Meat Science 93 (2013) 668–674

Contents lists available at SciVerse ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Effect of the type of fat on the physicochemical, instrumental and sensory characteristics of reduced fat non-acid fermented sausages

Héctor Mora-Gallego [a], Xavier Serra [a,*], Maria Dolors Guàrdia [a], Rikke Miklos [b], René Lametsch [b], Jacint Arnau [a]

[a] IRTA, XaRTA, Food Technology, Finca Camps i Armet, s/n, E-17121, Monells, Girona, Spain
[b] University of Copenhagen, Department of Food Science, Rolighedsvej, 30, DK-1958 Frederiksberg C, Denmark

ARTICLE INFO

Article history:
Received 18 July 2012
Received in revised form 2 November 2012
Accepted 10 November 2012

Keywords:
Fat reduction
Fat substitute
Diacylglycerol
Fermented sausage
Sensory quality
Instrumental texture

ABSTRACT

Four batches of reduced fat non-acid fermented sausages were manufactured with pork-ham lean, and the addition of no fat (Lean), 5% pork backfat (BF), 5% sunflower oil (SO) and 5% diacylglycerols (DAGs). The effect of the type of fat as pork-fat substitute on some physicochemical parameters, instrumental color and texture and sensory attributes of the sausages was studied. Results showed that reduced fat non-acid fermented sausages containing less than 12.5% of fat (BF, SO and DAGs) had a good overall sensory quality. This means a fat reduction of more than 70% compared with the average fat content of standard fermented sausages of similar characteristics. Sausages with SO showed higher sensory ratings in desirable ripened odor and flavor attributes and improved texture defined by lower hardness and chewiness (both sensory and instrumental) and higher crumbliness. Sausages with DAGs showed a similar behavior to that of BF, so they could be a good alternative to produce healthier reduced fat non-acid fermented sausages.

1. Introduction

Meat and meat products are important sources of dietary fat (Givens, Kliem, & Gibbs, 2006; Valsta, Tapanainen, & Männistö, 2005) which is considered a triggering factor in the development of some chronic diseases (World Health Organization, 2003). For this reason, the World Health Organization has proposed to limit the daily fat intake to less than 30% of the total calories and also to reduce the intake of saturated fatty acids and cholesterol. These recommendations have contributed to increase the interest on healthier diets among consumers and to consider the percentage of calories from fat as a criterion for evaluating food products (Jiménez-Colmenero, 2000).

'The Regulation (EC) No 1924, 1924/2006 of the European Parliament and of the Council on nutrition and health claims made on foods' considers a product as reduced fat when the reduction in fat content is at least 30% compared to a similar product. Likewise, this regulation considers a food as energy-reduced when the total energy value is reduced by at least 30%.

Traditional fermented sausages are meat products with fat contents up to 50% (Jiménez-Colmenero, 2000). Based on these data and the requirements of health authorities, the food research and the meat industry have developed new formulations by reducing or replacing the fat content (Mendoza, García, Casas, & Selgas, 2001). However, fermented sausages are among the meat products where fat reduction is more complicated because fat confers important sensory properties i.e. flavor, texture and mouthfeel (Mendoza et al., 2001). Fat also affects important technological functions such as water release during drying (Wirth, 1988). One of the most detrimental effects of fat reduction in fermented sausages is a harder instrumental and sensory texture (Bloukas, Paneras, & Fournitzis, 1997; Muguerza, Fista, Ansorena, Astiasaran, & Bloukas, 2002). Therefore, the modification of the composition of fermented sausages by reducing its fat content can lead to negative changes in the sensory characteristics of these products and affect consumers' acceptability.

