

# THE EFFECT OF TEMPERATURE ON THE PROTEIN SOLUBILITY OF SIX DIFFERENT MEAT TRIMS.

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## Story in Brief

Protein functionality of raw materials used in meat processing dictates final product quality and yield. The effect of temperature on the extraction of 2% salt-soluble proteins of bull, blade, cow heart, head and plate beef trimmings were evaluated. A control extraction at 24°C was used to monitor the effect of frozen storage on the solubility of total salt soluble protein and to estimate the sources of variability of the method used. Type of beef trimming had significant effects on total salt extracted protein and protein extraction efficiency. Maximum protein extraction occurred in two temperature regions: 12 and 18-24°C. An intermediate level of protein extraction occurred in two different regions: 0-9 and 15°C. Optimal temperatures for the extraction of protein differ due to the source of the beef trimmings.

(Key Words: Beef, Protein, Extraction, Temperature.)

## Introduction

Low fat and low salt meat products would help to meet consumers' desires for processed products having a perceived healthful benefit. The meat industry has responded by developing and formulating new low fat, low calorie products (Claus, 1990). However, maintaining the organoleptic and textural properties of such products has been difficult (Hand et al., 1987). As the fat level is decreased, the lean component becomes a dominant factor in determining the textural properties of low fat and low salt meat products. Replacement of fat with water in comminuted meat reduces the ability of the extracted proteins to bind or immobilize the added water. Thus, the role of proteins in low fat meat products becomes important. Of the major factors that affect protein solubility, extraction temperature, extraction time and meat source can be controlled easily during product manufacturing (Gadea De Lopez and Hand, 1993). However, beef trimmings typically used in the industry have not been comprehensively evaluated for protein extraction over a useful temperature range with sufficient resolution. The objective of this study was to evaluate and characterize the effect of temperature on the extraction of salt soluble proteins from the beef trimmings of six different carcass.

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## Materials and Methods

Three replicates of six different beef trimmings from bull, cow, blade, head, heart and plate (30 kg each) were obtained from a local supplier. Each trimming was approximately 10 days postmortem and had not been frozen. Beef trimmings were ground separately through a 2.0 cm plate at  $3.8 \pm 0.2^\circ\text{C}$ , frozen at  $-28 \pm 2^\circ\text{C}$  for 96 hours and then thawed at  $3 \pm 1^\circ\text{C}$  for 72 hours. Thawed trimmings were separately chopped at  $2 \pm 0.5^\circ\text{C}$  for 45 seconds at low speed, followed by an additional 45 seconds at high speed to ensure homogeneity. Chopped trimmings were divided into 11 portions, each  $0.68 \pm 0.1$  kg, packaged, assigned randomly to one of ten target temperature treatments and frozen at  $-29 \pm 1^\circ\text{C}$  until used. The eleventh portion was used to determine protein, fat, and moisture content (AOAC, 1990).

Protein extraction was carried out in triplicate on each beef trimming using a modified version of the method of Hand et al. (1987). Samples were extracted at one of ten temperature treatments from  $-3$  to  $24^\circ\text{C}$  in  $3^\circ\text{C}$  increments. Each beef trimming and trimming replicate was extracted at a given temperature separately and individually, and on different days. To reduce the possible day-to-day variation or an effect of freezing on protein extraction, samples also were extracted at  $24^\circ\text{C}$ , referred to as the standards at this standard temperature. Each sample was thawed at  $3 \pm 1^\circ\text{C}$  for eighteen hours before the start of protein extraction. Six samples of each trimming were weighed ( $10.00 \pm 0.05$  g) into 50 mL Nalgene polycarbonate centrifuge tubes. Three samples were allowed to equilibrate to the treatment temperature for seven to eight hours, whereas the other three were equilibrated to the standard temperature. Once samples and standards obtained the target temperature,  $20.0 \pm 0.1$  mL of NaCl 2% (W/V), also temperature equilibrated, was added to each treatment. Tubes containing the samples were placed in a covered shaking water bath and standards were placed in adjacent covered shaking water bath having a temperature of  $24^\circ\text{C}$ . The temperature inside the sample water bath was maintained at the treatment temperature by using the heating coils of the water bath to warm water chilled by a coil connected to a refrigerated circulator. Possible variations in protein extraction resulting from different shaking speeds between sample and standard shaking water baths were reduced by shaking both treatment and standard samples by way of a connecting arm. All extractions were for 1 hour at a shaking speed of 120 strokes per minute. After extraction, sample and standard treatments were centrifuged at  $1,860 \times g$  for 10 minutes at the same treatment temperature of the sample extraction. Supernatant fluids were filtered through number 4 Whatman paper. The protein content of duplicate 0.2 mL aliquots from treatment and standard filtrates was determined by the biuret test (Gornall et al., 1949) using Human Serum Albumin Globulin as the protein standard.

