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Modifications of fatty acids profile, lipid peroxidation and antioxidant capacity in raw and cooked rabbit burgers added with ginger

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ABSTRACT

Effects of ginger powder were evaluated on fatty acid (FA) profile, lipid peroxidation (TBARS) and antioxidant capacity (ABTS, DPPH and FRAP) of rabbit burgers. Burgers were manufactured as control samples (only meat) and two additions of ginger powder (1% and 2%) and stored raw at 4 °C for 7 days. At day 1, 4 and 7 of storage burgers were analysed both as raw and cooked. Ginger powder affected all the tested parameters; both PUFAω3 and PUFAω6 were incremented in raw and cooked samples leading to decreased atherogenicity and thrombogenicity indexes and increased hypo/hypercholesterolemic index and peroxidability index. Lipid peroxidation values of raw and cooked burgers added with ginger were lower than control burgers, at the same time, ABTS, DPPH and FRAP values were incremented by the addition of ginger powder. The results obtained demonstrate the antioxidant capacity of ginger powder as rabbit meat products additive and highlight the capacity of this spice to maintain its characteristics after burgers' cooking.

1. Introduction

Ginger (*Zingiber officinale* Roscoe) is widely used as spice in several recipes for its pleasant aroma and pungency taste. Moreover, several ginger medical properties are reported in the traditional herbal medicine, in particular for relieving nausea and indigestion (Tapsell et al., 2006) and are commonly used as eupeptic (stimulate the digestive processes) in several products (Zachariah, 2008).

Ginger products (mainly used as powder or ethyl extract) are rich of biological active compounds such as gingerol, paradol, shogaols, zingerone, zerumbone, terpenoids and other minority molecules as flavonoids and phenols (Rahmani, Al Shabrmi, & Aly, 2014). These molecules, involved in flavour and aroma, are also particularly active as antioxidants and modulator of lipid peroxidation. Several articles reported the efficiency of ginger and plant of the Zingiberaceae family as food additive (Abdel-Naeem & Mohamed, 2016; Cao et al., 2013; Mancini, Paci, Fratini, et al., 2017; Naveena & Mendiratta, 2004) or feed supplementation (Herawati & Marjuki, 2011; Mancini, Paci, Pisseri, & Preziuso, 2017; Zhao et al., 2011).

The latest data of FAOSTAT report that in 2014 the world annual production of rabbit meat has been estimated in 1.6 million tonnes; interestingly the first three producer countries of rabbit meat represent the 75.87% of the world production. The main producer was China (763,000 tonnes, 48.89% of the world production) followed by Italy and Democratic People's Republic of Korea (269,000 and 152,000 tonnes, respectively) (FAO, 2017). Rabbit meat is characterized by excellent dietetic and nutritive properties due to a low lipid content and a high essential amino acids levels (Dalle Zotte, 2002). As consequence of its high percentage of unsaturated fatty acids, rabbit meat is one of the most susceptible to lipid peroxidation and its employment in processed products is very limited (Dalle Zotte & Szendrő, 2011; Petracci & Cavani, 2013).

Burgers represent one of the main sold meat products both as raw (ready-to-cook) or cooked (ready-to-eat) and could easily meet consumers' demands. Burger, as a processed product, could rapidly lose its quality and nutrient values due to deterioration (both chemical and biological). Natural ingredients, widely used as flavouring, could play an important role in the stability of the products (Falowo, Fayemi, & Muchenje, 2014; Mariutti & Bragagnolo, 2017; Overholt et al., 2016; Shah, Bosco, & Mir, 2014).

For all the reasons reported above the aim of this research study was to test the capacity of ginger powder to affect fatty acids profile, lipid

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peroxidation and antioxidant capacity in burgers formulated with rabbit meat that could rapidly deteriorate. In order to estimate the potential activity of ginger powder two percentages were tested (1% and 2%) and compared to a control formulation (only rabbit meat) during a storage period of 7 days. Fatty acids profile, lipid peroxidation and antioxidant capacity were also determined on cooked samples in order to quantify these parameters in the ready-to-eat products.

2. Material and methods

2.1. Burger manufacture

Nine experimental units were used, each one consisting of one individual rabbit meat. Meat batches were randomly divided in three formulations (F, 3 batches per F) and meat samples were collected for proximate composition. One formulation was used as control (C, only meat) while the other two F consisted in meat added with ginger powder at the percentage of 1 or 2% (Z1 and Z2). Commercial ginger powder, ready to use, was purchased from 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.

