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ORIGINAL ARTICLE

Effect of mannan oligosaccharides on productivity and quality of slaughter pig products

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We presented our results on prebiotic containing mannan oligosaccharides (MOS) effectiveness as an immune response modifier in young pigs during their fattening. We found that MOS content at a dose of 0.06% from mixed feed contributed to increase in pig average daily growth by 7.5% and reduced the feed costs on growth gain by 6.3%. We observed that the animal productivity, feed costs per 1 kg of growth gain, slaughter weight, slaughter yield, and pig carcass weight were higher after introduction of prebiotics to mixed feed. We suggested the usage of the prebiotic with mannan oligosaccharides as immune response modifier for young pigs diet during the fattening increase the nutrient contents in slaughter products (meat, lard, and liver).

Key words: Young pigs; Fattening; Mixed feed; Nutrients; Prebiotic; Mannan oligosaccharides; Slaughter products

Introduction

The quality and safety of foodstuff for humans is a priority for animal husbandry and livestock production. More and more pig farmers aim to produce products safe for humans, ecologically pure and competitive. The key to obtaining environmentally safe, high-quality product is animal feeding; and feeds which are a part of the animal diet must satisfy the requirements of standards and contain all essential nutrients and biologically active substances for the growth and development of animals.

Various feed are used in the feeding of meat pigs for preventing he gastrointestinal diseases (Newman, 1994; Kucheruk & Zasyekin, 2008). They also effect the metabolic processes, qaualitative and quantitative composition of the digestive tract microflora (Ducatelle et al., 2015; Kuzmenko et al., 2018), digestibility and absorption of nutrients (Cherniavskyi et al., 2019), quality of slaughter products and ecological safety of the environment (Benites, 2008; Dyachenko et al., 2017). Widely used digestive grain feed for the pig feeding and stresses affect significantly the intestinal microflora and change the intensity of nutrients and biologically active substances absorption (Luk'janov, 2004; Lisicyn et al., 2007).

The use of various additives and their effect on pig organism are the core questions for the pig producers, which are concerned about the use of antibiotics in animal feed due to a number of negative consequences (Newman, 1994; Benites, 2008). The natural biologically active substances used as an alternative to feed antibiotics, among them pre- and probiotics, essential vegetable oils, plant extracts, flavours, enzymes, and organic acids (Yegorov & Makarynska, 2010; Vasileva et al., 2019). Previous studies have shown that mannan oligosaccharides (MOS), which contain sugars with mannose-specific lectins that can block intestinal colonization by pathogenic bacteria, have a positive effect on the intestinal microflora (Kuzmenko et al., 2018). The introduction of mannan oligosaccharides into the pig feeding and their interaction with the components of mixed feed are relevant issues for pig producers as an alternative to feed antibiotics.

Therefore, studying the effects of mannan oligosaccharides prebiotics on pig meat quality have very important scientific and practical interest.

Material and Methods

The experiment was conducted in agricultural holding "Nadia" in Cherkasy region (Ukraine) with two groups of Large White young pig, selected by group analogue method in live weight, age and origin during fattening. Each group consisted of 100 heads. The first group was the control where the animals received complete mixed feed accepted on the farm (Table 1).

The fodder includes 10% of maize, 50% of barley, 20% of wheat, and 20% of protein-mineral-vitamin additive (PMVA). Complete mixed feed was given from the hopper feeders. The composition and nutrient content of mixed feed was determined by the generally accepted method (Petukhova et al., 2010). Prebiotic containing mannan oligosaccharides (MOS) was fed as part of mixed feed for young pigs of the experimental group during 120 days, it was previously mixed with PMVA in the amount of 0.06% from mass of mixed feed. Bio-Mos is a water-insoluble, powdery feed additive, light brown colour, which contained a significant amount of mannan oligosaccharides with glucomannan protein. One kilo of product contained 20.7% of crude protein, 5.33% of crude fibre, 4.2% of crude fat, 1.85% of crude ash and 58.81% of nitrogen-free extractable substances. Weight fraction of moisture was

