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CHARACTERISTICS OF MEAT AND BONE MEAL USED AS ANIMAL FEED (PET FOOD)

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ABSTRACT: The goal of this study is to determine physico–chemical parameters of meat and bone meal obtained by processing animal by-products not intended for human consumption.

The variation of the values obtained by analyzing nine samples (each sample in three receptions) is very low.

Meat and bone meal obtained from category III byproducts (PAP), is an important source of animal protein, being an important ingredient for the production of pet food.

Keywords: physico–chemical parameters, bone meal, category III byproducts (PAP), protein

INTRODUCTION

The rendering process deals with high moisture, highly microbiologically active animal materials (byproducts) to which it applies heat to evaporate water, reduce microbiological "loading," and separate "cellular" fat (if present) from the other components (Taylor et al., 1997). If high levels of fat are present in the raw materials, the melted fat is removed from the material by physical means such as centrifugation or pressing. The two possible products of rendering are a high protein "solid" residue known as processed animal protein or meat and bone meal (MBM), and a lipid material known as rendered fat (tallow) (Woodgate and Van der Veen. 2004).

In the classic sense of rendering, the protein rich products use to be used in animal feeds and the tallow has been used in animal feed, oleo chemicals, and the soap production industries.(Woodgate 2006)

Today, in European Union the most important destination for meat and bone meal is pet food industry. (Dobbelaere 2014)

In the last years, pet food industry had a continuous development. More and more of the pet food producers are focusing on premium standards which come with a very strict Quality Assurance System applied above the rendering process. (Woodgate 2012)

The most important aspects of such system are described below:

-Specifications. Many raw materials and processed products are controlled by developing and using specifications describing key quality parameters and are agreed by contract between the two parties. An example of key parameter is the level of protein content.

-Freshness is the key to meet the exact requirements of the processed products. Most of the specification issues discussed for raw materials include aspects of time from slaughter to rendering and or a degree of cooling, if time cannot be kept to a minimum.(Woodgate 2004) "*Fresh means sure!"* is the base used.

-Contamination. Many contamination risks found in raw materials and in the finish product can and will be removed by the subsequent process by a series of filters, metal detectors and screens. Nonetheless, contamination of raw materials need to be avoided and steps to avoid problems and/or a recall system should be in place, if required (Reddy and Nemerow, 2014).

-Digestibilty. Processing by the application of heat alters the character of protein and fat in several different ways. Any alteration to the digestibility of protein (in particular) to the pet food industry is considered very important (Sulabo and Stein, 2013). A decrease caused by use of degraded material, excess temperature, too long a residence time for example, is considered to be a significant issue. From a routine analytical point of view, pepsin digestible protein is regularly included in the array of measurements made to ensure consistent quality of the product (Sulabo and Stein 2013).

-Oxidation represents one of the major areas of concern and has centred on proving the efficacy of antioxidants added (Rashed and Butnariu, 2014).

-Microbiology. In European Union, rendering companies are obliged to satisfy very exact microbiological sampling regimes, as part of authorization given by local Governments (Guldimann et al., 2012; Rashed and Butnariu, 2014).

A good example of a complete quality system can be described by the way that the modern processing, rendering and pet food industries work closely together to ensure that the quality of the product delivered to the pet food industry is of the highest possible standard.

The 3rd column of Table 1 gives an overview of all the quality assurance aspects applied in a modern and professional supply chain, divided in three sections: source, process and product.

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Table 1.
Key Aspects considered for an efficient Quality Assurance Programme

Source	Raw material	Time from slaughterhouse to rendering
		Temperature conditions from slaughterhouse to rendering
		Colour
		Contamination (plastic, metal)
		Overall quality index
		Audit for row material supplier.
Process	Rendering process	Mixing of raw material
		Process rate
		Temperature control
		Antioxidant adding
Product	Processed products	Fat content –FFA
		Moisture and impurities
		Peroxide value
		Colour and smell
		Digestibility
		Antioxidant residues

In case of not fulfilling the agreed requirements the suppliers are asked first of all to correct the non–compliance.

The risk to be eliminated from the supply chain because of non–compliance is close to minimum, but possible.

