EFFECTS OF PURIFIED LIGNOCELLULOSE ON HEALTH AND PRODUCTION RESULTS OF BROILERS

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Abstract

Purified lignocellulose represents a pronutritive substance that affects the viscosity of the intestinal content, increases the absorption of nutrients and reduces the number of pathogenic bacteria in the small intestine. In this experiment the effects of lignocellulose in poultry nutrition was studied. Trial included 384 broilers of Cobb 500 provenance, both male and female, divided into four groups (control group: C and three experimental groups: E-I, E-II and E-III), 96 animals in each. Animals were fed with standard feed mixtures, starter (from 1st to 13th day), grover (from 14th to 28th day) and finisher (from 29th to 42th day), according to the manufacturer's recommendation. A control group (C) diet was without additives. The experimental groups differed in the fact that in the first two mixtures (starter and grover) a commercial preparation of purified lignocellulose (Arbocel® R, J. Rettenmaier & Söhne GmbH + CO. KG, Rosenberg, Germany) was added in the amount of 4 g/kg of feed for the E-I group, 6 g/kg of Arbocel® R as an expense of 0.3% soybean meal and 0.3% maize was added for the E-II group and 6 g/kg of Arbocel® R as an expense of 0.6% soybean meal was added for the E-III group. Analyzing the entire period of observation (from 1st to 42th day), adding the lignocellulose in experimental E-II group resulted in the best production indicators (final body weight 2611.00 g, average daily feed intake 96.09 g, average weight gain 2569.29 g and feed to gain ratio 1.67). Based on the obtained results, it can be concluded that the use of lignocelluloses in broilers nutrition has its medical, nutritional and economical justification.

Key words: *broilers, purified lignocellulose, addition, production results*

1. INTRODUCTION

Thanks to numerous discoveries and the application of science in the last twenty years, great progress has been made in the development and improvement of poultry production in the world. There is no branch of animal husbandry where such progress has been made as in poultry farming. Undoubtedly, these were accompanied by appropriate changes in the system of keeping and feeding poultry. Compared to other types of meat, chicken meat has a relatively low price, as well as acceptance by all cultures and religions, which makes chicken products acceptable, desirable and suitable in the daily human diet. Large specialized farms for broiler fattening, growing interest of producers for this type of fattening through cooperation, as well as the favorable price of broiler meat, in relation to the prices of other types of meat (Jovanović et al., 2004), also had an important role in the rapid development of poultry meat production. . In addition to intensive keeping of poultry, broilers are kept in less intensive fattening in various European countries, and in the last ten years there has been an ecological production of broilers. The following hybrids are present in the world: Cobb 500, Ross 308, Hybro, Hubbard, Lohman, and among them the most common are Cobb 500 and Ross 308 (Bjedov et al., 2011).

According to the data of the FAO and the US Department of Agriculture, the production of poultry meat, including broiler meat, has been growing worldwide in recent years. In 2013, 94.2 million tons of poultry meat were produced in the world, with the share of broiler meat being 87.4-90.3%, i.e. 86.4 million tons of broiler meat. In 2009, the production of broiler meat increased by 1.0 million tons (1.4%) compared to 2008, while in 2010 more than 4.5 million tons (6.1%) were produced compared to the previous year. In 2011, more than 3.0 million tons (3.8%) of broiler meat were produced, in 2012 - 1.95 million tons (2.3%), and in 2013 - 3.2 million tons (3.8%) of broiler meat compared to the previous year (2010, 2011 and 2012) (Sakhatskiy, 2014).

Production results in broiler fattening period depend of the genetic potential of the line hybrid, nutrition, fattening technology, health status and preventive measures. The application of biotechnology and genetics in the last 20 years has improved the production performance of broilers. One of the significant improvements in performance is the growth potential, which increased by about 60 years, every year at six weeks of age. As a result of the goals set before geneticists, fast-growing, broad-breasted hybrids with poor plumage have been produced, in which the anatomical, physiological, metabolic and hematological parameters have changed over time. One of the tasks of selection is to produce a broiler that has as few feathers as possible at the moment of the end of fattening, because it is easier to manipulate in the slaughterhouse. Broilers have a high basal metabolism and require strictly balanced meals composed of energy-rich nutrients, which at the same time contain other nutrients necessary for the growth of their organism. In broilers, the heart and lungs are barely able to provide enough oxygen to meet the body's needs. With controlled management conditions and biosecurity measures, breeders managed to produce broilers that reach a weight of 2100 g on the 35th day and 2800 g on the 42nd day, with feed conversion up to 1.47 (Bjedov et al., 2011).

