AN APPROACH TO THE STUDY OF THE NUTRITIVE VALUE OF MULBERRY LEAF AND PALM OIL IN GROWING PIGS

Una Aproximación al Estudio del Valor Nutritivo de Hojas de Morera y Aceite de Palma en Cerdos en Crecimiento

***Carlos González*[1], *Ricardo Tepper*[1] *and Julio Ly*[2]**

[1]*Institute of Animal Production, Faculty of Agronomy, Central University of Venezuela. PO Box 4579, El Limón, Maracay, Venezuela.*
[2]*Swine Research Institute. PO Box 1, Punta Brava, Havana City, Cuba. E-mail: gonzalezc@agr.ucv.ve / jlyca@yahoo.com*

ABSTRACT

Forty eight crossbred castrated male pigs averaging 32 kg initial weight were employed according to a random block design arranged in a factorial 3×4 experiment to determine total tract digestibility coefficients of diets formulated to contain 0, 10 and 20% of mulberry (*Morus alba*) leaf meal and 0, 3, 6 and 9% of crude palm (*Elaeis guineensis Jacq*.) oil. Feed intake was fixed as 0.08 g DM/kg$^{0.75}$ per day given in two daily equal rations. The mulberry leaf meal contained crude protein (N×6.25) 14.50 and NDF 34.55% and 17.81 kjoule/g on dry matter basis respectively. There was no significant interaction (P > 0.05) between mulberry foliage meal and crude palm oil levels in any digestibility index. Overall, digestibility indices were high. Increasing levels of mulberry leaf meal in diet had a significant (P < 0.01) negative influence on DM, organic matter, NDF, N and energy respectively, This same trend, although not significant (P > 0.05) was observed for increasing levels of crude palm oil in the diet on digestibility indices of pigs. N and organic matter digestibility of mulberry as determined by difference were 43.65 and 64.65 % respectively, whereas digestible energy accounted for 9.41 kjoule/g DM. Digestible energy estimated for the crude palm oil was rather low 16.12 kjoule/g DM). It is suggested that mulberry leaf meal could be introduced up to 20% in diets for growing pigs with no deleterious influence on total tract digestibility indices. The use of palm oil up to 9% can contribute to increase the energy density of the diet. Due to the relatively low digestibility of crude palm oil, methods should be investigated in order to improve its nutritive value.

Key words: Pigs, mulberry leaves, crude palm oil, digestibility.

RESUMEN

Se emplearon 48 cerdos machos castrados con un peso promedio inicial de 32 kg, según un diseño de bloque al azar en arreglo factorial 3×4 para determinar coeficientes de digestibilidad aparente en todo el tracto digestivo, de dietas formuladas para contener 0; 10 y 20% de harina de hojas de morera (*Morus alba*), y 0; 3; 6 y 9% de aceite crudo de palma (*Elaeis guineensis Jacq*.). El consumo de alimento se fijó en 8% del peso metabólico (PV^{0,75}) por día en dos raciones iguales. La harina de hojas de morera contenía 14,50 y 34,55% de proteína bruta (N×6,25) y FDN así como 17,81 kjoule/g MS respectivamente. No hubo interacción significativa (P > 0,05) entre los niveles de harina de hojas de morera y aceite crudo de palma para ningún índice de digestibilidad. El incremento del nivel de harina de hojas de morera tuvo una influencia negativa (P < 0,01) en la digestibilidad de MS, materia orgánica, FDN, N y energía respectivamente. La digestibilidad del N y la materia orgánica de la morera determinada por diferencia fue 43,65 y 64,65% respectivamente, mientras que la energía digestible fue 9,41 kjoule/g MS. Se sugiere que la harina de hojas de morera pudiera ser introducida hasta un 20% en dietas para cerdos en crecimiento con baja influencia negativa de este nivel de inclusión sobre los índices digestivos de todo el tracto. El uso de aceite crudo de palma hasta 9% puede contribuir a incrementar la densidad energética de la dieta. Debido a la digestibilidad relativamente baja del aceite crudo de palma, debieran investigarse métodos para mejorar su valor nutritivo.

