A Research Note

Effect of Temperature on Collagen Extractability and Kramer Shear Force of Restructured Beef

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ABSTRACT

Collagen extractability and Kramer shear force were measured for raw and heated restructured beef products made with trimmed (epimysium removed) and untrimmed clods (triceps brachii, infraspinatus, and supraspinatus). Collagen extractability was significantly ($p<0.001$) higher for untrimmed samples heated at 50°C than for trimmed samples. Kramer shear forces were significantly higher ($p<0.01$) for untrimmed than trimmed when raw or heated at 35°C, 45°C, 50°C, and 55°C. Collagen extractabilities showed no distinct changes with temperature for trimmed samples. Collagen extractability of untrimmed samples increased then decreased as heating temperature increased. Kramer shear forces decreased between 55°C and 60°C for both trimmed and untrimmed samples.

INTRODUCTION

TEXTURE of restructured beef (RSB) meat products is dependent on connective tissue content (epimysial and intramuscular) and myofibrillar structure of meat as well as binding between meat pieces. Muscles with most intramuscular collagen were reported to be toughest (Dransfield, 1977); muscles with higher rates of intramuscular and/or epimysial collagen solubilization were reported to have lower shear forces and better sensory scores (Goll et al., 1964a; Moller, 1980-81; Light et al., 1985). Others reported that total intramuscular collagen was unrelated to Warner-Bratzler measurements or that soluble intramuscular collagen had no major influence on sensory or Instron texture characteristics of muscle (Goll et al., 1963; Fogle et al., 1982; Naewbanij et al., 1983). The lack of standardization in cooking and analytical procedures in various studies make comparisons difficult.

The objective of this study was to relate Kramer Shear force measurements to collagen extractability in RSB made with different epimysial collagen contents and heated at different temperatures.

MATERIALS & METHODS

THE TRICEPS BRACHII, infraspinatus and supraspinatus from three clods ('A' maturity, Choice grade, Yield grade 2, NAMP #114) were divided into two portions containing equal parts of each muscle. One portion was trimmed of visible epimysial tissue, while the other portion was not. Meat was crust-frozen and diced (0.62 cm on the side). RSB products were made by gently mixing diced meat with 0.75% sodium chloride and 0.125% sodium tripolyphosphate for 2 min in a Hobart mixer, stuffing into 5 cm diameter cellulose casings and holding at +11°C for 4 hr to enhance binding before freezing at −20°C. After initial freezing, products were tempered, sliced 2.5 cm thick and individually vacuum-packaged and stored at −20°C.

Slices of trimmed and untrimmed RSB (one slice from each clod for each temperature) were defrosted overnight at +4°C and heated in water baths at 35°, 45°, 50°, 55°, 60°, 65°, 70°, 75°, or 80°C for 1 hr in vacuum packages. After the slices had cooled to 20°C, each was divided into three pie-shaped wedges (mean wt = 19.3 ± 2.7g, N = 180) and peak force (Newtons/g product) was determined with a Kramer multiblade shear cell at a cross head speed of 50 mm/min.

Nine slices of trimmed and untrimmed RSB (three slices from each clod) were ground in a food processor. The pH of both ground products was 5.8 (combination electrode). Three five gram samples of the ground RSB products were heated in 50 mL round bottom tubes for 1 hr at the same temperatures as above. Ten grams water were added to each tube and to three raw samples of each (60 samples) and extracted overnight at +4°C before grinding with a Brinkman Polytron for 1 min (power setting of 5). The polytron was rinsed 4X with 3 mL water and the ground meat and rinses combined and centrifuged at 10,000 x*g* for 1 hr. The supernates were divided into three aliquots, freeze-dried, hydrolyzed with 2 mL 6N HCl at 120°C overnight and the hydroxyproline (Hyp) of the supernate determined (Woessner, 1961). The Hyp of each residue was determined in triplicate. Hyp values multiplied by 7.14 yield collagen content (Dransfield, 1977). Percent extractable collagen was calculated by dividing the total extracted collagen (supernates) by the sum of total insoluble collagen (residues) and total extracted collagen (supernates) times 100.

