Efficiency of soy protein concentrate in diets of weaned piglets

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ABSTRACT: The aim of this experiment was to determine the influence of "HP 300" soy protein concentrate (SPC) on the wellness, intestine microflora, growth rate and feed consumption compared with that of fish meal in weaned piglets. To create a balanced experiment on breed, gender, age and weight, two groups of 19 weaned piglets were composed. The first group was a control while the second group was experimental. The experiment was divided into two periods: the first period lasted for 27 days while the second lasted for 14 days. The duration of the experiment was 41 days in total. The composition of feed and sustenance were the same in both periods. The piglets from the second group receiving the feed without fish meal gained 69 g or 18.4% more ($P > 0.05$) weight on average than the piglets from the first group during the whole period. No essential differences in feed consumption per 1 kg of weight gain between the groups were identified during the whole period. While examining the amount of enterobacteria in faeces it was estimated that the amount of enterobacteria in the faeces of piglets of the second group decreased during the whole experimental period. At the end of experiment the amount of enterobacteria in the faeces of piglets of the second group gradually decreased by 12% compared with the enterobacteria amount at the start of experiment. The amount of enterobacteria in the faeces of piglets of the first group also decreased by 12%. However, the amount of enterobacteria in the faeces of piglets of the first group decreased more sharply than in piglets of the second group.

Keywords: piglets; fish meal; soy concentrate HP; microflora

Feed and its quality have a great influence on piglet productivity and health. Feed constitutes approximately 70% of all animal breeding production expenses. Therefore the composition of feed for piglets has a substantial economic role in pig breeding.

Pig weaning is a strong and stressful factor which has a negative influence on both pig productivity and their immunity (Simon, 2001). The security of optimal pig feeding conditions is recommended within this period. It is of fundamental importance to feed pigs with easily digestible feed which has a positive influence on the microflora. The normal intestine microflora of piglets influences their wellness, their formation of immunity and resistance to infections (Lovatto et al., 2005). The stress of weaning negatively affects the population of bifidobacteria by decreasing their number in the intestine of piglets (Etheridge et al., 1984; Freitag et al., 1998). Precisely, the change of microflora in the intestine of piglets determines their diseases, decreases productivity and influences deaths. A decrease in the intestine microflora (*Bifidobacteria, Enterococcus*) population of piglets at the time of stress leads to an increase in pathogenic microorganisms (Bertschinger and Fairbrothe, 1999). The security of stable microflora in the intestine of piglets after weaning is one of the main factors determining their health and productivity.

The feeding of antibiotics was a guarantee of stable microflora in the intestine for a long time (Kasper, 1998; Kroismayr et al., 2005; Roth and Ette, 2005). Currently, antibiotics can be used only for disease

treatment. Other feed supplements replaced antibiotic growth stimulants, i.e. organic acids (acidifiers), probiotics and prebiotics (Tsiloyiannis et al., 2001; Mosenthin, 2002; AWT, 2004; Hamidreza and Werner, 2005). In order to secure the intestine of piglets, the present feed supplements are applied (Denis et al., 1995; Tsiloyiannis et al., 2001).

Eubiotics (common microorganisms of the intestine) are attributed to the probiotics by the majority of the researchers. Mostly *Bifidobacteria* and *Lactobacillus* microorganisms positively affect the wellness of animals and are secreted from their own intestine. Natural bacteria of an organism positively affect the intestinal mucus and constitute a protective layer which protects from the penetration of bacteria causing diseases. It is known that *Bifidobacteria* and *Lactobacilli* are a significant part of metabolism processes in the organism. Therefore, no intrusive bacteria *(Escherichia coli, Citrobacter* spp.*),* fungi *(Ryzopus* spp.*)* or yeasts (*Saccharomyces* spp.*, Candida pintolepessii*) are identified within the intestine. One of the main reasons for a positive influence of probiotics on the intestine is their probiotic effect (Rolfe, 2000; Asahara et al., 2001; Ishibashi and Yamazaki, 2001; Ohya et al., 2001).

