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Utilization of temporal dominance of sensations and time intensity methodology for development of low-sodium Mozzarella cheese using a mixture of salts

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ABSTRACT

Evidence has linked excessive salt consumption to the development of chronic degenerative diseases. Therefore, special attention has been given to the consumption of healthier products with reduced sodium contents. This study aimed to develop a Mozzarella cheese with a reduced sodium content using a mixture of salts through acceptance testing and temporal sensory evaluation. The following 3 formulations of Mozzarella cheese were prepared: formulation A (control), which was produced only with NaCl (0% sodium reduction), formulation B (30% sodium reduction), and formulation C (54% sodium reduction). Every formulation was produced using a mixture of salts consisting of NaCl, KCl, and monosodium glutamate at different concentrations. The products underwent sensory acceptance tests, and the time intensity and temporal dominance of sensations were evaluated. The results showed that the proportions of salts used did not cause strange or bad tastes but result in lower intensities of saltiness. Mozzarella with low sodium content (B and C) had a sensory acceptance similar to that of traditional Mozzarella (A). Therefore, the use of a mixture of salts consisting of NaCl, KCl, and monosodium glutamate is a viable alternative for the production of Mozzarella, with up to a 54% reduction in the sodium content while still maintaining acceptable sensory quality.
Key words: KCl, monosodium glutamate, temporal dominance of sensations, time intensity

INTRODUCTION

Sodium chloride is traditionally used as a food additive in food processing. In addition to its influence on the taste of products, it has an important role with regard to texture and storage. However, due to the high sodium content, NaCl has also been associated with an increased risk of hypertension, the development of cardiovascular disease, osteoporosis, and the incidence of kidney stones (Weinsier, 1976; Sihufe et al., 2003; Heaney, 2006; WHO, 2007). Therefore, special attention has been paid to the consumption of foods containing sodium because of its role in increasing the risk of chronic diseases (Roberfroid, 2000; Menrad, 2003) and, consequently, the emerging need for low-sodium product development (Katsiari et al., 2001; Matthews and Strong, 2005; Ruusunen and Puolanne, 2005; Guàrdia et al., 2008; Albarracín et al., 2011).

Because of concerns about excess sodium intake, the Ministry of Health and the Brazilian food industry reached an agreement to reduce the sodium content of various categories of foods by 2016. The Food Standards Agency in the United Kingdom has also revised its targets for reducing salt (NaCl) in processed foods, and the Food and Drug Administration (FDA) is working with the US food industry to reduce sodium content in foods (FDA, 2010). However, the reduction in sodium content in food products is a challenge for the food industry because it is often reported that a decrease in NaCl content is associated with a decrease in product acceptance (Sofos, 1983; Breslin and Beauchamp, 1997; Toldrá, 2006).

Several substitutes for NaCl have been studied. One is KCl due to its similar physical properties, but complete replacement of NaCl by KCl is not recommended because of the bitter taste the latter gives to products, which is generally only somewhat acceptable (Nascimento et al., 2007). Thus, using a combination of salts for the preparation of products with reduced sodium and good sensory acceptance is an interesting option.

In addition to the use of KCl, an interesting alternative to promote the reduction of sodium content in foods is the use of flavor enhancers such as monosodium glutamate (**MSG**; Brandsma, 2006; Desmond, 2006). The umami taste allows the MSG to be used as a substitute for NaCl, reducing its usage between 30 and 40% in food (Yamaguchi and Takahashi, 1984). This additive contains approximately 13% sodium, leading to less than half of the sodium intake of NaCl, where the sodium ion is approximately 40% of the molecular

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mass. However, when the goal is to reduce the sodium concentration to prevent cardiovascular problems, it cannot be overlooked that MSG, even if at a lower concentration, is also an important source of sodium (Sugita, 2002). Mojet et al. (2004) showed that the umami taste of MSG helps the perception of saltiness in food and predicted that the NaCl content may be reduced in foods that contain a lot of umami without decreasing consumer acceptance. Therefore, it would be interesting to use a combination of NaCl, KCl, and MSG in the production of products with reduced sodium content.

