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GELATINIZED RECOVERED BEEF CONNECTIVE TISSUE PROTEIN GELS AS POTENTIAL WATER BINDERS

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BACKGROUND

Heating recovered beef connective tissue from desinewing operations may "activate" collagen by partial solubilization to gelatin. This "gelatinous" network may increase the number of sites available for binding added water. Upon cooling, the gelatinized connective tissue partially reforms to entrap fat and bind water. Beef connective tissue gels may bind large amounts of added water by this mechanism. Incorporation of this recovered protein gel in low-fat products may increase yields and improve product texture, thus adding value to recovered beef connective tissue as a potential water binder.

OBJECTIVES

This study consisted of two experiments. The objective of Experiment I was to:

- Determine temperature and time parameters that enhance conversion of beef connective tissue to gelatin.

The objective of Experiment II was to:

- Manufacture and determine basic properties of high-added water beef connective tissue gels.

MATERIALS AND METHODS

Experiment I

Beef connective tissue (BCT) that had been passed through a desinewing machine twice was obtained from a commercial beef slaughter facility. The BCT was frozen, coarse ground (1.27 cm), refrozen and flaked (1.5 mm) in an Urschel Comitrol, double bagged in polyethylene plastic bags and frozen (-32°C) until analyzed for proximate composition (AOAC, 1990) and released fluids (Modification of Townsend et al., 1968). Twelve 17 g (± 0.05 g) BCT samples were weighed in 50cc polycarbonate syringes, placed in a water bath, heated at a single temperature (50, 60, 70 or 80°C) and removed at a specified time period (0.5, 1.0, 1.5 or 2.0 hr). Additional 17 g BCT samples were used to monitor sample temperature with a thermocouple placed in the geometric center of the "test" samples. Time did not begin until the internal samples of the samples reached 70°C. Water bath and sample temperatures were monitored every 10 min and adjusted as necessary. Fluids released from each sample were decanted into 15 ml graduated cylinders, and the cylinders centrifuged for 10 min at 5500 rpm. Total fluids, fat, gel-water and solids released were recorded. Each temperature x time treatment combination was analyzed in triplicate, averaged and reported as ml released fluids per 100 g sample The experiment was designed as a split plot with a 4 x 4 factorial arrangement of treatments. Water bath temperature was the whole plot factor and time period the split plot factor. Least squares means were used to separate significant main effects and interactions. Single degree of freedom orthogonal contrasts were used to determine trends. The experiment was replicated twice (N = 32).

Experiment II

The BCT described in Experiment I was used to determine its ability to form a gel and bind added water. Appropriate amounts of BCT and distilled, deionized water were combined in 600 ml beakers to produce ~ 500 g BCT gels containing 100, 200, 300, 400, 500 or 600% added water (AW) (Table 1).

Based on the results from Experiment I, BCT x water treatments were heated at 70°C for 30 min. The beakers were removed from the water bath, placed on stirring plates and mixed with stir bars in a refrigerated cooler (6 ± 2°C) at high speed until the gels thickened and the stir bars could not move. This was done to enhance the uniform dispersion of flaked BCT throughout the BCT gel matrix. The stir bars were removed, beakers covered with parafilm and remained refrigerated 8-10 hr until analyzed. Duplicate pH readings of each BCT gels were taken with a spear-tip electrode attached to a pH meter. Samples approximately 10 cm in length were obtained from each BCT gel treatment by pushing a stainless steel coring device measuring 22 mm (internal diameter) down the long axis of the gel and boring completely through the sample. The sample cylinder (10 cm in length) was sliced into 12 mm discs, producing samples measuring 22 mm (diameter) x 12 mm (height) for HunterLab color and texture profile analysis. Three sub-sample discs were used for HunterLab Colorimeter analysis (Illuminant A, 2°C standard observer). One reading was taken on each exposed surface of each sample disc for HunterLab L*, a*, and b*. Three sub-sample discs were used for two-cycle compression test by compressing each sample twice to 25% of average sample height. A 500 kg load cell was used with a full scale load range of 1, crosshead speed of 50 mm/min and a chart ratio of 5:1. Hardness (HARD), cohesiveness (COH) (Bourne, 1968), springiness (SPRING) and chewiness (CHEW) (Bourne, 1978) were determined. Sample temperatures for color and texture profile analysis were 2°C. Analysis for hydration, a measure of water binding, was conducted by removing duplicate 25 g (± 0.05 g) subsamples and placing them in 50 cc polycarbonate centrifuge tubes and centrifuging at 15,000 rpm for 15 min at 2°C. Samples were removed and the expressed fluids decanted through one layer of cheesecloth into 50cc polycarbonate tubes. Hydration of each sample was determined and expressed as g water held/g wet tissue. To account for the variability in the total amount of BCT contained in each treatment,the hydration ability of BCT was determined and expressed as g water held/g BCT on a fat-free basis. Cook stability (Townsend et al., 1968) was determined by removing 25 g (± 0.05 g) into 50cc polycarbonate centrifuge tubes and placing them in a 48.8°C water bath. The temperature of the water bath was raised until the internal temperature of the samples reached 68.8°C within

