ELECTRON BEAM TREATMENT AND STORAGE ON COLOUR AND LIPID OXIDATION OF DRY-CURED IBERIAN HAM SLICES

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Introduction

Irradiation is the most effective technology in eliminating pathogens in meat and meat based products. Significant progress has been made in this respect by using irradiation doses lower than 10 kGy to control the growth of pathogenic and spoilage bacteria on meat and meat products, such as *Listeria monocytogenes* and *Salmonella typhimurium*, *Escherichia coli* O157:H7 and *Yersinia enterocolitica* (Fu *et al.*, 1995; Shenoy *et al.*, 1998; Olson, 1998). One of the major concerns in irradiating meat and meat products, however, is its effect on meat and meat product quality, mainly because of free radical reactions resulting in the possibility of colour change, lipid oxidation and odour generation, and consumer responses to these quality changes are quite negative (Patterson and Stevenson, 1995; Ahn *et al.*, 2000; Jo and Ahn, 2000; Du *et al.*, 2002). Dry-cured Iberian ham is a meat product with a high consumer acceptance due to its particular sensory characteristics derived from both raw meat composition (high intramuscular fat and oleic acid contents) and the physical, chemical and biochemical changes that take place during the ripening period (Cava *et al.*, 1997; *Cava et al.*, 1999). Irradiation of dry-cured ham could have important effects on overall quality of dry-cured Iberian ham, characterized by a high content of intramuscular fat, heme pigments and unsaturated fatty acids and a desirable and characteristic flavour. The quality characteristics of irradiated dry-cured hams would be very important for the acceptance of the irradiation technology. The objective of the present study was to investigate the effect of using different ionization doses (0 kGy, 5 kGy and 10 kGy) and storage time on instrumental colour, lipid oxidation and hexanal changes of vacuum-packaged slices of dry-cured Iberian hams.

Materials and Methods

Dry-cured ham samples

Dry-cured Iberian hams from pigs free-range reared and feeding on acorns and grass were used for the experiment. *m. Biceps femoris* was dissected and sliced using a slicing machine obtaining 2mm thickness slices.

Vacuum-packaging, irradiation and refrigerated storage.

Dry-cured ham slices were vacuum-packaged in nylon/polyethylene bags (9.3ml $O_2/m^2/24h$ a 0ºC) containing 3 slices/pack. Dry-cured ham slices (3 slice/pack/treatment/sampling) were irradiated at a 0, 5, or 10 kGy dose using an Electron Beam irradiator (Rhodotron TT200, IBA, Louvain La Neuve, Bélgica). The irradiation process was conducted at room temperature with single layer display and single-sided dosage. To confirm the target dose, 2 alanine dosimeters per cart were attached to the top and bottom surfaces of the sample. The final doses were 5.21± 0.32 kGy for 5 kGy treatment and 10.47±0.65 for 10 kGy treatment. Irradiated samples were stored in a 4ºC refrigerator in the dark for 0, 30, 60 and 90 days.

Physico-chemical analysis

The CIELAB colour space was studied in accordance with Cassens *et al.* (1995). The colour parameters were determined using a Minolta CR-300 colorimeter (Minolta Camera Co., Osaka, Japan). The measurement was repeated on eight randomly selected locations on each loin slice and averaged for statistical analysis. Lipid oxidation was measured using a complete dry-cured Iberian ham slice and homogenised using a kitchen blender. The extent of lipid oxidation was estimated as TBA-RS using the method by Salih *et al.* (1987). TBA-RS were measured on one slice from each pack and were expressed as mg malondialdehyde (MDA)/kg meat. A Solid Phase MicroExtraction, SPME (Supelco Co., Bellefonte, PA) fibre (10 mm length) coated with DVB/Carboxen/PDMS (50/30 μm thickness) was used for the determination of hexanal content of the samples according to Carrasco *et al.*, (2005). Hexanal was tentatively identified by comparing its mass spectra with that contained in the NIST/EPA/NIH and Wiley libraries and by comparison of Kovats index with that reported in the literature. The quantification of the hexanal content was performed using an external standard.

Statistical analysis

Samples were completely and randomly assigned to the treatments. There were five replicates per dose. The effect of dose and time of storage were analyzed using the Analysis of Variance procedure of SPSS, version 10.0 (SPSS, 1999). Tukey's test was used to compare the mean values of the treatments. Mean values and standard error of the means (SEM) were reported (P<0.05).

