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Pineapple by-product and canola oil as partial fat replacers in low-fat beef burger: Effects on oxidative stability, cholesterol content and fatty acid profile

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ABSTRACT

The effect of freeze-dried pineapple by-product and canola oil as fat replacers on the oxidative stability, cholesterol content and fatty acid profile of low-fat beef burgers was evaluated. Five treatments were performed: conventional (CN, 20% fat) and four low-fat formulations (10% fat): control (CT), pineapple by-product (PA), canola oil (CO), and pineapple by-product and canola oil (PC). Low-fat cooked burgers showed a mean cholesterol content reduction of 9.15% compared to the CN. Canola oil addition improved the fatty acid profile of the burgers, with increase in the polyunsaturated/saturated fatty acids ratio and decrease in the n-6/n-3 ratio, in the atherogenic and thrombogenic indexes. The oxidative stability of the burgers was affected by the vegetable oil addition. However, at the end of the storage time (120 days), malonaldehyde values of CO and PC were lower than the threshold for the consumer's acceptance. Canola oil, in combination with pineapple by-product, can be considered promising fat replacers in the development of healthier burgers.

1. Introduction

Burger is one of the most popular processed meat products in the world. It is highly accepted and consumed, mainly due to the current increase in the number of fast foods worldwide and its convenience and low price (Hoogenkamp, 1997). However, burgers are also known by some negative aspects, such as the quantity (20–30%) (Jiménez-Colmenero, 2000) and quality of its fat (mostly saturated fatty acids), as well as the cholesterol content, which are associated with the occurrence of some chronic and cardiovascular diseases (Fernández-Ginés, Fernández-López, Sayas-Barberá, & Pérez-Alvarez, 2005).

With the increased concerns about the relationship between fat intake and health, consumers have become more conscious regarding a healthy diet, demanding products with reduced fat, cholesterol content, and altered fatty acid profile (Ospina, Sierra, Ochoa, Pérez-Álvarez, & Fernández-López, 2012). Thus, due to the high fat content and popularity of the burgers, they are considered an attractive choice for fat reduction and fatty acid profile improvement.

However, the fat reduction of meat products, with its direct substitution by water, can bring a series of deleterious effects in both sensory quality (reducing flavor and juiciness, and modifying texture) (Jiménez-Colmenero, 2000) and technological characteristics (increasing cooking loss, reducing yield, affecting emulsion stability) (Hughes, Cofrades, & Troy, 1997). In order to minimize these issues and to improve the quality of reduced-fat products, some ingredients have been studied to act as animal fat replacers, such as dietary fibers (DF) and vegetable oils.

The use of dietary fiber as a functional ingredient is related to their interesting properties that can positively affect some technological characteristics of the meat products. Fibers have been successfully applied to improve water holding capacity (WHC), oil holding capacity (OHC) and swelling capacity, which are useful in products that require hydration, to improve yield, stabilize emulsions, and modify texture and viscosity (Elleuch et al., 2011). Furthermore, it is well-known that DF plays an important role in human health, acting as a bulking agent, normalizing intestinal motility and then preventing constipation (insoluble fibers) and decreasing the intestinal absorption of cholesterol and glucose (soluble fibers) (Silveira Rodríguez, Monereo Megías, & Molina Baena, 2003).

Dietary fibers are obtained mainly from cereals. However, fruits and vegetable by-products still have high DF content, with the advantage of presenting considerable amounts of antioxidants (Deng, Penner, & Zhao, 2011; Martínez et al., 2012). Pineapple is a widely consumed tropical fruit and part of its production is intended to the manufacture of juices, fruit salads, canned fruits and jams. The residues generated by this industrial activity are composed mainly by peel and core and

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represent about 25–35% of the fruit (Larrauri, Rupérez, & Calixto, 1997). According to a previous study, pineapple by-product (peel and heart) presents DF as its major component (75.8%), in addition to have high water holding capacity, swelling capacity and an interesting antioxidant activity (Martínez et al., 2012).

Besides the dietary fiber, the replacement of animal fat with vegetable oil has been used as an alternative to improve technological and sensory aspects of low-fat meat products, in addition to enhance its nutritional value, by reducing saturated fatty acids (SFAs), cholesterol content and increasing monounsaturated (MUFAs), and polyunsaturated fatty acids (PUFAs). Canola oil has an interesting fatty acid profile, showing the lowest level of SFAs (7.36%) among the most common vegetable oils, such as sunflower (10.30%), corn (12.94%), olive (13.80%), soybean (15.65%), and cottonseed (25.9%) oils, high levels of monounsaturated fatty acids (MUFAs) (63.27%), and intermediate levels of polyunsaturated fatty acids (PUFAs) (28.14%) (USDA, 2015). Its lipid composition has motivated some studies based on canola oil application in meat products, resulting in positive effects regarding technological (Youssef & Barbut, 2011) and nutritional characteristics (Pelser, Linssen, Legger, & Houben, 2007) of the products.