1.1. Digestive tract of poultry

Digestive tract of poultry is a tubular system that extends from the oral cavity to the cloaca, and consists of specialized parts with associated glands. There are significant differences between individual animal species in the anatomy and physiology of individual segments, as well as the entire alimentary canal, and birds represent a unique animal order in this respect. The characteristic of digestion and resorption of feed is the basis of modern nutrition of certain species and categories of animals, as well as opportunities to improve the use of meal ingredients, i.e. diet management. The digestive system, and especially the intestines, represent the environment in which the most important physiological and biochemical processes of digestion take place, which are influenced by appropriate morphological, microbiological and physicochemical factors (MC Lelland, 1975).

In addition to macro-conditions, within the digestive system we can also discuss about micro-conditions, i.e. different ecological niches in certain parts of the intestine (Clarke and Bauchop, 1977). The surface of the epithelial cells, the mucus that coats the villi or the interior of the crypt, as well as the intraluminal contents provide different conditions for the development of certain types of bacteria. Based on that, it can be concluded that the conditions for the development of bacteria in the digestive tract of animals differ vertically from the esophagus to the rectum and horizontally from the lumen to the depth of the intestinal crypts. The microflora in each habitat is a typical, stable community of the highest order composed of a large number of different bacterial species. These communities are also characteristic of the animal species, but also depend on the diet, type of meal and housing conditions of the animal.

The activity of trypsin, protease and amylase increases rapidly during the first three weeks of broiler life, which is not the case with lipase. However, lipase activity did not increase until 21 days of age, and is thought to be a limiting factor in digestion. Using high-fat feed did not significantly increase lipase activity until 21 days of age. Several significant changes have been observed in the development of nutrient transport systems during ontogenesis in broilers. During the first week of broiler life, the absorption of proline in the small intestine is high compared to the absorption of glucose. Since the relative growth rate of broilers is highest during the first week, then the amino acid intake can be parallel to this growth pattern. During the second week, an increase in glucose absorption is visible. Due to the allometric growth of the intestine, during the second week of the broiler's life, a decrease in the intestine in relation to the body weight is visible. This may be another reason for the increase in glucose absorption that occurs during this period. During the sixth week, there is a temporary increase in proline absorption. This increase is parallel to the first post-juvenile moulting and the increase in the absolute growth rate. It is important that the absorption capacity of the intestine closely coincides with the nutritional needs of broilers (Kuenzel, 1994).

1.2. Fiber in poultry diet

Carbohydrates make up the largest feed component. Carbohydrates, as the most abundant ingredient in animal feed, represent a structural and supporting material in the body of plants, and they also have a significant role as an energy reserve created by photosynthesis. Structural carbohydrates, together with lignin, give shape and firmness to the plant, and non-structural ones represent energy reserves. Of the total amount of dry matter in plant tissues, carbohydrates contain for about 70%, while cereals contain up to 85% of carbohydrates. On the other hand, in the body of animals, carbohydrates are the main source of energy, and they have a significant role in ensuring normal peristalsis of the digestive tract (balance). Based on structure, carbohydrates can be divided into two groups: simple and complex sugars. Simple sugars are monosaccharides, and they differ in the number of carbon atoms and are divided into trioses, tetroses, pentoses, hexoses and heptoses. They can be interconnected to form di-, tri-, tetra- and penta oligosaccharides. Polysaccharides (glucans) are polymers of monosaccharides and are divided into homoglucans composed of the same units of monosaccharides and heteroglucans composed of different units of monosaccharides, and their derivatives (Binkley, 1988).

