefly from buffalo milk (Abd El-Salam and Alichanidis, 2004). Buffalo milk is preferred for the manufacture of Domiati cheese owing to its property of faster coagulation and requirement for less rennet.

Queso Blanco cheese

Queso Blanco is a fresh cheese made with organic acid or starter culture; it is usually consumed with fruit. For the manufacture of Queso Blanco cheese, buffalo milk is standardized to about 3% fat and is preheated to 80°C, followed by the addition of dilute glacial acetic acid with gentle stirring.

Mascarpone cheese

Mascarpone - a cheese of Italian origin (Lombardy region) tastes like thick, cream-cheese-textured whipping cream; sweet and dessert-like. It is made by curdling milk cream with citric or acetic acid. The cheese is a thick, double or triples cream, soft cheese which has a very high fat content. It is used in desserts like Tiramisu and cheese cakes. Buffalo milk can be used as a suitable raw material in preparation of this cheese variety.

Cottage cheese

The cottage cheese prepared from buffalo milk had higher fat (24.2 %), protein (19.03 %) and yield (i.e. 20.65 vs. 19.68%) as compared to the one prepared from cow's milk. However, the overall acceptability of cow milk cottage cheese was superior (i.e. 8.4 vs. 8.1 for buffalo; out of sensory score of 9.0) (Rasheed *et al*, 2016). Cottage cheese with yield similar to the cheese made using calf rennet has been successfully prepared from buffalo milk using papain enzyme (from papaya latex) (Rana *et al*, 2017).

Cheddar cheese

Czulak (1964) used pre-salting of buffalo milk with NaCl at a level of 1%. Addition of NaCl to milk resulted in increased hydration of casein micelles and thereby increased the voluminosity and reduced the firmness of cheese. It also led to calcium solubilisation, which is otherwise a problem faced when preparing cheese from buffalo milk.

Accelerated ripening of Cheddar cheese

Several approaches, such as an elevated ripening temperature, use of attenuated starter culture, use of an adjunct culture, addition of enzymes (i.e. Accelerzyme® CPG, enzyme preparation derived from *Aspergillus niger*), high pressure processing of milk, lactose hydrolysis of milk and supplementation with goats' milk has proved useful in accelerating the ripening of Cheddar cheese (Kanawjia and Singh, 1991; Rao and Singh, 2007).

Modification in the cheese making protocol when preparing cheese from buffalo milk

Approaches explored to improve upon the quality of buffalo milk cheeses include the use of alternative processing technologies (e.g., membrane filtration, high-pressure treatment, homogenization, heat treatments more severe than pasteurization) or addition of whey protein products, enzymes or even emulsifying salts (Arora and Khetra, 2017).

A higher heat treatment of the buffalo milk (vs. for cow milk) increased the moisture content of cheese curd and facilitated normal syneresis of the curd, even during pressing. The resultant lower salt-in-moisture ratio promoted normal acid development and proteolysis in cheese. Use

of *Mucor miehei* rennet (vs. other rennet substitutes) led to Cheddar cheese with less incidence of bitterness. The increase in free fatty acid (FFA) content of Cheddar cheese prepared using high heat treated milk was greater than that attained through use of additional food grade enzymes (Krishna *et al*, 1980). Buffalo milk cheeses made with 'non-bitter' starter developed more acid soluble protein than those made with 'bitter' starter.

Homogenization of buffalo milk, even at very low pressures, yielded Mozzarella cheese that was softer and with significantly higher yield; the yield was higher by 8.0 and 9.0% over unhomogenized milk cheese when milk was homogenized at 2.45 MPa and 4.9 MPa pressure respectively. Such treatment led to buffalo cheese having moderate chewiness when judged as pizza topping, which was advantageous in sensory terms (Jana and Mandal, 2011).

Cheese obtained by blending buffalo milk with other milks

Mozzarella cheese prepared from a blend of cow and buffalo milk has been reported to possess better sensory quality and meltability than cheese made from milk of a single species. Buffalo milk Mozzarella cheese contains significantly higher protein, ash, Na, Ca and P content but had significantly lower moisture content than cheese made from mixed (cow and buffalo) milk. The buffalo milk cheese was firmer than that prepared from mixed milk (Sameen *et al*, 2008). Buffaloes' milk alone or combined with cow's milk is feasible for preparing Mozzarella cheese.

Mixing camel milk with buffalo milk (70:30 w/w) increased soft cheese yield, total solids, fat, ash, protein content and recovery of milk constitutes in resultant cheese and simultaneously decreased the weight loss of cheese during pickling period. Mixing of camel milk with buffalo milk improved the microbiological quality and organoleptic properties of resultant cheese during pickling (Shahein *et al*, 2014).

CLA enriched buffalo cheese

Conjugated Linoleic Acid (CLA) is an intermediary product produced during biohydrogenation of poly unsaturated fatty acids (PUFA) in the rumen. Buffalo milk fed on berseem (Trifolium alexandrinum Linn) fodder helped in enriching the buffalo milk with CLA. The Mozzarella cheese produced from such enriched milk had CLA content of 16.3 mg/g of fat (Tyagi *et al*, 2007). Lactococcus lactis *LMG*, L. rhamnosus *C14*, L. casei *CRL431*, L. acidophilus *Lac1*, L. plantarum-2, B. bifidum *CRL1399* and B. animalis *Bb12* have been successfully used as adjunct cultures for the manufacture of high CLA-content buffalo milk cheese (Van Nieuwenhove *et al*, 2007).

Traceability of buffalo milk cheese

In many countries, laws require producers to clarify the type of milk used for manufacturing dairy products. In the dairy industry, protection against species substitution or admixture is important for several reasons, including frequent human adverse reactions toward some species milk proteins, and trade and government regulations. The production of Mozzarella di Bufala Campana (MBC) is relevant for the agro-food economy of the Campania Region of Italy and the mark of Protected Designation of Origin (PDO) has been assigned to MBC in relation to its geographical origin. Advanced analytical methods are a requirement to assess the authenticity and traceability of MBC.

Use of species-specific primers in duplex polymerase chain reaction (PCR) assay has been recommended to detect the fraudulent addition of cow's milk to buffalo's milk and its products. The limit of detection of cow's milk in buffalo's cheese is 4% (Zarei *et al*, 2016). Another test uses SYBR green real-time PCR technique to detect cow milk in water buffalo cheese (Feligini *et al*, 2007). High Resolution Magic Angle Spinning Nuclear Magnetic Resonance (HRMAS-NMR) spectroscopy has been applied to identify specific metabolites (β-galactose, β-lactose, acetic acid, and glycerol) in MBC. Such spectroscopic method can rapidly characterise the metabolic profile of intact MBC samples and statistically distinguish the geographical origin of buffalo milk mozzarella and its freshness (Mazzei and Piccolo, 2012).

Conclusions

In countries where buffalo milk has a share in the total milk production, preparation of cheese should be encouraged for value addition to buffalo milk. The cheese technologists has the prowess to incorporate judicious modifications in the conventional cheese making protocol to obtain satisfactory quality cheese from buffalo milk with attendant higher yield and functionality (e.g. for baking). A time may come when there could be a compelling reason for the world to sample India's buffalo Mozzarella.

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