THE EFFECT OF TEMPERATURE ON THE PROTEIN SOLUBILITY OF BEEF SHOULDER CLODS

G. Gadea de Lopez[1] and L.W. Hand[2]

Story in Brief

The study of protein functionality of raw materials used in meat processing is important for final product quality and yields. In this study, the effect of temperature on the solubility of beef shoulder clod muscle proteins was evaluated in the range of -2 to 26°C at 2°C intervals. Samples were treated with 2% NaCl, 0.03 M phosphate or 1.1 M KI for the extraction of total, sarcoplasmic and myofibrillar fractions, respectively. Regression models indicated maximum amounts of solibilized total protein were obtained at 14°C, sarcoplasmic at 26°C and myofibrillar at 6°C. This research indicates that 14°C is the temperature to obtain maximum solubility of beef shoulder clods used in meat products.

(Key Words: Protein Solubility, Beef Clods, Temperature.)

Introduction

With the increased interest in the consumption of low-fat, low-sodium meat products, research addressing the effects of processing conditions on the functionality of meat proteins have become a matter of major importance. The problems of adequate water binding have become a main issue in processing with the increased amount of added water present in low fat products due to the USDA "40 percent rule" (Federal Register, 1988). Water binding potential (expressed as water holding capacity, WHC) and protein solubility may be considered the two most important functional properties that define the characteristics of the final product. Previous studies typically examined functionality of trimmings using high salt concentrations to obtain maximal protein extractions. However, these results may not be as useful in a lower salt system, as is the current industry norm. The objective of this study was to determine the effect of temperature on the water holding capacity and solubility of beef shoulder clod muscle proteins.

[1]Graduate Student [2]Assistant Professor

Materials and Methods

Three USDA Choice beef shoulder clods were obtained (approximately 72 hr post-mortem) from a local supplier. The clods were frozen (-29±2°C for 72 hr) and thawed (3±1°C, 72 hr). Each clod represented one replication.

The clod muscles were separated and trimmed of all visible fat. The weight of the clods after fat removal was 5.4±0.1 kg. The meat was ground (grinder, model 5424852, Biro Mfg. Co., Marblehead, OH) using a 2.54 cm plate and reground through a 5 mm plate before mixing (Leland ribbon-paddle mixer) for 1 min. The ground meat was divided into 16 portions and vacuum packaged (Multivac, Kansas City, MO). One sample portion was used for the determination of protein (20.21%, SE 0.388), fat (5.82%, SE 1.03) and moisture (72.67%, SE 0.81) content (AOAC, 1984). Each sample was randomly assigned to one of 15 temperature treatments (from -2 to 26°C, 2°C intervals, ±0.1°C) and frozen (-29±2°C) until analyzed. Each sample was thawed (3±1°C) for eighteen hours prior to the start of protein extraction.

Total proteins were extracted (quadruplicate) using a modified version of the method of Hand et al. (1985). The samples were weighed (50±0.1 g) in 250 mL Nalgene bottles and allowed to equilibrate to the required temperature. Then, a 100±0.1 mL NaCl 2% (w/v) solution (also at the required temperature) was added to each sample. The bottles were placed in a covered shaker water bath (model BKS-350, Gallenkamp and Co., Sussex, England) and shaken at 120 rpm for 10 min. The temperature of the water bath (±0.1°C) was regulated by a refrigerated circulator (Lauda model RMS-20, Brinkmann Instruments, Westbury, NY). After the extraction period, samples were centrifugated at 1860 x g for 10 min (model J-6M Beckman Instruments, Palo Alto, CA) at the same temperature of extraction, and filtered through #1 Whatman filter paper. The protein content of the filtrates was determined by the Biuret method (Gornall et al., 1949).

Sarcoplasmic and myofibrillar proteins were extracted using a 0.03 M potassium phosphate solution at pH 7.4 and 1.1 M potassium iodide in a 0.1 M phosphate solution at pH 7.4, respectively, according to a modified version of the methods of Helander (1957) and Sayre and Briskey (1963). Samples weighing 5±0.05 g were placed in 50 mL polycarbonate tubes (quadruplicate) and temperature was equilibrated to that required by each treatment. Sarcoplasmic proteins were extracted first with 30 mL of 0.03 M potassium phosphate at pH 7.4 (also at the same temperature). The samples were shaken at 90 rpm for 2 hr. After the extraction period, the tubes were centrifuged at 3640 x g for 15 min at the temperature of extraction. After separation of the supernatant, 30 mL of KI 1.1 M solution (pH 7.4) were added to each tube. The samples were shaken for 4 hr at 90 rpm and centrifuged at 3640 x g for 15 min. The supernatant containing the extracted myofibrillar proteins was separated by

filtration. Sarcoplasmic and myofibrillar extracts were analyzed for protein content using the Biuret method (Gornall et al., 1949).

Water holding capacity was determined by a modified method of Jauregui et al. (1981). The temperature of operation was varied, as needed for each of the treatments, and the centrifugation time and rotor speed were changed from 15 min and 30,900 x g to 45 min and 3640 x g, respectively. This experiment was performed in triplicate.

The results from this experiment were analyzed using linear regression (Steel and Torrie, 1980) and the analysis of variance was performed with the SAS program (SAS Institute, Inc., Version 6.1), with temperatures as treatments.

