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EFFECT OF DIETARY CRUDE FIBER ON ENDOGENOUS DRY MATTER AND NITROGEN EXCRETION IN COCKERELS

V. GEORGIEVA, S. CHOBANOVA, N. TODOROV and D. PAVLOV
Trakia University, Faculty of Agriculture, BG – 6000 Stara Zagora, Bulgaria

Abstract

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The experiments were carried out with 10 cecectomised cockerels for each diet. They are force fed by method of Sibbald (1986) with nitrogen free diets of pure nutrients and with sunflower meal with different crude fiber and crude protein content. The endogenous excretion of nitrogen was established by quantity excreted when cockerels are kept without feeds (fasting), by extrapolation (regression) of excretion when fed nitrogen free diet with different level of cellulose, by feeding nitrogen free diet, and extrapolation (regression) when cockerels are fed sunflower meal with different protein and crude fiber content. The endogenous nitrogen was 1.69, 1.73, 1.78, and 1.80 g respectively. The differences between data obtained by different methods are not significant ($P > 0.05$). There are tendency for increasing endogenous nitrogen excretion with increasing pure cellulose or crude fiber in diets. Endogenous dry matter excretion was 8.00 g in fasting cockerels, 9.26 g by extrapolation nitrogen free diets with different cellulose level, and 9.61 g by extrapolation diets with sunflower meal (SFM) with different crude protein, and crude fiber content. Differences between different methods are not significant ($P>0.05$). Although there is some impact of type of fiber, differences are small. However, the results with fasting bid tend to be lower. Part of the observed small difference was probably due to the incomplete digestibility of dietary mineral supplements in diets with pure nutrients and in SFM, and partly on increased secretions and raw (desquamation) of epithelial cells, which are not reabsorbed completely. Therefore, level of insoluble feed fiber in diet is not expected to be serious obstruction to establish basic value for endogenous nitrogen excretion in practical diet with normal fiber content.

*Key words***:** endogenous nitrogen, endogenous dry matter, effect of fiber, cockerels, methods of estimation, cellulose, nitrogen free diets

Introduction

The determination of endogenous secretion and flow in the different parts of avian alimentary tract is important for understanding both the digestion physiology and evaluation of the true digestibility of energy and different nutrients. At the same time, endogenous excretion is related to the determination of energy, protein and amino acid needs with the factorial method. It is usually considered that the endogenous excretion increases proportionally to the amount of dietary dry matter intake (Todorov et al.. 1995).

Recently, in pigs and poultry, the so called standardized amino acid digestibility of amino acids is used. Its determination is made on the basis of endogenous ileal amino acids profile provided that feeds do not contain antinutritional factors increasing endogenous secretion over its normal level.

Parsons et al. (1983) found out that endogenous nitrogen and amino acids secretion was higher in poultry fed diets composed from pure nutrients without protein (nitrogen), containing more crude fiber compared either to low fiber rations or fasting birds. In the belief of authors, large intestinal and caecal microflora also influences the endogenous secretion rate.

Cowieson et al. (2004) established increased endogenous nitrogen and amino acids secretion in broiler chickens fed a synthetic nitrogen-free diet supplemented with phytic acid.

Smith and Annison (1996) showed that physico-chemical properties of non-starch polysaccharides were of primary importance for their effect on digestion in poultry. While the ef-

E-mail: georgieva_vili@yahoo.com

fect of fiber which are insoluble and do not increase intestinal viscosity could be beneficial, the soluble fiber impedes the digestion of nutrients.

There is evidence that at higher levels of dietary insoluble fiber, more mucin is released to protect the epithelium from physical damage and microbial invasion of animals (Montague et al., 2003). Furthermore, hypertrophy of the digestive tract and enhanced epithelial cells replacement occur (Jin et al., 1994). Soluble fiber is known to increase the viscosity of chyme (Mosenthin et al., 2001; Noblet and LeGoff, 2001) and have a negative impact on digestibility of starch and other nutrients (Choct et al., 1999).

Villamide and San Juan (1998) found out that sunflower meal with lower crude fiber content resulted in higher true faecal digestibility of amino acids in force-fed birds, 89% vs 86% for high-fiber diet. In earlier research on colostomised chickens, Siri et al. (1994) also established increased protein excretion after increasing dietary fiber content. The data provided by Ivanov et al. (2001) demonstrated that supplementation of rations with insoluble fiber (straw neutral detergent fiber and acid detergent fiber) reduced the digestibility of the other nutrients in geese.

It should be also considered that a large part of nutrients released in the alimentary system, are digested and reabsorbed at the end of the small intestine. According to Bielorai et al. (1985) about 95% of endogenous nutrients are reabsorbed.

