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ORIGINAL ARTICLE

Amino acid composition of meat and bone meal from various manufacturers of pet food and animal feed

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The study aimed to determine the peculiarities of the chemical composition of meat and bone meal (MBM) from different manufacturers as raw materials for the production of animal feed. To characterize feed additives of imported origin. To ensure the achievement of the goal, a mass fraction of protein, fat, mineral elements, amino acid composition of meat and bone meal from poultry farm "Ular" was established. The results obtained were compared with the mass fraction of protein, fat, mineral elements, amino acid composition of meat and bone meal (MBM) of other manufacturers. The composition of feed additives of imported origin was described with the possibility of their use in feed technology for non-productive animals. We studied the meat and bone meal (MBM) from Poland and Ukraine manufacturers and concentrated feed additives manufactured by the company "PashemKemos Sp. J." (Poland), "Pet Kea" (Poland), and "Rovimix TM Folik 80 SD" (Belgium). The MBM of Ukraine (Ular Farm, sample 3) was not inferior to MBM from poultry of other producers. It contains 56.3% of protein, 11% of fat, 5.5% of moisture, P, Ca, and Na, which concentrations were 0.5, 1.0, and 0.2 mg/100 g respectively. The protein share of MBM absorbed by the animals was 85%. Pet Kea additives includes poultry meat, offal processing products, soybean meal, and antioxidant, therefore it could significantly enrich the chemical composition of the product with minerals. Folic acid, which is part of the "Rovimix TM Folik 80 SD", could ensure the normal development of the animals. Termoks TM BPS and Termoks TM are able to keep the nutritional properties of the feed and extend the shelf life.

Keywords: Meat and bone meal; Poultry; Mineral composition; Protein; Feed additives; Animal feed

Introduction

Finding new and effective ways of recycling raw meat and poultry processing plants for feed is an urgent issue that indirectly affects the food security of the country. Efficient use of material resources in the meat processing industry is characterized by a system of cost and natural indicators (Sukhenko et al., 2015). Large quantities of proteins, fats, vitamins, phosphorous and calcium salts and trace elements are included in the waste of the meat industry. Therefore, their processing in order to obtain feed flour is receiving great attention (Batalov et al., 2016; Mushtruk, 2018). Thus, the use of meat and bone meal (MBM) and feed additives that are of high nutritional value and used for the manufacture of feed (Sobolev et al., 2017; Gutyj et al., 2017; Sobolev et al., 2019; Khalak et al., 2020) is an important issue.

The production of pet food in Ukraine has started 20 years ago, while in Europe and the United States the similar products have been produced for more than 150 years (Mamchyn, 2018). Yehorov et al. (2005) proposed the technology of moist dog food containing meat and meat by-products, grain raw materials, raw materials that contain fat, salt, vegetables, bone meal, and broth. It includes heat-treated cereals, fishmeal, fodder yeast, brewer's yeast and herbal flour, bone meal, iodized salt. Known technology of dog food use the oats, meat component in the form of first category by-products (ABPs), meat cuts and fat composition, MBM, fish meal, wheat, and premixes (Yehorov & Voietska, 2005). Parii (2002) developed the technology of dog food containing meat component – bone meal. As an additional source of protein he used wheat, barley, corn, and rye. The composition of the feed also includes herbal, fishmeal, egg powder and yeast feed.

The results of studies of the technology of semi-moist dog food "TOBBI" were presented in Peshuk et al. (2013). It included beef meat, mechanically deboned meat (MDM), vitamin E, soybean meal, wheat bran, cornmeal, water, fish oil, and calcium. The compound feed formula for canine food contains chicken meat (category II), liver, heart and udder of beef, tripe and lungs of beef, fish, cereals extruded, fishmeal, beef and pork fat, vitamin A and taurine.

The feed technology for pet animals are very popular nowadays. CJSC "Junkers" Food Company" (Ukraine) has developed a method of food preparation (sausages) for pet animals "Cat and Dog»". It consists of crushed bone remains. The bone remnants are enriched the diet with calcium, and soy, bran, flour residues are rich in protein. Analyzing the formulas and technologies of pet food, we noticed that meat and bone meal (MBM) is one of the important component of mixtures. It consists of trace elements indispensable in animal nutrition: calcium, phosphorus, and sodium. Adding bone meal (MBM) in the daily diet of animals makes it possible to significantly increase the productivity and improve the nutritional value of food (Iehorov et al., 2007). However, the issues of the use of MBM produced in Ukraine, in particular the "Ular" farm remain unresolved. This is due to the costs associated with the production of MBM from wastes food and processing industries for feed purposes. Competition with other producers offering the use of bone meal obtained from beef, pork and poultry processing. In particular, the company "Senda" (Poland) offers wholesale supply of MBM as an effective source of protein, and balanced amino acid composition in order to improve the feed