Modern approach defines carbohydrates as polyhydroxy aldehydes, ketones, alcohols or acids, and their simple derivatives, which are product of hydrolysis. Insoluble carbohydrates in plants, especially cellulose, are responsible for stability and their mechanical strength, while carbohydrates of higher solubility, such as starch, serve as energy depots. According to Jovanović et al. (2004), poultry has a natural ability to digest starch, glycogen, sucrose, maltose and simple sugars glucose and fructose, while lactose or milk sugar of poultry is very poorly digested due to limited lactase activity in the intestines.

Fibers are defined as skeletal remains of plant cells that are not susceptible to decomposition by digestive enzymes present in the animal body and represent a quantitatively respectable part of feed of plant origin. The variation in the amount and structure of fiber is large between different nutrients of plant origin. They consist of polymeric carbohydrates derived from the plant cell wall, including non-carbohydrate components such as lignin, which are not or are minimally digestible in the small intestine.

The U.S. Food and Nutrition Committee defines "total dietary fiber" as a set of "dietary fibers" consisting of indigestible carbohydrates and lignins derived from plant interiors, consisting of isolated, indigestible carbohydrate components with proven positive physiological effects on people.

According to Jovanović et al. (2004), crude fibers are divided depending on their type and origin into cellulose, hemicellulose and lignin (highly insoluble fibers found in the outer part of cereal grains and woody part of trees and shrubs). Fibers affect the development of the gastrointestinal tract, intestinal morphology and enzyme secretion, as well as the absorption of nutrients in animals, and these effects depend primarily on the physicochemical properties of the fibers, but also the age of the animals (Mateos et al., 2012). The physicochemical properties of fibers primarily depend on the type of polysaccharides that make up the cell wall, i.e. their intermolecular bonds determine the solubility of fibers, and they refer to water solubility, gel formation, crystallization, and the possibility of aggregation into complex plant cell wall structures.

Fiber is predominantly found in plant cell walls and consists of NSPs and some other non-carbohydrate compounds including lignin, proteins, fatty acids, and waxes to which the fiber is inextricably linked (Bach Knudsen, 2001).

Physicochemical properties of NSP in plants have an important role in human nutrition. Fiber aims to improve the health of the colon, reduce the amount of cholesterol, increase glucose metabolism, improve the insulin reaction, reduce the amount of lipids in the blood, as well as to reduce the frequency of certain types of cancer.

The main problems related to the use of NSP in poultry feed are viscosity and water binding capacity. Studies have shown that viscosity is a consequence of the presence of soluble pectins or -glucans, which even in small quantities significantly increase intestinal viscosity. On the other hand, undissolved polysaccharides such as cellulose and xylans can bind water in limited quantities, provided that they do not increase the viscosity in the digestive tract too much.

The addition of certain NSPs in the poultry diet has a negative effect on the digestion of starch, proteins and lipids. This effect is attributed to the presence of viscous sugars that interfere with the diffusion and transport of lipases, oils and bile salt mycelium within the gastrointestinal chyme.

Increased viscosity of intestinal contents can interfere with the interaction between the substrate and lipases or bile salts in the small intestine and thus reduce the resorption of certain nutrients. It is assumed that β -glucans found in barley and oats form complex connections with digestive enzymes and reduce their activity. However, contrary to the above, Ikegami et al. (1990) proved that the activity of GIT enzymes in rats increases after feeding with nutrients that increase viscosity in the digestive tract, so it can be concluded that although some NSP fractions have an antinutritive role in poultry metabolism, it is possible that some beneficial properties may be related with the final products of NSP fermentation.

Fiber content in nutrients of plant origin depends of the type and part of the plant, as well as the phase of vegetation. Young green or canned plants and root-tuberous nutrients contain the least amount of fiber, which increases with the vegetation phase. Hay, and especially straw, are very rich sources of fiber. Granular nutrients contain a relatively small amount of fiber, and the differences are related to the presence of chaff. The content of BEM in by-products varies relatively, which is conditioned by the type and method of processing the starting material. Nutrients of animal origin do not contain fiber, except for those left in the digestive tract after processing whole animals into meat meal.