Palabras clave: Cerdos, crecimiento, hojas de morera, aceite crudo de palma, digestibilidad.

Recibido: 25 / 11 / 2004. Aceptado: 29 / 09 / 2005.

INTRODUCTION

The use of tree foliage for feeding animals has been examined in several moments [6], whereas in the specific case of mulberry (*Morus alba*) leaves or foliage, there are some indications suggesting that either its nutritive value [4, 9, 12] or its feeding value [13, 15, 21] for pigs, is not negligible. In parallel to these investigations, several studies has been conducted related to the possibility of use of palm (*Elaeis guineensis Jacq*) oil as a common ingredients in diets for pigs fed several types of foliage [2, 8, 17, 19] in order to compensate the decrease in energy density of such fibrous diets. In this aspect, it has been observed that total tract digestibility coefficients tend to decrease in the same manner that the proportion of palm oil increases in the diet [2, 17]. Moreover, Leduc [11] observed that pigs fed on crude palm oil showed a clear deterioration in DM and energy digestibility.

This communication reports further studies concerning the effect of the use of palm oil on mouth-to-rectum nutrient digestibility in pigs, and the nutritive value of mulberry leaf for pigs.

MATERIALS AND METHODS

A total of 48 crossbred castrated male pigs averaging 32 kg initial weight were employed according to a random block design arranged in a factorial 3×4 experiment to determine total tract digestibility coefficients of diets formulated to contain 0, 10 and 20% of mulberry (*Morus alba*) leaf meal and 0, 3, 6 and 9% of crude palm (*Elaeis guineensis Jacq*.) oil according to swine nutritional requirements of National Research Council [14]. Mulberry leaves and petioles from an unknown cultivar grown at the Animal Production Institute (Universidad Central de Venezuela, Maracay), were separated from the stems, then sun-dried and milled to obtain a dry meal. Feed intake was fixed as 0.08 kg DM/kg$^{0.75}$ per day given in two daily equal rations. The mulberry foliage meal contained DM 89.34% and protein (N×6.25) 14.50, NDF 34.55, ether extract 3.81, ash 15.44% on dry matter basis respectively. The calorific value of mulberry leaf meal and crude palm oil were 17.81 and 40.00 kjoule/g DM respectively. Details related to the characteristics of the diets are presented in TABLE I.

The animals were housed in metabolism cages, in an open building at the Institute of Animal Production, Universidad Central de Venezuela, Maracay. Water was provided for *ad libitum* consumption from drinking nipples attached to the cages. Each experimental period consisted of five days of adaptation of the animals to the experimental diets, followed by another three days of collection of faeces. Feed refusals if any and faeces were collected two times per day, and conveniently frozen until analysis. Other details of the daily routine work are exposed elsewhere [19].

Duplicate samples of feed were analyzed for DM, ash, ether extract and N content as outlined by Association of Official Analytical Chemist (AOAC) [1]. Cell walls, identified as the insoluble material in neutral detergent solution (neutral detergent fibre, NDF), were determined as described by Van Soest *et al.* [22]. The organic matter content of samples was defined as the difference of 100 minus % ash. The gross energy con-

TABLE I

CHARACTERISTICS OF THE DIETS (PER CENT IN DRY BASIS) / CARACTERÍSTICAS DE LAS DIETAS (% MS)

