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Effect of the addition of hop (infusion or powder) on the oxidative stability of lean lamb patties during storage

Luz H. Villalobos-Delgado[a], Irma Caro[b,c], Carolina Blanco[d], Raul Bodas[d], Sonia Andrés[d], Francisco J. Giráldez[d], Javier Mateo[b,*]

[a] Instituto de Agroindustrias, Universidad Tecnológica de la Mixteca, Carretera a Acatlima Km. 2.5, 69000, Huajuapan de León, Oaxaca, Mexico
[b] Departamento de Higiene y Tecnología de los Alimentos, Universidad de León, Campus Vegazana, s/n, 24007, León, Spain
[c] Departamento de Pediatría, Inmunología, Obstetricia-Ginecología Nutrición-Bromatología, Psiquiatría e Historia de la Ciencia. Universidad de Valladolid Avenida de Ramón y Cajal, 7, 47005 Valladolid, Spain
[d] Instituto de Ganadería de Montaña (CSIC-Universidad de León), Finca Marzanas, E-24346 Grulleros, León, Spain

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ABSTRACT

The effects of adding hop to lamb patties on their oxidative stability were evaluated. Two experiments were performed. In the first experiment, patties were prepared by adding water (control), hop infusion (2 g infused hop/kg) or a sodium ascorbate solution (0.5 g/kg), then cooked and refrigerated stored for 3 days. In the second one, patties were prepared by adding water (control), hop infusion (2 g infused hop/kg) or a hop powder dispersion (2 g hop/kg), and then stored either raw: 4 °C for 7 days or −18° C for 90 days, or cooked: 4 °C for 3 days. The antioxidant effect of hop was assessed by means of thiobarbituric acid reactive substances, protein carbonyls, colour, and sensorial analysis. Hop showed a significant antioxidant effect, which was stronger for hop powder than for hop infusion. The addition of hop powder caused a slight decrease in the consumer acceptance of patties as compared to control and hop infusion-added patties.

1. Introduction

Ground meat preparations, such as meat patties, burgers, fresh sausages, meatballs, and so on are produced in many different ways worldwide and with different types of meat (Feiner, 2006). Hence, increasing the production and quality of ground lamb preparations could provide an interesting option in order to favour the sheep sector in those regions with tradition in sheep meat production and consumption.

Muscle foods are under constant oxidising conditions that results in a damage of lipids and proteins (Decker, 1998; Min and Ahn, 2005; Estévez, 2011). In fact, processed meat products are highly susceptible to oxidation as mincing, the addition of common salt and cooking promote the occurrence and intensity of oxidative reactions (Faustman et al., 2010; Leygonie et al., 2012). Oxidation is a main cause of deterioration of flavour, texture and colour of meat and meat products, and has been related to adverse changes in their nutritive value and the production of toxic compounds (Gray et al., 1996; Shahidi, 2002; Vicente et al., 2012). Regarding flavour deterioration, in cooked meat, lipid oxidation results in a distinctive off-flavour defined as rancid, stale or cardboard-like, and known as warmed over flavour (Byrne et al., 2001; Tikk et al., 2008).

Meat oxidation could be prevented or at least controlled through the use of antioxidants. A recent approach to improve oxidative stability of meat and meat products has been the direct addition of natural antioxidants,

* Corresponding author. Tel.: +34 987291284; fax: +34 987291284.
E-mail address: jmato@unileon.es (J. Mateo).

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including a selection of food sources which are naturally high in antioxidants, e.g., polyphenols (Decker, 1998; Jayathilakan et al., 2007; Karre et al., 2013; Hygreeva et al., 2014). The rationale for this approach is that naturally occurring compounds showing antioxidant properties not only contribute to extend the shelf life of these products but also could present potential health benefits.

Numerous studies have been aimed at assessing the effect of different plant materials on the oxidative deterioration of meat and meat products (Karre et al., 2013; Hygreeva et al., 2014). However, to our knowledge none of them have investigated the effect of the addition of hop (*Humulus lupulus L.*). Hop, which is rich in polyphenolic compounds and acyl phloroglucides, has long been widely used in brewing to preserve beer and to give it characteristic aroma and flavour. In recent years, hop has been increasingly used for culinary, medicinal, and cosmetic purposes (Attokaran, 2011; Zanoli and Zavatti, 2008). The antioxidant effect of hop has mainly been related to its polyphenol content, which greatly depends on the hop variety (Lermusieau et al., 2001). Taking into account all this; the aim of this study was to evaluate the potential use of hop as a natural antioxidant in meat patty preparations. This study was specifically intended to evaluate the effect of the addition of hop as hop infusion or powder on the oxidative stability of lipids, proteins and/or colour in raw and cooked lamb patties during storage (refrigerated or frozen), and the sensory acceptance of these patties.

