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Effect of Degree of Connective Tissue Removal on Raw Material Yield, Chemical and Sensory Characteristics of Restructured Beef Steaks

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ABSTRACT

Beef shoulder clods were subjected to various degrees of connective tissue removal—no trim (NT), intermediate trim (IT) and extensive trim (ET)—before being manufactured into restructured steaks. Trimming yields for the NT, IT and ET treatments were 100.0%, 92.5% and 87.3%, respectively. Palatability evaluations revealed significant differences between steaks from the NT treatment compared with either the IT and ET treatments. Based on economic projections and palatability evaluations, no real advantage could be found for the production of steaks from ET clods, but advantages were found for steaks from IT clods compared to NT clods.

INTRODUCTION

RESTRUCTURED MEATS offer many advantages—one of which is the production of an attractive product that adds worth to otherwise lower valued, underutilized cuts of meat (Anonymous, 1981). Consistency and control of portion size, shape, texture and fat are other advantages that restructured meats offer to consumers and food purveyors (Anonymous, 1981; Mandigo, 1975).

Of particular interest is the use of the chuck to produce restructured steaks. Due to its size and lower value in relation to the "middle meats" (rib and loin) of the carcass, the chuck is a viable raw material for restructured steaks. Booren et al. (1981a,c) found that connective tissue residue was not a palatability problem in restructured steaks after trimming excess connective tissue from beef chucks. In another study, Booren et al. (1981b) found that both tenderness and connective tissue residue were rated less desirable in sectioned and formed steaks made from the chuck than those from the round. However, values for sensory determination of both tenderness and connective tissue residue were in an acceptable range for the sectioned and formed steaks.

Booren et al. (1981c) stated that acceptable restructured steaks could be made from the muscles of U.S. Choice chucks if they were passed twice through a blade tenderizer. However, Secrist (1982) stated that when use of large pieces of meat is necessary to provide a texture or bite similar to that of intact muscle, mechanical needle-tenderizers do not offer a practical solution to the problem of connective tissue in restructured meat products. Huffman (1979) reported that mechanical tenderization of meat before its use in restructured products ensures maximum cell disruption that will ultimately result in superior binding properties. The utilization of chucks in the production of restructured beef products may result in problems due to the amount and type of connective tissue associated with the muscles in that wholesale cut. Secrist (1982) and Breidenstein (1982) placed the reduction, control and utilization of connective tissue high on their priority lists of long-term research needs and goals for restructuring of beef. The purpose of this study was to examine the feasibility of utilizing beef shoulder clods to manufacture restructured steaks and to determine the effect of degree of trimming of connective tissue components on the sensory, chemical and textural properties of restructured beef steaks.

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MATERIALS & METHODS

Basic design

Twenty-seven, Yield Grade 2 beef shoulder clods (#114—NAMP, 1976) were used. The clods were removed from their vacuum packages at 10 days postmortem and randomly assigned to one of three groups (n = 9 per group) for application of the appropriate treatment. Trimming yields were calculated on the basis of weights of raw materials before and after treatment application. Restructured beef steaks were then produced and vacuum packaged using a high-barrier, skin-type package and then frozen at −30°C for subsequent palatability, crude collagen content, Kramer shear and proximate composition determinations.

Steak preparation

Each clod was trimmed of all fat over the major muscles of the clod—triceps brachii, infraspinatus, brachialis, and deltoid muscles. In that process, care was taken not to remove any connective tissue from around any muscle or muscle group.

A calculated amount of subcutaneous fat (15%) removed from each clod served as the fat fraction in the meat mixture. Treatments were then applied to the defatted clods (lean fraction). Treatments were as follows: (1) no trimming (NT)—NT served as the control as there was no trimming of any connective tissue that was attached, around or within the muscle/muscle group; (2) intermediate trimming (IT)—clods in this group were trimmed of all visible, surface connective tissue, which included: (a) the tendons that attached the infraspinatus to the humerus and the triceps brachii to the olecranon of the ulna along with any other visible tendons, (b) any periosteum remaining on the medial side of the infraspinatus, and (c) any epimysium located on the surface of the lateral and/or medial side of the defatted clod; and (3) extensive trimming (ET)—clods in this group were trimmed of all heavy connective tissue found attached, around or within a muscle/muscle group. Each ET clod was trimmed exactly as described for IT; however, each muscle/muscle group was physically dissected, through the use of a boning knife, to remove any other tendons, periosteum, epimysium or any heavy connective tissue found within.

