Meat Science 129 (2017) 153–160

Contents lists available at ScienceDirect

Meat Science

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

Effect of borage and green tea aqueous extracts on the quality of lamb leg chops displayed under retail conditions

M. Bellés, V. Alonso, P. Roncalés, J.A. Beltrán *

Grupo de investigación de Calidad y Tecnología de la Carne, Instituto Agroalimentario de Aragón – IA2 - (Universidad de Zaragoza-CITA), Miguel Servet 177, 50013 Zaragoza, España

ARTICLE INFO

Article history:
Received 30 August 2016
Received in revised form 24 February 2017
Accepted 4 March 2017
Available online 06 March 2017

Keywords:
Antioxidant activity
Herb extracts
Borage
Green tea
TBARS

ABSTRACT

Different concentrations of two aqueous extracts from green tea leaves and borage seeds with potential antioxidant activity were evaluated in lamb leg chops. Chops were sprayed with 0.005, 0.05, 0.5, 5% (p/v) green tea extracts (T) and 0.5, 5 and 10% (p/v) borage seed extracts (B) and displayed under retail conditions for 13 days. Total polyphenols, TBARS, colour, microbial and sensory analyses were performed. The extracts showed a concentration-dependent action; the minimum concentration of polyphenols which significantly reduced lipid oxidation was 2.08 mg GAE/100 cm^2 of meat. Both 0.5% T and 10% B limited colour deterioration, reducing also metmyoglobin formation. The extracts showed no antimicrobial effect, exceeding microbial counts of 7 log CFU/-cm^2 at 13 days of display. Sensory analyses determined that none of the extracts added herb odours or flavours to lamb. In conclusion, 0.5% T or 10% B extracts extended lamb shelf life from 8 to 11 days, so both would be recommended for lamb chops preservation.

1. Introduction

Lamb for retail display is currently packaged in modified atmospheres including high percentage of O_2 for providing a desirable red colour to meat. However, the presence of O_2 could enhance lipid oxidation and ultimately oxymyoglobin oxidation, leading to a loss of colour and off flavour and odour development (Sañudo, Muela, & Campo, 2013).

The addition of antioxidant compounds into the package or onto the meat surface may retain product quality by reducing lipid oxidation. Natural antioxidant compounds are being studied for this purpose. In contrast to chemical additives, essential oils and herb extracts, which are included in the Generally Recognised As Safe (GRAS) list of the American Food and Drug Administration and natural compounds, are not rejected by consumers. Several studies have already reported the effectiveness of natural compounds on reducing lipid oxidation of meat (Alp & Aksu, 2010; Wu, Wang, & Chen, 2010; Camo, Lorés, Djenane, Beltrán, & Roncalés, 2011).

Borage (*Borago officinalis* L.) is an annual herb cultivated for medicinal and culinary uses (Asadi-Samani, Bahmani, & Rafieian-Kopaei, 2014). However, since Wettasinghe and Shahidi (1999) demonstrated the antioxidant properties of borage seeds, several studies have focused on its application to food preservation (Giménez, Gómez-Guillén, Pérez-Mateos, Montero, & Márquez-Ruiz, 2011; Sánchez-Escalante, Djenane, Torrescano, Beltran, & Roncalés, 2003). The high antioxidant activity of borage extracts is associated with their high content of phenolic compounds, which are able to quench reactive oxygen species (Wettasinghe & Shahidi, 1999). Rosmarinic, syringic and synapic acids have been determined to be the major compounds present in borage seed extracts (Wettasinghe, Shahidi, Amarowicz, & Abou-Zaid, 2001). Sánchez-Escalante et al. (2003) and Martínez, Cilla, Beltrán, and Roncalés (2006) reported that the inclusion of a defatted borage seed meal in beef patties and fresh pork sausages significantly inhibited lipid oxidation; however, this meal brought about a greyish colour to product. Therefore, the development of a new methodology of extraction, optimization and application to make a profit of borage antioxidant properties is still a point of concern. The antioxidant effect of green tea has been also thoroughly studied. Green tea composition includes catechin, flavones, anthocyan and phenolic acid (Huang, Huang, Liu, Luo, & Xu, 2007). Catechin represents up to 30% of water-soluble solids of the dry weight of green tea (Harbowy & Balentine, 1997) while myricetin, quercetin and kaempferol are the main derivatives of the flavonol group (Colon & Nerín, 2016). Green tea has been used for preserving meat and meat products, significantly reducing lipid oxidation as well as microbial growth (Bañón, Díaz, Rodríguez, Garrido, & Price, 2007; Lorenzo, Sineiro, Amado, & Franco, 2014b).

