

EFFECTS OF BLADE TENDERIZATION AND TRIMMING ON  
HOT-BONED, RESTRUCTURED, PRE-COOKED ROASTS FROM COWS

by

HECTOR ANGEL FLORES

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Major Professor

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## ORGANIZATION OF THE THESIS

The format of this thesis is presented in a series of chapters. Chapter I is a general introduction to the thesis. Chapter II includes a general review of literature pertaining to all topics discussed herein. Chapter III is a summary of results in manuscript form. Chapter IV is an appendix which includes detailed analytical procedures and supplementary information. Chapter V is a general abstract of the thesis. All chapters conform to the style guide for research papers for the Journal of Food Science.

## Chapter I

### GENERAL INTRODUCTION

The primary goal of the red meat industry is to efficiently market a high quality product. The realization of maximum yield from carcasses and minimizing processing cost is important in maintaining industry profitability and minimizing cost to the consumer (Huffman et al., 1984). Traditional methods of processing beef carcasses generally involve the chilling of carcasses in a drip cooler at  $-1^{\circ}\text{C}$  for 18 to 24 hr. Carcasses are then transported to a holding cooler (approximately  $0^{\circ}\text{C}$ ) for up to 48 hr. (Kastner, 1982). After chilling, the carcasses are shipped as quarters or are fabricated into wholesale, subprimal, or retail cuts before shipping.

An economical alternative to conventional processing is the use of hot boning. Savings in refrigeration input and space, due to the removal of excess fat and bone before conventional chilling, are attributed to hot boning. Hot boning improved muscle functional properties for restructuring when compared with conventionally boned raw materials (Kastner and Gray, 1984; Breidenstein, 1982a). Hot-boned meat used for restructuring improved myosin extractability, texture, color, cooking yields, and water and fat binding when compared to conventionally boned meat (Breidenstein, 1982a).

Economic pressure to minimize processing cost and maximize product yield and utilization provides incentives to develop new products using less valuable

carcasses and carcass portions to produce products of acceptable quality and higher value (Huffman and Cordray, 1982). Restructured meat items provide uniform and controlled products for the HRI trade. With the cost of intact muscle cuts increasing, restructured products may compete favorably in the retail market. The combination of restructuring and hot boning produces beef steaks of good quality (Huffman et al., 1984).

Connective tissue is an important meat component that exerts a negative influence on the value and use of a large portion of meat raw materials. Possibilities of dealing with the negative influence of connective tissue are by mechanical tenderization or manual removal of the large connective tissue deposits from the products (Breidenstein, 1982a). However, manual removal is difficult, labor intensive, and costly. Therefore, the use of mechanical tenderization to reduce the influence of connective tissue might reduce the cost of processing and the negative impact of connective tissue in restructured products. Savell et al. (1977) and Seideman et al. (1977) reported that the use of blade tenderization on less tender muscle is an attempt to make older animals comparable in tenderness to younger animals. This is particularly important for cow beef which is characteristically less tender because of the influence of connective tissue. Miller (1975) attributed the increase in tenderness associated with blade tenderization to the partial destruction of connective tissue and severance of muscle fibers which lead to reduced resistance to shear force, mastication, and swallowing.

This study was designed to evaluate restructured pre-cooked roasts from hot-boned cows. The effects of trimming connective tissue and blade tenderization were also studied. The reasoning behind this study appears consistent with industry goals of reducing processing costs and improving product functionality and utility while increasing the value of cow beef.



## Chapter II

### GENERAL REVIEW of LITERATURE

#### Hot boning

The realization of maximum yield from carcasses and minimum processing costs is important in maintaining industry profitability and minimizing costs to the consumer (Huffman et al., 1984). With the increased cost of energy and labor, the meat industry is continually looking for methods of reducing processing costs and increasing product value. An economical alternative to processing restructured products from conventionally processed carcasses is to use hot boning. Hot boning before conventional chilling is more economically efficient than conventional processing (Huffman et al., 1984; Seideman et al., 1982; Ray et al., 1980). Additionally, Huffman et al. (1984) suggested that the combination of hot boning and restructuring, to produce beef steaks of good quality, would be an excellent way to upgrade low quality cuts of beef while reducing energy needs.

Breidenstein (1982a) stated that using pre-rigor beef to produce restructured products has several advantages including superior myosin extractability, textural appearance, color, and higher cooking yield when compared with post-rigor beef. Kastner and Gray (1984) suggested that the improved binding of hot-boned muscle is due to more extractable salt-soluble protein than in conventionally processed muscle. Similar results were mentioned

earlier by Solomon and Schmidt (1980) where they found greater crude myosin extractability and less mechanical damage in pre-rigor than in post rigor meat. Kastner (1977) and Cuthbertson (1979) reported that hot-boned beef exhibited excellent cure penetration which is an essential factor in processed meats. Kastner and Gray (1984) also mentioned that the pH of pre-rigor beef is relatively high, consequently increasing the potential for binding of water and fat. These characteristics of hot-boned meat have been observed to decrease shrinkage during processing. Kastner and Gray (1984) found a 5 to 8% less shrinkage for hot-boned restructured beef roasts compared to those made from conventionally processed restructured beef. Pepper and Schmidt (1975) determined that hot-boned restructured beef rolls were very acceptable from a firmness and textural standpoint, and those qualities along with higher yields made hot-boned rolls more desirable. However, Ray et al. (1980) indicated that decreased tenderness due to cooking pre-rigor, hot-boned beef roasts made hot boning of questionable value, at least for conventional methods of marketing roast beef.

Savings in refrigeration input and space, due to the removal of excess fat and bone before chilling, have been attributed to hot boning. Specifically, it has been estimated that hot processing beef carcasses could result in 40 to 50% less refrigeration input, up to a 25% reduction in labor, a 2% reduction in shrinkage, a reduction of in-plant residence time of 20 %, and a 50 to 55% reduction in cooler space required (Kastner, 1982). Ray et al. (1980) also indicated significant energy savings and higher cooking yields in pre-cooked, hot-boned beef roasts. Other potential advantages of hot processing include: 1) facilitation of centralized processing; 2) reduction in chilling time; 3) no reduction in cutting yield; and 4) improvement of emulsifying properties (Kastner, 1982).

Further reductions in labor, material, and equipment costs were reported by Kastner (1977) and Cuthbertson (1979) since neck pinning, scribing, and shrouding would no longer be required. One potential advantage of hot boning is improved yield. If initial chilling is accomplished in a vacuum package, evaporation losses during cooling could be significantly reduced (Cuthbertson, 1979; Dransfield et al. 1976; and Taylor et al., 1980).

Contrary to the advantageous factors mentioned above, hot boning presents some potential disadvantages. One problem is the difficulty of quality and yield grading of hot carcasses, since the hot-boned carcasses would not be chilled before processing. New methods of grading would need to be developed to solve this problem (Kastner, 1977). Possible quality control problems due to hot boning may include a high incidence of boning defects and increased microbial counts which may result in reduction of shelf life. However, Kastner (1977) and Cuthbertson (1979) agreed that with good hygiene practices during slaughter followed by a clean fabrication operation, product shelf life could be improved.

#### Blade tenderization effects on meat texture

Connective tissue is an important meat component that exerts a negative influence on the value and the use of many meat raw materials. Two possibilities of dealing with connective tissue are by mechanical tenderization or manual removal of the large deposits from the products (Breidenstein, 1982a). However, manual removal is difficult and costly. The use of mechanical tenderization to reduce the influences of connective tissue may reduce the cost of processing in restructured products.

Savell et al. (1977) and Seideman et al. (1977) reported the use of blade tenderization on less tender muscle to reduce the effect of connective tissue between weight-grade groups is an attempt to make muscle from older animals comparable in tenderness to that from younger animals. This is particularly true for beef from older cows which is characteristically less tender because of the influence of connective tissue. Booren et al. (1981a) also reported the necessity of blade tenderization to produce acceptable restructured steaks from less tender muscle. Mechanical tenderization of beef substantially improves the tenderness of muscle from youthful maturity group carcasses. (Schwartz and Mandigo, 1974).

Generally, blade tenderization significantly reduced Warner-Bratzler values in a variety of cooked meat cuts (Schwartz and Mandigo, 1974; Davis et al., 1975; Glover et al., 1977; Tatum et al., 1978). Miller (1975) attributed the increased tenderness associated with blade tenderization to partial destruction of connective tissue and/or severance of muscle fibers which leads to reduced resistance to shear force, mastication, and swallowing. Seideman et al. (1977) suggested that blade tenderization disrupts connective tissue, but not enough to allow blade tenderized muscle, high in connective tissue, to be used interchangeably with untreated intact muscle of low connective tissue content.

Miller (1975) justified blade tenderization because it: 1) insured acceptable tenderness of normal table-grade cuts; 2) equalized tenderness in portioned items containing two or more muscles that differed in tenderness; 3) was more effective against connective tissue and more uniform and controlled than enzyme treatments. Hayward et al., (1979) noted that blade tenderization reduced connective tissue amount detected by taste panel members. Seideman et al. (1977)

also found that blade tenderization of psoas major and semitendinosus muscles improved tenderness, juiciness, and overall palatability. However, Tatum et al. (1978), Glover et al. (1977), and Savell et al. (1977) indicated that blade tenderization significantly improved tenderness, but there was little or no evidence to support such claims for juiciness and flavor. Glover et al. (1977) reported that blade tenderization caused significant increases in drip loss of beef roasts, however, Tatum et al. (1978), Schwartz and Mandigo (1974), Savell et al. (1977), and Seideman et al. (1977) reported that neither drip loss nor cooking losses were significantly affected by needle or blade tenderization.

The number of repetitions or passes through the blade tenderizer required to produce acceptable tenderness has been studied. Savell et al. (1977) found that one pass through the mechanical blade tenderizer reduced Warner-Bratzler values for different muscles. Two passes through the tenderizer reduced Warner-Bratzler values when compared with one pass. A third pass further reduced Warner-Bratzler values, but increased cooking losses. Bowling et al. (1976) determined that more tender cuts can be tenderized with one pass through the mechanical tenderizer, whereas less tender cuts may require more than one pass through the mechanical tenderizer. Schwartz and Mandigo (1974) studied three conveyor speeds of 2.54, 3.81, and 7.62cm per movement, where they found that conveyor speed did not affect Warner-Bratzler values.

