AgroLife Scientific Journal - Volume 6, Number 2, 2017
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

THE INFLUENCE OF THE CHEMICAL COMPOSITION OF MAIZE, BARLEY AND PEAS HYBRIDS ON THE DIGESTIBILITY OF COMPOUND FEED FOR PIGS

Monica MARIN, Camelia HODOȘAN, Georgeta DINIȚĂ, Carmen Georgeta NICOLAE

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd., District 1, Bucharest, Romania

Corresponding author email: georgetadinita@yahoo.com

Abstract

The development of animal production is a priority because it provides the most important food resources from the nutrition point of view for the entire population, and the demographic explosion and rise of living standard have led to the increased demand for food of animal origin. The profitability of pig growth is influenced by their rational feeding. It is known that food production expenses have the largest share in food production, varying between 60 and 80% of the total of these expenditure. As a result, particular attention should be paid to the maximum efficiency of compound feed in order to make it transformed in human food products with an as high as possible percentage. To achieve this goal, the nutrients from the ratio should be correlated with the physiological requirements of the animals. For this purpose, in this paper was analyzed the influence of maize, barley and peas hybrids on the apparent digestibility of nutrients from the compound feeds for pregnant sows, lactating sows and piglets during weaning. The preparation of recipes for mixed feeds requires a good understanding of the basic principles of nutrition and how diet should be individualized based on age, gender, physiological status. The apparent digestibility of the analyzed organic substances (crude protein, crude fat, crude fiber) from the compound feed recipes was influenced by the chemical composition of the compound feeds used, especially the crude fiber content, as well as the swine physiological state.

Key words*: digestibility, pig, nutritive substances, hybrids of mayze, barley, peas.*

INTRODUCTION

The need to achieve higher results in the animal husbandry domain has resulted in artificial breeding conditions, especially for pigs. In parallel with this, the widening of the range of fodder feed components of compound feed used in the feeding of these species, the introduction of new qualitatively differentiated ingredients (new hybrids of cereals or oil plants) has required the reassessment of the nutritional potential of fodder on new bases.

Based on the knowledge gained in the field of animal nutrition, technical and scientific progress has led both to the development of biochemical testing methods and methodologies, as well as the use of new procedures to elucidate some morpho-productive aspects of animals. Among these, it is of particular importance to know the way in which animal nutrients are used by animals (Marin et al., 2016).

One of the most important factors which determine the nutritional value of a fodder is its digestibility. The apparent or actual digestibility values can provide an overview of the proper feeding of animals.

Of the various techniques that have been used so far, conventional digestibility experiments are the safest method for measuring feed digestibility. However, generally, these methods are generally quite costly and require a relatively long time. The time and expenses involved in digestion experiments can be saved by using the inertial indicator method.

The digestibility of nutrients in a fodder composition can also be assessed on the basis of the chemical composition of the feed (Șara and Bența, 2011).

In order to determine the level of amino acids to be provided through compound feed for pigs, a number of techniques have been developed to allow the appreciation of apparent and real digestibility of protein and amino acids in the small intestine (Gâlcă and Drăgotoiu, 2003).

It is important to consider when it is appreciated the fodder digestibility, the fact that it is influenced by a number of feed-dependent

factors (chemical composition, ingested quantity, proportions of fodder that compose the ratio, ratio volume, preparation technique), animal (species, breed, age, physiological state, health), feeding technique (number of meals, presentation form).
The aim of the paper is to determine the influence of maize, barley and peas hybrids on the apparent digestibility of nutrients from compound feed recipes for pregnant sows, lactating sows and piglets during weaning.

MATERIALS AND METHODS

The biological material was represented by pigs of the Big White breed, respectively 12 pregnant sows in the second month, which were divided into 4 batches, 12 lactating sows were divided into 4 batches and 20 piglets aged about 35 days were divided into 4 homogeneous batches according to age and weight.
The ingredients that have been used to formulate the compound feed recipes can be grouped into raw energy materials, vegetal origin proteins, animal origin proteins, mineral ingredients, vitamin-mineral premixes.
In order to formulate the recipes for the compound feed intended for feeding pregnant sows and piglets during the weaning period will constitute the biological material used in the done research were determined a number of constituents of the main ingredients used, as well as of improved plants represented by the Turda maize, 21-1G barley and Tudor pea (Table 1).

