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Impact of ingredient replacers on the physicochemical properties and sensory quality of reduced salt and fat black puddings

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ABSTRACT

Twenty-two black puddings possessing different fat (10%, 5%) and sodium (0.6%, 0.4%) levels were used as base formulations for 11 different salt and fat replacers. Compositional, physicochemical and sensory analyses were conducted. Black pudding samples with 5% fat and 0.6% sodium containing potassium chloride (KCl), potassium chloride and glycine mixture (KClG), and seaweed, respectively, and 10% fat and 0.4% sodium containing carrageen were rated higher ($P < 0.05$) for spiciness and saltiness. Samples with 10% fat and 0.4% sodium containing KClG were rated positively ($P < 0.05$) to fatness. Samples with 5% fat and 0.6% sodium containing pectin and a combination of potassium citrate, potassium phosphate and potassium chloride (KCPCl), as well as samples containing 10% fat and 0.4% sodium with waxy maize starch (WMS) were liked ($P < 0.05$) for flavor and overall acceptance. The Food Safety Authority of Ireland (FSAI) recommends a sodium target level of 0.6% and an even lower sodium level (0.4%) was achieved.

1. Introduction

Processed meats have moved more into public focus over the past 20 years for many reasons, but particularly with respect to health concerns. Irrespective of public opinion, the processing of under-utilized meat is necessary on ethical grounds alone as it is responsible for converting inedible material to a more palatable form, thereby reducing food waste and generating more protein-based food products which also present product diversity in the marketplace. Additionally, and more specifically, processing extends shelf-life, improves texture and enhances overall flavor. However, meat processing inevitably leads to products having higher amounts of salt, saturated fatty acids and preservatives such as nitrates which have health implications (de Barcellos, Grunert, & Scholderer, 2011), particularly where overconsumption of such products occurs. A higher risk of coronary heart disease, stroke, cancer and obesity has been tenuously linked with their consumption (Demeyer, Honikel, & De Smet, 2008; Gilbert & Heiser, 2005; Verbeke, Pérez-Cueto, De Barcellos, Krystallis, & Grunert, 2010; WHO, 2003, 2009). In recent years, worldwide healthcare campaigns have attempted to educate consumers with respect to the associated risks of an over-dependency of a fat-, sugar- and salt rich diet.

Meat product suppliers have already commenced reformulating their recipes, and now offer lower levels of nitrate, salt and fat, or even higher levels of polyunsaturated fatty acids in processed meat products on the market (Verbeke et al., 2010). Additionally, several studies have looked at sensory focused salt and fat reduction in processed meats including beef patties (Tobin, O'Sullivan, Hamill, & Kerry, 2012b), breakfast sausage (Tobin, O'Sullivan, Hamill, & Kerry, 2013), frankfurters (Tobin, O'Sullivan, Hamill, & Kerry, 2012a) and white pudding (Fellendorf, O'Sullivan, & Kerry, 2015) to mention but a few. However, there is still a huge potential to produce even healthier and more sensory accepted products. With regard to achieving such acceptable products, the use of ingredient replacers such as hydrocolloids (a range of polysaccharides and proteins) could be utilized in the meat processing industry, as they have been used in processed meat products for many years to improve properties such as water binding and texture due to their ability to thicken, gel, bind, stabilize emulsions and pH (Andrès, Zaritzky, & Califano, 2006). Hydrocolloids, based on animal proteins, include; casein, whey, gelatin and blood-derived protein. Additionally, an enormous range of polysaccharides are available on the market, such as starches (corn, wheat, maize, potato, tapioca, pea), celluloses (carboxymethylcellulose), gums (guar, alginate, pectin, locust bean), fibers (β-glucan), chitin/chitosan and xanthan derived from microorganisms (Cutter, 2006). Recently, published studies have also presented the use of different types of edible seaweed (Sea Spaghetti, Wakame and Nori) in meat products (Cofrades, López-López, Solas, Bravo, & Jiménez-Colmenero, 2008; Jiménez-Colmenero et al., 2010; López-López, Cofrades, Yakan, Sola, & Jiménez-Colmenero, 2010). Seaweeds are a rich source of minerals, trace elements, proteinaceous compounds and flavor precursors (reducing sugars) which can act as flavor enhancers, or even as reactants in the flavor developing process

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(Maillard reaction, caramelization), within processed meats. Additionally, seaweeds comprise a unique taste profile, which might replenish lost flavor in reduced salt and fat processed meat products (Hotchkiss, 2012). However, the most commonly used salt replacer is potassium chloride, although it is self-limiting due to its bitterness and metallic flavor when used above certain concentrations (Dzendolet & Meiselman, 1967). Nevertheless, Zanardi, Ghidini, Conter, and Ianieri (2010) reduced successfully the sodium content in Cacciatore salami, a typical Italian dry fermented sausage, by using a mixture of KCl, $CaCl_2$, and $MgCl_2$. Recently, the authors dos Santos, Campagnol, Morgano, and Pollonio (2014) reported that fermented cooked sausages containing monosodium glutamate combined with lysine, taurine, disodium inosinate and disodium guanylate masked the unpalatable sensory attributes linked with the replacement of 50% and 75% NaCl with KCl. Following, salt enhancers such as amino acids (glycine, glutamate), lactates and yeast extracts have found applications in processed meat. These substances have no salty taste themselves, although with the combination of sodium chloride, they are able to enhance the salty flavor (Desmond, 2006).