To have a good control of the rendering process and to have a clear view of the physical and chemical content of the products, the supplier (producer) has to monitor a number of parameters.

The most common parameters and typical values for meat and bone meal are presented in table 2.

Tabel 2.
Typical values for meat and bone meal parameters

Parameter / species	Typical values (%)		
	Poultry	Pork	Fish
Protein	60	50–55	60
Fat	8–15	12–16	9–10
Ash	20–25	25–35	9–12
Moisture	2–7	2–7	14–17
Peroxide value	< 10		
FFA* in fat	< 3		
*FFA– Free Fatty Acids			

METHODS AND METHODS

The material used for this study was meat and bone meal obtained in a real rendering plant from processing animal byproducts category III porcine. The analysed parameters were: protein, fat, ash and moisture.

Determination of protein content (Kjeldahl method)(AOAC 984.13):

The central basis used in this procedure is the oxidation of the organic compound using strong sulfuric acid. As the organic material is oxidized the carbon it contains is converted to carbon dioxide and the hydrogen is converted into water.

The nitrogen, from the amine groups found in the peptide bonds of the polypeptide chains, is converted to ammonium ion, which dissolves in the oxidizing solution, and can later be converted to ammonia gas.

The Kjeldahl method of nitrogen analysis is the worldwide standard for calculating the protein content in a wide variety of materials ranging from human and animal food, fertilizer, waste water and fossil fules.

The Kjeldahl method consists of three steps, which have to be carefully carried out in sequence:

1. the sample is first digested in strong sulphuric acid in the presence of a catalyst, which helps in the conversion of the amine nitrogen to ammonium ions,
2. the ammonium ions are then converted into ammonia gas, heated and distilled. The ammonia gas is led into a trapping solution where it dissolves and becomes an ammonium ion once again,
3. finally the amount of the ammonia that has been trapped is determined by titration with a standard solution, and a calculation made.

Step one: Digestion of the sample:

This is the most time–consuming step in the analysis. The purpose of this step is to break down the bonds that hold the polypeptides together, and convert them to simpler chemicals such as water, carbon dioxide and, of course, ammonia.

Such reactions can be considerably speeded up by the presence of a catalyst and by a neutral substance, such as potassium sulphate (K_2SO_4), which raises the boiling point of the digesting acid and thus the temperature of the reaction.

Catalysts are also used to help in the digestion process; many different one have been tried including selenium, mercury, copper, or ions of mercury or copper.

Digestion is accomplished by:

1. Weighing out approximately 1 gm of the sample containing protein, making a note of the weight, and placing the sample into a digestion flask, along with 12–15 ml of concentrated sulphuric acid (H_2SO_4).
2. Adding seven grams of potassium sulphate and a catalyst, usually copper.
3. Bringing the digestion tube/flask and mixture to a "rolling boil" (about 370°C to 400°C) using a heating a block.
4. Heating the mixture in the tube/flask until white fumes can be seen, and then continuing the heating for about 60–90 mins.
5. Cooling the tube/flask and cautiously adding 250 mls of water.

Step Two: Distillation:

The purpose of the next step, distillation, is to separate the ammonia (that is, the nitrogen) from the digestion mixture. This is done by, raising the pH of the mixture using sodium hydroxide (45% NaOH solution).

This has the effect of changing the ammonium (NH_4^+) ions (which are dissolved in the liquid) to ammonia (NH_3), which is a gas.

Removing the trapping flask and rinsing the condenser with water so as to make sure that all the ammonia has been dissolved.

Step Three: Titration

Titration is made by putting a standard solution of HCl into the buret (a long tube with a tap at the end), and slowly, slowly adding small amounts of the HCl into the solution left from distillation, until it reaqched the end point which turnes the liquid soft pink.

Calculation*:*

$CP=(n_1 \cdot f_1) \cdot 0{,}0014 \cdot 10 \cdot 6.25 / n_2$

n_1–volume HCl used for titration (mL); f_1–factor

n_2–weight of sample (g)

Determination of fat (AOAC 920.29):

This international method specifies a reference method for the determination of the hexane extract (or petroleum ether extract), called "oil content", of oil seeds used as industrial raw materials (i.e. rapeseed, soya beans, sunflower and other seeds used for plant oils production).