9.11%. The basis of prebiotic was the cell membranes of the yeast *Saccharomyses cerevisiae*. Pigs were kept in groups and weighed monthly. For zootechnical analysis, the mixed feed was selected in accordance with State Standards of Ukraine ISO 6497: 2005 *Animal feed. Sampling methods*. Researching of the selected samples of complete mixed feed was carried out in Laboratory of Zootechnical Analysis of Bila Tserkva NAU according to the main indicators provided by State Standards of Ukraine 4124-2002 *Complete feeds for pigs*.

Table 1. Scheme of feeding.

Group	Livestock, heads	Feeding conditions	
		comparative period (30 days)	main period (90 days)
Control	100	MF*	MF
Experimental	100	MF	MF +0.06% Bio-Mos from mass of mixed fodder

*MF - Mixed Fodder

During the experiment several indicators were considered, namely the actual consumption of feed by animals, the dynamics of their live weight and average daily gain provided by monthly individual weighing, feed costs per unit of growth gain and slaughter rates. Changes in live weight during the experiment were determined by individual weighing of animals at the end of every 30 days in the morning before feeding. Based on these data, the average daily gains and feed costs per 1 kg of gain were calculated.

The average daily gain (C) was calculated by the formula:

$$C = W_t - W_0 /t,$$

where: C is the average daily gain, g; W_t - live weight at the end of the period, g; W_0 - live weight at the beginning of the period, g; t - duration of the period, days

To determine the anatomical and morphological composition, we selected three pigs from each group with subsequent carcass opening and weighing of individual parts and organs. Piglets with the average live weight per group were selected for the slaughter. Slaughter was carried out according to regulations on animal protection (Polivoda A. M., 1977; European Communities, 2009).

The concentration of nutrients in 1 kg of mixed feed corresponded with the specified norms of feeding meat pigs (Table 2).

Table 2. Nutritional value of 1 kg mixed feed.

Index	The first period of fattening (40–70 kg)	The second period of fattening (71–120 kg)
Metabolic energy, MJ	12.63	12.47
Crude protein, g	151	145
Lysine, g	6.9	6.7
Methionine+ cystine, g	4.6	4.6
Crude fibre, g	51	46
Salt, g	5.0	5.0
Calcium, g	8.7	8.2
Phosphorus, g	6.8	6.5

We assess the quality of slaughter products according to Kovalenko V.A. (1987) and State standard of Ukraine 4823.2:2007.

Physical and chemical characteristics of meat were determined by conventional methods, taking into account State standard of Ukraine ISO 2917:2001; State standard of Ukraine ISO 1442:2005; State standard of Ukraine ISO 1443:2005; State standard 25011-81; State standard of Ukraine ISO 2294:2005. The total moisture in the lard was determined by drying the sample at temperatures of 100–105ºC to constant weight; melting point was determined in the open tube melting point; refractive index was determined with refractometric method with the IRF-456 at lenses temperature of 40ºC. The amino acid composition of the longissimus muscle and liver was determined on the automatic analyser TTT-339 using cation exchange resin LG ANB with active group SO_3. The probability of the differences between the indicators was assessed by Student's criteria (Melnichenko et al., 2006).

Results and Discussion

Live weight of the pigs from experimental group, where pigs were fed with the prebiotic, were differed from the control group at 90-180 days. The live weight of young pigs from the experimental group was higher by 4.6% at the age of 180 days. Feeding young pigs with a prebiotic containing mannan oligosaccharides affected the average daily growth gain (Table 3).

During the equalization period, the pigs had a similar increase in live weight, and after 30 days of MOS introduction, the average daily live weight gain of pigs from the experimental group exceeded the control by 6.0% ($p \leq 0.05$). At the age of 121–150 days, the pigs from the experimental group prevailed control values by 8.5% ($p \leq 0.05$), which showed a positive effect of mannan oligosaccharides on the digestive process and the intensity of pig growth caused by symbiotic microflora increase.

