MODIFYING THE TEXTURAL CHARACTERISTICS OF FORMED BEEF PRODUCTS.

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SUMMARY

The textural characteristics of formed or restructured beef products were modified in two different ways. First, the characteristic connective tissue toughness common to these products was reduced by the addition of a bacterial collagenase. When compared to a control treatment, Warner-Bratzler shear force measurements indicated that this toughness had been reduced, since the maximum force required to shear the collagenase treated product was approximately 56% of that required to shear the control.

An attempt was also made to improve the binding in the product by replacing NaCl with several nonmeat ingredients. Using two different types of tensile tests, the strength of the bind obtained with these ingredients was compared to the bind obtained in a control product manufactured with 0.75 % NaCl. The alternative binding systems used were effective in providing an intimate bind between the meat pieces; further development may lead to their industrial utilization.

INTRODUCTION.

Restructured beef products have been the object of extensive research during the last decade. One of the major areas of research has been the study of the factors affecting the textural characteristics of the final product. Two important areas in which problems have been identified are the effect of raw material connective tissue on the final texture and the development of a good and reproducible bind between the meat pieces present in the product (Breidenstein, 1982).

The raw materials most commonly used in restructured beef products have high amounts of extensively crosslinked connective tissue. Most attempts at controlling this connective tissue toughness have been mechanical (i.e., particle size reduction or mechanical tenderization). Enzymatic modification of connective tissue, although not economically sound at this time, may eventually be considered an attractive option if its technological feasibility can be demonstrated. One of the objectives of this work was to assess the technological feasibility of this approach in controlling connective tissue toughness in formed beef products.

An important part of the meat restructuring process is the bind that develops from a heat-set mechanism involving salt-extracted myofibrillar proteins. However, as an alternative to heat-setting, non-meat ingredients could also be used as binders. Although most of the ingredients used up to now have been proteins such as soy, milk or egg proteins (Moore et al., 1976; Hand et al., 1981; Terrel et al., 1982), polysaccharides have also been utilized (Anonymous, 1985; Means and Schmidt, 1986). The second objective of this work was to evaluate the bind developed between meat pieces using a mixture of egg albumen and gluten, or two polysaccharides, sodium alginate and methylcellulose, used alone or in combination with whey protein concentrate.

EXPERIMENTAL METHODS.

Frozen commercial beef fronts, cut into 5 cm^2 cubes with an electric bench saw, were flaked in an Urschell Comitrol (Urschell Laboratories Inc., Valparaiso, IN) using a 2-K-030240 cutting head. The flaked meat was mixed for 10 min with one of the following ingredients: 0.25 %, 0.5 %, or 0.75 % NaCl, Achromobacter iophagus collagenase, 1 % sodium alginate (Kelco, Merck and Co., Chicago, IL), 1 % methylcellulose (Dow Chemical Co., Midland, MI), 0.8 % sodium alginate + 0.2 % whey protein concentrate (New Zealand Milk Products Inc., Petaluma, CA), 0.8 % methylcellulose + 0.2 % whey protein concentrate, or 1% of a mixture containing egg albumen and gluten. Calcium chloride was added to the samples containing alginate. The samples treated with collagenase contained 0.75% NaCl.

The mixtures were stuffed into polyethylene bags fitted inside 10 x 15 cm cylindrical molds and stored at -30oC for 36 hr. After tempering to -4oC, the meat logs were pressed (700 psi), released from the molds and stored again at -30oC. The meat logs were sliced (2 cm thickness), vacuum packaged and kept at - 30oC. The samples were broiled from the frozen state in standard convection ovens to an internal temperature of 70oC.

All instrumental texture analyses were performed at room temperature. For the Warner-Bratzler test, 1.25 cm diameter cores were removed from the restructured samples and subjected to single-blade shear. A Warner-Bratzler cell in an Ottawa Texture Measuring System at a crosshead speed of 85.7 mm/min was used to measure maximum shear force.