A complete block design with meat trimming replicates as blocks, and meat and temperature as treatments was used to analyze extracted protein and protein extraction efficiency using Analysis of Variance.

## Results and Discussion

**Effect of Meat Types.** The effect of different beef trimmings on the total salt extractable protein is presented in Table I. Meat sources were quite variable in protein extraction due to the variation in proximate composition among meat trimming replicates. This latter point probably accounts for a significant effect ( $P < .05$ ) of trimming replication. The anatomical source of each beef trimming had an effect ( $P < .05$ ) on total salt extracted protein. The largest amount of protein was extracted from blade trimming followed by heart trimming. The extraction of salt soluble protein was similar for bull and cow. The least amount of protein was extracted from head and plate trimmings with the amount extracted half of the quantity extracted from blade trimming. Both of these trimmings had higher fat (Table I). Fat may have masked some differences either by interfering with protein dissolution or binding extracted protein. Beef head trimming has been found to contain 23.6 mg collagen/g and plate trimming contains 12.8 mg collagen/g (Wiley et al., 1979). Both of these values are considerably higher than cow meat trimming (Wiley et al., 1979). The high amount of connective tissue in both of these trimmings may act as a barrier entrapping protein within cells or preventing the breakage of cells so that the proteins are not extracted.

**Effect of Temperature.** The effect of temperature upon the extraction of salt soluble protein from bull trimming is shown in Figure 1. The protein extraction-temperature profile of bull trimming exhibited several maxima and minima when a 2% NaCl solution was used to extract protein. Three maxima were present: 0-6, 12 and 18-24°C with the regions of 12 and 18-24°C having the highest amount of extracted protein. Minima were located at -3, 9, and 15°C with -3°C exhibiting the lowest amount of extracted protein. The bull trimming protein extraction-temperature profile revealed that it may be practical to extract protein at 18-24°C during processing to obtain results similar to processing procedures occurring at 0-6°C. Other regions, namely 3, 9 or 12 could be utilized to decrease the amount of protein extracted if that were desired.

Figure 1 also shows the effect of temperature upon the extraction of 2% NaCl soluble protein from blade trimming. Protein extraction maxima existed at -3, 9-12 and 21-24°C. Two minima were apparent in the protein extraction-temperature profile. One occurred at 3 with the other occurring at 15°C. The minima at 3°C had the lowest amount of extracted protein. These results suggest that to extract salt soluble protein from blade trimming, processors may

take advantage of these variations to control protein extraction. Reports from other studies indicated that the optimal temperature for the extraction of the total protein from beef shoulder clods was 14°C using 2% NaCl (Gadea de Lopez, 1993). That study also indicated that the maximum solubility of sarcoplasmic and myofibrillar protein occurred at 26 and 6°C, respectively.

The effect of temperature on the extraction of protein from cow trimming by 2% NaCl is shown in Figure 1. The protein extracted from cow blade trimming displayed three maxima at 3-6, 12 and 18-24°C with 18 and 24°C having the highest amount of extracted protein. Protein extraction minima occurred at temperatures of -3, 9 and 15°C with -3 and 9°C having the lowest amount of extracted protein. These results are qualitatively similar to the protein extraction-temperature profile of bull trimming (Figure 1).

The protein extraction-temperature profile for heart trimming (Figure 1) was different from either bull, blade or cow trimming in that a broad intermediate level of protein extraction occurred at 12-18°C. Maxima appeared at 3 and 21°C with both having the highest quantity of extracted protein. The lowest amount of protein extracted occurred at extraction temperatures of -3 and 9°C. The broad intermediate level of extracted protein from 12-18°C may be explained by the relatively high sarcoplasmic protein content of heart trimming.

The extraction of protein from head trimming using 2% NaCl resulted in the protein extraction-temperature profile displayed in Figure 1. Three maxima of extracted protein occurred at -3, 0, 12 and 18°C. Intermediate amounts of extracted protein were located in three regions at 6-9, 15 and 21-24°C. One low extraction region existed at 3°C. The intermediate protein extraction regions occurred over temperatures that differed from the intermediate region of heart trimming (Figure 1).

The effect of temperature upon the extraction of salt-soluble protein from plate trimming is presented in Figure 1. Data revealed two extraction temperature regions. Three maxima were observed at 0-3, 9 and 15-24°C with the 15-24°C region appearing relatively broad. The lowest amount of protein was extracted at temperatures of -3, 6 and 12°C. These results are relatively similar to the protein extraction-temperature profile obtained from head meat (Figure 1).

