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Texture, flavor, and sensory quality of buffalo milk Cheddar cheese as influenced by reducing sodium salt content

M. A. Murtaza,*[1] N. Huma,† A. Sameen,† M. S. Murtaza,† S. Mahmood,* G. Mueen-ud-Din,* and A. Meraj*
*Institute of Food Science and Nutrition, University of Sargodha, Sargodha-40100, Pakistan
†National Institute of Food Science and Technology, University of Agriculture, Faisalabad-38040, Pakistan

ABSTRACT

The adverse health effects of dietary sodium demand the production of cheese with reduced salt content. The study was aimed to assess the effect of reducing the level of sodium chloride on the texture, flavor, and sensory qualities of Cheddar cheese. Cheddar cheese was manufactured from buffalo milk standardized at 4% fat level by adding sodium chloride at 2.5, 2.0, 1.5, 1.0, and 0.5% (wt/wt of the curd obtained). Cheese samples were ripened at 6 to 8°C for 180 d and analyzed for chemical composition after 1 wk; for texture and proteolysis after 1, 60, 120, and 180 d; and for volatile flavor compounds and sensory quality after 180 d of ripening. Decreasing the salt level significantly reduced the salt-in-moisture and pH and increased the moisture-in-nonfat-substances and water activity. Cheese hardness, toughness, and crumbliness decreased but proteolysis increased considerably on reducing the sodium content and during cheese ripening. Lowering the salt levels appreciably enhanced the concentration of volatile compounds associated with flavor but negatively affected the sensory perception. We concluded that salt level in cheese can be successfully reduced to a great extent if proteolysis and development of off-flavors resulted by the growth of starter and nonstarter bacteria can be controlled.
Key words: Cheddar cheese, sodium salt, texture, flavor, sensory quality

INTRODUCTION

Cow milk is under focus in most of the studies on milk, although milk of other species, such as sheep, goats, camels, and buffaloes, has nutritional potential in the human diet in different parts of the world (Ménard et al., 2010). Globally, Cheddar-type cheese is manufactured from cow milk; however, buffalo milk is at the top in milk production of Pakistan. India and Pakistan together produce more than 80% of the world's buffalo milk (Murtaza et al., 2012). It is more nutritious, being richer in lactose, fat, protein, calcium, magnesium, inorganic phosphate, and vitamins compared with cow milk (Ahmad et al., 2008). On account of its composition, buffalo milk offers exceptional prospects for the manufacture of different milk products (Murtaza et al., 2008).

Cheddar is a nutritious, hard type of cheese. It endures substantial modifications on account of ripening, which is the consequence of glycolysis, lipolysis, and proteolysis (Farkye 2004; Murtaza et al., 2012). These microbial and biochemical reactions are the foundation for development of flavor, texture, and sensory perception of cheese (Lucey and Singh 2003; Smit et al. 2005; Murtaza et al., 2013).

Sodium salt is extensively and effectively used as a preservative and flavor enhancer. Its concentration is imperative for physicochemical and sensory characteristics of dairy foods, particularly cheese (Mendil, 2006). Sodium chloride affects the compositional profile of cheese as well as water activity, microbial growth and activity of enzymes, curd syneresis, and solubility and hydration of protein during the course of ripening, leading the synchronized improvement in flavor and texture (Johnson et al., 2009; Murtaza et al., 2012; Rulikowska et al., 2013).

Consuming sodium contributes to the progression of hypertension, a predecessor for disorders, such as cardiovascular problems, leading to increased risk of heart attacks or strokes in many people (Cotugna and Wolpert, 2011; Grummer et al., 2013). Traditionally, the level of sodium salt in Cheddar-type cheese is about 2.0%. However, because of its adverse health effects, great demand exists to reduce the salt levels in cheese manufacturing (Rulikowska et al., 2013).

Keeping the particulars mentioned above in vision, this study was aimed to assess the effect of reducing the level of sodium chloride on water activity, proteolysis, texture, flavor, and sensory quality of Cheddar cheese prepared from buffalo milk.

