## DIE GEWINNUNG DES PROTEINS VON KNOCHEN DURCH MECHANISCHE KNOCHENENTFERNUNGSGERÄTE

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Moderne Knochenverarbeitungsanlagen gewinnen den Talg aus Knochen mit heissem Wasser, entfernen das kollagene Protein durch Ausschleuderung und chemische Auflösungsmittel, dann trocknen und mahlen sie das Übriggebliebene, um gedampftes Knochenmehl zu erhalten. Diese Produkte werden selten für menschliche Nahrung gebraucht und haben einen relativ minderen Geldwert. Wenn der Prozentsatz des auf dem Knochen bleibenden mageren Fleisches dem Gewicht des entfernten Gebeins beigefügt wird, so ergibt dieses ungefähr 20 bis 25% des Gesamtkörpergewichts unserer Fleischproduktion. Durch mechanische Knochenentfernung kann 20 bis 50% des Knochengewichts für menschliche Nahrung gewonnen werden. Der Prozentsatz ist oft höher für Fisch- und Geflügelknochen.

Zwölf Gruppen von Knochen aus verschiedenen anatomischen Stellen in Schweine-, Kalb- und Rindfleisch Körpern wurden durch eine 9,5mm Platte gemahlen, und die Knochen mechanisch entfernt durch ein "Beehive" mechanisches Knochenentfernungsgerät[1], ausgestattet mit 0,46 mm Löchern im Zylinder. Vor dem Mahlen wurden Knochenproben aus jeder Gruppe wahllos ausgesucht für physische Trennung mit der Hand.

Der Fleischgewinn durch mechanische Knochenentfernung war höher, als möglich war, wenn das ganze Fleisch mit der Hand von den Knochen entfernt wurde. Das Knochenmark, das von 30 bis 70% des Gewichts der entfleischten Knochen ausmacht, war die Ursache des höheren Gewinns. Mechanisch entferntes Fleisch von runden Knochen enthielt weniger Protein und mehr Trockenstoff: Fett, Asche und Kalzium, als mechanisch entferntes Fleisch von der Wirbelsäule. Grössere Mengen von Fleisch und mehr rotes Knochenmark wurden von der Wirbelsäule als von runden Knochen erhalten. Mechanisch entferntes Fleisch von allen Quellen enthielt weniger kollagenes Protein und mehr Kalzium als mit der Hand entferntes Fleisch, also hatte das mechanisch entfernte Fleisch einen höheren Nahrungswert.

Die Knochenreste hatten einen hohen Trockenstoffgehalt: Asche und Kalzium, hatten aber weniger Fett, wenn mit mechanisch entferntem Fleisch oder mit markenthaltenden Knochen verglichen. Die Knochenreste enthielten 20 bis 25% rohes, grösstenteils kollagenes Protein (Frischgewicht Basen).

[1] Hergestellt von: Beehive Machinery, Inc., P. O. Box CC, 9100 South 500 West, Sandy, Utah 84070, U. S. A.

## Le désossement mécanique des carcasses: : RENDEMENT SUPÉRIEUR EN CE QUI CONCERNE LE TAUX DES PROTÉINES

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La poudre obtenue par le broyage et l' étuvage des os, après en avoir extrait le suif et le collagène par action centrifuge, n' a guère de valeur commerciale et de toute façon ces produits ne sont pas comestibles. Quand on ajoute au poids net des os le pourcentage de la viande maigre attachée à ceux-ci, on réalise de 20 à 25 % du poids total de la carcasse. Le désossement mécanique des carcasses donne un résultat bien plus élevé : de 20 à 50 % du poids total peut être récuperer à l' usage de la consommation humaine. Ce chiffre est encore plus élevè dans le cas du désossement mécanique des os de volailles et de poissons.

Douze échantillons se composant de divers os de porcs, de beuofs et de veaux, broyés pas une plaque de 9.5 mm, ont été désossés par un Beehive Mechanical deboner (désosseur),[1] équipé d' un cylindre (perforé de trous de .46mm). On a prélevé au hasard, préalablement au broyage des douze lots, des échantillons destinés qu désossement manuel.