Some vegetable oils have been used as animal-fat substitutes in different studies. Positive results have been obtained regarding instrumental texture and sensory properties when compared to products without fat reduction: olive oil in *salami* (Del Nobile et al., 2009; Severini, De Pilli, & Baiano, 2003) and *chorizo de Pamplona* (a traditional type of Spanish fermented sausage) (Muguerza, Gimeno, Ansorena, Bloukas, & Astiasaran, 2001), soy oil in *chorizo de Pamplona* (Muguerza, Ansorena, & Astiasarán, 2003), linseed oil in *cervelat* (Dutch style fermented sausage) (Pelser, Linssen, Legger, & Houben, 2007) and *chorizo de Pamplona* (Ansorena & Astiasarán, 2004; Valencia, Ansorena, & Astiasarán, 2006) and palm and cotton seed oils in semi-dry sausages (Vural, 2003). Sunflower oil has been used as fat replacer in frankfurters (Ambrosiadis, Vareltzis, & Georgakis, 1996; Paneras & Bloukas, 1994) but no studies about reduced fat fermented sausages with sunflower oil and diacylglycerols (DAGs) have been found.

Triacylglycerols (TAGs) are the main component of pork fat. TAGs can be converted into DAGs with enzyme treatment (lipase-catalysed

* Corresponding author. Tel.: +34 902 789 449; fax: +34 972 630 980.
E-mail address: xavier.serra@irta.cat (X. Serra).

0309-1740/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.meatsci.2012.11.042

glycerolysis) leading to changes in the physical and chemical properties of the fat. DAGs have beneficial effects on the texture and improve water and fat retention (Miklos, Xu, & Lametsch, 2011). In addition, DAGs have been reported to result in a lower fat accumulation in the human body compared to TAGs (Flickinger & Matsuo, 2003; Maki et al., 2002; Meng, Zou, Shi, Duan, & Mao, 2004; Murase, Aoki, Wakisaka, Hase, & Tokimitsu, 2002). Thus, the use of DAGs may represent an improvement in both technological and health aspects of meat products. A number of animal and human studies have confirmed the safety of DAGs in consumption at similar levels as other edible lipids (Morita & Soni, 2009). DAGs have been evaluated as "Generally Recognized as Safe" (GRAS) by the US Food and Drug Administration (FDA) and are approved by the Ministry of Health and Welfare of Japan as Food for Special Health Use (FOSHU). Furthermore, the European Commission issued an authorization permitting placement of DAG oil on the market (Empie, 2008). Currently, commercially available plant-based DAGs have been withdrawn from the market due to the presence of process contaminants (American Oil Chemists' Society [AOCS], 2012). So far animal-based DAGs (e.g. lard-based DAGs) have not been commercially produced.

This work aims to assess the effect of sunflower oil and lard-based diacylglycerols as pork-fat substitutes on the sensory attributes, physicochemical parameters and instrumental texture of reduced fat non-acid fermented sausages.

2. Materials and methods

2.1. Sausage manufacture and drying

Two replicates of the experiment were carried out. For each replicate, three batches of reduced fat non-acid fermented sausages (*fuet* type) were manufactured using pork-ham lean (95%) and different types of fat (5%): backfat (BF), sunflower oil (SO) and diacylglycerols (DAG). A fourth batch was manufactured using only pork-ham lean with no added fat (Lean batch). The Lean batch was used as the control batch to assess the technological and sensory changes and/or improvements of non-acid fermented sausages manufactured with pork-ham lean and the addition of 5% of different types of fat. The ham lean (pH_{24h}<6.2 in the *semimembranosus* muscle) and backfat were purchased at a local supplier. The sunflower oil used was Koipesol (Koipesol Semillas S.A., Sevilla, Spain). Non-commercial lard-based DAGs were used. DAGs were produced by enzymatic glycerolysis using lard and glycerol at a substrate ratio of 9:1. The subsequent purification of acylglycerol fractions by short path distillation yielded a final product with 96.5% DAG, 3% TAG and 0.5% MAG (monoacylglycerols) (Aarhus University, Aarhus, Denmark). The ham lean was trimmed of fat and minced through an 8 mm plate. For each batch with 5% added fat, a total of 0.6 kg of the corresponding fat: backfat, sunflower oil or DAGs was mixed in a bowl chopper (Dito-Sama K55, Dito-Sama S.A., Aubusson, France) with 1 kg of ground ham lean for 2 min until forming an emulsion that was later added to the rest of the meat of each batch (10.4 kg). A total of 12 kg of minced meat per batch was obtained. The same procedure was followed for the Lean batch (1 kg of ground ham lean with no added fat). All mixtures were then minced through a 3 mm plate. The following additives per kilogram of meat were added to the mixtures and mixed for 3 min: 20 g NaCl, 1.50 g black pepper, 20 g lactose, 20 g potassium lactate (78% purity; PURAC bioquímica, S. A., Montmeló, Barcelona), 0.5 g sodium ascorbate, 0.15 g sodium nitrite and 0.15 g potassium nitrate. The meat mixture was stuffed into Ø 50 mm Fibran casings (Fibran, S. A., Sant Joan de les Abadesses, Girona, Spain), immersed in a water bath containing a suspension of *Penicillium candidum* and hung to dry for two months, as in traditional non-acid fermented sausages, with increasing temperature and decreasing relative humidity (RH) from 3 °C and 85% RH to 18 °C and 70% RH. Periodically, a sausage from the batch with the highest weight loss, i.e. the Lean batch, was evaluated and checked for optimal drying. Once the optimal drying was obtained, the same water content on a defatted-dry-matter basis was targeted to be reached by all four batches. An estimation of the theoretical initial water and fat contents for each batch was calculated (based on the batch formulations) and used to define the target water content on a defatted-dry-matter basis. Consequently, a specific weight loss for each batch was established to attain the same final water content (on a defatted-dry-matter basis) in all four batches. Once the sausages of each batch reached the specific final weight loss, they were packaged in polyamide-polyethylene bags with modified atmosphere (80% N_2:20% CO_2) and stored at 3 °C for one month for moisture equalization before analysis.

