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EFFECT OF ADDING CRUDE OR REFINED GLYCEROL TO PIG DIETS ON FATTENING PERFORMANCE, NUTRIENT DIGESTIBILITY AND CARCASS EVALUATION*

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Abstract

The effect of crude or refined glycerol on performance, carcass and meat quality was studied in 30 pigs weighing about 30 kg at the beginning of the experiment. Animals were kept and fed individually with a standard mixture supplemented with 10% of crude or refined glycerol, a by-product from biodiesel production. Pigs were slaughtered at about 110 kg of body weight and their carcasses were analysed. Meat acidity, colour and water holding capacity were determined in samples of *longissimus* muscle. Digestibility of nutrients was evaluated on the other 30 fatteners. Crude glycerol reduced the weight gains of animals, with no significant differences in the case of refined glycerol. Mean body weight gains of control pigs and those fed crude or refined glycerol were 826, 776 and 808 g, respectively. There were no significant differences in feed conversion between the groups. Pigs fed crude glycerol had thinnest backfat and largest loin eye area. Refined glycerol significantly improved digestibility of fibre. Both glycerols significantly increased water holding capacity. It is concluded that crude glycerol has limited value as a feed supplement for pigs.

Key words: glycerol, pig, fattening performance, carcass evaluation, meat quality

The present interest in biodiesel as a renewable energy source creates a surplus of glycerol, which is a byproduct from biofuel production. About 10 kg of glycerol is obtained for every 100 kg of raw material (oil) produced (Schumacher, 2007), which means that the amount of glycerol will rise with growing biofuel production.

Glycerol is a normal component of all fats and it can be used in human food as low-energy sweetener (food additive E422). One of the ways of utilizing growing

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amounts of glycerol is to use it as a component of animal feeds. It was experimentally used in dairy cattle (Donkin, 2008) and poultry feeding (Cerrate et al., 2006). Results obtained in pig nutrition are not consistent. While Lammers et al. (2008 a) found no negative effect of glycerol on performance, carcass composition and meat quality of pigs receiving 10% of glycerol in feed, Casa et al. (2009) showed reduced growth and poorer feed:gain ratio in pigs receiving 10% of glycerol. In both these experiments crude rather than refined glycerol was used. Crude glycerol typically contains unreacted oil, a catalyst and some amount of methanol. Refined glycerol is used in the cosmetic and food industry but it involves the additional cost of refining. On the other hand, it is possible that refined glycerol will produce better results in pig feeding than crude glycerol.

The aim of this experiment was to compare the effect of crude and refined glycerol on fatteners' performance, nutrient digestibility and carcass and meat quality.

Material and methods

The fattening experiment was performed on 30 pigs weighing about 30 kg and derived from Polish Landrace sows mated to a Duroc × Pietrain boar. Pigs were allocated to three groups with 10 animals per group. Group I (control) was fed standard mixture. Pigs from groups II and III received 10% of crude or refined glycerol, respectively. Composition of diets is given in Table 1. The animals were kept and fed individually, weighed every two weeks and fed restrictedly according to their body weight. Water was supplied *ad libitum*. Crude glycerol was produced in a small-scale plant in the Experimental Station in Grodziec Śląski (south-western Poland) and refined glycerol was supplied by ZT Bielmar, Bielsko-Biała, Poland. Crude and refined glycerol preparations contained 76.8 and 85.2% of pure glycerol, 1.8 and 0.3% of methanol and their pH was 6.9 and 5.7, respectively.

The pigs were slaughtered at about 110 kg of body weight, their carcasses were evaluated and samples of *longissimus* muscle were taken from the area of the last thoracic and first lumbar vertebrae. Meat acidity was measured with a pH-meter equipped with a Metron OSH 12-00 electrode, 45 min and 24 h after slaughter. Meat colour was assessed with a Minolta colorimeter. Water holding capacity (WHC) was determined according to Grau and Hamm (1953). The sensory evaluation of meat after cooking was made on a 5-point scale.