Le rendement du désossement méchanique est bien supérieur à celui du désossement manuel : l' augmentation de rendement est dû au fait que la moelle forme de 30 à 70 % du poids total des os. Quelque soit son origine, la viande désossée mécaniquement contient moins de protéine et plus de résidu : matières sèches, cendre et calcium que la viande des vertèbres désossées mécaniquement. Celles-ci produisent plus de viande et plus de moelle rouge que les os longs. Il en résulte que la viande désossée mécaniquement, contenant plus de calcium et moins de collagenè a plus de valeur nutritive que celle désossée manuellement.

Les résidus osseux sont donc caractérisés par la présence d' un taux plus élevé des matières seches, de la cendre, et du calcium et par un taux moins élevé des matières grasses que dans le cas où le désossement est effectué mécaniquement, où dans le cas où l' on considère l' ensemble des os et de la moelle. Le résidu osseux contient donc de 20 à 25 % de protéine brut (an grande partie de la collagène).

[1] Manufactured by Beehive Machinery, Inc., P. O. Box CC, 9100 South 500 West, Sandy, Utah 84070, U. S. A.

## RECOVERY OF PROTEIN FROM BONES BY MECHANICAL DEBONERS

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Modern bone processing plants extract tallow from bones with hot water, remove the collagen protein through centrifugation and chemical liquefying agents and then dry and grind the remaining residue into steamed bone meal. These products are seldom used for human consumption and they are relatively low in monetary value. When the percentage of lean meat which remains attached to bone is added to the cleaned bone weight approximately 20 to 25% of our total carcass meat production is accounted for. Through mechanical deboning 20 to 50% of the bone weight can be saved for human consumption. The figures are often higher for fish and poultry bones.

Twelve lots of bones from different anatomical locations within pork, veal and beef carcasses were ground through a 9.5 mm plate, and mechanically deboned using a Beehive mechanical deboner[1] equipped with .46 mm holes in the cylinder. Prior to grinding, random samples of bones from each lot were selected for physical separation by hand.

The yield of mechanically deboned meat was higher than was possible when all meat was removed from the bones by hand. Bone marrow, which makes up 30 to 70% of the cleaned bone weight was responsible for the increased yields. Mechanically deboned meat from round bones contained less protein and more dry matter, fat, ash and calcium than mechanically deboned meat from vertebrae. Greater amounts of meat and more red bone marrow were obtained from the vertebrae than from round bones. Mechanically deboned meat from all sources contained less collagen and more calcium than hand boned meat making mechanically deboned meat higher in nutritional value.

Bone residue was high in dry matter, ash and calcium, and low in fat when compared to mechanically deboned meat or when compared to whole bone containing marrow. Bone residue contained 20 to 25% crude protein (fresh wt. bases) most of which was collagen.

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## ВОССТАНОВЛЕНИЕ КОСТЯНОГО БЕЛКА МЕХАНИЧЕСКИМИ СЕПАРАТОРАМИ

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Современные костеобрабатывающие заводы извлекают сало из костей центрифугированием или превращают его в жидкость химическими способами. Тогда, костяные остатки высушиваются, и, после этого, перемалываются в паренную муку. Эти продукты редко назначаются для человеческого потребления, и следовательно имеют относительно низкую денежную ценность. Когда процент постного мяса, еще прикрепленного к костьям прибавляется к чистой кости, то получается до 20-25 % продукции парного мяса.

Путем механического снимания мяса с костей, от 20-50 вес.% костей может сохраниться для человеческого потребления. Эти цифры часто выше для костей рыбы и домашних птиц.

Двенадцать долей костей из разных мест анатомии свиной, телячьей и говяжьей туши раздробилось через сито с 9,5 мм. дырками и кости механически снимались мясным сепаратором "Бигайв" ("Улей")[I], снабженным 0,46 мм. отверстиями в цилиндре. До раздробления, экземпляры брали из костей теорией вероятности для ручной очистки.