The use of crude fiber in poultry nutrition formulas is often a controversial topic among many non-ruminant nutritionists. On the one hand, international organizations (Isa, Lohman) consider crude fiber an essential component, since their presence in feed, among other things, causes an increase in the size of the stomach, improves the digestibility of starch and limits or reduces the boiling of feathers. On the other hand, many nutritionists still avoid the significant use of fiber in poultry nutrition, explaining that fiber is not a significant source of energy, i.e. that the presence of fiber in feed inevitably leads to its energy dilution. In addition, traditional sources of fiber are associated with some negative properties, such as the possibility of contamination with mycotoxins. One of the reasons that fiber in poultry diet is still insufficiently accepted may be the fact that different fibers have different effects primarily on the digestive tract, but also on other non-ruminant organic systems.

Insoluble fiber present in feed has a dominant effect on intestinal function and thus modulates the utilization of nutrients. Definitely, the digestibility of starch, as well as the passage of intestinal contents, are under the direct influence of the insoluble fibers present in feed, which reduces the risk of colonization of harmful bacteria. It can be concluded that insoluble fibers affect the health of the intestine through two different mechanisms of action, which relate to the faster transit of intestinal contents, but also to the increased number of goblet cells. Goblet cells are a special type of epithelial cells whose basic function is the formation of mucin, a constituent component of intestinal mucus. It is a known fact that harmful types of bacteria cannot be so easily attached to the unaltered intestinal mucosa and colonize them, so that an increased number of goblet cells has a positive effect on the health of the digestive tract and the maintenance of eubiosis. Also, insoluble fibers have a very high water binding capacity, so by binding water in the upper parts of the intestine, they release the same water by osmotic pressure in the lower parts, which makes it available for resorption and does not appear in the environment, i.e. directly affects the humidity of the mat.

Traditional source of fiber in our conditions are mainly wheat bran, which still contains an insufficient amount of fiber (about 10%) and carries with them the risk of the presence of mycotoxins. The solution could be the use of oat bran, which contains a high percentage of insoluble fiber, but they can rarely be found on the market, and there is a possibility of contamination with mycotoxins. For this reason, the use of insoluble crude fiber concentrates (CFCs) is imposed, the chemical composition and purity of which would differ significantly from standard sources of fiber in the diet of non-ruminants. According to Hetland et al. (2004), insoluble fiber has traditionally been viewed as an inert diluent of nutrients with little or no nutritional value in the diet of monogastric animals. However, recent research indicates a positive role of insoluble fiber on the development and health of the digestive tract of poultry, and thus increase the resorption of essential nutrients and control the behavior of animals. (Mateos et al., 2012).

Although previous studies (Sklan et al., 2003) indicated a negative impact of fiber on feed consumption, digestibility of basic nutrients and general production results, recent data (Gonzalez-Alvarado et al., 2010) indicate that fibrous materials in moderate amounts improve broiler performance. The type and amount of fiber present in feed affect the development of the gastrointestinal tract and the production results of broilers in fattening (Jim'enez-Moreno et al., 2009).

A specific characteristic of different fibers is their solubility, which crucially affects the health and behavior of poultry. Plant roots, sugar beets, as well as certain fruits (apples, oranges, etc.) are sources of primarily soluble fiber, unlike all types of cereals that contain a large percentage of insoluble fiber. Although soluble fibers can show a mild prebiotic effect, their presence in feed increases the viscosity of intestinal contents, which reduces the digestibility of starch, fats and proteins, and binds certain nutrients, which negatively affects their digestibility. (Iji et al., 2001). Unlike soluble, insoluble fibers increase the speed of passage of intestinal contents, which reduces the possibility of accumulation of toxic substances in the digestive tract. They also stimulate the development of intestinal villi, have a positive effect on the digestibility of starch and prevent the occurrence of cannibalism (Farran and Akilian, 2014).

Insoluble and swollen fibers such as cellulose complex fill the digestive system as they have a good water binding capacity. The effect of swollen fiber affects the stimulation of the intestinal edge receptor thus facilitating the passage of feed through the intestine. On the other hand, soluble and fermentable fibers are a nutritious basis for lactic acid bacteria in the back of the intestine. Among fermentable fibers, pectin present primarily in sugar cane and apple pulp has a very important role as an energy source for animals. Unlike young animals whose diet should be formulated without the use of large amounts of soluble and fermentable fiber sources, because digestion in the back of the intestine is not well developed, older categories of animals are able to use these feed sources efficiently. Increased intake of soluble fiber has a positive effect on energy digestibility, while the presence of insoluble fiber reduces energy digestibility, which indicates the fact that the ratio of soluble and insoluble fiber affects the digestibility of feed.

