HIGH MANNURONATE ALGINATES FOR RESTRUCTURING BEEF

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S-VIB.33

SUMMARY

The binding potential of three high mannuronate-type alginates in restructured beef (M. semitendinosus) was studied. Experiments were performed using finely and coarsely ground meat. Treatments were formulated with varying alginate- and calcium carbonate ($CaCO_3$) levels. Parameters measured were raw breaking strength, cooked tensile strength, cooking loss and pH.

Among alginate types studied, Sobalg Fd 176 resulted in the highest raw breaking strengths and the lowest cooking loss ($P<0.05$). Overall, elevating the alginate level from 0.50% to 1.25 % resulted in increased raw breaking strengths, provided the level of $CaCO_3 \geq 0.15\%$. When using Sobalg Fd 176, cooked tensile strenghts ranged from 11.6 N to 17.9 N, corresponding to a satisfactory bind. Cooking loss were reduced when elevating the alginate level, whereas pH increased as a function of the level of $CaCO_3$ ($P<0.05$). The present study shows, that acceptable bind can be obtained using high mannuronate-type alginates, especially Sobalg Fd 176, in restructured beef.

Introduction

In the meat processing industry, the interest in a value enhancement of secondary meat cuts and trimmings has been increasing. The production of restructured meat plays a central role in this context.

The traditional manufacturing principle for restructured meat, is based on meat particle binding by a heat set protein matrix, after extraction of salt soluble myofibrillar proteins (Booren and Mandigo, 1987). A considerable disadvantage of this binding mechanism is, however, that the products can only be marketed in a precooked or frozen state.

An alternative preparation principle, using the alginate/calcium binding mechanism, has been developed (Means and Schmidt, 1986). Binding of meat particles are accomplished by a calcium alginate gel, after mixing of meat with the hydrocolloid sodium alginate and a calcium salt (calcium carbonate, $CaCO_3$). The alginate/calcium binding mechanism function in both the raw, refrigerated state and in the cooked state, and allows the products to be marketed at the meat display with other fresh meats.

An important factor determining the properties of alginates, is the relative proportions of the building units guluronic acid (G) and mannuronic acid (M), dividing alginates into high G- and high M types (Sime, 1990). Until now, studies on the alginate/calcium binding mechanism in restructured meat has been done only with high G alginates, probably because high G types usually form the strongest gels. However, when the alginate/calcium ratio is either high or low, high M types are able to produce the strongest gels (Sime, 1990). Because the binding properties of high M alginates in meat systems seems unknown, basic studies are required.

The objective of this study, was to evaluate the binding potential of high M alginate types in restructured meat using varying levels of alginate and $CaCO_3$, and, at the same time, to optimize the ingredient levels.

Materials and methods

The study includes two experiments.

Experiment 1 The meat source was M. semitendinosus from 2-4 year old cows. Alginates used were 3 high M types, Sobalg Fd 155, 176 and 275, from Grindsted Products; Sobalg Fd 155 and 176 are sodium alginates, Sobalg Fd 275 is a potassium alginate; Sobalg Fd 155 and 275 are medium viscosity types, Sobalg Fd 176 is a

relatively high viscosity type. Moreover, $CaCO_3$, glucono-delta-lactone (GDL) (0.80%) and destilled water (5%) was applied. A complete randomized factorial arrangement of treatments (3 x 4 x 4) with two replications was used (3 alginate types, 4 alginate levels (0.50%, 0.75%, 1.00% and 1.25%) and 4 $CaCO_3$-levels (0.10%, 0.15%, 0.20% and 0.25%)). Analysis of variance was carried out using a statistical PC package (SAS).

The meat was trimmed, cut in smaller pieces and afterwards stored at -18°C for no more than two weeks before use. Formulations were made, in which additives were mixed with finely ground (4.5 mm) thawed meat according to the following sequence: alginate (1 min.), $CaCO_3$ and destilled water (1/2 min.) and GDL (1 min.). The meat mass was transferred to small glass bowls, vacuumized and stored for 22 hours at 5°C.

