VARIATIONS IN THE NUTRIENT CONTENT OF MEAT AND BONE MEAL

A Report by

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Faculty of Veterinary Medicine
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Khulshi, Chittagong-4225, Bangladesh

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List of abbreviations

Abbreviation	Elaboration
CF	Crude fiber
CP	Crude protein
DM	Dry matter
EE	Ether extracts
g	Gram
MBM	Meat and Bone Meal
TA	Total ash

Variations in the Nutrient Content of Meat and Bone Meal

Abstract

The study was undertaken to estimate the variations in the chemical composition of different meat and bone meal (MBM) available in different feed markets of Chittagong, Bangladesh. Secondary data for one hundred ten different MBM samples 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 were collected, compiled and analyzed. Results indicated that, there were wide ranges of variations in chemical compositions for different parameters. DM contents varied from 98.7 to 91.9 g/100g and CP contents varied from 74.5 to 18.5 g/100g. Similarly, CF contents varied from 2.9 to 1.1 g/100g and EE contents varied from 45 to 7.5 g/100g. TA varied from 33.6 to 4.8 g/100g. It was concluded that, chemical composition of MBM is widely variable. Wet chemistry analysis is suggested before inclusion of MBM in the ration of poultry, dairy and pet animals.

Keywords: Ash, Crude protein, Crude fiber, Dry matter, Ether extract, Meat and bone meal

Introduction

Meat and Bone Meal (MBM) 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 (**Kratzer & 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. 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. In poultry diets, MBM is typically limited to less than 5% 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; Ashley, 1983).** 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 is also increaing. For optimum commersial 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 of proximate analysis of 110 feed samples of MBM were collected. Name of the company, address, sample ID, receive data, DM, CP, CF, EE, Ash those parameters were collected from previews records of 21st October of 2014 to 2nd December of 2016.

Analysis of data

After collection, all data were inputted into the MS Excel 2007. Data were sorted and compiled for further analysis. Sorting was done according to date of receiving sample. Data were analyzed for descriptive statistics i.e., mean, median, mode, maximum value, standard deviation and satandard error for DM, CP, CF, EE and Ash. One sample t-test was carried out using reference value to analyze the data in SPSS 16.O **(Winer *et al*., 1991)**. Statistical significance was accepted at 55 level ($P<0.05$).

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 94.9% (Table 2). The maximum and minimum DM percent were 98.7% and 91.9% respectively.

Crude protein (CP)

The CP contents differed significantly ($p<0.001$) among the supplied samples. The average CP content of MBM in this study was 53.2%. The maximum and minimum CP percent obtained in current study were 74.5% and 18.5% respectively.

Crude fiber (CF)

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

Ether extracts (EE)

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

Total ash (TA)

TA content differed significantly ($p<0.001$) among the samples. The average TA content of MBM in this study was 20%. The maximum and minimum TA percent obtained in current study were 33.6% and 4.8% respectively.

Table 1. Chemical composition (g/100g) of MBM (N=110)

Sample ID	Chemical components (g/100g)				
	DM	CP	CF	EE	Ash
1		27.7	-	-	-
2	98.0	44.5	-	17.0	-
3	97.0	47.5	1.1	13.0	31.6
4	94.1	44.6	-	16.5	27.0
5	95.3	44.5	-	15.0	27.0
6	95.0	44.5	-	16.0	27.0
7	94.4	45.0	-	45.0	27.0
8	96.3	74.5	-	10.0	4.8
9	94.5	50.9	-	14.0	22.5
10	97.4	51.0	-	16.0	22.9
11	97.4	52.0	-	16.5	23.8
12	97.3	53.0	-	14.5	23.1
13	97.2	52.0	-	14.0	23.5
14	97.3	49.0	-	13.5	32.0
15	94.0	55.0	-	28.0	8.4
16	97.2	54.0	-	13.5	23.5
17	93.1	50.6	-	8.6	26.5
18	98.2	68.5	-	11.5	10.5
19	98.1	68.5	-	11.8	10.5
20	98.1	69.0	-	11.9	10.6
21	98.7	64.0	-	11.5	16.0
22	96.1	48.5	-	7.5	27.5
23	95.4	71.6	-	10.7	11.0
24	97.9	52.9	-	12.3	28.7
25	98.3	51.5	-	12.5	28.1
26	95.4	60.5	-	11.6	15.3
27	-	46.6	-	-	-
28	-	40.6	-	-	-
29	-	43.2	-	-	-
30	-	46.4	-	-	-
31	-	46.7	-	-	-
32	-	54.0	-	-	-
33	-	54.0	-	-	-
34	94.7	53.9	-	9.9	18.0
35	95.0	48.8	2.8	14.8	26.6
36	95.0	48.7	2.8	15.0	26.0
37	95.0	48.5	2.8	14.8	26.0
38	95.0	48.7	2.9	14.5	25.5
39	95.0	48.8	2.9	14.8	25.9
40	95.6	42.5	-	12.9	-
41	-	42.7	-	-	-
42	-	51.5	-	-	-
43	-	52.5	-	-	-
44	93.0	58.0	-	26.0	7.5
45	94.0	45.2	-	12.8	33.5
46	94.2	45.2	-	12.9	33.4

