Nutrient content of meat and bone meal available in the market of Chittagong district of Bangladesh

ME Hossain¹, FI Zummy¹, MM Khatun² and S Islam³

¹Department of Animal Science and Nutrition, Chittagong Veterinary and Animal Sciences University, Khulshi, Chittagong-4225, Bangladesh; ²Product Executive, Agrovet division, Square centre, 48 Mohakhali CA, Dhaka-1212; ³Department of Animal Science and Nutrition, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706, Bangladesh

Abstract

Meat and bone meal (MBM) is a potential source of animal protein for poultry. The study was undertaken to investigate the variations in the chemical composition of MBM available in different feed markets of Chittagong, Bangladesh. Secondary data from one hundred ten different MBM samples were analyzed in triplicate for dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and total ash (TA) in the Poultry Research and Training Centre laboratory of Chittagong Veterinary and Animal Sciences University, Chittagong, Bangladesh during 21st October 2014 to 2nd December 2016. Data were collected, compiled and analyzed. Results indicated that, there were wide ranges of variations in the chemical compositions for different parameters. DM varied from 91.9 to 98.7% and CP varied from 18.5 to 74.5%. Similarly, CF varied from 1.1 to 2.9% and EE varied from 7.5 to 45.0%. TA varied from 4.8 to 33.6%. There was a strong negative relationship between CP and TA (r=-0.831; R²=0.691; P<0.001). However, DM and TA were positively correlated (r=0.374; R²=0.139; P=0.003). It was concluded that, chemical composition of MBM is widely variable. Wet chemistry analysis is suggested before inclusion of MBM in the diets of dairy, poultry and pet animals.

Key words: ash, crude protein, crude fiber, dry matter, ether extract, meat and bone meal

Introduction

Meat and bone meal (MBM) is a potential feed supplement for dairy, poultry and pet animals (Dale, 1997; Parsons et al., 1997; Liu, 2000; Hendriks, 2002; Ziggers, 2010; Jacob, 2015; Moutinho et al., 2017). This is a rendered product derived from mammalian tissues including bone, exclusive of added blood, hair, hoof, horn, hide trimmings, manure, stomach and rumen contents except in such amounts as may occur unavoidably in good processing practices (Meeker, 2009). MBM is a good source of protein (48-52%), fat (8-12%) and ash (33-35%) which has widely been utilized as a protein source in animal and pet foods to improve the quality of livestock feed (Kratter and Davis 1959; Hendriks et al., 2002). MBM may contribute up to 30% of the dietary protein supply in poultry and pig ration. Besides being a valuable protein source, MBM also serves as a vital source of energy, calcium, phosphorus and other trace minerals (Hendriks et al., 2002) and can successfully replace up to 50% of the dietary fish meal (Yang et al., 2004). Raw materials used for MBM come mainly from the slaughter house by-products of pig, cattle and sheep and their main components are residual bone, skin, fat, offal and meat after removal of the edible parts using advanced processing technology and high temperature sterilization to make the organic components more absorbable and palatable to the animals (Parsons et al., 1997; Jayathilakan et al., 2012). There are different types of MBMs in the market. High quality MBM usually contains a minimum of 50% crude protein. However, low quality MBM contains a minimum of 45% protein (Meat and Livestock Australia, 2003). In poultry diets, MBM is typically limited to less than 5% (Sell, 1996) of the dietary protein content because of high calcium, phosphorus and lysine content. Poultry industry consumes most of the MBM produced in Brazil (Sartorelli et al., 2003). The main export markets of MBM are Asia, Australasia, Central South America, Eastern Europe, Mid East Africa, North America and West Europe. MBMs produced in the United Kingdom and Europe show wide variability in the crude protein, fat and ash contents (Skurray and Herbert, 1974; Jayathilakan et al.,