### Restructuring

Economic pressure to minimize cost and maximize product utilization provides incentives to develop new products using less valuable carcasses and carcass portions to increase product quality and value (Huffman and Cordray,

1982). The concept of restructuring is used to produce from less expensive beef cuts a more uniform and completely edible product with satisfactory eating qualities that resembles an intact muscle in textural properties at a lower unit cost (Seideman et al., 1981).

Today's trend for more meals to be eaten away from home makes an extremely fertile market for restructured products. A recent economic survey indicated that never before have consumers spent so much time in choosing their food products (Huffman and Cordray, 1982), and consumers will not accept products that do not meet their needs and expectations at a reasonable price (Schmidt, et al., 1985). Breidenstein (1982b) reported that restructuring technology allows the processor to have control over product characteristics. Characteristics influenced by the restructuring technology include appearance characteristics like shape, color, and texture, and compositional traits like protein, moisture, and fat content. Huffman et al. (1984) agreed that the combination of restructuring and hot boning produced beef steaks of good quality.

### Raw materials

The selection and utilization of raw materials will determine the ultimate composition and texture of the finished restructured product. In selecting the raw material, one must consider the type of product desired, availability, and cost of the raw material. The ideal raw material for restructured meat products consists of uniformly colored muscle with low connective tissue and contains less than 10% fat (Schmidt et al., 1985). A wide range of beef raw material has been successfully used to produce restructured meat products. Cuts frequently used are portions of the chuck and the round (Seideman, 1982).

Sensory panel ratings of cooked restructured products have been rated superior to the mid-point of the acceptability scale in terms of flavor, tenderness, and juiciness (Huffman, et al., 1981). Booren et al. (1981a) compared restructured steaks made from USDA Standard grade rounds and USDA Choice grade plate with those made from USDA Choice grade chucks and plates, and he found USDA Choice grade steaks made from the Choice grade chucks to have more desirable color. The TBA, cooking yield, flavor, and juiciness values were not related to anatomical origin of raw material. Tenderness and connective tissue residue scores were rated lower for the chuck product. However, Instron deformation curves and Kramer shear values were not significantly different.

Cuts from cows are normally less expensive than the same cuts from block beef. Only selected parts of the beef carcass are normally used for intact steaks and roast purposes, with the less tender portions (primarily due to influences of connective tissue) normally being used for ground beef or sausage raw materials. This is particularly true for cow carcasses. However, restructured roast products can be processed from less tender portions of cow and block beef carcasses, and the potential exists for increasing the value of those portions. With the cost of intact muscle cuts increasing, restructured products may compete favorably in the retail market (Huffman and Cordray, 1982).

#### Salt effects in restructuring

Salt (sodium chloride) has long been used as a facilitator of intracellular protein extraction to form the protein matrix responsible for the successful binding in meat processing. Since the binding or particle adhesion of lean and fat

is dependent on salt, it has been and remains an important processing ingredient (Breidenstein, 1982a). However, as salt increases in concentration it is expected to have adverse effects on meat color, but there is some evidence that salt and sodium tripolyphosphate (STP) added to meat may have a beneficial effect on color (Breidenstein, 1982b).

Neer and Mandigo (1977) demonstrated that increasing the amount of salt increased cooking yields, tenderness, and water-binding capacity in flaked, cured pork products. Breidenstein (1982a) and Huffman et al. (1981) reported that when salt and sodium tripolyphosphate (STP) were used in combination, the products were rated more favorably for texture and general acceptability.

Moore et al. (1976) found binding strength and cooking yield increased as salt concentration increased from 1% to 3% when 0.25% STP was included in beef rolls. Huffman (1979), Pepper and Schmidt (1975), and Breidenstein (1982a) found similar results for beef rolls treated with salt and STP. However, Breidenstein (1982b) and Booren et al. (1981a) agreed that as salt concentration increased in formed beef steaks rancidity also increased after 90 days of freezer storage. Similar results for increased rancidity in restructured products were found by Campbell and Mandigo (1978), and Schwartz and Mandigo (1976).

Schwartz and Mandigo (1976) found increased rancidity but decreased color desirability when salt was added to restructured pork. Similar results were found by Mandigo and Booren (1981) in restructured steaks. Huffman et al. (1981) concluded that while the addition of salt to flaked beef patties altered the sensory, color, and physical properties, tripolyphosphate had little effect on these properties.



Mandigo and Booren (1981) recommended 0.75% salt, because it kept rancidity within an acceptable range while capitalizing on the positive influences of salt. Kastner and Gray (1984) suggested the use of low salt levels in conjunction with hot boning. Because of the improved functional properties of hot-boned beef, the protein is more readily available for extraction compared to conventionally processed post-rigor meat, thus less salt is required for successful restructuring.

#### Fat levels in restructuring

Fat has normally been shown to increase juiciness, flavor, and tenderness of processed meat products (Seideman, 1982). From the economic point of view, considering traits such as juiciness, flavor, and visual appearance, fat content of restructured products must be closely monitored and controlled (Mandigo, 1981). Cross and Stanfield (1976) conducted a consumer evaluation of flaked and formed steaks containing 0 and 0.75% salt along with 20 to 30% fat. Consumers tended to prefer steaks with added salt and 30% fat.

Mandigo and Booren (1981) found that high levels of fat decrease hardness and chewiness scores and recommended a 20% fat level for restructured and formed products. Sectioned and formed steaks have been very acceptable in palatability when 10 to 15% fat was added (Mandigo, 1981).

Keeping the fat level as low as possible may also be important because consumers are more concerned about caloric and cholesterol intakes, for reasons of health and physical appearance. Booren et al. (1981a) determined that with low fat levels, extracted myofibrillar protein would be maximized in restructured beef steaks. However, Saffle and Galbreath (1964) found that amount of fat in beef had no effect on the percent extractable protein in sausage emulsions.

Vacuum mixing and mixing time  
for restructuring

Mixing is very important in the production of a restructured product. The two most important functions of mixing are: 1) introduction and homogenization of components to achieve uniformity of the lean/fat distribution and additives and 2) solubility of protein through the mechanical action of impact and friction energies (Mandigo, 1982). Breidenstein (1982a) and Solomon and Schmidt (1980) reported that myosin extraction has been found to increase linearly with increased mixing time.

Booren et al. (1981b) studied the sensory response to vacuum mixing vs non-vacuum mixing for formed beef steaks, and no differences were observed for flavor, tenderness, or connective tissue residue. Breidenstein (1982a) also found similar results where cooking yields, flavor, and juiciness were not affected by vacuum mixing. However, Mandigo (1982) and Booren et al. (1981a) found that cooking yields, juiciness, and flavor increased with vacuum mixing time of 16 to 18 min compared to 24 min. Booren et al. (1981b) reported that subjective color scores indicated a significant superiority for vacuum mixed restructured steaks when compared to non-vacuum mixed counterparts. However, spectrophotometric measures indicated a less desirable surface color in vacuum mixed steaks. Breidenstein (1982a) reported that a vacuum mixing time of 18 min showed no adverse effects on color.

Durland et al. (1982) found that mixing time after 15 min had no further significant effect on bind, cooking yield, or any of the sensory attributes. Visual fat was not affected by mixing time, but the textural appearance of restructured products was scored significantly finer after 15 min as compared to 24 min of

mixing. Booren et al. (1981a) reported that a mixing time of 16 min resulted in a 60% increase in adhesion compared with mixing for restructured products. Booren et al. (1981a) agreed that vacuum mixing reduced oxygen availability and penetration in the emulsion resulting in the reduction of oxidative color changes and lower TBA values. Pepper and Schmidt (1975) found in both salt and salt-phosphate treated beef rolls, either cold- or hot-boned, that the binding strength generally increased with increased mixing time.

### Sensory evaluation

Some 40 years ago, when the Institute of Food Technologists was organized, the emphasis was on the organoleptic evaluation of food. But the development of new kinds of food items soon exceeded the research capabilities available. With the ever increasing cost of product development and marketing, the food industry could not longer afford costly hit or miss product decisions. The answer was to utilize valid sensory testing throughout the process of product development to save time, money, and improve products (Fossum, 1983).

A sensory evaluation, according to Larmond (1982), is made by "the senses of taste, smell, touch, and hearing when food is eaten, where the complex sensation that results from the interaction of the senses is used to measure food quality in programs for quality control and product development".

Difference testing is a common and useful sensory technique that can be applied in a variety of test situations. The triangle test is a difference test in which three samples are presented; two are identical and one is different. The objective is to detect the odd sample. This is the method preferred over other

tests because it reduces the panelist's chance of getting the right answer by guessing, reducing the chance from 50/50 down to 33 1/3%, and it is a relatively simple method. Anyone can become familiar with it, in that it does not require much training. It is informal, and is very brief. The more people used, the more confidence that is placed in conclusions. It is an effective way to determine if there is a difference between two products. The triangle test can be used to evaluate a standard product and a newly developed prototype or one that is different due to replacing raw materials or ingredients (Larmond, 1982).

Sensory evaluation panels can be grouped into three types; highly trained experts, laboratory panels, and large consumer panels. Evaluation by experts and trained laboratory panels can be useful for control purposes, while consumer panels are used to determine consumer reaction to a product. For the evaluation, a special testing area is used so that distractions can be minimized and conditions can be controlled. The testing area should be a quiet, comfortable environment. If possible, the use of positive pressure air conditioning is favorable where foreign odors and odors from food preparation should be kept from the testing area. The usual method is to construct a booth along the wall that divides the room from the preparation area. Several conditions should be carefully monitored during the evaluation. These conditions include 1) lighting, 2) sample preparation (all factors, such as time, temperature, and degree of doneness should be predetermined and kept constant throughout testing); 3) serving temperature (for acceptance/preference testing, the sample should be served at the temperatures at which they are normally eaten); 4) utensils (serving utensils should not impart any taste or odor to the product); and 5) quantity of sample (the amount of sample given to each panelist should be constant throughout the test) (Larmond, 1982).