Table 1. Nutritional value of the main feed materials used in compound feed recipes

Fodder	DM %	CP %	Lysine %	Met+Cist %	Tryptophan %	Calcium %	Phosphorus %	Crude fiber %	ME (kcal/kg)
Maize	86.12	8.21	0.20	0.30	0.07	0.03	0.23	3.07	3355
Turda maize	88.84	7.11	0.17	0.27	0.06	0.03	0.23	3.87	3330
Barley	86.09	10.48	0.33	0.41	0.14	0.13	0.30	3.55	2973
21-1G barley	89.90	11.69	0.35	0.42	0.15	0.13	0.30	5.89	2993
Soybean meal	88.21	46.17	2.90	1.33	0.55	0.22	0.71	3.54	2950
Sunflower meal	90.55	38.89	1.46	1.58	0.56	0.42	1.05	16.12	2740
Wheat bran	86.11	13.95	0.52	0.41	0.20	0.14	1.01	10.05	2414
Tudor pea	87.08	18.66	1.50	0.52	0.21	0.14	0.35	6.33	2942
Fish meal	90.00	60.00	4.11	2.24	0.60	6.50	3.20	0.00	2850

The Turda maize is a trilinear, semi-hard hybrid, with good resistance to low temperatures during the first part of the vegetation period, dropping and breaking, drought, grain defects, diseases and pests. The crude protein determined content is 7.11%, crude fat 2.92%, crude fiber 3.87%.
The maize is characterized by a high energy value. The biological value of the protein is low due to the low proportion of lysine, tryptophan. Corn is poor in mineral elements and especially in trace elements. For pigs, it represents often the basic feed in the compound feed structure.
Barley 21-1G is a hybrid with a crude protein content of 11.69%, a crude fat of 1.66%, a crude fiber of 5.89%. Barley can be used in all the categories of pigs, the barley protein being made of albumin, globulins and prolamins.
Peas are used in animal feed as a source of protein, but also energy. With a medium crude protein content, a balanced content of amino acids, peas are used as an intermediate source of protein and energy, between soy meals and cereal grains. The Tudor peas have a high production potential of over 5,000 kg/ha and resistance to fall, the grains having a content of crude protein of 18.66%, crude fat of 0.57%, crude fiber of 6.33%.
The chemical analyzes aimed to determine the crude chemical composition of feed: dry matter (gravimetric method), crude protein (Kjeldahl method), crude fat (Soxhlet method), crude fiber (intermediate filtration method), crude ash (gravimetric method). In addition, amino acids have been determined, such as lysine, methionine, cystine (HPLC method). The mineral elements that were analyzed are calcium (spectrophotometric method), phosphorus (photometric method).
The determination of cellulose through the Weende method leads to the obtained valyes not to be in line with reality, meaning that besides the cellulose are included other elements (pectic substances, hemicellulose, lignin) (Pop et al., 2006). For this reason, the expansion of the use of other methods that can

separate cellulose from other components, such as the method proposed by Van Soest, which determines the acid detergent fiber (ADF), which is cellulose and lignin from a fodder, and neutral detergent fiber (NDF), which contains in its composition cellulose, hemicellulose and lignin from fodder.

Table 2. Content in ADF and NDF of tested feeds

Fodder	ADF (% from DM)	NDF (% from DM)
Maize	2.98	7.85
Turda maize	3.11	8.54
Barley	2.84	7.93
21-1G barley	4.36	11.71
Soybean meal	7.58	12.01
Sunflower meal	15.03	39.25
Wheat bran	14.21	30.17
Tudor pea	6.25	14.59

Close results are presented by Sauvant et al. (2002) in the research undertaken.

The digestibility of the compound feed was determined in the *simple in vivo* experiments that involved the determination of ingested and faecal quantities. By doing the difference, the digested quantity for each nutrient is obtained (Drăgotoiu, 2014).

The tested foods were provided in appropriate quantities for the entire experimental period, and optimum storage conditions were maintained to maintain the chemical composition and nutrition value unchanged.

The spaces in which the animals were housed have made it possible to accurately measure the amounts of daily feed consumed, the possible food remainings, the faeces removed.

The digestibility experiments had a duration of 17 days and included 2 periods, respectively one preparatory (7 days) and one for control (10 days).

During the preparatory period, the batches of the animals are to be organized as homogeneously as possible, dewormed and dehilminise, as well as the health and behavior of the animals are monitored. Moreover, it is aimed to habituate animals to the experimental fodder, it is determined the amount of ration to be administered during the control period (in principle the ration must be consumed entirety), and ensure the removal of undigested residues from the food previously administered, so that the faeces produced effectively to represent the undigested parts of the tested feed (Pop, 2006).