The following parameters were measured: Raw breaking strength by compression, raw pH and cooking loss. Breaking strength measurements were performed on cylindrical samples (at 5.0°C) (diam. 24 mm, heigth 21.1 mm) using a computerized Instron Universal Testing Machine 4301 (load cell 1kN, compression plate diam. 35 mm, crosshead speed 60 mm x min^{-1} and degree of compression of samples 80%). The peak force (N) was measured, and was expressed as breaking strength (Klettner, 1989). Cooking loss was measured after heating at 80°C for 30 minutes and expressed as a percent of sample raw weight.

Experiment 2 The same materials, levels of additives and preparation technique were applied as in exp. 1, except that only one alginate type was used (Sobalg Fd 176) and that meat was coarsely ground (kidney plate, 3.5 cm x 1.4 cm). Thus a 4 x 4 complete randomized factorial arrangement of treatments with 2 replications was used in exp. 2. Statistical analysis was performed as in exp.1.

The following parameters were measured: Cooked tensile strength, cooking loss (heat treatment at 80°C for 30 minutes) and raw pH. Tensile strength (N) was measured on circular samples (diam. 70 mm, weigth 50 g), after cooling to ambient temperatures, applying the Instron machine (load cell 1kN, speed of jaws 60 mm x min^{-1}). Supplementary to the objective measurements, the handling ability of both raw and cooked samples was evaluated, e.g. by cutting the samples with a sharp knife.

Results and discussion

Experiment 1, Finely ground meat model

Significant main effects, due to type of alginate and levels of both alginate and $CaCO_3$, were observed regarding the parameters raw breaking strength, cooking loss and raw pH (P<0.05). The only significant interaction observed, was between levels of alginate and $CaCO_3$, regarding raw breaking strength (P<0.05). Sobalg Fd 176 showed the highest raw breaking strengths and the lowest cooking loss, when averaged across the levels of alginate and $CaCO_3$ (P<0.05) (table 1). pH was not affected by the type of alginate (P>0.05) (table 1). Raw breaking strength is a measure of the cohesion between meat particles, and is used as an indicator for the handling ability of raw restructured meat products. Prelimenary experiments in our laboratory has shown, that raw breaking strengths ranging from 30 N to 40 N corresponds to acceptable cohesion of the gelled finely ground meat mass. Based on these results only Sobalg Fd 176 was employed in exp. 2.

In table 2 and fig.1, mean values for raw breaking strength, cooking loss and raw pH are shown, averaged across the three alginate types.

Generally, a gradual rise in raw breaking strengths, with increasing alginate levels, was observed (fig.1). However, an interactive (synergistic) effect was observed between levels of alginate and $CaCO_3$ (P<0.05). The lowest raw breaking strengths were obtained with 0.10% $CaCO_3$, irrespective of the content of alginate, but at higher $CaCO_3$-levels ($\geq$ 0.15%), a substantial enhancement of raw breaking strengths, as a function of the alginate content, was demonstrated (fig.1).

With finely ground turkey meat, Ensor et al. (1989), too, demonstrated a marked increase in peak force when elevating the alginate/calcium binder level, especially in the presence of 0.6% encapsulated lactic acid. On the other hand, Clarke et al. (1988a) observed no further increase in penetration force in finely ground beef beyond a binder level of 0.85% (0.6% sodium alginate, 0.10% $CaCO_3$ and 0.15% encapsulated lactic acid).

A linear reduction in cooking loss was observed when elevating the alginate content from 0.50% to 1.25% (P<0.05) (table 2). The lowest cooking loss were obtained with $CaCO_3$-levels 0.15%-0.25% (P<0.05) (table 2). In accordance with our results, Ensor et al. (1989) observed a significant increase in cook yield (= (weight of cooked sample/weigth of raw sample) x 100%), when elevating the binder level in restructured finely ground turkey meat. In addition, Clarke et al. (1988b) pointed out, that the presence of alginate in structured finely ground beef was the principally reason for the noticed increases in cook yield.

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pH of the meat model system was only affected by $CaCO_3$-levels (P<0.05) (table 2). In both restructured pork chops and restructured beef steaks, Trout (1989a,b) demonstated a considerable pH elevating effect when $CaCO_3$-levels were increased, and contrary to our results, there was a minor pH increasing effect when alginate was added.

