INFLUENCE OF MEAT RESTRUCTURING SYSTEMS ON THE LIPID OXIDATION IN LAMB

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SUMMARY

Restructuring meat with the algin/calcium gelation mechanism (SMR) has been patented and approved for use in the United States. This study evaluated the influence of SMR ingredients on lipid oxidation (TBA) in raw and cooked lamb meat (4-6°C). It also compared lipid oxidation in these formulations with meat treated with sodium chloride, sodium tripolyphosphate and simple grinding and mixing. Grinding, mixing, and sodium chloride or alginate/calcium carbonate/lactate resulted in similar, but not significant ($P<0.05$), increases in TBA numbers. Sodium tripolyphosphate reduced increases in TBA numbers. High levels of lactate (2%) reduced pH to 4.6 and enhanced lipid oxidation. Individually, high levels (2%) of calcium carbonate or alginate had no major effect on lipid oxidation. Cooking of lamb meat increased TBA numbers and decreased the polyunsaturated fatty acid content in the phospholipid fraction of meat. Commercially used levels of algin/calcium carbonate/lactate should neither decrease nor enhance lipid oxidation and sensory rejection of restructured lamb meat.

INTRODUCTION

The algin/calcium restructuring system provides binding in raw or cooked meat products (Means and Schmidt 1986; Means et al. 1987). The process has been patented (Schmidt and Means 1986) and approved for use in meat in the United States (FSIS 1986). Meat is also restructured with sodium chloride and phosphates and marketed precooked or frozen because binding takes place only during cooking of meat with this system.

This study examined: (1) the effects of algin/calcium and sodium chloride/phosphate restructuring ingredients on lipid oxidation of restructured raw and cooked lamb meat; (2) the individual effects of alginate, calcium carbonate and lactate on lipid oxidation in lamb meat.

EXPERIMENTAL METHODS

Experimental design and treatments:

Randomized block designs were used to study six and five treatments, respectively in two replicates (Tables 1 and 2). Two different levels of alginate (Manugel, DMB, Kelco, San Diego, CA), calcium carbonate (Gamma Sperse 80, Georgia Marble, Tate, GA) and encapsulated lactic acid/calcium lactate (Cap-Shure®; Balchem Corp., Slate Hill, NY) were used. Sodium chloride and sodium tripolyphosphate (FMC Corp., Philadelphia, PA) were also used in additional treatments. The study also included treatments with ground and mixed meat, intact meat pieces, and alginate, calcium carbonate and lactate used individually- The data were analysed by analysis of variance and Duncan's Multiple Range Test.

Product preparation:

Fresh lamb leg muscles, (71.54% water and 7.54% fat) 7 days postmortem, were ground (1.27 cm plate). One-fifth of the coarse ground meat was reground (0.32 cm plate). Ground meat batches (2.25 kg per treatment) were mixed (Tables 1 and 2) in a Univex mixer (model M-20) at the speed of 2 for two minutes, stuffed into casings (7.5 cm diameter), and stored at -20°C for 24 hr. The frozen, restructured meat logs were sliced (100-110 g), wrapped with non-barrier film (aerobic) and stored at 2-4°C.

Thiobarbituric acid (TBA) test:

Malonaldehyde content in raw and cooked meat was determined with the method of Tarladgis et al. (1960) without any modification. The meat was cooked in test tubes in a water bath to an internal temperature of 70°C for 10 min.

Table 1. Formulations used to study the effect of ingredients and processing on lipid oxidation in lamb meat.

Treatments	A/C/L (%)	NaCl/STPP (%)	Ground Lamb (%)
ACL1	1.0/0.2/0.3	----	98.50
ACL2	0.4/0.08/0.7	----	98.82
SPO	----	1.4/0.32	98.28
SAL	----	1.4/0.00	98.60
PRO	----	----	100 (mixed)
CON	----	----	100 (intact)

A: alginate; C: calcium carbonate; L: lactate; STPP: Sodium tripolyphosphate; PRO: ground and mixed without additives; CON: control (intact meat pieces).