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[1]Corresponding author: anjum_ft@yahoo.com or mian.anjum@uos.edu.pk

MATERIALS AND METHODS

Manufacturing and Ripening of Cheddar Cheese

Buffalo milk was obtained from the dairy farm at the University of Agriculture (Faisalabad, Pakistan) and standardized to a 4.0% fat level. Cheddar cheese was manufactured using commercially available freeze-dried mesophilic starter cultures (*Lactococcus lactis* ssp. *cremoris* and *Lactococcus lactis* ssp. *lactis*) and by adding sodium chloride at 2.5, 2.0, 1.5, 1.0, and 0.5% (wt/wt of the curd obtained), following the standard procedure described by Murtaza et al. (2012). Cheese samples were ripened at 6 to 8°C for 180 d.

Chemical Composition

One-week-old cheese was grated and analyzed for salt (NaCl), moisture, fat, protein, ash, pH, salt-in-moisture, fat-in-DM, and moisture-in-nonfat-substances in triplicate samples. Salt (by titration), moisture (oven drying), fat (Babcock method), protein (Kjeldahl method), and ash (ignition) content were determined as described by Kirk and Sawyer (1991). The pH was measured with a digital pH meter (Ong et al. 2007).

Proteolysis

Proteolysis in cheese samples was assessed at 60-d intervals during ripening using HPLC, following the procedure detailed by Hickey et al. (2006) and modified by Rulikowska et al. (2013). Five grams of cheese was homogenized in 20 mL of 0.1 *M* citrate buffer at pH 3.6 at 40°C for 1 h to separate the fat. The whole suspension was centrifuged at 3,000 × *g* for 30 min at 4°C. The resulting pellet (100 mg) was dissociated in 5 mL of disassociating solution and held in a water bath at 40°C for 1 h with periodic mixing. This mixture was then centrifuged at 20,000 × *g* for 10 min at room temperature and filtered through a nylon 0.45-mm syringe filter. An aliquot of 20 mL was injected into a Shimadzu liquid chromatograph (LC-10 AT VP series; Shimadzu Corp., Kyoto, Japan) with a UV-visible detector at 214 nm (Shimadzu Corp.). Separation was achieved using a gradient of 2 mobile phases: (A) 90% water and 10% acetonitrile with 0.1% trifluoroacetic acid and (B) 90% acetonitrile and 10% water with 0.1% trifluoroacetic acid at a flow rate of 0.8 mL/min. The gradient was 75% A for 12 min, reduced to 51% A over 31 min, a further reduction to 20% A over the next 13 min, held at 20% A for another 3 min, and then an increase to 75% A over 3 min and held at this concentration for a further 2 min; the total run time was 54 min. The column was a C4 Jupiter 5 mm 300 A column (Shimadzu Corp.).

Texture Profile Analysis

The effect of salt addition on the texture of Cheddar cheese was evaluated after 1, 60, 120, and 180 d of ripening by performing the texture profile analysis of the cheese samples on a texture analyzer (Stable Micro Systems Ltd., Godalming, UK), using compression plate probe P-75 as described by O'Mahony et al. (2005).

Volatile Flavor Compounds

The volatile compounds of Cheddar cheeses with varying salt levels were isolated using a dynamic headspace analyzer coupled with a gas chromatograph (Agilent Technologies Ireland Ltd., Little Island, Co. Cork, Ireland). The samples were prepared using the procedure of Rulikowska et al. (2013). The trapped volatiles were injected to the column of the gas chromatograph equipped with a capillary column. Mean peak areas were calculated for individual compounds using the Chemstation software and standard library (Agilent Technologies Ireland Ltd.). Volatiles analyses were performed in triplicate after 180 d of ripening.

Sensory Evaluation

Cheddar cheese samples was evaluated for sensory characteristics (odor, flavor, texture, mouthfeel, and overall acceptability) after 180 d of ripening on a hedonic rating scale (0–9) by a panel of 10 assessors drawn from faculty members and postgraduate students, as described by Awad et al. (2004). The samples awarded scores less than 5 were considered as of low quality.

Statistical Analysis

Each treatment (salt level) of cheese was produced in triplicate (n = 3). The results obtained from different parameters (no. of factors 1 and 2) were subjected to statistical analysis by ANOVA under a completely randomized design, as described by Steel et al. (1997).

RESULTS AND DISCUSSION

Cheese Composition

The compositional profile of Cheddar cheese is illustrated in Table 1. The cheese samples were significantly different in salt concentration as per addition of salt during manufacturing. Notably the reduction in sodium chloride content significantly decreased the losses of salt in whey. The noncomparative increase in salt uptake might be because of the associated variation in level of whey discharged from the curd after salt addition. As