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Textural and viscoelastic properties of pork frankfurters containing canola–olive oils, rice bran, and walnut

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ABSTRACT

Textural, rheological and microstructural properties of frankfurters made with 20% pork backfat, 20% canola or 20% canola–olive (3:1) oils, including rice bran (RB) and walnut extract (WE) as macronutrients (2.5%) were investigated. Textural parameters, including hardness, gumminess and rupture–force, were highly ($P<0.05$) influenced by the fat-oil composition. Addition of RB or WE in vegetable oil emulsions improved textural consistency ($P<0.05$). However, RB addition reduced gelling capacity, suggesting antagonistic interactions between fiber and oil droplets. Vegetable oil addition favored gel network formation, and, when combined with WE, showed the highest improvement of gel elasticity. These textural and gelling properties were corroborated by frankfurter micrographs, which revealed interactions between vegetable oils, RB, or WE with protein matrix and fat globules affecting these parameters. The results suggest that functional plant-derived ingredients can be valuable to the modification of frankfurter formulations for improved nutrition and as well as textural quality.

1. Introduction

The growing emphasis on health has led the food industry to constantly strive to develop new foods with improved functional properties, palatability and nutritional value. Currently, the meat industry is utilizing nutraceutical ingredients and reducing the use of animal fats by replacement with vegetable oils to achieve this goal. The addition of vegetable oils (e.g., canola and olive oils) and dietary fiber (e.g., from rice bran and walnuts) in meat products is desirable not only for their nutritional properties and health benefits (Álvarez et al. 2011), but also for their technological improvement related to textural and protein gelling properties (Fernández-Ginés, Fernández-López, Sayas-Barberá, & Pérez-Álvarez, 2005). It is recognized that gelation of myofibrillar proteins during cooking is required for obtaining high quality finely comminuted meat products (Barbut, 1995).

Many investigations have been conducted to explore the feasibility to substitute vegetable oils or fibers for animal fat in value-added emulsion-type meat products, emphasizing the rheological properties in relation to animal fat reductions. Emulsified vegetable oils have been shown to favor tenderness of meat products (Marquez, Ahmed, West, & Johnson, 1989). Olive oil has been shown to increase emulsion capacity, apparent yield stress values of raw emulsions, and gelling capacity of cooked emulsions (Zorba & Kurt, 2008). Canola oil has also a reported positive effect on improving yield and restoring textural parameters in comminuted meat products made with reduced fat levels (Youssef & Barbut, 2011). On the other hand, substitutions of vegetable oils for fat could be done without significantly influencing other quality attributes of comminuted meat products, such as appearance, color, and flavor (Vural, Javidipour, & Ozbas, 2004). Aside from vegetable oils, dietary fiber has been used in low-fat meat products as a fat substitute to restore products' rheological properties and cooking yield due to its water-binding and fat-binding properties (Cofrades, Guerra, Carballo, Fernández-Martín, & Jiménez-Colmenero, 2000; Hsu & Chung, 2001).

However, the addition of new ingredients and the substitution of animal fats with oils could provoke changes in the emulsion stability. A reduced emulsion stability would mean a reduced final product yield and quality, economical losses, and consumer rejection. Functional products like low-fat meats are often rejected by the consumer because they are considered less acceptable in flavor and texture than traditional meat products (Keeton, 1994). Therefore, the most important factor during animal fat substitution by plant oil is not to cause unwanted quality changes, notably emulsion stability and rheology of the meat products (Zorba & Kurt, 2008).

The objective of the study was to determine the effect of rice bran and walnut extract on textural and rheological properties of cooked meat emulsions made with pork backfat, canola oil or canola–olive oil blends. The motivation of this research was the use of natural replacements for animal fats that provide the meat industry with the

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commercialization of improved meat products assuming low risks during manufacturing.

2. Material and methods

2.1. Ingredients

Fresh pork meat and pork backfat obtained from a local meat purveyor were trimmed of excess fat and connective tissue. Lean meat and backfat were separately ground twice through 25.4–9.6 mm (meat) and 9.6–3.2 mm (fat) orifice plates, vacuum packed, and frozen at −18 °C until use. Canola and olive oils (Pompeian, Inc., Baltimore, MD. USA), rice bran (Ener-G Foods, Inc. Seattle, WA. USA) and walnut halves were obtained from a local purveyor (Kroger Co., Cincinnati, OH. USA). Walnut halves were processed (ground at 1750 rpm for 1.5 min and preheated at 80 °C for 1 h) in order to obtain a refined extract before use, following the directions described by Álvarez et al. (2011). Salt, spice mix blend 125, erythorbic acid (Old Plantation Seasoning, A.C. Legg Packaging Co. Inc. Birmingham AL, USA), sodium tripolyphosphate, and sodium nitrite were other ingredients used during emulsion manufacturing. The detailed product formulations are presented in Table 1.