Table 2. Formulations used to study the effect of ingredients on lipid oxidation in lamb meat.

Treatments	A/C/L (%)	Ground Lamb (%)
A	2/0/0	98
C	0/2/0	98
L	0/0/2	98
PRO	---	100 (mixed)
CON	---	100 (intact)

Treatment designation the same as in Table 1.

Table 3. Days of storage (4°C) for restructured lamb meat to reach a sensory score of 3 (moderately rancid odor/WOF)

Treatments	Raw Meat Rancid Odor (Days)	Cooked Meat Warmed-Over-Flavor (Days)
ACL1	5.2^{b}	6.2^{b}
ACL2	5.0^{b}	6.5^{b}
SPO	10.1^{c}	10.5^{c}
SAL	4.2^{a}	3.5^{a}
PRO	6.3^{b}	6.4^{b}
CON	6.2^{b}	7.2^{b}

Treatment initials the same as in Table 1. Different superscripts within each column indicate significant ($P<0.01$) difference between mean scores. Score 1: very pronounced rancid odor or WOF; 5: no rancid odor or WOF.

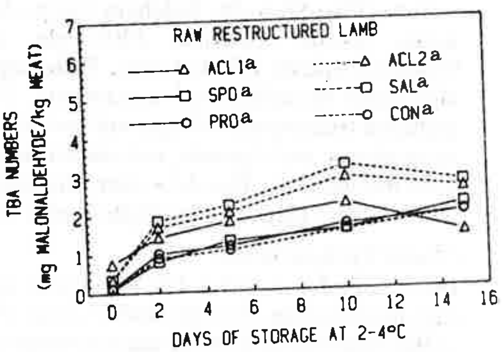

Fig. 1. TBA numbers of raw restructured lamb during aerobic storage. No significant (P>0.05) treatment differences (a).

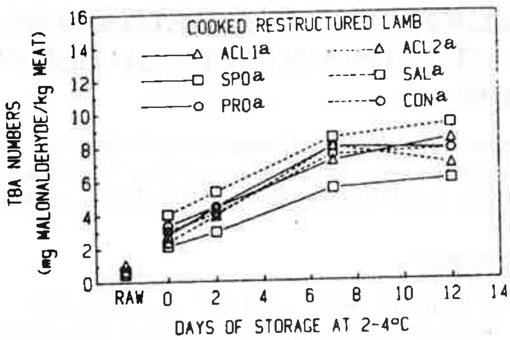

Fig. 2. TBA numbers of cooked restructured lamb during aerobic storage. No significant (P>0.05) treatment differences (a).

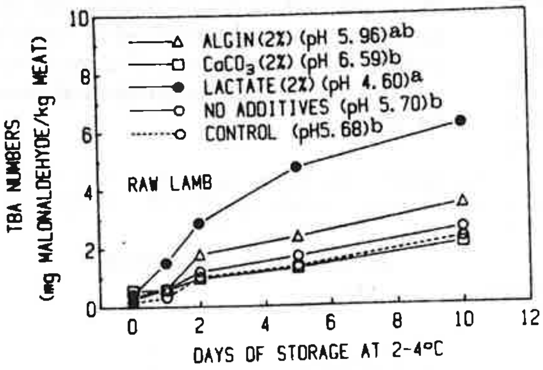

Fig. 3. TBA numbers of raw lamb during aerobic storage. a,b: significantly (P<0.01) different.