Heating temperature effects were tested for trimmed or untrimmed RSB by Duncan's New Multiple Range Test and differences between the means of trimmed and untrimmed RSB at the same temperature were tested using Student's t (Steel and Torrie, 1980).

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RESULTS & DISCUSSION

UNTRIMMED RSB had higher shear forces when raw or heated below 55°C than for higher temperatures (Fig. 1). Trimmed RSB was significantly tougher ($p<0.05$) when heated at 50°C and 55°C than at other temperatures. Differences in shear forces of trimmed and untrimmed RSB were significant ($p<0.05$) at temperatures ≤ 60°C.

The epimysial connective tissue in untrimmed RSB resulted in higher shear forces when heated ≤ 60°C compared to trimmed RSB. Trimmed RSB averaged 1.86% collagen while the untrimmed RSB averaged 3.51% collagen ($t = 7.25$, $p<0.01$, $N = 40$). Shear forces changed similarly in both trimmed and untrimmed RSB. Shear force increased before 55°C for both trimmed and untrimmed RSB due to coagulation and shrinkage of myofibrillar proteins. Heat denaturation of connective tissue usually results in decreased shear force while heat denaturation of myofibrillar protein results in increased shear force (Schmidt and Parrish, 1971).

At temperatures of 60°C, the contribution of the collagen to the overall texture decreased, and there were no significant differences in shear force values between trimmed and untrimmed RSB. Penfield and Meyer (1975) showed decreases in shear values after cooking beef semitendinosus to 60°C, and Laakkonen et al. (1970) and Laakkonen (1973) reported several studies which showed decreases in shear values of various beef muscles heated between 50°-60°C, due to the shrinkage of intramuscular collagen. In other studies (Paul et al., 1973; Moller, 1980-81; Brady and Penfield, 1981) heating above 60°C showed no effect of ultimate temperature on shear values.

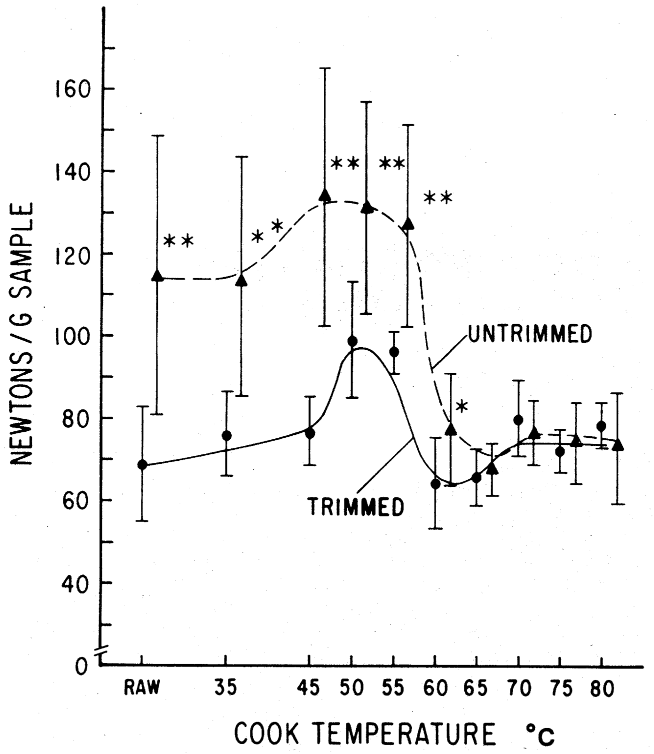

*Fig. 1—Relationship between Kramer multiblade shear forces and cooking temperature (°C) of restructured meat products made from trimmed and untrimmed beef clods: ● — ● trimmed samples; △ — △ untrimmed samples; bars on graph are standard deviation; **p<0.01 and *p<0.05 for Student's t of Kramer shear force between trimmed and untrimmed samples cooked at temperature shown.*