Получение мяса механическим процессом было больше, чем ручным. Повышение продукции было осуществлено благодаря костному мозгу, который составляет от 30-70 вес.% очищенного веса костей. Мясо от круглых костей, которое снимается механическим способом, содерживает меньше белка и больше сухих веществ, жира, золы и кальция, чем мясо, которое снимается от позвонков тем же способом. Более повышенное количество мяса и красного костного мозга получалось от позвонков, чем от круглых костей. Мясо из любого источника, снимаемое с костей механическим способом, содерживает меньше коллагена и больше кальция, чем мясо снимаемое ручным способом. Это значит, что мясо, механически снимаемое с костей, обладает высшей питательностью.

Костяные остатки обладают высоким уровнем сухих веществ, золы и кальция, и низким уровнем жира в сопоставлении или с мясом механически снимаемым с костей, или целой костью, которая содерживает костный мозг. Костяные остатки содерживают от 20-25 вес.% белка, главным образом в виде коллагена.

[I] Производится фирмой Beehive Machinery, Inc., P. O. Box CC, 9100 South 500 West, Sandy, Utah 84070, U. S. A.

# RECOVERY OF PROTEIN FROM BONES BY MECHANICAL DEBONERS

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## Introduction

The volume of fresh beef, pork and lamb bones produced by today's meat fabricating industry is increasing rapidly as boxed meat replaces carcasses. Modern bone processing plants extract the tallow from these bones with hot water, remove the collagen protein through centrifugation and chemical liquefying agents and then dry and grind the remaining residue into steamed bone meal. These products are not used for human consumption and they are relatively low in monetary value. Kelly et al., (1968) reported that bone cleaned of visible lean varied from 12.1 to 27.6% of the beef carcass weight. Bone from typical choice grade cattle, sheep and hog carcasses makes up 10 to 18% of the carcass weight (Hedrick et al., 1969; Epley et al., 1971; Field et al., 1963 and 1967; Craddock et al., 1974; Brooks et al., 1964; Cuthbertson and Pomeroy, 1962). When the percentage of lean meat which remains attached to the bone is added to the cleaned bone figures, approximately one-fifth of our total carcass meat production is accounted for. According to Field (1974), recovering meat from bones by mechanical deboning can increase the monetary value of bone and supply additional protein for world needs.

The objective of this research was to determine the amount of edible protein that can be recovered from bones now being processed for inedible uses.

## Methods

Four lots of trimmed pork bones, five lots of trimmed beef bones and three lots of partially trimmed veal bones were obtained from meat fabrication plants, ground through a 9.5 mm plate and mechanically deboned using a Beehive mechanical deboner[1] equipped with .46 mm holes in the cylinder. All frozen bone lots were tempered in the same room and they had some frost remaining in them at the time of grinding. Prior to grinding, random samples of bones representing three to thirteen carcasses were selected from each lot for physical separation. These bones were trimmed of all adhering lean, fat and tendon. Yield of lean, fat and tendon was recorded as hand separated meat yield. Major butcher hog bones involved were: radius, ulna and humerus from the picnic; tibia, fibula, femur and ox coxae from the ham; and scapula from the Boston butt. Sow loin bones included the lumbar and thoracic vertebrae and the dorsal portion of the ribs normally left in the wholesale loin. Major bones from 1 to 2 month old veal were: scapula, humerus, radius and ulna from the shoulder; lumbar, thoracic and cervical vertebrae, ribs and sternum from frames; lumbar, thoracic and cervical vertebrae and the dorsal portion of the ribs from backs. Veal frames and backs were not closely trimmed and meat was left between the ribs. Major bones from cutter and canner cow beef included: thoracic vertebrae and ribs (6 through 12) from the rib and plate; os coxae from the rump; and lumbar vertebrae from the shortloin. Major bones from choice beef were: cervical vertebrae from the neck and ribs 6 through 12 from the plate. Because of a limited supply of some of the above bones and because of time involved in collecting the data, economic considerations allowed only one 200 to 400 kg batch of each group of bones to be mechanically deboned.