mixtures. Unlike similar MBM, the Sonac (Poland) uses the internal organs of the poultry and other post-slaughter waste in the production of MBM.
KrebsFeed Limited Liability Company (LLC) is a distributor of MBM from Europe and China. Raw materials for MBM are the animal slaughter waste (adipose tissue, bones, and by-products).
Particular attention should be paid to safety control of MBM. For example, in the USA these requirements are established and regulated by the Association of American Feed Control Officers. In order to prevent the development of epidemics of spongiform encephalopathy, the meat of diseased animals is utilized (Gu et al., 2014). MBM derived from cattle secondary raw materials can also be used as fertilizer. In order to neutralize the pathogenic factors, raw materials should be pasteurized and sterilized using microwave drying, which resuot on the reduction in moisture mass fraction. Excessive heating during the MBM processing can also reduce protein digestibility (Mahesh & Madhu, 2013; Mohite et al., 2013; Hao et al., 2014; Rey et al., 2016; Średnicka-Tober et al., 2016; Mizanbekova et al., 2017).
Determination of recycling and the presence of protein fractions in MBM was used by Debbelaere (2012) and Kneisel & Laux (2012). However, there is insufficient data on the digestibility of MBM proteins from manufactures accepted and used in Ukraine, like "Ular" Farm. It is necessary to carry out the research on improving the technology of pet food using MBM from domestic producers.
Therefore, the purpose of our study was to determine the amino acid composition of MBM from different manufacturers of animal feed. We also planned to check the composition of feed additives of imported origin intended for the production of pet food.

Research Methods

We studied the MBM from poultry, namely Sample 1-Meat and bone meal from poultry Sonac (Poland), (http://agroforward.com.ua/product/mjasokstkove-kurjache-boroshno-60-sonac), Sample 2 - Krebs Feed Poultry Meat (Ukraine) (https://krebs-feed.com.ua), Sample 3 of Ular Farm (Ukraine) recommended by manufacturers for the production of animal feed; concentrated feed additives of the company Pasz Kemos Sp. J. (Poland), "PetKea" (Poland), "RovimiksTM Folik 80 SD" (Belgium). MBM is a source of protein. which is made from raw materials of 3 categories from slaughter of poultry, is used in the production of pet food, as well as for carnivorous animals. It helps to balance essential amino acids in compound feed, except for methionine and cystine. Meat and bone meal is a source of B vitamins.
MBM of Sample 3 was tested for: protein, moisture, fat, minerals, and amino acid composition. Determination of the property of protein of MBM to be absorbed by the body was carried out on the content of soluble nitrogen after treatment with pepsin in dilute hydrochloric acid. The studies were conducted in the State Scientific-Research Control Institute of Veterinary Medicinal Products and Feed Additives (Ukraine), and in the educational laboratory of the Department of Meat Technology, Oil and Fat Products of the Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv (Ukraine).
Moisture content was determined in accordance with DSTU ISO 6496:2005. "Animal feed. Determination of moisture and other volatile substances". Determination of crude ash content and mineral composition was carried out in accordance with the methods and regulations: DSTU ISO 5984: 2004. "Animal feed. Determination of crude ash content"; DSTU ISO 6490-1:2004 and DSTU ISO 6491:2004. The amino acid composition of proteins was determined by ion-column chromatography using a T339 analyzer (Drachuk et al., 2018).
Determination of fat and protein in feeds was carried out in accordance with DSTU ISO 6492: 2002. "Animal feed. Determination of fat content" and DSTU ISO 5983: 2003 Animal feeding stuffs. Determination of nitrogen content and calculation of crude protein content" by the Kjeldahl method. The method of determining the digestibility of MBM: a weight of 500 mg weighed to the nearest 0.001 g was transferred into pre-weighed bags made of polyamide cloth. A total of 23 samples were prepared in triplicate. Purses with samples were hung on tripods. Pepsin solution, heated to 45°C, was poured into the bath by the tripod holders and covered. Then it was moved for 4 hours into thermostat at 45°C, where the "digestion" begins. After 24 hours of "digestion" the device was removed from the thermostat, the cover was removed, the rods with bags were removed from the bath and poured pepsin solution. The bath was washed with water, filled with citrate-buffer solution in 3.5 L at 45°C. Purses wee not washed with water after the first stage of digestion. Thus, the pH of the buffer solution must be 3.5. The bath was again covered with a lid, sealed with a plastic putty and placed in a thermostat for 48 hours. After that the appliance was removed from the thermostat, the lid was removed, the bags were washed under a stream of distilled water. The test rods were left to drain water. Then the sample bags were dried in an oven for 8 hours at 105°C, cooled and weighed.
The digestibility of feed (%) was calculated by the formula (1):

$$X = \frac{M1*M2*100}{M0}, \qquad (1)$$

where: M1 – gross weight of sample (g); M2 is the mass of the gross residual (g); M0 – Net weight of sample (g).