The digestibility experiment was performed on 30 fatteners weighing about 50 kg, which were kept in individual balance cages and fed the same diets as in the fattening experiment. The initial period lasted 10 days and the balance (faeces collection) period 5 days. Faeces from each barrow were collected once a day, weighed and frozen at –20°C. At the end of the collection period all daily faeces were mixed together and mean samples were prepared for each animal.

Gross composition of feed and faeces was analysed according to standard methods (AOAC, 1995).

Table 1. Composition of basal feed mixture (%)

Component	Without glycerol		Glycerol	
	grower	finisher	grower	finisher
Barley, ground	50.42	57.00	37.45	44.90
Wheat, ground	20.00	20.00	20.00	20.00
Soybean meal	22.00	16.00	25.00	18.00
Glycerol			10.00	10.00*
Wheat bran	5.00	5.00	5.00	5.00
Salt (NaCl)	0.25	0.20	0.25	0.20
Limestone	0.90	1.00	0.90	1.00
Dicalcium phosphate	0.70	0.20	0.70	0.30
Premix PT1[1]/PT2[2]	0.50	0.50	0.50	0.50
L-lysine	0.18	0.10	0.15	0.10
DL-methionine	0.05		0.05	
Metabolizable energy (MJ)**	12.7	12.6	12.7	12.5
Crude protein (g)	184	169	180	160
Digestible protein (g)	154	141	148	138
Lys (g)	10.0	8.04	9.94	8.05
Met + Cys (g)	6.21	5.31	6.02	5.04
Thr (g)	6.10	5.44	6.08	5.30
Trp (g)	2.10	1.87	2.09	1.83

Explanations :

[1]PT-1 premix composition: Vitamin: A – 1600000 IU; D_3 – 200000 IU; E – 6.0 g; K_3 – 0.3 g ; B1 – 0.2 g; B_2 – 0.6 g; B_6 – 0.3 g; B_{12} – 0.002 g; Pantothenic acid – 2.0 g; Choline chloride – 40 g; Folic acid – 0.04 g; Nicotinic acid – 3.0 g; Magnesium – 8.0 g; Manganese – 10.0 g; Iodine – 0.06 g; Zinc – 14.0 g; Iron – 20.0 g; Copper – 4.0 g; Cobalt – 0.04 g; Selenium – 0.04 g; complete limestone to 1000.0 g.

[2]PT-2 premix composition: Vitamin: A – 1600000 IU; D_3 – 200000 IU; E – 4.0 g; K_3 – 0.3 g; B_2 – 0.6 g; B_{12} – 0.002 g; Pantothenic acid – 1.6 g; Choline chloride – 40 g; Nicotinic acid – 2.0 g; Magnesium – 8.0 g; Manganese – 10.0 g; Iodine – 0.06 g ; Zinc – 14.0 g; Iron – 10.0 g; Copper – 4.0 g; Cobalt – 0.04 g; Selenium – 0.04 g; complete limestone to 1000.0 g.

*Crude glycerol (diet II), refined glycerol (diet III).

**ME calculated with help of Hoffmann and Schiemann equation (1980).

Statistical analysis of treatment effects was conducted using analysis of variance with comparison of means by Duncan's multiple range test at P<0.05 and P<0.01 levels of significance using the Statistica v 5.1 package.

Results

Crude glycerol lowered animals' body weight gains (Table 2), especially in the first period of the experiment, i.e. between 30 and 60 kg of body weight (P<0.01). In spite of similar results in the second period of the experiment (between 60 kg of body weight and the end of the experiment) this difference persisted and at the end of the experiment it was still significant (P<0.05). Mean body weight gains of pigs fed refined glycerol during the whole experiment did not differ significantly from both control group and group II (808, 826 and 776 g, respectively). There was no significant difference in feed conversion between control and experimental groups.

