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The effect of breed and dietary level of avocado fat on the N and energy balance in young pigs*

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ABSTRACT

The effect of breed and dietary avocado level on the total apparent digestibility (RAD) and balance of nitrogen (N) energy, in young pigs, was studied. Four Pelón Mexicano (PM) and four Yorkshire × Landrace (Y×L) barrow male pigs (39.2 kg average inital liveweight) distributed in two groups according to a change over design in a 2×2 factorial arrangement (breed and diet) were used. The pigs received on a pair feeding basis (0.10 kg DM/kg $W^{0.75}$ per day), the experimental diets. The diets were formulated to contain 30 or 150 g crude fat by partial replacement of the maize/soyabean meal diet by avocado (*Persea americana* Mill.) fresh pulp. The RAD of crude fat was 73.8 and 71.5% and that of N was 83.4 and 82.8 % in PM and Y×L pigs, respectively. There was no significant effect ($P>0.10$) of crude fat level on RAD of N and energy. N and energy balance significantly ($P<0.05$) favoured Y×L as compared with PM pigs. In conclusion, the poor N retention of PM pigs could be related to body composition of this local, non improved genotype. The use of avocado for feeding pigs, PM included, should determine a high digestibility of the crude fat fraction and at the same time a considerable deterioration of N retention, probably due to an unbalanced composition of amino acids. The level of avocado pulp inclusion in the diet of the pig should be involved in these circumstances.

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INTRODUCTION

The Pelón Mexicano (PM) breed is a fat-type pig currently reared in Mexico in an outdoors, extensive system. These animals are considered to be descendents of Iberian pigs, which were introduced in the country some 500 years ago during Spanish colonization (Lemus and Alonso, 2005). This type of animal is particularly fed on either discarded or dropped avocado (*Persea americana* Mill.) fruits in all Mexican regions were this fruit tree is cultivated. Mexico is the first country of the world where avocado fruits are produced and exported (FAO, 2007), and discarded fruits from packing plants can account for not less than 10% of avocados (Arpaia et al., 1987; Zamora et al., 1999).

During the biological harvesting of avocados in Mexican plantations, pigs, including those from the local breeds reared by small holders, use to eat the avocado pulp from ripe fruits found on the ground, after discarding peel and seed. This practice observed *in natura*, suggested to farmers to feed pigs with avocados, and this became a common fact which is predominant when these fruits are abundant during the yearly harvesting peak. However, there is no previous information concerning the nutritive value of avocado pulp for pigs (Göhl, 1975), although some early information regarding digestibility studies in humans (Mattil, 1916; Holmes and Deuel, 1920) is available elsewhere.

The aim of the present investigation was to evaluate the effect of breed (PM and Yorkshire × Landrace) and dietary levels of avocado pulp on the total apparent digestibility and balance of N and energy in young pigs. A preliminary report related to this subject was previously published by Grageola et al. (2008b).

MATERIAL AND METHODS

Animals and feeding.

The effect of breed and dietary fat level on the total apparent digestibility (TAD) and N and energy balance, of young pigs, was studied using four Pelón Mexicano (PM) and four Yorkshire × Landrace (Y × L) barrow male pigs weighing on average 39.2 kg initial liveweight at similar age. Pigs of each genotype were of similar age, and therefore different initial liveweight (PM and Y×L, 32.6 and 45.7 kg, respectively) mainly due to the slow growth rate of PM animals (Becerril et al., 2009). The pigs were distributed in two groups according to a change over design

and received on a pair feeding basis (0.10 kg DM/kg $W^{0.75}$ per day), one of the two experimental diets. The diets were formulated to contain 30 or 150 g crude fat per kg of diet in dry basis by partial replacement of the maize/soyabean meal diet by ripe avocado (*Persea americana* Mill.) fresh pulp. The avocados were of the Hass cultivar, and were obtained from discarded but not overripe fruits available either at local markets at Tepic City, or avocado orchards from either Xalisco or Tepic municipalities. Reasons for discarding fruits were small size, defective, wound or extremely rugous skin, blows, crushing or even failure to be sold at market after certain length of time. In any way, the avocados were able for consumption, due to its well recognized flavour and aroma, with no symptoms of putrefaction.