Results and Discussion

In recent scientific literature, the relatively high concentration of nurients in MBM derived from slaughter products of farm animals and poultry were reported. However, its chemical composition is different and in most cases depends on raw materials, mainly the ratio of meat to bone content. This is especially typical in the ratio between high N, P, Ca content and low K content (Mohite et al., 2013; Rey et al., 2016). Moller (2015) reported the different content of macro-, micronutrients in bone and MBM, which depends on the raw material for the flour (Table 1).

Table 1. Quantity of macro- and micronutrients in bone and MBM, % dry matter.

Raw Materials	(% on dry matter)	N	P	K	S	Mg	Ca
Bone flour	95.3 (92.5–97.3)	5.30 (1.00–8.00)	10.5 (5.24–16.5)	0.34 (0.05–1.66)	0.42 (0.27–0.62)	0.48 (0.06–1.81)	21.6 (7.06–32.30)
Meat flour	93.9 (54.4–98.9)	8,00 (5.80–15.00)	3.42 (0.30–4.74)	2.09 (0.08–6.50)	0.44 (0.33–0.50)	0.16	6.79 (0.11–9.44)
MBM	96.2 (91.2–99.3)	8.28 (3.00–12.0)	5.31 (2.21–9.62)	0.67 (0.14–3.95)	0.45(0.04–1.90)	0.29 (0.14–1.02)	9.6 (5.30–

19.60)

It should be noted that the content of N in the MBM is 8.28%, the average concentration of dry phosphorus in MBM ranges from 10.5 to 83.42%. Usually, the phosphorus content in MBM is 5.31% and it largely depends on its content in meat and bone meal.
It is accepted that the calcium content in the bone meal is 21.6%, in meat – 6.79 (Średnicka-Tober et al., 2016; Mizanbekova et al., 2017). The content of these elements can determine the prevailing fractional composition in meat and bone meal and MBM predominates more than bone (Debbelaere, 2012). Macro- and micronutrients in MBM (sample 3) determined the content of P, Ca, and Na. We established that the content of phosphorus is 0.5, calcium – 1.0, sodium – 0.2 mg/100 g in raw material. The results of studies of the mass fraction of protein, moisture and fat are presented below (Table 2).

Table 2. Physico-chemical parameters of MBM from different producers, %.

Characteristic	Sample 1	Sample 2	Sample 3
Mass fraction of protein	≥58.0	≥50.0	≥56.3
Mass fraction of moisture	≤5.0	≤9.0	≤5.5
Mass fraction of fat	≤13.0	≤11.0	≤11.0

Meat-bone meal of sample 3 differs from the rest by the protein content, which is 56.3%. It moisture content is 5.5% that mainly affected by microwave drying. We think that the use of microwave drying provides the rapid heating of the product, and therefore a uniform distribution of the moisture. In addition, the bones can be treated with a microwave field after the emitters at a power of 800 Wt. This contributes to the intensive separation of fat from the bones. We defined that the mass fraction of fat is 11.0%.
The feeding value of MBM was explained by the high content of high-grade proteins and sufficient quantity of all the essential amino acids. The results of the study of the amino acid composition of MBM of sample 1 and 3 are given below (Table 3).

Table 3. Amino acid composition of MBM from different producers, g/kg.

Amino acid	Sample 1	Sample 3
Essential Amino Acids		
Leucine	32.0	31.4
Lysine	27.4	24.5
Phenylalanine	18.8	18.2
Threonine	18.1	17.9
Valine	23.3	22.8
Isoleucine	17.5	16.9
Methionine	8.3	7.4
Tryptophan	3.6	not investigated
Nonessential Amino Acids		
Glutamic acid	67.3	65.9
Aspartic acid	43.7	42.1
Arginine	36.9	35.2
Serine	21.4	20.6
Proline	42.5	41.5
Alanine	40.7	38.7
Glycine	68.7	64.5
Tyrosine	10.9	9.6
Histidine	8.3	7.4
Cystine	4.3	3.7