The results from exp.1 confirms, that the main reason for the reduced cooking loss is the pronounced water binding properties of alginates, irrespective of optimal gelling conditions is achieved or not. The pH increase, due to the $CaCO_3$ addition, is relatively small, owing to the presence of the acidulant GDL in the recipe. However, when $CaCO_3 \geq 0.15\%$, part of the reduction in cooking loss, may be due to improved water binding properties of the myofibrillar proteins at the slightly elevated pH-values. In conclusion, the results from this experiment indicate, that treatments containing 0.75%-1.00% high M alginates and 0.20%-0.25% $CaCO_3$ are acceptable, as evaluated by the parameters raw breaking strength, cooking loss and pH.

Experiment 2, Coarsely ground (kidney plate) meat model

Cooked tensile strengths for Sobalg Fd 176, the selected alginate type from exp.1, ranged from 11.6 N to 17.9 N (fig.2). Main effects, due to alginate- and $CaCO_3$ levels, were not significant (P>0.05). Probably, this may be due to a relatively large variation among treatments, examplified by the distinctive reduction in tensile strength, as a function of the level of alginate, when only 0.10% $CaCO_3$ is present. The subjective evaluations of handling ability (data not shown) indicated a satisfactory bind, in both the raw and the cooked state, for all alginate- and $CaCO_3$ levels. Thus acceptable product bind was obtained with not more than 0.50% Sobalg Fd 176 and 0.10% $CaCO_3$. Unlike the results for raw breaking strengths in exp.1, an increase in product bind, as a function of binder level, was not observed. This may be due to the larger meat particle size, and the consequently smaller surface area for the alginate binder to function in exp.2.

Regarding cooking loss and pH, the same conclusions as in exp.1 were drawn (P<0.05) (data not shown). An approximately linear reduction in cooking loss (from 26.9% to 16.7%) was observed when increasing the level of Sobalg Fd 176 (averaged across $CaCO_3$ levels). The corresponding cooking loss reduction in exp.1 was from 21.9% to 9.2%. The lower cooking loss values in exp.1 is probably due to the smaller meat particle size. When the meat used for restructuring has been coarsely ground, as was done in exp.2, contradictory results for cook yields appears in the litterature. Thus Ensor et al., (1990), in a study on restructured beef, showed significant increments in cook yields when elevating the binder level. However, Means and Schmidt, (1986), did not demonstrate a binder level effect on cook yields in their study with restructured beef, and Ensor et al., (1989) only noticed very small increments in cook yield when elevating the binder level in restructured turkey breast meat. Variable experimental procedures and conditions may contribute to this disparity in results.

Although adequate cooked bind has been achieved in the coarsely ground product in exp.2, with only 0.50% Sobalg Fd 176 and 0.10% $CaCO_3$, the fact that cooking loss was increased when reducing the alginate level must be taken into account. Thus, an appropriate estimate is 0.75%-1.00% Sobalg Fd 176; with some uncertainty, an estimate for the $CaCO_3$ level is 0.20%, based on the present data.

Conclusion

When evaluated in a finely ground restructured beef product, the three high mannuronate alginates resulted in acceptable raw bind. On an average, Sobalg Fd 176 showed the highest raw breaking strengths and the lowest cooking loss. Supported by the cooked tensile strength and cooking loss measurements in the coarsely ground (kidney plate) restructured beef product, the optimal binder level was found at 0.75-1.00% Sobalg Fd 176 and 0.20% $CaCO_3$.

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Table 1. Effect of alginate type (Sobalg Fd 155, 176 and 275) on raw breaking strength, cooking loss and raw pH in finely ground (4.5 mm) restructured beef.

Table 2. Effect of levels of alginate and $CaCO_3$ on cooking loss and raw pH in finely ground (4.5 mm) restructured beef.

Fig. 1. Raw breaking strengths in finely ground (4.5 mm) restructured beef. Values are averaged across the three alginate types Sobalg Fd 155, 176 and 275.

Fig. 2. Cooked tensile strengths in coarsely ground (kidney plate) restructured beef.