Replacement salts containing K, Mg, and Ca have been investigated in various cheeses (Katsiari et al., 2001; Johnson et al., 2009; Ayyash and Shah, 2011a,b; Gomes et al., 2011; Ortakci et al., 2012). Grummer et al. (2012) showed that KCl can be used successfully to achieve large reductions in sodium when replacing a portion of the NaCl in Cheddar cheese. It is possible to produce this low-sodium Cheddar cheese in a way that results in high consumer acceptance and low bitterness (Grummer et al., 2013). Another cheese that can be prepared by partial substitution (25%, wt/wt) of NaCl with KCl at the salting step is low-sodium Minas fresh cheese (Gomes et al., 2011). Kamleh et al. (2012) and Karimi et al. (2012) also demonstrated that Halloumi cheese and Feta cheese could be successfully manufactured using NaCl and KCl. Kamleh et al. (2012) further suggested using ingredients that would help mask this bitterness and thus improve the acceptability of Halloumi. Drake et al. (2011) studied the sodium reduction in cheese sauce, cottage cheese, and milk-based soup and they found that the complexity of the food matrix influenced salty taste perception and the percentage sodium reduction that was noticeable to consumers. Thus, further research for each product is necessary to further clarify salty taste perception in each product.

Among products with high sodium content, Mozzarella cheese, which, according to research from the National Brazilian Sanitary Surveillance (ANVISA), has an average sodium content of 577 mg/100 g, with results ranging from 309 to 1,068 mg (Brazilian Health Surveillance Agency, 2012), stands out. In addition, due to changes in eating habits, including the increased consumption of foods such as fast food and pizza, Mozzarella cheese is currently one of the most manufactured and consumed cheeses in Brazil and in the world (Santos, 2009), In addition, use of Mozzarella cheese as an ingredient in sandwiches and for other culinary applications, has increased, which has resulted in a natural tendency for these products to contain increased sodium contents (Cruz et al., 2011a). Cheeses enhance the taste of preparations to which they are added, including pies, stuffings, and pasta sauces. Recently, high sodium contents of several hot takeout meals in the United Kingdom have been reported, with sodium contents varying from 1.32 to 1.65 g of salt/100 g across several pizzas, for which the main ingredient is Mozzarella cheese (Jaworowska et al., 2012), which makes reducing the sodium content of this cheese important.

Because the replacement of NaCl with other salts during the preparation of Mozzarella cheese raises several questions about the potential to reduce the saltiness and the possible introduction of metallic, bitter, and astringent tastes, it is necessary that, in addition to sensory acceptance tests, tests to characterize the sensory profile of the product during its consumption, such as the analysis of time-intensity (**TI**) and the analysis of temporal dominance of sensations (**TDS**), are also performed. Therefore, this study aimed to develop an accepted Mozzarella cheese with reduced sodium content, using a mixture of salts consisting of NaCl, KCl, and MSG in different concentrations, through acceptance testing and temporal sensory evaluation (TI and TDS).

MATERIALS AND METHODS

Ingredients

The materials used in the preparation of Mozzarella cheese were standardized and pasteurized milk (3% fat), mesophilic starter TCC-20, which is a starter culture for direct use that contains *Streptococcus salivarius* ssp. *thermophilus* (40%) and *Lactobacillus helveticus* (60%; Chr. Hansen A/S, Hørsholm, Denmark), 50% (wt/vol) calcium chloride solution, bovine rennet powder (Hansen Industries and Co., Valinhos-SP, Brazil), potassium chloride (99%; Vetec Química Fina Ltda, Duque de Caxias, RJ, Brazil), MSG (99%; Ajinomoto, São Paulo, SP, Brazil), and NaCl (99%; Vetec Química Fina Ltda).

Preparation of Mozzarella Cheese

The Mozzarella cheeses were manufactured according to the methodology described by Furtado (1990), with some modifications. Figure 1 shows a flowchart of the manufacturing process for Mozzarella cheese.

For the preparation of Mozzarella formulations, 40 L of homogenized, pasteurized, and standardized milk was tempered to 35 ± 1°C with mesophilic starter in the amount recommended by the manufacturer. Subsequently, the milk was subjected to preaging for a period of 40 min at the same temperature. After preripening, the milk was added to the 50% $CaCl_2$ solution (0.4 mL/L of milk) with rennet powder in an amount sufficient for clotting to occur in 50 min. The obtained curd was cut to obtain 1-cm^3 edges.

After the cutting step, the solution was allowed to clot at rest for 5 min; then, the curd was slowly stirred for 10 min. To enhance the desired Mozzarella cheese