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Semi purified glycerins in growing and finishing pigs feeding (30-90 kg)

Glicerinas semipurificadas na alimentação de suínos nas fases de crescimento e terminação (30-90 kg)

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SUMMARY

Two experiments were carried out to determine the nutritional value and to evaluate the performance and carcass traits in the growing-finishing pigs fed on two types of semipurified glycerin, which were made from vegetable oil (SPGV) and mixed of animal + vegetable oil (SPGM). In the digestibility trial (experiment I) 32 crossbreed barrows were used with initial body weight of 45.08 ± 4.11kg. It were used three levels of inclusion (6, 12 e 18%) of semipurified glycerin (SPGV and SPGM) in the basal diet. The metabolizable energy (ME) value of glycerin were estimated by regression of ME (kcal/kg) intake associated with glycerin *vs.* glycerin intake (kg). The values of ME (kcal/kg) obtained were: 2,731 for SPGV and 2,210 for SPGM. In experiment II, 72 pigs (30.08 ± 1.65 to 60.58 ± 3.57) in growing and (60.83 ± 2.63 to 93.79 ± 5.72) in finishing phase, were allotted in a completely randomized design in a 2 x 4 + 1 factorial scheme, with two types of semipurified glycerin (SPGV and SPGA), four inclusion levels (4; 8; 12 and 16%), eight experimental unit and a control diet containing no glycerin (0%). All pigs were slaughtered to evaluate the carcass traits. The performance results suggest that it is feasible to use up to 16% of both semipurified glycerins on growing and finishing pigs feeding, without impairing performance and carcass traits.

Keywords: carcass, coproduct, glycerol, performance

RESUMO

Dois experimentos foram conduzidos com o objetivo de determinar o valor nutricional e avaliar o desempenho e características de carcaça de suínos na fase de crescimento-terminação, alimentados com rações contendo dois tipos de glicerinas semipurificadas, uma de óleo vegetal (GSPV) e uma mista de óleo de soja + gordura animal (GSPM). No ensaio de digestibilidade (experimento I) foram utilizados 32 suínos mestiços, machos castrados, com 45,08 ± 4,11kg. Foram utilizados três níveis de inclusão (6; 12 e 18%) de glicerina semipurificada (GSPV e GSPM) na dieta referência. A energia metabolizável (EM) das glicerinas foi estimada pela análise de regressão do consumo de EM (Kcal/kg) associada à glicerina *vs*. o consumo de glicerina (kg). Os valores de EM (Kcal/kg) obtidos foram: 2.731 para GSPV e 2.210 para GSPM. No Experimento II, 72 suínos (30,08 ± 1,65kg a 60,58 ± 3,57kg) na fase de crescimento e (60,83 ± 2,63kg a 93,79 ± 5,72kg) na fase de terminação, foram distribuídos em delineamento inteiramente ao acaso, em esquema fatorial 2 x 4 + 1, sendo dois tipos de glicerina semipurificada (GSPV e GSPM), quatro níveis de inclusão (4; 8; 12 e 16%), oito unidades experimentais e uma ração testemunha, não contendo glicerina (0%). Todos os suínos foram abatidos para determinação das características da carcaça. Os resultados de desempenho sugerem que é viável a utilização em até 16% de ambas as glicerinas na alimentação de suínos em crescimento e terminação, sem prejuízos no desempenho e características de carcaça.

Palavras-chave: carcaça, coproduto, desempenho, glicerol

INTRODUCTION

The high prices of oil and the concerns related to the environmental pollution justify the evaluation of alternative sources of energy such a biodiesel, produced from vegetable oils or animal fats. The major co-product of the biodiesel production is glycerin which can be marketed according to, Carvalho et al. (2012), in crude form (high content of fatty acids) or semi purified (low content of fatty acids).

Coupled with growing supply of glycerin in the market adds to the fact that food is the most expensive in modern pig farming. These factors arouse interest in the use of glycerin in animal feeding because of their energy, as energy is one of the most important nutrients for the performance of pigs during the growing and mostly finishing and are also the nutritional component that most onerous feeding.

Recent studies by Carvalho et al. (2012) demonstrate that glycerin in crude form can be used as energetic ingredient with potential for use in diets of growing-finishing pigs and can be considered an alternative ingredient to replace these traditional components of pig diets.

Glycerin has been studied as a feed ingredient for pigs for several years, and it has been shown to be highly palatable and can increase daily feed intake and daily weight gain when included at up to 10% of the diets fed to growing and finishing pigs (SCHIELDS et al., 2011). Crude glycerin not affect animal performance, carcass traits and meat quality (LAMMERS et al., 2008a; LAMMERS et al., 2008b) and can benefit the processing of feed (SCHIELDS, 2011). However regarding glycerin semipurified, scientific information is limited to feeding pigs in these categories.

Given the limited scientific information on the use of semipurified glycerin, this study was conducted to determine the nutritional value of vegetable and mixed semi purified glycerin and to evaluate the effects of their inclusion in practical diets on performance of growing (30-60kg) and finishing (60-90kg) pigs and to study the economic feasibility of its use.

