INFLUENCE OF ALGINATE AND ADDITION OF LACTIC ACID ON COLOUR CHANGES OF RESTRUCTURED BEEF DURING COLD STORAGE.

Caroline P. Baron[1]; Anders J. Møller[1] & Henrik J. Andersen[2]

[1]Department of Dairy and Food Science, The Royal Veterinary and Agricultural University, Rolighedsvej 30, DK-1958 Frederiksberg C
[2]Department of Product Quality, Danish Institute of Animal Science, Research Center Foulum, DK-8830 Tjele, Denmark.

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Introduction.
Restructured meat products have long been considered for their potential in upgrading low grade cuts. However, the conventional salt/phosphate processed products give rise to several problems. The salt/phosphate binding system requires heat treatment to bind the meat pieces together, and for this reason only distribution of frozen or pre-cooked products is possible. Moreover, the presence of salt at high concentrations gives rise to problems with colour and rancidity. Use of the alginate/calcium binding system in the production of restructured meat products makes it possible to overcome some of these problems. The possibility for production of restructured steaks in the raw state is an advantage as such products have a higher status among the consumers compared to frozen or pre-cooked products. Additionaly, restructured meat products based on the alginate/calcium binding system do not need addition of salt and therefore eliminate salt induced discoloration. Restructured meat products are prepared with low quality cuts which are often associated with low tenderness. Lactic acid treatment has been proposed as a possible alternative to increase meat tenderness (Eilers *et al.*, 1994), and addition of lactic acid to low quality cuts for the production of restructured meat products might further increase the commercial value of these products. However, lactic acid treatment in tenderisation of beef may enhance discoloration due to a fast autoxidation of the meat pigment at low pH.
The present study investigates the effect of 3 different alginate levels (0.5, 0.75 and 1.0 %) and addition of 0, 0.25 and 0.5 M lactic acid on the colour stability during cold storage of restructured beef, as measured by tristimulus colorimetry (L*-, a*- and b*-values). This has been carried out to determine whether calcium carbonate in the alginate/calcium binding system can counteract the negative effect of addition of lactic acid on pigment oxidation.

Materials & Methods.
All experiments were performed with *M. semitendinosus* from mature cows (2-4 years) 4 days *post-mortem*. The muscles were trimmed for visible connective tissue and fat, cut into pieces (*approx.* 350 g) and stored at -18°C in polyethylene bags for no longer than three weeks. Frozen meat was thawed at 5 °C for 24hs4 and ground coarsely through a kidney plate (35 mm x 14 mm). The meat was added at 3 different levels of alginate (0.5; 0.75; 1.0%) and 10% water or lactic acid (0.25 M; 0.5 M), resulting in a 3x3 factorial design. The total weight of each formulation was 180g and all ingredients were added on a w/w basis. All combinations were added 0.6 % glucono-δ-lactone (GDL) and calcium carbonate in a ratio of 1/5 of the corresponding alginate content. Each formulation was divided into three samples of 50 g in dishes (Ø 7 cm; h 4 cm) and placed at 5 °C covered with polyethylene. The remaining 30 g of each formulation were used for pH measurements. After 7 h, to allow the alginate gel to set, each of the restructured steaks was removed from the dish and wrapped in polyethylene and immediately placed at 5 °C for subsequent storage.
Colour measurements (L*-, a*- and b*-values) were performed on each steak in triplicate 7, 24, 48, 72 and 120 hours after preparation using a Minolta spectrophotometer CM-508 (Minolta Camera Co. Ltd, Japan). Simultaneously, pH measurements were performed using a standard pH meter (PHM 62, Radiometer, Denmark) equipped with an insert electrode (Radiometer, Denmark).
The experiment was carried out in duplicate and standard analysis of variance using the GLM procedure was performed using SAS STAT™ software.