Two different tests were used to measure tensile strength in the cooked samples. The first, originally used by Pool (1967) to measure connective tissue tenacity in cooked poultry meat, was adapted to measure binding strength perpendicular to the product surface plane. Cylindrical cores (2.2 cm diameter) were removed from restructured products and centered and glued between aluminum stubs (2.54 cm diameter; Marivac Ltd., Halifax, N. S.) with cyano acrylate glue (Krazy Glue Inc., Chicago, IL). These pins were carefully mounted in two chucks installed in an M5K Tensile Testing Machine (J. J. Lloyd Instruments Ltd., Southampton, England), avoiding any sample torsion. The samples were pulled apart at a crosshead speed of 20 mm/min and the maximum rupture force was recorded.

A second test, using a device analogous to the one described by Gillet et al. (1978) attached to the M5K tensile testing machine, was utilized to measure the tensile strength along the product surface plane. Cooked restructured sections (2.0x2.0x6.5 cm) were pulled apart in the tensile testing attachment at a crosshead speed of 20 mm/min; the maximum force exerted at rupture was recorded. Data analysis was performed using the multiple-range test procedure of Duncan, following analysis of variance (ANOVA), using the SAS statistical software for personal computers (SAS Institute, 1985).

RESULTS AND DISCUSSION.

The maximum force required to shear a sample in a Warner-Bratzler test cell was reduced from 13.33 $\pm$ 1.22 N for a control manufactured with 0.75% NaCl to 7.43 $\pm$ 1.44 N for a sample manufactured with the same amount of NaCl but to which a bacterial collagenase had been added. While reductions in mechanical strength produced by collagenase in intact muscle are well documented in the literature (Bonnet and Kopp, 1984; Bernal and Stanley, 1986; Foegeding and Larick, 1986), to the best of our knowledge similar reductions in restructured beef products have not been reported before. The results presented here suggest that the use of collagenase to modify the textural characteristics of restructured beef may be, at least in principle, technologically feasible. Factors such as enzyme cost and safety must be taken into account before future applications of this enzyme could be considered.

Of all binders tested, the mixture containing egg white and gluten seemed to provide the strongest bind (Table 1). Using the tensile test adapted from Pool (1967) it was observed that products manufactured with the egg/gluten mixture were better bound than the 0.75% NaCl control; however, the other tensile test indicated that bind in the control was strongest. Neither of the tests showed significant (P<0.05) differences among the products manufactured with the hydrocolloid-based binders. The replacement of 20% hydrocolloid by WPC in the binder did not affect (P<0.05) final product binding.

When tensile stress was applied perpendicularly to the product surface plane, no significant differences (P<0.05) were found between the tensile strength of the hydrocolloid-containing samples and the 0.75% NaCl control. However, when this stress was applied along the product surface plane, significant differences (P<0.05) were found. This suggests that some differences in the usefulness of these two tests may exist. Nevertheless, tensile testing may be one of the best methods for the evaluation of binding strength in processed meat products. Binding strength being defined as the force required to pull apart bound pieces of meat (Schmidt and Trout, 1984).

Table 1. Tensile strengths of restructured beef products containing nonmeat binders. Values in the same column followed by different letters are significantly different (P>0.05).

Sample	Tensile strength(1)	Tensile strength(2)
0.75% NaCl	6.65 ± 1.61 a,b	15.42 ± 3.26 a
MC(3)	6.23 ± 0.49 a	10.55 ± 2.26 b
MC/WPC	5.55 ± 1.06 a	11.16 ± 1.36 b
Alginate	5.53 ± 0.83 a	11.15 ± 1.77 b
Alginate/WPC	5.24 ± 3.41 a	10.24 ± 1.70 b
Egg/gluten	8.57 ± 3.41 b	13.44 ± 1.39 c

(1) Tensile stress applied perpendicular to the product surface plane.
(2) Tensile stress applied parallel to the product surface plane.
(3) Methylcellulose.

The success of the binders may rely on their ability to interact with the meat proteins present at the meat particle interface. More work should be done to determine whether other combinations of cold-setting hydrocolloids and heat-setting proteins could produce effective binders. The sensory acceptability of formed products manufactured with these new binders must also be evaluated.

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