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Physical and sensory characteristics of pork sausages from enzymatically modified blends of lard and rapeseed oil during storage

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ABSTRACT

Physical and sensory characteristic of pork sausages produced from enzymatic interesterified blends of lard and rapeseed oil during storage were evaluated. All three enzymatic interesterified blends (IE90, IE70 and IE50) had ratios of unsaturated to saturated fatty acids within the range of 1.47–2.84 which is favourable for cardiovascular disease risk reduction. Blends of IE90 and IE70 were found to have suitable solid fat content, melting and crystallization profile suitable for sausages production. Sausages were produced from blends of IE90 and IE70 with different muscle types (musculus longissimus dorsi and musculus sternomandibularis) and processing conditions such as cooling rates and final processing temperature. Cooling rate was found to have no significant ($P > 0.05$) effect on hardness of the sausages throughout storage. Both musculus longissimus dorsi and high final processing temperature of 20 °C increased the hardness of the sausages during storage. In terms of fat particle size distribution, it was found that sausages IE70 had significantly ($P < 0.05$) lower amount of small fat particles (<4 μm) and higher amount of big fat particles (4–500 μm). This is in agreement with the findings on softer texture of sausages IE70. All the sausages produced from interesterified blends of lard and rapeseed oil had no apparent fat excretion and were rated as having acceptable sensory attributes as compared to reference sausage which was produced from pure lard.

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1. Introduction

Sausages are among the most consumed meat products. It is traditionally prepared from ground meat, fat, salt and spices (Whiting & Miller, 1992). In recent years, efforts have been made to produce sausages with improved nutritional values such as low-salt phosphate-free sausages (Ruusunen et al., 2004) and low fat sausages with inulin (Mendoza, García, Casas, & Selgas, 2001), konjac and gellen gum (Lin & Huang, 2003) and enzymatically extracted potato fibre (Kaack, Laerke, & Meyer, 2006) as fat substitutes. Using fat substitutes in sausages may be a healthful option; nevertheless, it can be detrimental to the texture and organoleptic properties of the meat products. For example, Kaack et al. (2006) found substituting fat with enzymatically extracted potato fibre produced sausages with increased toughness. As fat contributes to flavour, texture, mouthfeel and overall sensation of smoothness of the meat products, other approaches should be considered to improve nutritional values of meat products.

One of the approaches used is to increase the total content of unsaturated fatty acids (FA) in fat of sausages by physical blending with highly unsaturated oils such as olive (Muguerza, Fista, Ansorena, Astiasaran, & Bloukas, 2002), fish (Valencia, Ansorena, & Astiasarán, 2006) and hazelnut (Yıldız-Turp & Serdaroğlu, 2008) oils. Although these studies found physical blending of fat with highly unsaturated oils produced sausages with similar organolectic and shelf-life properties, this may not be viable as the sausages also showed reduced stability. Muguerza, Gimeno, Ansorena, Bloukas, and Astiasaran (2001) found blends of pork back fat with olive oil produced sausages with considerable dripping of fat during ripening.

Another approach to increase the total content of unsaturated FAs is to interesterify the fat with highly unsaturated oils. Interesterification which is the exchanging of fatty acids within glycerol backbone is more favourable for producing stable fat products with higher degree of unsaturation (Özvural & Vural, 2008; Vural, Javidipour, & Ozbas, 2004). These studies found sausages produced from

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interesterified blends had similar ($P > 0.05$) appearance, colour, texture and organoleptic properties as control which was produced from conventional animal fat. Adopting interesterified fat for meat applications is not common at present. To the authors' knowledge, studies by Vural et al. (2004) and Özvural and Vural (2008) were the only ones conducted so far which adopted interesterified fats for meat applications.

Rapeseed oil is the third largest vegetable oil produced after palm and soybean oil. It is high in monounsaturated fatty acids and contains a good balance between the omega-6 (linolenic acid) and omega-3 (linolenic acid) fatty acids. It has been used quite widely in enzymatic interesterification to increase the degree of unsaturation in saturated fats such as beef tallow (Kowalski, Tarnowska, Gruczynska, & Bekas, 2004); butterfat (Rønne, Yang, Mu, Jacobsen, & Xu, 2005) and anhydrous milk fat (Giet et al., 2009). In a recent study by Pelser, Linssen, Legger, and Houben (2007), rapeseed oil has been blended with pork back fat for production of Dutch style fermented sausages. This study showed a substitution of up to 20% of pork back fat with rapeseed oil produced sausages with no reduction in shelf life. This study aims to evaluate the physical and sensory characteristics of sausages produced from enzymatically interesterified blends of lard and rapeseed oil during storage.