Following treatment application, each separated lean and fat fraction was placed in polyethylene bags, removing as much air as possible, and crust-frozen at −30°C for 1 hr. Both fractions were taken out of their bags for further processing. The lean fraction was coarsely ground through a grinder equipped with a 3-hole, "kidney-shaped," plate and conventional knife with four full-length arms. The fat fraction was flake-cut using a Comitrol® (model 3600 Urschel Laboratories, Inc., Valparaiso, IN) equipped with head size 2-K-020060. Both the lean and the fat fractions were sampled and a Modified Babcock analysis (Terrell, 1980), performed in duplicate, was used to determine fat content. The fractions were then formulated into meat blocks containing 15% fat. Each meat block was placed in a Butcher Boy mixer (model 150, Lasar Manufacturing Co., Inc., Los Angeles, CA) and 0.5% sodium chloride along with 0.125% sodium tripolyphosphate was added. Batches were then mixed for 10 min, stuffed into bags (Cryovac® 18 × 70 cm "keeper casing;" Cryovac Inc., Duncan, SC) crust-frozen for 3 hr at −30°C and tempered at −4°C for 1 hr. The logs were unwrapped and pressed into the shape of a

Table 1—Proximate composition of restructured beef steaks

	Degree of trimming					
	No trim		Intermediate trim		Extensive trim	
Component	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
Moisture (%)	66.82^a	(1.21)	66.34^a	(0.26)	66.18^a	(1.40)
Fat (%)	15.00^a	(1.39)	15.68^a	(0.55)	15.70^a	(1.21)

^{a} Means in the same row bearing the same superscript are not different ($P>0.05$).

Table 2—Effect of degree of trimming of connective tissue on properties of restructured beef steaks

	Degree of trimming					
	No trim		Intermediate trim		Extensive trim	
Trait	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
Raw material yield (%)^a	100.0^b	(0.00)	92.5^c	(0.01)	87.3^d	(0.02)
Kramer shear value (kg)	331.2^b	(58.4)	300.8^b	(33.4)	295.9^b	(48.0)
Crude collagen (%)	2.28^b	(0.63)	1.95^b	(0.76)	1.46^c	(0.49)

^{a} Based on lean fraction only.
^{b,c,d} Means in the same row bearing the same superscript letter are not different ($P>0.05$).

Table 3—Effect of degree of trimming on sensory attributes of restructured beef steaks

	Degree of trimming					
	No trim		Intermediate trim		Extensive trim	
Sensory attribute	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
Juiciness^a	5.6^f	(1.19)	5.6^f	(1.09)	5.8^f	(1.28)
Ease of fragmentation^b	5.5^f	(1.41)	5.9^g	(1.09)	6.0^g	(1.09)
Connective tissue amount^c	4.9^f	(1.96)	5.7^g	(1.58)	6.1^g	(1.46)
Overall tenderness^d	5.3^f	(1.52)	5.7^g	(1.16)	5.9^g	(1.14)
Palatability^e	5.0^f	(1.60)	5.5^g	(1.28)	5.7^g	(1.26)

^{a} 8 = extremely juicy, 1 = extremely dry.
^{b} 8 = extremely easy, 1 = extremely difficult.
^{c} 8 = none, 1 = abundant.
^{d} 8 = extremely tender, 1 = extremely tough.
^{e} 8 = extremely palatable, 1 = extremely unpalatable.
^{f,g} Means in the same row bearing the same superscript are not different ($P>0.05$).

loaf using a Ross hydraulic press (model 914 Ross Industries, Midland, VA). Each log was then sliced into 2.0 cm steaks using a Ross slicer (model 950-2). The steaks were then vacuum packaged using a high oxygen-barrier, skin-type package and subsequently frozen at −30°C for further analyses.

Proximate composition analysis

One raw steak from each log was ground and homogenized through the use of a Robot Coupe® (type R-6 Robot Coupe, U.S.A., Jackson, MS). Fat and moisture determinations were performed in duplicate by ether extraction and oven-drying, respectively (AOAC, 1980).

Palatability evaluations

Three frozen steaks from each log were used for trained (Cross et al., 1978) sensory panel evaluations (n = 8 panelists). Steaks were tempered to −3°C and broiled on a Farberware Open-Hearth broiler to an internal temperature of 70°C for sensory panel palatability determinations. Internal temperature was monitored by a copper-constantan thermocouple wire placed in the geometric center of each steak. Panelists were served two 2.0 × 1.2 × 2.0 cm cubes from different areas of each steak and rated each cube separately. Panelists rated nine steaks per session (one session per day) in a sensory panel laboratory equipped with partitioned booths and controlled levels (860 lux) of incandescent light. Samples were evaluated using the following scales: juiciness (8 = extremely juicy, 1 = extremely dry); ease of fragmentation (8 = extremely easy, 1 = extremely difficult); connective tissue amount (8 = none, 1 = abundant); overall tenderness (8 = extremely tender, 1 = extremely tough) and palatability (8 = extremely palatable, 1 = extremely unpalatable).

Measurement of physical properties

Two steaks from each log were used for Kramer shear force determinations. Steaks were tempered to −3°C and broiled on a Farberware Open-Hearth broiler to an internal temperature of 70°C. Steaks were then cooled to room (22°C) temperature. Each cooked steak was then cut into 6.35 cm^2 portions. Each sample was then placed into a Kramer cell and sheared for determination of the maximum force required to shear through the sample.