On the other hand, the inclusion of small amounts of insoluble fiber (oat hulls) in the ration improves the development of digestive organs, the secretion of enzymes, digestibility of nutrients and the growth of broiler chickens (Jimenez-Moreno et al., 2009; Mateos et al., 2011). To some extent, the effect is influenced by fiber particle size and origin, and oat hulls were reported to exert a more beneficial effect than pure cellulose (Jimenez-Moreno et al., 2010). In broiler chickens, the dietary fiber level influences the alimentary tract microflora and the synthesis of volatile fatty acids (Denayrolles et al., 2007)

Insoluble fiber influences gut motility, the rate of chyme movement and could improve the contact of digestive enzymes and their substrates (Choct, 2001).

Kalmendal et al. (2011) established a beneficial effect of increased dietary level of sunflower meal, which is rich in hulls, on ileal fat and protein digestibility, despite the lower dry matter and energy digestibility. Furthermore, the authors established a reduction in pathogenic bacteria such as *Clostridium* spp. in the gut of broilers. As seen from productive traits, broilers could tolerate significantly more insoluble dietary fiber than is usually used in practice.

Sarikhan et al. (2010) utilized a special commercial product containing 72.5% insoluble crude fiber (90.5% neutral detergent fiber) designed as poultry feed supplement. The experiments demonstrated a beneficial effect on intestinal villi development, intestinal motility, nutrients digestibility and productive traits in male broiler chickens.

It could be seen that there lacks a unanimous opinion on the effect of crude fiber on the digestibility of the other dietary nutrients and the release of endogenous nutrients in the digestive tract.

Various methods for assessment of the flow of nitrogen and different amino acids of endogenous origin through the gut are applied. Most commonly, the nitrogen and amino acids in the different parts of the alimentary tract are measured in fasting birds, in birds fed nitrogen-free diets or diets containing highly digestible protein (casein) (Adedokun, 2007). Other methods include feeding rations with enzymatically degraded protein, use of homoarginine (for endogenous lysine determination), the isotope dilution method and the regression method in feeding diets with various protein content (Donkoh, 2000). All methods have their advantages and flaws and are subject to dispute. The differences in results impede the selection of a standard method for determination of the true or standardised nitrogen and amino acid digestibility (Borin et al., 2002; Adedokun et al., 2011).

Apparently, the utilisation of nitrogen-free diets, regardless of the belief that they underestimate the amount of endogenous nitrogen and amino acids, as well as non-physiological feeding yield the most consistent results (Adedokun, 2007; Adedokun et al., 2011). Golian et al. (2008) affirm that the regression method and the use of nitrogen-free diets gave similar results. On the other hand, the deprivation from protein in short-term force feeding experiments by the method of Sibbald (1986) actually has a minor effect on endogenous amino acid losses.

The aim of the present study was to evaluate the changes in endogenous nitrogen output occurring after increasing the proportion of insoluble fiber in poultry diets. The problem emerged in connection with solving the practical task to determine the effect of the amount of hulls in sunflower meal on its energy and protein nutritional value.

Material and Methods

The experiment was performed with adult White Plymouth Rock cockerels weighing 3.7±0.194 kg, with surgically removed caeca. Cockerels were housed in individual cages in a premise with ambient temperature between 18–22^{0}C. The birds had a constant access to drinking water.

Cockerels were force-fed by the method of Sibbald (1986). They were deprived by food for 48 hours prior to administration of precisely weighed pure nutrient mix (approximately 56 g dry matter per bird) into the crop. After the application, mixed excreta were collected for 48-hour period in bags placed and secured to the body by ammunitions as described by Sibbald (1986). After that, the excreta of fasting birds were collected for another 48 hours to determine the excretion of endogenous dry matter and nitrogen. After each experiment with fed birds, the fasting endogenous secretion was determined.

Four nitrogen-free rations composed by pure nutrients with various cellulose levels were tested (Table 1). Each ration was tested on 10 cockerels. The different dietary ingredients were tested for nitrogen content and none of the detected amounts were of importance for the purpose of the trial (not exceeding 0.001% of dry matter). The results from nitrogen-free feeding trials with different cellulose levels were used by two methods - first, for determination of mean nitrogen excretion, and second, for estimation of the influence of different cellulose level on nitrogen excretion.

The apparent digestibility was determined by the difference between dry matter intake and in excreta. After subtracting the dry matter of endogenous excretion from the total dry matter excretion, the true dry matter digestibility was obtained. The calculation of the true dry matter digestibility used averaged data for dry matter endogenous secretion, determined in fasting birds, and by extrapolation to zero cellulose level when feeding pure nutrients rations.