MATERIAL AND METHODS

The experiments were carried out at the Pig Barn in the Fazenda Experimental de Iguatemi, belonging to Universidade Estadual de Maringá (UEM), located in State of Parana, Brazil.

Two semi purified glycerin were studied: SPGV – made from vegetable oil (soybean) and SPGM - mixed, made of about 80% animal fat + 20% soybean oil.

To determine the chemical composition and energy (Table 1) of the glycerin (SPGV and SPGM), the density, water content (Karl Fisher) and total glycerol analysis were carried out in the Paraná Institute of Technology (TECPAR). The values of pH, crude protein, ash, minerals and gross energy (Adiabatic calorimeter - Parr Instrument Co. AC720) were evaluated by the Laboratório de Nutrição Animal (LANA - UEM), according to the procedures described by Silva & Queiroz (2002). The concentration of sodium chloride was determined at the Biopar Analyses Control Laboratory. The matter organic non-glycerin (MONG) was calculated using the equation given by Hansen et al. (2009) in which MONG = 100 - (% glycerol +% moisture +% ash).

The determination of lipids and methanol were carried out by chromatography at the Departamento de Química e Física (UEM), respectively.

Two experiments were conducted: a digestibility assay (Experiment I) and a performance trial (Experiment II). In experiment I, 32 crossbred barrows from commercial line, of 45.08±4.11kg initial live weight were used. The animals were kept individually in metabolism cages similar to those described by Pekas (1968), in a room with partially controlled temperature. Ambient average temperatures showed minimum of 17.4±1.19ºC and maximum 20.4±3,11°C. The average relative humidity of ambient air showed minimum of 50.5±13.25% and a maximum of 79.3±14.21%.

The control diet (CD), consisted of corn (72.90%), soybean meal (24.45%), salt (0.570%), limestone (0.640%), dicalcium phosphate (0.870%) and mineral-vitamin premix (0.570%), was calculated according to the requirements indicated by Rostagno et al. (2005).

The experimental design of blocks (weight) at random was used. Two types of semi purified glycerin (SPGV and GSPM) were studied by using three levels of substitution of the CD (6, 12 and 18%), for each glycerin and four units per treatment.

Table 1. Chemical and energetic composition of semipurified glycerins

Nutrients	Vegetable oil semipurified glycerin	Mixed semipurified glycerin
Moisture, %	4.38	15.07
Total Glycerol, %	74.94	68.66
Crude protein, %	0.06	0.04
Gross energy, kcal/kg	3,760	3,217
Total fatty acid, %	9.0	5.1
MONG, %[1]	18.62	13.05
Methanol, %	10.32	6.28
Ash, %	2.06	3.22
Sodium chloride, %	0.23	0.35
Calcium, ppm	26.25	79.81
Phosphorus, ppm	157.43	653.44
Potassium, %	0.116	0.006
Magnesium, ppm	7.07	38.99
Copper, ppm	0.132	0.532
Chrome, ppm	0.000	8.571
Iron, ppm	14.01	256.57
Zinc, ppm	0.194	2.234
Manganese, ppm	0.464	1.487
Aluminum, ppm	1.90	13.86
Cobalt, ppm	0.100	0.220
Molybdenum, ppm	0.000	0.000
Lead, ppm	0.294	0.526
pH	5.60	1.67
Density, kg/m^3	1.183	1.189

[1]MONG: matter organic non-glycerol, defined as 100 – [glycerol content (%) + water content (%) + ash content (%)].

Feed supply, feces and urine collection were according to those described by Sakomura & Rostagno (2007). In the collection period, the feed supply was calculated based on metabolic weight ($kg^{0.75}$) from each pig and on the average intake recorded in the pre-experimental phase. Feeding was offered at 08h and 15h, with 55% of the total in the morning and 45% in the afternoon. All diets were moistened with approximately 20% of water, aiming to avoid waste, reduce dustiness and improve feed acceptability by the animal. After each meal, water was provided at 3mL of water/g of diet.

To mark the start and the end of the total feces collection period, 3% of Fe_3O_2 was used as a marker. Feces were collected once a day, packed in plastic bags and stored in a freezer (-18ºC). Subsequently, the material was thawed, homogenized and dried (about 350g) in a forced-ventilation oven 55ºC for 72h and ground in a knife mill (1mm sieve). The urine was collected in plastic buckets containing 20 mL of HCl 1:1 to prevent bacterial proliferation and possible volatility losses.

The digestibility coefficient of dry matter, organic matter, gross energy and the metabolization coefficient of gross energy (GEMC) were calculated according to Matterson et al. (1965). Traditional methods to determine the digestibility and metabolizability of conventional foods are described by Adeola (2000), although as the glycerines are classified as alternative food, so the digestible energy (DE) and metabolizable energy (ME) values were estimated by regression analysis (ADEOLA & ILELEJI, 2009) of DE and ME intake (kcal/kg) associated of glycerin vs. glycerin intake (kg).