Principle

Extraction of a test portion, in a suitable apparatus, with technical hexane or petroleum ether.

Elimination of the solvent and weighing of the extract obtained.

Apparatus: extraction unit, Soxtec System; service unit Soxtec System; extraction cups; cup holder; tongs for extraction cups; thimbles; thimble adapters; thimble stand; thimble support; thimble handler; and holder of thimble support.

Procedure

- Turn on the Service Unit and start to heat up the oil bath (adjusted temperature will be).
- Open the cold water tap for the reflux condensers.
- Attach the thimbles to the adapters.
- Weigh the sample into the thimbles (use the thimble support).
- Move the thimbles to the thimble stand (use the thimble handler).
- Put a cotton plug on the top of the sample and place the thimbles into thimble support attached to the holder (use again the thimble handler).
- Insert the thimbles into the Extraction Unit.
- Weigh the extraction cups (with boiling chips).
- Insert the extraction cups, each with 50 ml of extraction solvent, into the Extraction Unit (use the cup holder).
- Move the extraction mode knobs to the "BOILING" position (thimbles will now be immersed in the solvent) and extract your samples 25 minutes. Make sure that the condenser values are open.
- Move the extraction mode knobs to the "RINSING" position (thimbles will now hang above the solvent surface) and continue in extraction 20 minutes.
- Close the condenser valves and remove extraction solvent from the
- Release the extraction cups from the Extraction Unit.
- Dry the extracts (the extraction cups) in an oven with adjusted temperature between 103 and 105ºC for 20 minutes.
- Cool the extraction cups in a desiccator (20 minutes) and weigh them.

Calculation:

$FC=n_1/n_2 \cdot 100$

n_1 – weight of extract (g), n_2– weight of sample used (g)

Determination of moisture content (AOAC 934.06):

This method relies on measuring the mass of water in a known mass of sample. The moisture content is determined by measuring the mass of a meal sample before and after the water is removed by evaporation at 103–105ºC for 2 hours. After evaporation the sample is kept for cooling in desiccators for 30 minutes prior to be weight.

$MC=(n_1-n_2)/n_1 \cdot 100$

n_1 – initial weight, n_2 – final weight

Determination of ash content (AOAC 942.05, 2012)

A sample of meal (3 to 5 grams) is weighed and placed in an ash cup. The sample is heated at 585 degrees Celsius in an ash oven until its weight is stable (usually overnight). The residue is cooled to room temperature and then weighed. Ash content is

determined by high temperature incineration in an electric oven. When a sample is incinerated in an ash oven, the high temperature drives out the moisture and burns away all the organic materials (starch, protein, and oil), leaving only the ash. The residue (ash) is composed of the non–combustible, inorganic minerals that are concentrated in the bran layer. Ash content results are expressed as a percentage of the initial sample weight. (Thiex, Novotny, and Crawford 2012)

RESULTS AND DISCUSSIONS

The goal of this study was to determine a few physico–chemical parameters of meat and bone meal obtained in a rendering plant by processing animal by-products not intended for human consumption.

In figure 1 and table 3 it can be seen the results for the nine samples used in this study. We can observe that the variation of the parameters is not too large and the results are usually not exceeding the typical limits.

