Meat Science 110 (2015) 9–14

Contents lists available at ScienceDirect

Meat Science

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

Effect of jabuticaba peel extract on lipid oxidation, microbial stability and sensory properties of Bologna-type sausages during refrigerated storage

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ARTICLE INFO

Article history:
Received 31 March 2015
Received in revised form 24 June 2015
Accepted 25 June 2015
Available online 02 July 2015

Keywords:
Natural antioxidant
Co-product
Lipid oxidation

ABSTRACT

This study investigated the lipid oxidation and the microbiological and sensory quality of Bologna-type sausages produced with the addition of jabuticaba peel extract (JPE). Instrumental parameters of color (L*, a* and b*), pH, thiobarbituric acid reactive substance (TBARS) values, microbiological profile, and sensory properties were determined during 35 days of storage. The addition of JPE had an effect on pH and protected the samples from color changes during storage. However, JPE had no positive effect on microbial stability during storage. Samples produced with 0.5, 0.75, and 1% JPE had significantly lower TBARS values ($P < 0.05$) compared with the control group. The addition of up to 0.5% JPE did not affect sensory quality, but prevented the decrease of sensory acceptance during storage. Therefore, due to its antioxidant effect JPE can be used in Bologna-type sausages in order to improve the oxidative stability during the shelf life.

1. Introduction

Lipid oxidation is one of the main reactions that determine the end of shelf life of emulsified meat products. Such a reaction that occurs during processing and storage causes undesirable changes in color, flavor, aroma, and texture, in addition to a loss in nutritional value (Shahidi, 2002). Synthetic antioxidants such as butylated hydroxyanisole, butylated hydroxytoluene, tert-butylhydroquinone, and propyl galate are the main resources used by the meat industry to delay the occurrence of lipid oxidation. These synthetic antioxidants have the advantage of low cost and high efficiency. Since consumers are increasingly aware of the toxicological implications of artificial additives and the demand for products with healthier characteristics has increased considerably in recent years, there is a growing interest in the meat industry to replace artificial additives with natural compounds.

The antioxidant potential of many natural compounds has been reported. Currently, there is a global trend of using co-products of the fruit industry as a source of natural antioxidants. Jabuticaba (*Plinia jabuticaba* Berg) is a fruit native to Brazil, which belongs to the Myrtaceae family. Due to recent studies that have shown the numerous health effects of jabuticaba (Alezandro, Granato, & Genovese, 2013; Leite et al., 2011; Leite-Legatti et al., 2012; Lenquiste, Batista, Marineli, Dragano, & Maróstica, 2012; Wu, Long, & Kennelly, 2013), this fruit has gained tremendous popularity. Consequently, products derived from jabuticaba (juices, sweets, jellies, liqueurs, etc.) that used to be artisanally developed have started to be produced by large industries. However, the peel, which accounts for approximately 50% of the fruit, is not used and it is usually disposed of improperly in the environment. Thus, it is necessary to seek alternatives in order to reduce the environmental impact caused by the industrialization of jabuticaba and add value to this co-product. Studies have shown that jabuticaba peel is a rich source of phenolic compounds such as anthocyanins and flavonols (Leite-Legatti et al., 2012; Reynertson et al., 2006), which are capable of complexing free radicals and inhibiting chain initiation or breaking the chain of propagation of oxidative reactions promoted by free radicals, which delays or prevents lipid oxidation reactions in food (Podsedek, 2007). In addition, the intake of foods with a high content of phenolic compounds is associated with a reduction in oxidative stress, prevention of some inflammatory diseases, prevention of cardiovascular diseases, protection against obesity and hypoglycemia, and improved memory (Ebrahimi & Schluesener, 2012; Mursu, Virtanen, Tuomainen, Nurmi, & Voutilainen, 2014). Despite the fact that the antioxidant and functional potential of jabuticaba peel has already been shown (Leite et al., 2011; Leite-Legatti et al., 2012), to date there are no reports on the use of this co-product as an alternative to improve the quality of meat products. Based on this, this study evaluated the effect of an extract prepared with jabuticaba peel (*P. jabuticaba* (Vell.) Berg) on lipid oxidation and the microbiological and sensory quality of Bologna-type sausages during storage.