Sample ID	Chemical components (g/100g)				
	DM	CP	CF	EE	Ash
47	93.8	45.0	-	12.7	33.6
48	95	66.5	-	10.2	17.0
49	92.9	57.5	-	24.5	8.7
50	92.8	58.0	-	24.0	8.8
51	95.8	57.5	-	14.2	20.5
52	92	60.0	-	22.5	22.5
53	92.1	60.5	-	22.0	9.0
54	92.3	60.5	-	22.5	8.8
55	92.4	62.0	-	19.0	8.4
56	92	60.5	-	22.0	8.5
57	91.9	60.6	-	22.0	9.0
58	92.1	58.5	-	22.0	9.6
59	92.4	59.0	-	22.0	9.1
60	92.3	59.5	-	22.0	9.0
61	-	60.5	-	-	-
62	-	46.0	-	-	-
63	-	64.0	-	-	-
64	-	46.0	-	-	-
65	-	65.0	-	-	-
66	-	50.5	-	-	-
67	-	52.0	-	-	-
68	-	49.5	-	-	-
69	-	44.0	-	-	-
70	-	60.5	-	-	-
71	-	55.5	-	-	-
72	-	55.0	-	-	-
73	-	66.0	-	-	-
74	92.7	64.5	-	17.8	9.4
75	92.6	64.5	-	17.6	9.3
76	92.7	64.8	-	17.7	9.3
77	92.7	65.0	-	17.9	9.2
78	94.9	48.1	-	14.2	26.7
79	-	34.5	-	-	-
80	-	53.0	-	-	-
81	-	42.5	-	-	-
82	-	56.0	-	-	-
83	-	46.5	-	-	-
84	-	53.0	-	-	-
85	-	61.0	-	-	-
86	-	48.5	-	-	-
87	-	25.0	-	-	-
88	96.7	64.8	-	10.1	16.7
89	96.3	64.5	-	10.4	16.5
90	-	53.0	-	-	-
91	-	50.5	-	-	-
92	-	50.0	-	-	-
93	-	62.0	-	-	-
94	-	18.5	-	-	-

Sample ID	Chemical components (g/100g)				
	DM	CP	CF	EE	Ash
95	95.3	48.4	-	12.2	31.3
96	96.8	51.5	-	11.3	30.0
97	-	**48.0**	-	-	-
98	-	54.7	-	-	-
99	-	55.3	-	-	-
100	-	54.3	-	-	-
101	-	52.7	-	-	-
102	-	51.9	-	-	-
103	95.0	56.5	-	10.3	25.6
104	95.3	48.3	-	12.0	30.3
105	95.2	48.4	-	11.9	30.5
106	95.0	55.4	-	10.0	28.5
107	-	47.5	-	-	-
108	-	54.5	-	-	-
109	94.2	48.2	-	11.7	30.4
110	95.6	59.5	-	10.5	21.0

Table 2. Statistical analysis of chemical composition of MBM (N=110)