### Meat texture

Texture, appearance, and flavor are the three major components of food acceptability. The texture of meat is undoubtedly the most important property appreciated by the consumer in western civilizations (Harries et al., 1972). How people perceive and quantify textural characteristics are very important issues that have significantly improved the fundamental understanding of texture and of correlations between instrumental and sensory measurements (Szczesniak, 1977).

Sherman (1970) described texture as the composite of those properties which arise from the structural elements, and the manner in which it registers with the physiological sense. However, among the different textural properties, mechanical properties are probably the most important and have received the greatest attention (Szczesniak, 1977).

Measurement of food texture plays important roles in the industry such as in new product development, control of manufacturing processes, product improvement, and in the quality evaluation of the finished product (Finney, 1969). An ever-growing need for an objective method for characterizing food textural properties lead to the investigation of the mechanical parameters of texture (Friedman et al., 1963). The kinesthetic characteristics of food are generally considered in relation to those attributes of quality associated with the sense of feel, as experienced either by fingers, hand, or in the mouth (Finney, 1969). Also it includes such sensations as hardness, tenderness, mealiness, and crispness which adults frequently consider as signs of excellence in the cooked product (Szczesniak, 1977).

### Objective and subjective measurements of tenderness

Meat tenderness is extremely important for consumer acceptability of meat. Therefore, the ability to predict and measure meat tenderness is imperative to meat scientists (Hayward et al., 1979). Instrumental methods for texture measurement have been divided into three classes of tests. Fundamental tests measure properties that are familiar to the engineers. These properties include ultimate strength, Poisson's ratio, and various moduli such as Young's modulus, shear modulus, and bulk modulus. These type of tests usually correlate poorly with sensory evaluation of textural properties of food. Empirical tests, which cover miscellaneous tests such as puncture and shear, also correlate poorly to texture quality. Imitative tests attempt to imitate the condition to which the food is subjected in the mouth. It is in this area that texture profile analysis (the sensory analysis of the texture complex of a food in terms of its mechanical, geometrical, fat, and moisture characteristics; the degree of each present and the order in which they appear from first bite through complete mastication, Szczesniak, 1963) falls.

Tenderness measurement is a relative evaluation of one of the most important quality factors in meat. Dodge and Stadelman (1959) mentioned the two most commonly used methods to evaluate tenderness. The first is the organoleptic panel where members are given a sample to evaluate. This is considered to be the most accurate evaluation. Tenderness is also evaluated by machine. However, none of the machines appear to be able to simulate the true action of chewing. Since meat composition is of primary importance, subjective measurements, or taste panel testing, will remain as the ultimate testing method (Harris, 1976; Larmond, 1976).

Sensory assessment of food quality is frequently time consuming and very expensive. The results are very dependant on the observer's preferences unless highly trained people are used, and even then this technique may suffer from bias (Rhodes et al., 1972). Harris (1976) mentioned that problems existed with the taste panel because of its subjectivity and reliability on human interpretations which are often vague. This makes it difficult to compare results between laboratories and different organoleptic panel methodology (Larmond, 1976).

#### Objective measurement requirements

Various devices which simulate the action of the chewing process have been used. However, none of these devices are ideal predictors of meat tenderness (Harris, 1976). A major inhibitor factor for developing an ideal objective test lies in the conflicting correlation between objective measurements and sensory panels. Apparently, mechanical devices seem to measure different structural characteristics of meat when compared with taste panel evaluations (Harris, 1976). Szczesniak (1968) concluded that conditions under which both methods are performed and how their results are expressed have a tremendous bearing on their correlations.

Harris (1976) concluded that a single device will not be sensitive enough to measure all the factors influencing taste panel assessment; therefore, a combination of results from several objective measurements, each of which relates to different structural properties of meat, may solve the problem.

### Mechanical measurements of meat texture

Measurements of meat texture have been divided in three objective methods based on chemical, histological, and mechanical techniques (Hayward, et al., 1979). Chemical analyses often measure connective and/or myofibrillar tissues. Histological analyses utilize structural appearance of muscle for texture classification, while mechanical methods are simpler to use and have been widely accepted (Pearson, 1963).

### Warner-Bratzler apparatus

The Warner-Bratzler shear is the most widely used apparatus for shear measurement, but its single measurement of maximum shear force during the complete severance of the sample may be its most serious limitation (Rhodes et al., 1972). The majority of studies report that the Warner-Bratzler shear value accounts for only 30 to 60% of the variation in tenderness as evaluated by a sensory panel (Hurwicz and Tischer, 1954; Bailey et al., 1962; and Szczesniak, 1968). Results obtained with the Warner-Bratzler device indicate that the peak force value relates more closely to the myofibrillar component of toughness than to the connective tissue component (Bouton and Harris, 1972; Paul et al., 1973; Cross et al., 1973). Shear force values correlated poorly with subjective assessments of tenderness when there was a large difference in connective tissue strength between samples (Bouton et al., 1973; Paul et al., 1973; and Penfield and Meyer, 1975). However, studies on the force deformation curves obtained from the



Warner-Bratzler apparatus have shown that treatments such as aging, cooking, and myofibrillar contraction which predominantly influence the muscle fiber mainly affect the initial yield force value. Differences between the initial yield and peak force values reflect changes due to animal age and muscle connective tissue differences (Bouton et al., 1975). Results from the Warner-Bratzler shear device has been correlated more highly with sensory estimates of tenderness than those from the Kramer shear press device (Pangborn et al., 1965; Sharrah et al., 1965; Hurwicz and Tischer, 1954; and Cover and Hostetler, 1960). However, Moller, (1980), Szczesniak (1968), Dodge and Stadelman (1959), and Deatherage and Garnatz (1952) found poor correlations between the Warner-Bratzler shear results and competent sensory panels when working with beef.

Pangborn et al. (1965) mentioned that due to the small sample size required for the Warner-Bratzler device it could be used advantageously in cases where only a small amount of sample is available. However, by direct observation, Voisey et al. (1976) and Pool and Klose (1969) found that the recorded force from the Warner-Bratzler shear apparatus did not indicate the shear rupturing characteristics of meat. Voisey et al. (1976) also explained that rupture occurs under complex stress (tension, shear, compression, and flow) in a situation that is difficult to analyze.

Voisey and Larmond (1974) and Pool and Klose (1969) observed that the Warner-Bratzler shear force readings are related to tensile properties of the sample, since the sample bends over the edges of the blade while the sample is being severed.

### Kramer shear press

The standard shear compression cell of the texture test system (Allo-Kramer also known as the L.E.E. Kramer shear press) has become one of the most popular texture testing accessories since it was introduced by Kramer et al. (1951) (Cat.No.CS-1, Food Technology Corp., Rockville, Maryland). It is used in a variety of testing machines for research and quality control applications on a great range of food since a wide variety of product can be placed in the cell for testing (Voisey and Kloek, 1981; Kramer, 1961; Anonymous, 1968; Voisey, 1970; and Szczesniak et al., 1970).

The main advantage of the Kramer shear press over the Warner-Bratzler device is that the Kramer shear press takes a larger sample so that the sampling errors are reduced without using a greater number of samples (Sale, 1960). Wells et al. (1962), working with chicken, found it difficult to obtain a core, therefore the Kramer shear press was more satisfactory than the Warner-Bratzler apparatus. However, Szczesniak (1969); Voisey (1977); and Shama and Sherman (1973) found that sample size (weight) affected results from the Kramer compression cell and this effect varied with different products.

Studies by Deatherage and Garnetz (1952), Shannon et al. (1957), Wise (1957), Bailey et al. (1962), and Penfield et al. (1976) reported that Kramer shear values versus sensory panels results showed significant correlations. However, Palmer et al. (1965) and Burrill et al. (1962) reported that shear resistance of fried meat with the Warner-Bratzler and the Kramer shear apparatus correlated well, and both also correlated with untrained panel evaluations where differences

between both Warner-Bratzler and Kramer shear press were not significant. Burrill et al. (1962) also mentioned that good agreement can be expected between tenderness measurement by panel score and by maximum force determined by either the Warner-Bratzler or the Kramer shear instrument.

#### Kramer shear press and restructured beef

Some research has been conducted utilizing the Kramer shear press on restructured beef roasts. Rogers and Althen (1985) reported the use of the Kramer shear press to determine tenderness differences between continuous and intermittent tumbling conditions. They found the Kramer shear press effective for the determination of tenderness differences. However, Moody et al. (1985) reported low and negative correlation coefficients between Kramer shear force values and taste panel scores for juiciness, tenderness, flavor, and amount of connective tissue, even though the Kramer shear force showed tenderness differences between treatments.

#### Factors affecting use of the Kramer shear press

Voisey and Kloek (1981) and Voisey (1970) mentioned several factors which influence the use of the Kramer compression cell. These factors are: effect of friction, difficulty of assembly during testing because the multiblade must be aligned and fed into the slots, and cleaning of the cell is difficult because of the many confined spaces. Sample size, crosshead speed, and interpretation of deformation curve are also important considerations. Assembly and cleaning of the

Kramer shear press is time consuming and tedious particularly when testing a large number of samples.

#### Force deformation measurements

Interpretation of the Instron force-deformation curves in terms of food properties is very important. Incorrect interpretation may affect the relationship between instrumental and sensory tests (Voisey, 1977). Deformation curves of the Instron and the Kramer shear press show sharp peaks at the end of each compression. This is because the compression force of the Instron is constant, and there is an abrupt reversal motion at the end of each compression which gives both a force time curve and a force-distance curve, allowing the true work function to be calculated (Bourne, 1978).

Bourne (1976) reviewed a quick method which showed that by direct observation of the sample undergoing deformation one is able to interpret most accurately the deformation curve. Szczesniak et al. (1970 and 1977) and Voisey (1977) determined that "few foods appear to undergo pure shearing and most foods are subjected to two or more types of force which may be combinations of compression, extrusion, and shear"; but it is generally agreed that the predominant factor depends on the food. Voisey et al. (1976) also agreed that few foods can be subjected to "pure shear" because they are highly deformable, and this introduces compression and tensile stress that may be the predominant cause of rupturing of the sample.