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http://dx.doi.org/10.1016/j.meatsci.2015.06.012
0309-1740/

2. Material and methods

2.1. Preparation of jaboticaba peel extract

Jaboticaba fruits (*Plinia jaboticaba* (Vell.) Berg, genotype Sabará) were bought at the local market in Uberlândia, Minas Gerais State, Brazil, in September, 2014. The fruits were washed with tap water and sanitized by immersing them in a solution of sodium hypochlorite (200 mg·kg^{-1}) for 10 min. The fruits were manually peeled and frozen at −18 °C. The peels were subjected to lyophilisation (L101, Liotop, São Carlos, São Paulo, Brazil) at 30 °C, 300 μm Hg for 95 h, and the freeze-dried product was stored at −80 °C. After lyophilisation, the jaboticaba peels were ground in a knife mill (MA-102, Marconi, Piracicaba, Brazil) for 5 min.

The dried ground product was homogenized with a solvent (ethanol (95%) in distilled water (12:1)) and stirred for 1 h at room temperature. After this period, the mixture was filtered through Whatman # 6 filter paper. The solid phase was subjected to two successive extractions with ethanol (95%), aiming to fully extract the active principle of the raw material. Three filtrates were collected and concentrated in a rotary evaporator (Rotavapor® RE 120 — Büchi, Flawil, Switzerland) until all the ethanol was removed. The volume was adjusted to 50 mL with distilled water, and the extract at a liquid–solid ratio of 12:1 was kept under refrigeration (4 °C) in a glass bottle protected from light (Campagnol et al., 2011). The total phenol content was determined in triplicate in three jaboticaba peel extracts using Folin–Ciocalteu reagent according to the procedure reported by Ozsoy, Can, Yanardag, and Akev (2008). The results were expressed in gallic acid equivalents (GAE), determined utilizing a separately prepared absorbance versus concentration curve for gallic acid.

2.2. Addition of jaboticaba peel extract in Bologna-type sausages

Five treatments were manufactured to determine the effect of the jaboticaba peel extract (JPE) on lipid oxidation, as well as on the microbiological and sensory quality of Bologna-type sausages. Treatments were prepared according to the formulation illustrated in Table 1. Pork meat (*Triceps brachii*, moisture: 73.12% ± 0.15; protein: 20.92% ± 0.65; fat: 4.22 ± 0.31) and pork back-fat (moisture: 11.99% ± 0.31; protein: 8.56% ± 0.14; fat: 79.62 ± 0.18) were obtained from a local meat market. The rest of the additives and spices used were donated by Ibrac Aditivos e Condimentos (Rio Claro, São Paulo, Brazil).

2.3. Manufacturing process of Bologna-type sausages

First, the pork meat, sodium chloride, and sodium tripolyphosphate were placed in the cutter (Model KJ20, Jamar, Brazil) for the extraction of myofibrillar proteins. When the temperature of the mixture reached 8 °C, the remaining ingredients and the pork back fat were slowly added, followed by comminution until complete homogenization. During comminution, the temperature of the meat mixture did not exceed 10 °C. The mixture was stuffed (Model EJV15, Jamar, Brazil) in cellulose casings (Viskase, São Paulo, Brazil) 40 mm in diameter with approximately 0.3 kg of product per package. The Bologna-type sausages were cooked in a water bath according to the following cooking cycle: 60 °C for 30 min, 70 °C for 30 min, and 80 °C until the internal temperature of the product reached 72 °C. A thermocouple was placed in the center of the samples to monitor and control the internal temperature. After cooking, the Bologna-type sausages were immediately cooled in an ice bath. The samples were vacuum-packed (200 Selovac Sealer, Selovac, Brazil) and stored under refrigeration (4 °C) for 35 days.