Results and Discussion

The effect of temperature on the total salt extractable protein is shown in Figure 1. The regression line ($P<0.05$) indicated that a maximum amount was solubilized at 14°C, within the range studied. Reports from other studies have indicated that the optimal temperature for the extraction of total protein from beef and pork combination sources is 7.2°C, using a 7.5% NaCl solution (Gillett

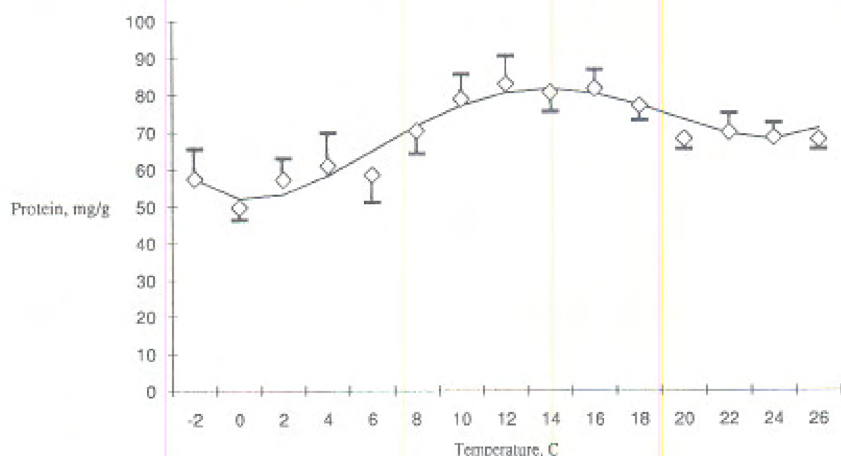

Figure 1. Effect of temperature on the solubility of total salt extractable proteins.

Solid line indicates significant regression line.
Diamonds and connecting bars indicate treatment means and standard errors.

et al., 1977). However, the NaCl solution used in this study was 2.0%, a level more characterisic of current meat industry conditions, especially in light of lower salt and sodium products.

Figure 2 shows the effect of the temperature on the solubility of sarcoplasmic proteins. The significant model indicated that the point of maximum solubility is 26°C. However, there were small magnitudes of change in the range of 6° and 16°C before increasing to the maximum at 26°C.

The effect of temperature on myofibrillar protein solubility is shown in Figure 3. The regression curve ($P<0.05$) indicated that the optimum temperature for extraction of myofibrillar proteins is 6°C. These results compare with those of Rust (1977), which suggest that the optimum temperature for the extraction of contractile proteins appears to be in the range of 4.4-7.2°C. The extent of protein recovery achieved in the total soluble, sarcoplasmic and myofibrillar solubility methods is comparable to the results of Helander (1957) and Ashgar and Yeates (1974), utilizing similar methodology.

Temperature had no ($P>0.05$) effect on water holding capacity (WHC). The overall mean was 43.7% (±0.2) which is similar to the findings of Jauregui et al. (1981).

From this study it can be concluded that maximum amounts of total salt extractable proteins are solubilized at 14°C. This temperature information could

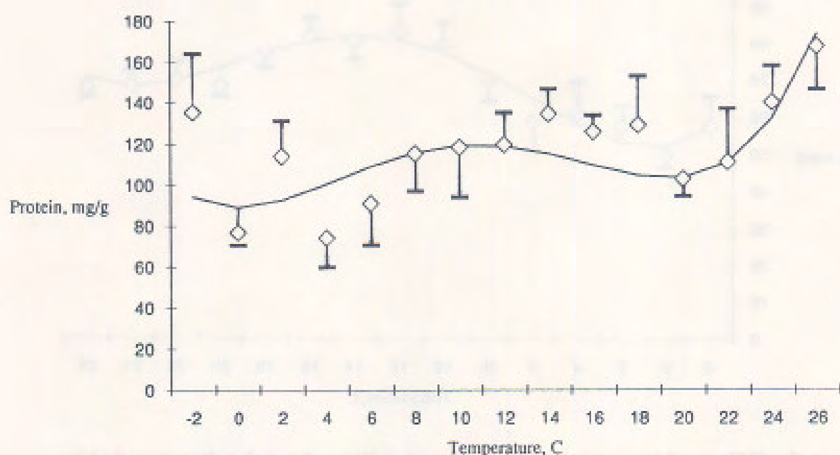

Figure 2. Effect of temperature on the solubility of sarcoplasmic proteins.

Solid line indicates significant regression line.
Diamonds and connecting bars indicate treatment means and standard errors.

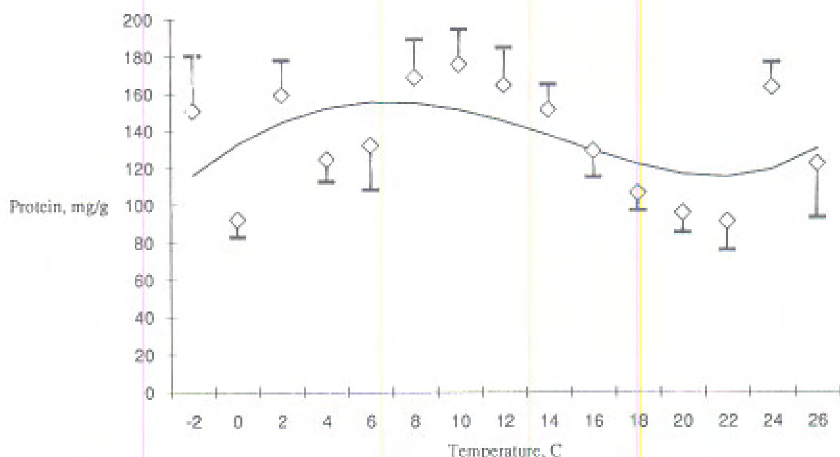

Figure 3. Effect of temperature on the solubility of myofibrillar proteins.

Solid line indicates significant regression line.
Diamonds and connecting bars indicate treatment means and standard errors.

be used to assist low fat meat products to perform to their maximum functionality capability. Further research is necessary to ascertain if these temperatures are still optimal in a final product such as a low fat, high moisture frankfurter.

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