The present study investigated black pudding typically made in the United Kingdom and Ireland, which contains lean pork meat, pork fat, grains, onions, salt, blood powder and seasonings. The majority of commercially available black puddings contain between 14% and 16% fat, whereas the maximum commercial levels determined for products exceed 20% (unpublished data, 2013). The Food Safety Authority of Ireland (FSAI) reported that the levels of sodium concentrations in black and white puddings range between 520 mg and 1190 mg, with an average of 867 mg (FSAI, 2014). Due to health issues pertaining to higher salt and saturated fat levels in meat products, the FSAI have set a guideline for the Irish industry to decrease the sodium level in black pudding to at least 600 mg/100 g (FSAI, 2011). Furthermore, the World Health Organization (WHO) recommends a lower intake of saturated fatty acids and additional a daily intake of polyunsaturated fatty acids (PUFAs) between 6% and 11%, based on daily energy intake (WHO, 2003).

In a previous study by Fellendorf, O'Sullivan and Kerry (unpublished, 2014) black pudding samples with 10% fat and 0.6% sodium was found to be accepted ($P < 0.05$) by consumers without the requirement for replacer usage at all. Consequently, there is an enormous potential to achieve lower salt and fat levels in black puddings through the use of ingredient replacers. Therefore, the objective of this work was to investigate the impact of using different salt and fat replacers on the physicochemical properties and sensory quality of low fat and low salt black puddings with the primary focus of producing a more highly accepted end product with further reductions in fat and salt levels.

2. Materials and methods

2.1. Sample preparation

Pork trimming lean (visual lean score of 95%) and pork fat were purchased from a local meat supplier (Ballyburden Meats Ltd., Ballincollig, Cork, Ireland). Meat and fat were minced to a particle size of 10 mm and 5 mm, respectively (TALSABELL SA., Valencia, Spain), vacuum packed and stored at −20 °C. Twelve hours before commencing production, required portions of meat and fat were defrosted at room temperature to reach a processing temperature of 4 °C. Eleven different replacers were investigated for black puddings containing either 10% fat and 0.4% sodium or 5% fat and 0.6% sodium. Replacers chosen for investigation were as follows; wheat bran, sodium citrate, carrageen, pectin, potassium chloride (KCl), a mixture of potassium chloride and glycine (KClG), carboxymethylcellulose (CMC), PuraQ®Arome NA4 (PuraQ) (Corbion Purac, Barcelona, Spain), seaweed wakame (seaweed), a combination of tripotassium citrate, monopotassium phosphate and potassium chloride (KCPCl) and waxy maize starch (WMS). PuraQ is a product from the fermentation of sugar resulting in a mixture of sugars, salts of organic acids and aromas. The used quantities of the replacers and the detailed formulations of black puddings are listed in Table 1. As the ingredient seaweed (wakame) already contained sodium, a lower amount of salt was required during production in order to achieve target levels. The required ingredients were then weighed according to the recipe. Meat, fat, seasoning, salt, replacer and three-quarters of the water were added into the bowl chopper (Seydelmann KG, Aalen, Germany) and chopped at high speed (3000 rpm) for 45 s, followed by addition and mixing of the remaining water and blood powder at high speed for 30 s. The required pinhead oatmeal and dried onions were then chopped at low speed (1500 rpm) for 15 s and finally, the required boiled pearl barley and rusk were chopped at low speed for 30 s. The batter was afterwards placed into a casing filler (MAINCA, Barcelona, Spain), filled into polyamide casings and cooked in a Zanussi convection oven (C. Batassi, Conegliano, Italy) using 100% steam at 85 °C until the internal product core temperature reached 75 °C, as ascertained by a temperature probe (Testo 110, Lenzkirch, Germany) placed in a pudding situated in the center of the oven. The temperature was held for 15 min and subsequently, the black pudding products were immediately placed in the chill to cool down and stored there at 4 °C. All sausage batches were produced in replicate.

2.2. Reheating procedure

Before serving black pudding at home, usually the cut slices are cooked in a frying pan. For experimental purpose, the reheating step was standardized with all samples cut into 1.2 cm thick slices, placed on aluminium plates and dry cooked at 100 °C for 7 min in a Zanussi convection oven (C. Batassi, Conegliano, Italy) and afterwards turned and heated up again at 100 °C for an additional 7 min.

2.3. Sensory evaluation

The sensory acceptance test was conducted using untrained assessors (n = 25–30) (Stone, Bleibaum, & Thomas, 2012a; Stone & Sidel, 2004) in the age range of 21–60. They were chosen on the basis that they consumed black pudding products regularly. The experiment was conducted in panel booths at room temperature which conform to the International Standards (ISO, 1988) under artificial light (1000 lx). The sensory test followed a balanced block design where assessors tested all samples whereby five reheated samples (coded and presented in a randomized order) were served to the assessors split into five sessions. The assessors were asked to assess, on a continuous line scale from 1 to 10 cm, the following attributes: liking of appearance, liking of flavor, liking of texture, liking of color and overall acceptability (hedonic). Black pudding samples were presented in duplicate (Stone, Bleibaum, & Thomas, 2012b). The assessors then participated in a ranking descriptive analysis (RDA) (Richter, Almeida, Prudencio, & Benassi, 2010) using the consensus list of sensory descriptors including grain quantity, fatness, spiciness, saltiness, juiciness, toughness and off-flavor (intensity), which was also measured on a 10 cm line scale. All samples were again presented in duplicate (Stone et al., 2012b).

2.4. Fat and moisture analysis

For investigating moisture and fat, both before and after reheating, 1.0 g of each of the homogenized vacuum packed black pudding samples was measured in triplicate using the SMART Trac system (CEM GmbH, Kamp-Lintfort, Germany) (Bostian, Fish, Webb, & Arey, 1985).

2.5. Protein analysis

Protein content was determined, in triplicate, both before and after reheating using the Kjeldahl method (Suhre, Corrao, Glover, &