Table 2. Fattening results

Production parameters	Glycerol			Sex		SEM
	0	crude	refined	gilts	barrows	
Initial BW (kg)	29.3	28.3	30.1	29.3	29.2	0.50
Final BW (kg)	113.2	113.0	112.1	113.5	112.2	0.50
Fattening period (days)	102 a	110 b	102 a	105	104	1.43
Average daily weight gain in fattening periods (g):						
30–60	736 B	677 A	734 B	713	719	8.63
61–113	885	851	858	861	868	12.82
30–113	826 b	776 a	808 ab	799	808	9.73
Average feed conversion per kg of body weight gain (kg):						
30–60	2.67	2.64	2.59	2.66	2.60	0.02
61–113	3.48	3.59	3.57	3.57	3.53	0.02
30–113	3.19	3.24	3.21	3.24	3.19	0.02

Values in the same rows with different letters differ significantly a, b – P< 0.05.

Refined glycerol slightly improved digestibility of fat and, to a larger degree (P<0.05), digestibility of fibre (Table 3).

Table 3. Apparent digestibility of nutrients (%)

Nutrient	Control	Crude glycerol	Refined glycerol	SEM
Dry matter	82.5 AB	81.3 A	83.3 B	0.31
Crude protein	83.8	81.9	83.4	0.49
Crude fat	56.9	51.6	57.4	2.23
Crude fibre	27.6 a	29.0 ab	34.7 b	1.36
N-free extractives	90.0	90.0	89.3	0.20

Values in the same rows with different letters differ significantly a, b – P<0.05; A, B – P<0.01.

Table 4. Results of the carcass analysis

Carcass trait	Glycerol			Sex		SEM
	0	crude	refined	gilts	barrows	
Body weight at slaughter (kg)	113.7	113.3	112.1	113.5	112.2	0.60
Cold dressing yield (%)	78.2	78.2	78.4	78.4	78.0	0.20
Meat in primal cuts (kg)	24.02	24.40	23.14	24.80 B	22.88 A	0.34
Loin eye area (cm^2)	55.45 ab	59.61 b	52.93 a	59.17 b	53.75 a	1.06
Meatiness of carcass (%)	55.48	56.57	54.43	57.24B	53.71 A	0.61
Backfat of 5 measurements (cm)	2.16	1.92	2.09	1.91 a	2.20 b	0.06
Backfat in point C (cm)	1.01	0.83	1.05	0.89	1.04	0.05

Values in the same rows with different letters differ significantly a, b – P<0.05; A, B – P<0.01.

Carcass traits of pigs receiving crude glycerol (Table 4) were slightly better than those of the other two groups. They had thinner backfat (1.92 cm) than control pigs (2.16 cm) and those receiving refined glycerol (2.09 cm). They had also the largest loin eye area (59.6 cm^2) compared to 55.5 cm^2 in the control group and 52.9 cm^2 in the group fed refined glycerol. This last difference was significant at P<0.05.

Table 5. Evaluation of meat (*M. longissimus*)

Quality traits	Glycerol			Sex		SEM
	0	crude	refined	gilts	barrows	
pH 45 min after slaughter	6.25	6.28	6.25	6.21	6.31	0.03
pH after 24 h cooling	5.62	5.58	5.53	5.56	5.59	0.02
L*a*b meat colour:						
lightness	49.81	51.01	52.19	50.09	51.91	0.56
redness	16.23	15.49	15.73	15.98	15.66	0.17
yellowness	2.19	2.20	2.31	2.15	2.31	0.13
Water holding capacity (%)	17.46 A	21.93B	21.36B	20.86	19.64	0.65
Sensory evaluation:						
odour	4.67 b	4.42 a	4.69 b	4.65	4.53	0.04
taste	4.67 b	4.38 a	4.52 ab	4.63 b	4.42 a	0.05
tenderness	4.37	4.35	4.31	4.35	4.35	0.06
juiciness	4.37	4.42	4.25	4.36	4.33	0.06

Values in the same rows with different letters differ significantly a, b – $P<0.05$; A, B – $P<0.01$.

Both glycerols significantly ($P<0.01$) increased water holding capacity (Table 5). Crude glycerol lowered sensory traits such as odour and taste ($P<0.05$).