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Fat, protein, dry matter and ash were run in duplicate on the meat and in triplicate on bone residue after thorough mixing, using standard AOAC methods (1970). Calcium was determined by atomic absorption spectrophotometry as outlined by the Perkin-Elmer Corp. (1964).

Weight of protein, fat and moisture recovered from hand separated and mechanically deboned meat was based upon yield and upon chemical analysis of the meat.

## Results and Discussion

Amount of meat adhering to bones from meat fabricating plants and yield of mechanically deboned meat from these bones is shown in table 1. The yield of Beehive mechanically deboned meat was higher than was possible when all meat (lean, fat and tendon) was removed from the bones by hand. Bone marrow, which makes up 30 to 70% of the cleaned bone weight (Field et al., 1975) was responsible for the increased yields. Temperature of ground bones out of the bone grinder fluctuated depending upon the bone source. Harder bones from the older, more mature cows had a higher temperature than most ground bones from younger animals with a similar amount of meat adhering to them. Veal bones showed the lowest temperature after grinding. Similar trends were present for mechanically deboned meat extruded from the cylinder. It is evident from these high temperatures (11 to 38 C) that mechanically deboned meat from all bone sources except veal (0 to 3 C) must be chilled immediately after deboning to prevent microbial growth and preserve color.

Composition of mechanically deboned meat from bones which are normally rendered is found in table 2. The highest protein percentages were in meat from sow loin bones (14.01%), veal frame bones (17.57%), veal back bones (15.98%) and beef necks (17.18%). In these bones, 37 to 46.7% of the weight was meat (table 1). In contrast, picnic and rump bones yielded 14.3 and 18.1% of their weight, respectively, as hand boned meat. The protein content of mechanically deboned meat from picnic bones was 9.06% and 10.05% from cow rump bones (table 2). Highest fat percentages in the mechanically deboned product were present in meat from picnics (42.37%) and rumps (41.89%). As would be expected, those bones which had the most meat adhering to them yielded the most protein. Bones which had the least meat adhering to them yielded mechanically deboned meat with the least protein and the most fat. In addition, most of the lots of mechanically deboned meat which were high in fat were also high in ash and calcium. An exception was mechanically deboned meat from the veal shoulder bones which contained 7.56% fat, but had the highest ash and calcium percentages (table 2). Calcium and ash percentages were lowest in deboned meat from sow loin bones and veal backs. Hand separated meat yield for sow loin and veal back bones was over 40%. It is evident that increasing the amount of meat on the bones will decrease fat, calcium and ash percentage in mechanically deboned meat. However, diluting bone with more meat does not reduce weight of calcium, ash or fat extracted from bone. It merely decreases these percentages because of more meat present.

When whole carcasses or whole carcass parts are mechanically deboned calcium percentages in the meat are often .10 to .30% (Field et al., 1974a,b). Mechanically deboned meat from whole carcasses or whole carcass parts is very similar to hand boned meat in moisture, fat, protein and ash percentage.

Higher levels of calcium in mechanically deboned meat when compared to hand boned meat are not detrimental. Even high calcium levels such as those



found in table 2 cannot be detected by a specialized panel when the meat is incorporated into sausage products at levels of 30% or less. In addition, a higher calcium content in mechanically deboned meat than in hand boned meat is beneficial in many diets. Meat is low in calcium (Watt and Merrill, 1963) and the human diet is low in calcium (Walker, 1972 and Lutwak, 1974). The retention of calcium from bone sources is high (Forbes et al., 1921 and Mitchell et al., 1937). Therefore, mechanically deboned meat which is higher in calcium than hand boned meat can help balance the calcium: phosphorus ratio and prevent calcium deficiencies in the human diet.

