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Novel utilization of milk-based ingredients in salt reduced fish pudding

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ABSTRACT

Both the food industry and the health authorities have increased their focus on salt reduction in food, due to the known negative health effect of high sodium intake. For this reason, there is great interest in developing products with reduced salt content without affecting properties related to sensory parameters, texture, yield and shelf-life. Whey and milk based permeates with favorable combinations of milk minerals and lactose can be used as natural ingredients in for instance meat and fish products and work as salt replacers. The aim of this study was to investigate how two different types of milk minerals; low mineral permeate, based on whey obtained in cheese production, and high mineral permeate, based on milk, affect the quality of comminuted fish products, using fish pudding as a model. Results showed that low mineral permeate can improve textural and water-holding properties of puddings at salt concentrations down to 0.8%, while it does not affect salt flavor. High mineral permeate contributes to changes in the textural and water-holding properties, and also increases salt flavor. Based on investigated factors, high mineral permeate is regarded as a promising salt replacer allowing for considerable salt reduction in fish puddings.

1. Introduction

Salt (NaCl) is a well-established and widely used food additive due to its contribution to several desired properties, in addition to being inexpensive. A high intake of sodium is associated with greater risk of high blood pressure, which is a major cause of cardiovascular disease and stroke (Cook et al., 2007; He, Burnier, & MacGregor, 2011). Based on this, public health and regulatory authorities (FSA, 2004; The Norwegian Directorate of Health, 2011; WHO, 2006) have published advisory guidelines for reduction of salt intakes down to 5 g/day or lower. However, the daily salt intake per person in most European countries is twice as high as the maximal recommended salt intake.

Salt is commonly employed in fish processing, due to its excellent preservative effects, taste as well as positive technological effects (Fuentes, Ferandez-Segovia, Barat, & Serra, 2010; Martínez-Alvarez & Gómez-Guillén, 2006). Favorable health effects from intake of fish combined with the need to lower salt intake in the population has led to the desire of producing fish-based products with high fish and low salt content. Whey and milk-based permeates with favorable combinations of milk minerals and lactose can be used as natural ingredients in for instance meat and fish products and work as salt replacers. The food industry employs various milk-based ingredients in form of powders such as whey, whey permeate, lactose, skimmed milk and whole milk, which contributes to textural properties, water-holding and desirable milk, sweet and umami flavor. In a product with a high percentage of milk and/or cream such as fish pudding, the flavor of milk and umami are desired. The lactose in the milk-based ingredients contribute to a browning Maillard reaction as well, this is desirable in products such as fish puddings (BeMiller & Whistler, 1996). Challenges connected to the use of high level of whey permeate and milk-based permeate are mainly connected to their contribution of flavors that might be unexpected in some foods.

In the manufacture of minced fish products such as fish puddings and pâtés, the functional properties of the milk proteins and the fish muscle proteins including water holding capacity and gelling properties are important influencing the product quality (Martinez-Alvarez & Gomez-Guillen, 2005). Fish muscle proteins

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can form stable gels when heated and the ionic strength as well as type of salt is important for the behavior of the proteins during heating. To form gels, the myofibrillar proteins must be solubilized (Jafarpour & Gorczyca, 2012). Both water binding and holding properties as well the gelling properties have been shown to be related to the solubility properties of the proteins in the food (Kinsella, 1976; Nayak, Kenney, & Slider, 1996; Nguyen, Thorarinsdottir, Gudmundsdottir, Thorkelsson, & Arason, 2011).

In addition to potentially allowing a salt reduction, the use of whey permeate in food for human consumption is favorable due to the fact that whey is a by-product and large amounts of whey is discarded without exploitation of its potential as a food ingredient. Whey and milk based permeates contain high amounts of minerals such as Ca^{2+}, Na^{+} and K^{+} and due to this it would be valuable to increase the knowledge of using whey permeate as a salt replacer. Various authors have reported that when NaCl is partially replaced with other salts like KCl, $MgCl_2$, $CaCl_2$ this will affect the enzyme activity, protein matrix and texture (Andreetta-Gorelkina, Greiff, Rustad, & Aursand, 2014; Barat, Pérez-Esteve, Aritoy, & Toldra, 2012; Martínez-Alvarez & Gómez-Guillén, 2013).

The aim of this study was to investigate the possibility of using milk minerals to reduce the salt content in products based on haddock (*Melanogrammus aeglefinus*) mince. Two different powders were tested; low mineral whey permeate (LM), which is based on whey obtained in cheese production, and high mineral milk permeate (HM), which is based on milk. In order to investigate the outcome of their addition in fish-based products, the effect on the flavor of fish puddings, and also their effect on other physical properties such as texture, color, water-holding properties and protein solubility were investigated.