Both borage and green tea extracts may be very profitable to extend lamb shelf life; however, the most suitable concentrations of each one should be determined. Nevertheless, they should offer a significant benefit without modifying lamb sensory quality. The development of aqueous antioxidant solutions emerged as a possible solution to visual problems reported when the extracts were used as a crude meal. Therefore, the aim of this study was to determine the effect of spraying

* Corresponding author.
E-mail address: jbeltran@unizar.es (J.A. Beltrán).

http://dx.doi.org/10.1016/j.meatsci.2017.03.003
0309-1740/

different concentrations of new aqueous extracts of borage seeds and green tea leaves on lamb quality throughout display. The physicochemical, microbiological and sensory data will help to determine the optimum concentrations of each extract for keeping lamb quality during display without modifying lamb characteristic odour and flavour.

2. Materials and methods

The lambs used for this trial were cared in accordance with the guidelines from the Spanish Ministry of Agriculture (Boletín Oficial del Estado (BOE), 2007).

2.1. Sampling

Eighty one lamb carcasses were randomly chosen among commercial lambs of the Rasa Aragonesa, a medium wool breed that is reared for meat purpose in Spain. Animals were reared together under intensive husbandry conditions with natural suckling until 40 days of age and fodder with concentrate and cereal straw ad libitum until they reached a body weight between 20 and 25 kg. The animals, aged about three months, were slaughtered in a commercial slaughterhouse (Mercazaragoza) on three different days (27 lambs each day, 3 lambs per treatment) following standard protocols. Within 15 min of dressing, carcasses were transported to the facilities of Casa de Ganaderos and Franco y Navarro S.A. and chilled for 24 h (4 ± 0.5 °C, 90% RH, 1–2 m/s). The two legs of each carcass were removed and randomly assigned to one of the nine treatments (the legs from 9 carcasses per treatment). The proximal part of each leg was then cut into 20-mm-thick chops and transported under refrigeration (4 °C) to the Food Technology Pilot Plant of the Faculty of Veterinary Science (University of Zaragoza). The treatments consist of two controls (no sprayed chops (C) and chops sprayed with water (WC)) and samples sprayed with the following extracts: 0.5% (p/v) borage aqueous extract (0.5% B), 5% (p/v) borage aqueous extract (5% B), 10% (p/v) borage aqueous extract (10% B), 0.005% (p/v) green tea aqueous extract (0.005% T), 0.05% (p/v) green tea aqueous extract (0.05% T), 0.5% (p/v) green tea aqueous extract (0.5% T), 5% green tea aqueous extract (5% T). Mean leg weight and meat pH were similar across all treatments ($P = 0.727$ and 0.107 respectively; data not shown).

2.2. Extract preparation

Borage seeds were purchased from a local market (Semillas Fitó, España). Borage meal was obtained as described by Sánchez-Escalante et al. (2003), with some modifications. Seeds were ground in a coffee grounder and the husk was separated from endosperm using a 1 mm sieve. The endosperm was recovered and defatted by removing continuously with hexane (1:5 w/v, 5 min, 3 times) in a magnetic agitator. After each extraction, the combination of ground seeds and solvent was centrifuged in a refrigerated centrifuge (Jouan, model CR-4.11, Saint-Herblain, France) at 2300*g* for 15 min at 10 °C. Hexane was eliminated by evaporation at ambient temperature overnight in a fume hood. Dried meal was vacuum packaged and maintained at 4 °C until its utilization.

Borage aqueous solutions (0.5, 5 and 10% p/v) were prepared by dissolving the dried meal in distilled water in a crystal flask (0.5, 5 and 10 g of meal in 100 ml of distilled water). To favor dissolution of phenolic compounds in water, the flask was placed into a water bath at 65 °C (Grant W14, Cambridge, UK) for 45 min in continuous agitation. After that, the solution was filtered through filter paper (Machery-Nagel number 43, Düren, Germany) and then sterilized using 0.2 μm cellulose acetate sterile syringe filter (VWR) and placed in a sterile commercial applicator. The resulting solutions were kept frozen at −20 °C.

