EFFECTS OF ANTIOXIDANTS ON THE PRESERVATION OF LAMB PRODUCTS

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Background

Salted and dried beef, "carne de sol", has been accepted in Brazil for many years as an ambient temperature preserved meat product. However, in spite of the large potential for sheep and goat production in the more arid tropical regions of this country, similar products from these meat sources are not well established. Zapata et al (1990) assessed the feasibility of utilizing similar intermediate-moisture meat technology to produce ambient temperature stable meat products appropriate for this region. This preliminary study, in which salted minced mutton was partially air dried to give an intermediate moisture meat product of A_w 0.75, suggested that such products were microbiologically stable for at least three months at tropical temperatures. However, it was also shown that these products were susceptible to oxidative changes which could have an adverse impact on the colour, flavour, texture and nutritive value of the product.

Objectives

The objective of this research was to investigate the effectiveness of some primary and secondary antioxidants on the subsequent stability of salted partially dried intermediate moisture minced lamb under aerobic and anaerobic storage conditions for 11 weeks at 30°C.

Methods

The carcass of each of three lambs, obtained from the chill room of a local abattoir 24h post-mortem, was de-boned at 2°C plus or minus 1°C. The lean meat from each carcass was then minced, salts added: 0.4% potassium sorbate (PS) and 25% sodium chloride (NaCl), and the mixture blended for 5 minutes prior to dividing into six equal batches, each subjected to one of following antioxidant treatments:

1. No further addition (control)
2. 0.01% tertiary butylhydroquinone (TBHQ)
3. 0.01% TBHQ + 0.04% sodium metabisulphite (Metab)
4. 0.01% TBHQ + 0.2% ascorbic acid (Asc)
5. 0.01% TBHQ + 0.1% citric acid (Cit)
6. 0.01% TBHQ + 0.3% sodium tripolyphosphate (STTP)

TBHQ was added on a fat weight basis (estimated fat content of 20% on a fresh weight basis) while the hydrophilic salts were added on a fresh weight basis. Each batch was then blended for a further five minutes and allowed to stand for 1h at 2°C to equilibrate. They were then sub-divided into 18 x 100g portions and pressed into cylindrical shaped products, 6.0cm in diameter and 3.5cm thick at a pressure of 400kg for one minute to expel surplus fluid and compress the meat. The products were then dried for 36h at 40°C in an air convection oven until they had lost 30-33% of their original weight. Once dried, each batch was divided in two. One batch was packed under vacuum and the other in gas-permeable polygrip bags to facilitate air exchange. All samples were subsequently stored in the dark at 30°C for up to 11 weeks. Assessment of lipid oxidation was carried out by 2-thiobarbituric acid (TBARS) method of Tarladgis *et al* (1960) and Gray and Pearson (1987). Internal colour was measured on the freshly cut interior of products from reflectance spectra recorded on a "Monolight" scanning spectrophotometer as described by Millar *et al* (1994).

The experiment was therefore designed to study the effects of different antioxidant treatments, type of packaging and storage time on the stability of lamb products using a 6 x 2 x 7 factorial design (respectively) with three replicates, each replicate prepared from a different lamb carcass.

Results and Discussion

The oxidative stability of these meat products during storage, as assessed by the formation of TBA reactive secondary products of lipid oxidation, is shown in Table 1a. It is clear that antioxidant treatment, packaging and storage time each had a significant ($p<0.001$) effect on the rate of oxidation (Table 1b). In addition, there were statistically significant interactions between all combinations of treatment, packaging and storage time (Table 1b). Vacuum packaging was particularly effective in inhibiting the rate of lipid oxidation with all treatments, including the control. While TBHQ on its own was effective as a primary antioxidant during the first seven weeks of storage in air, the treatments involving combinations of this primary antioxidant with the hydrophilic secondary antioxidants were all much more effective as suggested by Shahidi *et al* (1986). The most effective combinations for samples stored under vacuum were those involving the reducing agents ascorbic acid and sodium metabisulphite, whereas for samples stored in air, ascorbic acid was most effective. It would therefore appear that the synergistic effect of TBHQ acting as a primary antioxidant, combined with the O_2 scavenging ability of ascorbic acid and sodium metabisulphite, complemented by the exclusion of O_2 in the vacuum packed samples, were more effective than the combination of primary antioxidant and sequestering agents citric acid and polyphosphate.