During the control period, the amount of feed administered daily to the animals is registered, and are weighted after each and every meed, the eventual unspent food scraps, as well as the faeces produced. From food and faeces are taken samples to perform chemical analyzes. For the analyzed constituent nutrients of the compound feed, the apparent digestibility coefficients (aDC) were calculated according to the formula:

$$aDC(\%) = \frac{\text{Ingested substance - Faeces substance}}{\text{Ingested substance}} \times 100$$

The recipes of the compound feed have been developed for the three swine categories, namely pregnant sows in lactation and piglets aged about 35 days. The recipes are similar in terms of energy content, crude protein, amino acids, lysine, methionine + cystine, macroelements (Ca and P), crude fiber. The compound feeds have been formulated to meet the nutritional requirements of animals (Drăgotoiu et al., 2014).

The variables from the compound feed formulations were represented by the breeded plants included in the recipes, namely the Turda maize, 21-1G barley and Tudor peas (Tables 3, 4, 5).

Table 3. Recipes of compound feed intended for pregnant sows used during the experimental period

Specification	Compound feed recipes			
	C	E1	E2	E3
Maize	50.00	0.00	50.00	40.40
Turda maize	**0.00**	**50.00**	0.00	0.00
Barley	20.00	10.00	0.00	20.20
21-1G Barley	0.00	0.00	**20.00**	0.00
Tudor peas	0.00	0.00	0.00	**12.00**
Soya meal	0,00	3.00	0.00	0.00
Sunflower meal	17.50	14.50	16.50	13.00
Wheat bran	8.00	18.00	9.00	10.50
L-lysine	0.18	0.14	0.18	0.04
Carbonate calcium	1.82	1.80	1.82	1.61
Dicalcium phosphate	1.50	1.52	1.50	1.45
Vitamino-mineral premix	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Recipes parameters				
Metabolisable energy (kcal/kg)	2944	2883	2945	2913
Crude protein (%)	14.12	14.13	14.11	14.17
Lysine (%)	0.60	0.62	0.59	0.60
Methion.+cyst. (%)	0.54	0.52	0.53	0.51
Calcium (%)	1.17	1.17	1.17	1.08
Phosphorus (%)	0.72	0.78	0.72	0.70
Crude fiber (%)	5.87	6.54	6.28	5.86

Table 4. Recipes of compound feed for lactating sows used during the experimental period

Specification	Compound feed recipes			
	C	E1	E2	E3
Maize	62.00	0.00	62.00	58.00
Turda maize	**0.00**	**62.00**	0.00	0.00
Barley	10.00	8.00	0.00	7.50
21-1G Barley	0.00	0.00	**10.00**	0.00
Tudor peas	0.00	0.00	0.00	**12.00**
Soya meal	15.50	17.50	15.50	13.00
Wheat bran	3.00	3.00	3.00	0.00
Fish meal	6.00	6.00	6.00	6.00
L-lysine	0.18	0.13	0.13	0.09
Carbonate calcium	0.80	0.80	0.80	0.81
Dicalcium phosphate	1.52	1.57	1.57	1.81
Vitamino-mineral premix	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Recipes parameters				
Metabolisable energy (kcal/kg)	3078	3062	3080	3076
Crude protein (%)	17.31	17.34	17.43	17.39
Lysine (%)	1.01	1.00	1.01	1.01
Methionine+cystine (%)	0.58	0.58	0.58	0.57
Calcium (%)	1.13	1.14	1.13	1.12
Phosphorus (%)	0.79	0.80	0.79	0.81
Crude fiber (%)	3.11	3.60	3.34	3.26

Table 5. Recipes of compound feed for piglets used during the experimental period

Specification	Compound feed recipes			
	C	E1	E2	E3
Maize	62.00	0.00	62.00	60.00
Turda maize	**0.00**	**62.00**	0.00	0.00
Barley	10.00	8.00	0.00	3.00
21-1G Barley	0.00	0.00	**10.00**	0.00
Tudor peas	0.00	0.00	0.00	**12.00**
Soya meal	15.50	17.50	15.50	12.50
Fish meal	8.00	8.00	8.00	8.00
Vegetal oil	1.70	1.70	1.70	1.70
L-lysine	0.27	0.25	0.27	0.21
DL-methionine	0.10	0.10	0.10	0.10
Dicalcium phosphate	1.13	1.15	1.13	1.19
Vitamino-mineral premix	1.00	1.00	1.00	1.00
Salt	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00
Recipes parameters				
Metabolisable energy (kcal/kg)	3205	3189	3207	3195
Crude protein (%)	18.09	18.13	18.21	18.05
Lysine (%)	1.15	1.17	1.17	1.17
Methionine+cystine (%)	0.70	0.70	0.70	0.71
Calcium (%)	0.86	0.86	0.86	0.87
Phosphorus (%)	0.75	0.76	0.75	0.75
Crude fiber (%)	2.81	3.30	3.04	3.15

The results obtained have been statistically tested using the Student test to prove the differences between the environments.

