EFFECT OF *SPIRULINA PLATENSIS* ON THE PRODUCTIVITY AND DIGESTIBILITY OF NUTRIENTS IN FATTENING PIGS+

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The growing concern of the society regarding the safety of food and the animals' growing resistance to antibiotics makes the pig-breeding industry search some alternatives especially after the prohibition of the use of antibiotics as growth stimulator in European Union in 2006. Scientists keep going to search, develop and introduce, ecological alternatives as prebiotics, probiotics, enzymes, herb and plant extracts.

Herb and plant extracts are famous for their antimicrobial (**Singh et al.,** 2002; **Valero and Salmeron,** 2003), antioxidative (**Botsoglou et al.,** 2002; **Miura et al.,** 2002), stimulating effect on the digestive system (**Camps,** 2005; **Ingram,** 1997) and growing production of digestive enzymes (**Langhout,** 2000; **Hernandez et al.,** 2004) in system.

Kanev et al. (2002) studied the effect of Ropadiar (essential oils of marjoram, thyme and salvia) on growth of suckling piglets. The authors established that the use of Ropadiar in dose 0.05% in the compound feed of suckling piglets aged from 7 to 35 days insures higher consummation of feed, nutrients and energy, and higher average daily gain.

Nowadays the biologically active substances from natural sources are of a great importance. One of them is the biologically active supplement *Spirulina platensis* (blue-green algae). It is recommended as common strengthening means. It is also of a great importance for the different organisms' food: over 100 food components from which 60-70% proteins (dry matter), all amino acids, vitamins, phitonutrients, carotenoids, minerals, unique pigments, omega-3 fatty acids and omega-6 fatty acids, gama-linoleic acid, powerful probiotic compounds, chlorophyl and polysaccharides (**Tarko et al.,** 2012).

The aim of the present study was to establish the effect from the addition of the biologically active supplement *Spirulina platensis* in the compound feed on the productivity, state of health and digestibility of nutrients in fattening pigs.

MATERIAL AND METHODS

A scientific economic experiment was carried out at the Agricultural institute – Shumen with fattening pigs from the Danube white breed. Animals were divided into three groups with 11 pigs in each or 33 animals totally.

Scheme of the experiment

Groups Supplement	Control (I group)	Experimental (II group)	Experimental (III group)
Number of animals	11	11	11
Spirulina platensis	-	2 g/capita daily For period from 60 to 110 kg	2 g/capita daily For period from 30 to 110 kg

The experiment was divided in two subperiods. It started in 34.0 kg live weight and ended in 102.5-106.3 kg live weight. During the experiment animals were fed with compound feed containing the food content presented in Table 1. Animals from the control and experimental groups were fed with the same compound feed as in pigs from the second group was added 2 g *Spirulina platensis* capita/daily during the period from 60 to 110 kg live weight and in pigs from the III-rd group – 2 g *Spirulina platensis* capita/daily during the whole experimental period (from 30 to 110 kg live weight).

Pigs were raised and fed in individual pens and received food and water *at libitum*.

Table 1. **Energy and nutrients' content in kg of compound feed**

Groups Traits	I subperiod 30-60 kg live weight	II subperiod 60-110 kg live weight
Digestive energy, MJ	13.86	13.31
Metabolizable energy, MJ	12.83	12.76
Crude protein, %	17.15	15.17
Crude fibers, %	6.02	7.29
Fat, %	2.63	2.51
Lysine, %	0.84	0.72
Methionine, %	0.31	0.30
Calcium, %	1.01	0.52
Phosphorus, %	0.69	0.46

During the experimental period the following traits were controlled: feed intake, кg – daily; average daily gain, g individually; feed conversion per кg gain – by subperiods and for the whole period; state of health – daily.

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Physiological experiment with 6 castrated male pigs in two groups with 3 animals in each with live weight 62.000 – 62.333 kg was carried out for establishing the influence of the supplement Spirulina platensis on the digestibility of nutrients from the ration.

Scheme of the experiment

Groups Supplement	Control (I group)	Experimental (II group)
Number of animals	3	3
Spirulina platensis	-	*Spirulina platensis* 3 g/capita/daily

Animals were placed in special individual pens and bred in two weeks. The first seven days were for the preparatory period and the next – for the experimental period. Faeces, an analysis target, were taken twice a day. Animals were fed with compound feed with the following traits presented in Table 2.