This same methodology also applies to other monogastric animals such as rabbits (RETORE et al., 2012) and poultry (ADEOLA & ILELEJI, 2009), as a Bartlett & Schneider (2002), the production of energy from glycerin by animals can vary depending on the percentage of glycerin employed in the diet.In Experiment II, 72 crossbred pigs from commercial line with initial weight of 30.08±1.65kg and final weight of 60.58±3.57kg were used in growing and other 72 pigs with initial weight of 60.83±2.63kg and final weight of 93.79±5.72kg were used in the finishing phase. The minimum and maximum temperatures were 20.10±2.45°C and 32.71±2.87°C, respectively.

The pigs were housed in ten stalls (7.60m^2 each). Diets and water were provided *ad libitum* throughout the experimental period. The piglets were divided into experimental design of randomized blocks (time and weight) in a factorial 2 x 4 + 1, two types of semi purified glycerin (SPGV and GSPM) and four levels (4, 8, 12, e 16%) with eight replications and one piglet per experimental unit. In addition, a control diet was formulated containing no glycerin (0%).

The experimental diets (Tables 2 and 3), based on corn and soybean meal, were formulated according to Rostagno et al. (2005) for pigs in the growing (30-60kg) and finishing (60-90kg) phase.

The chemical and energetic composition of the two semi purified glycerin (SPGV and SPGM) obtained in the experiment of digestibility were used to formulate the diet. Crude protein, phosphorus, calcium and GE values were determined for corn and soybean meal. ME values were then obtained using the metabolization coefficient indicated by Rostagno et al. (2005).

The animals were weighed at the beginning and end of the experiment and the total feed intake was computed, in which daily feed intake (DFI), daily weight gain (DWG) and feed conversion (FC) of each experimental unit were calculated.

At the end of the growing and finishing phase the backfat thickness and loin depth at the position P2 were measured, using the Sono-Grader (Renco®).

At the end of the finishing phase, all pigs were slaughtered with electric stunning (200 watts) at the slaughterhouse of the Iguatemi Experimental Farm - FEI/UEM. The carcasses were chilled (1-2°C) for 24 hours and them subjected to a quantitative evaluation, according to the Brazilian Method of Carcass Classification (ABCS, 1973) and the American method (NPPC, 1991).

The pH of the *Longissimus dorsi* muscle was measured in the hot carcass 45 minutes postmortem (pH45) and in the chilled carcass kept in cold chamber (1-2°C) for 24 hours (pH24) using the portable pH meter Digital HI 99163 (Hanna Instruments), following the recommendations of Bridi & Silva (2006).

Table 2. Centesimal and chemical composition of diets containing different levels of two types of semipurified glycerin (vegetable oil and mixed) for growing pigs feeding (30-60 kg)

Item	Vegetable oil semipurified glycerin levels (%)					Mixed Semipurified glycerin levels (%)			
	0	4	8	12	16	4	8	12	16
Corn	70.37	65.02	59.70	54.39	49.07	64.53	58.73	52.93	47.13
Glycerin	0.00	4.00	8.00	12.00	16.00	4.00	8.00	12.00	16.00
Soybean meal	26.12	26.94	27.73	28.53	29.32	27.01	27.88	28.75	29.61
Soybean oil	0.690	1.219	1.747	2.275	2.802	1.632	2.573	3.514	4.455
Limestone	0.636	0.626	0.616	0.606	0.596	0.625	0.614	0.603	0.592
Dicalc. Phosp.	1.287	1.301	1.315	1.329	1.343	1.302	1.317	1.333	1.348
Common salt	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350
Min.vit. premix[1]	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Growth prom.[2]	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
L-Lys. HCl, 99%	0.173	0.158	0.144	0.130	0.116	0.156	0.141	0.126	0.111
DL-Meth. 99%	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
L-Thre. 98%	0.046	0.052	0.058	0.064	0.070	0.053	0.059	0.066	0.072
Calculated values[3]									
Met. En. kcal/kg[3]	3230	3230	3230	3230	3230	3230	3230	3230	3230
Crude protein, %[3]	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82	16.82
Calcium, %[3]	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631
Digest. phosph, %[3]	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332
Dig. lysine, %[3]	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895
Dig. met +cyst,%[3]	0.537	0.537	0.537	0.537	0.537	0.537	0.537	0.537	0.537
Dig. threonine, %[3]	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582
Glycerol, %[3]	-	2.998	5.995	8.993	11.99	2.746	5.493	8.239	10.99
Diet cost, R$/kg[3]	0.584	0.586	0.588	0.590	0.592	0.595	0.606	0.617	0.628

[1]Vitamin and mineral premix for growing pigs; [2]Leucomycin 30%; [3]Calculate based on Rostagno et al. (2005) and/or determined.