A representative sample of the avocado pulp used in the experiment revealed to contain 25.9% DM, and 8.1% crude protein (N × 6.25) in dry basis, and 63.2% crude fat, whereas mono- and polyunsaturated fatty acids accounted for 61.2 and 14.6%, respectively, of total fatty acids (Grageola et al., 2008a).

Table 1. Composition of the diets

Item	Avocado pulp, g/kg DM	
	0	200
Ingredients, %		
soyabean meal	22.0	17.6
maize	75.0	60.0
avocado pulp	-	20.0
$CaHPO_4.2H_2O$	1.0	0.8
$CaCO_3$	0.5	0.4
NaCl	0.5	0.4
vitamins and trace elements[1]	1.0	0.8
Chemical composition		
DM	87.27	63.10
DM basis, %		
ash	2.59	2.34
organic matter	97.41	97.66
crude fibre	3.34	3.36
crude fat	3.38	15.43
crude protein	16.00	15.23
energy, kJ/g DM	18.48	21.18

[1]supplied per kg of diet, IU: vit. 1600 A, vit. D_3, 160; mg: vit. K 2, thiamine 2, riboflavine 3, choline 300, niacin 15, panthotenic acid 5, pyridoxine 15, Cu 10, Fe 40, I 0.5, Co acetate 0.4, Cu 10

The fresh avocado pulp was extracted manually from fruits then thoroughly mixed to obtain a homogenous pulp, then mixing to the rest of the dry components of the diet. This ration manipulation was carried out daily, and offered to pigs at 9.00 a.m. every day. Details concerning the characteristics of the experimental diets are given in Table 1.

Sampling

All animals were from Nayarit, México. The pigs did not show any clinical symptom of disease. The animals were treated for external parasites, and weighed at the commencement of the period of adaptation for adjusting daily feed intake to 0.10 g DM per kg $W^{0.75}$. The pigs were assigned at random to one of the two diets. There were two experimental periods of 14 days each. During the first part of each experimental period, the animals were housed in individual cement floored pens provided of a metallic trough and a drinking nipple, and thereafter transferred to metabolic crates, where they were adapted to the new environment for another two days, followed of five days of quantitative collection of feed refusal if any, faeces and urine. Urine was collected in polypropylene buckets containing enough H_2SO_4 to keep the liquid below pH 4. Faeces and urine were quantitatively collected in the morning of every day and immediately weighed and frozen below - 5°C until analysis. At the end of this experimental period, the animals were re-weighed and changed to the other diet for a second 14-day period following the same above described routine.

Chemical analysis

After thawing, the fresh faeces were carefully mixed and then subjected to a drying process at 60°C in an air-forced oven, then milled in a laboratory mill. An aliquot of fresh materials were used for the analysis of DM and ash, according to AOAC (1990) procedures. N determination in faeces was carried out in fresh materials, and crude protein was assumed to be equal to N × 6.25. The crude fat determination was conducted in dried and milled faeces by an extraction procedure in a Soxhlet apparatus by means of acidified petroleum ether (boiling point 40-60°C), according to Ly et al. (1990) recommendations. Gross energy was determined in an adiabatic bomb calorimeter, except for urinary energy content, where a constant value accounting for 54.3 kJ/g N was assumed in all circumstances, according to Ly (2005) suggestions. The urinary N was determined by the Kjeldahl technique (AOAC, 1990). The same procedures used for faecal materials were applied to dry feeds and fresh avocado pulp. All analyses were conducted by duplicate.

The nutritive value of avocado pulp was determined by difference according to Crampton and Harris (1969).

Statistics

The analysis of variance technique was employed (Steel and Torrie, 1980) to examine the data collected on the pigs using the SAS (1999) software package, and the following model was used:

$$Y_{ijk} = \mu + a_i + b_j + ab_{ij} + e_{ijk}$$

where: Y_{ijk} is the digestion index in the k^{th} pig on the a_i diet on the b_j breed, μ is the overall meal, a_i is the effect of the i^{th} diet; b_j is the effect of the j^{th} body weight; ab_{ij} is the interaction term and e_{ijk} is the random error.

Some data were subjected to regression analyses, with linear components measuring the relationships between organic matter digestibility and other digestion parameters.