Table 1
Formulation of Bologna-type sausages containing four concentrations of JPE.

(%)	Control	T0.25	T0.50	T0.75	T1.0
Pork	71.06	71.06	71.06	71.06	71.06
Pork back-fat	15	15	15	15	15
Salt	2.5	2.5	2.5	2.5	2.5
Monosodium glutamate	0.3	0.3	0.3	0.3	0.3
Sodium nitrite	0.015	0.015	0.015	0.015	0.015
Sodium tripolyphosphate	0.3	0.3	0.3	0.3	0.3
Sodium erythorbate	0.025	0.025	0.025	0.025	0.025
Garlic	0.5	0.5	0.5	0.5	0.5
Coriander	0.2	0.2	0.2	0.2	0.2
Black pepper	0.1	0.1	0.1	0.1	0.1
Jaboticaba peel extract	0	0.25	0.5	0.75	1
Crushed ice	10	9.75	9.5	9.25	9
Total	100	100	100	100	100

2.4. Physicochemical analysis

The pH was determined in triplicate by mixing a 10 g sample with distilled water (1:10 sample/water) and the homogenate was subjected to pH measurements (DM 22, Digimed, São Paulo, Brazil). Color determination was performed using the Minolta CR-400 colorimeter (Konica Minolta Sensing Inc., Japan), according to the CIE L* a* b* system, using spectral reflectance included as calibration mode, illuminant D65, and observation angle of 10°. L* (lightness), a* (red intensity), and b* (yellow intensity) values were determined. Five pieces per treatment were used for color determination, and the color parameters were evaluated on internal surface at four different points. The extent of lipid oxidation was measured in triplicate by determining thiobarbituric acid reactive substance (TBARS) values (Raharjo, Sofos, & Schmidt, 1992) expressed as milligrams of malondialdehyde per kg sample. The pH, color, and TBARS were determined after zero, 7, 14, 21, 28, and 35 days of storage.

2.5. Microbiological analysis

The microbiological characteristics of the sausages were evaluated after 0, 18, and 35 days of storage according to the methodology described by Ownes and Ito (2001). For that, 25 g aliquot was homogenized with 225 mL 0.1% peptone water (Oxoid Unipath Ltd., Basingstoke, Hampshire, UK) and serial decimal dilutions were performed. Mesophilic aerobic bacteria were enumerated using standard agar (Oxoid) (35 °C/48 h), De Man Rogosa Sharpe agar (Oxoid) was used for enumeration of lactic acid bacteria (37 °C/48 h), crystal violet neutral-red bile agar (Oxoid) was used for total coliforms (37 °C/24 h), and EC broth (Oxoid) was used for enumeration of fecal coliforms (45 °C/48 h).

2.6. Consumer test

The color, aroma, flavor, texture, and overall acceptance were evaluated using a non-structured nine-point hedonic scale, with 0 being extremely disliked and 9 extremely liked. A total of 100 consumers that regularly consumed Bologna-type sausages participated in the test. Consumers were recruited among students and staff of the Federal Institute of Education, Uberaba, Brazil, with 54% being women and 46% being men, ranging in age from 18 to 60 years. The samples were assigned a three-digit code and were evaluated by each consumer in a monadic order, and the order of presentation followed a balanced design as described by Stone, Bleibaum, and Thomas (2012). The consumer test was performed in normalized booths under fluorescence lighting. Two slices (4 cm diameter and 0.3 cm thick), taken from the central part of the product, were given to each consumer, who were provided with water at room temperature and salted crackers for palate cleansing. The consumers test was performed immediately after manufacture (day 0) and after 18 and 35 days of refrigerated storage.

2.7. Statistical analysis

A randomized complete block design was adopted and the entire experiment was replicated three times on three different days. An analysis