Table 2. **Energy and nutrients' content in kg of compound feed**

Traits	Control and experimental group
Digestive energy, MJ	14.25
Metabolizable energy, MJ	12.95
Crude protein, %	15.17
Crude fibers, %	6.78
Fat, %	2.72
Lysine, %	0.71
Methionine, %	0.30
Calcium, %	0.61
Phosphorus, %	0.56

RESULTS AND DISCUSSION

The feed intake from the individual groups of animals didn't indicate any significant difference and could be interpreted as practically equal during the separate subperiods (Table 3). There was no difference of the intake of metabolizable energy, protein and lysine between groups regarding the scheme of the experiment.

The average daily gain in the first group was the same as in the second one and in the third group was insignificantly higher with 3.57% during the first subperiod (from 30 to 60 kg live weight). Results were analogical regarding the scheme of the experiment in which the animals from the third group were fed with Spirulina in dose of 2 g/capita/daily (Table 3).

There was insignificantly higher gain of pigs from the second and third experimental groups with 8.40% (6.978 g) and 5.60% (10.679 g) respectively compared with it from the first group (0.643 g) (Table 3). Our results were identical as the received ones from **Shimkus et al.** (2008a). There was an increase of the gain of fattening pigs with 5.2% in addition of 1.5g microalgae *Spirulina platensis*.

Our results (Table 3) presented insignificantly higher growth intensity in experimental groups having analyzed the data during the whole experimental period. There was higher gain in pigs from second and third groups with 4.97% (0.718 g) and 4.68% (0.716 g) respectively compared with those from the control I group (0.684 g).

Regarding the use of the feed, it is obvious that the feed conversion is related with the growth intensity. In pigs with higher gain, the feed conversion is lower with 8% in second group and with 9% in third group in second subperiod. For the whole experimental period, in pigs with higher gain, the feed conversion is lower with 5.0% (4.229 kg) in second and with 7.82% (4.104 kg) in third group.

The conversion of protein, metabolizable energy and lysine during the whole experimental period (Table 3) was better in second and third group with 8.99 – 11.68% for the protein, 5.09 – 7.89% for the metabolizable energy and 5.06 – 8.99% for the lysine in comparison from those in the control (I) group.

Shimkus et al. (2013) investigated fattening pigs fed with 2 g microalgae *Spirulina platensis* and indicated higher average daily gain with 9.26% in comparison with the control group. Authors pointed to the fact that pigs from the experimental group have reached 100 kg live weight with 7.37 days earlier compared with the control animals. **Shimkus et al.** (2013) and other authors (**Altunin et al.,** 2000; **Zaharchenko et al.,** 2001 and **Petrjanov et al.,** 2005) indicated to gain with 15-26% in pigs fed with the addition microalgae *Spirulina platensis* in their ration.

The data analysis for the coefficients of digestibility of the separate nutrients in both groups (I and II) indicated to insignificant differences (Table 4). Regarding the values of the coefficients of protein, fibers and fat, the differences between groups are statistically unproved and could be accepted as a tendency.

Notice that there were insignificant differences in the coefficients of digestibility of minerals, calcium and phosphorus. Pigs from the experimental (II) group differed with higher coefficients of digestibility of minerals with 4.91% (39.93% compared to 38.04%), of calcium with 3.07% and of phosphorus with 5.79%. The presented results indicated that pigs fed with *Spirulina platensis* assimilated in a better way the minerals from the compound feed in comparison with pigs from the control group. The above indicated also the chemical analysis of the separate faeces (Table 5), which contained with 6.43% less minerals, with 4.45% less calcium and with 5.46% less phosphorus in comparison with the control group. Differences were not proved and because of that they could be interpreted as tendency. There was tendency for a higher quantity of protein in the separate faeces – with 4.01% in pigs fed with