Parameter	Min.	Max.	Mean	Median	Mode	STD	SE	P value
DM	91.9	98.7	94.91	95	95	1.89	0.24	0.102
CP	18.5	74.5	53	52.6	60.5	9.03	0.86	<0.001
CF	1.1	2.9	2.6	2.8	2.8	0.72	0.29	0.870
EE	7.5	45	15.6	14.1	22	5.98	0.75	<0.001
Ash	4.8	33.6	20	22.7	27	8.91	1.13	<0.001

Figure 1. Relationship between total ash and crude protein contents in MBM (N=61)

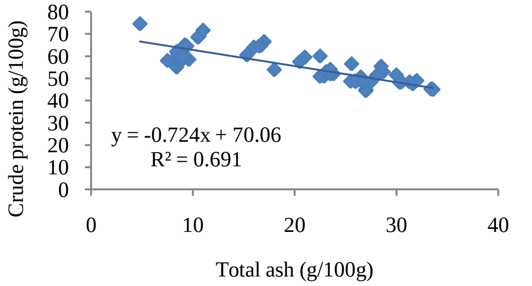


Figure 2. Relationship between dry matter and crude protein contents in MBM (N=61)

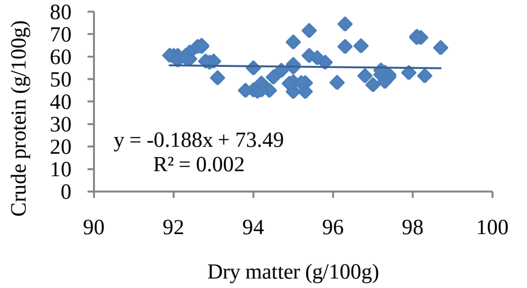


Figure 3. Relationship between ether extracts and crude protein contents MBM (N=61)

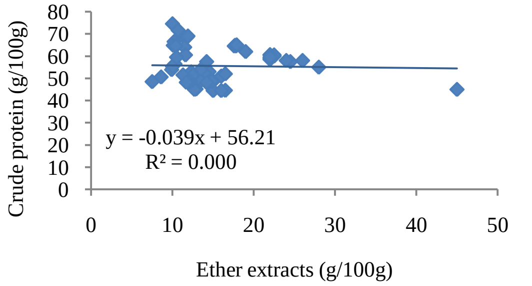
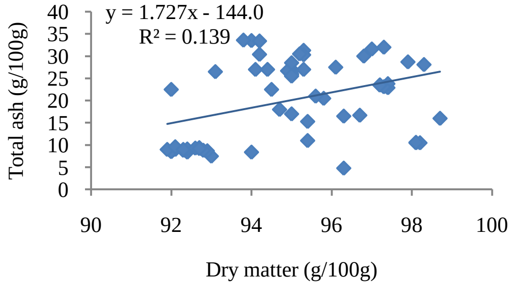


Figure 4. Relationship between dry matter and total ash contents MBM (N=61)