Observations of food behavior after the initial compaction in the Kramer cell were characterized by two modes of failure that depend on the resistance of

the material to compression and the resistance of the material to cutting (Voisey, 1977). It was apparent that the interaction between these two resistances governed the shape of the resulting force-deformation curve. After the rupture was initiated and propagated, the force changes were attributed to cohesion of the material and adhesion between the sample and the cell surfaces (Voisey, 1977). In this case the Kramer blades entering the grid slot may produce an increase in force as pieces of fiber, meat, or skin jam into the clearances. In this case the peak force had little relationship to the shear properties of the sample.

In the Kramer cell the sample is confined to two dimensions (horizontal plane) and the deformation is applied along the vertical axis. It is generally assumed that the linearity of the ascending force curve following compaction represents the elastic or firmness characteristics of the food (Voisey, 1977). Voisey (1977) concluded by direct observation of shear compression curves of the foods that it is incorrect to assume that the peak force always reflects the shear force of the food, because the shearing behavior only occurs with certain products and at a specific point in the deformation which does not necessarily coincide with the maximum force. It is probably more realistic to use general terms such as cutting, compression, and extrusion to describe the cell mode of action. However, the majority of users assume and report that the maximum force is the "shear strength" of the food (Szczesniak et al., 1970).

### Some terminology for Instron parameters

Hardness - is measured from the profile as the height of the peak force during the first compression (Friedman et al., 1962)

$$\text{hardness} = \text{height of the peak/kg input}$$

Area of compression - the area under the first compression force-distance curve as determined by an integrator or planimeter ( $\text{cm}^2$ ) (Hayward et al., 1979)

Fracturability - is characterized by the multippeak shape of the first compression, and is measured as the height at the first significant break in the peak (Bourne, 1978)

Work - area under each peak which is an integral of the force over a distance. This value is a direct function of the work needed to overcome the internal bonds of the material (Hayward et al., 1979).

Adhesiveness - the negative force curve area of the first compression, representing the work necessary to pull-the cell blades away from the sample (Bourne, 1978).

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## CHAPTER III

### EFFECTS OF BLADE TENDERIZATION AND TRIMMING ON HOT-BONED, RESTRUCTURED, PRE-COOKED ROASTS FROM COWS

#### ABSTRACT

Four USDA Utility grade cow carcasses were used to study the effects of blade tenderization and trimming of connective tissue when producing hot-boned, restructured, pre-cooked roasts from cows. Muscles from one side of each carcass were hot-boned within 1hr postmortem, blade tenderized, cut into large pieces, mixed, and divided into two batches. One batch was trimmed of large deposits of connective tissue (BTT) while the other was not trimmed (BTNT) before restructuring and pre-cooking. The muscles from the other side were not blade tenderized but were hot boned, cut into pieces, mixed, and divided into two batches. One batch was trimmed (T), while the companion batch was not trimmed (NT) before restructuring and pre-cooking. Overall, treatments involving trimming (T and BTT) proved to be the most effective. However, the blade tenderization treatment BTNT was frequently equal or superior to treatments involving trimming when considering product palatability, tenderness indicating Instron measures, and treatment variances. Some Instron parameters were correlated with taste panel parameters and total collagen determinations.

## INTRODUCTION

Improvements in the energy, labor, and yield efficiencies of beef processing are major goals of hot boning. Some potential advantages of hot boning include: 1) facilitation of centralized processing; 2) reduction in cooler space and energy input; 3) improvement in yields; 4) reduction in labor; and 5) improvement of emulsifying properties (Kastner, 1982).

Palatability preferences of a consumer taste panel for beef steaks from young and old animals indicated that eating preferences were consistently in favor of the more tender youthful animals (Dunsing, 1959). As a consequence of age-associated problems with tenderness, the majority of beef from older animals is currently utilized as ground beef or sausage raw material. If methods for increasing the palatability of meat from older animals could be developed to achieve a level comparable to the beef from younger carcasses, this would allow beef from older animals to be processed into products that could be marketed through retail channels, allowing for flexibility in marketing (Tatum et al., 1978).

Blade tenderization is one of the most effective mechanical methods of meat tenderization (Hayward et al., 1979). The use of blade tenderization on less tender muscle, to reduce the effects of connective tissue between weight-grade groups, may be used to make cuts from older animals comparable in tenderness to those from younger animals (Savell et al., 1977; Seideman et al., 1977).

Economic pressure to minimize processing cost and maximize product palatability and utilization provides incentives to develop new products of high quality and value using less valuable carcasses and carcass portions. The overall concept of restructured meat is to utilize less expensive beef cuts to manufacture

a product that provides satisfactory eating qualities at a low unit cost (Seideman et al., 1981).

This investigation was designed to evaluate the effects of blade tenderization and trimming of large deposits of connective tissue on hot-boned, restructured, pre-cooked roasts from cow carcasses.

## MATERIALS and METHODS

### Sample preparation

Four USDA Utility grade cows were slaughtered at the Kansas State University meats laboratory. The supraspinatus, and semitendinosus muscles, and the clod and inside round muscle systems were removed from both sides of each carcass within 1 hr postmortem. All muscles were trimmed of exterior fat, blade tenderized (BT) three times, cut into large pieces (approximately 8.0 x 10.0cm), mixed, and divided into two batches. One batch was trimmed of large deposits of connective tissue (blade tenderized and trimmed, BTT); while the companion batch was not trimmed (blade tenderized and non-trimmed, BTNT). The muscles from the other side were not blade tenderized but were also cut into large pieces, mixed, and divided into two batches. Pieces from one batch were trimmed of excess connective tissue (T) whereas those from the other batch were not trimmed (NT). The pieces from each treatment batch were coarsely ground through a three hole kidney plate yielding large irregular chunks (approximately 4.0 x 1.9cm). Ten percent of the weight of the lean chunks of each batch was ground through a 0.64cm plate.



Representative samples of the ground lean from each treatment were tested for pH and for fat content using the Hobart Fat Analyser. Subcutaneous fat previously removed was chilled in a freezer to firm the fat and ground through a 0.64cm plate. A preliminary study indicated that grinding and blending hot fat decreased product bind. This was possibly due to fat smearing over the lean surface which reduced myosin extraction.

The individual batches were placed immediately into a Hobart mixer with 1.5% salt and 0.25% sodium tripolyphosphate for 6 min pre-blending at 1°C. Salt and phosphate percentages were based on the weight of the lean plus fat needed to achieve 10% fat in the formulation. After pre-blending, the individual treatment batches were placed in a Keebler vacuum paddle mixer and mixed under vacuum (686 mm Hg) for 7 min. After the first 7 min of vacuum mixing, the ground fat component was added to each treatment batch to achieve a final fat content of 10%. The batches were vacuum mixed for an additional 7 min. The order of pre-blending and vacuum mixing of product from each treatment were randomized to eliminate variation in the time postmortem before blending and mixing. Product was stuffed through a 5.1cm horn into 20.4 X 81.6cm fibrous pre-stuck casings. Casings were compressed and clipped using a Polyclip device and roasts were individually weighed.

#### pH measurements

All pH values of the ground lean component were taken within 2 hr postmortem. A sample (1-2gm) from each treatment batch was blended with 10ml of 5mM NaIAc in 150 mM KCL solution (Bendall, 1973).

### Cooking procedures

Roasts were steam cooked in a smokehouse to an internal temperature of 62.8°C during a three-stage heating cycle. Roasts were cooked initially at 54.4°C for 45 min, followed by 65.8°C for 45 min, and finally at 82.2°C until an internal temperature of 62.8°C was reached. Roasts were weighed, chilled for 24 hr and reweighed prior to being frozen. Maximum frozen storage time was 1 mo before organoleptic evaluation. Subsequent analyses were performed after an overnight thawing period at 1°C.

### Organoleptic evaluations

Following overnight thawing at 1°C, .64cm slices were cut into four uniform wedges and stored at room temperature prior to evaluation. A consumer panel of 200 students was selected at Kansas State University from Animal Science and Industry classes. Panel members were given ballot instructions and sampling procedures before evaluation. Four wedges (one from each treatment) and an unsalted cracker were presented on odor-free, taste-free, white styrofoam plates. Each sample was assigned a three digit random number (Appendix C). Panelists were instructed to take a small bite of cracker between samples. Samples were evaluated based on flavor, juiciness, tenderness, and overall acceptability. A six descriptor hedonic scale (Fig. 1) was used to rate each characteristic. The descriptors were assigned values of 1 through 6, where 1= like extremely or extremely acceptable and 6= dislike extremely or extremely unacceptable.

Figure 1 - Taste panel evaluation sheet for flavor, juiciness, tenderness,  
and overall acceptability

## Samples code

	___FIRST	___SECOND	___THIRD	___FOURTH
1. -----				
F	_like extremely.	_like extremely.	_like extremely.	_like extremely.
L	_like very much.	_like very much.	_like very much.	_like very much.
A	_like slightly.	_like slightly.	_like slightly.	_like slightly.
V	_dislike slightly.	_dislike slightly.	_dislike slightly.	_dislike slightly.
O	_dislike very much.	_dislike very much.	_dislike very much.	_dislike very much.
R.	_dislike extremely.	_dislike extremely.	_dislike extremely.	_dislike extremely.
2. -----				
J				
U	_like extremely.	_like extremely.	_like extremely.	_like extremely.
I	_like very much.	_like very much.	_like very much.	_like very much.
C	_like slightly.	_like slightly.	_like slightly.	_like slightly.
I	_dislike slightly.	_dislike slightly.	_dislike slightly.	_dislike slightly.
N	_dislike very much.	_dislike very much.	_dislike very much.	_dislike very much.
E	_dislike extremely.	_dislike extremely.	_dislike extremely.	_dislike extremely.
S				
3. -----				
T				
E				
N	_like extremely.	_like extremely.	_like extremely.	_like extremely.
D	_like very much.	_like very much.	_like very much.	_like very much.
E	_like slightly.	_like slightly.	_like slightly.	_like slightly.
R	_dislike slightly.	_dislike slightly.	_dislike slightly.	_dislike slightly.
N	_dislike very much.	_dislike very much.	_dislike very much.	_dislike very much.
E	_dislike extremely.	_dislike extremely.	_dislike extremely.	_dislike extremely.
S				
4. -----				
A				
C				
C	_extremely	_extremely	_extremely	_extremely
O E	_acceptable.	_acceptable.	_acceptable.	_acceptable.
V P	_very acceptable.	_very acceptable.	_very acceptable.	_very acceptable.
E T	_slightly acceptable.	_slightly acceptable.	_slightly acceptable.	_slightly acceptable.
R A	_slightly	_slightly	_slightly	_slightly
A B	_unacceptable.	_unacceptable.	_unacceptable.	_unacceptable.
L I	_very unacceptable	_very unacceptable	_very unacceptable	_very unacceptable
L L	_extremely	_extremely	_extremely	_extremely
I	_unacceptable.	_unacceptable.	_unacceptable.	_unacceptable.
T				
Y				

