Influence of lecithin emulsifier on the utilisation of nutrients and growth of piglets after weaning

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ABSTRACT: The influence of supplementation of a lecithin emulsifier (0.1%) to the feed mixture for piglets after weaning was studied. 16 piglets in the control group (C – without lecithin) and 16 piglets in an experimental (E) group were monitored in three replications in a 28-day experimental period. We observed higher digestibility of monitored nutrients in the experimental group (crude fat: C = 66.28 ± 12.11, E = 69.75 ± 9.85%, crude protein: C = 78.72 ± 5.47, E = 82.17 ± 2.23%, crude fibre: C = 56.70 ± 12.85, E = 59.10 ± 12.04%, nitrogen free extract: C = 86.67 ± 3.32, E = 87.75 ± 3.00%, ash: C = 63.63 ± 11.59, E = 65.73 ± 10.35%). Statistically insignificantly higher daily average gain (C = 374.1 ± 107.0, E = 399.1 ± 104.7 g) of experimental groups and a lower feed conversion ratio (C = 2.285 ± 0.416, E = 1.768 ± 0.048 kg/kg) were found out. It was also confirmed in an additional field experiment (C = 279, E = 312 piglets from birth to 71 days of age) where average daily gain weight was 270 g in control and 290 g in experimental group. The influence of lecithin on the occurrence of haemolytic strains of *Escherichia coli* was not proved. This experiment confirmed a positive effect of the lecithin emulsifier supplement on the efficiency of piglets.

Keywords: piglets; weaning; lecithin emulsifier; weight gain; feed conversion ratio; digestibility; *E. coli*

Antibiotic growth stimulators significantly affect the efficiency of piglets in the post-weaning period. Their gradual elimination from feed mixtures calls for a necessity of looking for other supplementary substances that have a positive effect on the utilisation of feed by piglets with digestive systems not yet completely developed.

Milk fat contains a large amount of short chain fatty acids that are easily consumable and absorbable (Palmquist et al., 1993). The digestibility of milk fat of sows is set to be up to 95% (Heugten and Odle, 2000). In addition, the fat is emulsified and it can be more easily digested in this form. Piglets lose this nutrition source at the moment of weaning and it is a question how to substitute it adequately (Jensen et al., 1997).

Heugten and Odle (2000) considered insufficient digestibility to be the major problem of adding fats into feed mixtures for piglets. It may be caused by the size of fat droplets. In an experiment performed by the authors mentioned above higher digestibility of not only fat but also energy and proteins was detected after adding an emulsifier in the form of lysolecithin into the feed mixture for piglets. It was reported that a lecithin emulsifier could help piglets of the weight up to 22 kg to increase weight gains and improve feed conversion (Schwarzer and Adams, 1996). The effect of lecithin is higher immediately after weaning (Soares et al., 2002). With respect to these experiments the use of lecithin emulsifier in feed mixtures for piglets after wean-

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ing can be promising (Desouza et al., 1995; Gu and Li, 2003).

Lecithin need not have only positive effects on the efficiency of pigs. Sung et al. (1993) proved in *in vitro* experiments with *E. coli* and *Enterococcus fecalis* that this substance inhibited cytotoxic and bacteriostatic effects of biliary acids. There arises a question what effects the supplement of lecithin will have on enteropathogenic *E. coli in vivo* in weaned piglets.

The aim of the experiment was to test the effects of lecithin on the efficiency of piglets in the post-weaning period. Further, we monitored possible effects on the occurrence of enteropathogenic strains of *Escherichia coli K88+* (or other enteropathogenic strains of *E. coli*) in the rectal microflora of piglets as well as the faecal consistency.

MATERIAL AND METHODS

The experiment was conducted in the Research Institute of Animal Production at Prague-Uhříněves (RIAP), in experimental facilities of the Kostelec nad Orlicí workplace, on piglets from our own farm. The experiment was performed in three replications independent of each other. To exclude the influence of the mother, the piglets were divided into two groups so that piglets from one litter were represented in both groups in the same way. In the first and in the second part of the experiment there were six piglets in two groups, in the third replication there were only four piglets in each group. All the piglets were given the same commercial mixture ČOS for early weaning of piglets (Table 1). A lecithin emulsifier was added into the mixture for the experimental group at a dose of 1.0 kg/t. The experiment started on the weaning day at the age of 28 days and ended four weeks later. The weight of piglets and feed consumption were monitored in weekly intervals.