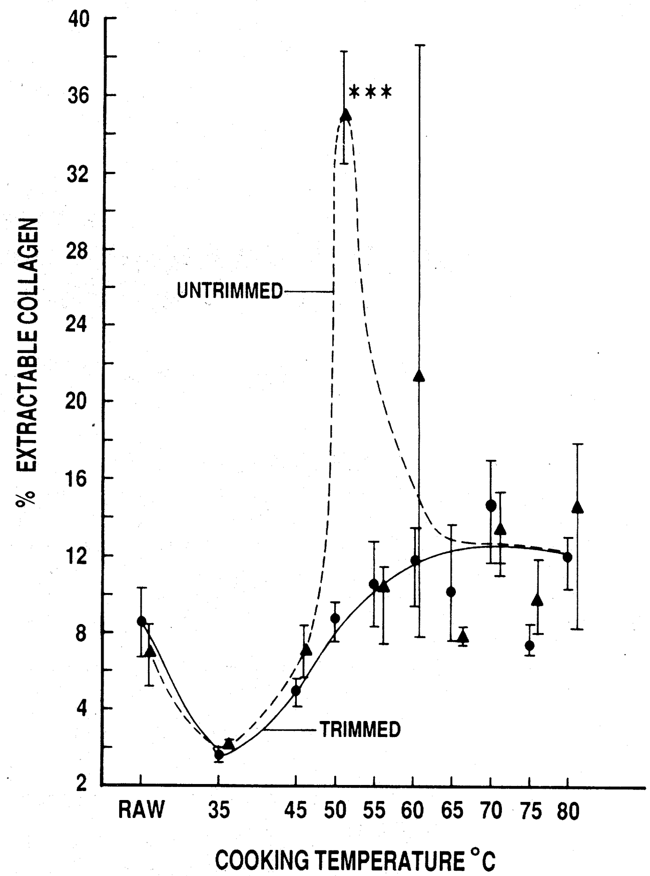

*Fig. 2—Relationship between % extractable collagen and cooking temperature of restructured meat products made from trimmed and untrimmed beef clods. ● — ● trimmed samples; △ — △ untrimmed samples; bars on graph are range of extractabilities; ***p<0.001 for Student's t of % extractable collagen between trimmed and untrimmed samples cooked at temperature shown.*

For trimmed RSB, the percent extractable collagen showed no distinct variation with temperature except for a decrease at 35°C (Fig. 2). Goll et al. (1964b) and Penfield and Meyer (1975) showed a minimum intramuscular collagen solubility at 40°C. The extractable collagen of untrimmed RSB, which contained more epimysial connective tissue than trimmed RSB, behaved similarly to the extractable collagen of trimmed RSB except for a peak between 50°C and 60°C. The variation in extractable collagen between 50°C and 60°C in RSB containing epimysial collagen and the subsequent decrease may possibly be due to interaction between localized aggregation and resolubilization of Type I collagen (Engel, 1987). Differences in the extractabilities of trimmed and untrimmed RSB were significant at 50°C. Strange and Whiting (1987) also noted greater collagen extractability in cooked (60°C) RSB samples with added epimysium compared to those made with trimmed meat. Mohr and Bendall (1969) showed that tendon was more soluble than intramuscular connective tissue. Field et al. (1970) showed that epimysial collagen from young pigs was more soluble than intramuscular collagen. Recently, Burson and Hunt (1986) demonstrated that Type I collagen was more heat-labile than Type III. Light et al. (1985) found that epimysial connective tissue contained more Type I collagen than did the intramuscular connective tissues.

Collagen extractability is a function of type of collagen present and temperature of heating. Shear force is unrelated to total collagen extractability in RSB if several types of connective tissue are present. Increasing solubility of specific collagens by using collagenases or chemical treatments may be effective for tenderizing restructured meats by lowering the temperature where collagen solubilizes during heating, thereby reducing the contribution of connective tissue to shear force of RSB.

In conclusion, collagen content was related to shear force only if the shear force was measured on restructured samples cooked to less than 60°C; collagen extractability was a poor predictor of texture for restructured meat.

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