Table 3. Centesimal and chemical composition of diets containing different levels of two types of semipurified glycerin (vegetable oil and mixed) for finishing pigs feeding (60-90 kg)

Item	Vegetable oil semipurified glycerin levels (%)					Mixed Semipurified glycerin levels (%)			
	0	4	8	12	16	4	8	12	16
Corn	81.45	75.70	70.38	65.07	59.75	75.22	69.41	63.61	57.81
Glycerin	0.00	4.00	8.00	12.00	16.00	4,00	8.00	12.00	16.00
Soybean meal	16.37	17.60	18.40	19.19	19.98	17.67	18.54	19.41	20.27
Soybean oil	0.007	0.550	1.078	1.606	2.134	0.964	1.905	2.846	3.787
Limestone	0.575	0.564	0.554	0.544	0.534	0.563	0.552	0.541	0.531
Dicalc. Phosp.	0.877	0.889	0.903	0.917	0.931	0.890	0.905	0.921	0.936
Common salt	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350
Min.vit. premix[1]	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Growth prom.[2]	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
L-Lys. HCl, 99%	0.182	0.155	0.141	0.127	0.113	0.154	0.139	0.124	0.108
DL-Meth. 99%	0.026	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
L-Thre. 98%	0.010	0.012	0.018	0.024	0.030	0.013	0.019	0.026	0.032
Calculated values[3]									
Met. En. kcal/kg[3]	3236	3236	3236	3236	3236	3236	3236	3236	3236
Crude protein, %[3]	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85
Calcium, %[3]	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
Digest. phosph, %[3]	0.248	0.248	0.248	0.248	0.248	0.248	0.248	0.248	0.248
Dig. lysine, %[3]	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680
Dig. met +cyst,%[3]	0.422	0.422	0.422	0.422	0.422	0.422	0.422	0.422	0.422
Dig. threonine, %[3]	0.456	0.456	0.456	0.456	0.456	0.456	0.456	0.456	0.456
Glycerol, %[3]	-	2.998	5.995	8.993	11.99	2.746	5.493	8.239	10.98
Diet cost, R$/kg[3]	0.535	0.536	0.538	0.540	0.542	0.545	0.556	0.567	0.578

[1]Vitamin and mineral premix for finishing pigs; [2]Leucomycin 30%; [3]Calculate based on Rostagno et al. (2005) and/or determined.

The *Longissimus dorsi* and fat areas were determined using a digitizing tablet and with the help of the Spring software (CÂMARA et al., 1996). For a qualitative assessment of the carcass, samples were collected from all pigs (2.5cm thick) from the *Longissimus dorsi* muscle in the 8th and 10th rib for subsequent measurement of drip loss and cooking loss, according to Bridi & Silva (2006).

The color of *Longissimus dorsi* muscle was measured 24 hours after slaughter, with samples collected between the 8th and 10th rib, as described by Bridi & Silva (2006). On the surface of the muscle, six Minolta (L*, a* and b*) were performed using the CR-400 Konica Minolta's portable colorimeter (settings: Illuminant D65; 0° angle and four self-average). The components L* (lightness), a* (red-green component) b* (yellow-blue component) were expressed in the CIELAB color system.

A score was performed on the *Longissimus dorsi* muscle surface to measure the color, consistency (CONS) and marbling using a score with a 5-point scale (1 = pale, soft and devoid of marbling and 5 = dark, moderate firm or abundant marbling) as described by NPPC (1991). All samples of the *Longissimus dorsi* were cooked and used to determine the shear force (kgf). For each sample, five subsamples in cylindrical form were taken along the direction of muscle fibers (diameter 1.27), as recommended by Ramos & Gomide (2007). The analysis was performed in a Stable Micro Sytem TA-XT2i texturometer, coupled with the Warner-Bratzler Shear Force probe and the Exponent Texture Expert - Stable Micro Systems software.

To evaluate the economic feasibility of including the SPGV and GSPM semi purified glycerin in pigs feeding, prices of feedstuffs in the market were collected and the cost of feed per kilogram of body weight gain was calculated, according to Bellaver et al. (1985): Yi (R$/kg) = Qi X Pi/ Gi, where: Yi = feed cost per kg of body weight gain in the *i*-nth treatment; Qi = feed consumed in the *i*-nth treatment; Pi = price per kg of feed used in the *i*-nth treatment; Gi = weight gain in the *i*-nth treatment.

It was also calculated the Index of Economic Efficiency (IEE) and the Cost Index (CI), according to the methodology proposed by Gomes et al. (1991) where: IEE (%) = MCe/CTei X 100 and IC (%) = CTei/MCe X 100 where: MCe = lower feed cost per kg gain observed among the treatments, Ctei = cost of *i* treatment considered,

Prices of inputs in Maringá / PR were used to calculate the costs of the experimental diets. Corn (grain) cost R$ 0.475/kg, soybean meal R$ 0.629/kg, soybean oil R$ 2.63/kg and semi purified glycerin (SPGV and GSPM) R$ 0.20/kg.