1.3. Lignocellulose, role, significance and mode of action

Lignocellulose is a product obtained from wood and is used as a high-quality source of fiber in animal nutrition. It consists of carbohydrates (cellulose, hemicellulose) and lignin, which is not a well-defined substance, but an aromatic polymer derived from three phenyl-propane derivatives, namely coumaril, coniferial and sinapil alcohol. Also, pectin is present, and traces of certain minerals and salt (Singh et al., 2014). All plants contain lignocellulose, but among them lignin is almost completely insoluble and provides physical strength and firmness to the cell wall of the plant. On the other hand, the presence of lignin in lignocellulose prevents its efficient enzymatic degradation and subsequent microbiological fermentation of the resulting sugars (Zeng et al., 2014).

Due to its complex structure, lignocellulose is very insoluble and cannot be used directly in microbiological processes. However, by exposing lignocellulose to enzymatic hydrolysis, enzymatic sugars are released, which can be used by microorganisms to produce enzymes for their growth (Meng and Ragauskas, 2014).

Shivus and Denstadli (2010) found that the presence of lignocellulose in the meal prolongs the retention time of feed in the muscular part of the stomach, which increases the efficiency of exogenous (added) enzymes. First of all, the described effect should be expressed in the digestion of proteins, since the first step in their digestion is hydrolysis in the stomach under the action of gastric acid. Similar results related to proteolytic enzyme activity and increased amino acid digestibility were found by Yokhana et al., (2014). On average, the addition of 0.8% lignocellulose to the broiler meal increased the digestibility of essential amino acids by 5.8%, based on which a matrix value for insoluble CFC was calculated that allows a reduction in the amount of soybean meal when optimizing the meal.

Farran et al. (2013) proved that lignocellulose added to feed in the amount of 0.8% increased protein digestibility and meat yield, i.e. significantly reduced the amount of abdominal fat in broilers in fattening. The obtained results are confirmed by Bogusławska-Tryk et al. (2015), who proved that lignocellulose in the amount of 0.5-1.0% has a positive effect on the composition of the intestinal microbiota and the degree of microbiological fermentation in the intestines.

Lignocellulose affects the health of the small intestine by preventing the colonization of harmful bacteria through two different mechanisms of action, which are related to increasing the number of goblet cells and accelerating the passage of intestinal contents. Rezaei et al (2011) demonstrated a significant increase in goblet cell count, and Hetland et al. (2004) acceleration of intestinal passage when a moderate amount of chlorofluorocarbons was present in the broiler meal.

2. MATERIAL AND METHODS

In order to study the justification for the use of purified lignocellulose in broiler feed, tests were performed to provide detailed insight into production results (body weight, feed consumption and feed conversion).

Trial was organized according to the group control system on the farm Pileprom d.o.o., Srbac, Republika Srpska (BiH) for a period of 42 days. Cobb 400 provenance broilers originating from the commercial incubator station "Insta d.o.o, Srbac, Republika Srpska, (BiH)" were used for the experiment. The tests were performed on one-day-old broilers of both sexes with an average body weight of 41.84 g. During the experiment, all experimental groups were fed with mixtures of standard raw material composition that fully met the needs of broilers in all phases of fattening. The feeding program included three periods of fattening from 1-42 days, during which three nutritionally different concentrated mixtures were applied in pelleted form: starter (from 0-13 days, crushed pellets), grover (14-28 days, pellets 3,5 cm) and finisher (days 29-42, pellets 3.5 cm) manufactured by Feed Factory Rapić d.o.o, PJ Farmofit, Gradiška, Republika Srpska (BiH). The basal diet was formulated to meet the maintenance and growth requirements of the animals used in the experiment.