Table 1
Composition of nitrogen free diets of pure nutrients

Ingredients, %	Variants			
	3	15	30	45
Starch	71	59	44	29
Cellulose	3	15	30	45
Sunflower oil	7	7	7	7
Glucose	15	15	15	15
Dicalcium phosphate	2.5	2.5	2.5	2.5
Limestone	1	1	1	1
Common salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

In a separate analogous experiment, the regression method was employed to evaluate endogenous nitrogen and dry matter excretion. The same birds were force-fed 60 g sunflower meal containing 25, 35, 40, 46 and 50% crude protein, and different level of crude fiber. Endogenous dry matter and nitrogen was determined by extrapolation of dry matter and nitrogen in excreta to zero dietary dry matter and nitrogen.

The dry matter in the ration and in excreta was determined after drying, initially at 65^0C, and then – at 105^0C to constant weight. Nitrogen content of fresh excreta sample was determined by the Kjeldahl technique (Todorov, 2010).

Experimental data were statistically processed and differences among rations were evaluated by analysis of variance with Statistica software (2005)

Results and Discussion

The averaged data from the experiment are presented in Table 2. As expected, the increased proportion of dietary cellulose in the pure nutrient ration increased statistically significantly ($P<0.05$) the dry matter output in excreta (Figure 1). The apparent and true dry matter digestibility was correspondingly considerably reduced ($P<0.05$) (Figure 2).

The endogenous dry matter excretion, determined through extrapolation of experimental data, tended to be higher compared to that determined after fasting of the same birds (Table 3). At least part of the observed small difference was probably due to the incomplete digestibility of dietary mineral supplements (see Table 1). Reason for that conclusion is fact that the excreted mineral decreased slower than decrease of quantity of excreted dry matter, with decreasing cellulose or crude fiber in the rations. Therefore, endogenous excretion of organic matter estimated by fasting bird and by extrapolation should be closer then endogenous dry matter excretion.

There is no statistically significant difference in the endogenous nitrogen excretion when cockerels were fed diets with various cellulose levels (Table 2). There was however a marked tendency for higher endogenous nitrogen excretion

Table 2
Intake of nitrogen free diet and excreted dry matter (DM) and nitrogen (N) by cockerels, and digestibility of dry matter

Cellulose in diet,%	DM intake, g	Excreted, g		Digestibility of DM, %	
		DM	N	Apparent	True
3	55.74a	11.77a	1.72a	78.88a	93.29a
15	55.48a	16.47b	1.76a	70.31b	84.79b
30	56.22a	21.92c	1.84a	61.01c	75.29c
45	56.24a	33.24d	1.79a	40.90d	55.29d
Extrapolation*		9.26e	1.78a	83.21e	97.84e

abc Data in one column without common letter differed significantly at $P < 0.05$
* Extrapolation to zero percent cellulose

when the dietary cellulose level was higher (Figure 3). The increase was evidently due to desquamation of more epithelial cells by the increased amount of cellulose in the ration. The increase was however small due to the subsequent digestion and reabsorption of a large part of dry matter and nitrogen (Bielorai et al., 1985).

The comparison of endogenous nitrogen excretion, determined using various methods, did not show a statistically significant difference when used rations were composed by nitrogen (protein)-free pure nutrients, in fasting birds or using the regression method with rations with highly digestible nutrients and indigestible cellulose as sole source of insoluble dietary fiber (Table 3). With the regression method and diets based on sunflower meal with various crude fiber and crude protein (nitrogen) content, a slightly higher value was obtained, but the difference was not significant (P>0.05). The cause for observed differences with pure nutrients rations were probably due to the nature of crude fiber. The higher physical roughness of substantially lignified sunflower hulls compared to pure cellulose was of importance as well. This would result in an enhanced desquamation of the intestinal epithelium.

It is clear that insoluble crude fiber such as pure cellulose or sunflower hulls did not increased significantly the endogenous nitrogen output. This experiment could not though provide an answer about the effect of insoluble crude fiber on the true digestibility of the separate amino acids.

There are literature data about the beneficial effect of commercial insoluble fiber preparations on the digestibility of nutrients (Sarikhan et al., 2010), as well as of natural sources of insoluble dietary fiber (Kalmendal et al., 2011). Choct (2001) explains this effect with increased contact surface between digestive enzymes and the respective substrate. Beyond any doubt, the digestibility of the dry matter and energy was expectedly reduced after insoluble fiber increase in the ration.