In each part of the experiment a check of digestibility was performed, in the first and in the fourth week. From the first to the 15th day after weaning the faeces quality in piglets was examined while the following key was used for faeces evaluation: 0 – solid and formed; 1 – soft and formed; 2 – soft and non-formed; 3 – liquid. For digestibility determination the faeces were collected on the last but one and on the last day of the particular week. The digestibility was determined by calculating the content of nutrients in feed and faeces concerning the content of the marker (insoluble portion of ash). In the laboratories of RIAP the contents of dry matter, crude protein, crude fat, crude fibre, ash and insoluble portion of ash in HCl were measured. Dry matter was determined by weighing after drying at the temperature of 105°C for 4 hours. The content of crude protein in the sample was calculated after determining the nitrogen content by coulometric titration according to the formula: crude protein = N × 6.25. Nitrogen in the sample was transformed after mineralization by sulphuric acid while boiling with catalyst to ammonium sulphide and by titration with hypobromite generated coulometrically from potassium bromide using biamperometric indication its amount was calculated. Fat was determined by weighing as the residue after extraction by means of diethyl ether. Fibre was determined as the solid residue after acid and alkaline hydrolysis by sulphuric acid and the solution of sodium hydroxide after having estimated the ash by weighing. Ash was determined as the

Table 1. Composition of the feed mixture ČOS

Wheat (%)	16.1
Barley (%)	30.0
Corn (%)	25.0
Soybean meal (%)	20.0
Fish Flour (%)	4.0
Vegetable fat (%)	1.3
Mineral and vitamin supplement (%)	3.6
Calculated content of amino acids	
Lysine (g/kg)	13.1
Methionine (g/kg)	3.7
Sulphur amino acids (g/kg)	7.0
Threonine (g/kg)	8.6
Tryptophan (g/kg)	2.5

Table 2. Content of nutrients in the feed mixture

Dry matter (g/kg)	888.13
Crude protein (N × 6.25) (g/kg)	202.09
Crude fat (g/kg)	50.22
Crude fibre (g/kg)	37.17
Ash (g/kg)	48.49
ME_p (MJ/kg)	14.41

residue after complete combustion of organic substances at 550°C by weighing. The insoluble portion of ash in HCl was determined as the residue of ash after dissolving ash in diluted hydrochloric acid by weighing. Laboratory analysis of the used feed mixture ČOS was performed at the same time (Table 2).

To monitor the occurrence of *E. coli K88+* in the rectum of piglets rectal smears were collected on the weaning day and subsequently seven days later using a commercial transportable kit with the Amies medium. The samples were anonymously transported to the microbiological laboratory and their cultivation was performed within 48 after collecting. Without multiplication by a semi-quantitative method the samples were inoculated directly onto the surface of blood agar (Columbia agar base Oxoid CM 331 supplemented with 5% of sheep blood) and MacConkey agar No. 3 Oxoid CM 115. After 18 hrs incubation in aerobic conditions at 37°C the occurrence of haemolytic and non-haemolytic colonies of *E. coli* as well as *Enterococcus spp*. was detected. The isolates identified biochemically as *E. coli* were examined for the presence of fimbrial antigen *K88* by means of a coagglutinating reagent prepared from the serum of immunized rabbit (Alexa et al., 2001). Haemolytic isolates of *E. coli K88-* were also examined for the known factors of virulence (Alexa et al., 2000) and if these were not proved, isolates were interpreted as nonpathogenic.

To confirm the results from experimental conditions an additional experiment was organized on the pig farm. The feed mixture for the experimental group was complete with the same lecithin supplement (1 kg/t). Weight of piglets was registered after birth and before transport to the fattening station. Feed intake was not registered for technical problems.

The statistical program Qcexpert (TriloByte) was used for statistical evaluation.