2. Materials and methods

2.1. Animals and meat

The meat from the legs of 21 male Merino lambs was used in this study. The lambs were weaned (6–8 week old and average body weight of 14 kg) and then housed in individual pens where they remained until reaching approximately 24 kg of body weight. Lambs were fed following a conventional system consisting on barley straw and concentrate in separated feeding troughs. Fresh drinking water was constantly provided. All handling practices followed the recommendations of the Directive 2010/63/EU of the European Parliament and of the Council on the protection of animals used for scientific purposes, and all of the animals used could see and hear the other sheep. When the lambs reached the intended body weight, they were stunned and slaughtered by exsanguination from the jugular vein and then eviscerated and skinned. Carcasses were refrigerated at 4 °C for 24 h and subsequently halved. Then, the left-side legs were separated from the carcasses. The 21 legs were randomly assigned to one of two experiments: Experiment 1 ($n = 10$) and Experiment 2 ($n = 11$). The following groups of muscles were then obtained from the legs using a boning knife: *M. Biceps femoris* and *M. Semitendinosus*; *M. Rectus femoris, M. vastus intermedius, M. vastus lateralis* and *M. vastus medialis*, and *M. Adductor*; *M. Gracilis*, *M. Semimembranosus, M. Pectineus and M. Sartorius*. The muscles from each leg were vacuum packaged and kept frozen (−47° C) until further processing (up to 5 months). The muscles were thawed at 4 °C for 1 day before patty preparation. Then, visible fat and connective tissues were removed and the lean meat from each leg was cut into cubes and minced in a butcher mincer through a 9-mm plate hole. Minced meat was manually mixed and a 30-g sample was used for the determination of moisture, fat and protein (Official Methods 950.46, 991.36 and 981.10, respectively; AOAC, 1999). The composition (%) of the lamb meat used for the patties was as follows (mean ± standard deviation; $n = 21$): moisture, 75.3 ± 0.4; fat, 2.3 ± 0.4; protein, 19.1 ± 2.3.

2.2. Experimental design

The experimental design is shown in Table 1. Experiment 1 was a preliminary study aimed to assess the effect of the use of hop infusion as an ingredient in lamb patties on their oxidative stability. The legs used in this experiment were assigned to three batches (two batches of three legs and the other one of four legs) so as patties were prepared in three different processing days (one per batch). For each leg, minced lean meat was salted and mixed, and the mixture was divided into three equal parts. Water was added to part one (CONTR1), hop infusion to part two (HOPINF1), and a solution of the antioxidant additive sodium ascorbate to part three (NaASC). Afterwards, patties were formed, cooked, and then stored under refrigeration (4 °C) for 3 days. The content of thiobarbituric acid reactive substances (TBARS) and protein carbonyls and the intensity of oxidised flavour (sensory ranking test) were determined in the three-day stored cooked lamb patties.

Experiment 2 evaluated the antioxidant effect of the addition of hop infusion or powder on the oxidative stability of raw or cooked lamb patties. The 11 legs used in this experiment were assigned to three batches (two batches of four legs and the other one of three legs), one per processing day. The lean meat from each leg was salted, spiced and mixed and the mixture was divided into three equal parts. Water was added to part one (CONTR2), hop infusion to part two (HOPINF2), and a dispersion of hop powder to part three (HOPPOW); afterwards patties were formed. Patties were either, refrigerated-stored (4 °C, 7 days), frozen-stored (−18 °C, 90 days) or cooked and stored (4 °C, 3 days). TBARS content, pH and instrumental colour were analysed in refrigerated-stored raw patties at days 1, 3 and 7 of storage. Freeze-stored raw patties were analysed after thawing for TBARS content, pH, instrumental colour and protein carbonyls; protein carbonyl analysis was also performed over the patties before freezing. Finally, cooked patties were analysed for cooking loss, hop flavour intensity (sensory ranking test) and acceptance (hedonic test) and TBARS content; this last analysis was carried out at days 1 and 3 of storage.

2.3. Hop preparation and patty manufacture and storage

Pelleted powdered hop (*H. lupulus L.*) cones of the Nugget variety supplied by the Sociedad Española de Fomento del Lúpulo (León, Spain) was used in this study. Nugget variety was selected in this study because it is by far the most produced in Spain. Compared with other common varieties, this variety seems to have a relatively