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Improving pork burgers quality using *Zingiber officinale* Roscoe powder (ginger)

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ABSTRACT

Pork burgers were evaluated for physical-chemical characteristics, fatty acids profile, lipid oxidation, antioxidant capacity, microbiological growth and sensory evaluation during storage time of seven days at 4 °C as function of three formulations as only meat (control, B) and meat added with ginger powder at the percentage of 1 and 2% (BG1 and BG2).

BG1 and BG2 were less redness than control ones with incremented yellow hue. These modifications in color parameters did not modify sensory characteristics of burgers. PUFA were incremented (both PUFAω3 and PUFAω6) by the addition of ginger. Furthermore, BG1 and BG2 burgers showed to be less sensitive to lipid oxidation and to possess an increase in antioxidant capacity. Microbial growth evaluation of total aerobic count and *Pseudomonas* spp. showed that ginger powder delayed in time the bacterial contamination. Results highlighted that the presence of ginger led to an enhanced shelf life and health characteristics of burgers (increasing peroxidisability, ratio hypocholesterolemic/hypercholesterolemic and ratio ω3/ω6; reducing atherogenicity and thrombogenicity).

1. Introduction

Ready-to-cook products represent an important percentage of food production for their high usage and acceptance by high number of consumers. Burgers are one of the most consumed meat product for their practicality to be cooked and for their ease of consumption.

As well known grinding process, as a result of disruption on muscle structure, leads to a less stable food matrix that could occur more easily to chemical and enzymatic oxidation processes and in an increased microbial growth (Emswiler, Pierson, & Kotula, 1976; Mancini & Hunt, 2005). Several factors as production processes, packaging and food additives were studied during the last decades in order to reduce oxidations and enhance shelf life of meat products (Hygreeva & Pandey, 2016; Jiang & Xiong, 2016; Overholt et al., 2016; Shahidi & Ambigaipalan, 2015; Yang, Lee, Won, & Song, 2016). Antioxidant molecules, as food additives, seem to protect from oxidation and delay microbial growth (Falowo, Fayemi, & Muchenje, 2014) as well as improve or to carry on nutraceutical properties (Decker & Park, 2010).

After the controversial due to the potential adverse effects on health of synthetic antioxidant molecules a growing attention was shown by consumers to prefer products with natural antioxidant, encouraging food industries to research continuously newest natural food additives (Brewer, 2011; Jiang & Xiong, 2016; Shahidi & Ambigaipalan, 2015; Shahidi & Zhong, 2010).

Plant products might be well accepted by the consumers for their natural origin. Several spices, essential oils, extracts, powders and other plant by-products were studied in the last decades in order to assess their activity and their effects on meat products as feed/food supplementation (Burt, 2004; Jiang & Xiong, 2016; Mancini, Preziuso & Paci, 2016; Mancini, Paci, Pisseri & Preziuso, 2017; Shah, Bosco, & Mir, 2014).

Ginger (*Zingiber officinale* Roscoe) is one of the most common spice used worldwide, as a condiment for food and beverage. Ginger flavor is a mix of spicy, peppery and sweet with a strong pungent characteristic. *Zingiber officinale* is a species of the *Zingiberaceae* family as well other spices as galangal (*Alpinia galangal*), cardamom (*Elettaria cardamomum*) and turmeric (*Curcuma longa*). Ginger rhizome is generally consumed fresh, dried powder or candy; in some countries, as India and China, ginger is historically used in several food preparation and meat dishes (Zachariah, 2008). Ginger's antioxidant and anticarcinogenic properties have been quantified in several researches (Manju & Nalini, 2005; Mi, Guo, & Li, 2016) and the use of ginger was evaluated both in food (Abdel-Naeem & Mohamed, 2016; Cao et al., 2013; Naveena & Mendiratta, 2004) and feed (Herawati & Marjuki, 2011; Zhao et al., 2011; Zomrawi, Abdel Atti, Dousa, & Mahala, 2012). Ginger powder

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contains several antioxidant molecules as gingerol, paradol, shogaols, zingerone, zerumbone, terpenoids as well flavonoids and phenols (Kikuzaki & Nakatani, 1993; Rahmani, Al Shabrmi, & Aly, 2014).

The aim of this research was to evaluate the effect of the addition of two different percentage of ginger powder during a refrigerate storage on pork burger's meat quality (pH, color and water holding capacity), fatty acid profile, lipid oxidation, antioxidant capacity, microbial growth and sensory evaluation.

2. Material and methods

2.1. Meat

Meat was obtained from nine female pigs (Cinta Senese breed, 125 ± 4 kg) reared under pasture system and fed commercial pelleted feed. Pigs were slaughtered after electrical stunning and chilled for 24 h at 4 ± 0.5 °C. *Longissimus lumborum* muscles of the left carcasses were removed and transported to the laboratory (Department of Veterinary Science, Pisa) for the formulation of the burgers.

2.2. Experiment design and preparation of burgers

Each *Longissimus lumborum* muscle was considered as an experimental unit and was analyzed to determine the proximate composition after grinding.

Loins were minced separately and randomly assigned to three different formulations (F, three loins per formulation): control burgers (only meat, B), burgers added with 1% of ginger powder (10 g of ginger for kg of meat, BG1) and burgers added with 2% of ginger powder (20 g of ginger for kg of meat, BG2). Commercial ginger powder, ready to use, was purchased from wholesaler (Drogheria e Alimentari S.p.A., Scarperia e San Piero, Florence, Italy; rhizomes of ginger from India, batch number: L65069N). Proximate composition, antioxidant capacity (ABTS, DPPH and FRAP) and fatty acids profile of ginger powder were reported in Table 1.