2.2. Preparation of frankfurters

Frankfurters were prepared in a cooler room (6–8 °C) to obtain 4 kg batter (Table 1), containing three different formulations, 20 g/100 g backfat, 20 g/100 g canola oil, and 20 g/100 g canola–olive oils (3:1). The proximate composition (AOAC, 1996) of the trimmed pork meat was; moisture 72.9 g/100 g, fat 5.1 g/100 g, protein 21.1 g/100 g and ash 0.9 g/100 g. Plant extracts, rice bran (RB) and walnut extract (WE), were added separately to these emulsions at an addition rate of 2.5 g/100 g (RB; dietary fiber 28.4 g/100 g, carbohydrates 50.7 g/100 g, fat 20.9 g/100 g, protein 10.0 g/100 g, WE; dietary fiber 6.7 g/100 g, carbohydrates 13.4 g/100 g, fat 66.7 g/100 g, protein 16.7 g/100 g). Overall control emulsions without RB and WE were also prepared in order to obtain a total of nine treatments (3 × 3 factorial design) by replicate (*x*2). Before emulsion preparation, frozen meat and backfat were thawed overnight in a refrigerator at 4°C. Partially thawed pork meat was placed in a silent cutter (Model CM-14, Mainca USA, St. Louis, MO, USA) and homogenized during 1 min. The total amount of ingredients (salt, spice and cure mix) was dissolved in water (7%), and keeping in refrigeration (4–6 °C) before adding to the meat batter. This mixture were then chopped during another 2 min. Partially pork fat thawed or vegetable oil replacements, ice (8%) and RB or WE were then added and chopped during 3 min. Total mixing time was standardized to 6 min and the final temperature was below 12 °C in all treatments. The chopping speed of blades and plates were adjusted to minimal (1500 × 10 rpm − 1 min) and high (3000 × 10 rpm − 5 min) revolutions. Approximately 3000 gr was transferred into a hand stuffer (The Sausage Maker, Buffalo, NY, USA) and stuffed into 27.0 mm diameter frankfurter cellulose casings. The frankfurters were manually tied into approximately 12 cm links, washed to remove materials on the outside of the casing, and kept at 4–6 °C for 20–30 min before cooking. The links were cooked in an Alkar smokehouse (Model 450U, Alkar-Rapid Pak Inc., Lodi, WI, U.S.A.) with a programmed temperature-time cooking schedule until the internal temperature of frankfurters reached 71 °C. The relative humidity of the smokehouse was controlled between 36 and 68% and the cooking was completed in about 90 min. After cooking, frankfurters were washed with cold water for 2 min in order to reach a final temperature bellow 10 °C, and then casings were removed. Finally, frankfurters were vacuum packed and stored in a 4 °C cooler room until analysis within 2 d.

2.3. Texture profile analysis (TPA)

Textural properties of cooked frankfurters were evaluated by compression tests using a Model 4301 Instron Universal Testing Machine (Instron Corp., Canton, MA, USA) according to the procedure described by Wang and Xiong (1999). Before analysis, cooked frankfurters roll were equilibrated at room temperature (22 °C) for approximately 90 min. Twenty cylindrical samples of 15 mm length were cut from the frankfurters and carefully cored (12.7 mm diameter) by driving a hollow tube into the frankfurter samples and withdrawing it with its contained core. Ten samples were compressed axially between two parallel plates to 80% of the original height (20% deformation), in two consecutive cycles, and other ten samples to 20% of their original height (80% deformation), at a crosshead speed of 50 mm/min. The capacity of the load cell used was 100 N (10 kg). Peak values from these two compressions (20% and 80%) were recorded as descriptive texture parameters of these frankfurter-type sausages. Hardness, which was defined as the resistance force at the first compression at 20% (first peak value). Deformability, defined as the percent reduction in the resilient force from the first peak value after the second compression, and expressed as [(first peak force − second peak force) / first peak force] × 100. Cohesiveness and Gumminess were calculated as described by Bourne (1978). Cohesiveness was the ratio of the positive force area during the second compression to that during the first compression (A_2/A_1; total area of second peak divided by total area of first peak) and Gumminess was defined as the product of hardness multiply by the cohesiveness. Breaking strength (Fracturability), defined as the rupture force (peak value) during the 80% compression, was determined by compressing the samples until the structure failure.

2.4. Measurement of rheological properties

Dynamic viscoelasticity measurements of meat emulsions were performed in duplicate samples using a Bohling VOR rheometer

Table 1
Quantities of ingredients (g/100 g) used in the formulation of meat emulsions.

Emulsion treatment*	Meat	Backfat (B)	Canola oil (C)	Olive oil (O)	Rice bran (RB)	Walnut extract (WE)	Salt	Spice	Cure mix	Ice + water (I + W)
B control	62.5	20	–	–	–	–	1.5	0.6	0.4	15
B + RB	60	20	–	–	2.5	–	1.5	0.6	0.4	15
B + WE	60	20	–	–	–	2.5	1.5	0.6	0.4	15
C control	62.5	–	20	–	–	–	1.5	0.6	0.4	15
C + RB	60	–	20	–	2.5	–	1.5	0.6	0.4	15
C + WE	60	–	20	–	–	2.5	1.5	0.6	0.4	15
CO control	62.5	–	15	5	–	–	1.5	0.6	0.4	15
CO + RB	60	–	15	5	2.5	–	1.5	0.6	0.4	15
CO + WE	60	–	15	5	–	2.5	1.5	0.6	0.4	15

*B control, overall control made with 20 g/100 g backfat; B + RB (+2.5 g/100 g RB); B + WE (+2.5 g/100 g WE); C control, overall control made with 20 g/100 g canola oil; C + RB (+2.5 g/100 g RB), C + WE (+2.5 g/100 g WE); CO control, overall control made with 15 g/100 g canola and 5 g/100 g olive oils; CO + RB (+2.5 g/100 g RB); CO + WE (+2.5 g/100 g WE); Cure mix (sodium erythorbate, 0.05%; sodium tripolyphosphate, 0.3%; sodium nitrite, 0.05%); I + W, ice and water (8:7).