2. Materials and methods

2.1. Blends preparation for enzymatic interesterification

Lard was firstly heated to a temperature of 65 °C until it was completed melted. The completely melted lard was then mixed with rapeseed oil to produce three different blends at a weight ratio 90:10, 70:30 and 50:50 (w/w lard:rapeseed oil). The prepared blends were then used as feedstock for enzymatic interesterification in a packed bed reactor.

2.2. Enzymatic interesterification in a packed bed reactor

A packed bed reactor with column dimension of 47 mm × 500 mm was used to produce the enzymatically interesterified fats. Firstly, the column was packed with a total of 468.5 g of Lipozyme TL IM (Novozyme A/S, Bagsvaerd, Denmark) which had been dried overnight under vacuum condition at temperature of 40 °C. The whole packed bed reactor set-up was then placed in a temperature-controlled chamber which was maintained at 50 °C to avoid solidification of the pipes and pump head. After that, the reactor was heated to 60 °C using a water jacket connected to a water bath. Once the temperature was maintained at 60 °C, feedstock was pumped into the packed bed reactor at an optimized flow rate of 9.6 g/min to achieve more than 80% of interesterification degree. The receiver for the interesterified product, which was covered by nitrogen, was placed outside the temperature-controlled chamber to minimize risk of oxidation. The interesterified products were finally stored in a −40 °C freezer for further usage and analysis.

2.3. Determination of fatty acid composition

Fatty acid composition is determined according to a previously described method (Cheong, Zhang, Xu, & Xu, 2010). The fat samples were firstly dissolved in 1 ml of heptane and methylated with 60 μl of 2 M methanolic potassium hydroxide. The mixtures were then added with sodium sulphate anhydrous and centrifuged at 4000 rpm for 10 min. One hundred microlitres of the supernatant was added to 1 ml of heptane and analyzed for fatty acid composition. Fatty acid composition was determined using a Hewlett–Packard 5890 GC system equipped with flame-ionization detector, HP automatic sampler and a Supelco SP-2380 fused silica capillary column (60 m × 0.25 m × 0.2 μm). Helium was used as a carrier gas at a flow rate of 40 ml/min. The injector and detector temperatures were set at 260 and 280 °C, respectively. The oven temperature was initiated at 70 °C for 2 min. Then, the temperature was increased to 160 °C at 15 °C/min and to 200 °C at 1.5 °C/min. The temperature was maintained at 200 °C for 15 min before increasing to 225 °C at 25 °C/min and held for 10 min. The total run time was 59 min. The peaks were identified by comparison of retention time with fatty acid methyl ester standard. All measurements were conducted in duplicate.

2.4. Melting and crystallization profile

Melting and crystallization profiles were analyzed according to a previously described method (Cheong et al., 2010) using a Perkin–Elmer Pyris 6 DSC (PerkinElmer, Massachusetts, USA). Samples weighed between 6 and 10 mg were sealed in aluminium pans. The prepared pans were firstly heated to 80 °C for 15 min to ensure no residual nuclei remained. To obtain the crystallization curve, the samples were then cooled from melt (80 °C) at 5 °C/min to −60 °C. To obtain the melting curve, the samples were equilibrated at −60 °C for 15 min before heating the samples to 80 °C at 5 °C/min. The samples were analyzed in duplicates.

2.5. Solid fat content profile

SFC as a function of temperature was determined using a Bruker Minispec mq 20 pulse nuclear magnetic resonance (pNMR). The samples were firstly heated at 70 °C for 30 min to destroy any crystal history, followed by chilling at 0 °C for 60 min and then kept at the desired temperatures for 30 min prior to measurements. The melting, chilling and holding of the samples were carried out in pre-equilibrated thermostated baths. SFC was measured in duplicates within the temperatures ranges from 0 °C to 40 °C in 5 °C increments.

2.6. Production of canned sausages

Based on the fatty acid composition, solid fat content, melting and crystallization behaviour, suitable interesterified fat systems were selected for sausages production. The recipe for canned sausages is shown in Table 1. Pork muscle [musculus longissimus dorsi (L) or musculus sternomandibularis (D)] was chopped together with salt, phosphate and half amount of water using a meat chopper (Machine Alimentari, Misanoa, Italy) at a chopping speed of 2880 rpm for 10 rounds. Casein and the remaining amount of water were then added and grinded for 20 rounds at 2880 rpm. Finally, the suitable interesterified fat systems and potato starch were added to the meat batter and chopped at the same speed to three different final chopping temperatures of 12, 16 and 20 °C. In short, for each interesterified fat mixture, six different mixtures

Table 1
Recipe for canned sausages.

Ingredients	Percentage (%)
Muscle types (musculus longissimus dorsi or musculus sternomandibularis)	53.7
Interesterified fat	25
Casein	2
Salt	2
Phosphate	0.3
Potato starch	2
Water	15

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