Green tea extract Sunphenon 90 MB (GTE) was obtained from TAIYO Europe (Filderstadt, Germany), and the extract contained around 75% total catechins (w/w, HPLC determination provided by the supplier Company). The aqueous extracts (0.005, 0.05, 0.5 and 5% p/v) were prepared by dissolving the dry meal in distilled water (0.005, 0.05, 0.5 and 5 g of the meal in 100 ml of distilled water). Then, aqueous extracts were filtered through filter paper (Machery-Nagel number 43, Düren, Germany) and sterilized by filtration (0.2 μm cellulose acetate sterile syringe filter) (VWR). The resulting solutions were placed in commercial applicators and frozen stored (−20 °C).

Prior to its utilization, the aqueous extracts were completely thawed at 4 °C over 12 h.

2.3. Packaging and storage conditions

Chops were sprayed with the corresponding solution (C, WC, 0.005% T, 0.05% T, 0.5% T, 5% T, 0.5% B, 5% B, 10% B) (1 ml of solution per 100 cm^2 of meat approximately) and modified atmosphere packaged (40% O_2/30% CO_2/30% Ar) (ULMA-SMART-500) with a product to gas ratio of 1:3. Polystyrene trays were used and sealing was done with a polyethylene and polyamide laminate film. The film was 30 μm thick, its oxygen permeability rate at 23 °C was 15 cm^3/m^2/24 h/0% RH and the water vapour transmission rate at 23 °C was 7 g/m^2/24 h/85% RH, (Linpac Packaging S.L., Spain). Afterwards, samples were placed in a commercial refrigerator at 4 ± 0.5 °C with 14 h of artificial light per day over 13 days. A standard supermarket fluorescent tube (Mazdafluor Aviva TF/36w; Philips, Eindhoven, Holland) with an UV-filter plate of polycarbonate was used. The UV-filter plate of polycarbonate allowed transmission of about 80% of the visible light (410 to 710 nm) but it was about 0% below 390 nm (Djenane, Sánchez-Escalante, Beltrán, & Roncalés, 2001). Light intensity (1000 lx) was measured with a luxometer (Chauvin Arnoux 810; Paris, France).

Specific analyses were performed at 0 (approximately 24 h post mortem), 5, 8, 11 and 13 days post packaging using 36 packages per treatment on each sampling day (4 packages from each lamb, 9 lambs per treatment). One package from each lamb was used for microbial, instrumental colour and TBARS analyses while the other three packages were assigned to sensory analyses. Samples for sensory analyses were vacuum packaged (−900 mbar of pressure) in polyethylene-polyamide bags with ethyl vinyl acetate sealant layer (30 × 25 cm, 90 μm thickness, water vapour transmission rate at 23 °C of 2.8 g/m^2/24 h/85% RH, an O_2 transmission rate at 23 ± 1 °C of 50 cm^3/m^2/24 h/75% RH; Eurobag & Film S.L., Spain) using a Tecnotrip EV-13-L-CD-SC machine (Tecnotrip S.A., Spain) and frozen stored in each sampling day at −20 °C until sensory analysis was performed.

2.4. Total phenolic compounds

Total phenolic compounds were determined in the extracts following an adaptation of the method described by Matthaüs (2002). In brief, 2 ml of the extract was filled with 0.3% HCl (Panreac) to 5 ml. A 100 μl aliquot of the resulting solution was mixed with 2 ml of 2% Na_2CO_3 (Merck) and then 2 ml 100 μl of Folin Ciocalteau reagent (diluted with methanol 1:1) (Sigma-Aldrich) was added. After 30 min of incubation, the absorbance was measured at 750 nm using a spectrophotometer. Gallic acid (Sigma-Aldrich) was used as a standard, expressing the results as milligrams of gallic acid equivalents (GAE) per ml of extract.

2.5. Instrumental colour

A Minolta CM-2002 (Osaka, Japan) spectrophotometer was used to measure colour at the surface of a 20-mm-thick chop after opening the trays and exposing the samples to air for 2 h at 4 °C. The parameters registered were L^* (lightness) and a^* (redness). A D65 illuminant was used at an observation angle of 10° and with a cell opening of 30 mm. Equipment was previously calibrated using a white and black standard. Ten measurements were done on *Semimembranosus*, and averaged. As an indirect measure of metmyoglobin formation, and therefore of colour