RESULTS AND DISCUSSIONS

Following the performed digestibility experiments on the three swine categories, the digestibility coefficients were obtained for the 12 types of compound feed recipes (Table 6).

Table 6. Apparent digestibility of organic substances in the compound feed recipes for pigs

Compound feed	Apparent digestibility (%)		
	PB	GB	CB
For pregnant sows			
Control recipe	83.3 ±9.12	64.0 ±8.53	35.7 ±4.12
E1 recipe	83.1 ±8.12	63.5 ±7.39	33.8 ±7.22
E2 recipe	85.1 ±8.55	63.1 ±9.12	32.8 ±5.44
E3 recipe	82.9 ±7.69	63.8 ±6.06	35.4 ±5.96
For lactating sows			
Control recipe	88.3 ±7.14	62.8 ±5.14	38.9 ±5.12
E1 recipe	85.2 ±8.03	63.5 ±7.22	37.7 ±6.03
E2 recipe	86.4 ±8.54	62.9 ±6.45	37.0 ±4.38
E3 recipe	87.7 ±6.67	63.5 ±7.87	38.5 ±4.14
For piglets			
Control recipe	83.3 ±7.83	60.4 ±5.27	33.6 ±3.77
E1 recipe	80.4 ±8.42	58.2 ±4.69	30.4 ±5.32
E2 recipe	82.4 ±7.26	61.4 ±7.17	31.8 ±4.46
E3 recipe	81.1 ±7.54	59.6 ±4.95	32.4 ±3.69

For pregnant sows, if the variable in the compound feed recipe was Tudor maize (Table 3), soybean meal was added in combination with the one of sunflower for balancing the protein from recipes. If in the compound feed recipe was added the 21-1G barley, which replaced the barley, the nutritional balancing of the experimental recipes to the control was made by modifying the proportion of sunflower grain and wheat bran participation. By introducing Tudor pea into the compound feed recipe, it was required an adjustment of the share of maize (a decrease of 9.60%), a reduction in the proportion of vegetable protein feed (sunflower meal and wheat bran), and the reduction of synthetic lysine (from 0.18% at the control recipe to 0.04% at E3).

It is also noted that the use of 21-2G barley improved the apparent digestibility of crude protein over other recipes, with significant differences (Table 6). The digestibility of the crude fat did not show significant differences between batches, varying between 63.1% and

64%, while the digestibility of the fiber registered the lowest value in the case of the 21-1G barley (32.8%), the differences being significant compared to the control batch and E3.

For lactating sows, the compound feed recipes in which the Turda maize was used (Table 4) to replace the maize with a protein content of 8.21% required a protein balance by increasing the share of soybean meal by 2% at the E1 batch, in parallel with the reduction of L-lysine addition from 0.18% (at the control batch) to 0.13% (at E1). The recipe in which the barley was replaced with the 21-1G barley did not require adjustments to balance nutritional parameters. In the compound feed recipe with added Tudor peas, for the formulation of isocaloric and isoproteic recipes, no wheat bran was introduced, the proportion of participation was reduced compared to the control batch for maize by 4%, for barley by 2.50%, for soybean meal by 1.50%.

Regarding the apparent digestibility of the analyzed organic substances (Table 6), it was observed a diminution of the crude protein digestibility coefficient for the batch where the 21-1G barley was used due to the higher proportion of the crude fiber.

The structure of compound feed recipes for piglets during the weaning period, as well as their quality indexes were appropriate for the age category by respecting the nutritional requirements (Table 5). In order to ensure a protein level of 18.05-18.21% CP and energy level of 3189-3207 kcal ME/kg, in the case of use of Turda maize in recipes, it was necessary to reduce the participation proportion of barley by 2% (E1) and increase the participation of the soybean meal by 2% in the experimental recipe compared to the control. In the case of replacing the barley with the 21-1G barley in the compound feed recipe for piglets, the proportions of ingredients have not changed since the parameters of the recipes have been kept within the limits recommended for this category. The compound feed recipe in which the Tudor pea was introduced to ensure the nutritional balance of the piglets required a reduction in the proportion of maize by 2%, of barley by 7%, of soybean meal by 3%, as well as for the addition of synthetic lysine by 0.06%.