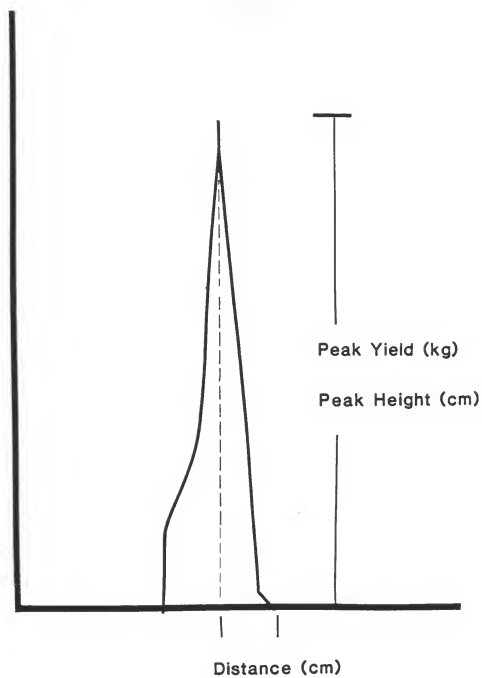
Comments:

### Objective textural measurements

Following overnight thawing at room temperature, samples were sliced from each roast. One thick sliced (1.27cm) and one thin sliced (series of approximately fifteen 0.15cm slices) sample were removed from the center of each roast. Thick and thin sliced samples were also taken within 7.5cm of the ends of each resulting half roast. Those samples were identified as center, end 1, and end 2. Both thick and thin slices were cut (6.5 X 6.5cm) to fit the L.E.E. Kramer cell. The 1.27cm thick samples, cut to fit the cell, weighed from 45 to 57gm and the thin slices varied in weight from 33 to 54gm after cutting. All samples were immediately wrapped in polyvinyl chloride film and stored (1°C) to minimize moisture loss before testing. Since sample weight might influence results, another series of thin slices (0.15cm) was taken from the remaining roast samples. After trimming to fit L.E.E. Kramer cell,  $50 \pm 2$ gm of the thin slices were placed in the cell. These samples were not identified by end and center locations.

Shear values were obtained by using the Instron Universal Testing Machine equipped with a L.E.E. Kramer cell. A crosshead and chart speed of 100mm/min was used, and the force ring was 500kg. Samples were placed into the L.E.E. Kramer cell and one shear measurement was obtained per sample. Using the force deformation curves (Fig. 2), peak yield was measured as maximum force (kg), distance was measured along the baseline from the point of initial contact with the sample to the point of peak yield; area 1 was measured as the area under the deformation curve by using a planimeter; and area 2 was calculated by measuring the distance along the baseline from the point of initial contact to the point of peak yield (cm) and multiplying by the peak height (cm/gm). All results were expressed per gm of sample.

Figure 2 - Sample Instron force deformation curve



### Hydroxyproline and total collagen determination

Samples were sliced from each roast and cut into wedges. Wedges then were frozen in liquid nitrogen and were pulverized in a Waring Blendor. Frozen pulverized samples were stored at  $-18^{\circ}\text{C}$  in clear plastic bags before hydroxyproline and total collagen determination. Samples (4gm) from each treatment were homogenized with a Polytron and hydrolyzed in 6N HCL for 6 to 12 hr in an autoclave at  $125^{\circ}\text{C}$ . Hydroxyproline was determined by a modified procedure of Bergman and Loxley (1963). The modification consisted on the addition of 2 ml of Ehrlich's reagent, rather than 13 ml recommended by Bergman and Loxley (1963). Absorbance was measured at 558nm on a Bausch and Lomb Spectronic 21 within 30 min of color development. Detailed procedures of hydroxyproline analyses, standard curve preparation, and total collagen determination are shown in appendix A and B. Total collagen content (mg/gm of sample) was computed by multiplying hydroxyproline content by 7.25 (Goll et al., 1964).

### Statistical analyses

The experimental design was a completely randomized block design with respect to assigning treatments to carcasses sides. Data were analyzed by analysis of variance, and main effect means were compared by using the least significance difference method (Snedecor and Cochran, 1978). Correlation coefficients and within treatment variances were also calculated and analyzed. Variances were used to obtain an evaluation of product uniformity as influenced by treatment. The analysis was performed by using the Statistical Analysis System Package (SAS,



1982). Because the study was primarily designed to evaluate the effects of trimming and blade tenderization, results pertaining to these main effects are emphasised. The trends among treatment means may be evaluated considering that in no case was the trimming x tenderization interaction found to be significant ( $P>.05$ ).

## RESULTS and DISCUSSION

### Taste panel analyses

Juiciness and tenderness main effect means (Table 1) for trimmed vs non-trimmed were different ( $P < .05$ ). No other statistical differences were noted. Trimming of large deposits of connective tissue improved ( $P < .05$ ) the evaluation of juiciness and tenderness scores for T and BTT compared with NT and BTNT treatments, respectively. Even so, all treatment means were in the "like very much" to "like slightly" categories for juiciness and tenderness (Table 1, Fig. 1). Blade tenderization slightly improved tenderness when comparing BTT vs T and BTNT vs NT. These blade tenderization data agree with those of Savell et al. (1977), Seideman et al. (1977), Schwartz and Mandigo (1974), and Miller (1975). Those authors attributed the increase in tenderness associated with blade tenderization to the partial destruction and severance of connective tissue and muscle fibers thereby reducing the resistance to shear force, mastication, and swallowing. Results also agreed with those reported by Tatum et al. (1978), Glover et al. (1977) and Savell et al. (1977), where blade tenderization was found to have little or no effect on juiciness and flavor. Blade tenderization without trimming of connective tissue (BTNT) may produce a restructured product with a level of overall acceptability and flavor equivalent to the T and BTT treatments (Table 1).

It should be noted that for all treatments, the influence of connective tissue on tenderness may also have been minimized by chunking before restructuring and by the method of pre-cooking.

Table 1.-Taste panel traits means for treatments and main effects

Taste panel traits <sup>c</sup>	Treatments				Main Effect Comparisons			
	Non-trimmed (NT)	Trimmed (T)	Tenderized, trimmed (BTT)	Tenderized, non-trimmed (BTNT)	Non-trimmed vs Trimmed	Trimmed vs Non-trimmed	Tenderized vs Non-tenderized	LSD
Flavor	2.86	2.80	2.83	2.94	2.81 <sup>a</sup>	2.90 <sup>a</sup>	2.83 <sup>a</sup>	.25
Juiciness	2.70	2.47	2.53	2.81	2.50 <sup>a</sup>	2.75 <sup>b</sup>	2.58 <sup>a</sup>	.16
Tenderness	3.04	2.70	2.51	2.93	2.61 <sup>a</sup>	2.98 <sup>b</sup>	2.87 <sup>a</sup>	.35
Overall acceptability	2.82	2.67	2.62	2.84	2.65 <sup>a</sup>	2.83 <sup>a</sup>	2.75 <sup>a</sup>	.35

<sup>a</sup><sup>b</sup>Main effect means for trimmed vs non-trimmed and tenderized vs non-tenderized with the same superscript are not different ( $P > .05$ ).

<sup>c</sup>Taste panel traits: 2=like very much or very acceptable, 3=like slightly or slightly acceptable.

### Chemical analyses and cooking loss

Total collagen and cooking loss main effect means (Table 2) were less ( $P < .05$ ) for trimmed than non-trimmed. Tenderized vs non-tenderized main effect mean comparisons for total collagen and cooking loss were not significantly different. These results agree with those of Tatum et al. (1978), Schwartz and Mandigo (1974), Savell et al. (1977), and Seideman et al. (1977), where neither drip loss nor cooking loss were significantly affected by needle or blade tenderization. As expected, trimming reduced the total collagen (Table 2) and improved the taste panel perception of tenderness (Table 1). The improved perception of juiciness due to trimming (Table 1) agrees with reduced cooking losses resulting from trimming (Table 2). Tenderization within 2 hr postmortem reduced ( $P < .05$ ) pH values (Table 2) apparently due to disruption of pre-rigor muscle which accelerated postmortem glycolysis.

### Instron evaluations

#### Fixed weight thinly sliced samples

Instron parameter means for fixed weight ( $50 \pm 2$  gm) thinly sliced (0.15 cm) samples by treatments and main effects are shown in Table 3. Trimmed vs non-trimmed main effect means showed trimmed to have a smaller ( $P < .05$ ) peak yield than non-trimmed. The reduction in peak yield due to trimming agrees with the same main effect mean comparison for taste panel tenderness and total collagen. No other significant differences were noted in Table 3. However, the

Table 2-Cooking loss, total collagen, and pH means for treatments and main effects

	Treatments				Main Effect Comparisons			
	Non-trimmed (NT)	Trimmed (T)	Tenderized, trimmed (BTT)	Tenderized, non-trimmed (BTNT)	Trimmed vs Non-trimmed	LSD	Tenderized vs Non-tenderized	LSD
Cooking loss (%)	4.53	3.38	2.35	2.90	2.86 <sup>a</sup>	0.38	2.63 <sup>a</sup>	1.58
Total collagen (mg/gm)	19.15	11.45	10.81	16.68	11.13 <sup>a</sup>	2.45	13.75 <sup>a</sup>	2.22
pH	6.51	6.52	6.31	6.34	6.43 <sup>a</sup>	0.04	6.33 <sup>a</sup>	0.09
					3.72 <sup>b</sup>		3.95 <sup>a</sup>	
					17.91 <sup>b</sup>		15.30 <sup>a</sup>	
					6.42 <sup>a</sup>		6.52 <sup>b</sup>	

ab Main effect means for trimmed vs non-trimmed and tenderized vs non-tenderized with the same superscript are not different (P>.05).