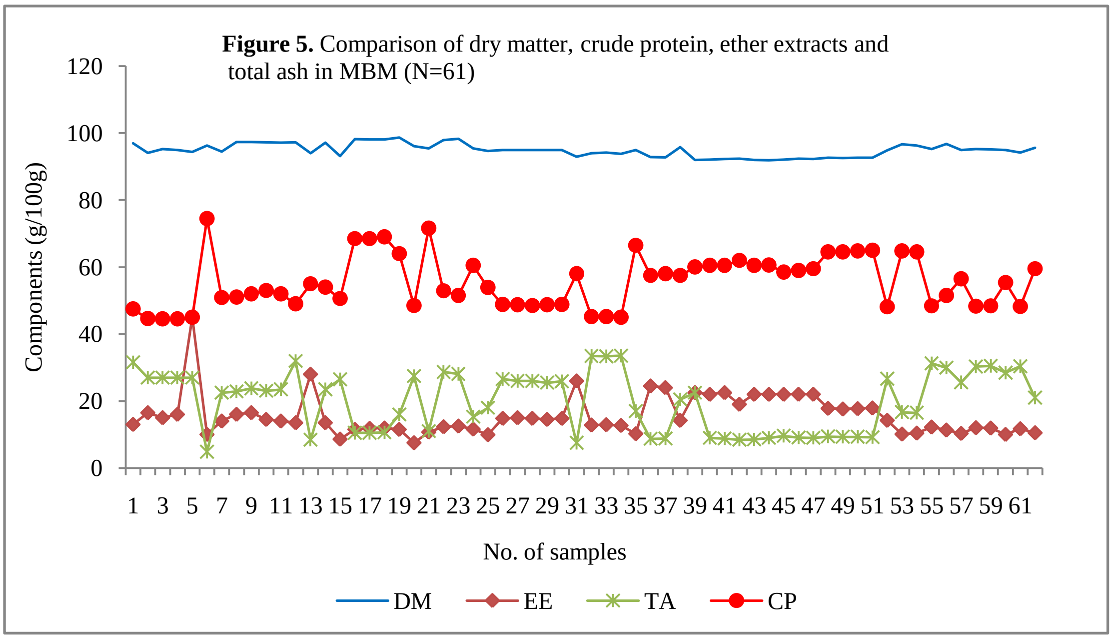


Figure 5. Comparison of dry matter, crude protein, ether extracts and total ash in MBM (N=61)

Discussion

Variations in the nutrient content of MBM

The chemical composition of MBM are affected by the type of raw materials used and their process of handling **(Bremner, 1976),** the rendering process i.e., batch dry, continuous dry or low temperature rendering **(Kondos and McClymont,** 1972**; Batterham et al.,** 1986) and the processing conditions employed during rendering **(Skurray and Herbert, 1974; Knabe et al., 1989; Donkoh et al., 1994; Wang and Parsons, 1998; Shirley and Parsons, 2001**). The influence of the raw materials on the nutritional quality of MBM has been found to be larger compared to the effects of processing **(Skurray and Herbert, 1974; Dawson and Savage, 1983)**. An increase in the nutritive value of MBM derived from hard offals with prolonged pressure cooking was reported elsewhere (**Skurray and Herbert, 1974).** Fat removal process and the amount of bones present in the MBM may also have great influence on their nutritive value **(Dolz and De Blas, 1992).** The apparent metabolizable energy content and nutrient digestibility of MBM can also be affected by the origin and inclusion level of MBM in the diet **(Ravindran and Bryden,** 1999). However, the species of origin had no influence on the nutritive value of MBM (**Karakas et al., 2001).**

In present study, wide range of variations in the DM contents of MBM were observed. The result is 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)**, 88.8-97.0% **(Ziggers, 2010)** and 93.0% **(Nick, 1997)** DM in MBM. The low moisture content (2-4%) of MBM is well accepted by pet food producers because of low risks for microbiological contamination.

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 protein quality i.e., true ileal digestibility, biological value and net protein utilization of MBMs were more affected by type of offal than the rendering process used (**Dawson and Savage, 1983).** The average CP contents in present study was 53.0% 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, 1848)**, 56.7% **(Hendriks *et al*., 2004)** and 50.4% **(Nick, 1997)**. Although the digestibility coefficients of CP for MBM is 69.0 percent however, in many cases it is less satisfactory since it is relatively deficient in lysine and isoleucine (**Waring, J. J. 1969**) . The protein in bone is approximately 83.0% collagen **(Eastoe and Long**, **1960**) and collagen is deficient in most of the essential amino acids. Therefore, a high bone concentration may negatively affect the amino acid profile of MBM.

The CF and EE contents in MBM samples 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, 1848)**, 12% **(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)**, 10.0% **(Hendriks *et al*., 2004)**, 10% **(Nick, 1997)**.

Remarkable differences among the TA contents 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 **(**S**ummers et al., 1964; Saihe and McClymont, 1964)**. High levels of ash in MBM may have negative effects on digestibility of other nutrients such as fat and energy (**Liu, M. 2000**). The higher level of ash in MBM can be a challenge to formulate pet food **(Olukosi and Adeola, 2009).**

Association between TA and CP

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% 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 nonessential 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 Dale, 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 **(Boomgamino acid rdt 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 to1.0 as ash content increased from 24 to 35% **(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 Dale, 1998 and 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 i.e., carbohydrate, fat and vitamins**.**

Conclusion

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

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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.

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