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Free-sodium salts mixture and AlgySalt® use as NaCl substitutes in fresh and cooked meat products intended for the hypertensive population

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ABSTRACT

This work aims at reducing the use of added NaCl in processed meat products because of its negative effects on hypertensive population by replacing it by sodium-free salts mixture (SM: KCl, $MgCl_2$ and $CaCl_2$) in fresh and cooked sausages. The technological, sensory, and microbiological effects of SM were compared with a commercial replacer based on seaweed extracts (AlgySalt®). A total substitution of NaCl with the latter and a partial one with SM (80% and 50%) were studied in cooked sausages and a total NaCl substitution with both substitutes was performed in fresh sausages. As a result, hardness increased in AlgySalt® reformulated samples, while it decreased when 80% SM were used. Whereas, AlgySalt® induced less cooking loses than SM. To some extent, microbiological counts showed a similarity between reformulated and control samples for both sausage types, whereas reformulated products containing SM revealed better sensory properties for both meat products. Therefore, using SM as NaCl replacer is adequate for processed meat products.

1. Introduction

In the recent decades, the agro-food sector has registered a much accelerated growth mainly thanks to the technological innovation of its products, which was mainly based on their organoleptic acceptability by the consumers. This growth is primarily due to the evolution of lifestyles, urbanization, and habits which are heading more towards the consumption of processed foods. However, in order to be well accepted by the consumers, the industry promotes food products containing high amounts of *trans* acids, saturated fat, sugars, and salt (NaCl). The latter is the main source of sodium, which, when overconsumed, causes an increase in blood pressure and leads to several complications either at heart muscle or arteries level (Doyle & Glass, 2010). Moreover, a large percentage of the World's population has a genetic predisposition to high blood pressure which is being caused by weight excess and high sodium consumption. Several scientific studies such as those by Doyle and Glass (2010) and Haizhou et al. (2015) showed that over-consumption of sodium and insufficient absorption of potassium (< 3.5 g/day, (WHO, 2016)) contribute to the appearance of non-communicable diseases NCD such as high blood pressure, cardiovascular disease (CVD) and strokes. These are the main causes of morbidity (45% of CVD are caused by hypertension) and mortality (13% of deaths) in the world. Salt can become harmful when consumed in amounts which exceed the recommended daily intake of 5 g/day, equivalent to 2 g/day of sodium (WHO, 2016). It should be noted that one gram of sodium chloride (NaCl) contains 0.40 g of Na (i.e. 17 mEq). However, the daily food intake in Western countries provides 9 to 12 g of NaCl, 3.6 to 4.8 g of Na (172–258 mEq) which is twice the recommended maximum level of intake.

Therefore, a reduction in NaCl consumption has been recently recommended by qualified international institutions such as the NAOS (2009) strategies. The latter published a report analyzing the main sources of sodium in the diet, among which meat products are the most represented ones. Indeed, Meat derivatives have high concentrations of sodium, including transformed meat products such as cooked and fresh ones (about 1720 mg/100 g and 925 mg/100 g, respectively) (ANSES, 2013). The estimates indicate that approximately 30% of the dietary sodium comes from the consumption of meat and its products (NAOS, 2009), although sodium is relatively low in meat (contains < 100 mg of Na per 100 g [Ruusunen & Puolanne, 2005]). Several publications put emphasis on the importance of sodium content reduction and its impact on techno functional and the food organoleptic properties of different

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types of meat products (Gelabert, Gou, Guerrero, & Arnau, 2003). As to our knowledge, there are few studies on the reduction of sodium in fresh meat products (Pasin et al., 1989; Triki, Herrero, Jiménez-Colmenero, & Ruiz-Capillas, 2013). However, significant efforts have been made to reduce the contents of Na in fermented, matured, and cooked meat products (Aaslyng, Vestergaard, & Koch, 2014; Ruusunen et al., 2005). These strategies are essentially based on either simple reduction or partial substitution of sodium chloride with other compounds that might produce similar effects to NaCl. Depending on the product type, these substitutions revealed different problems mainly because salt (NaCl) is essential for the preparation of meat products as it has various functions on the texture, flavor, and microbial development (Weiss, Gibis, Schuh, & Salminen, 2010). To address these primary functions of salt, different alternatives have been studied a case in point is the use of KCl. Nevertheless, the concentration of the latter was limited to 0.5–0.6% because of its bitter and metallic flavors that can reduce sensory properties (Desmond, 2006). Other compounds were incorporated such as phosphate and organic acid salts that are associated with other ingredients and additives, such as proteins, dietary fibers, hydrocolloids, and starches. The latter was used as supplements to alternative salts to improve the stability of the products, because they have a high water and fat retention capacity (Ruiz-Capillas & Jiménez-Colmenero, 2009; Ruusunen & Puolanne, 2005; Totosaus & Perez-Chabela, 2009; Verma, Sharma, & Banerjee, 2010). According to the existing literature, the decrease in the level of sodium in meat products through NaCl substitution by a mixture of salts of potassium, calcium, and magnesium yielded very satisfying results (Armenteros, Aristoy, & Toldrá, 2009; Gimeno, Astiasarán, & Bello, 2001; Triki et al., 2013; Zanardi, Ghidini, Conter, & Ianieri, 2010). Therefore, it would be interesting to study this type of reduction in processed meat products offered to consumers.