2.2. Instrumental color analysis

Instrumental color measurements were carried out with a colorimeter Konica Minolta Chroma Meter CR-400 (AQUATEKNICA, S.A., Valencia, Spain) with illuminant D65 (2° standard observer and specular component included) in the CIE-LAB space: L^*(lightness), a^*(redness) and b^*(yellowness) (Commission Internationale de l'Éclairage [CIE], 1976). Color measurements were performed on five sausages per batch and averaging eight readings on new cut surfaces per sausage.

2.3. Instrumental texture analyses

2.3.1. Texture profile analysis

A RT/5 Universal MTS Texture Analyser (Sistemas de Ensayo de Materiales, S.A., Barcelona, Spain) was used to perform a modified Texture Profile Analysis or TPA (Bourne, 1978). Specimens (15 mm height) were compressed twice to 50% of their original height. Force-time curves were recorded at a crosshead speed of 1 mm/s. The following TPA parameters were obtained: springiness, hardness (N/cm^2), cohesiveness and chewiness (N/cm^2). The mean of three specimens per sample was used for statistical analyses. Hardness values were corrected for the different sample areas and expressed as N/cm^2. Chewiness (N/cm^2) was calculated as follows: corrected hardness × cohesiveness × springiness (Bourne, 1978).

2.3.2. Stress relaxation test

A stress relaxation (SR) test was performed on all the samples with the same equipment used for the TPA test. Specimens (15 mm height) were compressed to 25% of their original height at a crosshead speed of 1 mm/s. The force versus time after the compression was recorded at 2 s and 90 s (relaxation time). The relaxation curves obtained for each specimen were normalized, i.e. the force decay $Y(t)$ was calculated as follows:

$$Y_{(t)} = \frac{F_0 - F_{(t)}}{F_0}$$

where F_0 (N) is the initial force and $F(t)$ is the force recorded after t seconds of relaxation. F_0, F_2 and F_{90} values were corrected for the different sample areas and expressed as N/cm^2. The force decay at 2 s (Y_2) and 90 s (Y_{90}) were calculated (Morales, Guerrero, Serra, & Gou, 2007). The mean of three specimens per sample was used for statistical analysis. After texture analysis the specimens were minced and vacuum-packed and kept frozen at −18 °C for further physicochemical analysis.

2.4. Physicochemical analysis

The pH was measured in the meat mixture before stuffing, and in sausages during the drying process (7 days, 18 days and in the final product). A pH penetration electrode (Crison 52-32) on a portable pH-meter (CRISON PH 25, Crison Instruments S.A., Alella, Spain) was used. The pH of the final product was measured in a homogenised sample solution (10 g sample/40 ml ultrapure H_2O). Water activity (a_w)