*Corresponding author: emrancvasu@yahoo.com
Additionally, true ileal digestibility, biological value and net protein utilization of MBMs are affected by the type of offal used (Dawson and Savage, 1983). Reasonably, there may have considerable variations in the nutrient contents of MBM. In Bangladesh, feed cost alone accounts 60-70% of the total production cost (Bulbul and Hossain, 1989). The high price and non-availability of feed ingredients are two major constraints to the growth and production of poultry. Therefore, it is important to explore high quality feedstuff to enhance optimum productivity of livestock in a cost effective way (Chang et al., 2015). MBM, in this regards, may play a vital role by minimizing feed cost. The demand for high quality MBM is increasing gradually in the global market (Muirhead, 1996; Narodoslawsky, 2003). As the production and demand of MBM is increasing day by day, variations in the nutrient contents of MBM are also increasing. For optimum commercial use of MBM in feed, it is essential to ensure chemical composition of MBM. The current study, therefore, aims to investigate variations in the chemical composition of MBM to formulate balanced ration for poultry, pet and other monogastric animals.

Materials and Methods

Study area

The study was carried out in the Department of Animal Science and Nutrition, Faculty of Veterinary Medicine, Chittagong Veterinary and Animal Sciences University, Khulshi, Chittagong-4202, Bangladesh during January to June of 2017.

Collection of data

During January to March, data related to proximate analysis of 110 MBM samples were collected. Name of the company, address, sample ID, receive data, DM, CP, CF, EE and TA parameters were collected from laboratory register during 21st October 2014 to 2nd December 2016. Finally, data were entered into an electronic spreadsheet, sorted and compiled for statistical analysis. Sorting was done according to date of receiving sample. After entering data into the spreadsheet, integrity of the data set was checked. Data missing with CP value (Although contained DM, CF, EE and TA) were not considered for the study purpose. The final database consisted of 110 samples. Out of 110 samples, 62 were selected for linear regression as they contained most of the proximate parameters (DM, CP, EE and TA) of interest.

Data analysis

Data were analyzed for descriptive statistics (mean, median, mode, maximum, minimum, standard deviation and standard error) for DM, CP, CF, EE and TA. One sample t-test was carried out using reference value to analyze the data in Stata (Stata/SE 14.1, StataCorpLP, 4905 Lakeway Drive, College Station, TX77845, USA). CP was predicted from TA, DM, EE using simple linear regression. Associations between CP, TA, DM and EE were determined using Pearson’s correlation coefficient. Statistical significance was accepted at P<0.05.

Results

Dry matter (DM)

The DM contents did no differ (p>0.05) among MBM samples. The average DM content of MBM in this study was 94.91%. The maximum and minimum DM percent were 98.7% and 91.9% respectively (Table 1).

Crude protein (CP)

The CP contents differed significantly (p<0.001) among the supplied samples. The average CP content of MBM was 53.0%. The maximum and minimum CP percent obtained in current study were 74.5% and 18.5% respectively (Table 1).

Crude fiber (CF)

The CF contents were similar (p>0.05) among the samples. The average CF content of MBM was 2.6%. The maximum and minimum CF percent obtained in current study were 2.9% and 1.1% respectively (Table 1).

Table 1. Chemical composition (%) of meat and bone meal (N=110).

| Parameter          | Min.  | Mean  | Median | Mode | STD | SE  | P-value |
|--------------------|-------|-------|--------|------|-----|-----|---------|
| Dry matter         | 91.9  | 95.0  | 95.0   | 1.89 | 0.24| 0.102|
| Crude protein      | 18.5  | 52.6  | 60.5   | 9.03 | 0.86| <0.001|
| Crude fiber        | 1.1   | 2.8   | 2.8    | 0.72 | 0.29| 0.870|
| Ether extract      | 7.5   | 14.1  | 22.0   | 5.98 | 0.75| <0.001|
| Ash                | 4.8   | 22.7  | 27.0   | 8.91 | 1.13| <0.001|
Nutrient content in meat and bone meal

Ether extracts (EE)

The EE contents differed significantly (p<0.001) among the samples. The average EE content of MBM was 15.6%. The maximum and minimum EE percent obtained in current study were 45% and 7.5% respectively (Table 1).

Total ash (TA)

The TA content differed significantly (p<0.001) among the samples. The average TA content of MBM in this study was 20.0%. The maximum and minimum TA percent obtained in current study were 33.6% and 4.8% respectively (Table 1).