Thirty burgers per F were sized in Petri dishes (85 mm of diameter, burger of 100 g, 108 burgers in total) and packaged in single Styrofoam trays, overwrapped with polyethylene film. Burgers were stored raw at 4 ± 0.5 °C to be analysed at day 1, 4 and 7 (Storage time, T; T1, T4 and T7) of storage as raw and cooked. At the fixed storage times from each batch of each formulation, two burgers were used as raw samples and two burgers were cooked (for each F six raw burgers and six cooked burgers were analysed at each T). Burgers derived from the same batch and analysed as raw or cooked samples at a fixed storage time were used as sub-replicates to calculate the experimental unit (batch) value.

Burgers were cooked in a preheated oven at 163 °C to an internal temperature of 71 °C and were turned every 4 min to prevent excess surface crust formation (AMSA, 1995).

Raw and cooked burgers were analysed at T1, T4 and T7 for the determination of fatty acid profile, lipid peroxidation (TBARS) and antioxidant capacity (ABTS, DPPH, FRAP).

2.2. Fatty acids profile

The extraction of intramuscular fat was based on the method of Folch, Lees, and Sloane-Stanley (1957) with chloroform/methanol (2/1); total lipids were extracted from 5 g of burger and fatty acid composition of meat was determined by gas chromatography using a gas chromatograph equipped with a flame ionization detector (Fisons mega 2, Fisons Instruments S.p.A., Rodano, Milano, Italy). 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 DBWax stationary phase (film thickness of 0.25 μm). Nonadecanoic acid (C19:0) was used as internal standard. The fatty acid methyl esters were identified by retention times compared to the internal standard; the fatty acid profile was calculated using Chrom-Card software and was expressed as percentage of the total fatty acids.

Fatty acid means were used to calculate atherogenicity (AI), thrombogenicity (TI), hypocholesterolemic (h), hypercholesterolemic (H) and peroxidisability (PI) indexes as reported below:

AI: (C14: 0∗2 + C16: 0)/(MUFA+PUFAω3 + PUFAω6)

TI: (C14: 0 + C16: 0 + C18: 0)/(MUFA∗0.5 + PUFAω6∗0.5 + PUFAω3 ∗3 + PUFAω3/PUFAω6)

h: C18: 1 + C18: 2ω6 + C18: 3ω3 + C18: 3ω6 + C20: 4ω6 + C20 : 5ω3 + C22: 6ω3

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

Table 1
Proximate composition, antioxidant capacity and fatty acid profile of ginger powder.

Proximate composition (%)		Fatty acid 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.
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 also detected in lower amounts. All the mentioned fatty acids have been utilised for calculating sum of the fatty acid fractions.

2.3. Thiobarbituric acid reactive substances (TBARS)

Lipid peroxidation was evaluated with thiobarbituric acid reactive substances (TBARS) method according to Ke, Ackman, Linke, and Nash (1977) and modified by Dal Bosco et al. (2009). Briefly, samples were homogenized with trichloroacetic acid and diethylenetriaminepentaacetic acid and then centrifuged and filtered. Thiobarbituric acid was mixed with the filtrate and tubes were placed in a water bath at 95 °C for 45 min. The absorbance (532 nm) of the samples was recorded and the mg of malondialdehyde (MDA) on 100 g of sample were calculated based on a calibration curve using 1,1,3,3-tetraethoxypropane (TEP).

2.4. Antioxidant capacity (ABTS, DPPH and FRAP)

Five g of samples were homogenized in 10 ml of ethanol at 9000 rpm (Polytron PT 3000, Kinematica AG, Eschbach, Germany) for 45 s in a plastic tube wrapped in aluminium foil. After a centrifugation at 10,000 rpm (4235A CWS, ALC International, Milan, Italy) for 10 min, the supernatant was filtered through Whatman filter paper (N 4). The antioxidant capacity was performed on ethanol extracted samples according the minor modifications reported in Mancini et al. (2015) to the methods of Re et al. (1999) for ABTS reducing activity assay (ABTS, 2,20-azinobis(3-ethylbenzthiazoline-6-sulphonic acid)), of Blois (1958) and Jung et al. (2010) for DPPH scavenging activity (DPPH, 2,2-diphenyl-1-picrylhydrazyl), and Descalzo et al. (2007) for FRAP assay method (ferric reducing ability).

2.5. Statistical analysis

Data of fatty acids profile, lipid peroxidation and antioxidant capacity of both the raw and cooked samples were analysed by applying ANOVA according to a two factorials design with repeated measurements in time. The fixed factors were formulation F (C, Z1, Z2) and storage time T (1, 4, 7 days) and random factors were meat batches. The interaction F × T was also analysed. The two-way repeated measures ANOVA was conducted separately for raw and cooked samples, and the data are reported as the mean of the fixed effects F and T; the variability