RESULTS

There were not feed refusal in any circumstances. Although a very slight decrease in eating rate of feed was observed in pigs fed on the avocado containing diet, this was not considered to account for any failure in acceptability. In fact, in a parallel study, it was found that eating rate of the diets containing non or 20% avocado pulp was 29.2 or 28.6 g DM/min, with no differences between PM and Y×L pigs (Peralta et al., 2008). Nevertheless, differences in overall intake of nitrogen and energy existed due to the fact that the diets were formulated to contain either none of 30% avocado pulp. As it is known, the avocado pulp is very poor in N and very rich in energy (*vide supra*). On the other hand, the animals were in good health, and at the end of the trial, all pigs were in positive weight balance.

The interaction breed x diet was not significant ($P>0.05$) for any of the evaluated indices. Nutrient digestibility of diets is shown in Table 2. There were no significant ($P>0.05$) differences in the apparent digestibilities of DM, N, energy, ash and organic matter between both types of diets. In contrast, crude fat apparent digestibility showed a highly significant ($P<0.001$) improvement when pigs were fed the diet containing avocado pulp. On the other hand, there was no breed effect on the evaluated TAD values.

Table 2. Nutrients and energy total apparent digestibility in growing pigs fed avocado pulp based diets

Total digestibility, %	Avocado pulp, g/kg DM			Breed		
	0	200	SEM	Pelón Mexicano	Y×L	SEM
Dry matter	87.31	85.67	0.41	86.97	86.91	0.61
Ash	27.91	31.60	0.60*	29.90	29.60	0.61
Organic matter	84.34	83.82	0-35	84.11	84.05	0.53
Crude fat (acidified)	65.57	83.43	2.48***	73.85	71.55	3.36
Crude protein	84.14	82.12	0.69	83.42	82.84	060
Energy	85.75	86.11	0.65	84.73	85.09	0.84

SEM - pooled standard error; significance of effects: * P<0.05; *** P<0.001

The nutritive value of avocado pulp is presented in Table 3. The coefficient of variation for DM and organic matter digestibility of the evaluated pulp was considerably low, 1.99 and 1.78%, respectively. Higher variation, although not so high, were encountered for crude fat and crude protein digestibility, 4.35 and 3.80%, in this same order. Variability for energy and ash digestibility was found to be in the middle of these fluctuations, 3.29 and 3.24%.

Table 3. Composition of avocado pulp for growing pigs (calculated by difference)

Total digestibility, %	Mean[1]	SD
Dry matter	84.08	1.68
Ash	46.35	1.50
Organic matter	83.82	1.49
Crude fat (acidified)	83.44	3.63
Crude protein	82.13	3.12
Energy	84.08	2.77

[1] mean and standard deviation of eight observations

The N balance results are presented in Table 4. Intake of N was not affected (P>0.05) by the dietary avocado content, but Y×L pigs had a higher N consumption (P<0.001) than the Pelón Mexicano. Faecal, urinary, and total excretion as well as digestion of N were not affected (P>0.05) by the dietary avocado pulp content. However, faecal excretion and digestion of N were affect by breed; Y×L pigs had a higher faecal excretion (P<0.05) and digestion (P<0.001). Urinary and total excretion of N were not affected by breed. Dietary content of avocado pulp reduced the retention of N, expressed either as g/d, % of intake, or % of digested N (P<0.05). On the other hand, Y×L pigs retained more N, expressed either as g/d (P<0.001), % of intake, or % of digested P<0.05). In general, N balance was negatively influenced by the inclusion of avocado pulp in the diet and, when comparing Y×L with Pelón Mexicano, it was more favourable in the commercial breed.

Table 4. N balance in growing pigs fed on avocado pulp based diets

Item	Avocado pulp, g/kg DM			Breed		
	0	200	SEM	Pelón Mexicano	Y×L	SEM
Balance, g/day						
intake	42.12	41.01	0.37	37.65	45.48	0.27***
faecal excretion	6.65	7.33	0.09	6.21	7.77	0.07*
digestion	35.47	33.67	0.33	31.44	37.71	0.26***
urinary excretion	15.42	17.83	0.32	18.21	15.03	0.31
total excretion	22.07	25.17	0.32	24.43	22.80	0.33
retention	20.06	15.84	0.38*	13.22	22.68	0.25***
Retention, % of intake	47.89	37.46	0.70*	35.57	49.79	0.62*
Retention, % of digestion	57.04	45.59	0.84*	42.68	59.95	0.72*

