ANTIOXIDANT ACTIVITY OF BORAGE (*BORAGO OFFICINALIS*) IN FRESH AND COOKED BEEF PATTIES

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Background

Lipid oxidation causes a rancid off-flavour and off-odour in meat. Numerous factors affect lipid oxidation including light, oxygen concentration, temperature, presence of anti- and pro-oxidants, degree of unsaturation of the fatty acids and the presence of enzymes (Skibsted *et al*., 1998). Lipid oxidation is normally not considered to be a limiting factor for shelf life of aerobic packed chill stored meat, as lipid oxidation occurs at a slower rate than discoloration or microbial growth (Zhao *et al*., 1994).

Meat colour is the primary attribute of fresh meat that affects consumer purchase decision. Consumers expect a uniform appearance within a group of similar ground beef products (i.e. patties with the same fat percentage) and relate any colour differences within similar products to deficiencies in product quality (Faustman & Cassens, 1990; Hood, 1990). Thus, any process that negatively affects the colour of fresh ground beef can lead to lower consumer appeal and marketability.

For cooked meat, thermal processes can promote lipid oxidation by disrupting cell membranes and releasing pro-oxidants, thereby inducing ‘‘warmed-over flavour’’ (WOF) during refrigerated storage and subsequent reheating (Sato and Hegarty, 1971). With the rapidly increasing consumer demand for precooked convenience meat items, a proper control of oxidation is of particular importance. One of the ways to minimize lipid oxidation and WOF in cooked meats is to use antioxidants.

There has been in the last years an increasing interest in borage (*Borago officinalis* L.), especially of its seed oil, by medical and nutritional research groups, due to the presence of high levels of γ-linolenic acid. Wettasinghe and Shahidi (1999) showed that borage meal exerted a concentration-dependent antioxidant activity in a meat model system. Borage extracts have demonstrated excellent antioxidant properties; the ability to retard lipid oxidation was attributable to the ability of its phenolic constituents to quench reactive oxygen species. Wettansinghe *et al*. (2001) reported that rosmarinic, syringic and sinapic acids are the major phenolic compounds present in the ethanolic extract of borage meal. It has been demonstrated that natural antioxidants rosemary extract, oregano extract and borage meal were highly effective in inhibiting lipid oxidation (TBARS formation) in beef patties packaged in modified atmosphere and stored in the dark at 2±1°C; in fact, borage meal suppressed totally TBARS formation (Sanchez-Escalante *et al*., 2003). The antioxidant activity of borage meal has been not studied in cooked meat products.

Objective

The purpose of this study is to determine antioxidant capacity of borage meal in fresh and cooked beef patties formulated with different content of fat and packaged in modified atmosphere and over-wrapped, respectively.

Materials and methods

Preparation of borage meal. Borage seeds were obtained from Spain. Seeds were cleaned, washed and dried, and after were stored vacuum packaged in polyethylene/polyamide pouches at 2-4°C until used. Borage seeds were ground in a mortar. The meal was defatted by shaking ground seeds with hexane (1:5 w/v, 5 min, three times). Dried and defatted borage meal was sifted with sieves of decreasing sizes (l.0, 0.5 and 0.2 mm) to eliminate the remaining husk and reduce the particle size of the meal.

Fresh patties and atmospheres. Meat was obtained fresh (3 day post-mortem) with a local producer, was excised from 2 beef carcasses, and minced using a conventional mincer through a plate with 4 mm holes. All two minced muscles were thoroughly mixed together in a single batch. Portions of uniform weight of the minced muscle (about 90 g) were mixed with salt (2%), borage (1%), and fat (10% for fresh patties and 10% and 20% for cooked patties). Also controls (no borage meal) were prepared with different fat levels. Fresh

beef patties were formed. One group was placed on styrofoam trays, for the study of fresh patties. Each tray with the round beef patty was introduced in a pouch made of a nylon and polyethylene laminate of water vapour and oxygen permeability 0.6 g/110 sq inch/24 hr and 3.5 cc / 100 sq inch / 24 hr 5-7 g/m^2/24 h at 23°C, respectively. The pouches were filled with a gas mixture of 80% O_2 + 20% CO_2, and sealed. Fresh patties were stored for 12 days at 2±1°C in the dark. Four packs were opened for subsequent analysis for each formulation every 3 days of storage; two of them were used for microbial sampling alone, while the 2 other were used firstly for colour instrumental analysis and thereafter for the determination of pH and TBARS.

