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Metabolizable energy and true digestibility of the protein of extruded of bakery by - products (bread wastes) in balanced experiments with poultry

Обменна енергия и истинска смилаемост на протеина на екструдирани вторични продукти от хлебопроизводството (хлебни отпадъци) при балансови опити с птици

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ABSTRACT

Using methods for balance experiments, the apparent (AMEn), the true (TMEn) metabolizable energy (0-n balance corrected) and the coefficient of true digestibility of the nitrogen/protein (CTDP) of extruded bread wastes have been studied. The chemical composition of the dry matter of the fodder was, as follow (in %): crude protein – 12.28; crude fats – 1.34; crude fiber – 2.28; NPE – 80.1. The following energy/protein levels in the DM have been established: (AMEn – 14.17 MJ/kg; TMEn – 15.37 MJ/kg; CTDP - 84.15. The established nutritional values are similar to those of wheat, both fodders can be replaced each other in the production of compound feed for poultry.

Keywords: extruded bakery wastes, metabolizable energy, poultry, protein

РЕЗЮМЕ

Ползвайки методика за балансови опити са установени видимата (AMEn), истинската (TMEn) обменна енергия (коригирани към 0-n баланс) и коефициент на истинска смилаемост на протеина (CTDP) на екструдирани хлебни отпадъци. Химичният състав на сухото вещество на фуража е (в%): суров протеин – 12.28; сурови мазнини – 1.34; сурови влакнини – 2.28; БЕВ – 80.1. Установени са следните енергийни/протеинови нива в сухо вещество: (AMEn – 14.17 MJ/kg; TMEn – 15.37 MJ/kg; CTDP - 84.15. Установените хранителни нива са близки до тези на пшеницата, двата фуража могат да са взаимозаменяеми при производството комбинирани фуражи за птици.

Ключови думи: екструдирани хлебни отпадъци, обменна енергия, птици, плотеин

INTRODUCTION

Every year, 1.3 billion tonnes of food produced for human consumption, a third of total production, is lost or wasted (FAO, 2011), while a significant part of them are the cereals and bakery by products. Buzby and Hyman (2012) and US-EPA (2016) reported, that food is being wasted at harvest, processing/manufacturing, wholesale, retail, and consumer levels with 22% of unused food relocated to landfills. The waste chemical stability is a problem, because the putrefactive degradation can begin in relatively short time (Chung, 2001). The problem can be overcome by fast removal of moisture by extrusion.

The poultry industry has an important role in the provision of a sustainable food supply, especially because the layers and broilers have a high feed conversion efficiency compared to other birds or livestock (FAO, 2010) so as the chicken meat is a low greenhouse gas emission food compared to other sources of dietary protein (Caro et al., 2017).

Birds are competitors of humans in feeding with grain foods, therefore alternative sources for providing of nutrients for them are seeking out. Such potential (mostly energetic) sources are the by-products of bakery industry (bread wastes) according to Yadav et al. (2014) and Al-Tulaihan et al. (2004). Krička et al. (2019) reported that bakery products at 10% - 20% can be included in broiler feed without a negative effect on their productivity. Dabron et al. (1999) conducted experiments with broilers with inclusion in the diets of various amounts of the product, calculated its metabolizable energy on the basis of content of crude nutritive substances.

For proper balancing of compound feed for poultry it's important to know the exact contents of standardized productive energy and available nutrients in feed components (Marinov, 2004). Their most correct establishing is by using balance experiments.

The aim of the present research is to establish the content of metabolizable energy and (true) digestible protein in the by-products of bakery industry (bread wastes) from Bulgarian bakery industry.

MATERIALS AND METHODS

The sampling was conducted at a private company that owns two major factories, ten smaller bread and pastry shops and its own department for retraction and utilization of expired bread-based products located throughout the country. During one month, the incoming quantities of white bread, brown bread and pastries were weighted separately every five days while their percentage distribution as part of the overall waste was determined. Three samples were taken from each type of waste and each was subjected to a chemical analysis and gross energy content. A proportional sample of approximately 100 kg of waste was taken and subjected to dry cold extrusion. The nutrient and energy content of the final sample was calculated as follows:

$$A = (A1*\%A1 + A2*\%A2 + A3*\%A3)/100,$$

where:

A = mean content of substance (for a full list of substances, refer to Table 1)
A1, A2, A3 = content of brown bread, white bread and pastries respectively
%A1, %A2, %A3 = percentage of each type of waste in the total amount of the fodder.

The experiments were carried out in the experimental section of Trakia University – Stara Zagora. Intact Sussex roosters of 25-30 weeks of age were used in accordance with balance methods of Sibbald (1986). After preliminary 48 hour starving period, six birds were tube fed with proximally 60 g fodder and 6 analogs were feed deprived. The excreta collection period continued 48 hours. In order to prevent energy shortage, the roosters were given glucose solution per os according the scheme of Penkov (2008). The content of energy in fodder and excrements was determined by using a microprocessor calorimeter KL 11 Mikado. The total nitrogen content in all the samples was determined by the Kjeldahl method (AOAC, 2007) and the content of organic nitrogen in the excrements was determined by coagulation of the sample via lead acetate (Stoyanov, 1957).

The apparent and the true metabolizable energy were calculated according the methods of Sibbald (1986):

AME = (EI – EO) / FI

AMEn = AME–34.4*ANR/FI TME = AME + (FEL/FI)

TMEn = TME – [(34.4*ANR/FI) – (34.4*FNL/FI)

where:

AME – apparent metabolizable energy/AMEn – AME corrected to zero nitrogen balance
TME – true metabolizable energy/TMEn - TME corrected to zero nitrogen balance
EI/FI – energy/feed intake; ANR - apparent nitrogen losses; FNL – fasting nitrogen losses
EO – (tube fed) energy output.