Table 3. Average daily gain in live weight of pigs, g (mean and standard errors).

Age, days	Group	
	control	experimental
61–90	435.7 ± 8.68	435.5 ± 3.36
91–120	568.6 ± 16.72	602.6 ± 10.51*
121–150	728.6 ± 9.81	790.5 ± 20.53*
151–180	809.5 ± 13.34	883.3 ± 26.82**
91–180 (main period)	702.2 ± 11.12	758.8 ± 12.42***

* – $p \leq 0.05$; ** – $p \leq 0.01$; *** – $p \leq 0.001$ compared to control group

The advantage of pigs from the experimental group over animals from the control group at the age of 151–180 days with average daily gain was 9.1% ($p \leq 0.01$). Thus, the symbiotic microflora, which contributes to the optimization of digestive processes, reproduced better in the digestive tract of pigs from the experimental group, which allowed to obtain an average daily increase in live weight of pigs by 8.1% ($p \leq 0.001$) higher compared to the control group during the main period of the experiment.

The difference between the indicators of feed consumption in the experimental and control groups for the whole period of the experiment was 6.3%. In particular, pigs from experimental group consumed mixed feed 6.2% less by weight, 6.4% less by energy and 6.7% less by digestible protein per 1 kg of gain than analogues from the control group. In addition, during the main period of the experiment, feed consumption per 1 kg of live weight gain in the experimental group was 3.1 kg, which is by 7.2% less compared to the analogues from the control group. Enrichment of mixed feed with prebiotic containing mannan oligosaccharides did not significantly affect the weight of the internal organs of pigs, but the tendency to increase a number of slaughter rates still took place.

The slaughter weight of the animals from the experimental group exceeded control by 6.2 kg or 7.1%. Slaughter yield, rib eye area and fat thickness in experimental group of pigs were similar to control analogues. The length of the carcass of pigs from the experimental group exceeded control analogues by 3.0 cm, and the coefficient of entire pig body was higher by 3.9% compared to the control.

The quality of meat is characterized by chemical and physicochemical properties of muscle tissue, as the most valuable in nutrition. When evaluating the quality of meat, first, attention is paid to the characteristics that describe the appearance of meat and its technological properties. Among them there are tenderness, juiciness, marbling, colour, which can be assessed both subjectively (visually, organoleptic test) and objectively (with the help of devices). In addition, meat is evaluated for chemical composition, completeness, caloric content, acidity and other indicators. The chemical characteristics of pork with the action of MOS are given in Table 4.

Table 4. Chemical characteristics of pork (n = 3).

Index	Group	
	control	experimental
Moisture, %	72.05 ± 0.302	72.62 ± 0.403
Dry matter, %	27.95 ± 0.654	27.38 ± 0.583
Crude protein, %	21.89 ± 0.323	22.18 ± 0.294
Crude fat, %	3.73 ± 0.131	3.20 ± 0.142
Crude ash, %	2.33 ± 0.192	2.00 ± 0.061

An important indicator of the meat quality is the protein content. The protein content in the meat of animals from the experimental group was 22.18%, which is by 0.29% more compared to the meat of pigs from the control group. The difference was statistically insignificant. However, according to fat content in the longissimus muscle, animals from the control group had its amount of 3.73%. According to this indicator, the animals from the experimental group were inferior to control by 0.53%. The highest ash content in the dry matter of meat was observed in meat of pigs from the control group. However, the difference in this indicator between the analogues from the control and experimental groups was not significant.

Physicochemical lard characteristics of pigs fed with prebiotic containing mannan oligosaccharides are given in Table 5.

The lard of animals from the control and experimental groups had good physicochemical properties. There was no significant difference in moisture, protein and fat content.

Table 5. Lard properties (n = 3).