Composition of hand separated meat from samples of the same bones used for mechanical deboning are shown in table 3. In every case the percentage fat in mechanically deboned meat (table 2) was higher than the percentage fat in hand boned meat from the same bones. The reverse was true for protein where hand boned meat had the highest protein percentage. Calcium percentage in hand boned meat was higher than the .01% reported by Watt and Merrill (1963) for red meat and was undoubtedly a result of bone chips resulting from thorough hand cleaning of the bones.

The data in tables 2 and 3 were used to derive the figures in table 4 where weight of protein, fat and moisture recovered from 100 kg of bones destined for rendering are reported. Here again veal back and frame bones and sow loin bones which had the most separable meat attached to them (table 1) yielded the most protein. Mechanically separated protein from veal frames and backs superseded hand separated protein from frames and backs but protein yields were similar for hand and machine boned meat (table 4). Since all the protein was removed from the bone surface by hand, the increased amounts in veal frame bones must have come from bone marrow. Mechanically deboned meat from sow loin bones did not show the same increase in protein yield over hand separated meat as veal frames because bone marrow in older animals has a much higher proportion of fat to protein than veal bones (Dietz, 1949). In many of the lots of bones studied (ham, picnic, Boston butt, rump, shortloin and plate) total protein weight was actually higher in the hand boned meat. In these instances, more protein was discarded with the bone residue than was recovered from bone marrow. Bone marrow in the femur, tibia, fibula and pelvic girdle of adult animals has high concentrations of fat and therefore is low in protein (Gong and Arnold 1965). Mechanically deboned meat is always lower in connective tissue than hand boned meat because some tendon is discarded with the bone (Field et al., 1974 a,b). Therefore, mechanical removal of tendon that was present in hand boned meat and addition of very little protein from marrow resulted in lower amounts of protein removed by machine even though the machine removed more total weight (table 1). Machine deboning of the femur, tibia, fibula and pelvic girdle of adult animals clearly does not yield as much protein as vertebrae and ribs. Moisture recovered from bones was about equal in 100 kg of hand vs. 100 kg of machine boned meat except for veal bones where the high moisture content of the marrow increased the amount of water in mechanically deboned veal.

Composition of residue from bones which are normally rendered is found in table 5. Fat percentages are much lower and protein percentages are much higher when compared to mechanically deboned meat in table 2. This confirms our earlier observation that much of the fatty marrow is extracted from the bone and combined with the meat during mechanical deboning. Higher protein values in bone residue than in mechanically deboned meat (table 2) also help to confirm the observation that connective tissue in meat is passed out with the bone. The composition of whole bone plus marrow as reported by Field



et al., (1974c) is also different than the data for bone residue in table 5. They reported that veal bone and cow bone contained 6.44 and 17.05% fat, respectively. The bone residue in table 5 ranged from .52 to 1.85% fat for veal and 4.65 to 8.07% fat for cows. Field et al., (1974c) also found that whole bone contained much less protein than the bone residue analyzed in this study. Crude protein found in bone residue is high in collagen and is therefore low in nutritional value. Dickerson (1962) and Campo and Tourtellotte (1967) found that 90 to 95% of bone nitrogen was accounted for by collagen. Field et al., (1970) found 67% collagen in epimysial tissue and tendon which are removed with bone. Ash and calcium in the bone residue was high as expected. Field et al., (1974c) found that calcium in dry-fat-free bone ranged from 18.4 to 24.1% of the weight depending upon species and age of animal.

## Summary

Composition of hand boned meat, mechanically deboned meat and bone residue from 12 different groups of veal, beef and pork bones were studied to determine potential edible protein yields from bones destined for rendering. Yield of mechanically deboned meat was higher than when the bones were hand cleaned of all visible lean, fat and tendon. However, percent protein in mechanically deboned meat was lower and fat content was higher when compared to hand boned meat. Differences were due to bone marrow which was extracted as deboned meat and to connective tissue which was removed from the meat during mechanical deboning.