The apparent digestibility of the crude protein (Table 6) showed diminished values while using the Tudor maize due to an increase in the crude fiber of the compound feed recipe, situation which was maintained in the case of crude fat and brute fiber.

Close results have been obtained by Lowell et al. (2015), who introduced in the compound feed recipes corn, wheat, sorghum, and combinations of corn and soybean meal, canola meal, distillers dried grains, corn germ meal, corn bran, wheat middlings, and soybean hulls. The results of this research indicate that the apparent digestibility values of CP and GE obtained in gestating sows are greater than the values obtained in growing pigs, but apparently the digestibility of the fiber obtained in growing pigs is not different from the digestibilities in gestating sows.

Differences of apparent digestibility between adult and young swine have been observed by Le Goff and Noblet (2001), Guilloteau et al. (2010), Hanczakowska si Świątkiewicz (2014), because the older animals have better developed digestive tract and thus can digest fibre more efficiently.

CONCLUSIONS

For the efficient use of feeds both in terms of quality and quantity (improved performance), several aspects need to be combined, respectively the compound feed recipes should be balanced in terms of nutritional principles.

The compound feed recipes must incorporate all the categories of raw materials to give them added value, enabling them to improve the quality of the products obtained.

The weight of inclusion of the improved raw material should be optimal for the structure formulated by the compound feed according to the nutritional recommendations specific to the animal species, age category etc.

The apparent chemical digestibility differences of the analyzed organic substances (crude protein, crude fat, crude fiber) were influenced by the chemical composition of the feeds used, namely Turda maize, 21-1G barley and Tudor peas that were introduced into the compound feed recipes, the determinant being the crude fiber content.

The apparent digestibility of organic substances in the compound feed recipes was further influenced by the age and the physiological state of the swine.

ACKNOWLEDGEMENTS

This research work was financed from Project ADER 6.1.1./2015 "Nutritional innovative technologies based on the use in animal feed of raw materials recently improved, with implications over the safety and quality of products".

REFERENCES

Drăgotoiu D., Pogurschi Elena, Marin Monica, 2014. Nutriția și alimentația animalelor. Caiet de lucrări practice. Ed. Granada, Bucureşti.

Gâlcă I., Drăgotoiu D., 2003. Tehnologii de creştere şi exploatare a animalelor. Ed. ECA.

Guilloteau P., Zabielski R., Hammon H.M., Metges C.C., 2010. Nutritional programming of gastrointestinal tract development. Is the pig a good model for man? Nutr. Res. Rev., 23, p. 4–22.

Hanczakowska Ewa, Świątkiewicz Małgorzata, 2014. Legume seeds and rapeseed press cake as replacers of soybean meal in feed for fattening pigs. Ann. Anim. Sci., Vol. 14(4): p. 921–934.

Le Goff G., Noblet J., 2001. Comparative digestibility of dietary energy and nutrients in growing pigs and adult sows. J. Anim. Sci., 79, p. 2418-2427.

Lowell Jessica Erin, Liu Y., Stein H.H., 2015. Comparative digestibility of energy and nutrients in diets fed to sows and growing pigs. Arch Anim Nutr., 69(2): p. 79-97.

Marin Monica, Hodoşan Camelia, Nicolae Carmen, Diniță Georgeta, Drăgotoiu Tomița, Nistor Lucica, 2016. Researches regarding the chemical composition and gross energy of sorghum in comparison to other forages for feeding cattle and pigs. Scientific Papers, Series D, Animal Science, Vol. LIX, 95-98, ISSN 2285-5750.

Pop I.M., Halga P., Avarvarei Teona, 2006. Nutriția și alimentația animalelor, Vol. I, II, III. Ed. Tipo Moldova, Iași.

Sauvant D., Perez J.M., Tran G., 2002. Tables de composition et de valeur nutritive des matieres premieres destinees aux animaux d`elevage. In: Porcs, Volailles, Bovines, Ovins, Caprins, Lapins, Chevaux and Poisons, INRA, Versailles.

Șara A., Bențea M., 2011. Alimentația animalelor. Ed. Risoprint, Cluj-Napoca.