There are few studies evaluating the association of fiber and vegetable oils as fat replacers. Choi et al. (2010) studied the replacement of pork back fat by different vegetable oils (olive, grape seed, corn, canola and soybean oil) and rice bran fiber in frankfurters and reported that the products had a decrease in cholesterol and trans-fat levels, an increase in cooking yield and TBARS values, in addition to have showed sensory properties similar to control frankfurters containing pork fat. Another study found that the incorporation of sunflower seed oil and dietary fiber from *makgeolli* lees in reduced-fat frankfurters minimized the texture alterations associated with fat reduction, reduced cooking loss and improved emulsion stability of the product (Choi et al., 2013). The replacement of pork back fat by olive oil emulsion and wakame (brown seaweed high in fiber) fortified patties with dietary fiber and minerals, improved the texture and the fatty acid profile and resulted in a healthier meat product (López-López, Cofrades, Yakan, Solas, & Jiménez-Colmenero, 2010).

In this context, the present work aimed to study the impact of animal fat reduction and its partial substitution by pineapple by-product (peel and pomace) and canola oil on the oxidative stability (during 120 days of frozen storage), cholesterol content and fatty acid profile of beef burgers.

2. Material and methods

2.1. By-product preparation

Pineapple by-product (peel and pomace) was obtained from a fruit and vegetable processing industry (Jundiaí, SP, Brazil). At the industry, the fruits were sanitized with 200 ppm of sodium hypochlorite, rinsed with water and then passed through the pulp extractor, where the by-product was collected. The material was kept frozen until its transportation to the Laboratory of Food and Nutrition of the Universidade de São Paulo (ESALQ/USP, Piracicaba, SP, Brazil). Samples were freeze dried (EC Modulyo, EC Apparatus Inc., New York, USA), ground using a knife mill (Marconi, Piracicaba, SP, Brazil), passed through a 40-mesh sieve (420 μm) and stored at −18 °C. Before the burger processing, pineapple by-products underwent a thermal treatment (100 °C, 2 h) in order to inactive the bromelain.

2.2. Burger manufacture

Fresh beef (moisture 77.24%, fat 1.29%) and pork back fat (moisture 12.06%, fat 84.09%) were purchased from a local slaughterhouse (Piracicaba, SP, Brazil). Beef and fat were separately ground (Hobart 4B22-2, Troy, OH, USA) using a 0.8 cm plate and then beef was divided into 5 treatments. The first treatment was used as a conventional formulation (CN) and the fat content was adjusted to 20% by the addition of back fat. The second treatment was used as a low-fat control (CT) and the fat content was adjusted to 10%. For the other treatments, pineapple by-product (1.5%) and/or canola oil emulsion (5%) were used and the fat content was also adjusted to 10% (Table 1). The concentration of pineapple by-product was selected based on a previous experiment that evaluated different concentrations of pineapple by-product (1.0, 1.5, 2.0, 2.5%) and canola oil (5%) as fat substitutes in low-fat beef burger (Selani, Margiotta, Piedade, Contreras-Castillo, & Canniatti-Brazaca, 2015). Canola oil emulsion was prepared by mixing eight parts of mineral hot water (50–55 °C) with one part of soy protein isolate by using a high speed mixer (Ultra Turrax Ika T18 basic, Wilmington, NC, USA) at 10,000 rpm for 2 min, and then 10 parts of canola oil was gradually added to this mix and homogenized for 3 min at 10,000 rpm (Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001).

After the addition of the respective amount of beef, fat, pineapple by-product and canola oil emulsion, the treatments were mixed with salt (1.5%), a commercial mix for burger (salt, maltodextrin, sodium polyphosphate, sodium erythorbate, natural spices, monosodium glutamate) (IBRAC, Rio Claro, SP, Brazil), and cold water. The formulations were kneaded by hand for 5 min and from the homogenized meat mixture, 100 g portions were manually shaped using a burger-maker, to give the dimensions of 10 cm diameter and 1 cm thickness. The beef burgers were then placed in polyethylene packages. The processing occurred in triplicate (all the formulations were applied to three independent batches of meat and fat).

2.3. Storage of the samples

After packaging, raw burgers were stored under −18 °C, for further analyses. The cholesterol content and the fatty acid profile of the burgers were determined during the first 15 days of storage. For the oxidative stability, beef burgers were stored up to 120 days and the samples were analyzed at 30 days intervals (1, 30, 60, 90, and 120 days).

2.4. Cooking procedure

The burgers were cooked before the analyses (without previous defrosting), in an electrical grill (Edanca, São Bernardo do Campo, SP, Brazil) pre-heated at 150 °C. The core temperature of the beef burgers was measured using a digital thermometer (Incoterm, Porto Alegre, RS, Brazil) to ensure an internal temperature of 75 °C was reached. Right after the samples have reached 75 °C, they were placed on trays and cooled at room temperature for about 30 min before the analysis.

Table 1
Formulation of beef burgers.

Ingredients	Treatments (%)				
	CN	CT	PA	CO	PC
Beef meat	70	70	70	70	70
Back fat	20	10	10	10	10
Cold water	7.5	17.5	16	12.5	11
Canola oil emulsion	0	0	0	5	5
Pineapple by-product	0	0	1.5	0	1.5
Salt	1.5	1.5	1.5	1.5	1.5
Mix for burger*	1	1	1	1	1

CN: conventional, with 20% fat; CT: control, with 10% fat; PA: with 10% fat and 1.5% of pineapple by-product; CO: with 10% fat and 5% of canola oil; PC: with 10% fat, 1.5% of pineapple by-product and 5% of canola oil.

* Commercial mix for burger: salt, maltodextrin, sodium polyphosphate, sodium erythorbate, natural spices and monosodium glutamate.