From each experimental unit ten burgers of 100 g were shaped in Petri dishes (85 mm of diameter) for a total of 30 burgers for formulation (a total of 90 burgers). Burgers were placed in single Styrofoam trays and were overwrapped with polyethylene film.

Burgers were stored at 4 ± 0.5 °C and three burgers for experimental unit (9 burgers per formulation) were analyzed after 1, 4 and 7 days (Storage time - ST: D1, D4 and D7) for the determination of the pH, color, water holding capacity (drip loss and cooking loss), fatty acid profile, lipid oxidation (TBARS), antioxidant capacity (ABTS, DPPH, FRAP), microbial growth and sensory.

Table 1
Ginger powder proximate composition, antioxidant capacity evaluations and fatty acids profile.

Proximate composition (%)		Fatty acids profile (%)	
Moisture	6.47	C16:0	20.49
Fat	6.51	C18:0	10.08
Protein	13.80	SFA	37.52
Ash	8.02	C18:1	15.85
		MUFA	21.23
Antioxidant capacity		C18.3ω3	2.90
ABTS	118.34	C22:5ω3	2.02
DPPH	10.99	PUFAω3	7.90
FRAP	75.51	C18.2ω6	27.35
		C20:2ω6	2.03
		C22:2ω6	2.00
		PUFAω6	33.35
		PUFA	41.25

ABTS and DPPH in mmol of Trolox equivalent per kilogram of ginger powder; FRAP in mmol of Fe^{II} equivalent per kilogram of ginger powder.
Also C14:0, C15:0, C17:0, C20:0, C22:0, C24:0, C14:1, C16:1, C17:1, C22:1, C20:5ω3, C22:6ω3, C18:3ω6 and C20:4ω6 were detected in lower amounts. All the mentioned fatty acids have been utilized for calculating sum of lipid fractions.

2.3. Proximate analysis, pH, color and water holding capacity

Proximate composition (moisture, ash, ether extract) was determined on grounding meat derived from each pig (AOAC, 1995).

A pH meter equipped with glass electrode suitable for meat penetration and an automatic temperature compensator was used to determine the pH (Hanna pH 211 equipped with Hanna FC 200B, Hanna Instruments, Padova, Italy), prior to each session pH meter was calibrated with two buffer solutions at pH 4.01 and 7.01 (respectively HI7004L and HI7007L Hanna instruments, Padova, Italy).

Chroma meter Minolta CR300 (Minolta, Osaka, Japan) was used to measure the color parameter (aperture size of 8 mm, illuminant D65, incidence angle of 0°). Lightness (L*), redness (a*) and yellowness (b*) indexes were recorded as reported by CIE (1976), after a calibration section using a white tile ($L^* = 98.14$, $a^* = -0.23$ and $b^* = 1.89$). Numerical total color difference (ΔE) was calculated as proposed by Sharma (2002), as well a* and b* indexes were used to calculate the hue (H*) and the chroma (C*) parameters (CIE, 1976). The water holding capacity was calculated as drip loss between D1 and D4 or D1 and D7 (Lundström & Malmfors, 1985) and as cooking loss after a cooking section in a preheated oven at 163 °C to an internal temperature of 71 °C (burgers were turned every 4 min to prevent excess surface crust formation; AMSA, 1995).

2.4. Fatty acids profile

The extraction of intramuscular fat was based on the method of Folch, Lees, & H. G. Stanley (1957). Total lipids were extracted from 5 g of burger and fatty acid composition of meat was determined by gas chromatography. The separation of fatty acid methyl esters (FAME) was performed with an Agilent capillary column (30 m × 0.25 mm I.D., CPS Analitica, Milan, Italy) coated with a DB-Wax stationary phase (film thickness of 0.25 μm). Nonadecanoic acid (C19:0) was used as internal standard. Fatty acid composition was calculated using the peak areas and was expressed on a percentage basis. The average amount of each fatty acid (FA) was used to calculate the sum of the saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) and to calculate the atherogenicity (AI), thrombogenicity (TI), hypocholesterolemic (h), hypercholesterolemic (H) and peroxidisability (PI) indexes as reported below:

$$AI : (C14:0 * 2 + C16:0)/(MUFA + PUFA\omega3 + PUFA\omega6)$$

$$TI : (C14:0 + C16:0 + C18:0)/(MUFA * 0.5 + PUFA\omega6 * 0.5 + PUFA\omega3 * 3 + PUFA\omega3/PUFA\omega6)$$

$$h : C18:1 + C18:2\omega6 + C18:3\omega3 + C18:3\omega6 + C20:4\omega6 + C20:5\omega3 + C22:6\omega3$$

$$H : C14:0 + C16:0$$

$$PI : \sum monoenoic * 0.025 + \sum dienoic * 1 + \sum trienoic * 2 + \sum tetraenoic * 4 + \sum pentaenoic * 6 + \sum hexaecoic * 8$$

2.5. Thiobarbituric acid reactive substances and antioxidant capacity

Thiobarbituric acid reactive substances (TBARS) were evaluated spectrophotometrically following the method modified from Ke, Ackman, Linke, & Nash (1977) by Dal Bosco et al. (2009).

Five gram sample was homogenized for 45 s at 9000 rpm (Polytron PT 3000, Kinematica AG, Eschbach, Deutschland) with 10 mL of 7.5% trichloroacetic acid (TCA) and 0.1% diethylenetriaminepentaacetic acid (DTPA) in distilled water (final concentration). The homogenized sample was centrifuged at 10,000 rpm for 10 min (4235A CWS, ALC International, Milan, Italy) and filtered through Whatman number 1 filter