The main task of the study was to determine the influence of broiler diet in fattening mixtures with different amounts of purified lignocellulose on health status and production results. Therefore, minimal corrections were made in the feed mixtures of the experimental groups in order to achieve the set goal (Tables 1 and 2). The mixtures for the experimental groups differed only in fact that in the first two mixtures (starter and grover) a preparation of purified lignocellulose was added in quantities of 4 g / kg of feed and 6 g / kg of feed for the first and second experimental group, i.e. 6 g / kg for the third experimental group with a reduction of soybean meal by 0.6%. The commercial preparation Arbocel® (R, J. Rettenmaier & Söhne GmbH + CO. KG, Rosenberg, Germany) was added to the meal for all three experimental groups, containing about 70% acid detergent fibers (ADF) and 24% acid lignin detergent (ADL).

Nutrients	**Mixtures, (%)**		
	I-starter	**II-grover**	**III-finisher**
Maize	40.86	46.40	44.83
Wheat	15.00	15.00	20,.00
Soybean meal	31.10	21.86	17.75
Full Fat soya	7.00	12.00	12.00
Soybean oil	1.71	0.78	1.68
Chalk	1.44	1.26	1.24
Monocalcium phosphate	1.02	0.86	0.66
Salt	0.20	0.19	0.19
Sodium bicarbonate	0.17	0.15	0.15

Premix	1.50	1.50	1.50
Total	**100.00**	**100.00**	**100.00**

Table 1. Raw material composition of broiler feed mixtures in fattening, (%)

	Starter 0-13 days				Grover 14-28 days				Finisher 29-42 days
Nutrient	**C**	**E-1**	**E-2**	**E-3**	**C**	**E-1**	**E-2**	**E-3**	
Metabolic energy Kcal/kg	2990	2984	2979	2985	3045	3037	3033	3040	3150
Moisture	10.93	10,93	10.87	10.88	11.09	11.1	11.03	11.04	11.11
Total ash	5.92	5.92	5.89	5.88	5.56	5.56	5.54	5.53	5.16
Crude protein	22	21.95	21.87	21.84	20	19.26	19.89	19.87	18.5
Crude fiber	3.4	3.82	3.97	3.95	3.25	3.67	3.85	3.82	3.15
Total lipids	5.21	5.21	5.19	5.2	5.31	5.31	5.29	5.3	6.19
Calcium	0.95	0.95	0.95	0.95	0.9	0.9	0.9	0.9	0.8
Phosphorus total	0.67	0.67	0.66	0.66	0.62	0.62	0.61	0.61	0.56
Phosphorus available	0.44	0.44	0.44	0.44	0.42	0.42	0.42	0.42	0.40
Sodium	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Chlorine	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
NFE***	52.44	52.21	52.21	52.25	54.79	55.1	54.4	54.44	55.89
Lysine (total)	1.30	1.30	1.30	1.30	1.18	1.18	1.18	1.18	1.06
Met+Cys (total)	0.98	0.98	0.98	0.98	0.88	0.88	0.88	0.88	0.80
Threonine (total)	0.87	0.87	0.87	0.87	0.80	0.80	0.80	0.80	0.72

Table 2. Chemical composition of mixtures for feeding broilers in fattening (%)

Premix provided per kg of complete diet: Vitamin A 13500 IU, Vitamin D3 5000 IU, Vitamin E 80 IU,Vitamin K3 4 mg, Vitamin B1 4 mg,Vitamin B2 6 mg, Vitamin B6 5 mg, Vitamin B12 0.025 mg, Vitamin C 25 mg, Biotin 0.15 mg, Niacin 60 mg, Calcium pantothenate 16.5 mg, Holin hlorid 750 mg, Folic acid 2 mg, Iodine 1 mg, Selenium 0.3 mg, Iron 40 mg, Copper 20 mg, Manganese 100 mg, Zinc 80 mg, Antioxidant 125 mg, Endo-1,3(4)-beta-glucanase (4a15) EC3.2.1.6 - 152 U, Endo-1,4-beta-xylanase (4a15) EC 3.2.1.8 – 1220 U, 6-phytase (4a1640) EC3.1.3.26 – 500 FTU

Control measurements of experimental units were performed individually during the introduction of one-day-old broilers, as well as at the end of each phase of broiler fattening. Measurements were performed on an electronic scale with an accuracy of 1 g. Based on the measurement results, the average body weight of broilers was calculated at the end of each phase, as well as at the beginning and end of the experiment collectively. From the differences in body mass at the beginning and end of each phase, the total gain was calculated, and based on the duration of individual phases, as well as the experiment itself, the total and daily gain.