Table 3—Instron measurement means for fixed weight (50±2gm), thinly sliced samples for treatments and main effects

Instron measurements	Treatments				Main Effect Comparisons				
	Non-trimmed (NT)	Trimmed (T)	Tenderized, non-trimmed (BINT)		Trimmed vs Non-trimmed	LSD	Tenderized vs Non-tenderized	LSD	
			Trimmed (BTT)	non-trimmed (BINT)					
Peak yield <sup>c</sup> (kg/gm)	5.46	4.55	4.35	5.08	4.45 <sup>a</sup>	5.27 <sup>b</sup>	4.72 <sup>a</sup>	5.01 <sup>a</sup>	.46
Distance <sup>d</sup> (cm/gm)	0.028	0.025	0.027	0.028	0.026 <sup>a</sup>	0.028 <sup>a</sup>	.004	0.028 <sup>a</sup>	.006
Area 1 <sup>e</sup> (cm <sup>2</sup> /gm)	0.253	0.372	0.211	0.252	0.292 <sup>a</sup>	0.253 <sup>a</sup>	.178	0.232 <sup>a</sup>	.240
Area 2 <sup>f</sup> (cm <sup>2</sup> /gm)	0.381	0.292	0.284	0.354	0.288 <sup>a</sup>	0.367 <sup>a</sup>	.082	0.320 <sup>a</sup>	.047

ab>Main effect means for trimmed vs non-trimmed and tenderized vs non-tenderized with the same superscript are not different (P>.05).

<sup>c</sup>Peak yield: maximum force.

<sup>d</sup>Distance: distance from initial contact with the sample to peak yield.

<sup>e</sup>Area 1: measured as the area under the deformation curve by the use of a planimeter.

<sup>f</sup>Area 2: distance from initial contact to peak yield (cm) x peak height (cm/gm).

treatment mean comparisons tended to show a reduction in peak yield due to blade tenderization (BTT vs T and BTNT vs NT).

#### Variable weight thinly sliced samples

Table 4 shows Instron measurement means for treatments and main effects for variable weight thinly sliced samples. An analysis of covariance indicated that within the sample weight ranges used; peak yield, distance, or areas per gm were not significantly different as sample weight varied within a treatment. The area 2 main effect mean was higher ( $P < .05$ ) for non-trimmed than trimmed. Treatment means for area 2 showed T and BTT treatments to have smaller means than NT and BTNT treatments, respectively. The peak yield main effect mean was higher ( $P < .05$ ) for non-tenderized than for tenderized. Treatment means for peak yield for BTNT and BTT were smaller than for NT and T respectively. No other significant main effect mean differences were noted in Table 4.

#### Variable weight thick sliced samples

For variable weight thick sliced samples the difference between trimmed and non-trimmed main effect means for area 2 was significant ( $P < .05$ ) Table 5. Trimming treatments (T and BTT) resulted in smaller area 2 means than non-trimmed (NT and BTNT) treatments. Blade tenderization decreased peak yield means for BTT and BTNT relative to T and NT, respectively, and the main effect mean difference for tenderized vs non-tenderized was significant. These results correspond to those for thinly sliced variable weight samples (Table 4). Other

Table 4-Instron measurement means for variable weight thinly sliced samples for treatments and main effects

Instron measurements	Treatments				Main Effect Comparisons					
	Non-trimmed (NT) (36-55gm)	Trimmed (T) (36-53gm)	Trimmed (BTT) (35-53gm)	Tenderized, trimmed non-trimmed (BTNT) (33-52gm)	Non-trimmed	Trimmed vs Non-trimmed	LSD	Tenderized vs Non-tenderized	LSD	
Peak yield <sup>c</sup> (kg/gm)	5.92	5.16	4.96	4.78	5.06 <sup>a</sup>	5.35 <sup>a</sup>	.75	4.87 <sup>a</sup>	5.54 <sup>b</sup>	.36
Distance <sup>d</sup> (cm/gm)	0.070	0.031	0.050	0.031	0.041 <sup>a</sup>	0.051 <sup>a</sup>	.050	0.041 <sup>a</sup>	0.051 <sup>a</sup>	.070
Area 1 <sup>e</sup> (cm <sup>2</sup> /gm)	0.327	0.300	0.300	0.300	0.300 <sup>a</sup>	0.313 <sup>a</sup>	.072	0.300 <sup>a</sup>	0.313 <sup>a</sup>	.061
Area 2 <sup>f</sup> (cm <sup>2</sup> /gm)	0.450	0.370	0.334	0.370	0.350 <sup>a</sup>	0.410 <sup>b</sup>	.050	0.352 <sup>a</sup>	0.410 <sup>a</sup>	.062

ab Main effect means for trimmed vs non-trimmed and tenderized vs non-tenderized with the same superscript are not different (P>.05).

c Peak yields maximum force.

d Distance: distance from initial contact with the sample to peak yield.

e Area 1: measured as the area under the deformation curve by the use of a planimeter.

f Area 2: distance from initial contact to peak yield (cm) x peak height (cm/gm).



Table 5-Instron measurement means for variable weight thick sliced samples for treatments and main effects

Instron measurements	Treatments			Main Effect Comparisons						
	Non-trimmed (NT) (46-55gm)	Trimmed (T) (44-54gm)	Tenderized, trimmed (BTT) (47-56gm)	Tenderized, non-trimmed (BTNT) (46-57gm)	Trimmed vs Non-trimmed	Tenderized vs Non-tenderized	LSD	LSD		
Peak yield <sup>c</sup> (kg/gm)	7.33	6.26	5.65	6.55	6.00 <sup>a</sup>	6.94 <sup>a</sup>	1.11	6.10 <sup>a</sup>	6.80 <sup>b</sup>	.60
Distance <sup>d</sup> (cm/gm)	0.032	0.028	0.032	0.032	0.030 <sup>a</sup>	0.032 <sup>a</sup>	.005	0.032 <sup>a</sup>	0.030 <sup>a</sup>	.007
Area 1 <sup>e</sup> (cm <sup>2</sup> /gm)	0.471	0.373	0.380	0.443	0.376 <sup>a</sup>	0.457 <sup>a</sup>	.086	0.411 <sup>a</sup>	0.422 <sup>a</sup>	.070
Area 2 <sup>f</sup> (cm <sup>2</sup> /gm)	0.621	0.455	0.440	0.606	0.447 <sup>a</sup>	0.614 <sup>b</sup>	.175	0.523 <sup>a</sup>	0.540 <sup>a</sup>	.130

ab>Main effect means for trimmed vs non-trimmed and tenderized vs non-tenderized with the same superscript are not different (P>.05).

c Peak yield: maximum force.

d Distance: distance from initial contact with the sample to peak yield.

e Area 1: measured as the area under the deformation curve by the use of a planimeter.

f Area 2: distance from initial contact to peak yield (cm) x peak height (cm/gm).

differences between main effect means in Table 5 were non-significant.

Considering treatment means, treatments involving trimming and blade tenderization (T, BTT, and BTNT) generally tended to reduce Instron measurements relative to NT.

#### Sample location comparisons

Tables 6 and 7 show Instron measurement means for sampling location for thinly sliced and thick sliced variable weight samples. Sampling locations were not different ( $P>.05$ ) for any of the Instron parameter for the thinly sliced samples. In data not shown, total collagen content was also not different ( $P>.05$ ) among sampling locations for each treatment. Thick sliced sample means were significantly affected ( $P<.05$ ) by sampling location. However, no consistent locational trends were noted. This indicates that sampling location did not consistently influence results, and that roasts within treatment were reasonably uniform throughout their length.

#### Correlations

Peak yield ( $r=.73$ ), area 1 ( $r=.60$ ), and area 2 ( $r=.65$ ) were correlated ( $P<.05$ ) with taste panel scores for tenderness as were correlations between areas 1 ( $r=.53$ ) and 2 ( $r=.60$ ) and total collagen values. As those Instron measurement means decreased corresponding tenderness evaluations became more desirable and total collagen amounts decreased. Therefore, for restructured products that vary in taste panel tenderness due to the influence of connective tissue, the L.E.E. Kramer cell

Table 6-Instron measurement means for thinly sliced variable weight samples for sampling locations

Instron Measurements	Sampling Locations		
	End1	Center	End2
Peak yield <sup>b</sup> (kg/gm)	5.13 <sup>a</sup>	5.48 <sup>a</sup>	5.01 <sup>a</sup>
Area 1 <sup>d</sup> (cm <sup>2</sup> /gm)	0.300 <sup>a</sup>	0.333 <sup>a</sup>	0.290 <sup>a</sup>
Distance <sup>c</sup> (cm/gm)	0.032 <sup>a</sup>	0.32 <sup>a</sup>	0.073 <sup>a</sup>
Area 2 <sup>e</sup> (cm <sup>2</sup> /gm)	0.383 <sup>a</sup>	0.370 <sup>a</sup>	0.382 <sup>a</sup>

<sup>a</sup>Means in the same row with the same superscript are not different ( $P>.05$ ).

<sup>b</sup>Peak yield: maximum force.

<sup>c</sup>Distance: distance from initial contact with the sample to peak yield.

<sup>d</sup>Area 1: measured as the area under the deformation curve by the use of a planimeter.

<sup>e</sup>Area 2: distance from initial contact to peak yield (cm) x peak height (cm/gm).

Table 7-Instron measurement means for thick sliced variable weight samples for sampling locations

Instron Measurements	Sampling Locations		
	End1	Center	End2
Peak yield <sup>b</sup> (kg/gm)	5.70 <sup>a</sup>	7.35 <sup>b</sup>	6.32 <sup>a</sup>
Area 1 <sup>d</sup> (cm <sup>2</sup> /gm)	0.358 <sup>b</sup>	0.476 <sup>a</sup>	0.415 <sup>ab</sup>
Distance <sup>c</sup> (cm/gm)	0.029 <sup>a</sup>	0.032 <sup>a</sup>	0.032 <sup>a</sup>
Area 2 <sup>e</sup> (cm <sup>2</sup> /gm)	0.415 <sup>b</sup>	0.645 <sup>a</sup>	0.532 <sup>ab</sup>

<sup>a,b</sup>Means in the same row with the same superscript are not different ( $P>.05$ ).