The true digestibility of the protein/nitrogen were calculated by using the formula:

TDP = [(NI-(NTFB-NFDB)]/NI

where:

TDP – true digestible protein; NI – nitrogen intake;
NTFB – organic nitrogen from tube fed bird's excrements;
NFDB - organic nitrogen from feed deprived bird's excrements.

All results were processed using the program Biostatistics – Excel.

RESULTS AND DISCUSSION

The average data for the chemical composition and gross energy content in the mixed bakery wastes are shown in Table 1. It is evident that the process of extrusion acts favourably towards removing water from the fresh waste, whereas the percentage of dry content increases from 50-60% to 85-90%, making the final product relatively resistant to mold attack for a longer period of time.

The amount of crude protein in the dry matter varies from 11.6% to 13.3%; the highest relative variation is observed in raw fats – from 1.05% to 5.2%. A high amount of fat is found in pastries which have a relatively small share in the total bread waste (less than 15% of the overall amount). The content of crude ash is also high mainly due to lower hygiene in the storage rooms.

Table 1. Chemical composition and energy content of dry matter (DM) of average sample of extruded bakery wastes and variations

Indexes (%)	Mean from 9 samples		Varations from.... to*
	Mean	SE	
Dry matter	87.53	1.24	84.20 – 90.28
Crude protein	12.28	0.53	11.6-13.33
Crude fats	1.34	0.02	1.05 – **5.2** **(only in the snacks)**
Crude fiber	2.28	0.08	1.24 – 2.92
Ash	4.00	0.16	2.80-5.5
Non protein extract	80.1	2.12	74.50-84.11
Gross energy – J/g	17555.12	154.19	17290 – 18340

*Approximate percentage of the wastes: 55% "white" bread, 30% "brown" bread, 15% snacks

The average gross energy of the fodder is 17.56 MJ with variations from 17.29 to 18.34 MJ/kg.

By input of mean 52.71 g fodder and 925.54 KJ, the tube fed cocks separated 178.33 KJ and the feed deprived analogs – only 12.03 KJ. The total nitrogen output from the tube fed and feed deprived birds is 2.17 and 4.39 g respectively, but the organic nitrogen – 0.38 and 0.22 g, respectively (Table 2).

On this base, the recalculated energy values for poultry are: AMEn-o 14.17 MJ/kg DM; TMEn-o – 15.37 MJ/kg DM (Table 3). The average true digestible protein in the (DM of) the fodder, obtained by using of system "organic nitrogen in the excrements" is 103 g with variations from 98 to 112 g. The coefficient of digestibility of the protein is 84.15.

The main sources that cover the metabolizable energy for poultry are as follows: Sauvant et al. (2004), WPSA (1989), NRC (1994), Kearl et al. (1979), Lesson and Summers (2005). When comparing the metabolizable energy found in bread waste with that found in the different sources that cover the metabolizable energy for

Table 2. Results from the balanced experiments

Indexes	Tube fed birds		Fed deprived birds	
	Mean	SE	Mean	SE
Dry matter input (g)	52.71	0.22	-	-
Energy input (J)	925371.25	3918.60	-	-
Nitrogen input (g)	1,01	0.03	-	-
Energy output (J)	178330.80	12029.17	13834.73	490.31
Nitrogen output (g)	2.17	0.06	4.39	0.10
Organic nitrogen output (g)	0.380	0.05	0.220	0.04
Apparent nitrogen retained (g)		-1.16		

Table 3. Content of apparent and true metabolizable energy and digestible protein in waste from the trade with bakery waste products

Indexes (MJ/kg dry matter)	Mean	SE
AME	14.17006	0.235
AMEn*	14.17072	0.235
TME	15.37151	0.089
TMEn*	15.37218	0.089
Coef. of the true digestibility of the CP	84.15	
Digestible protein in 1 kg DM of the fodder (average) – g	103.33 ± 4.86	

*zero corected

poultry (Sauvant et al., 2004; WPSA, 1989; NRC, 1994; Kearl et al.,1979; Lesson and Summers, 2005), it can be seen that bread waste contains metabolizable energy closest to that of wheat. For instance, the differences in AMEn between bread waste and wheat are between -0.5MJ/kg and +0.3MJ/kg of dry matter; the difference in TMEn is between -0.6MJ/kg and +0.2 MJ/kg of dry matter.

When comparing the values of AMEn from the most widely utilized sources in Bulgaria (Todorov et al., 2016; Marinov, 2004; Todorov et al., 1997) to those from this study, it can be seen that the differences in nutrients are minimal: between -0.02 MJ/kg and +0.5 MJ/kg.

When comparing the results obtained from this study with the calculated on base crude substances' content (Hoffmann et al., 1993), a more significant difference is observed with respect to the apparent metabolizable energy (14.17 MJ/kg DM for this study and 15.66 MJ/kg DM for the calculated), but he differences in TMEn are insignificant (only 0.34 MJ/kg DM).

CONCLUSIONS

The following average values of the chemical compsition of Bulgarian extruded by- products of bakery industry (bread wastes) have been established (in%): Dry matter (DM) – 87.53; crude protein in DM – 12.28; fats in DM – 1.34; crude fiber in DM – 2.28, non-protein extract in DM – 80.01.

On the base of provided balance experiments, the following nutritive values have been established: AMEn - 14.17±0.23 MJ/kg DM; TMEn – 15.37±0.09 MJ/kg DM.

The coefficient of the true digestibility of the crude protein is 84.15.

The most insignificant differences in nutrients come from the comparison of the bread waste and wheat, which indicates that both of the fodders are mutually interchanging by diet's formulations.

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