Cooking and packaging. Meat patties were cooked on an open electric broiler by flipping every 3 min until the final internal temperature of 70 ºC (measured with a thermocouple) was reached. Samples were weighed before and after cooking to measure cooking losses. After cooling down to room temperature, meat patties were placed in styrene foam trays, over-wrapped in an oxygen permeable (6000–8000 cm^3/m^2/24 h at STP) cling film (Cryovac USA) and stored in a 2±1 ºC dark room for up to 12 days. Also a group of cooked meat patties were storage under light (1000 lux) at 2±1 ºC.

Colour measurement. Colour changes in the surface of fresh meat samples during storage were monitored by recording the CIE L*, a* and b* values using a Hunter Lab Colorimeter (D25 model). Measurement was achieved 30 min after package opening.

Lipid oxidation. Lipid oxidation in stored meat patties was also measured as thiobarbituric acid-reactive substances (TBARS) as described by Pfalzgraf *et al*. (1995).

Microbial analysis. Counts of aerobic psychrotrophic flora were determined in fresh and cooked patties in Plate Count Agar (Merck; Darmstadt, Germany) after incubation at 10°C for 7 days (Elliott *et al*., 1983). Counts were expressed as log cfu/g.

Statistical analysis. The significance of differences among samples at each day of storage was determined by analysis of variance (ANOVA) using the Least Square Difference method of the General Linear Model procedure of SPSS (SPSS 1995). Differences were considered significant at the $p<0.05$ level.

Results and discussion

Colour Measurement. Figure 1 shows that fresh beef patties with borage meal had ($p<0.05$) higher a* values, than those of controls with 10% of fat and without fat. The value of a* was influenced by the days of storage in each one of the treatments. The red colour diminished progressively along the storage in all the hamburgers, without caring the treatment neither the quantity of added fat. The control treatments, independently of the quantity of applied fat, showed significantly lower values ($p<0.05$) than the treatments with borage meal until day 9 of storage. It indicates that the borage meal is able to maintain high values of a* for more time. Red colour of borage samples was very intense instead to presence of meat pigments. These results were in agreement with Sánchez-Escalante *et al*. (2003) who reported that borage was effective in maintaining red colour for the first 10-12 days.

Lipid Oxidation. Figure 2 shows the changes in TBA value for fresh patties. Lipid oxidation increased rapidly with increasing time ($p<0.05$) in control samples. However, TBA values were kept to a minimum in samples containing borage meal. These results agree with the results of Wettasinghe and Shahidi (1999) and with Sánchez-Escalante *et al*. (2003), who found that borage meal possess antioxidant properties. With respect to cooked patties stored under darkness (Figure 3), our results show that the addition of borage meal is effective still after heating at 70ºC, since it delays the formation of TBARS; while control samples show an intense oxidation. Fat level did not affect antioxidant activity of borage meal; lipid oxidation was not increased with increasing time ($p<0.05$). Figure 4 show that lighting not increased lipid oxidation, thus borage meal was effective delaying TBARS formation, while controls developed an important lipid oxidation. The type of lighting significantly affected the shelf life of meat when is displayed for retail sale. The use of a lamp emitting radiation in the UV range (conventional supermarket fluorescent tube) is severely detrimental for the retail life of meat. TBARS values reveal that the retail life of beef meat is significantly more stable in the absence of UV light (Djenane *et al*., 2001).

Microbial Analysis. The results of counts of psychrotrophic aerobes (data not shown) in fresh and cooked patties show that the borage meal addition did not present an inhibitory effect on the growth of psychrothophic flora. Same behavior was already reported for Sánchez-Escalante *et al*. (2003) who observed that the borage meal has important antioxidant properties, but it does not have any antimicrobial effect in fresh beef patties.

Conclusions

Borage was very effective in preventing lipid oxidation, without dependence on the level of fat; thus the addition of borage meal resulted in a significant antioxidant activity in fresh and cooked beef patties, while it inhibited only partially metmyoglobin formation in fresh meat. All effects contributed to extending the shelf life of fresh and cooked beef patties. It is also important to consider that the smallest amount of UV radiation should be avoided in lighting devices for the retail display of meat.