Relationship among CP, TA, DM and EE

Regression coefficient for prediction of CP from TA was moderate ($R^2$=0.691) with a negative slope (-0.724). There was a strong reverse relationship ($r$=-0.831; P<0.001) between CP and TA (Figure 1). However, the CP and DM was weak and negatively correlated ($r$=-0.047; $R^2$=0.002; P=.718) (Figure 2). Similarly, association between CP and EE were also negative ($r$=-0.031; $R^2$=0.000; P=0.813) (Figure 3). In contrast, the relationship between DM and TA was positive ($r$=0.374; $R^2$=0.139; P=0.003) (Figure 4).

Acknowledgement

The authors are greatly acknowledged for the funding and contribution of ITA, UPM, Malaysia for conducting the project.

Conclusion

An overview of the results obtained in this current study revealed that, the growth performance of broilers and manurial value of litter materials were not affected by the litter density of wood shavings, but the incidences of leg disorders (HB and FPD) were found to reduce by using high density wood shaving in raising broiler chickens.

Discussion

Variations in the nutrient content of MBM

The chemical composition of MBM may be influenced by the type of raw materials (Bremner, 1976), the rendering process (Kondos and McClymont, 1972; Batterham et al., 1986) and the processing conditions (Skurray and Herbert, 1974; Knabe et al., 1989; Donkoh et al., 1994; Wang and Parsons, 1998; Shirley and Parsons, 2001). In present study, wide ranges of variations in the DM contents of MBM were observed. The results are in line with previous studies where DM was reported to be 95.0% (Wapak, 1848) 95.4% (Hendriks et al., 2002), 94.3% (Nash and Mathews, 1971), 95.3% (Hendriks et al., 2004). However, the result slightly differs with the findings of other investigators who reported 93.0% (Jacob, 2015), 96.9% (Garcia et al., 2006) and 88.8-97.0% (Ziggers, 2010) DM in MBM. Throughout the world, MBM has been used as a good source of protein in poultry, cattle and pet food for many years. However, CP contents in MBM are widely variable. The average CP content in present study was 53% which is in well agreement with earlier studies where it was reported 53.0% (Moutinho et al., 2017), 54.0% (Nash and Mathews, 1971) and 49%-52.8% (Ziggers, 2010).
However, the result differs with the reports of other investigators who reported 55.0% (Jacob, 2015), 56.6% (Garcia et al., 2006), 56.8% (Hendriks et al., 2002), 48%-56% (Parsons et al., 1997), 58% (Wapak, 18848) and 56.7% (Hendriks et al., 2004).

The CF and EE contents in MBM may also vary. The variations of CF obtained in present study are in line with previous studies where CF was 2.5% (Jacob, 2015). However, the result differs with the findings of other investigators who reported it 4.5% (Wapak, 18848), 12.0% (Nash and Mathews, 1971). Besides, CF, the result of EE is also aligned with earlier studies where EE was 12.2% (Garcia et al., 2006). However, the result differs with the findings of other investigators who reported it 7.2% (Jacob, 2015), 10.0% (Hendriks et al., 2002), 8.5%-14.8% (Ziggers, 2010) and 10.0% (Hendriks et al., 2004).

Remarkable differences among the TA% of different MBM samples were noticed globally. The current result of TA contents is in line with previous studies where TA was 25.3% (Garcia et al., 2006). However, the result differs with the findings of other investigators who reported it 27.0% (Moutinho et al., 2017), 28.4% (Hendriks et al., 2002), 29.2% (Nash and Mathews, 1971), 28.1% (Hendriks et al., 2004). Increasing bone ash content has been reported by Dale (1997) and Wang and Parsons (1998) to have a negative effect on protein and energy concentration. Higher ash levels in MBM are associated with a lower nutritional quality of MBM protein (Johnson and Parsons, 1997; Hendriks et al., 2002). It is also reported that, a high level of TA in MBM may be a disadvantage as it may interfere with digestion and absorption of amino acids and decrease protein quality (Summers et al., 1964; Sathe and McClymont, 1964). High levels of ash in MBM may have negative effects on digestibility of other nutrients such as fat and energy (Liu, 2000). The higher level of ash in MBM can be a challenge to formulate pet food (Olukosi and Adeola, 2009).