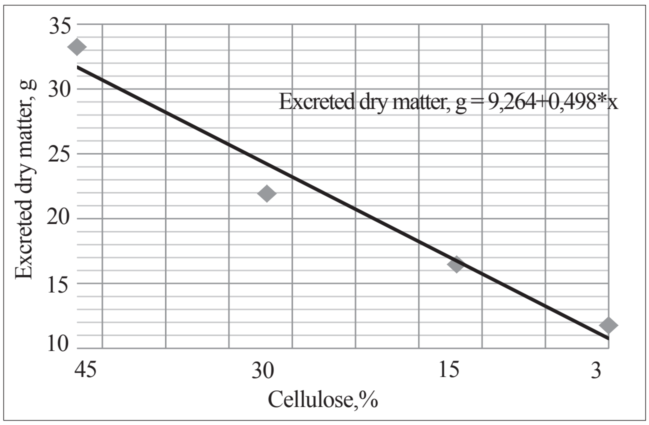

Fig. 1. Quantity of excreted dry matter when cockerels are fed diets with different percent of cellulose

Table 3
Comparison of endogenous excretion of dry matter (DM) and nitrogen (N), estimated by different methods

Methods of estimation	DM, g	N, g
Feeding with nitrogen free diet, average value	-	1.78a
Chicken without feed (Fasting)	8.00a	1.69a
Extrapolation – diets of pure nutrients	9.26a	1.73a
Extrapolation – diets of sunflower with different protein and crude fiber content	9.61a	1.80a
Average	8.95a	1.75a

a Data in one column don't differed significantly at P < 0.05

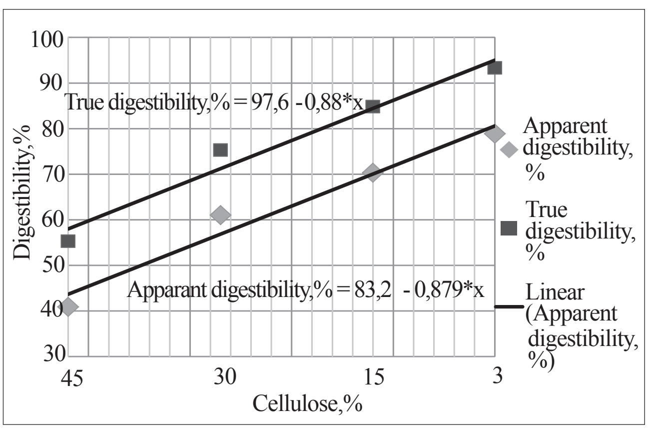

Fig. 2. Apperant and true digestibility of dry matter in experiment and after extrapolation to zero cellulose content

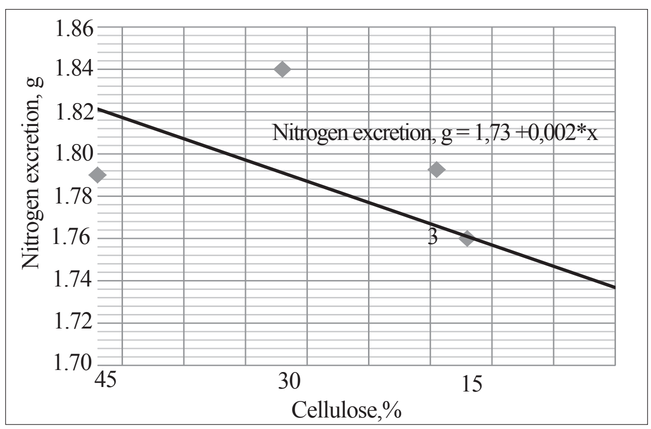

Fig. 3. Excretion of nitrogen when cockerels are fed with nitrogen free diets containing different quantity of cellulose

On the contrary, other researchers provided evidence about adverse effect of fiber on the digestibility of other nutrients (Siri et al., 1994; Villamide and San Juan, 1998; Ivanov et al., 2001). The various effects of insoluble fiber on the digestibility of the other nutrients, reported by authors, were probably due to the balance between the tendency towards improved digestibility and the increased nitrogen loss with desquamated gut epithelium (Jin et al., 1994) or mucin release (Montague et al., 2003). The observed differences, regardless of their direction, were in general small. The highest difference in the digestibility of all amino acids was 3% after feeding sunflower meal with different crude fiber content (Villamide and San Juan, 1998). There were, however, substantial differences in the digestibility of the separate amino acids.

There is tendency for increasing endogenous dry matter excretion with increasing crude fiber (P>0.05) part of which is due to mineral low digestion and excretion.

Conclusions

The increased insoluble fiber content in poultry (cockerel) rations resulted in increased dry matter excretion and respectively, reduced digestibility of dietary dry matter. There was a weak trend towards increased endogenous nitrogen output with excreta when the cellulose content of a pure nutrient nitrogen-free diet was increased or crude fiber in sunflower meal is increased. The occurring small differences would not impede the determination of the basal endogenous nitrogen excretion in rations used in practice, where the variations in dietary fiber level were not considerable. Part of tendency for increase of endogenous dry meter excretion estimated by extrapolation method is due to low mineral digestibility.

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