SEM – pooled standard error; significance of effects: * P<0.05; *** P<0.001

There was a highly significant (P<0.001) effect of avocado pulp on the energy intake of animals (Table 5). This was due to the fact that daily feed intake was adjusted to DM and not to energy basis. Nevertheless, energy retention expressed as percentage of that consumed or digested was without any dietary effect. On the other hand, energy retention calculated as the percentage of digested energy, reflected a significant (P<0.05) effect due to breed, with Y×L individuals expressing a better energy utilization, as compared with PM pigs.

Table 5. Energy balance in growing pigs fed on avocado pulp based diets

Item	Avocado pulp, g/kg DM			Breed		
	0	200	SEM	Pelón Mexicano	Y×L	SEM
Balance, kJ/day						
intake	20.96	29.37	0.25***	22.64	27.70	0.35***
faecal excretion	2.97	4.02	0.04***	3.22	3.77	0.04
digestion	17.99	25.31	0.21***	19.41	23.93	0.29
urinary excretion	0.80	0.75	0.04	0.88	0.63	0.04
total excretion	3.77	4.81	0.04**	4.10	4.39	0.04
retention	17.20	24.56	0.21***	18.49	23.26	0.29***
Retention, % of intake	81.85	83.44	0.71	81.61	83.68	0.71
Retention, % of digestion	95.47	96.88	0.54	95.10	97.25	0.50*

SEM – pooled standard error; significance of effects: * P<0.05; ** P<0.01; *** P<0.001

DISCUSSION

Nutritive value of avocado pulp. Taking into account that avocado pulp contains a high amount of lipids (Ozdemir and Topuz, 2004; Tango et al., 2004), and the product evaluated in the current investigation was not an exception, since crude fat accounted for 63.2% in dry basis (Grageola et al., 2008a), it is obvious that

the fate of lipid digestibility must influence to a great extent the nutritive value of avocado pulp.

Li and Sauer (1994) did not find any influence of canola oil on piglet faecal digestibility of DM, N and amino acids as a result of increasing graded levels of this oil of vegetable origin up to 12.2% in the diet, therefore supporting the herein findings concerning the effect of avocado pulp on faecal digestibility of nutrients in young pigs. Similarly, inclusion of 18.9 to 19.2% crude fat from fish oil, rapeseed oil or coconut oil in diets did not affect total digestibility of DM, energy and protein in young pigs (Jorgensen et al., 2000). However, in other experiments, such as that of Jorgensen and Fernández (2000), fat inclusion in the diet determined a clear improvement of crude protein and amino acid digestibility. In this connection, level as well as nature of fats included in the diet of pigs could be implied in different animal response through digestibility indices. On the other hand, an increase in digestive capacity, in terms of linear increase in weight of digestive system was noted by Terán et al. (2004) as a consequence of increasing the percentage of palm oil in the diet. However, a clear explanation of these interdependences, involving the avocado pulp, is not apparent.

As to be expected, due to its high content of unsaturated fatty acids (Grageola et al., 2008a), the nutritive value of avocado pulp was relatively high. It is well known that the digestibility of unsaturated fatty acid is practically complete even at the ileum level in pigs (Jorgensen and Fernández, 2000; Duran-Montgé et al., 2007). On the other hand, it could be expected that an improvement in crude fat digestibility should occur in pigs as a result of increasing the percentage of dietary crude fat (Just, 1989). In fact, although a high volume of information concerning crude fat content and fatty acid composition in avocados is available (e.g., Ozdemir and Topuz, 2004; Tango et al., 2004), and details of digestion and absorption of lipids is increasingly understood (Demarne, 1982; Jorgensen et al., 2000), very few is known about digestive utilization of the avocado ether extract fraction, either in pigs (Göhl, 1975) or even in humans (Ortega, 1983). In this connection some earlier reports have indicated that crude fat digestibility of avocado mesocarp is relatively high in human beings, 89.1-93.7% (Mattil, 1916; Holmes and Deuel, 1920). In the current investigation this same index was somewhat lower, 83.4% (Table 3). In this connection, it appears that more research should be useful to conduct, in order to know the degree of ileal digestibility of fatty acids in pigs fed on avocado pulp, since it has been claimed that faecal digestibility of fatty acids does not reflect true digestive utilization of these acids by this animal species (Just, 1989; Jorgensen et al., 1996, 2000; Averette Gatlin et al., 2002).