<sup>b</sup>Peak yield: maximum force.

<sup>c</sup>Distance: distance from initial contact with the sample to peak yield.

<sup>d</sup>Area 1: measured as the area under the deformation curve by the use of a planimeter.

<sup>e</sup>Area 2: distance from initial contact to peak yield (cm) x peak height (cm/gm).

may be used to predict relative tenderness differences. Additionally, the Kramer device may be used to predict relative differences in connective tissue amount in restructured products. Percent cooking loss was correlated ( $P < .05$ ) with taste panel scores for tenderness ( $r = .56$ ) and overall acceptability ( $r = .48$ ). Total collagen also was correlated with taste panel scores for juiciness ( $r = .57$ ) and tenderness ( $r = .71$ ). Therefore, as percent cooking loss and total collagen values increased; juiciness, tenderness, and overall acceptability values tended to become less desirable.

### Variance Analyses

The variance analysis was conducted in an effort to measure product uniformity as influenced by treatment. It is proposed that as variance decreases product uniformity increases, and this is a desirable trait for meat products. Treatment variances for taste panel traits, pH, and cooking loss were not different ( $P > .05$ ) among treatments, as were treatment variances for the thinly sliced fixed weight samples for Instron measures of distance and areas 1 and 2 (Tables 8, 9 and 10). Similar results were found for the thick sliced variable weight samples (Table 11), where treatment variances for Instron measures were generally not different ( $P > .05$ ). However, for the thinly sliced variable weight samples T, BTT, and BTNT treatments generally tended to decrease treatment variances for Instron measurements of peak yield, distance, and area 2 relative to NT (Table 12).

Treatments involving trimming significantly reduced treatment variances for total collagen (Table 9) and peak yield (Table 10) when compared to NT and BTNT treatments. Though, not always significant, the general trend was to the NT treatment to have the largest treatment variances for taste panel traits (Table 8),

Table 8-Variations for each treatment for taste panel traits

Treatments	Taste Panel Traits						Overall acceptability	
	df	Flavor	df	Juiciness	df	Tenderness		
Non-trimmed(NT)	3	0.063 <sup>a</sup>	3	0.031 <sup>a</sup>	3	0.200 <sup>a</sup>	3	0.072 <sup>a</sup>
Trimmed (T)	3	0.003 <sup>a</sup>	3	0.003 <sup>a</sup>	3	0.020 <sup>a</sup>	3	0.005 <sup>a</sup>
Tenderized, trimmed (BTT)	3	0.031 <sup>a</sup>	3	0.022 <sup>a</sup>	3	0.023 <sup>a</sup>	3	0.041 <sup>a</sup>
Tenderized, non-trimmed (BNT)	3	0.007 <sup>a</sup>	3	0.009 <sup>a</sup>	3	0.030 <sup>a</sup>	3	0.003 <sup>a</sup>

<sup>a</sup>Variations in the same column with the same superscript are not different (P>.05).

Table 9-Variations for each treatment for pH, cooking loss, and total collagen

Treatments	df	pH	df	Cooking loss	df	Total collagen
Non-trimmed (NT)	3	0.008 <sup>a</sup>	3	4.54 <sup>a</sup>	6	24.00 <sup>a</sup>
Trimmed (T)	3	0.007 <sup>a</sup>	3	1.97 <sup>a</sup>	6	1.84 <sup>b</sup>
Tenderized, trimmed (BTT)	3	0.004 <sup>a</sup>	3	0.37 <sup>a</sup>	6	0.85 <sup>b</sup>
Tenderized, non-trimmed (BTNT)	3	0.001 <sup>a</sup>	3	0.18 <sup>a</sup>	6	13.25 <sup>a</sup>

<sup>a,b</sup> Variations in the same column with the same superscript are not different ( $P > .05$ ).

Table 10-Variations for each treatment for thinly sliced fixed weight samples for Instron measurements

Treatments	Instron Measurements							
	df	Peak yield <sup>c</sup>	df	Area 1 <sup>e</sup>	df	Distance <sup>d</sup>	df	Area 2 <sup>f</sup>
Non-trimmed (NT)	4	0.550 <sup>a</sup>	4	0.0020 <sup>a</sup>	4	1x10 <sup>-6a</sup>	4	0.006 <sup>a</sup>
Trimmed (T)	4	0.024 <sup>b</sup>	4	0.0030 <sup>a</sup>	4	1x10 <sup>-6a</sup>	4	0.001 <sup>a</sup>
Tenderized, trimmed (BTT)	4	0.100 <sup>b</sup>	4	0.0004 <sup>a</sup>	4	4x10 <sup>-6a</sup>	4	0.001 <sup>a</sup>
Tenderized, non-trimmed (BTNT)	4	0.960 <sup>a</sup>	4	0.0020 <sup>a</sup>	4	5x10 <sup>-6a</sup>	4	0.007 <sup>a</sup>

<sup>a</sup><sup>b</sup>Variations in the same column with the same superscript are not different ( $P>0.05$ ).

<sup>c</sup>Peak yield: maximum force.

<sup>d</sup>Distance: distance from initial contact with the sample to peak yield.

<sup>e</sup>Area 1: measured as the area under the deformation curve by the use of a planimeter.

<sup>f</sup>Area 2: distance from initial contact to peak yield (cm) x peak height (cm/gm).

Table 11-Variations for each treatment for thick sliced variable weight samples for Instron measurements

Treatments <sup>c</sup>	Instron Measurements						
	df	Peak yield <sup>d</sup>	df	Area 1 <sup>f</sup>	df	Distance <sup>e</sup>	Area 2 <sup>g</sup>
Non-trimmed (NT)	6	2.75 <sup>a</sup>	6	0.008 <sup>a</sup>	6	8x10 <sup>-6a</sup>	0.034 <sup>a</sup>
Trimmed (T)	6	1.01 <sup>a</sup>	6	0.018 <sup>a</sup>	6	3x10 <sup>-5a</sup>	0.026 <sup>a</sup>
Tenderized, trimmed (BTT)	6	0.87 <sup>a</sup>	6	0.005 <sup>a</sup>	6	2x10 <sup>-5a</sup>	0.006 <sup>a</sup>
Tenderized, non-trimmed (BTNT)	6	2.96 <sup>a</sup>	6	0.030 <sup>a</sup>	6	1x10 <sup>-5a</sup>	0.103 <sup>b</sup>

<sup>a,b</sup> Variations in the same column with the same superscript are not different (P>.05).

<sup>c</sup> Sample weight range by treatment: Non-trimmed (46-52gm), Trimmed (44-54gm), Tenderized, trimmed (47-56gm) and Tenderized, non-trimmed (45-57gm).

<sup>d</sup> Peak yield: maximum force.

<sup>e</sup> Distance: distance from initial contact with the sample to peak yield.

<sup>f</sup> Area 1: measured as the area under the deformation curve by the use of a planimeter.

<sup>g</sup> Area 2: distance from initial contact to peak yield (cm) x peak height (cm/gm).



Table 12.-Variances for each treatment for thinly sliced variable weight samples for Instron measurements

Treatments <sup>c</sup>	Instron Measurements							
	df	Peak yield <sup>d</sup>	df	Area 1 <sup>f</sup>	df	Distance <sup>e</sup>	df	Area 2 <sup>g</sup>
Non-trimmed (NT)	6	1.43 <sup>a</sup>	6	0.004 <sup>a</sup>	6	0.016 <sup>a</sup>	6	0.030 <sup>a</sup>
Trimmed (T)	6	0.12 <sup>b</sup>	6	0.002 <sup>a</sup>	6	7x10 <sup>-6b</sup>	6	0.007 <sup>b</sup>
Tenderized, trimmed (BTT)	6	0.36 <sup>b</sup>	6	0.014 <sup>a</sup>	6	0.004 <sup>a</sup>	6	0.002 <sup>b</sup>
Tenderized, non-trimmed (BTNT)	6	0.71 <sup>b</sup>	6	0.003 <sup>a</sup>	6	3x10 <sup>-6b</sup>	6	0.009 <sup>b</sup>

<sup>a</sup><sup>b</sup>Variances in the same column with the same superscript are not different ( $P>.05$ ).

<sup>c</sup>Samples weight range by treatment: Non-trimmed (36--55gm); Trimmed (36--53gm); Tenderized, trimmed (35--53gm) and Tenderized, non-trimmed (33--52gm).

<sup>d</sup>Peak yield: maximum force.

<sup>e</sup>Distance: distance from initial contact with the sample to peak yield.

<sup>f</sup>Area 1: measured as the area under the deformation curve by the use of a planimeter.

<sup>g</sup>Area 2: distance from initial contact to peak yield (cm) x peak height (cm/gm).

cooking loss and total collagen (Table 9), and peak yield (Tables 11 and 12). Blade tenderized without trimming of connective tissue (BTNT), may produce a restructured product that has reasonable uniformity as indicated by the variance analyses and a level of overall acceptability and flavor equivalent to the treatments involving trimming (T and BTT) Table 1.

### Summary

Treatments involving trimming of large deposits of connective tissue overall had superior palatability, greater tenderness as indicated by Instron measures, smaller cooking losses, less connective tissue, and smaller variances compared with NT and BTNT treatments. However, the BTNT was frequently equal and in some cases superior to T and BTT for palatability, tenderness as indicated by peak yield measures, and uniformity as indicated by treatment variances. Some Instron measurements were correlated with taste panel traits and with total collagen. As Instron measures increased taste panel tenderness evaluations became less desirable and total collagen content tended to increase. Total collagen and percent cooking loss also were correlated to taste panel traits, where greater cooking losses and total collagen values were associated with less desirable perceptions of tenderness, juiciness, and overall acceptability.