In this context, the objective of this study is to reduce sodium level in meat products through the substitution of added NaCl by a mixture of KCl, $CaCl_2$ and $MgCl_2$ salts (SM). Moreover, the effects of SM use will be compared to the one of a commercial substitute which is an extracted from seaweed (AlgySalt®). The studied meat derivatives are processed fresh and cooked products that will be compared to the reformulated products in terms of sensory, technological and microbiological attributes. AlgySalt® was chosen as one of the studied substitutes because of its natural and innovative composition in seaweed extracts, which is totally different from SM, as well as its commercial appeal to the international market (a wide range of countries from the European, Asian and African continents).

2. Material and methods

2.1. Fresh and cooked meat sausages manufacturing

2.1.1. Fresh meat sausages

Fresh meat sausages were made from minced turkey meat and beef fat as raw material. Other ingredients were added such as 3.9% of spices (including 0.5% of coriander [Naturel, Conditionnement de produits agricoles, El Sahlin, Tunisia], 0.8% of fennel, 0.2% of paprika, 0.2% of hot pepper, and 0.2% of mint [the four spices were obtained from Kamy S.A., Nabeul Tunisia] and 2.0% of a commercial preparation of Harissa [Le phare du Cap bon Ferrero, SCAPCB S.A., Grombalia, Tunisia]. The harissa paste is composed of 87% of chili pepper, 4% of garlic, 4% of coriander, 3% of salt, and 2% of caraway), water, NaCl, and 2.254% of additives (including 0.004% of E250 sodium nitrite, 0.03% of E120 dye, and 2.22% of E1422 modified starch all of them purchased from Sigma Aldrich, France). AlgySalt® was used for the reformulated products. It is a seaweed mixture including an ensemble of algae which are *Lithothamnium calcareum*, *Laminaria*, *Enteromorpha*, *Ascophyllum nodosum*, *Palmaria palmata*, *Fucus vesiculosus*, *Himanthalia elongata*, *Laminaria saccharina*, *Ulva lactuca*, *Chondrus crispus*, *Porphyra umbilicalis*, Palmaria/Porphyra/Ulva, and *Undaria pinnatifida*. This product also contains minerals, hydrocolloids, and fibers of the aforementioned seaweeds origin. First, minced meat (70%) and fat (20%) were mixed in a cutter (GARANT 35 H Bowl Chopper, floor-mounted, Germany). Then the ingredients and additives (6.154%) were added uniformly, including NaCl (0.846%) (for control samples), during 5 min at 4 °C. Finally, water (3%) was added to the final mixture. Four formulations were manufactured: a control sample with 0.846% of NaCl (FC); a total NaCl substitution with a Salt Mixture (SM: 50% KCl, 35% $MgCl_2$, and 15% $CaCl_2$) (FSM); a total NaCl substitution with AlgySalt® (FA); and a sample without NaCl (FN), which was substituted by water. The later was chosen as a NaCl replacer for different reasons. The main ones were the following: a) The FN formulation was used as a positive control in terms of NaCl total absence; and b) In order to have results that can be interpreted, the experimental design took into consideration that water is a non-meat ingredient which is present in all formulations as well as being the major component (moisture) of the fresh sausages (Triki et al., 2013). Therefore no additional variables would interfere in the discussion of our findings. The embossing was conducted manually into a 22 mm-diameter natural casings (mutton origin). The fresh meat products were stored at 4 °C in EPS trays (Type 89 white SPT—Linpac Packaging Pravia, S.A. N R.G.S., Spain) and covered with oxygen-permeable cling film (LINPAC Plastics, Pontivy, France) in aerobic conditions during 7 days. This manufacturing process was repeated three times to assure the process repeatability. Thus, three separate independent batches of the base sausage mixture were prepared. Every manufactured formulation yielded an average of 190 sausages per formulation.

2.1.2. Cooked meat sausages

Cooked meat sausages were made from mechanically separated turkey meat (MSM) as raw material. Other additives (including 0.002% of E450 diphosphate, 0.002% of E451 triphosphate, 0.002% of E452 polyphosphate, 0.04% of E120 dye, 8.15% of E1422, 0.094% of E300, and 0.01% of E250 sodium nitrite purchased from Sigma Aldrich, France) and ingredients (including 0.85% of paprika and 0.85% of hot pepper obtained from Kamy S.A., Nabeul Tunisia) were used for the formulation as well as AlgySalt® as one of the substitutes of NaCl.

The Protocol for the manufacturing of the cooked meat product was similar to the one used for fresh meat sausage with the exception using mechanically separated meat (MSM) (80%) instead of minced meat. Then, additives and ingredients (10%) as well as NaCl (2%) (for control samples) and water (8%) were added and mixed using a cutter (GARANT 35 H Bowl Chopper, floor-mounted, Germany). The embossing was made in 58 mm-diameter opaque Polyvinylidene chloride (PVDC) artificial casings (Krehalon, France). After that, the embossed sausages underwent a cooking stage at 80 °C for 30 min in a water bath (Haake L, Haake Buchler Instruments, Karlsruhe, Germany). A thermocouple was set in the center of the sample to follow the product core temperature. Afterwards, sausages were first cooled in a mixture of cold water and ice until core temperature reached < 10 °C and then stored at 4 °C during 15 days. Four formulations were developed: a control sample with 2% of NaCl (CC); two partial NaCl replacements with the SM, one sample with 50% substitution of the NaCl (C50) and another one with 80% substitution (C80); and a total NaCl substitution with AlgySalt® (CA). The manufacturing process was repeated three times to assure the process repeatability. Thus, three separate independent batches of the base sausage mixture were prepared. Every manufactured formulation yielded an average of 95 sausages per formulation.

2.2. Physicochemical properties

2.2.1. Mineral composition

For minerals determination (Na, Ca, and K), we used the methodology of Serrano et al. (2005). Mineral content was expressed in mg/kg of the product that is obtained through an atomic absorption