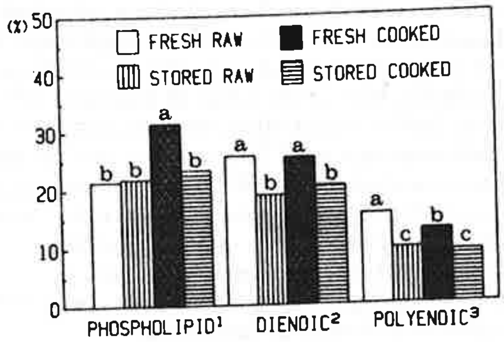

Fig. 4. Effect of cooking (70°C) and aerobic storage (15 days, 4°C) on phospholipids and their fatty acids. a,b,c: significantly (P<0.01) different.

Phospholipid and its fatty acid methyl esters:

Lipids were extracted (Folch et al. 1957). and their phospholipid content was determined (Choudhury and Arnold 1960). The phospholipids were converted into their fatty acid methyl esters (FAME) (Morrison and Smith 1964), which were separated on a Hewlett Packard Gas Chromatograph (model 5830A), and determined with a Hewlett Packard GC Terminal (model 18850A).

Sensory evaluation:

Five trained panelist evaluated rancid odour and warmed-over flavour (WOF) on raw and cooked products, respectively.

RESULTS AND DISCUSSION

Restructuring (grinding and mixing), without any additives, increased ($P<0.05$) TBA numbers, while the control which received a minimum mechanical treatment (only stuffing) had the lowest TBA numbers (Fig.1).

Algin/calcium restructured lamb products had higher TBA numbers than that of no additive, control products. The higher levels of algin/calcium binder (ACL2) had higher TBA numbers than the lower levels (ACLl). This may have been due to the higher level of lactate (0.7) which resulted in a lower pH value. All these differences, however, were not significant ($P<0.05$). Sodium chloride (1.4%) functioned as a prooxidant, while sodium tripolyphosphate (0.32%) inhibited lipid oxidation (Fig.1), which is in agreement with previous studies (Schwartz and Mandigo 1976; Ramsey and Watts 1963).

In the cooked state, sodium chloride had the highest, while STPP treated samples had the lowest TBA number (Fig.2). The algin/calcium treated samples had similar TBA numbers with the no additives processed and control samples. Cooking increased the TBA numbers.

When used by itself and at a high concentration (2%) lactate caused significantly ($P<0.01$) higher TBA numbers than other treatments (Fig.3). High levels of alginate (2%) resulted in slightly higher TBA numbers, while calcium carbonate (2%) resulted in lamb with TBA numbers similar to control treatments. Lactic acid (2%) decreased the pH of meat to 4.60, while calcium carbonate and alginate increased the pH to 6.59 and 5.96, respectively (Fig.3). Although the levels used in this experiment are unrealistic for restructured meat, the results demonstrate the importance of pH on lipid oxidation.

Objectionable rancid odour and WOF were detected after four days of storage (2-4°C) in the sodium chloride containing products while STPP treated products were not rancid for up to 10 days (Table 3). The algin/calcium treated products were rejected due to rancid odour or WOF at about the same time with the control and no additives samples (5-6 days).

Cooking to an internal temperature of 70°C for 10 minutes, increased ($P < 0.01$) the concentration of phospholipids in the samples (Fig.4). Cooking decreased polyenoic fatty acid contents, compared to the raw state. Storage at 4°C for 15 days decreased the dienoic and polyenoic fatty acid content in the phospholipid fraction.

CONCLUSION

Algin/calcium carbonate/lactate at levels higher (0.4/ 0.08/ 0.7 and 1.0/ 0.2/ 0.3) than those used in meat restructuring accelerated increases in TBA numbers, but not significantly ($P < 0.05$). High levels of lactate (2%) increased ($P < 0.01$) TBA numbers and decreased meat pH to 4.6. High levels of alginate (2%) had only a minor effect, while calcium carbonate had no influence on rancidity. Most samples were rejected after 6 days of storage due to objectionable rancid odour when stored raw, or WOF when stored cooked. Rancidity development and sensory rejection of algin/calcium restructured lamb meat is at a rate similar to that with salt, or ground meat mixed without additives.

ACKNOWLEDGEMENTS

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