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Development of combinations of chemically modified vegetable oils as pork backfat substitutes in sausages formulation

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ABSTRACT

Today's consumers look for foods which provide nutrition and pleasure, while safeguarding their health, the result of which is that they increasingly avoid foods containing cholesterol and saturated and *trans* fatty acids. Chemically modified vegetable oils can help tailor meat products to meet this growing need and at the same time fulfil the technological needs of the meat processing industry. In this study, 16 backfat samples were characterised for their solid fat content (SFC) and melting point and these characteristics were used to design a mixture of chemically modified vegetable oils for use as a pork fat substitute for elaborating sausages. The mixtures were prepared with different vegetable oils bearing in mind with stearic acid content due to its close correlation with the SFC. The backfat was characterised as a function of its SFC and some modified vegetable oil mixtures were proposed, which led to a 10–20% diminution in saturated fatty acids and with a melting point similar to those observed in the backfat. The fatty acid profile pointed to a polyunsaturated/saturated fatty acids ratio higher than 0.4, and an $n-6/n-3$ fatty acid ratio of less than 4 in both modified vegetable oil mixtures proposed.

1. Introduction

Fat is added to meat products to provide good sensory attributes, especially those related with taste and texture. Backfat is the most studied and most commonly used fat because of its superior technological characteristics compared with beef or poultry fat. However, the saturated fatty acids (SFA) contained in pork fat is precisely why consumers are reluctant to increase their intake of sausages. Saturated fatty acids are associated with an increased risk of cardiovascular diseases and so it is important to reduce their levels in sausages while maintaining the sensorial characteristics of the final product (Fernández-Gines, Fernández-López, Sayas-Barberá, & Pérez-Alvarez, 2005; García-García & Totosaus, 2008; Wood et al., 2003).

One possibility is to partially replace the saturated fat content with other ingredients, and several materials have been tried in this respect; for example, maltodextrin, gums, hydrocolloids, starches, fibres and vegetable oils. Different results have been obtained with there ingredients depending on the composition of the product and the levels used (Crehan, Hughes, Troy, & Buckley, 2000; Fernández-López, Sendra, Sayas-Barberá, Navarro, & Pérez-Alvarez, 2008; Fernández-López et al., 2003; García-García & Totosaus, 2008; Muguerza, Gimeno, Ansorena, & Astiasarán, 2004; Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001; Sampaio et al., 2004; Tan, Aminah, Zhang, & Abdul, 2006; Tan, Liao, Jhan, & Liu, 2007; Vural, Javidipour, & Ozbas, 2004; Yildiz-Turp & Serdaroglu, 2008). Vegetable oils have been used to replace backfat in several meat products, with favourable results being obtained from a sensorial point of view at levels below 30% (Bloukas, Paneras, & Fournitzis, 1997; Fernández-Gines et al., 2005; Hsu & Yu, 2002; Muguerza, Ansorena, & Astiasarán, 2003; Muguerza, Fista, Ansorena, Astiasarán, & Bloukas, 2002; Muguerza et al., 2001). However, from a production point of view, this is inefficient because of the intermediate processes that need to be carried out to stabilise the oils before they can be used with complete confidence.

Pork backfat is a "hard" fat from the adipose tissue of the dorsolumbar region of the animal, between the *Longissimus dorsi* muscle and the skin. Its high SFA content has led to it being the most widely used fat in cooked meat products because of its effect on the taste and texture of the final product. "Soft" fats contain a increased proportion of unsaturated fatty acids (UFA), which lead to both technical and sensorial problems in the product, making them difficult to cut and more prone to oxidation (Maw, Fowler, Hamilton, & Petchey, 2003). In other words, the nutritional and technological qualities of backfat are inversely related (Hugo & Roodt, 2007).

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In the search for alternatives to backfat, certain prerequisites must be borne in mind. The quality attributes associated with backfat include colour, consistency, stability in the face of oxidation, taste, percentage of extractable fat, iodine index, C18:2 content and C18:0/C18:2 ratio, the double bond index, firmness, fatty acid composition, fusion behaviour, solid fat content (SFC) and crystallisation time (Gläser, Wenk, & Scheeder, 2004; Hugo & Roodt, 2007; Pérez-Alvarez & Fernández-López, 2007; Wood et al., 2003). Monounsatured fatty acids (MUFA) constitute about 47% of the total fatty acid content of pork and are considered to have a neutral or even favourable effect regarding cardiovascular diseases (Warnants, Van Oeckel, & Boucqui, 1998). They therefore do not need to be replaced, while the SFA fraction must be minimized to levels at which the backfat will fulfil the looked for functionality.

The objective of this work was to characterise pork backfat, using the solid fat content at different temperatures (10–40 °C), and to propose combinations of chemically modified vegetable oils (CMVO) that behave in the same way to replace the animal fat, and so diminish the saturated fatty acid content of processed meat products.