The results were subjected to analysis of variance, according to the following statistical model: $Y_{ijk} = \mu + B_i + N_j + F_k + NF_{jk} + e_{ijkl}$, where Y_{ijk} = observation of the animal *l*, within the block *i*, inclusion level *j* and type of semi purified glycerin *k*; μ = constant associated to all observations; Bi = block effect, being i = 1, 2, 3, 4, 5; Nj = effect of semipurified levels of glycerin, being j = 0, 3, 6, 9, 12%; Fk = effect of semi purified glycerin type, being k = SPGV and SPGM; NF_{jk} = interaction effect of the inclusion level j and type of semi purified glycerin k and e_{ijkl} = random error associated with observation.

To compare the results of the control diet (with no inclusion of semi purified glycerin) with each of the inclusion levels of SPGV SPGM the Dunnett's test was applied (SAMPAIO, 1998). Statistical analyzes were performed using the statistical and gene analysis system (SAEG) developed by the Federal University of Viçosa (UFV, 2007).

RESULTS AND DISCUSSION

The digestibility coefficients (DM, OM and GE), metabolism and digestible nutrients (Table 4) of semipurified glycerin (SPGV and SPGM) showed that both are good energy sources to feed growing and finishing pigs.

Coefficient of greater than 100% digestibility were also observed and described by Lammers et al. (2008bc), which highlight these values higher nutritional value of glycerine to pigs. One possible reason for these results is that glycerins also act as additives/promoters that enhance the metabolic activities of swine besides being energy source. Other authors such as Carvalho et al. (2012) and Gonçalves et al. (2013) also obtained results with digestibility coefficients above 100% for pigs at different stages of creation.The slope of the linear relationship between the metabolizable energy intake (kcal/kg) associated with glycerin *vs* glycerin intake (kg) (Figure 1), showing that the SPGV presented energetic value (2,731kcal/kg of ME) 23.5% higher than the SPGM (2,210kcal/kg ME). Kerr et al. (2009) reported that higher levels of total fatty acids provide higher energetic value.

Table 4. Apparent digestibility coefficients (DC), metabolization coefficient (MC) and digestible values of nutrients of two types of semipurified glycerin (vegetable and mixed) used on growing and finishing pigs feeding

Digestibility coefficients (%)	Vegetable oil semipurified glycerin	Mixed semipurified glycerin
DC of dry matter	92.38	85.19
DC of organic matter	106.14	98.91
DC of fat	99.81	95.50
DC of gross energy	100.45	96.05
MC of gross energy	72.55	69.22
Digestible nutrients[1]		
Dry matter,%	88.33	72.99
Organic matter,%	98.85	91.53
Fat,%	8.98	4.87
Digestible energy, kcal/kg	3,777	3,090
Metabolizable energy, kcal/kg	2,731	2,210
ME:DE ratio	0.72	0.72

[1]As fed basis.

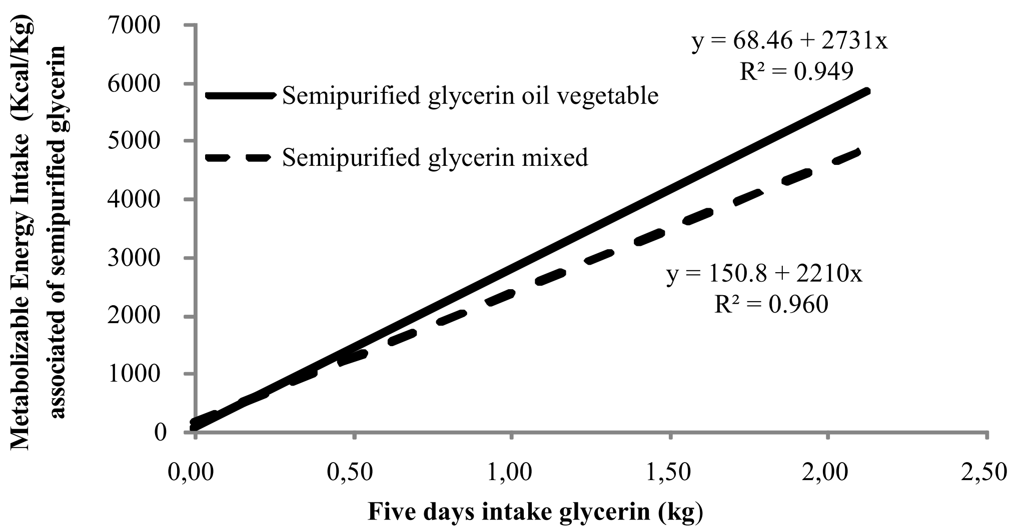

Figure 1. Equations of metabolizable energy (ME) of two types of semipurified glycerin, obtained from regression of ME (kcal/kg) intake associated of semipurified glycerin *vs.* semipurified glycerin intake (kg), for 24 growing pigs, in five days

The SPGV showed higher levels of total fatty acids compared to SPGM (Table 1). In the performance experiment (Table 5), for growing and finishing phases, there was no interaction between the inclusion levels and types of semi purified glycerin. The regression analysis indicates that there was no effect (P>0.05) of inclusion level of semi purified glycerin for DFI, DWG and FC.