The number of indispensable amino acids of MBM of sample 3 differs slightly from their number in the sample of imported origin. The content of amino acids such as leucine, lysine, phenylanine, threonine, valine, isoleucine, and methionine in sample 3 is lower by 4% on average from sample 1 (Poland). The tryptophan content was not investigated. Such results can be explained not only by the mass fraction of the protein, but also by the raw materials used by the poultry processing enterprises such as paddy, non-food trimmings and small contaminants; crumbs of meat, bones, fat and tendons, bones and other non-food waste. This makes it possible to obtain biologically valuable, safe and sustainable feed flour produced in accordance with regulatory documents. It should be noted that the amount of arginine in the test sample is 35.2 g per kg, which allows the use of this raw material in the production of feed for young animals.
The protein digestibility of the MBM was studied by dissolved nitrogen content after treatment with pepsin in dilute hydrochloric acid. Protein solubility in hydrochloric acid in pepsin was 85%.
The raw material base for the production of concentrated directional additives for use in feed technology for non-productive animals is constantly evolving. There is no information in scientific literature regards their use in feed technology for the dogs and cats. This determines the relevance of the study of their chemical composition and properties. In particular, the feed addition of the company "Kemos" Pasz Sp. J. (Poland) is a powder of protein-mineral concentrate for the production of dry pet food for dogs and cats "PetKea". It contains poultry meat and by-products, soybean meal and antioxidant. The chemical composition is characterized by high protein content – at least 58%. Mass fraction of fat is 6%, ash – 25%, moisture – 10%, and sodium chloride – no more than 1%. Adding this protein-mineral concentrate to the dog and canine food will provide the animals with the required amount of nutrients, vitamins, and trace elements and will promote metabolism, improve appetite, growth and development of hair.
For the purpose of enrichment of fodder acid for dogs and cats, we propose the use of the feed additive "RovimixTM Folik 80 SD". One g of feed additive contains 800 mg of folic acid. It is a powder and the recommended dose is 0.6–1.2 mg/kg. Feed additives, which prevent the oxidation, sagging of raw materials and manufactured feeds, should preserve their nutritional properties and prolong the shelf life. The recipe composition of the additives is given in Table 4.
"TermoksTM" BPS and "TermoksTM" RS can be made as dry powder and liquid solution. These additives should be added to the feed at the rate of 250–1000 g per 1 ton.

Some attempts were made to compare the MBM from the bird of Ular farm with the MBM from the bird of other producers. We determined the content of P, Ca, and Na in this raw material and it were 0.5, 1.0, and 0.2 mg/100 g. In contrast to the results by Deydier et al. (2005), Coutand et al. (2008), Warren et al. (2009) and Pinnekamp et al. (2011), we found that in the studied MBM the meat share was greater than bone one. The raw materials for the production of MBM of "Ular" farm are the waste of own poultry processing, namely fall, non-food scraps and small contaminants, crumbs of meat, bones, fat and tendons, bones and other non-food waste. This probably determined the mass fraction of protein (56.3%) and mass fraction of fat (11.0%) we fixed.

Table 4. Prescription composition of the additive "TermoxTM", %.

Components	"TermoksTM" BPS dry	"TermoksTM" RS premium liquid
Butylhydroxyanisole	10.012	24.000
Gallic Acid Propyl Ester	10.013	8.000
Glycerin	24.975	15.000
Citric acid	10.000	8.000
Corn starch	5.000	–
Quartz	40.000	–
Propionic acid	–	20.000
Monolaurin sorbitan	–	25.000

The solubility of protein in HCl pepsin MBM from "Ular" farm is 85%. This confirms its nutritional value and full absorption by the animals of all nutritional nutrients. The MBM from sample 3 it is a product of integrated non-waste poultry processing that allows to maximize production capacity. The quality of MBM from poultry during the technological operations may be affected by the moisture content. The elimination of this disadvantage is facilitated by the treatment of bones after the collapse of the microwave field at power emitters of 800 W. The even distribution of moisture in the MBM ensures the use of microwave drying.

Particular interest is the study of concentrated directional additives for use in feed technology for non-productive animals. The composition of Pasz Kemos Supplement Sp. J. (Poland) contains poultry meat and by-products, soybean meal and antioxidant. Its use in feed technology for dogs and cats will enrich the chemical composition of the product with minerals that are necessary for the normal development and vitality of unproductive animals. Feed additive "RovimiksTM Folik 80 SD" is intended for the enrichment of feed with folic acid, which is necessary for the normal development of blood cells, synthesis of amino acids, nucleic acids, and metabolism of choline. Feed additives "Termoks TM" BPS and "Termoks TM" RS manufactured in dry powder and liquid solution. Adding them in the feed compositions prevents the oxidation and undesirable changes in organoleptic indicators of raw materials, ready-to-use feeds, and preserves the feed nutritional properties during the storage.

Our further research will focus on the development of pet food technology by means of MBM from sample 3 and the additives mentioned above.

Conclusion

We selected the mineral concentrate "PetKea" for use in feed technology for pet animals from the concentrated feed additives of imported origin; we also suggested additives of directed action "RovimiksTMFolik 80 SD", "TermoksTM" BPS (dry), and "TermoksTM" RS (premium liquid).

MBM sample 3 (Ukraine) contained 56.3% of protein, 11% of fat and 5.5% of moisture; therefore it has well-balanced amino acid composition. The contamination of P, Ca, and Na was 0.5, 1.0, and 0.2 mg/100 g and the animals absorbed almost 85%.

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