**Association between TA, CP and EE**

Typical levels of readily available calcium and phosphorus in MBMs are 7.5% and 5.0. The high levels of ash in MBM are a challenge to formulate ration for pet foods since they contain more than 30.0% protein (Olukosi and Adeola, 2009). Although, increasing levels of ash in meat and bone meal have not been shown to lower protein digestibility, however, it decreases the amount and quality of protein (Butnariu and Caunii, 2013). It also leads to the decreased amount of essential amino acids and a higher proportion of non-essential amino acids (Sulabo and Stein, 2013). Increased ash content has also been shown to have a negative effect on protein and energy concentrations (Dale, 1997; Mendez and Nick, 1998; Wang and Parsons, 1998). It was reported that 83% of the protein in bone is collagen (Eastoe and Long, 1960). Collagen and gelatin are deficient in most of the essential amino acids (Boomgaardt and Baker, 1972; Berdanier, 1998). Therefore, any increase in ash content of the raw materials may have negative effect on protein quality due to its high collagen content and poor amino acid balance.
It is assumed that, some decrease in protein quality with increased ash will occur due to the changes in amino acid concentrations. In addition, an increase in ash could further decrease protein quality if bioavailability of amino acids is reduced. The effects of ash content on amino acid digestibility are unknown. In previous studies, protein efficiency ratio decreased from 1.70 to 1.0 as ash content increased from 24.0 to 35.0% (Johnson and Parsons, 1997; Johnson et al., 1998). It was reported that, CP and gross energy content of the MBM decreased as ash contents increased, whereas the Ca and P contents increased as ash content increased (Dale, 1997; Johnson and Parsons, 1997; Johnson et al., 1998; Mendez and Nick, 1998; Wang and Parsons, 1998; Shirley and Parsons, 2001; Hendriks et al., 2002). It was concluded that, a high level of ash in MBM interferes the digestion and absorption of amino acids (Summers et al., 1964; Sathe and McClymont, 1964) and affect the digestibility of other nutrients (carbohydrate, fat and vitamins). Similarly, high levels of dietary calcium available in MBM may tie up dietary fat in the intestine through production of stable calcium soaps, reducing its availability to the chick and consequently the available energy in the diet (Atteh and Leeson, 1983).

Acknowledgement

We gratefully acknowledge Poultry Research and Training Centre, CVASU for providing secondary data. We extend gratitude to other team members for collection, compilation and analysis of data set.

Conflicts of interest

We, the affiliated authors whose names are mentioned in the manuscript, hereby, clearly certify that, we have NO affiliations with or involvement in any organization or entity with any financial interest or non-financial interests in the subject matter or materials discussed in this manuscript.

Conclusion

Current study indicates that, the quality of MBM is variable. Therefore, to formulate least cost balanced ration, MBM must be analyzed first in the laboratory and then incorporate it into dairy, poultry and pet rations.
References

Alvarez C, M Rendueles and M Diaz (2012). The yield of peptides and amino acids following acid hydrolysis of haemoglobin from porcine blood. Animal Production Science 52:313-320.

Atteh JO and S Leeson (1984). Effects of dietary saturated or unsaturated fatty acids and calcium levels on performance and mineral metabolism of broiler chicks. Poultry Science 63: 2252-2260.

Batterham ES, RE Darnell, LS Herbert and DJ Major (1986). Effect of pressure and temperature on the availability of lysine in meat and bone meal as determined by slope-ratio assay with growing pigs, rats and chicks and by chemical techniques. British Journal of Nutrition 55: 441-453.

Berdanier CD (1998). Advanced Nutrition: Micronutrients. CRC Press, Washington, DC.

Boomgaardt J and DH Baker (1972). Sequence of limiting amino acids in gelatin for the growing chick. Poultry Science 51: 1650-1655.