Index	Group	
	control	experimental
Moisture, %	6.7 ± 0.45	6.7 ± 0.19
Protein, %	1.3 ± 0.11	1.5 ± 0.04
Fat, %	91.5 ± 0.47	92.6 ± 0.32
Iodine adsorption value	63.4 ± 0.24	63.3 ± 0.43
Refraction index	1.4588	1.4590

The protein content was maximum in the lard of animals from the experimental group and it was 1.5%, which is by 0.2% more compared to control analogues. No significant intergroup difference was found in fat content, but pigs from the experimental group were inferior to control by 0.9%. The iodine value and refractive index did not differ significantly in the lard of the experimental animals.

An important indicator for the food industry is the incipient and complete fusion melting point of lard (Figure 1). According to these indicators, melting temperatures in the experimental and control groups did not differ significantly, which indicates the safety of using MOS in the feeding of young pigs during fattening. Therefore, the lard of animals from both groups was of high quality in terms of melting point, iodine value and refractive index. It is referred to the first type as dense.

The use of a prebiotic containing mannan oligosaccharides in the feeding of young pigs increased the content of crude protein in meat. This encouraged us to determine the content of lysine and methionine with cystine in meat and liver.

The results of analysis of lysine content in the longissimus muscle and liver are shown in Figure 2.

Lysine is not only an essential but also a critical amino acid. The level of this amino acid in taken with food is controlled in the animal husbandries of almost all species. This is because lysine is a catalyst for deamination and transamination reactions, which promotes the synthesis of nonessential amino acids. In general, lysine affects significantly energy, fat, mineral and, of course, protein metabolism. It stimulates the activity of a number of enzymes.

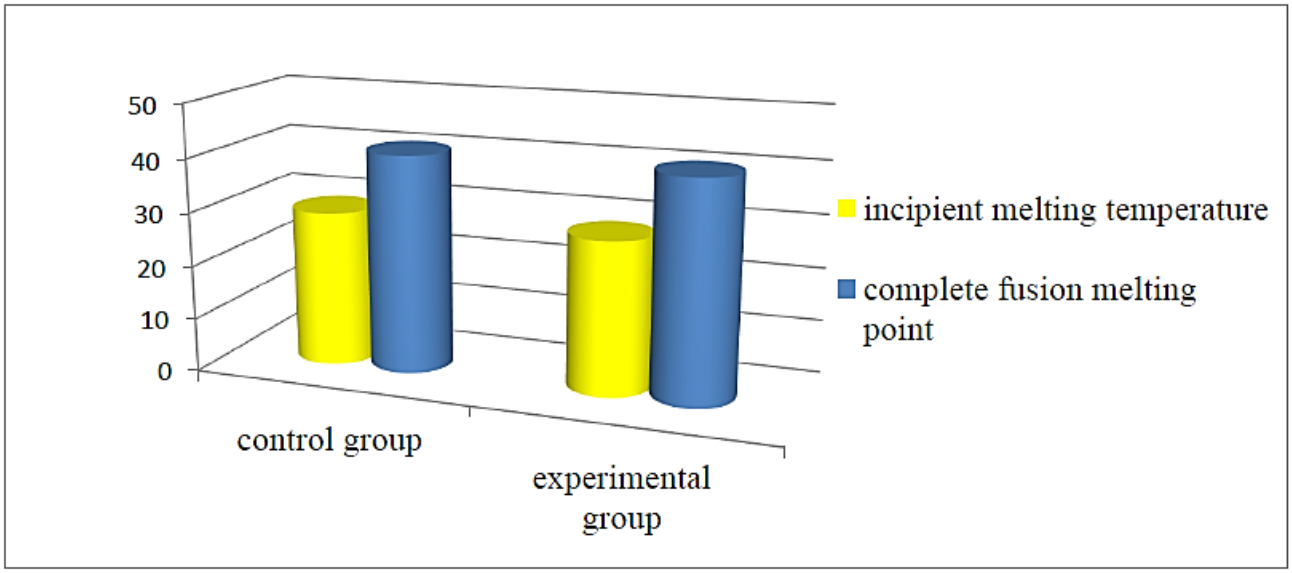

Figure 1. Lard melting point, °C.