Table 3. **Productive traits of fattening pigs**

Traits / Groups	I group (control) without *SP**			II group (experimental) *SP** – 60 kg to 110 kg live weight			III group (experimental) *SP** – 30 kg to 110 kg live weight		
	$\bar{x}$	*C*	*E*	$\bar{x}$	*C*	*E*	$\bar{x}$	*C*	*E*
Productive traits of fattening pigs (30 kg–60 кg live weight)									
Average feed intake capita/daily, kg	2.453	4.61	1.46	2.451	3.98	1.505	2.426	4.728	1.576
Metabolizable energy intake, MJ	31.48	4.61	1.46	31.45	4.00	1.510	31.13	4.736	1.579
Live weight at the beginning, kg	34.500	10.06	3.18	34.857	10.00	3.779	34.000	12.478	4.159
Live weight at the end, kg	62.500	9.67	3.06	62.857	7.02	2.654	63.000	9.014	3.005
Average daily gain, g	0.757	11.78	3.73	0.757	5.77	2.182	0.784	8.775	2.925
Feed conversion per kg gain, kg	3.274	9.77	3.09	3.248	6.75	2.552	3.112	8.211	2.737
Metabolizable energy conversion, MJ	42.00	9.78	3.09	41.68	6.75	2.55	39.93	8.21	2.74
Productive traits of fattening pigs (60 kg–110 кg live weight)									
Average feed intake capita/daily, kg	3.330	4.37	1.38	3.349	2.64	1.00	3.214	4.08	1.36
Metabolizable energy intake, MJ	42.600	4.32	1.37	42.830	2.64	1.00	41.110	4.08	1.36
Live weight at the beginning, kg	62.500	9.67	3.06	62.857	7.02	2.65	63.000	9.01	3.01
Live weight at the end, kg	103.750	7.59	2.40	108.571	3.60	1.36	107.889	3.48	1.16
Average daily gain, g	0.643	14.51	4.59	0.697	10.73	4.05	0.679	10.71	3.57
Feed conversion per kg gain, kg	5.261	12.68	4.01	4.844	9.96	3.76	4.777	11.32	3.77
Metabolizable energy conversion, MJ	67.340	12.68	4.01	61.950	9.96	3.76	61.100	11.32	3.77
Productive traits of fattening pigs (30 kg–110 кg live weight)									
Average feed intake capita/daily, kg	3.010	4.11	1.30	3.026	2.952	1.116	2.932	3.63	1.21
Metabolizable energy intake, MJ	38.560	4.12	1.30	38.700	2.95	1.12	37.600	3.62	1.21
Live weight at the beginning, kg	34.500	10.10	3.20	34.900	10.000	3.800	34.000	12.500	4.200
Live weight at the end, kg	103.750	7.59	2.40	108.571	3.601	1.361	107.889	3.482	1.161
Average daily gain, g	0.684	12.85	4.06	0.718	6.243	2.359	0.716	5.926	1.975
Feed conversion per kg gain, kg	4.452	10.95	3.46	4.229	6.540	2.472	4.104	6.484	2.161
Metabolizable energy conversion, MJ	57.03	10.95	3.46	54.14	6.54	2.47	52.54	6.48	2.16

*SP** – *Spirulina platensis*

Table 4. **Coefficients of digestibility**

Traits / Groups	I (control) without *Spirulina platensis*			II + 3g *Spirulina platensis*/daily		
	$\bar{x}$	*C*	*E*	$\bar{x}$	*C*	*E*
Dry matter, %	82.60	0.69	0.40	82.27	8.40	4.85
Organic matter, %	84.37	0.34	0.20	83.94	1.40	0.81
Protein, %	81.36	1.18	0.68	79.93	3.76	2.17
Fat, %	47.59	4.37	2.52	46.16	18.53	10.70
Fibres, %	47.80	5.09	2.94	48.4	8.85	5.11
Minerals, %	38.04	20.20	11.66	39.93	19.01	10.98
Non-nitrogenous extract substances, %	90.967	0.436	0.252	90.807	0.319	0.184
Calcium, %	45.92	20.13	11.64	47.33	10.24	5.91
Phosphorus, %	34.57	21.77	12.57	36.57	5.73	3.31