Bremner HA (1976). Batch dry rendering: the influence of controlled processing conditions on the quality of meat meal prepared from sheep stomachs. Journal of the Science of Food and Agriculture 27(4): 307-314.

Bulbul SM and MD Hossain (1989). Probable problems of poultry feed formulation in Bangladesh. Poultry Adviser 12(3): 27-29.

Butnariu M and A Caunii (2013). Design management of functional foods for quality of life improvement. Journals of Agricultural and Environmental Medicine 20(4):731-736.

Chang M, J Xiao, R Liu, L Lu, Q Jin and X Wang (2015). Effect of defatting on quality of meat and bone meal. Animal Science Journal 86(3): 319-324.

Dale N (1997). Metabolizable energy of meat and bone meal. Poultry 6: 169-173.

Dawson CO and GP Savage (1983). Biological value of some New Zealand processed meals. Proceedings of the Nutrition Society, Newziland. pp. 138-139.

Dolz S and C De Blas (1992). Metabolizable energy of meat and bone meal from Spanish rendering plants as influenced by level of substitution and method of determination. Poultry Science 71: 316-322.

Donkoh A, PJ Moughan and WC Smith (1994). True ileal digestibility of amino acids in meat and bone meal for the growing pig-application of a routine rat digestibility assay. Animal Feed Science and Technology 49: 73-86.

Eastoe JE and JE Long (1960). The amino acid composition of processed bones and meat. Journal of the Science of Food Agriculture 11: 87-92.

Garcia RA, KA Rosentrater and RA Flores (2006). Characteristics of North American meat and bone meal relevant to the development of non-feed applications. Applied Engineering in Agriculture 22(5): 729-736.

Hendriks WH, CA Butts, DV Thomas, KAC James, PCA Morel and MWA Verstegen (2002). Nutritional Quality and Variation of Meat and Bone Meal. Institute of Food, Nutrition and Human Health, Massey University, New Zealand.

Hendriks WH, YH Cottam, PCH Morel and DV Thomas (2004). Source of the Variation in Meat and Bone Meal Nutritional Quality. Asian-Australasian Journal of Animal Science 17(1): 94-101.

Jacob J (2015). Feeding Meat and Bone Meal to Poultry, Small and Backyard Flocks. University of Kentucky.

Jayathilakan K, K Sultana, K Radhakrishna and AS Bawa (2012). Utilization of byproducts and waste materials from meat, poultry and fish processing industries: a review. Journal of Food Science and Technology 49(3): 278-293.

Johnson ML and CM Parsons (1997). Effects of raw material source, ash content and assay length on protein efficiency ratio and net protein values for animal protein meals. Poultry Science 76: 1722-1727.

Johnson ML, CM Parsons, GC Fahey, NR Jr Merch en and CG Aldrich (1998). Effects of species raw material source, ash content, and processing temperature on amino acid digestibility of animal by-product meals by cecckitized roosters and ileally cannulated dogs. Journal of Animal Science 76: 1112-1122.

Karacas P, HA Versteegh, TY Van der Honing, TJ Kogut and AW Jongbloed (2001). Nutritive value of the meat and bone meals from cattle or pigs in broiler diets. Poultry Science 80: 1180-1189.

Knabe DA, DC LaRue, EJ Gregg, GM Martinez and TD Tanksley (1989). Apparent digestibility of nitrogen and amino acids in protein feed stuffs by growing pigs. Journal of Animal Science 67: 441-458.

Kondos AC and GL Mc Clymont (1972). Nutritional evaluation of meat meals for poultry. VII Effects of processing temperature on total and biologically available amino acids. Agriculture 23: 913-922.

Kratzer FH and PN Davis (1959). The feeding value of meat and bone meal protein. Poultry Science 38(6): 1389-1393.

Liu M (2000). Nutritional Evaluation of High Ash Meat and Bone Meal for Poultry. MS Thesis, University of Manitoba.

Meeker DL (2009). North American Rendering processing high quality protein and fats for feed. Revista Brasileira de Zootecnia 38: 432-440.
Nutrient content in meat and bone meal

Mendez A and D Nick (1998). Rapid assay to estimate calcium and phosphorous in meat and bone meal. *The Journal of Applied Poultry Research* 7: 309-312.