Even though blade tenderization was not as totally effective as trimming of connective tissue, it may be a viable alternative or aid to trimming considering that it is much less labor intensive and it does not reduce yield due to trimming. The use of blade tenderization to insure a quality restructured product from hot-boned cows appears reasonable and warrants further consideration.

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CHAPTER IV

APPENDIX

## APPENDIX A

## DETERMINATION OF TOTAL COLLAGEN

1. Weigh duplicate 4gm samples of muscle into a 50 ml screw top test tube. Add 20 ml of 6 N HCl and homogenize with the Polytron. Wash the Polytron with an additional 10 ml of 6 N HCl. Seal the tubes with a teflon cap.
2. Autoclave for at least 6 hr or overnight at 800 mm Hg and 125°C.
3. Cool autoclaved sample to room temperature.
4. Add 500-700 mg carbon decolorizing alkaline Norit A to clarify and filter through Whatman #1 filter paper. Wash down filter paper with distilled water.
5. Add five drops of methyl red indicator and titrate to a yellow endpoint with 5 N NaOH.
6. Dilute to 500 ml for samples low in collagen and to 1000 ml for samples high in collagen.
7. Analyze for hydroxyproline.

## Reagents:

1. 6 N HCl - Dilute 495 ml concentrated HCl to 1 with distilled water.
2. 5 N NaOH - Dissolve 200gm NaOH and dilute to 1 liter with distilled water.
3. Methyl red indicator (.02%) - Dissolve 0.02gm methyl red in 95% ethanol and dilute to 100 ml.

## APPENDIX B

DETERMINATION OF HYDROXYPROLINE BY A  
MODIFIED BERGMAN AND LOXLEY PROCEDURE

## Rapid Procedure

1. Pipette 1 ml aliquots of sample into clean 15 ml glass screw top test tubes.
2. Add 2 ml isoproponal and mix.
3. Add 1 ml oxidant solution, mix well and allow to stand 4 ( $\pm$ .5) min at room temperature. Add the oxidant solution to the tubes in a specific order and at 4 min after starting with first tube proceed to the next step.
4. Add 2 ml Ehrlich's reagent and mix well. Since timing is critical, be sure to add the Ehrlich's reagent to the tubes in the same order that the oxidant solution was added.
5. Cap the tubes and heat in a 60°C ( $\pm$ 0.2C) water bath for 25 min.
6. Cool the tubes for 5 min in running tap water.
7. Shake the tubes after cooling just before reading.
8. Use the Bausch and Lomb Spectronic 21 and measure the absorbance at 558 nm against a 0 ug/ml standard. Use a 1 cm cuvette and measure within one half hr.

Modification of the Bergman and Loxley procedure is that 2 ml Ehrlich's reagent is used in the rapid procedure rather than 13 ml as recommended in that paper.

## Reagents:

## 1. Oxidant Solution

A. 0.35gm chloramine T dissolved in 5 ml deionized water.

B. Acetate/citrate buffer pH 6.0

57gm Sodium acetate -  $3H_2O$  or 34.4gm sodium acetate anhydrous.

37.5gm Trisodium citrate -  $2H_2O$

5.5gm Citric acid -  $1H_2O$

385 ml Isoproponal

Dissolve sodium acetate, trisodium citrate and citric acid in 500 ml deionized water. Check pH and adjust with acetic acid if necessary. Add isoproponal and dilute to 1:1 with deionized water.

Oxidant Solution: Mix 1 volume A to 4 volumes B. Make fresh within 3 hr of use.

## Note:

1. If chloramine T is insoluble in water or if the samples after color development are turbid the chloramine T may be partially inactive or no good.
2. Adjustment of the pH with acetic acid can give turbidity when the chloramine T is added and so if the pH is close it is best to leave it unadjusted.
3. Make fresh buffers every 2-3 weeks to insure activity. Store at room temperature.

## 2. Ehrlich's Reagent:

A. 2gm p-Dimethylaminobenzaldehyde (DABA) dissolved in 2.5 ml of 70% perchloric acid. Be sure to use a perchloric acid hood.

B. Isoproponal

Ehrlich's reagent: mix 3 volumes of A with 13 volumes of B.

## Note:

1. Solution A can be stored in a brown bottle for about 4 weeks.
2. Final color development of green instead of pink or red indicates inactive Ehrlich's reagent.
3. Stock hydroxyproline.

Dissolve 0.100gm hydroxyproline and dilute to 1 liter with .001 N HCl. Be sure the hydroxyproline is dry. Store solution at 4°C.

## Preparation of Standards

<u>ml stock solution to dilute to 100 ml</u>	<u>standard ug/ml</u>
2	2
4	4
6	6
8	8
10	10
12	12
14	14



Reference

Bergman, I. and R. Loxley. 1963. Two improved and simplified methods for spectrophotometric determination of hydroxyproline. *Anal. Chem.* 35:1961.

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## APPENDIX C

RANDOMIZATION OF SAMPLE PRESENTATION  
FOR TASTE PANEL EVALUATION

<u>678</u>	<u>790</u>	<u>054</u>	<u>423</u>	
BTT	NT	BTNT	T	1
NT	T	BTT	BTNT	2
NT	BTNT	BTT	T	3
NT	BTT	BTNT	T	4
BTNT	T	BTT	NT	5
NT	BTT	T	BTNT	6
T	BTNT	BTT	NT	7
T	NT	BTT	BTNT	8
BTT	BTNT	NT	T	9
BTT	NT	T	BTNT	10
BTNT	BTT	NT	T	11
T	NT	BTNT	BTT	12
T	BTT	NT	BTNT	13
BTT	T	BTNT	NT	14
T	BTNT	NT	BTT	15
BTNT	NT	T	BTT	16
BTT	BTNT	T	NT	17
T	BTT	BTNT	NT	18
NT	T	BTNT	BTT	19
BTNT	T	NT	BTT	20
BTNT	BTT	T	NT	21
BTNT	NT	BTT	T	22
BTT	T	NT	BTNT	23
NT	BTNT	T	BTT	24

All possible treatment combinations of the four treatments were assigned to random numbers as shown. Fifty samples were taken from roasts from each of the four animals. Treatment combinations were assigned in order (as indicated, 1-24) and repeated until 200 treatment combinations were assigned. The plate for each panelist was prepared accordingly.

EFFECTS OF BLADE TENDERIZATION AND TRIMMING ON  
HOT-BONED, RESTRUCTURED, PRE-COOKED ROASTS FROM COWS

by

HECTOR ANGEL FLORES

B.S., Kansas State University, 1983

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AN ABSTRACT OF A MASTER'S THESIS

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1985

Four USDA Utility cows carcasses were used to study the effects of blade tenderization and trimming of large deposits of connective tissue on hot-boned, restructured, pre-cooked roasts. Muscles from one side were removed within 1 hr postmortem, blade tenderized, cut into large pieces, mixed, and divided into two batches. One batch was trimmed of large deposits of connective tissue (BTT), while the companion batch was not trimmed (BTNT) before restructuring and pre-cooking. The muscles from the other side were not blade tenderized but were also hot boned within 1 hr postmortem, cut into large pieces, mixed, and divided into two batches. One batch was trimmed of connective tissue (T), while the companion batch was not trimmed (NT) before restructuring and pre-cooking. Taste panel analysis showed that trimming significantly improved ( $P < .05$ ) the evaluation for juiciness and tenderness when compared to the non-trimmed main effect means. However, all treatments were scored in the "like very much" or "very acceptable" and "like slightly" or "slightly acceptable" categories. Trimmed vs non-trimmed main effect means were different ( $P < .05$ ) for total collagen and cooking loss, and trimming significantly reduced those mean values. Main effect mean comparisons for tenderized vs non-tenderized were not different ( $P > .05$ ) for total collagen and cooking loss. However, pH was significantly decreased by tenderization ( $P < .05$ ). Instron measurements for fixed weight ( $50 \pm 2$  gm) thinly sliced samples showed that the trimmed and non-trimmed main effect mean comparison for peak yield was significant ( $P < .05$ ) with trimming giving the smallest main effect mean. Variable weight thinly sliced samples also showed that the difference between trimmed and non-trimmed main effect means for area 2 was significant. T and BTT treatments had smaller area 2 means than the NT and BTNT treatments, respectively. The difference between tenderized and non-tenderized

main effect means was significant for peak yield, showing BTNT and BTT treatments to have smaller peak yield values when compared to NT and T, respectively. A similar pattern for treatment difference was found for the variable weight thick sliced samples. Treatments involving trimming and blade tenderization tended to have smaller within treatment variances than the NT treatment for taste panel parameters, cooking losses, and Instron measures.

Peak yield ( $r=.73$ ), area 1 ( $r=.60$ ), and area 2 ( $r=.65$ ) were correlated ( $P<.05$ ) with taste panel scores for tenderness as were correlations between areas 1 ( $r=.53$ ) and 2 ( $r=.60$ ) and total collagen values. Therefore, for restructured products that vary in taste panel tenderness due to the influence of connective tissue, the L.E.E. Kramer cell may be used to predict relative tenderness differences. Additionally, the Kramer device may be used to predict relative differences in connective tissue amount in restructured products. Percent cooking loss was correlated ( $P<.05$ ) with taste panel scores for tenderness ( $r=.53$ ) and overall acceptability ( $r=.48$ ). Total collagen also was correlated with taste panel scores for juiciness ( $r=.57$ ) and tenderness ( $r=.71$ ). Therefore, as percent cooking loss and total collagen values increased; juiciness, tenderness, and overall acceptability values tended to become less desirable.

Treatments involving trimming of large deposits of connective tissue generally had superior palatability, greater tenderness as indicated by Instron measures, smaller cooking losses, less connective tissue, and smaller variances compared to NT and BTNT treatments. However, the BTNT treatment was frequently equal and in some cases superior to T and BTT for palatability,

tenderness as indicated by peak yield measures, and uniformity as indicated by treatment variances. Even though blade tenderization was not as totally desirable as trimming of connective tissue, it may be a viable alternative or aid to trimming considering that it is much less labor intensive and it does not reduce yield due to trimming. The use of blade tenderization to insure a quality restructured product from hot-boned cows appears reasonable and warrants further consideration.