Results and discussion.
Figure 1, 2 and 3 shows the tristimulus parameters (a*- , L*- and b*-values) on the surface of restructured beef steaks as affected by alginate concentrations and the content of lactic acid during cold storage (5 °C). Table 1 represents the pH-values of the different formulations at 7 and 48 h after preparation. No further changes in pH were observed during prolonged storage (not shown). The changes in the a*-values indicate change in red meat colour. In all restructured beef steaks a significant decrease ($P<0.001$) in the a*-values was observed during storage due to pigment oxidation. The measured a*-values for the steaks prepared without lactic acid indicated a significant decrease in redness ($P<0.001$) with increasing alginate content (Figure 1). Increased alginate content results in increased pH (Table 1) which theoritically should enhance pigment stability and therefore redness. Consequently, the data indicates that alginate has a negative effect on meat colour and supports the findings from Chen *et al.* (1992). Addition of lactic acid to the preparations decreases the pigment stability as observed from measured a*-values (Figure 1). This can be attributed to a systematic decrease in pH with increasing lactic acid levels resulting in fast discoloration of the meat samples. However, the combination of 0.25 M lactic acid and 0.75 or 1% alginate decreases the rate of discoloration compared to steaks prepared with 0.25 M lactic acid and 0.5% alginate. This can be explained by the increase in pH upon addition of high concentrations of alginate in combination to calcium carbonate (Table 1). At a high lactic acid concentration (0.5 M), the initial a*-values (7 h after preparation) are lower compared to the a*-values obtained for samples prepared with 0.25 M lactic acid or without lactic acid. High lactic acid concentration decreases the pH to a critical value where acidic denaturation of the meat pigment becomes important (Table 1) and where the combination of alginate/calcium carbonate, even at high levels (0.75% and 1%) is not sufficient to counteract the effect of lactic acid by increasing the pH above the critical value (pH:5.0). Measured L*-values (lightness) (Figure 2) depend significantly on both storage and alginate concentrations. No significant interaction ($P<0.001$) between time and alginate concentrations on the L*-values was observed for restructured steaks prepared with 0.25 M lactic acid. Therefore, the difference in L*-values for restrucured steaks does not reflect the observed variation in the a*-values but directly reflects the alginate content. The steaks prepared with 0.25 M lactic acid give a higher initial level for the L*-values compared to the samples prepared with 0.5 M lactic acid and without lactic acid. This could be due to the interaction between lactic acid and alginate. The measured b*-values (yellowness) presented in Figure 3 were also significantly

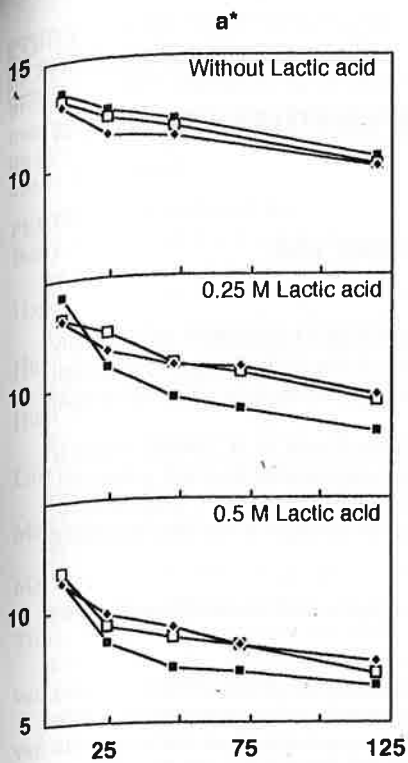

Figure 1: Influence of lactic acid and alginate on a*-values at the surface of restructured steaks during storage. (—■— 0.5% alginate; —□— 0.75% alginate; —◆— 1% alginate).