Tabel 3.
Characteristics of meat and bone meal

Sample	proteins [%]	ash [%]	fat [%]	moisture [%]
1a	55.15	27.45	13.9	3.45
1b	52.86	29.35	15.09	3.1
1c	51.42	30.72	16.35	2.63
the average 1	**53.14**	**29.17**	**15.11**	**3.06**
2a	53.07	23.53	13.32	2.08
2b	50.41	27.49	16.74	1.15
2c	59.77	24.4	15.27	1.25
the average 2	**54.42**	**25.14**	**15.11**	**1.49**
3a	52.37	28.98	11.89	3.95
3b	55.33	24.95	12.4	2.24
3c	59.67	24.14	12.9	1.5
the average 3	**55.79**	**26.02**	**12.40**	**2.56**
4a	55.95	24.28	14.08	3.75
4b	55.99	27.16	13.71	2.94
4c	58.35	25.7	14.65	1.18
the average 4	**56.76**	**25.71**	**14.15**	**2.62**
5a	55.05	24.64	12.85	4.57
5b	57.45	24.93	13.83	2.61
5c	55.85	26.03	15.35	2.45
the average 5	**56.12**	**25.20**	**14.01**	**3.21**
6a	53.2	27.51	14.33	4.66
6b	54.01	25.8	14.33	2.98
6c	55.29	25.68	17.26	3.04
the average 6	**54.17**	**26.33**	**15.31**	**3.56**
7a	55.41	25.83	12.61	4.44
7b	56.78	24.43	14.82	3.26
7c	56.97	22.99	13.49	3.08
the average 7	**56.39**	**24.42**	**13.64**	**3.59**
8a	54.52	26.43	13.97	1.91
8b	56.41	27.62	16.61	1.99
8c	57.52	26.06	14.62	1.87
the average 8	**56.15**	**26.70**	**15.07**	**1.92**
9a	52.68	24.8	20.79	2.9
9b	54.52	23.85	14.64	3.26
9c	53.02	24.51	12.78	2.62
the average 9	**53.41**	**24.39**	**16.07**	**2.93**

Protein content:

We can observe that the level of protein is between 50–60% which means an adequate level for traditional pet food diets with protein levels between 18 and 26%. To have a lower variation of the protein level, a precise mixing of the raw material processed would be needed.

Fat content:

Fat composition ranges from 10 % to as high as 20 %, depending on the process. A good pressing is giving low fat percentage. (Tibru, Abraham-Barna and Pescheke 2008). The fatty acid profile can vary but for pork the saturation is 92–93 %.(Litherland, Thire, Beaulieu, Reynolds, Benson, and Drackley 2005). As more saturated nature of the fatty acids in meat and bone meal it is inherently more resistant to oxidation. The developing of free fatty acid level is typically controlled by addition of antioxidants.

Ash content:

The higher level of ash in meat and bone meal can be a challenge to formulate the receipt for pet food (Olukosi and Adeola, 2009). The ash level in meat and bone meal is given by the content of calcium and phosphorus. Typical levels of calcium and phosphorus in meat and bone meal are 7.5% and 5.0, respectively, and they are readily available.

However, this level of minerals becomes problematic when formulating higher protein (more than 30%) for the finished pet food. Increasing levels of ash in meat and bone meal have not been shown to lower protein digestibility, but what is happening is that the amount and quality of connective tissue is decreasing (Butnariu and Caunii, 2013). So quality of protein is decreasing, because inside the protein we will find lower essential amino acids and a higher proportion of nonessential amino acids, and this gives a lower digestibility.(Sulabo, Stein 2013)

Moisture content:

The low moisture content (2–4%) is well accepted by pet food producers because low moisture gives low risks of microbiological activity.

Microbiological control is a critical control point for rendering so low moisture will be often found in MBM, but higher moisture content will increase yields and will give better income. We can observe that the focus for the analyzed samples was to lower the risk of microbiological activity.

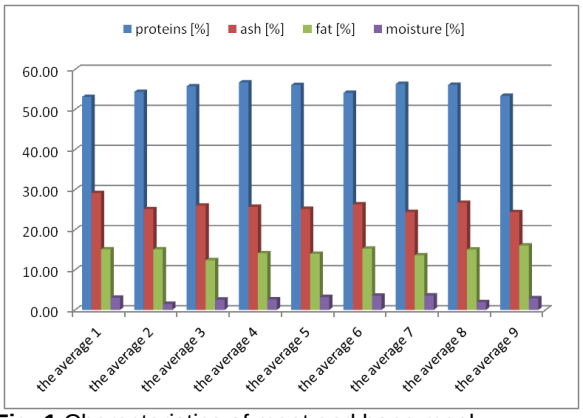

Fig. 1 Characteristics of meat and bone meal

CONCLUSIONS

The scope of this experiment was to show the importance of meat and bone meal characteristics for the pet food producers, and also for controlling the rendering process in order to supply a "safe" product and a requested product.

The analysed parameters are used as a good tool in controlling and fulfilling the requested aspects of the Quality Assurance System, and also are helping nutritionally the pet food producers.