The absorption of high amounts of unsaturated fatty acids from avocado pulp, mainly oleic and linoleic acids, may determine a high iodine index value of body fat of pigs fed diets prepared with an important proportion of avocado

pulp, since it is well known that pig carcass fat largely reflects dietary fatty acid composition (Madsen et al., 1992; Averette Gatlin et al., 2002; Pascual et al., 2006; Durant-Montgé et al., 2007). On the other hand, it is unknown to what extent this phenomenum should be similar in improved and in local Mexican pigs. Therefore, experiments designed to determine carcass composition and meat and fat quality of pigs as affected by avocado pulp could be of great interest to be conducted. Moreover, these types of investigation should be of importance in the case of the Mexican Pelón pig, which is known to be of the fat type animal (Lemus and Alonso, 2005).

The inclusion of 20% avocado pulp in the diet resulted in a clear depression in N retention of pigs, therefore suggesting that perhaps amino acid composition of avocado pulp is far to be similar to the amino acid proportion required for pig growth (NRC, 1998). Very few information, if any, is available about amino acid composition of avocado pulp (Hall et al., 1980; Ortega, 2003), and this aspect would merit more concern taking into consideration that feeding pigs with a relatively high proportion or avocado pulp would determine a necessity for balancing the ration from the point of view of essential amino acids. As illustration, Ortega (2003) reported values of 59, 40 and 29 mg of lysine, threonine and methionine per 100 g of avocado pulp.

The effect of breed on nutrient digestibility and balance. The current investigation provided evidence in support to the fact that there are not digestive disadvantages in PM pigs from the point of view of an efficient utilization of energy, as opposed to what does occur when this local genotype is fed on diets high in fibre (Chel et al., 1983; Trejo, 2005). These findings are in accordance with results from other American Creole animals with similar genetic origin (Ly et al., 1998). On the other hand, a poor retention of N in PM pigs, as compared to improved, exotic breeds of animals has been reported elsewhere (Ly et al., 2000; Trejo, 2005). However, there are not previous observations, in the knowledge of the authors, of the nature of fat utilization in PM pigs. In this connection, Ly et al. (2000) observed that fat utilization in Cuban Creole pigs is considerably enhanced if measured at the rectal site, if contrasted to what it takes place in Cuban imported, exotic individuals. Other pigs of the Iberian, contemporary type, such as Alentejano and Retinto animals, apparently show a similar digestive advantage (Boza et al., 1969; Freire et al., 1997, 1998). Since energy retention appears to be better in Y×L than in PM pigs, perhaps this finding could be related to dietary fat utilization by the animals.

A noteworthy decrease in N retention of PM pigs as compared to Y×L individuals is in agreement with previous studies concerning Cuban Creole and Mexican Hairless pigs (Ly et al., 2000; Trejo, 2005). It has been suggested that N balance could be an indicator of N requirements in pigs (McConell et al., 1971,

1972). If this is the case in PM animals, then it follows that probably less protein should be necessary for supporting maximal rate of growth in this Mexican type of local pig breed. In fact, it is reasonable to accept that a slow growth rate of PM pigs, as well as its fat-type body composition (Lemus and Alonso, 2005) could be highly related to a lower N retention and higher fat digestibility. Both above mentioned characteristics are not suitable for adjusting feeding management of this type of local animals to nutrient and energy requirements recommended for improved pigs (NRC, 1998).

CONCLUSIONS

In conclusion, a lower N retention in Pelón Mexicano (PM) pigs could be related to body composition of this local, non improved genotype, which otherwise does not appear to be inferior when compared to improved breeds of pigs for digesting diets at least similar to those assayed in the current investigation. Further research would be necessary to establish the proper recommendation for N consumption of this type of Mexican animals. On the other hand, the use of avocado for feeding pigs, PM included, should determine a high digestibility of the crude fat fraction and at the same time a considerable deterioration of N retention, probably due to an unbalanced composition of amino acids. The level of avocado pulp inclusion in the diet of the pig should be involved in these circumstances.