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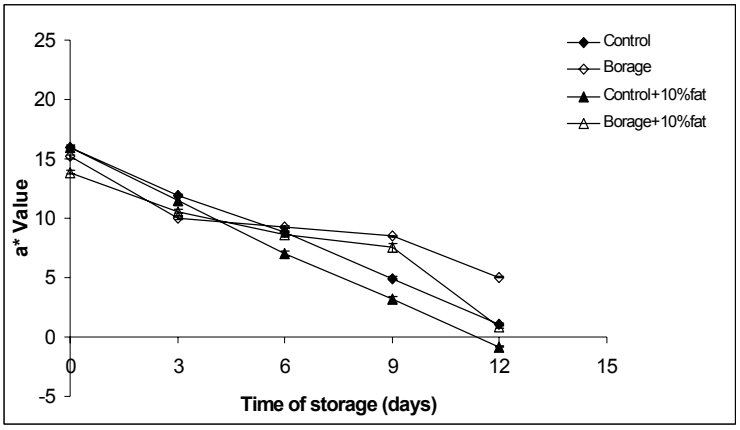

Figure 1. Effect of storage time at 2°C under darkness on CIE a* values of fresh beef patties.

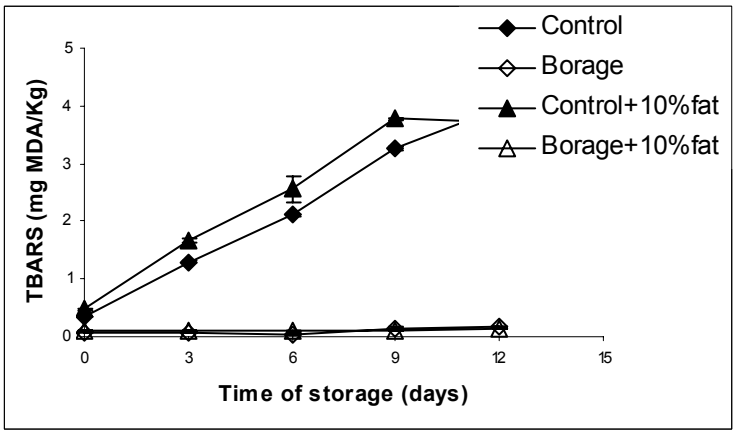

Figure 2. Effect of storage time at 2°C under darkness on TBARS of fresh beef patties.

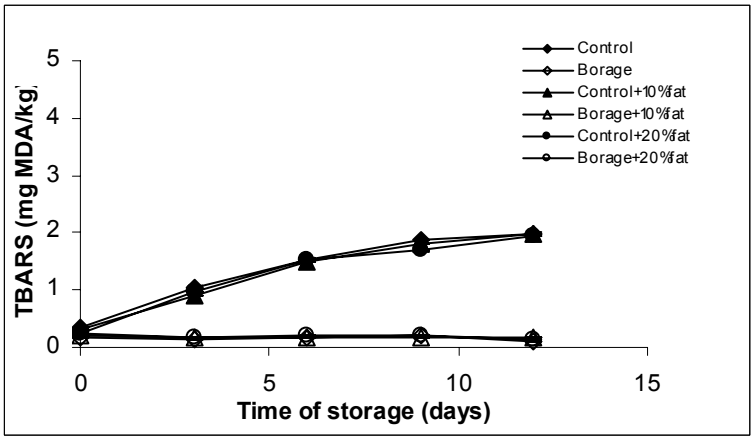

Figure 3. Effect of storage time at 2°C under darkness on TBARS of cooked beef patties.

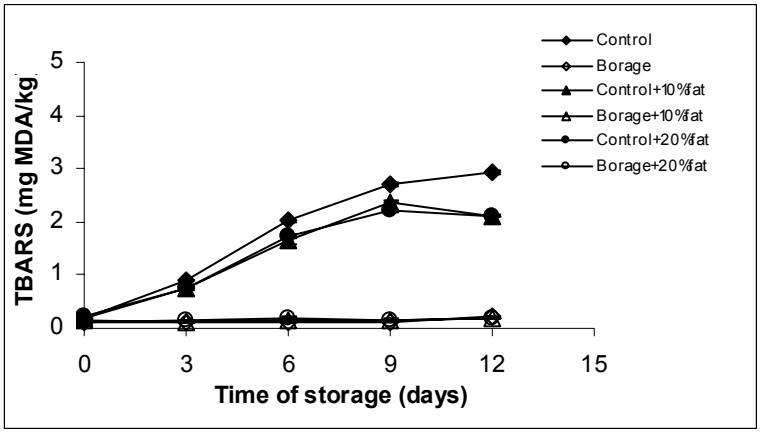

Figure 4. Effect of storage time at 2°C under lighting on TBARS of cooked beef patties.