It is known that the productivity as well as the immunity of piglets depend on feed sustenance which is determined by the raw material used for their production. Starter compound feeds for weaned piglets have to be well-balanced according to the feed substances. The raw material to be used for the production of starter compound feeds should be highly digestible. As a result of unadjusted digestive system functions during weaning, the piglets digest a raw material of animal sources most easily. However, it is expensive. In order to reduce the price of feed, it is advisable to use alternative raw materials of plant sources. It has been estimated that the composition of feed also affects the intestine microflora of piglets (Mathew et al., 1987; Moore et al., 1987). The replacement of a feed raw material of animal sources by feed of plant sources should not affect the microflora population in the intestine of the piglets.

The dependence of fattened pigs on the composition of starter compound feeds has also been noticed. Therefore, the previously mentioned factors appear while feeding the weaned piglets. Firstly, the feed of weaned piglets should be easily digestible and nutritious. Secondly, feed raw materials should be the same as those used for the feed of fattened pigs. Thirdly, the feed of weaned piglets should have a positive influence on the intestine under formation as well as compensate some of its functions that cannot be performed yet. Fourthly, the feed for weaned piglets has to be safe and should not cause any harm to the condition of the intestine microflora.

It has been estimated that fish meal, applied in the production of starter compound feeds in Lithuania, is often contaminated by the bacteria *Escherichia coli* and/or *Clostridium perfringens*. In 2003 the analysis of microbiological impurity in five samples of fish meal was accomplished. This product (fish meal) was imported from South America to Lithuania and was used for industrial compound feed production. In one sample *Clostridium perfringens* was found. In 2004 the analysis of 15 industrial compound feed samples was accomplished. Bacterial impurity was found in three samples (http://www. lvvpi.lt). So, the most common cause of piglet diarrhoea and insufficient pig productivity is the application of insecure raw materials in their feed. It is necessary to find a safe, easily digestible and nutritious raw material for the production of starter compound feeds which also positively affects the intestine microflora and is close to the raw material further applied in pig feeding. The cause of depression while digesting feed substances can be attributed to feed protein of animal sources and condensation of carbohydrates (called Mailard's reaction) which appears after a longer storage of feed compounds together with albuminous raw material of animal sources (Jeroch et al., 1999).

Due to Mailard's reaction the contained products become dissolved with difficulties by the organism ferments. The assimilation of amino acids becomes worse and the fermentation processes are affected in the large intestine as a result of the amount of increased substratum (Ulbrich et al., 2004).

The aim of the present paper was to determine the influence of "HP 300" soy protein, compared to fish meal, on the wellness, intestine microflora, growth and feed consumption of weaned piglets.

MATERIAL AND METHODS

An experiment was conducted with the crossbreds of Lithuanian Large White (mother) and Norwegian Landrace and Yorkshire (sire) on a pig farm located in the Pakruojis region in 2005. Weaned piglets at 35 days of age were selected for the experiment. On the grounds of symmetry considering the breed, gender,

age and weight, two groups of 19 weaned piglets in each were set up. The first group was a control while the second was an experimental one. The process of the experiment was divided into two periods: the first that lasted for 27 days and the second lasting for 14 days. The duration of the experiment was 41 days in total. The composition of feed and sustenance were the same in both periods.

During the experiment the piglets of both groups received dry powder compound feed from automatic feeders. Automatic separate water-troughs were used in order to supply enough water. Each stall was equipped with one automatic water-trough and feeder. Two piglets were able to eat from the feeder at once. During the experiment piglets were kept in sectional stalls, 19 piglets in each. A stall area of 1.2 m^2 was given to each of the piglets. The floor of the stalls was made of concrete and covered with sawdust every day. Average temperature in the stall was 18–20°C, relative air humidity reached 70% during the experiment. No other parameters of microclimate were estimated.

Table 1. Composition and nutritive value of compound feeds

Item	Group I	Group II
Wheat (%)	43.0	40.5
Barley (%)	20.0	20.0
Maize (%)	8.0	8.0
Soybean meal (%)	3.0	4.5
Fish meal (%)	10.0	–
HP 300 Hamlet protein (%)	–	10.0
Whey (%)	7.0	7.0
Lyprot SG 9%	2.0	3.0
Canola oil (%)	3.0	3.0
Mineral vitamin supplement Schaumalac F60 (%)*	4.0	4.0
Analytical data (1 kg)		
Metabolizable energy (MJ)	13.99	13.63
Dry matter (%)	88.0	88.0
Crude protein (%)	18.22	17.36
Fibre (%)	2.40	2.65
Fat (%)	5.21	4.85
Ash (%)	4.6	4.6
Starch (%)	41.26	40.22
Sugar (%)	2.06	2.17
Calcium (%)	1.26	0.77
Phosphorus (%)	0.80	0.57
Sodium (%)	0.29	0.26
Lysine (%)	1.40	1.33
Methionine + cistine (%)	0.89	0.86
Threonine (%)	0.81	0.75
Tryptophan (%)	0.22	0.22
Lactose (%)	4.0	4.0