The internal colour stability of these meat products is shown in Table 2a as a function of antioxidant treatment, type of packaging, and storage time. Comparing the effect of antioxidant treatment, it is clear that the treatments incorporating the reducing agents sodium metabisulphite and ascorbic acid were most effective in retaining the redness of the product, as seen by the higher a* values. In contrast, vacuum packaging significantly lowered L* (lightness) and b* (yellowness) values and increased a* values, giving a more acceptable appearance to the products. The major effect of storage time appeared to be a gradual increase in b* values, indicative of partial dissociation and degradation of myoglobin and/or possible Maillard browning at this storage temperature and Aw value (Ames, 1990). Confirmation of the pigment forms, however, requires a detailed analysis of the reflectance spectra. The statistically significant interactions between antioxidant treatment and type of packaging (Table 2b) were primarily indicative of the polyphosphate treated samples under vacuum having much lower L* values than those in air compared to the other treatments. Similarly, the significant interactions between packaging and storage time (Table 2b) were greatest for b* values, which increased steadily during storage in air while those under vacuum remained stable throughout the storage period.

Conclusions

It would therefore appear that a combination of primary antioxidant (TBHQ) and reducing agent (sodium metabisulphite or ascorbic acid) is an appropriate method for limiting the rate and extent of both lipid and pigment oxidation in heavily salted comminuted lamb products during processing and subsequent ambient temperature storage. These treatments are much more effective when combined with vacuum packaging. Combinations of primary antioxidant (TBHQ) with a transition metal sequestering agent (citric acid or polyphosphate) were less effective. This would suggest that the role of oxygen scavengers is more important in inhibiting secondary oxidation reactions in such meat systems than pro-oxidant transitional metal sequesterants, and that the vacuum packaging of such products enhances the effectiveness of these antioxidants through the exclusion of O_2

Pertinent Literature

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Table 1a Mean TBARAS values (expressed as mg malonaldehyde kg^{-1} product) for lamb products during storage

		Days of Storage					
Treatment	**Package**	**0**	**7**	**21**	**35**	**49**	**77**
CONTROL	Vac	0.74	0.79	1.03	1.11	1.82	2.17
	Air	0.73	1.18	2.28	2.75	2.91	4.29
TBHQ	Vac	0.40	0.46	0.52	0.69	1.21	2.07
	Air	0.38	0.72	1.61	2.38	3.25	3.83
TBHQ/meta	Vac	0.24	0.34	0.29	0.34	0.57	1.16
	Air	0.24	0.74	0.58	1.78	2.44	3.36
TBHQ/Asc	Vac	0.35	0.41	0.47	0.57	0.69	0.93
	Air	0.36	0.42	0.66	0.86	1.10	1.68
TBHQ/Cit	Vac	0.37	0.36	0.50	0.70	1.03	1.34
	Air	0.34	0.57	1.62	1.38	3.06	3.55
TBHQ/STTP	Vac	0.34	0.33	0.45	0.63	0.95	1.68
	Air	0.34	0.51	1.99	2.48	2.76	3.30

Table 1b Significance of interactions

Day	**Treatment**	**Package**	**Storage Time**	**T x P**	**T x ST**	**P x ST**	**T x P x ST**
SEM	0.09	0.02	0.04	0.10	0.13	0.06	0.17
LSD	0.25	0.06	0.11	0.28	0.36	0.16	0.47
Significance	***	***	***	***	***	***	***

Table 2a Analysis of Variance for CIELAB values on freshly cut internal surface of lamb products

Treatment	**L***	**a***	**b***	**Package**	**L***	**a***	**b***	**Storage Days**	**L***	**a***	**b***
Control	54.31	6.85	17.12	**Vac**	52.95	8.25	15.83	**7**	54.34	6.21	15.93
TBHQ	53.91	6.74	16.95	**Air**	55.14	5.34	19.45	**21**	50.97	6.88	16.60
+meta	53.77	7.12	17.56					**35**	54.03	6.89	17.90
+Asc	52.32	8.67	17.86					**49**	54.97	7.19	18.72
+Cit	53.52	5.93	17.22					**77**	54.68	6.78	19.11
+STTP	56.41	5.46	19.13								
SEM	1.48	0.43	0.44	**SEM**	0.29	0.15	0.22	**SEM**			
Sig	NS	**	*	Sig	***	***	***	**Sig**	***	NS	***

Table 2b Significance of interactions

	T x P	**T x ST**	**P x ST**	**T x P x ST**
L*	***	NS	**	NS
a*	**	NS	**	NS
b*	**	NS	***	NS