The Dunnett's test showed no differences between the levels of inclusion of glycerin and the control diet (0% glycerol). This answer demonstrates that the nutritional values used for the glycerin are the real, since the diets were isonutritives. It also suggests that these co-products have no harmful components to the performance of pigs.

Table 5. Performance of growing (30-60 kg) and finishing (60-90 kg) pigs, fed on diets with semipurified glycerin (vegetable oil and mixed)

Item	Inclusion level of semipurified glycerin (%)									P Value	CV (%)
	Vegetable oil semipurified glycerin					Mixed semipurified glycerin					
	0	4	8	12	16	4	8	12	16		
Growing											
DFI, kg	2.231	2.303	2.202	2.213	2.266	2.237	2.323	2.297	2.256	0.558	9.49
DWG, kg	0.953	0.935	0.904	0.900	0.952	0.946	0.959	0.951	0.956	0.878	9.60
Feed:gain	2.345	2.475	2.453	2.462	2.384	2.377	2.420	2.423	2.364	0.698	6.48
BT, mm	9	8	9	10	10	9	9	10	10	0.885	17.63
LD, mm	41	40	39	39	39	40	42	41	42	0.556	12.43
Finishing											
DFI, kg	2.813	2.631	2.755	3.035	2.880	2.688	2.942	2.926	2.875	0.780	12.59
DWG, kg	0.911	0.890	0.932	1.024	0.944	0.909	0.981	0.981	0.936	0.565	10.17
Feed:gain	3.099	2.984	2.965	2.966	3.077	3.014	3.029	2.990	3.077	0.873	6.08
BT, mm	12	13	14	15	15	12	12	14	14	0.709	14.99
LD, mm	54	51	52	52	53	53	53	55	55	0.881	8.99

DFI = daily feed intake; DWG = daily weight gain; BT = backfat thickness; LD = loin depht.
CV = coefficient of variation.

Different results were observed by Kijora & Kuppsch (1996), in which there was an increase in feed intake in growing pigs (24.1 to 54.2kg), fed up to 10% of two types of glycerin with different levels of purification.
Mourot et al. (1994), Lammers et al. (2008a) and Schieck et al. (2010) found similar results on performance of growing-finishing pigs fed with 5-10% of semi purified glycerin. Mendoza et al. (2010) using purified glycerin recommend adding up to 15% in the diet of growing pigs, without loss impairing performance.
Other studies show that addition of up to to 10% glycerin purified (DELLA CASA et al., 2009) and semi purified (HANSEN et al., 2009; BERENCHTEIN et al., 2010), negative effects were observed on performance of growth pigs.

The backfat thickness (BT-P2) and loin depth (LD) (Table 5) showed no interaction between the inclusion levels of glycerin and the semi purified glycerin type. Regression analysis indicated that the inclusion of semi purified glycerin did not influence (P>0.05) the BT-P2 and LD. The Dunnett's test showed no difference in BT-P2 and LD between the inclusion levels of glycerin and the control diet (0% glycerol).

Hansen et al. (2009) did not obtain an effect on BT-P2 of growing pigs (50.9 to 105.2 kg) fed with up to 16% semi purified mixed glycerin. Duttlinger et al. (2008) did not find effect on the LD by including up to 5% of glycerin.

The BT (Table 6) increased linearly (P≤0.05) with the inclusion of different levels of SPGM. For finishing pigs, the net energy of glycerol is greater than the net energy of corn and soybean meal, which may have given the increase in BT, found in present study (Table 5).

Except the backfat thickness (ET), the remaining carcass quantitative characteristics (Table 6) were not affected (P>0.05) by the addition of semi purified glycerin. Likewise, the Dunnett's test showed no differences (P>0.05) between the glycerin inclusion levels and the control diet (0% glycerol) for the different carcass quantitative characteristics. These results indicate that semi purified glycerin used by 16% do not compromise the quantitative carcass characteristics of pigs.

These results are in agreement with Kijora & Kuppsch (1996) that found similar results with swine fed with 10% of inclusion of two types of glycerin with different levels of purification, Lammers et al. (2008a) and Berenchtein et al. (2010), using semi purified glycerin derived from soybean oil and beef tallow, and Della Casa et al. (2009) and Mendoza et al. (2010) with purified glycerin, found no effect on carcass traits of pigs. On the other hand, Schieck et al. (2010) observed an increase in hot carcass weight of pigs (31.3 to 91kg) fed with 8% of semi purified glycerin inclusion.

The qualitative carcass traits (Table 7) were not affected (P>0.05) by the addition of semi purified glycerin to the diets. The Dunnett's test also indicated no significant difference (P>0.05) between the glycerin inclusion levels and the control diet (0% glycerol) for the qualitative carcass traits.