Raw, fresh, human edible and alternative protein sources are competing to supply the protein and fat needs in pet foods. Opportunities for various rendered ingredients especially those that are able to retain their species identity and maintain control over processing conditions while retaining nutrient quality, will be welcome.

REFERENCES

Association of Official Analytical Chemists. 1990. Official Methods of Analysis: Protein (Crude) Determination in Animal Feed: Copper Catalyst Kjeldahl Method. (984.13). 15th Edition

Association of Official Analytical Chemists. 1990. Official Methods of Analysis: Fat or Ether Extract in animal feed. (920.29) 15th Edition

Association of Official Analytical Chemists. 1990. Official Methods of Analysis Official Method of analysis for Moisture. (934.06)

Butnariu, M., Caunii, A. Design management of functional foods for quality of life improvement. Annals of Agricultural and Environmental Medicine, 2013 20(4), pp. 731–736.

Dobbelaere, D., Statistical overview of the Animal By-Products Industry in the EU in 2013**,** European Fat Processors and Renderers Association Congres, Stockholm 2014.

Guldimann C., Gsponer M., Drögemüller C., Oevermann A., Seuberlich T. Atypical H–type bovine spongiform encephalopathy in a cow born after the reinforced feed ban on meat–and–bone meal in Europe. J Clin Microbiol. 2012, 50(12), pp. 4171–4.

Litherland, N.B., S. Thire, A.D. Beaulieu, C.K. Reynolds, J.A. Benson, and J.K. Drackley 2005. Dry matter intake is decreased more byabomasal infusion of unsaturated free fatty acids than by unsaturated triglycerides. J. Dairy Sci. 88:632-643.

Olukosi O.A., Adeola O. Estimation of the metabolizable energy content of meat and bone meal for swine. J Anim Sci. 2009, 87(8), pp. 2590–9.

Rashed K., Butnariu M. Antimicrobial and antioxidant activities of *Bauhinia racemosa* lam. and chemical content, Iranian Journal of Pharmaceutical Research, 2014, 13(3), pp. 1073–1080

Rashed K., Butnariu M. Isolation and antimicrobial and antioxidant evaluation of bio-active compounds from *Eriobotrya japonica* stems, Advanced pharmaceutical bulletin, 2014, 4(1), pp. 75–81

Reddy V.S., Nemerow G.R. Structures and organization of adenovirus cement proteins provide insights into the role of capsid maturation in virus entry and infection. Proc Natl Acad Sci USA. 2014; 111(32) pp. 11715–20.

Sulabo R.C., Stein H.H. Digestibility of phosphorus and calcium in meat and bone meal fed to growing pigs. J Anim Sci. 2013, 91(3), pp. 1285–94.

Taylor D.M., Woodgate S.L., Fleetwood A.J., Cawthorne R.J. Effect of rendering procedures

on the scrapie agent. Vet Rec. 1997; 141(25) pp.643–9.
Thiex N, Novotny L, Crawford A. Determination of ash: AOAC Official Method 942.05 revisited. J AOAC Int. 2012 Sep-Oct;95(5):1392-7.
Tibru I., Abraham-Barna T., Pescheke M K, Economic and environmental impact of the industrial treatment of corpses, suppressed products and slaughterhouse by-products, Lucrări ştiintifice medicină veterinară vol. XLI, 2008, Timişoara
Woodgate S. L. "What would a world without rendering look like" in Essential Rendering: All about the animal by-products industries. Ed D.Meeker p 277. 2006 ISBN: 0-9654660-3-5
Woodgate S.L., Ensuring the safe supply of animal-derived ingredients for animal feed, in Animal feed contamination: Effects on Livestock and Food Safety, Ed J. Fink-Gremmels 2012, p 589 ISBN: 978-1-84569-725-9
Woodgate, S.L., and J. Van der Veen. The role of fat processing and rendering in the European Union animal production industry. Biotechnology, Agronomy, Society and Environment, 2004. 8(4):283-294.
Woodgate, SL. Nutritional Biotechnology in the Feed and Food Industries: Proceedings of Alltech's 20th Symposium 2004, pages 449-456