RESULTS AND DISCUSSION

In all three replications the average daily gain was always higher in the experimental groups of piglets for the whole duration of the experiment (Table 3). In particular replications this increase was 4–9% compared to the control group. The higher daily gain of piglets was also reflected in the higher final weight – by 4–9% or 0.5–1.1 kg in comparison with the control. A reduction of the feed mixture consumption per kg of gain by 5–7% or 0.1–0.32 kg was noticed at the same time. A higher gain tendency (C = 374.1, E = 399.1 g/day) and a better feed conversion ratio (C = 2.285, E = 1.768 kg/kg) after the addition of LSF into the feed mixture became

Table 3. Weight gains and feed conversion ratio in particular repetitions

		Number of piglets	Starting weight (kg)		Final weight (kg)		Average daily weight gain (g/day)		Feed conversion ratio (kg/kg)	
			$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
	control	6	7.2	0.7	16.9	3.5	346	109	2.05	
Repetition1	experiment	6	7.3	0.7	17.4	3.5	360	111	1.73	
	index (C = 100%)		101.4		103.0		104.0		84.4	
	control	6	9.8	0.6	22.0	1.6	435	57	1.87	
Repetition2	experiment	6	9.8	0.6	23.1	2.0	475	59	1.73	
	index (C = 100%)		100.0		105.0		109.2		92.5	
	control	4	9.4	0.6	18.5	3.9	325	118	1.94	
Repetition3	experiment	4	9.4	2.7	19.2	3.6	350	84	1.84	
	index (C = 100%)		100.0		103.8		107.7		94.8	
	control	16	8.713	1.371	19.188	3.799	374.1	107.0	2.285	0.416
Summary	experiment	16	8.775	1.867	19.950	3.931	399.1	104.7	1.768	0.048
	index (C = 100%)		100.7		104.0		106.7		77.4	

evident in the summary of all three replications, the improvement was however statistically insignificant.

The comparison of digestibility coefficients also proves a better utilisation of the experimental mixture. The digestibility of crude fat (C = 66.28, E = 69.75%), crude protein (C = 78.12, E = 82.17%), crude fibre (C = 56.70, E = 59.10%), nitrogen free extract (C = 86.67, E = 87.75%) and ash (C = 63.63, E = 65.73%) was higher in experimental piglets. These differences were not statistically significant (Table 4). Relatively high digestibility of feed mixture, especially the coefficient of crude fibre digestibility, is caused by good-quality raw material and production progress evidently. It is in agreement with findings of Zobac and Kumprecht (1999).

At the end of the first week of experiment we observed an increase in fat digestibility in particular replications in piglets from experimental groups between 5% and 19% in comparison with the respective control. Our results agree with the results reported by Heugten and Odle (2000). The digestibility of crude protein increased by 9.5 or 4.7% in the first two replications in piglets from experimental groups. The other traits (digestibility of fibre, nitrogen free extract and ash) were higher in all the replications in experimental piglets. In all monitored traits the highest tendency of an increase was observed in ash in two out of the three replications (Table 5).

Compared to the control, the digestibility of fat, examined at the end of the fourth week of the experiment (Table 6), was higher in the first and third replication in experimental pigs by 4.5% and 2.1%, respectively; in the second replication it was by 2.7% lower. The digestibility of crude protein was higher in the experimental group in the last replication; in the other replications the increase was not significant – by 2 and 0.1%. The digestibility of fibre was higher in the experimental group of piglets in the second replication – by 10%, while in the other replications the differences were imperceptible. The digestibility of nitrogen free extract was also almost the same; ash was digested better in two replications than in control groups.

From the comparison of average values of digestibility coefficients of particular nutrients (Table 7) in piglets from control and experimental groups at the end of the first and fourth week after weaning we can conclude that the effect of the dietary emulsifier was highest immediately after weaning. The differences between the groups in fat, fibre and ash are

Table 4. Digestibility coefficients (%) of control and experimental feed mixtures

	Control ($\bar{x}$ ± SD)	Experiment ($\bar{x}$ ± SD)	Index (C = 100%)
Crude fat	66.28 ± 12.11	69.75 ± 9.85	105.2
Crude protein	78.72 ± 5.47	82.17 ± 2.23	104.4
Crude fibre	56.70 ± 12.85	59.10 ± 12.04	104.2
Nitrogen free extract	86.67 ± 3.32	87.75 ± 3.00	101.2
Ash	63.63 ± 11.59	65.73 ± 10.35	103.3