Table 5. **Chemical composition of faeces, %.**

Traits / Groups	I (control) without *Spirulina platensis*			II + 3g *Spirulina platensis*/ daily		
	$\bar{x}$	*C*	*E*	$\bar{x}$	*C*	*E*
Dry matter, %	22.91	0.41	0.23	22.61	6.10	3.52
Organic matter, %	19.80	1.28	0.74	19.7	7.17	4.14
Protein, %	4.24	2.26	1.31	4.41	6.82	3.94
Fat, %	2.14	6.47	3.74	2.11	2.24	1.29
Fibres, %	5.32	6.68	3.86	5.10	10.46	6.04
Minerals, %	3.11	9.28	5.36	2.91	2.86	1.65
Non-nitrogenous extract substances, %	8.097	2.176	1.256	8.020	11.680	6.744
Calcium, %	0.50	13.41	7.74	0.47	18.91	10.92
Phosphorus, %	0.55	8.45	4.88	0.52	12.01	6.93

Spirulina platensis in comparison with the control group. Differences were not proved.

In spite of the few and unproved differences in the coefficient of digestibility mainly of minerals, calcium and phosphorus, the analysis of results indicated that *Spirulina platensis* influenced on the processes related with the mineral exchange in organism. Better values of those traits in pigs fed with *Spirulina platensis* presented that the supplement could be useful for decreasing the phosphorus pollution in some endangered regions.

The obtained results in our study were similar to those of **Sacid et al.** (2013), as in their investigation didn't establish any differences in the coefficients of digestibility of the organic matter, the protein, fat and fibers. Authors, in contrast to our study, have obtained lower coefficients of minerals with 24% in pigs fed with *Spirulina maxima* in ration.

Our study differed from the investigation of **Shimkus et al.** (2008a). Authors, in their study, indicated better digestibility of the protein, dry matter and fibers by adding 1.50 g *Spirulina platensis* in a liquid state (mixed with molasses 10:5) in compound feeds. Probably the dose of the used *Spirulina platensis* (3 g/capita/daily), as well the form (dry spirulina) influenced the values of the obtained results of the coefficients of digestibility in our investigation.

CONCLUSIONS

The phytobiotic *Spirulina platensis* can be added successfully in dose 2 g per capita daily in the compound feed of fattening pigs from the Danube White breed only in the finishing period (60 to 110 kg live weight).

The addition of *Spirulina Platensis* (3 g/capita daily) didn't influence significantly on digestibility coefficients of the nutrients. There is a tendency for higher digestibility coefficients of minerals, calcium and phosphorus respectively with 4.91%, 3.07% and 5.97% in animals, fed with this addition.

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SUMMARY

A scientific – economic experiment with fattening pigs from Danube white breed was carried out. Animals were divided into three groups of 11 pigs in each or 33 pigs totally.

The experiment was divided into two subperiods: 30 – 60 kg live weight and 60 – 110 kg live weight. Pigs from the control (I) and the experimental (II and III) groups were fed with one and the same compound feed to which was added *Spirulina platensis* (2 g/capita daily) for animals in the II group during the period 60-110 kg live weight, and for those in III group – *Spirulina platensis* (2 g/capita daily) during the whole experimental period.

Physiological experience with 6 barrows divided into two groups of 3 animals in each with 62.000-62.333 kg live weight was carried out to establish the effect of the supplement *Spirulina platensis* on the digestibility of nutrients from the ration.

The following traits were controlled during the experimental period : feed intake, kg – daily; average daily gain, g individually; feed conversion per kg gain – by subperiods and for the whole period; health condition – daily.

The aim of the present study was to determine the effect of the addition of the biologically active supplement *Spirulina platensis* in compound feed on the productive traits, health condition and digestibility of nutrients in fattening pigs.

The phitobiotic *Spirulina platensis* can be successfully added at a dose of 2 g/capita daily in compound feed for fattening pigs from Danube white breed only during the finishing period (60 to 110 kg live weight).

The addition of *Spirulina platensis* (3 g/capita daily) didn't influence significantly on digestibility coefficients of individual nutrients. There is a tendency for higher digestibility coefficients of minerals, calcium and phosphorus with 4.91%, 3.07% and 5.79% respectively in animals fed with the addition.

Key words: *animals, biologically active supplements, Spirulina platensis*

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