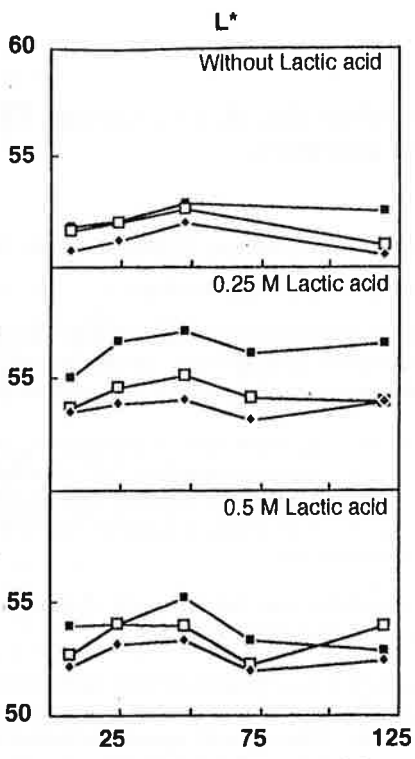

Figure 2: Influence of lactic acid and alginate on L*-values at the surface of restructured steaks during storage. (—■— 0.5% alginate; —□—0.75% alginate; —◆— 1% alginate).

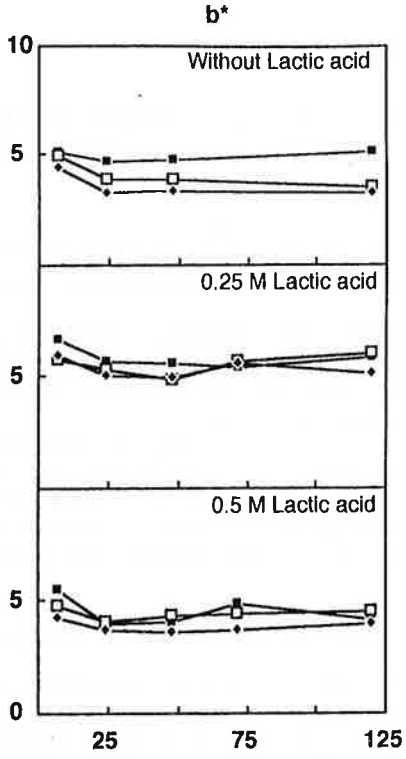

Figure 3: Influence of lactic acid and alginate on b*-values at the surface of restructured steaks during storage. (—■— 0.5% alginate; —□— 0.75% alginate; —◆— 1% alginate).

Table 1. pH in restructured meat preparations 7 and 48 hours after processing as affected by added lactic acid and alginate.

Lactic Acid (M)	Time (hours)	Alginate 0.5%	0.75%	1%
0	7	5.33 (0.05)[a]	5.37 (0.07)	5.48 (0.02)
	48	5.23 (0.05)	5.37 (0.08)	5.47 (0.01)
0.25	7	5.10 (0.07)	5.07 (0.06)	5.24 (0.06)
	48	5.06 (0.08)	5.16 (0.06)	5.29 (0.05)
0.5	7	4.84 (0.03)	4.91 (0.06)	5.03 (0.06)
	48	4.84 (0.04)	4.89 (0.03)	5. 06 (0.05)

[a] Numbers in brackets represent standard deviation

affected by storage and alginate levels ($P<0.001$). The time effect found for b*-values must be due to the drastic decrease in b*-values observed within the first 24 hours of storage. The b*-values also reflect the difference in the alginate level ($P<0.001$) but to a lesser extent compared to the measured L*-values. As observed for the L*-values, b*-values in the presence of 0.25 M lactic acid are higher than b*-values measured in the presence of 0.5 M lactic acid or without lactic acid. This could be explained by the interaction between alginate and lactic acid.

Conclusion

Addition of lactic acid and alginate decrease the level of surface redness of restructured steaks. However, high alginate content (0.75% or 1%) and low concentration of lactic acid (0.25 M) minimize the rate of discoloration and increase lightness and yellowness (L*- and b*- values, respectively). With regards to the a*-values, this can be explained by an increase in pH with increasing alginate/calcium carbonate content. Alginate itself affects meat pigment as an increasing level of alginate decreases the level of the initial red color. Interaction between alginate and proteins has been reported (Imeson, 1984) but further investigations need to be carried out to understand the mechanism by which alginate influence pigment denaturation, in order to optimize colour of restructured meats.

References.

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