The biological function of lysine has a positive effect on the growth rate and resistance of young animals and product synthesis. The lysine content in the meat of pigs from the experimental group increased compared to control. The advantage of pigs from the experimental group over animals from control in lysine content in meat was 0.9%. This indicates sufficiently high biological value of the studied meat samples. The content of lysine in the liver of pigs from the experimental group increased by 1.7% compared to control. It promoted the intensive growth and resistance of young pigs and the synthesis of products.

The liver is the largest parenchymal organ of mammals. Oxidation, reduction, decarboxylation, transamination, phosphorylation reactions take place in it continuously. It performs an important function in the intermediate metabolism. Synthesis of blood plasma proteins, fibrinogen, prothrombin, albumins and a number of globulins takes place in microsomes. Proteins from organs and tissues of the animal body compensate protein deficiency of feed initially. Liver proteins (40% or more) are used first, followed by blood proteins, later muscle, and other tissue proteins.

Therefore, the content of amino acids such as lysine and methionine with cystine in the liver are important indicators that characterize the metabolism of amino acids in animal organism (Figure 3).

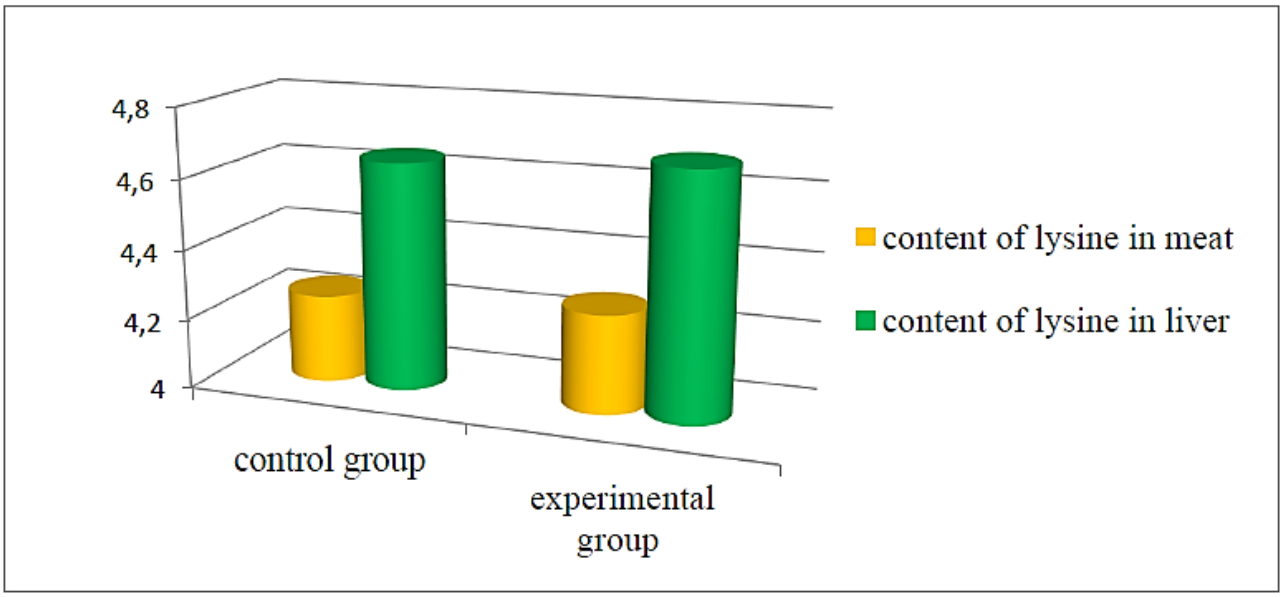

Figure 2. Content of lysine in longissimus muscle and liver of pigs, g/100 g.