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Table 1. MEAT YIELD AND MEAT TEMPERATURE FROM BONES WHICH ARE NORMALLY RENDERED

| Bone source | No.[a] | Yield, %[b] | | Temperature of mechanically deboned meat, °C | |
|---|---|---|---|---|---|
| | | Hand | Mechanical | Out of grinder | Out of deboner |
| Butcher hogs | | | | | |
| Ham | 4 | 25.1 | 27.5 | 5 | 11 |
| Picnic | 5 | 14.3 | 21.7 | 2 | 20 |
| Boston butt | 13 | 18.7 | 22.6 | 2 | 13 |
| Sows | | | | | |
| Loin | 3 | 46.7 | 51.0 | 1 | 15 |
| Veal | | | | | |
| Shoulder | 4 | 16.7 | 36.2 | -1 | 0 |
| Frames | 3 | 37.0 | 60.8 | 0 | 3 |
| Backs | 3 | 42.0 | 63.0 | -1 | 0 |
| Cow beef | | | | | |
| Rib, plate | 3 | 26.2 | 32.9 | 5 | 20 |
| Rump | 4 | 18.1 | 26.3 | 8 | 38 |
| Short loin | 4 | 25.6 | 34.0 | 7 | 20 |
| Choice beef | | | | | |
| Neck | 3 | 41.3 | 48.4 | 4 | 14 |
| Plate | 3 | 26.9 | 28.8 | 4 | 13 |

[a] Each number represents more than one bone, i.e., 4 indicates that all bones from 4 different hams of 4 different hogs were cleaned of all fat, lean and tendon.

[b] Weight of boneless product divided by fresh meat and bone weight.

Table 2. COMPOSITION OF MECHANICALLY DEBONED MEAT FROM BONES WHICH ARE NORMALLY RENDERED[a]

| Bone source | Dry matter | Ether extract | Crude protein | Ash | Calcium |
|---|---|---|---|---|---|
| Butcher hogs | | | | | |
| Ham | 54.81 | 39.02 | 10.21 | 4.07 | 1.39 |
| Picnic | 55.59 | 42.37 | 9.06 | 3.68 | 1.22 |
| Boston butt | 43.15 | 26.04 | 13.50 | 2.71 | .73 |
| Sows | | | | | |
| Loin | 46.15 | 29.53 | 14.01 | 1.77 | .41 |
| Veal | | | | | |
| Shoulder | 26.27 | 7.56 | 12.85 | 5.36 | 1.76 |
| Frames | 26.64 | 6.79 | 17.57 | 2.59 | .71 |
| Backs | 24.21 | 5.81 | 15.98 | 2.21 | .54 |
| Cow beef | | | | | |
| Rib, plate | 50.33 | 31.87 | 12.98 | 4.57 | 1.55 |
| Rump | 58.06 | 41.89 | 10.05 | 4.35 | 1.55 |
| Short loin | 50.97 | 33.38 | 11.62 | 4.35 | 1.50 |
| Choice beef | | | | | |
| Neck | 35.13 | 13.76 | 17.18 | 3.43 | 1.06 |
| Plate | 49.88 | 32.70 | 11.43 | 4.35 | 1.49 |

[a] Data expressed as a percent of fresh weight.



Table 3. COMPOSITION OF HAND SEPARATED MEAT FROM BONES WHICH ARE NORMALLY RENDERED[a]

| Bone source | Dry matter | Ether extract | Crude protein | Ash | Calcium |
|---|---|---|---|---|---|
| Butcher hogs | | | | | |
| Ham | 50.39 | 27.99 | 15.67 | .54 | .029 |
| Picnic | 42.15 | 22.29 | 19.17 | .68 | .043 |
| Boston butt | 38.24 | 12.78 | 19.21 | .86 | .079 |
| Sows | | | | | |
| Loin | 45.73 | 23.49 | 16.72 | .72 | .037 |
| Veal | | | | | |
| Shoulder | 24.33 | 3.06 | 20.23 | .92 | .035 |
| Frames | 26.68 | 5.57 | 18.86 | .92 | .045 |
| Backs | 24.29 | 3.69 | 18.69 | 1.05 | .042 |
| Cow beef | | | | | |
| Rib, plate | 47.97 | 31.65 | 14.16 | .81 | .013 |
| Rump | 33.43 | 11.85 | 17.56 | .80 | .083 |
| Short loin | 43.42 | 22.52 | 16.38 | .98 | .014 |
| Choice beef | | | | | |
| Neck | 30.16 | 8.99 | 19.33 | 1.05 | .056 |
| Plate | 51.89 | 27.92 | 13.20 | .50 | .051 |

[a] Data expressed as a percent of fresh weight.