2. Materials and methods

2.1. Animals

Samples were taken from 16 pig carcasses at a Colombian industrial slaughterhouse (Central Ganadera de Medellin, Colombia). The carcasses were selected from 22 week-old females and castrated males with approximately body weights of 110 ± 5 kg, all hybrids of Large White, Pietrain, Landrace and Duroc. The production zone is located in the southwest of the Antioquia department and the "Coffee Axis" (Colombia). All the pig farms sited at altitudes between 1000 and 1800 m. The pigs were reared under intensive conditions.

2.2. Backfat analysis

The physical properties of fat and the sensorial attributes of fatty foods depend on temperature. These attributes can be studied knowing the SFC in the food, which determines the fatty solid portion at a fixed temperature. Using these data, the mouth feel and the hardness in the food can be predicted (Singh, Mcclements, & Marangoni, 2004), for which reason SFC was selected as response variable for evaluating the physical properties of the backfat.

Sixteen samples of backfat were obtained from the above mentioned pigs and the fatty acid composition, SFC at different temperatures (10–40 °C) and melting point were determined for each sample.

2.2.1. SFC measurement by NMR

The SFC at 10, 20, 25, 30, 35 and 40 °C was determined following the recommendations of the AOCS (1998) with low resolution NMR equipment (Minispec PC 120 Bruker), operating at a frequency of 20 MHz. The samples were placed for 1 h in a bath at 0 °C, then for 30 min at the required temperatures prior to NMR measurement at each temperature.

2.2.2. Fatty acid composition

Fatty acids were analysed by gas liquid chromatography after methylation of 0.02 g of lipids with n-heptane/methanolic KOH as described by the AOCS (1998). The gas chromatograph was equipped with an on-column injector and a flame ionisation detector (Hewlett–Packard 6890). The derivatives were separated on an SP2560 fused-silica capillary column (100 m length, internal diameter 0.25 mm, film thickness 0.25 m). Operating conditions were: a helium flow rate of 1.0 ml/min, air flow rate of 350 ml/min, hydrogen flow rate of 35 ml/min and a makeup flow of 25 ml/min; the oven temperature was held at 160 °C for 3 min and subsequently increased to 220 °C in 34 min; detector and injector temperature was held at 206 °C; the volume injected was 1 μl. Retention time and area of each peak were computed using the ChemStation GC system software. Individual fatty acids methyl esters (FAME) peaks were identified by comparing their retention times with those of standards (Sigma–Aldrich). The results are expressed as percentages of the total fatty acids analysed (m/m) and saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) were determined.

2.2.3. Melting point

The melting point of the fat was determined using the "slip point" method described by AOCS (1998), whereby the temperature at which the fat slipped in the capillary tubes was recorded as the melting point.

2.3. Preparation of the different combinations of chemically modified vegetable oils (CMVO)

The different combinations of CMVO was prepared by interesterification. The interesterification reaction was carried out by adding sunflower, soy been, palm, canola, cotton, cartamo, olive and maize oils in different proportions according to the final content of C18:0. The reaction was made in a vacuum-evaporator at 88–94 °C for 5 min. The oils mix was previously dried at 90–95 °C for 15–20 min in vacuum conditions to remove moisture. A 0.3–0.5% of $NaOCH_3$ was added as catalyzer. After the mix was heated for 5–8 min (and the mix showed a coffee brown colour) the process was stopped. The catalyzer was inactivated by the addition of 2% citric acid and the mix was kept under stirring for 15 min at the same temperature. The reaction product was washed three times with hot water (200 ml at 50–55 °C) to remove citric acid and $NaOCH_3$. Residual water was removed by adding a 2% of powder filter aid (2%, Celite Hyflo Super Cel filter aid, Fisher Scientific Co., Pittsburgh, PA), followed by mixing and filtering through a filter paper.

2.4. Statistical analysis

A repeated measurement model was constructed using the SFC of the backfat as response variable and temperature and stearic acid content as explicative variables, the latter because of its high correlation with SFC. The regression parameters were estimated using a repeated measurement model (mixed) of the statistical software R (R Development Core Team, 2008).

3. Results and discussion

3.1. Composition and SFC of backfat

Fig. 1 shows the SFC of the 16 backfat samples. As can be seen, the curves showed a similar behaviour with a slight concavity in the temperature range 10–30 °C, for higher temperatures the phase change began in all the samples. This behaviour demonstrates that the samples can be considered as similar. Between 10 and 30 °C a quadratic tendency was observed in the SFC, while between 30 and 40 °C the behaviour was linear, which can be explained by the solid content present in the sample at the beginning of treatment, which is reduced as the melting point is approached (around 30 °C, depending on the chemical composition). Above this