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REFERENCES

AOAC, 1990. Association of Official Analytical Chemists, Official Methods of Analysis. 15th Edition. Washington, DC

Arpaia M.L., Mitchell F.G., Katz P.M., Mayer G., 1987. Susceptibility of avocado fruit to mechanical damage as influenced by variety, maturity and stage of ripeness. South Africa Avocado Growers Assn. Yearbook 10, 149-151

Averette Gatlin L., See M.T., Hansen J.A., Sutton D., Odle J., 2002. The effects of dietary fat sources, levels, and feeding intervals on pork fatty acid composition. J. Anim. Sci. 80, 1606-1615

Becerril M., Lemus C., Herrera J.G., Huerta M., Alonso-Spilbury M., Ramírez-Necochea R., Mota-Rojas D., Ly J., 2009. Studies on growth of Pelón Mexicano pigs: effect of rearing conditions on performance traits. J. Anim. Vet. Advan. 8, 208-212

Boza J., Fonollá J., Varela G., 1969. Comparative study of digestibility and nutritive value of the sorghum in Retintos and Landrace pigs. Rev. Nutr. Anim. 7, 112-120

Chel L., Aguilar A., Castellanos A., 1983. Digestive use of the alfalfa by the Mexican Hairless pig. Tec. Pec. Mexico 44, 27-34

Crampton E.W., Harris L.E., 1969. Applied Animal Nutrition. The Use of Feedstuff in the Formulation of Livestock Rations. W.H. Freeman and Co. San Francisco, pp. 753

Demarne Y., 1982. Digestion and absorption of the lipids in the pig. In: Digestive Physiology in the Pig. Les Colloques de l'INRA 12, 99-109

Duran-Montgé P., Lizardo R., Torrallardona D., Esteve E., 2007. Fat and fatty acid digestibility of different fat sources in growing pigs. Livest. Sci. 109, 66-69

FAO, 2007. Annual Production Yearbook. Rome

Freire J.P.B., Peiniau J., Cunha L.F., Almeida J.A.A., Aumaitre A., 1997. A comparative study on the digestive performance and the activity of digestive enzymes in Alentejano and Large White piglets. In: Proceedings of IV International Seminar on Digestion Physiology in Pigs. Saint Malo, pp. 140-143

Freire J.P.B., Peiniau J., Cunha L.F., Almeida J.A.A., Aumaitre A., 1998. Comparative effects of dietary fat and fibre in Alentejano and Large White piglets: digestibility, digestive enzymes and metabolic data. Livest. Prod. Sci. 53, 37-47

Gohl B., 1975. Tropical Feeds. In: Feeds Information Summaries and Nutritive Value.FAO, Rome

Grageola F., Sanginés L., Castillo R.M., Lemus C., Ly J., 2008a. Some characteristics of avocados (*Persea americana* Mill.) Mexican of Nayarit with potential in the feeding of pigs. Proceedings of IV International Seminar on Digestion Physiology in Pigs. Havana City (electronic version available in compact disc, ISBN 978-959-282-075-3)

Grageola F., Sanginés L., Lemus C., Ly J., 2008b. Faecal output and digestibility of dry matter in nayaritas Mexican Pelón pigs fed with diets of fresh pulp of avocado (*Persea americana* Mill.). Rev. Computad. Prod. Porcina 15, 54-56

Hall H.T., Smoot J.M., Knight R.J., Nagy S., 1980. Protein and aminoacid composition of ten tropical fruits by gas-liquid chromatography. J. Agr. Food Chem. 28, 1217-1221

Holmes A.D., Deuel H.J., 1920. Digestibility of certain miscellaneous fats. J. Biol. Chem. 41, 227-235

Jorgensen H., Fernández J.A., 2000. Chemical composition and energy value of different fat sources for growing pigs. Acta Agr. Scand., Sect. A, Anim. Sci. 50, 129-136

Jorgensen H., Gabert V.M., Hedemann M.S., Jensen S.K., 2000. Digestion of fat does not differ in growing pigs fed diets containing fish oil, rapeseed oil or coconut oil. J. Nutr. 130, 852-857

