USE OF STARCHES TO ENHANCE COOKING YIELDS AND BINDING OF ALGIN/CALCIUM RESTRUCTURED BEEF

SCHMIDT G.R., SOFOS J.N. and PEREJDA J.A.

Department of Animal Sciences, Colorado State University, Fort Collins, USA

S-VIB.31

SUMMARY

The ability of different cook-up or pregelatinized (instant) commercially available starches to increase cooking yields and binding force in algin/calcium (AC) restructured beef was evaluated. In the absence of added starch, a salt/phosphate (SP) control had the highest ($P<0.05$) cooking yields and bind, while AC products had higher values than the no-additive control. Cooking yield increased with added water, but cooked product bind decreased. Cook-up starches increased ($P<0.05$) cooking yields of the AC product, especially in treatments with no water added, and had positive or negative effects on bind, depending on type of starch and water added. The effect of instant starches on cooking yield was less pronounced than that of cook-up starches, but more pronounced (negative) on bind.

Introduction

Previous studies in our laboratory have shown that addition of starch to AC restructured beef (Means and Schmidt, 1986) increased percent cooking yield, while maintaining cooked product binding strength (Perejda, 1991). Increases in cooking yield due to starch were greater for AC than for SP samples, and quantitative values were greater than all-beef (no additives) samples. For this reason, the AC meat product was selected for additional testing with starch. The objective of the present studies was to measure the ability of different starches to affect cooking yield and cooked product bind of AC restructured beef with or without added water.

Materials and Methods

Two randomized block designs were used to evaluate ten starches added (3% dry-weight basis) to algin/calcium (AC) restructured beef. Two additional meat treatments without added starch (all-beef and SP restructured beef) were included as controls. Treatments and controls were tested with and without 10% added water. Each experiment was replicated three times. The starches tested included five requiring heating before water was absorbed (cook-up) and five not requiring heating (i.e., instant or pregelatinized). Within each type, the five starches included: waxy maize, potato, rice, tapioca and granular starch. Most starches were modified by their manufacturers, although the nature and extent of this was not determined. The boneless riblifter beef used contained 73.4% moisture and 2.6% fat, and had a pH of 5.60. The algin/calcium (AC) restructured beef contained 0.4% sodium alginate (Manugel DMB, Kelco, San Diego, CA), 0.075% calcium carbonate (Gamma Sperse 80, Georgia Marble Co., Tate, GA), and 0.6% encapsulated lactic acid/calcium lactate (CapShure® LCL-135-50, Balchem Corp., Slate Hill, NY). The SP treatment included 1.5% sodium chloride (Morton-Thiokol, Chicago, IL) and 0.3% sodium tripolyphosphate (FMC Corporation, Philadelphia, PA).

Each ground beef treatment (350 g) was mixed for 2.5 min in a Kitchen-Aid mixer (model K45SS, Hobart Co., Troy, OH) at speed two with a paddle attachment, and the ingredients were added at 30-sec intervals. The products were extruded into pre-weighed 6-cm diameter cellulose casings using a hand-operated extruder. They were then tensioned, clipped closed, vacuum packaged (Multivac, Allgau, Germany) and refrigerated 20-24 hr (4 °C) prior to heat processing for 90 min in a water bath (70 ± 1 °C). After cooking, the products were cooled for 15 min in an ice water bath and refrigerated for 12 hr (4 °C).

The pH was measured in blends (20 g product with 80 g deionized distilled water), and percent cooking yield was determined as the difference of cooked and raw product weight expressed as a percent. Meat particle binding was determined as the force required for a 1.8-cm spherical brass probe to penetrate a meat sample (10 ± 1 mm thick) placed over a 5-cm diameter opening (Field et al., 1984). The force was measured with a 100 Newton load cell transducer attached to a J.J. Lloyd Tensile Testing matching (type T5002, Pacific Scientific, Santa Ana, CA) with a crosshead speed of 110 mm/min, and recorded (J.J. Lloyd Recorder, model PL3 XY/t, Pacific Scientific, Santa Ana, CA) as peak deflection. Internal calibration standards allowed for length to force conversions. The products were also evaluated by a six-member sensory panel, for purposes of brevity, these results are not presented in this report. Analysis of variance and Duncan's new multiple range test (Duncan, 1955) were used to separate significant ($P<0.05$) main effects for percent cook yield and cook bind, while Dunnett's test (Dunnett, 1955) was used to compare individual treatments with controls.