Results and Discussion

After treatment, 10 kGy treatment increased significantly TBARS values of sliced dry cured Iberian ham when comparing to the 0 kGy dose level (Table 1). With respect to control, TBARS increased in ~12% and ~44% at 5 kGy and 10 kGy, respectively. After 30 days of refrigerated storage, treated samples at 5kGy and 10kGy showed higher TBARS than the control. After 60 and 90 days of storage, no differences in TBARS were found between treated and control samples. At day 0, the 10kGy dose significantly increased hexanal content in vacuum-packed slices of dry-cured Iberian ham (Table 2). However, 5kGy dose significantly reduced hexanal content when compared to control. At the end of storage, control samples (0 kGy) showed lower hexanal content than samples treated at 5 kGy ($p<0.05$) and 10 kGy ($p>0.05$).

Table 1: TBARS (mg MDA/kg meat) of vacuum-packaged slices o dry-cured Iberian ham stored for different period of time after treatment[a,b].

	Dose			
Days of storage	0 kGy	5 kGy	10 kGy	SEM [c]
Day 0	1.21 b xy	1.36 b	1.75 a	0.09
Day 30	0.98 b y	1.28 a	1.43 a	0.06
Day 60	1.18 xy	1.37	1.77	0.11
Day 90	1.35 x	1.48	1.54	0.10
SEM [d]	0.1	0.1	0.1	

Table 2: Hexanal contents (ng hexanal/g sample) of vacuum-packaged slices of dry-cured ham stored for different period of time after treatment [a,b].

Dose			
0 kGy	5 kGy	10 kGy	SEM [c]
21.3 b xy	17.9 c y	34.7 a x	2.3
25.7 x	20.3 xy	25.0 y	1.4
20.6 xy	24.0 x	22.3 y	1.0
17.3 b y	24.8 a x	20.2 ab y	1.2
1.1	1.2	1.5	

a Means with a different letter (a,b,c) within a row of the same day of storage are different ($p<0.05$). b Means with a different letter (x,y,z) within a column of the same irradiation dose are different ($p<0.05$). c SEM: Standard error of the mean among the same irradiation dose (n=15). d SEM: Standard error of the mean among the same storage day (n=20).

Table 3: The surface colour of vacuum-packaged slices of dry-cured Iberian ham stored for different period of time after treatment [a,b].

	Dosage			
	0 kGy	5 kGy	10 kGy	SEM [c]
CIE L*-value				
Day 0	37.56 xy	38.49 x	39.44 x	0.37
Day 30	38.59 a x	39.05 a x	35.40 b y	0.52
Day 60	36.95 xy	36.31 y	35.00 y	0.37
Day 90	35.44 y	36.97 xy	35.72 y	0.39
SEM [d]	0.37	0.35	0.50	
CIE a*-value				
Day 0	24.07 c x	27.11 b x	30.47 a x	0.77
Day 30	22.96 a x	21.93 a y	19.80 b y	0.49
Day 60	20.29 y	20.17 y	20.52 y	0.29
Day 90	19.02 y	17.90 z	19.22 y	0.50
SEM	0.55	0.82	1.13	
CIE b*-value				
Day 0	10.97 xy	11.51 x	12.08 x	0.21
Day 30	11.31 a x	10.64 a x	9.38 b y	0.26
Day 60	9.88 a yz	8.83 b y	8.46 b y	0.23
Day 90	8.92 z	8.73 y	9.17 y	0.14
SEM	0.26	0.29	0.34	

Regarding instrumental colour, treatment at 5kGy and 10kGy did not affect CIE L*-value (lightness) at day 0, 60 and 90 of storage. Lightness tended to decrease with time of storage being darker. At day 0, CIE a*-value (redness) was significantly affected by treatment, being linearly increased with dose. Storage significantly affected CIE a*-value, decreasing redness with time of storage. After 30 days of storage, 0kGy and 5kGy samples showed significantly higher CIE a*-values than those treated at 10kGy dose. No differences in redness were found at day 60 and 90 of storage.

Conclusion

Electron beam treatment induced changes were only of importance after treatment. During storage, decolouration and oxidative changes were similar in treated and non-treated samples, storage induced changes being of a greater importance than those induced by electron beam treatment. The absence of great differences in +30 days stored products treated with respect to non-treated products shows that application of 5kGy or 10kGy dose could not compromise their sensory characteristics, with the exception of hexanal content and thus their flavour.

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