1.25 to 1.50 hr. The free liquid was decanted and cook stability expressed on a sample percentage basis, and as well as on a fat-free BCT basis. The experiment was designed as a randomized complete block design with a single factorial (AW) treatment design. Water bath temperature was the whole plot factor and time period the split plot factor. Least squares means were used to separate significant main effects and interactions. Single degree of freedom orthogonal contrasts were used to determine trends. The experiment was replicated three times (N = 18).

RESULTS AND DISCUSSION

Experiment I

Proximate analysis showed BCT composition to be 56.92% moisture, 18.47% fat and 25.49% protein. A Temperature x Time interaction existed for BCT for total released fluids ($P < 0.05$) and released gel-water ($P < 0.01$). This interaction displayed a quadratic trend for total released fluids ($P < 0.01$) and released gel-water ($P < 0.001$). Less total fluids were released from BCT at 70°C than the other temperatures. The main effect of Temperature was significant ($P < 0.05$, quadratic trend, $P < 0.001$) for released fat. No measurable fat was released at 60 or 70°C. The observed decreased in released fluids may be due to conversion of connective tissue collagen to gelatin, which may have absorbed any moisture and fat released from the BCT sample. Least squares means of Temperature x Time interaction within the 70°C treatment means for each time period indicated no significant differences for released gel-water. Based on the results of Experiment I it was concluded that heating BCT at a temperature of 70°C for approximately 30 min was sufficient to "activate" the conversion of collagen to gelatin, thereby enhancing its potential capacity to bind added water.

Experiment II

The main effect of AW was not significant for pH. Only the 100, 200, 300 and 400% AW treatments produced a gel that was firm enough to analyze for color and texture. As AW levels increased, a significant linear decrease in L* , a* and b* values was observed. Increasing AW levels had a quadratic effect on COH and SPRING. AW affected HARD and CHEW ($P < 0.10$), with the 100% AW treatment being approximately 4X harder (52.171 N) than the 200% AW treatment. CHEW decreased in a linear fashion with increasing levels of AW. AW affected sample hydration and fat-free BCT hydration values ($P < 0.0001$). Hydration values for both sample and fat-free BCT increased in a cubic fashion ($P < 0.01$ and $P < 0.05$, respectively). Sample cook stability decreased in a quadratic manner ($P < 0.0001$) as AW levels increased ($P < 0.0001$). When expressed on a BCT fat-free basis, the main effect of AW on cook stability was not significant. These values ranged from 49.86% (100% AW) to 43.26% (600% AW).

CONCLUSION

Results from this study indicate the feasibility of heating recovered beef connective tissue to form a gel capable of binding significant amounts of added water.

LITERATURE CITED

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Table 1. Treatment formulations for the manufacture of BCT gels (Experiment II)

Treatment	Connective Tissue	Added Water
1	250 g	250 g (100%)
2	167 g	334 g (200%)
3	125 g	375 g (300%)
4	100 g	400 g (400%)
5	83 g	415 g (500%)
6	71 g	426 g (600%)

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