Table 4. WEIGHT OF PROTEIN, FAT AND MOISTURE RECOVERED FROM 100 kg OF BONES DESTINED FOR RENDERING

| Bone source | Protein recovered, kg | | Fat recovered, kg | | Moisture recovered, kg | |
|---|---|---|---|---|---|---|
| | Hand | Machine | Hand | Machine | Hand | Machine |
| Butcher hogs | | | | | | |
| Ham | 3.93 | 2.81 | 7.02 | 10.73 | 12.45 | 12.43 |
| Picnic | 2.74 | 1.97 | 3.19 | 9.20 | 8.28 | 9.64 |
| Boston butt | 3.59 | 3.06 | 2.39 | 5.89 | 11.55 | 12.85 |
| Sows | | | | | | |
| Loin | 7.81 | 7.15 | 10.97 | 15.06 | 25.35 | 27.47 |
| Veal | | | | | | |
| Shoulder | 3.37 | 4.66 | .51 | 2.73 | 12.64 | 26.69 |
| Frames | 6.98 | 10.69 | 2.06 | 4.12 | 27.13 | 44.61 |
| Backs | 7.85 | 10.07 | 1.55 | 3.66 | 31.80 | 47.75 |
| Cow beef | | | | | | |
| Rib, plate | 3.71 | 4.27 | 8.29 | 10.49 | 13.64 | 16.35 |
| Rump | 3.18 | 2.65 | 2.14 | 11.02 | 12.05 | 11.03 |
| Short loin | 4.19 | 3.95 | 5.75 | 11.35 | 14.49 | 16.67 |
| Choice beef | | | | | | |
| Neck | 7.98 | 8.32 | 3.71 | 6.66 | 28.85 | 31.40 |
| Plate | 3.55 | 3.30 | 7.51 | 9.42 | 12.95 | 14.44 |



Table 5. COMPOSITION OF BONE RESIDUE FROM BONES WHICH ARE NORMALLY RENDERED[a]

| Bone source | Dry matter | Ether extract | Crude protein | Ash | Calcium |
|---|---|---|---|---|---|
| Butcher hogs | | | | | |
| Ham | 65.63 | 19.61 | 21.47 | 25.10 | 10.62 |
| Picnic | 64.22 | 6.87 | 20.05 | 30.41 | 11.71 |
| Boston butt | 64.70 | 7.73 | 19.66 | 32.84 | 12.84 |
| Sows | | | | | |
| Loin | 61.59 | 9.00 | 22.74 | 26.57 | 10.07 |
| Veal | | | | | |
| Shoulder | 50.60 | .69 | 22.22 | 26.25 | 8.34 |
| Frames | 45.06 | .52 | 23.80 | 22.63 | 8.32 |
| Backs | 36.88 | 1.85 | 22.23 | 12.89 | 3.66 |
| Cow beef | | | | | |
| Rib, plate | 72.43 | 6.13 | 23.05 | 40.49 | 14.94 |
| Rump | 72.58 | 4.65 | 24.70 | 38.42 | 14.08 |
| Short loin | 70.09 | 8.07 | 23.98 | 35.38 | 14.21 |
| Choice beef | | | | | |
| Neck | 63.07 | 3.72 | 23.42 | 31.54 | 12.41 |
| Plate | 59.73 | 9.77 | 21.93 | 23.82 | 9.67 |

[a] Data expressed as a percent of fresh weight.