Table 5. Digestibility coefficients (%) determined at the end of the first week of experiment

	Repetition 1			Repetition 2			Repetition 3		
	control	experiment	improvement index (C = 100%)	control	experiment	improvement index (C = 100%)	control	experiment	improvement index (C = 100%)
Crude fat	56.3	59.4	105.5	48.4	57.7	119.2	70.6	76.2	107.9
Crude protein	72.3	79.2	109.5	76.4	80.0	104.7	86.0	85.3	99.2
Crude fibre	52.6	53.8	102.3	43.7	47.4	108.5	58.0	62.6	107.9
Nitrogen free extract	84.4	86.5	102.5	84.3	86.6	102.7	91.3	92.7	101.5
Ash	53.5	60.9	113.8	53.6	56.0	104.5	66.4	75.4	113.6

Table 6. Digestibility coefficients (%) determined at the end of the fourth week of experiment

	Repetition 1			Repetition 2			Repetition 3		
	control	experiment	improvement index (C = 100%)	control	experiment	improvement index (C = 100%)	control	experiment	improvement index (C = 100%)
Crude fat	66.9	69.9	104.5	73.8	71.9	97.3	81.7	83.4	102.1
Crude protein	80.9	82.5	102.0	83.1	83.2	100.1	73.6	82.8	112.5
Crude fibre	54.9	54.2	98.7	50.0	55.0	110.0	81.0	80.6	99.5
Nitrogen free extract	89.0	88.7	99.7	88.2	88.3	100.1	82.8	83.7	101.1
Ash	61.2	62.2	101.6	62.2	58.2	93.6	84.9	81.7	96.2

Table 7. Changes in the coefficients of nutrient digestibility (%) in experimental and control piglets in dependence on the weaning time

	1st week of experiment		4th week of experiment		Control (1st week = 100%)	Experiment (1st week = 100%)
	control ($\bar{x}$ ± SD)	experiment ($\bar{x}$ ± SD)	control ($\bar{x}$ ± SD)	experiment ($\bar{x}$ ± SD)		
Crude fat	58.4 ± 11.3	64.4 ± 10.2	74.1 ± 7.4	75.1 ± 7.3	126.9	116.6
Crude protein	78.2 ± 7.0	81.5 ± 3.3	79.2 ± 5.0	82.8 ± 0.4	101.3	101.6
Crude fibre	51.4 ± 7.2	54.6 ± 7.6	62.0 ± 16.7	63.3 ± 15.0	120.6	115.9
Nitrogen free extract	86.7 ± 4.0	88.6 ± 3.6	86.7 ± 3.4	86.9 ± 2.8	100.0	98.1
Ash	57.8 ± 7.4	64.1 ± 10.1	69.4 ± 13.4	67.4 ± 12.6	120.1	105.1

significantly lower in the fourth week; it is a result of significant improvement of the digestibility of these nutrients in the control group. We can suppose that this fact is due to the development of the digestive system of pigs. Cera et al. (1988) and Soares et al. (2002) proved the tendency of a gradual increase in the digestibility of fat with the increasing temporal distance from weaning. The comparison of differences in the average daily gains and feed conversion ratio in the first and fourth week of the experiment shows a similar reduction of differences like between the control and experimental piglets in the digestibility of nutrients (Table 8) – the difference in daily weight gains and feed conversion ratio 26.3% and 17.5% for the benefit of experimental groups reduced to 3.1 and 13.7% in the fourth week.

Our results support the results of the experimental utilisation of phospholipides obtained so far and published by Schwarzer and Adams (1996).

During the replications of the experiment succeeding to each other according to the birth date or piglet weaning no clinical changes in the health condition were revealed. The consistency of faeces (Table 9) was evaluated with 0 in most cases during the first week, except for one day in each of the control groups (2 × grade 1, 1 × grade 2) and one of the experimental groups (1 × grade 1). In the second week the consistency of faeces of experimental and control groups in the first two replications was evaluated with 0, in the temporally last – the third replication – with grade 1 for the period of one week in piglets from the control group and grade 2 (for the period of two days up to 3) in piglets from the experimental group. More liquid consistency of faeces can be connected with the isolation of *E. coli K88+* in the rectum of one piglet on the 7th day after weaning. The deterioration of the faecal consistency can be put in connection with the average daily gain that was the lowest of all the replications for the control and the experiment. On the other hand, the feed conversion was average compared to other replications. Comparing the evaluation of the faeces quality in stalls only in the third replication soft up to non-formed faeces occurred more frequently after the 7th day after weaning. According to a bacteriological examination in this