Protein extraction-temperature profiles exhibited several maxima and minima ( $P < .05$ ) with each meat trimming exhibiting a unique protein extraction-temperature relationship. The unique protein extraction-temperature profiles for each of the trimmings studied offers a new approach in formulating low-salt meat products that utilize the extracted proteins for bind, emulsions or other textural properties. Combining trimmings that have protein extraction-temperature profiles that take advantage of complementary extraction maxima would appear to produce a meat block having high protein extractability over a broad processing temperature range. This would ensure that protein extraction

would be optimized over the temperature range encountered during processing. On the other hand, it may be desirable to minimize the extraction of protein to maintain the native textural property of the selected meat trimmings. In this case, combining trimming sources that share common minima would minimize protein extraction as long as the processing temperature remained within the overlapping minima. In general, blade trimming had the highest amount of extracted protein (5.37 g/100 g trim obtained at 12°C) whereas the lowest amount of extracted protein occurred with head trimming (2.32 g/100 g trim obtained at 3°C), a decrease of 57%. It is difficult to explain this large difference and the several maxima and minima at each trimming extraction temperature. Perhaps protein extraction is dependent on inherent factors such as species, age, sex, composition, pre- and post-mortem events, in addition to whether the meat was fresh or frozen. The lack of a standard method for determining salt extractable protein makes comparisons between this work and that of others especially difficult when different salt concentration as well muscle trimming or species are used.

### **Implications**

Optimal temperatures for the extraction of protein from different beef trimmings differs. Processors could utilize these differences in manufacturing low fat meat products with higher moisture content. The options from results of this research may help meat processors to select the desirable combination of raw meat material. Much work, however, remains to be done to identify optimal temperature protein extractability of the entire carcass and of specific muscle groups.

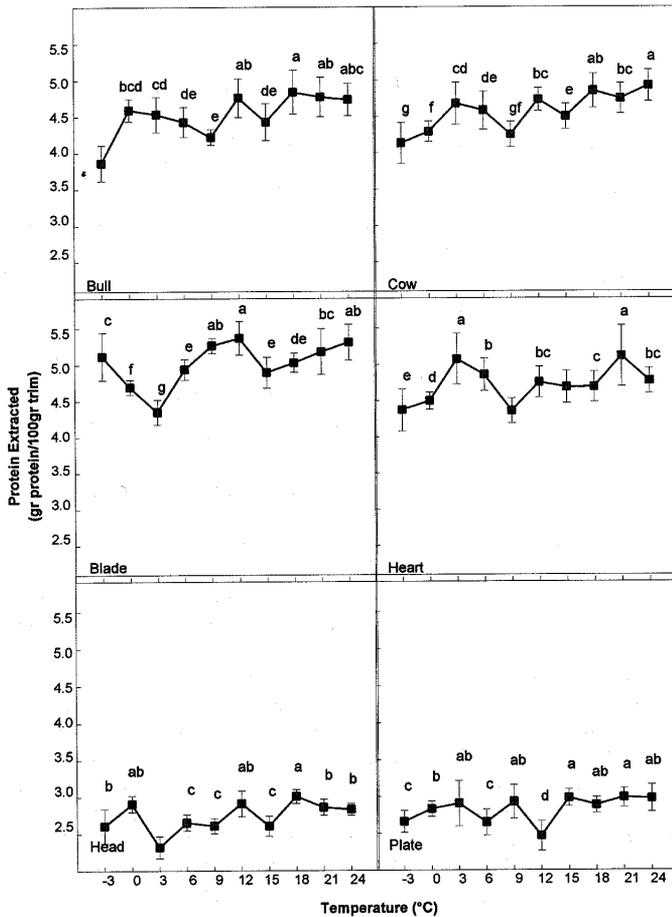
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**Table 1. Protein extraction and protein extraction efficiency from beef trimmings of six different carcass sources.**

Meat	Protein Extraction (g/100 g trimming)	Extraction Efficiency (%)	% Fat
Blade	5.01 <sup>a</sup>	24.46 <sup>b</sup>	3.6 <sup>d</sup>
Heart	4.72 <sup>b</sup>	31.41 <sup>a</sup>	4.2 <sup>d</sup>
Bull	4.57 <sup>c</sup>	21.98 <sup>d</sup>	9.9 <sup>cd</sup>
Cow	4.52 <sup>c</sup>	23.61 <sup>c</sup>	11.9 <sup>c</sup>
Head	2.83 <sup>d</sup>	19.53 <sup>e</sup>	28.4 <sup>b</sup>
Plate	2.73 <sup>d</sup>	21.89 <sup>d</sup>	39.6 <sup>a</sup>

<sup>abcde</sup> Numbers within a column not followed by a common superscript are significantly different ( $P < .05$ ).



**Figure 1. Effect of temperature on the protein extraction from bull, cow, blade, heart, head and plate trimming.**