Berenchtein et al. (2010) observed no effect of glycerin on the lightness and final pH, and Duttlinger et al. (2009) also observed no effect for shear force, cooking loss and sensory characteristics.

The results of the economic analysis (Tables 8 and 9) of SPGV in pigs diets during the growing (30-60kg) and finishing (60-90kg) showed no change in cost of feed per kg of weight gain. It should be noted that as the SPGV is added, there is a reduction in the inclusion of corn to the diet.

Economic analysis (Tables 8 and 9) showed a linear increase in the cost of feed as there was a SPGM inclusion because, even reducing the use of corn, it was necessary to increase the amount of soybean oil in the feed to meet the energetic requirements, which raised the cost of feed. The SPGM used showed a reduced energetic value (Table 4) due to high water content (Table 1) in its composition, which led to increase in cost (Tables 2 and 3) of diet.

The Dunnett's test indicated that for growing and finishing pigs, the levels 8, 12 and 16% inclusion of the SPGM had higher CR (Tables 8 and 9), compared with control diet (0% SPGM). These results were not observed for SPGV.

Table 6. Carcass traits of pigs fed diets with semipurified glycerin (vegetable oil and mixed)

Item	Inclusion level of semipurified glycerin (%)									P Value	CV (%)
	Vegetable oil semipurified glycerin					Mixed semipurified glycerin					
	0	4	8	12	16	4	8	12	16		
Fasting losses, %	3.73	3.30	4.53	5.19	3.59	4.48	4.38	3.58	2.69	0.834	38.65
Hot carcass weight, kg	72.93	73.23	73.62	74.76	74.25	72.72	74.31	75.40	75.52	0.792	2.32
Hot carcass yield, %	81.67	82.18	82.74	82.19	82.31	82.30	81.75	82.31	82.78	0.562	2.23
Cold carcass weight, kg	71.36	71.30	71.48	72.73	72.46	70.86	72.30	73.51	73.73	0.758	1.36
Cold carcass yield, %	79.92	80.00	80.34	79.95	80.32	80.20	79.56	80.26	80.82	0.453	1.28
Loss of yield, %	2.14	2.65	2.90	2.72	2.42	2.54	2.68	2.50	2.37	0.791	22.85
Ham yield, kg	30.99	31.53	31.31	30.54	31.80	31.85	31.22	31.48	31.68	0.873	3.47
Ham weight, kg	11.06	11.23	11.18	11.09	11.53	11.28	11.26	11.59	11.68	0.664	3.07
Backfat thickness, cm	2.83	2.75	3.10	3.05	2.93	2.60	2.88	2.98	3.18	0.04*	12.92
Carcass lenght, cm	88.35	88.06	90.88	92.36	89.10	90.35	92.00	90.78	88.18	0.548	3.59
Eye loin area, cm^2	39.17	37.54	39.27	38.69	38.61	39.83	38.88	39.71	39.46	0.559	9.56
Fat area, cm^2	21.00	21.05	21.82	22.20	20.79	19.23	20.45	21.85	23.28	0.623	17.38
Lean meat in the carcass, kg	56.73	55.34	56.62	55.92	56.63	57.13	57.25	57.20	57.56	0.461	6.47
Lean meat in the carcass, %	77.81	75.72	76.99	74.97	76.21	78.66	77.21	75.77	76.19	0.592	5.18
Lean:fat ratio	0.54	0.57	0.56	0.57	0.55	0.49	0.53	0.57	0.60	0.346	20.92
Liver, kg	1.34	1.30	1.33	1.36	1.34	1.35	1.40	1.36	1.29	0.872	6.67

*Linear effect ($P<0.05$)of mixed semipurified glycerin (Backfat thickness= 0.245083 + 0.459167 X).

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Table 7. Qualitative traits of *Longissimus dorsi* muscle in pigs fed diets with semipurified glycerin (vegetable oil and mixed)

Item	Inclusion level of semipurified glycerin (%)									P Value	CV (%)
	Vegetable oil semipurified glycerin					Mixed semipurified glycerin					
	0	4	8	12	16	4	8	12	16		
pH, 45 min,	6.56	6.52	6.59	6.67	6.55	6.63	6.52	6.68	6.52	0.871	2.88
pH, 24 hs	5.66	5.65	5.63	5.64	5.57	5.71	5.59	5.65	5.51	0.734	3.22
Drip loss, %	2.00	2.19	2.31	2.00	2.56	1.56	2.06	2.44	2.06	0.589	43.04
Marbling	1.75	2.13	2.00	1.88	2.00	2.00	1.75	2.00	2.13	0.436	27.49
Minolta a*1	6.90	6.39	6.51	6.60	6.94	5.81	6.29	6.30	6.72	0.587	13.80
Minolta b*1	5.94	6.11	6.15	6.19	6.40	5.43	5.99	5.94	5.97	0.890	11.29
Minolta L*1	51.26	52.74	53.21	52.95	53.73	52.10	53.40	53.23	52.42	0.834	4.09
Firmness	2.75	3.00	2.63	2.63	2.38	2.63	2.63	2.88	2.75	0.536	15.12
Color	2.00	1.88	1.88	1.88	1.88	2.13	1.75	1.75	1.88	0.439	11.24
Defrosting loss, %	9.67	10.11	9.41	9.87	9.32	9.92	10.3	10.39	9.76	0.387	16.63
Cooking loss, %	30.21	32.37	30.24	30.51	31.07	30.70	30.89	31.23	30.07	0.977	8.23
Shear force, Kgf/seg	3.32	3.32	3.52	3.10	3.49	3.40	3.54	3.44	3.10	0.546	16.91