Isolation of crude collagen

Two steaks (approximately 250g each) from each batch were ground through a 4.8 mm plate and blended with six times (w/w) the amount of double-distilled (DD) water (4°C) in a Waring Blendor at full speed for 1 min. The slurry was filtered through a 250 μ mesh metal screen. These blending and filtration steps were repeated at least twice. The resulting residue was blended and filtered three more times (same as above), using 1.1M KCl and 0.1M potassium phosphate buffer (pH 7.4) instead of DD water.

The residue was agitated for 1 hr and centrifuged (3,000 × *g*) for 15 min after adding 150–200 mL 1.0M KCl and again after adding 150–200 mL 0.9% NaCl. The pellet was rinsed with DD water, agitated and then centrifuged. The pellet or crude collagen was rinsed with a chloroform:methanol (2:1) mixture to remove fat. After evaporation of organic solvents under the hood, the crude collagen was subjected to drying at 110°C for 16 hr and then weighed and expressed as a percentage of the raw steak weight.

Statistical analysis

Means and standard deviations were calculated for each variable. Data were analyzed by analysis of variance using the General Linear Models program of Statistical Analysis System (SAS, 1982). Means were separated using Duncan's multiple range test (Duncan, 1955).

RESULTS

PERCENTAGE MOISTURE (Table 1) ranged from 66.18 (for the ET treatment) to 66.82 (for the NT treatment) and mean values for percentage fat ranged from 15.00 (for the NT treatment) to 15.70 (for the ET treatment). No significant differences were observed among the treatments for percentage moisture or percentage fat. Thus, after formulation and manufacturing of the three treatments, the proximate compositions of the three kinds of restructured beef steaks were essentially the same.

Trimming yields (Table 2) were calculated (fat excluded) for all beef shoulder clods assigned to the three treatments. As expected, significant differences in yields were observed among the three treatments.

Although large numerical differences were observed among Kramer shear values for steaks from the three treatments (Table 2), no significant differences were found. The lack of statistical difference was primarily due to the large variation observed in shear values within each treatment. This finding, in part, could be explained in that small particles of connective tissue throughout the log were assumed to be equally distributed. However, heavy pieces of connective tissues (e.g., tendons) probably were located in one or more areas of the log. This unequal distribution of heavy connective tissue could account for the large variation observed in shear values within each treatment.

As expected, the largest percentage crude collagen (Table 2) was found in NT steaks, with ET steaks having the lowest percent crude collagen and IT steaks being intermediate. Significant differences ($P<0.05$) in crude collagen were found between ET steaks and the remaining two treatments; however, no differences ($P>0.05$) were found between NT and IT steaks. Correlation coefficients between percentage crude collagen and palatability attributes or Kramer shear values revealed significant r-values only for connective tissue amount ($-.54$) and palatability ($-.42$); all other traits were not related to percentage crude collagen.

Statistical differences were observed between restructured steaks from the NT treatment as compared to the steaks from either the IT or ET treatments for ease of fragmentation, connective tissue amount, overall tenderness and palatability (Table 3). No significant differences were observed between steaks from the IT treatment versus steaks from the ET treatment for any sensory attribute. It would appear that panelists were more critical and objected to steaks containing large pieces of heavy connective tissue found in the NT treatment even though no significant difference was detected in percentage crude collagen between NT and IT treatments. From a palatability standpoint, no advantage was found for the further removal of connective tissue performed in transforming the beef shoulder clod from the intermediate trim to the extensive trim treatment.

DISCUSSION

FOR A RESTRUCTURED beef product to be successfully marketed, the cost of production cannot be prohibitive. Assuming a raw material cost of $4.40 per kg, a labor cost of 20% of the raw material cost for the NT treatment, and a 1/8 kg portion serving, the cost of a restructured steak manufactured following the no-trimming treatment procedures would be $0.66 per steak. Using the same logic, but changing the labor cost to 30% of the raw material cost (which also must be increased because of decreased yield), the cost of a restructured steak manufactured following the IT treatment procedure would be $0.77 per steak. Finally, changing the labor cost to 40% of the raw material cost and adjusting the raw material cost to reflect the 87.3% yield, the cost of a restructured steak manufactured following the ET treatment procedures would be $0.88 per steak. Of course, these figures are only estimates; meat processors interested in manufacturing restructured beef steaks would need to calculate their own processing yields and labor costs to determine which system of producing restructured beef products would be the most appropriate for them.

In conclusion, removing some (IT treatment), but not all (ET treatment) of the heavy connective tissue from beef clods appeared to be worthwhile. Using the estimated figures on yields and labor requirements to produce restructured steaks from extensively trimmed beef clods, the projected increased costs did not seem to be warranted based on trained sensory panelist data.

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