During the experiment, at the end of each phase, the amount of feed consumed for each group was precisely measured. From the obtained data on feed consumption and growth, feed conversion was calculated separately for each phase, as well as for the entire experiment.

On day 28 of the experiment, five samples were taken from each box from all layers of litter (4 near the walls and one in the middle). Samples from each group were assembled and thoroughly mixed, and the moisture content was determined by drying at 103 ± 2 ° C to constant weight (ISO 1442: 1997).

3. RESULTS

3.1. Broiler body weight during fattening

The movement of broiler body weight in the experiment is shown in Table 3, where it can be seen that broilers at the beginning of the experiment had a uniform body weight (41.71 ± 1.41-42.16 ± 1.31 g) and that no statistically significant differences were found. After three weeks of fattening, the highest body weight (826.20 ± 118.94 g) was achieved by the group of broilers (O-II) which received a larger amount of lignocellulose preparations through feed and which was statistically significantly higher (p <0.05) in relation to the body weight of the broilers in control group (772.10 ± 117.47 g) and in first experimental group (782.10 ± 96.93 g). At the end of the experiment, only the group of broilers fed with a smaller amount of added lignocellulose achieved a slightly lower body weight (0.02%) compared to the control group of broilers. The highest body weight was achieved by the experimental group of broilers (O-II) to which a higher amount of lignocellulose was added to the feed, without reducing the share of soybean meal, by 7.5% compared to broilers of control group, respectively 7.7 and 4.6 % in relation to broilers of O-I and O-III groups. A statistically significant difference (p <0.05) was found between the average weight of broilers of the experimental group O-II and other observed groups (Table 3).

Day of measuring	**Groups**			
	C	**E-I**	**E-II**	**E-III**
$\bar{X}$± SD				
Day 1	41.72±1.41	42.16±1.31	41.71±1.40	41.93±1.98
Day 21	772.10±117.47^{a}	782.10±96.93^{a}	826.20±118.94^{b}	785.90±123.03^{ab}
Day 42	2420±332.15^{a}	2432±260.32^{a}	2611±266.69^{b}	2495±309.56^{a}

Legend: same letters a, b, c, ab p <0.05;

Table 3. Broiler body weights during the experiment, G

3.2. Average growth of broilers during fattening

Average growth of broilers during the experiment is shown in Table 4, which shows that the addition of larger amounts of lignocellulose to the meal resulted in the highest daily gain in the second (784.00 ± 118.81 g) and third (743.97 ± 117.98). d) experimental group of broilers during the first half of the experiment. The same trend was maintained in the second part of the experiment (21-42 days) where the highest average daily gain was achieved by the O-II group (1781.80 ± 278.99 g) and which was statistically significantly higher (p <0.05) in relation to the realized average daily gain of the control (1647.90 ± 330.58 g) and O-I (1640.90 ± 269.32 g) group, but not O-III (1709.10 ± 305.97 g) groups of broilers. Observed for the whole experiment, collectively (1-42 days) the lowest average daily gain was achieved by broilers of the control (2378.28 ± 332.14 g), and the largest average daily gain was achieved by broilers of O-II (2569.29 ± 266.50 g) group, which was statistically significantly higher in relation to the growth of the control and O-I (2389.84 ± 263.01 g) groups.