[1] a*: indicate the color of meat ranging from red to green (red color indicate high, green indicate low); b*: indicate the color of meat ranging from yellow to blue (b* high indicate more yellow color, b* low indicate more blue color); L*: indicate the degree of brightness of meat (L* = 0 dark meat, L = 100 white meat); NS = non-significant (P>0.05).

Table 8. Economic analysis of using semipurified glycerins on growing (30-60 kg) pigs feeding

Item	Levels of inclusion of glycerin, %					CV (%)[1]	Dun[2]	Reg[3]
	0	4	8	12	16			
Semipurified glycerin vegetable oil								
Initial weight, Kg	29.71	30.12	30.00	29.97	30.50	-	-	-
Final weight, Kg	60.613	60.44	59.29	59.25	61.38	-	-	-
Diet cost	0.584	0.586	0.588	0.590	0.592	-	-	-
FC, R$/kg BW [4]	1.370	1.451	1.443	1.429	1.411	7.55	NS	NS
EEI[4]	100.0	94.4	95.0	95.9	97.1	-	-	-
CI[4]	100.0	105.9	105.3	104.2	103.0	-	-	-
Semipurified glycerin mixed								
Initial weight, Kg	29.71	30.07	30.10	30.14	30.10	-	-	-
Final weight, Kg	60.61	60.79	61.24	60.99	61.20	-	-	-
Diet cost	0.584	0.595	0.606	0.617	0.628	-	-	-
FC, R$/kg BW [4]	1.370	1.415	1.467*	1.484*	1.485*	8.25	0.01	L:0.03
EEI[4]	100.0	96.8	93.4	92.4	92.3	-	-	-
CI[4]	100.0	103.3	107.1	108.3	108.4	-	-	-

[1]Coefficient of variation (%); [2]Dunnett; [3]Regression analysis: linear effect: SPGM=1.38108+0.0772352X; [4]FC, R$/kg BW= Feed cost per Kg of body weight gain; EEI= economic efficiency index (EEI); CI=cost index; NS=Non significant.

Table 9. Economic analysis of using semipurified glycerins on finishing (60-90 kg) pigs feeding

Item	Levels of inclusion of glycerin, %					CV (%)[1]	Dn[2]	Reg[3]
	0	4	8	12	16			
Semipurified glycerin vegetable oil								
Initial weight, Kg	60.96	60.99	60.91	60.06	60.69	-	-	-
Final weight, Kg	92.75	92.18	93.26	95.93	93.60	-	-	-
Diet cost	0.535	0.536	0.538	0.540	0.542	-	-	-
FC, R$/kg BW[4]	1.657	1.580	1.595	1.601	1.667	5.95	NS	NS
EEI	95.31	100.00	99.07	98.70	94.79	-	-	-
CI	104.92	100.00	100.94	101.32	105.50	-	-	-
Semipurified glycerin mixed								
Initial weight, Kg	60.96	60.88	61.10	60.78	61.13	-	-	-
Final weight, Kg	92.75	92.56	95.09	94.99	93.79	-	-	-
Diet cost	0.535	0.545	0.556	0.567	0.578	-	-	-
FC, R$/kg BW[4]	1.657	1.643	1.684*	1.695*	1.778*	7.63	0.01	L:0.04
EEI[4]	99.11	100.00	97.57	96.91	92.41	-	-	-
CI[4]	100.90	100.00	102.49	103.19	108.22	-	-	-

[1]Coefficient of variation (%); [2]Dunnett; [3]Regression analysis: linear effect: SPGM=1.162684+0.0785526X; [4]FC, R$/kg BW: Feed cost per Kg of body weight gain; EEI= economic efficiency index (EEI); CI=cost index; NS=Non significant.

In conclusion, it can infer that the values of metabolizable energy, as fed basis, for vegetable oil and mixed semipurified glycerins for growing-finishing pigs are 2,731 and 2,210_kcal/kg, respectively. There by providing a highly available energy source for growing and finishing pigs. It is possible to use up to 16% of both semipurified glycerins in diets without impairing performance carcass traits and meat quality of growing and finishing pigs. It is economically feasible to include up to 16% of vegetable oil semipurified glycerin in the growing-finishing pigs diets (30-90_ kg). On the other hand, mixed semipurified glycerin can be uneconomical. However, the economic feasibility of its use will depend on the price ratio of the ingredients, especially corn and soybean oil (or other energy source).

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