Moutinho S, S Martinez-Llorens, A Thomas-Vidal, M Jover-Cerda, A Oliva-Teles (2017). Meat and bone meal as partial replacement for fish meal in diets for gilthead seabream (Sparus aurata) juveniles: Growth, feed efficiency, amino acid utilization and economic efficiency. *Aquaculture* 468(1): 271-277.

Muirhead S (1996). Impact of ruminant-to-ruminant feed ban far reaching. *Feedstuffs* 68: 4-5.

Narodoslawsky M (2003). Renewable resources: New challenges for process integration and synthesis. Chemical and Biochemical Engineering Quarterly, 17: 55-64.

Nash HA and JR Mathews (1971). Food protein from meat and bone meal. *Food Science* 36(6): 930-935.

Olukosi OA and O Adeola (2009). Estimation of the metabolizable energy content of meat and bone meal for swine. *Journal of Animal Science* 87(8): 2590-9.

Parsons CM, F Castanon and Y Han (1997). Protein and Amino Acid Quality of Meat and Bone Meal. Department of Animal Sciences, University of Illinois. *Poultry Science* 76(2): 361-368.

Piazza GJ and RA Garcia (2014). Proteolysis of meat and bone meal to increase utilization. *Animal Production Science* 54(2): 200-206.

Ravindran V and WL Bryden (1999). Amino acid availability in poultry in vitro and in vivo measurements. *Australian Journal of Agriculture* 50: 889-908.

Sartorelli SA, AG Bertechini, EJ Fassani, RK Kato and ET Fialho (2003). Nutritional and microbiological evaluation of meat and bone meal produced in the state of Minas Gerais. *Revista Brasileira de Ciencia Avicola* 5(1).

Sathe BS and GL McClymont (1965). Nutritional evaluation of meat mals for poultry. Association of chick growth with the bone, calcium and protein contributed by meat meals to diets, and the effect of mineral and vitamin plus antibiotic supplementation. *Australian Journal of Agricultural Research* 16: 234-055.

Sell, JL (1996). Influence of Dietary Concentration and Source of Meat and Bone Meal on Performance of Turkeys. *Poultry Science* 75: 1076-1079.

Shirley RB and CM Parsons (2001). Effect of Ash Content on Protein Quality of Meat and Bone Meal. *Poultry Science* 80: 626-632.

Skurray GR and LS Herbert (1974). Batch dry rendering. Influence of raw materials and processing conditions on meat meal quality. *Journal of the Science of Food and Agriculture* 25: 1071-1079.

Sulabo RC and HH Stein (2003) Digestibility of phosphorus and calcium in meat and bone meal fed to growing pigs. *Journal of Animal Science* 91(3):1285-94

Summers JD, SJ Slinger and GC Ashton (1964). Evaluation of meat meal as a protein supplement for the chick. *Canadian Journal of Animal Science* 44: 228-234.

Wang X and CM Parsons (1998). Effect of raw material source, processing system and processing temperatures on amino acid digestibility of meat and bone meals. *Poultry Science* 77: 834-841.

Wapak 1848. Meats and Bone Meal. Wintzer GA and Son Co. http://www.gawintzer.com/products/wapak-meat-and-bone-meal.

Waring JJ (1969). The nutritive value of fish meal, meat-and-bone meal and field bean meal as measured by digestibility experiments on the adult colostomised fowl. *British Poultry Science* 10: 155-163.

Winer BJ, R Brown and KM Michels (1991). Statistical Principles in Experimental Design. McGraw-Hill, New York.

Yang Y, S Xie, W Lei, X Zhu and Y Yang (2004). Effect of replacement of fish meal by meat and bone meal and poultry by-product meal in diets on the growth and immune response of Macrobrachium nipponense. *Fish and Shellfish Immunology* 17(2): 105-114.

Ziggers D (2010). Meat and bone meal back into feed.http://madcowfeed.blogspot.com/2010/01/meat-and-bone-meal-back-into-feed-12.html.