*mineral vitamin supplement Schaumalac F60 contains per 1 kg: vitamin A 350 000 IU; vitamin D_3 50 000 IU; vitamin E 3 500 mg; vitamin K_3 100 mg; vitamin B_1 70 mg; vitamin B_2 180 mg; pantothenic acid 500 mg; niacin 900 mg; choline chloride 1 000 mg; vitamin B_6 120 mg; vitamin B_{12} 1.2 mg; biotin 4 mg; folic acid 40 mg; vitamin C 2 000 mg; iron 5 000 mg; copper 4 000 mg; zinc 3 000 mg; manganese 2 000 mg; iodine 50 mg; selenium 11 mg; cobalt 25 mg; phytase 12 500 FTU; bonvital *Enterococcus faecium* – 25×10^9 CFU

Compound feeds were produced from grain and other raw materials bought from other agricultural farms. All necessary feed raw materials were bought at once for the time of the experiment. In order to improve compound feeds according to piglets' physiological demands under farm conditions, the mineral vitamin additive "Schaumalac F60" was used.

The piglets from the control group were administered compound feed with the raw material of animal source, i.e. fish meal, while the piglets from the experimental group received feed with HP soy protein concentrate instead of fish meal. Biochemical composition and nutritive value of feeds are presented in Table 1.

The probiotic (*Enterococcus faecium*), phytase and other materials were the components of the additive "Schaumalac F60". While composing the recipes of compound feeds, the computer programme "Recept" was applied. The data of this programme contains nutritive values of feeds which were obtained from literature (NRC, 1998). The energy amount of compound feeds was calculated according to the formulas in literature (Jeroch et al., 2004). The nutritive value of feeds was estimated by valid methods of the EU (Naumann et al., 1976; Methods of Feed Research, 2003).

In order to determine weight growth, the piglets were weighed at the beginning of the experiment, after 27 days of the experiment and at the end of the experiment. The consumption of feeds was determined during the experiment as well as a record of feeds was kept.

In order to evaluate the health condition of piglets at the beginning of the experiment, after 27 days and at the end of experiment, microbiological analyses of piglet faeces were conducted and the piglets were kept under observation. Samples of faeces from the piglets of both groups were taken to sterile bottles before the experiment, during the experiment (after 27 days) and at the end of experiment. 1 g of faeces was used for a microbiological examination at the ratio of 1:99 suspended in physiological liquid. The initial dilution 1:100 of the faeces obtained was later diluted to the ratio from 1:9 to 10^{-7} × 0.05 ml of the suspension under investigation out of 10^{-4} dilution was inoculated onto the agar of Petri dishes. The total amount of enterobacteria was estimated while investigating the faeces. Experimental samples were inoculated onto three Petri dishes with McConkey agar. Cultivation was done under aerobic conditions for 24 hours at the temperature of +37°C. Colony-forming units (CFU/g) were calculated according to LST ISO 7 218:2 000 and displayed in logarithmic form.

The results were subjected to statistical processing using the program "R 2.20." (http://www.r-project.org) and WinExcel Program. Growth and enterobacteria data sets characterized by arithmetic means ($\bar{x}$) standard deviation (SD) and standard error of the mean (SE) are provided in tables (Juozaitienė and Kerzienė, 2001). Experimental average values ($\bar{x}$) were tested using Student's *t*-test. Statistical differences between means ($P < 0.05$) are indicated by a superscript (*).

RESULTS

The growth rate of piglets is presented in Table 2. It was estimated that during the first period the piglets of group II, fed the compound feed without fish meal, gained 20 g weight per day on average or 5.6% percent more ($P > 0.05$) than the piglets of group I.