Methionine is a critical essential amino acid. Its content in meat of pigs is especially important because methionine is a sulphur-containing essential amino acid. In addition, methionine has a great effect on the metabolism of fats, fat-soluble vitamins, prevents excessive accumulation of fat in the liver and its fat regeneration, as well as neutralizes toxic substances in the liver. The second sulphur-containing amino acid is cystine. Their content in the meat of pigs from the experimental group increased compared to control. The advantage of pigs from the experimental group over animals from control in the total content of methionine and cystine in meat was by 1.4%, and in the liver by 3.7%.

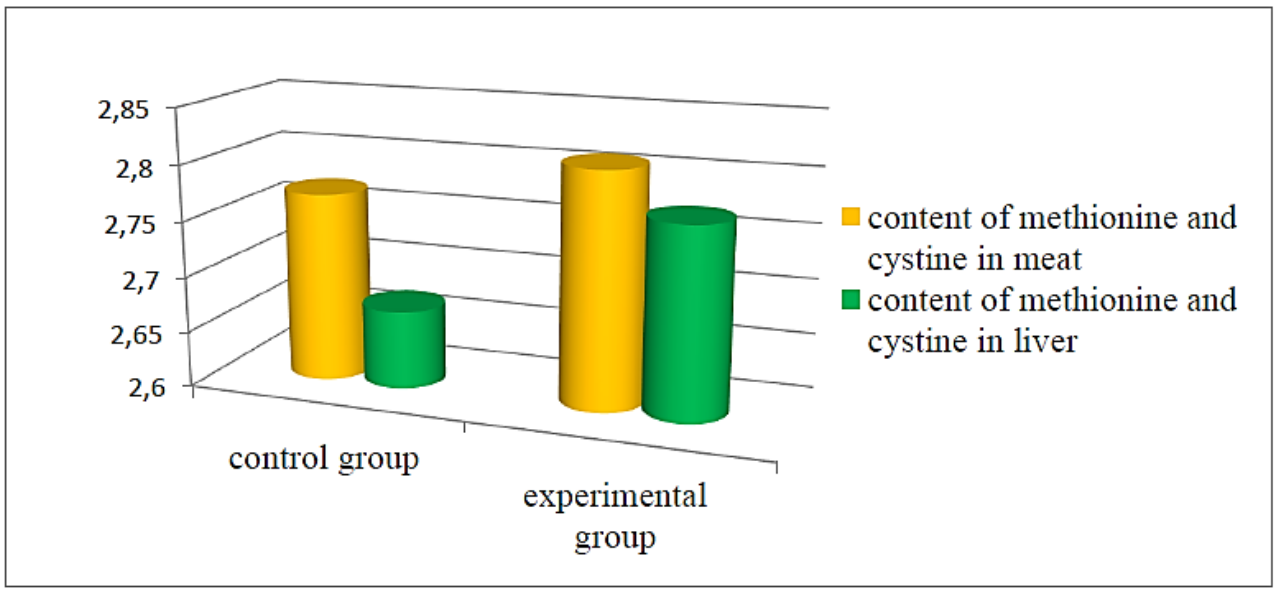

Figure 3. Content of methionine and cystine in longissimus muscle and liver of pigs, g/100 g.

Thus, amino acids in feed are the main source of renewal and formation of body proteins, and when the prebiotic containing mannan oligosaccharides was presented in the composition of feed for pigs during fattening, the amino acid composition of meat and liver of pigs was higher compared to control analogues.

Conclusion

We concluded that the prebiotic containing mannan oligosaccharides improved the vital functions of the symbiotic microflora in pig digestive tract, which affects the intensity of growth and development of animals. We therefore can justify their use in complete mixed feed for the meat pigs and confirm that prebiotics are suitable alternative to the feed antibiotics. Thus, we suggested that the introduction of prebiotic containing mannan oligosaccharides into the diet of young pigs at a dose of 0.06% from mixed feed increased the productivity of meat young pigs.

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