Results and Discussion

The pH values ranged between 5.54 and 5.83 in the raw state, and 5.81 and 6.08 in the cooked state. Without added starch, product type and level of water added had significant ($P<0.05$) effects on cooking yield and cooked product binding strength (Table 1). Differences between instant (pregelatinized) starches and cook-up starches include that the former absorb water without application of heat and are less able to maintain viscosity at higher temperatures, while the latter require heating (e.g., 50-65°C) for water absorption. These differences in physical properties provided a basis for testing them separately. Cooking yields of AC restructured beef treatments with added cook-up and instant starches averaged over both (0 and 10%) water levels and five types of starches were 95.6 and 87.6%, respectively, which were significantly ($P<0.05$) different. The corresponding binding values were 13.7 and 4.4 Newtons. Similarly, Wu et al. (1985) and Kim and Lee (1987) reported that pregelatinized starches inhibited protein gelation in surimi. Thus, cook-up starches had a more significant ($P<0.05$) effect in improving yield and bind than instant starches. Cook-up starch and water level interactions were not significant ($P>0.05$), indicating that data partition by water level to evaluate starch effects was unnecessary. Addition of granular cook-up starch to AC beef increased ($P<0.05$) cooking yields compared to addition of tapioca, potato or rice starch (Table 2). Each individual AC beef/starch-added treatment was also compared to AC and SP controls with or without added (10%) water. Cooking yields of all starch samples, with the exception of rice starch, were similar with that of the SP (no water added) control (Table 3). The cooking yields of water-added AC treatments with starches (except rice) were similar to SP controls with added (10%) water, which had the maximum yield. Cook-up starches varied in their ability to maintain bind, which may have been due to interactions with meat proteins, algin/calcium or starch-water interactions. Water addition decreased bind. Starch and water interactions did not affect ($P>0.05$) bind, indicating that data partition by water level was unnecessary for comparisons of cook-up starches. Granular, tapioca and waxy maize starches had the highest ($P<0.05$) bind (Table 2). Thus, treatments with the highest cook yields also had the highest bind. This was unexpected, since increasing yield was expected to decrease bind because binding more water would tend to dilute the concentration of meat binding proteins. All AC treatments with cook-up starches added had lower ($P<0.05$) bind values than the SP controls (Table 4). Differences from AC controls were less pronounced. Actually, granular ($P>0.05$) cook-up starch addition increased the bind value compared to AC controls.

Analysis of variance of cooking yields and cooked product binds of treatments with added instant (pregelatinized) starches indicated significant ($P<0.05$) starch and water level main effects, but interactions did not affect cooking yield or bind ($P>0.05$). Thus, data partition by water level was unnecessary for comparisons of instant starches. Individual instant starches averaged over replicate and water level effects had percent cooking yield values ranging from 84.2% to 90.4% for granular and tapioca and waxy maize starches, respectively, while bind values ranged from 2.6 Newtons for granular starch to 9.4 Newtons for tapioca. Cooking yields of AC restructured beef treatments with added instant starches were mostly higher ($P<0.05$) compared to AC products without added water; similar or lower than AC products with added (10%) water; and lower ($P<0.05$) compared to SP products, especially to SP with added (10%) water (Table 5). Cooked product bind values of AC restructured beef treatment with added (3%) instant starches (data not shown) were for the most part lower ($P<0.05$) compared to all AC and SP controls with or without added (10%) water. The potential effects of instant starch may have been destroyed after processing for 90 min at 70°C, because instant starches are more susceptible to structural disruption at elevated temperatures. Addition of instant starch to AC restructured beef also reduced ($P<0.05$) the overall acceptability of the products compared to the control (data not shown).

Conclusions

Starches added to algin/calcium restructured beef increased percent cooking yield and bind relative to no-starch controls, but the increases varied with different starches and water in the formulation. Increases in cook bind were reduced when water was included in the formulation. Cook-up starches in general functioned better than instant starch types in increasing cooking yield and bind. Several cook-up starch treatments were comparable in percent cook yield to salt/phosphate controls containing added water which represented maximal values. Cook-up granular starch having a low-pasting temperature (36°C), functioned best of the five cook-up starches tested, although the tapioca and waxy maize varieties also functioned well. Instant starches were found to be unsuitable for this application due to smaller increases in percent cook yield and drastic decreases in cook bind. Instant tapioca starch was an exception to this as it produced the highest cook yield of instant starches, but more importantly, cook bind was not reduced when compared to algin/calcium controls. Sensory evaluation by untrained panelists suggested that addition of certain cook-up starches did not compromise product acceptability compared to the control. A blend of instant and cook-up starches may function best for binding water in both uncooked and cooked products. A different ratio of starch, water and meat may further improve both cook yield and bind.

References

Duncan, D.B., (1955). Multiple range and multiple F tests. Biometrics, 11:1-42.

Dunnett, C.W., (1955). A multiple comparison procedure for comparing several procedures with a control. J. Am. Stat. Assn., 50:1096-1121.

Field, R.A., Williams, J.C., Prasad, V.S., Cross, H.R., Secrist, J.L. and Brewers, M.S., (1984). An objective measurement for evaluation of bind in restructured lamb roasts. J. Textural Studies, 15:173-178.

Kim, J.M. and Lee, C.M., (1987). Effect of starch on textural properties of surimi gel. J. Food Sci., 52:722-725.

Means, W.J. and Schmidt, G.R., (1986). Algin/calcium gel as a raw and cooked binder in restructured beef steaks. J. Food Sci., 52:252-256.

Perejda, J.A., (1991). Starch functionality as a water binding ingredient in restructured beef products. M.S. Thesis, Colorado State University, Fort Collins, Colorado.

Wu, M.C., Hamann, D.D. and Lanier, T.C., (1985). Rheological and calorimetric investigations of starch-fish protein systems during thermal processing. J. Texture Studies, 16:53-74.

Tables

Table 1. Effect of meat type and water added (no starch added) on cooking yields and cooked product binding strengths

Table 2. Effect of addition of cook-up starches on cooking yields and cooked product binding strength of algin/calcium restructured beef products

Table 3. Differences in percentage points of cooking yields between algin/calcium restructured beef with added cook-up starches and control algin/calcium and salt/phosphate beef treatments (Dunnet's statistical test)

Table 4. Differences in cooked product bind values (Newtons) between algin/calcium restructured beef with added cook-up starches and control algin/calcium and salt/phosphate beef treatments (Dunnet's statistical test)

Table 5. Differences in percentage points of cooking yields between algin/calcium restructured beef with added instant (i.e., pregelatinized) starches and control algin/calcium and salt/phosphate beef treatments (Dunnet's statistical test)