Table 2. Data on piglet growth

Parameters	Group I			Group II		
	$\bar{x}$	SD	SE	$\bar{x}$	SD	SE
Average weight of piglets at the trial start (kg)	9.49	3.43	0.77	9.51	3.43	0.77
Average weight of piglets after 27 days (kg)	19.62	5.99	1.38	19.87	7.57	1.74
Average weight of piglets at the end of the trial (kg)	25.82	7.14	1.64	27.94	10.20	2.35
Daily gain during the first period (g)	358.60	132.40	29.60	378.60	163.40	37.50
Daily gain during the second period (g)	442.90	168.60	38.70	576.20*	221.40	50.80
Daily gain during the whole trial (g)	376.70	142.10	31.80	446.10	174.50	40.00

*$P < 0.05$ statistical significance of differences compared with the first group

Table 3. Compound feed intake and feed consumption

Parameters	Group I	Group II
Feed intake (kg/pig/day)		
During the first period	0.563	0.600
During the second period	0.846	1.109
During the whole trial	0.660	0.774
Feed consumption (per 1 kg of weight gain in kg)		
During the first period	1.60	1.59
During the second period	2.01	1.92
During the whole trial	1.76	1.74

During the second period the piglets of group II grew much faster and their weight gain was 133 g per day on average or 30% more ($P < 0.05$) than that from the control group.

The group II piglets, receiving the feed without fish meal, gained the weight of 69 g per day on average or 18.4% more ($P > 0.05$) than those of group I. The hypothesis that the replacement of HP soy concentrate for fish meal was effective cannot thus be rejected.

The experiment enabled to assess that the feed intake of the second group piglets was better than that of piglets from the first group. The data on the experiment are presented in Table 3. The second group piglets ate 7% and 31% more feed per day on average than the animals from the first group. During the whole period the average feed intake of the second group piglets was 114 g or 17% higher than that of the first group piglets.

After the feed consumption per 1 kg of weight gain was calculated, it was estimated that the replacement of HP soy concentrate for fish meal did not influence this index in the first period while the group II piglets consumed 4% less feed per 1 kg of weight gain than the group I piglets during the second period. No essential differences between the control group and the experimental one were apparent while calculating the whole period of the experiment. The feed consumption of compound feed per l kg of weight gain is presented in Table 3.

During the experiment no health disorders were identified either in the control group or in the experimental group.

The variation of enterobacteria amount is presented in Table 3. The amount of enterobacteria in the second group piglets was 5% higher at the beginning of the experiment than that in the first group. The present tendency remained the same at the end of the experiment, i.e. the enterobacteria count of the second group piglets was 5% higher than that of the first group. However, while investigating the amount of enterobacteria in faeces after 27 days of the experiment, an increase of 5% in the faeces of the first group piglets was observed and it was 3% higher than at the beginning of the experiment. Compound feeds with fish meal of the first group had a positive effect on the number of enterobacteria in faeces.

A decrease in the enterobacteria amount in the faeces of the second group piglets was estimated. It was 7% lower after 27 days of the experiment and 12% at the end of the experiment as compared to the beginning of the experiment. The enterobacteria count decreased immediately in the faeces of the first group piglets and was 12% lower than at the beginning of the experiment. Therefore, the enterobacteria count in the faeces of the first and second group piglets decreased concurrently. The present index of the second group piglets decreased gradually, unlike that of the control group.

Table 4. Total enterobacteria count in piglet faeces (Log_{10} CFU/g)

Parameters	Group I			Group II		
	$\bar{x}$	SD	SE	$\bar{x}$	SD	SE
At the start of the trial	5.80	0.32	0.15	6.07	0.10	0.05
After 27 days	5.96	0.40	0.20	5.64	0.63	0.31
At the end of the trial	5.09	0.80	0.36	5.33	0.85	0.38

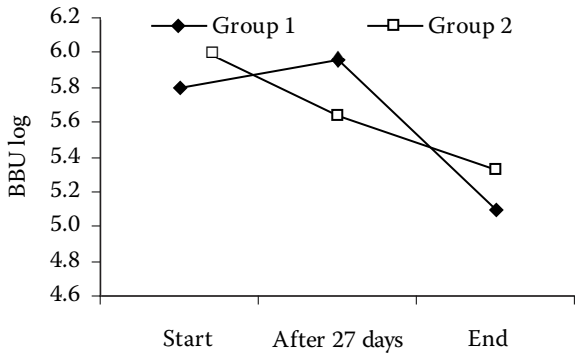

Figure 1. General variation dynamics of enterobacteria count during the experiment