2. Material and methods

2.1. Chemical compounds

Ammonium Chloride (PubChem CID:25517), Ammonium Hydroxide (PubChem CID:14923), Ammonium Hydrogen Fluoride (NH_4FHF < 1%, LD_{50} mg/kg not found), sodium chloride (PubChem CID:5234), potassium chloride (PubChem CID:4873), potassium dihydrogen phosphate (PubChem CID:516951), (Thermo Fisher Scientific, USA or ACS, ISO, Merck, MA, USA). All the chemicals were of analytical-reagent grades.

2.2. Materials

Haddock (*Melanogrammus aeglefinus*) fillets (Laks- & Vildtcentralen AS, Oslo, Norway) were stored at 4 °C until production of the fish mince (1 day), and put on ice during production. Two different permeate powders were used in this study; low mineral whey permeate (LM) with high lactose and low mineral content, and high mineral milk permeate (HM) with low lactose and high mineral content. LM is constituted by 85 g lactose/100 g, 7 g salt/100 g, 3 g NPN (non-protein nitrogen)/100 g and 1 g lipids/100 g and HM by 47 g lactose/100 g, 37 g salt/100 g, 5 g NPN (non-protein nitrogen)/100 g and <1 g lipids/100 g. Additional ingredients used in the minces were skimmed milk (TINE SA, Oslo, Norway), potato flour (HOFF SA, Gjøvik, Norway) and Jozo salt (iodine free, Akzo Nobel Salt, Göteborg, Sweden).

2.3. Sample preparation

Preparation of fish puddings was performed at TINE R&D (Oslo, Norway). Each recipe was produced in batches of 5 kg. The minces were prepared in a bowl cutter (KILIA, Neunmünster, Germany). Ingredients were added during mincing in the following order: haddock fillet, salt, spices and permeate powders, milk (1/2), potato flour and milk (1/2). Controls were produced without addition of permeate powder. Mincing was ended when the mince temperature had reached 15 °C (after ~4 min). Mince was transferred to aluminium moulds (lightly sprayed with cooking spray to avoid sticking) to give puddings of approximately 200 g, and were cooked in water bath at 110 °C for 45 min (preliminary experiment) or 50 min (main experiment). The puddings were vacuum-packed (98% vacuum, 0% gas, time 1.6, Tecnovac, Confezionatrici Packaging Machines, Grassobio, Italy) and stored at 4 °C until further analyses.

2.4. Preliminary experiment

The composition of fish puddings in the preliminary experiment are given in Table 1. Two salt levels (0.5 and 1.0 g/100 g) and five permeate powder levels (control), 1.5 g LM/100 g, 2.9 g LM/100 g, 1.5 g HM/100 g, 2.9 g HM/100 g were used in the preliminary experiment. The calculated salt concentration in the minces is based on the sodium content in all the added ingredients (total sodium content × 2.54). The potassium (K^{+}) content was calculated to be between 0.25 and 0.77 g/100 g. Three of the recipes were produced in duplicate batches to estimate reproducibility, giving a total of 13 batches. The minces had a content of 52.3 ± 1.0 g haddock fillet/100 g, 43.4 ± 0.8 g skimmed milk/100 g, 2.0 g potato flour/100 g, 0.1 g mace/100 g and 0.1 g white pepper/100 g.

2.5. Main experiment

The composition of fish puddings in the main experiment are given in Table 2. Based on the results from the preliminary experiment, three salt levels (0.6, 0.8 and 1.0 g/100 g) and three permeate powder levels (control, 2.9 g LM/100 g and 2.2 g HM/100 g) were used in the main experiment. The calculated salt concentration in the minces is based on the sodium content in all the added ingredients (total sodium content × 2.54). The potassium content in the control, LM and HM mince were calculated to be 0.25, 0.30 and 0.64 g/100 g, respectively. Three of the recipes were produced in duplicate batches, giving a total of 12 batches. The minces had a content of 52.7 ± 0.7 g/100 g haddock fillet, 43.6 ± 0.8 g/100 g skimmed milk, 2.0 g/100 g potato flour, 0.1 g/100 g mace and 0.1 g/100 g white pepper.

2.6. Physicochemical analyses

2.6.1. Cooking loss

Cooking loss (%) was determined by weighing the mince in preweighed moulds before cooking, and weighing them again after cooking and cooling.

2.6.2. Water holding capacity/water content

Water-holding capacity (WHC) of the puddings was determined using a low-speed centrifugation method as described by Eide, Børresen, and Strøm (1982). Analyses were run in quadruplicate. The WHC is expressed as percentage of water retained in the pudding cubes after centrifugation at 210 × g for 5 min.

Total water content in haddock fillet, fish minces and puddings was determined by drying approximately 2 g of sample ($n = 2$) at 105 °C for 24 h. Results were mean of 2 determinations and were expressed as g water/100 g of sample.

2.6.3. Extraction of water and salt soluble proteins

Proteins were extracted from the minces by a modification of the methods of Anderson and Ravesi (1968) and Licciardello et al. (1982), as previously described by Hultmann and Rustad (2002).