Discussion

In experiments on pigs, crude glycerol is usually used because of relatively high cost of its refining (Schumacher, 2007). Results of the current experiment are not in accordance with the results of Kijora et al. (1995) and Lammers et al. (2008 a), who did not find the negative effect of feeding pigs with up to 10% of crude glycerol. On the other hand, however, Casa et al. (2009), who used pure glycerol found no difference in growth performance of pigs fed 5% glycerol whereas those fed 10% glycerol showed reduced growth and poorer feed:gain ratio. Kerr et al. (2007) recommended that pig farmers start with a low inclusion rate (2%) and work up to a higher inclusion rate (10%) if pig performance can be maintained or improved. Probably these inconsistent results were due to the different composition of crude glycerol, which is not a standardized product.

Better digestibility of fibre could result from bacterial fermentation in the intestinal tract. According to Yuasa et al. (2003), permeability of glycerol across the intestinal membrane is relatively low. It is possible that glycerol reaching the colon and caecum stimulates development of fibre-degrading microorganisms.

According to Hansen et al. (2009) and Lammers et al. (2008 a), crude glycerol has no effect on pig performance and quality parameters at slaughter. The better meatiness of carcasses and especially the larger loin area of pigs fed crude glycerol in the current experiment (Table 4) were probably due to their slower growth. The beneficial effect of decreased body weight gains of pigs on post-slaughter indices was also reported by Tury et al. (2003).

There was no significant difference in meat colour or acidity, which is in accordance with the results of Lammers et al. (2008 a). The only difference in the results of physical analysis was higher water holding capacity (P<0.01). Changes (reduction) in drip loss in the muscle from pigs fed 5% crude glycerol were reported by Mourot et al. (1994). Better water holding capacity, found in a preliminary study of Kerr et al. was not confirmed in their later experiment (Kerr et al., 2007).

Information on sensory traits of meat from pigs fed glycerol is very scarce. Lammers et al. (2008 b) found no difference in meat quality or sensory evaluation measure of loin chops from pigs receiving 10% of crude glycerol. In the experiment of Casa et al. (2009), differences in sensory characteristic of meat from pigs fed pure glycerol were not consistent enough to draw any conclusion. In the current experiment, crude glycerol significantly decreased smell and taste of meat after feeding pigs with crude glycerol but such a deterioration was not found in the case of pure glycerol. Probably, this lowering was an effect of some substances present in crude preparation, not of glycerol per se.

In summing up the results of the present experiment it is concluded that crude glycerol has limited value as a feed supplement for growing-finishing pigs but its value can be improved by refining.

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Wpływ dodatku surowego lub oczyszczanego glicerolu do paszy na wyniki tuczu świń, strawność składników pokarmowych i ocenę tuszy

STRESZCZENIE

Badano wpływ surowego lub oczyszczonego glicerolu na wyniki tuczu oraz jakość tuszy i mięsa. Doświadczenie przeprowadzono na 30 tucznikach ważących około 30 kg. Świnie były utrzymywane i karmione indywidualnie paszą standardową z dodatkiem 10% surowego lub oczyszczonego glicerolu pozostałego po produkcji biopaliw. Świnie ubito przy wadze około 110 kg i przeprowadzono ocenę tuszy. Kwasowość, barwę i wodochłonność mięsa oznaczano w próbce mięśnia najdłuższego. Badania strawnościowe przeprowadzono na 30 innych tucznikach.

Surowy glicerol obniżył przyrosty zwierząt, a w przypadku glicerolu oczyszczonego różnice nie były istotne. Średnie przyrosty zwierząt kontrolnych oraz otrzymujących glicerol surowy lub oczyszczony wynosiły odpowiednio 826, 776 i 808 g. W wykorzystaniu paszy nie odnotowano istotnych różnic. Świnie otrzymujące surowy glicerol miały najcieńszą słoninę oraz największe oko polędwicy. Oczyszczony glicerol istotnie poprawił strawność włókna, a oba glicerole poprawiły wodochłonność mięsa. Wyniki sugerują, że surowy glicerol ma ograniczoną wartość jako dodatek do paszy dla tuczników.