DISCUSSION

The replacement of fish meal by a vegetative raw material in starter compound feeds is investigated for several economic and physiologic reasons. The requirements for feed safety initiate the investigation of the present problem in Lithuania due to inappropriate production, transport and storage conditions. Fish meal contains pathogenic *Escherichia coli* and *Clostridium perfringens*. In order to avoid the consumption of the present raw material, an alternative should be applied. Potato proteins, HP soy concentrate and other raw materials can be used in the production of starter feeds for weaned piglets as alternatives to fish meal (Kasper, 1998; Kerr et al., 1998) without having a harmful effect on piglet productivity (BVDO, 2003).

The HP 300 soy protein concentrate contains a large amount of protein (min. 48%), a small amount of crude fibre (max. 3.5%) and a small texture (Lindermayer and Propstmeier, 2004). Therefore, especially piglets like it. If the piglets are fed homemade feeds, the HP 300 soy concentrate need not be additionally ground as they easily mix up with other components of feeds. The EU agricultural reform caused a decrease in grain prices. Therefore, grains are a source of cheap food substances and increase the portion of cereal grains in feeds applying HP 300 soy. Animal breeders, who themselves produce compound feeds, should include grains in rations as much as possible. Applying the soy protein concentrate, the amount of crude fibre is decreased by 0.7% while the energy is increased by 0.3 MJ AE (BVDO, 2003). When compound feeds contain too much crude fibre, the energy involved decreases. As a result, weight gains also decrease and feed conversion becomes worse. In order to achieve a maximum benefit of the rations, the amount of crude fibre should not exceed 4–5%.

Nowadays the replacement of feed of animal origin by feed of plant origin is a relevant subject that interests scientists. The replacement of feed of animal origin by feed of plant origin in broiler chickens brought about a positive result (Suchý et al., 2002). We think that this topic is also relevant in piglets.

The aim of our paper was to determine the possibility of replacing fish meal by "HP 300" soy concentrate and its consequences for weaned piglets. Miller et al. (1986) and Kelly et al. (1990) indicated in their publications that feed replacement during the weaning of piglets determined clear morphological changes in the intestinal epithelium as the intestinal villus length decreased and the depth of crypts increased. The previously mentioned factors cause disorders of the digestive system and absorption. According to Hall and Byrne (1989) during the period of weaning piglet organisms are affected by various stress factors. Therefore, nutrition becomes especially important. The results of research indicate a positive effect of the HP 300 soy concentrate on the rearing of weaned piglets as well as on expenditures on feeds. First, it is necessary to state that compound feeds with HP 300 soy concentrate were better consumed by the piglets. This means that piglet organisms were provided with more food substances at the time when they usually refuse eating because of the weaning. The second group piglets ate 114 g more feeds on average than the piglets from the control group. As a result, the second group of piglets gained 18% more weight per day. Some scientists also estimated a positive effect of the HP soy concentrate on feed intake in their papers (Philpotts and Norton, 2003). The data of the experiments conducted by the Hamlet Protein company (2002, 2003, 2004) indicated that the replacement of fish meal by HP 300 soy proteins in the feeds of weaned piglets had a positive effect (Hamlet Protein Feeding Trial Report No. P26S, 2002; No. P27S, 2003; No. P32, 2004). Therefore, the results of our experiment confirmed that the use of fish meal in the production of compound feeds for weaned piglets can be excluded without having a harmful effect on piglet productivity. As estimated during the experiment, the second group piglets gained 30% more weight in the second period than the piglets from the control group. This

difference is statistically reliable and can be explained in the following way: the feeding of piglets with feeds which contained HP soy protein helped to avoid a harmful change in the enterobacteria count in the faeces of piglets. Furthermore, this positive effect on the steady intestine microflora was sufficient to increase piglets' resistance to pathogenic microorganisms. As the data in Table 5 indicate, the enterobacteria count in the faeces of the second group piglets decreased gradually while the enterobacteria count in the faeces of the first group piglets increased at the end of the first period and sharply decreased at the end of the second period, reaching the same difference that was indicated between both groups at the beginning of the experiment. We believe that the cause of higher productivity indices of the second group piglets should be attributed to the physiological condition of piglet organism.

Furthermore, the present replacement not only enables breeders to produce safe feed but also safe production of pig growing.

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