Just A., 1989. The net energy value of crude fat for growth in pigs. Livest. Prod. Sci. 9, 501-509

Lemus C., Alonso M.L., 2005. The Mexican Pelón Pig and Other Creoles Pigs. Autonomy University of Nayarit (Editor). Tepic, pp. 251

Ly J., 2005. An approach to the relationship between N and energy in urine of pigs fed sugar cane products. Rev. Computad. Prod. Porcina 12, 35-38

Ly J., Avila E., Mederos C.M., 1990. Effect of the method of determination of the crude fat digestibility in pigs. Diets with low level of ether extract. Cienc. Téc. Agr. Ser. Ganado Porcino 13 (2), 69-79

Ly J., Diéguez F.J., Martínez R.M., García A., 1998. Digestion of a diet very high in fibre in Cuban Creole pigs. Anim. Feed Sci. Tech. 72, 397-402

Ly J., Santana I., Macías M., 2000. Studies on digestibility of royal palm nuts in Cuban Creole pigs. Cuban J. Agr. Sci. 34, 327-335

Li S., Sauer W.C., 1994. The effect of dietary fat content on amino acid digestibility in young pigs. J. Anim. Sci. 72, 1737-1743

Madsen A., Jakobsen K., Mortensen H., 1992. Influence of dietary fat on carcass fat quality in pigs. A review. Acta Agr. Scand. 42, 220-225

McConell J.C., Barth K.M., Griffin S.A., 1971. Nutrient digestibility and nitrogen metabolism studies at different stages of growth with fat and lean type swine fed two levels of protein. J. Anim. Sci. 32, 654-657

McConell J.C., Barth K.M., Griffin S.A., 1972. Nitrogen metabolism at three stages of development and its relationship to measurements of carcass composition in fat and lean swine. J. Anim. Sci. 35, 556-560

Mattil H.A., 1916. The digestibility of the fat of the avocado. California Avocado Assn. Annu. Rep. 2, 93-95

NRC, 1998. Nutrient Requirements of Swine. 10th revised Edition. National Academy of Science Press. Washington, DC

Ortega T.M., 2003. Valor nutrimental de la pulpa fresca de aguacate Hass. In: Proceedings of V World Avocado Congress, pp. 741-748

Ozdemir F., Topuz A., 2004. Changes in dry matter, oil content and fatty acids composition of avocado during harvesting time and post-harvesting ripening period. Food Chem. 86, 79-83

Pascual J.V., Rafecas M., Canela M.A., Boatella J., Bou R., Baucells M.D., Codony R., 2006. Effect of increasing amounts of a linoleic-rich dietary fat on the fat composition of four pig breeds. Part I: Backfat fatty acid evolution. Food. Chem. 96, 538-548

Peralta V., Ponce J.L., Llamas C., Grageola F., Lemus C., Ly J., 2008. Pattern of feed intake of Pelón Mexicano pigs fed with diets of avocado (Persea americana *Mill.)*. Rev. Comp. Prod. Porcina 15, 63-67

SAS, 1999. SAS/STAT User's Guide. Release 6.12. Stat. Anal. Syst. SAS Institute Inc. Cary, NC

Steel, R.G.D., Torrie, J.H. 1980. Principles and Procedures of Statistics. A Biometrical Approach. 2nd Edition. McGraw-Hill Book Co. Inc. Toronto, pp. 481

Tango J.S., Carvalho C.R.L., Soares N.B., 2004. Physical and chemical characterization of avocado fruits aiming at its potential for oil extration. Rev. Bras. Frutic. (Jaboticabal) 26, 17-23

Terán G., Sarmiento L., Segura J.C., Torres F., Santos R., 2004. Productive performance, carcass characteristics and gastrointestinal tract weight of pigs fed with African palm oil (Elacis guineensis). Téc. Pec. México 42, 181-192

Trejo W., 2005. Strategies to improve the use of limited nutrient resources in pig production in the tropics. J. Agr. Rural Develop. Trop. Subtrop. 85, 1-108

Zamora M.T., Cajuste J., Colinas M.T.B., Santacruz H., 1999. Effect of the mechanical damages on the postharvest behavior of avocado fruit. Rev. Chapingo, Ser. Horticultura 5, 319-328