Period of fattening	Groups			
	К	**O-I**	**O-II**	**O-III**
X̄± SD				
Days 1-21.	730.38±109.44[a]	739.94±98.06[a]	784.49±118.81[б]	743.97±117.98[a]
Days 22-42.	1647.90±330.58[a]	1649.90±269.32[a]	1784.80±278.99[б]	1709.10±305.97[ц]
Days 1-42.	2378.28±332.14[a]	2389.84±263.01[a]	2569.29±266.50[б]	2453.07±307.11[ц]

Legend: same letters a, b, c p <0.05

Table 4. Average growth of broilers during the experiment, g

3.3. Consumption and conversion of broiler feed during fattening

Daily feed consumption is shown in Table 5, from which it can be seen that the control group of broilers consumed the usual amounts of feed during the experiment. In the first phase of the experiment (day 1-21), feed consumption did not differ significantly between the experimental groups of broilers fed mixtures to which different amounts of lignocellulose preparations were added, with the exception of broilers of group O-II that achieved the highest feed consumption (1063.30 g), which was 4.1% better compared to broilers of control group. An identical trend was found in the second phase of the experiment (days 21-42), where the highest feed consumption (3.254 g) was found in the group of broilers (O-II), with a larger amount of lignocellulose preparations was added to the feed without reducing the share of soybean meal.

Period of fattening	К	O-I	O-II	O-III
Days 1-21.	51.27	50.64	52.63	51.24
Days 22-42.	154.47	143.21	154.99	149.72
Days 1-42.	103.02	96.93	103,.81	100.48

Table 5. Average daily consumption during broiler fattening, g

Observed for the whole experiment, the addition of lignocellulose did not affect feed consumption, so that the control group achieved better consumption by 6.3 and 2.5% compared to O-I and O-III groups, and lower consumption by 0.80 % relative to group O-II.

Period of fattening	К	O-I	O-II	O-III
Days 1-21.	1.076	1.063	1.105	1.076
Days 22-42.	3.250	3.007	3.254	3.144
Days 1-42.	4.327	4.071	4.360	4.220

Table 6. Total feed consumption during broiler fattening, kg

The average feed conversion during the experiment is shown in Table 7, and the data show a positive effect of adding lignocellulose preparations to feed, with the highest feed conversion in the first phase of the experiment achieved by broilers of the control group (1,394), which was 2.5; 4.2 and 1.8% weaker in relation to the achieved feed conversion of broilers O-I, O-II and O-III groups. In the second phase of the experiment (days 21-42), the same trend was maintained, so that the best feed conversion was achieved by broilers of O-I group (1,822), and the worst by broilers (1,973) of the control group. Observed for the whole period of fattening, from the first to the forty-second day of fattening, broilers of the control group achieved the highest feed conversion (1,788), while broilers of experimental fed mixtures in which different amounts of lignocellulose were added achieved lower and almost identical (1,673; 1,669 and 1,691) feed conversion relative to control group broilers.

Period of fattening	K	O-I	O-II	O-III
Days 1-21.	1.394	1.359	1.337	1.369
Days 22-42.	1.973	1.822	1.823	1.839
Days 1-42.	1.788	1.673	1.669	1.691

Table 7. Feed conversion during broiler fattening, kg

4. CONCLUSION

Insoluble fiber has a positive effect on the utilization of nutrients, so that the presence of insoluble fiber in the meal prolongs the retention time of feed presence in the muscular part of the stomach, which increases the efficiency of exogenous (added) enzymes. First of all, the described effect should be expressed in the digestion of proteins, since the first step in their digestion is hydrolysis in the stomach under the action of gastric acid. On average, the addition of 0.8% lignocellulose to the broiler diet increased the digestibility of essential amino acids by 5.8%, based on which a matrix value for insoluble CFC was calculated that allows a reduction in the amount of soybean meal when optimizing the meal.

Adding higher amounts of lignocellulose to the meal resulted in the highest body weight and the highest average daily gain, which was statistically significantly higher than the achieved body weight and average daily gain of broilers in the control group, as well as O-I group of broilers that received less amount of lignocellulose preparations in feed. The highest body weight (2611 ± 266.69 g), as well as the highest average daily gain (2569.29 ± 266.50 g) was achieved by a group of broilers that received 0.6% of lignocellulose preparations through feed, without reducing the share of soybean meal (O-II).

By analyzing the basic economic indicators (total costs, production value, economy coefficient), we can conclude that the overall financial result was positive for all four observed groups of broilers, with the addition of a larger amount of lignocellulose preparations to the feed resulted in the best financial effect.

ACKNOWLEDGMENTS

This work was funded by the Ministry of Education, Science and Technological Development under Project TR 31034 and Project III 46002.

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