Table 8. Comparison of average daily gains (g/day) and feed conversion ratio (kg/kg) in particular weeks of the experiment

	Control ($\bar{x}$ ± SD)	Experiment ($\bar{x}$ ± SD)	Experiment (C = 100%)
1st week of experiment			
Average daily weight gain (g/day)	113.0 ± 58.3	142.7 ± 97.3	126.3
Feed conversion ratio (kg/kg)	3.015 ± 1.730	2.488 ± 0.901	82.5
4th week of experiment			
Average daily weight gain (g/day)	556.7 ± 125.3	573.7 ± 100.0	103.1
Feed conversion ratio (kg/kg)	2.259 ± 0.571	1.950 ± 0.519	86.3

Table 9. Evaluation of the average faecal consistency and results of bacteriological examination

	Repetition 1				Repetition 2				Repetition 3			
	control		experiment		control		experiment		control		experiment	
	Ech	Ec*K88*	Ech	Ec*K88*	Ech	Ec*K88*	Ech	Ec*K88*	Ech	Ec*K88*	Ech	Ec*K88*
Weaning[1]	1/6	0/6	3/6	0/6	3/6	0/6	1/6	1/6	1/4	0/4	0/4	0/4
7th day[1]	0/6	0/6	0/6	0/6	0/6	0/6	0/6	0/6	0/6	1/6	0/6	0/6
Average faecal consistency 1st week	0.14		0		0.29		0.14		0.14		0	
Average faecal consistency 2nd week	0		0		0		0		0.86		2.29	

Ech – *E. coli* haemolytica; Ec*K88* – *E. coli K88;* [1]number of positive samples/total number of samples

case no pathogenic *E. coli* was detected before the 7th day, in the following period no bacteriological examination of the faeces was performed. Out of the total of 64 examinations only in two cases the pathogenic *E. coli K88+* were detected in one case in each group – the control and the experimental one. Therefore we can conclude that was no difference in the occurrence of enteropathogenic strains of *E. coli K88+* in the experimental group due to LSF use. We did not detect a possible inhibiting effect of lecithin on hydrophobic biliary acids in contrast to the *in vitro* study carried out by Sung et al. (1993). In the samples collected on the 7th day of the experiment in the third replication in all piglets the presence of *Lawsonia intracelularis* was proved using the nested PCR method. Based on this detection we can assume that the deteriorated faecal consistency and the lower daily gain in the experiment and control group of piglets in the third replication were not caused by enteropathogenic *E. coli*, but by chronic proliferative enteropathy (Jacobson et al., 2003).

In the field experiment (Table 10) we monitored 279 piglets to the age of 71.25 days in the control group and 312 piglets in the experimental group to 71 days of age. The average final weight of the experimental piglets was higher (21.88 kg) than in the control (20.52 kg). The average daily weight gain

Table 10. Results of field experiment

	Control	Experiment
Piglets	295	312
Initial weight (kg)	1.3	1.3
Age at weaning (days)	25.25	26.70
index (%)	100	105.7
Final weight (kg)	20.52	21.88
index (%)	100	106.6
Final age (days)	71.25	71
index (%)	100	99.64
Average daily gain weight (g)	270	290
index (%)	100	107.4

was also higher in the experimental group (control 270 g/day, experimental piglets 290 g/day). These results are analogical to the results in experimental stalls.

CONCLUSION

According to the results presented in this study we can draw a conclusion that the supplementation of lecithin emulsifier to the commercial mixture for piglets in the period from weaning to 17–22 kg has a positive impact on the utilisation of dietary nutrients in piglets in the post-weaning period. The major effect was noticed immediately after weaning.

In the bacteriological study focused on the occurrence of enteropathogenic *E. coli K88+* or other enteropathogenic strains of *E. coli* in the rectal microflora in piglets after weaning only two isolates were found; however the presence of lecithin in the commercial mixture did not have any impact on the development of diarrhoea in piglets compared to the control group.

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