Mulberry leaf meal (%)	0				10				20			
Crude palm oil (%)	0	3	6	9	0	3	6	9	0	3	6	9
Ingredients												
Maize meal	84.0	81.5	79.0	76.4	75.6	73.1	70.6	68.0	67.2	64.7	62.1	59.6
Soybean oil meal	14.0	13.6	13.2	12.8	12.6	12.2	11.7	11.2	11.2	10.8	10.4	9.9
Mulberry meal	-	-	-	-	10.0	10.0	10.0	10.0	20.0	20.0	20.0	20.0
Crude palm oil	-	3.0	6.0	9.0	-	3.0	6.0	9.0	-	3.0	6.0	9.0
Premix1	2.0	1.9	1.8	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.5
Analysis												
DM	89.9	90.3	90.6	90.9	89.9	90.2	90.5	91.8	89.9	90.1	90.4	90.7
Ash	4.4	4.3	4.2	4.0	5.5	5.4	5.3	5.1	6.6	6.5	6.4	6.2
Organic matter	95.6	95.7	95.8	9.,0	94.5	94.6	94.7	94.9	93.4	93.5	93.6	93.8
NDF	135	13.1	12.7	12.3	15.7	15.2	14.8	14.4	17.7	17.3	16.9	16.5
Ether extract	1.6	4.5	7.5	10.4	1.8	4.8	7.7	10.6	2.0	5.0	7.9	10.9
N	2.50	2.41	2.40	2.33	2.50	2.41	2.33	2.33	2.50	2.42	2.30	2.20
Energy (kjoule/g DM)	17.43	18.11	18.84	19.50	17.50	18.12	18.83	19.50	17.54	18.20	18.94	19.5

1 Premix of vitamins and minerals according to NRC [14] requirements.

tent of the samples was determined in an adiabatic bomb calorimeter, using benzoic acid as calorimetric standard. The same analytical procedures were conducted in faeces, except for ether extract determinations. Estimations of nutrient digestibility of mulberry leaf meal and crude palm oil were made by difference [5].

Contrasts amongst means were made by the analysis of variance technique, and when significant differences ($P < 0.05$) were encountered, the Duncan´s multiple range and multiple F test was used for discrimination amongst means [20]. The SAS [18] computing package was used in all cases.

RESULTS AND DISCUSSION

There was not any symptom of animal discomfort during the conduction of the trial. Feed consumption was found to be complete, since no feed refusal was evident during the entire experimental work. There was no significant interaction ($P > 0.05$) between mulberry leaf meal and crude palm oil in any digestibility index.

A general significant trend ($P < 0.01$) of faecal DM concentration to decrease and excretion of fresh material to increase with increasing levels of mulberry leaves in the diet was observed (TABLE II). Accordingly, water and dry faecal output significantly ($P < 0.01$) increased with the introduction of mulberry leaf meal in the feed. In other experiments, Chiv *et al.* [4] observed an increased faecal material output when mulberry leaves were included in the diet up to 50%. This same trend was not significant when crude palm oil was introduced in the diet.

All digestibility criteria examined in the current experiment, except ash digestibility, decreased in value in the same manner that levels of either mulberry leaf meal or crude palm oil increased in the feed (TABLE III). In fact, either DM and organic matter digestibility or NDF, N and energy digestibility were significantly ($P < 0.01$) depressed when mulberry foliage was systematically increased in the diet.

Mouth-to-rectum digestibility values obtained by Ly *et al* [12] and Chiv *et al* [4] were rather high for pigs fed up to 50% of mulberry leaves. Nevertheless, it was not encountered in the above referred experiments, the same trend observed in the current study, of nutrient digestibility to vary inversely to the level of mulberry leaf meal included in the feed. The nature of the cultivar utilized in the Cambodian experiments, and the fact that petioles were not used in those studies could strongly ex-

TABLE II

FAECAL CHARACTERISTICS IN PIGS FED MULBERRY LEAF MEAL AND CRUDE PALM OIL / CARACTERÍSTICAS FECALES DE CERDOS ALIMENTADOS CON HARINA DE FOLLAJE DE HOJAS DE MORERA Y ACEITE CRUDO DE PALMA

	Mulberry leaf meal (%)				Crude palm oil (%)				
	0	10	20	SE ±	0	3	6	9	SE ±
DM (%)	43.81^{a}	41.12^{a}	35.44^{b}	5.10**	40.32	40.09	37.26	42.49	3.98
Output (g/kg DM intake)									
Fresh material	271^{a}	352^{ab}	488^{b}	44**	332	359	424	365	46
Water	152^{a}	207^{ab}	315^{b}	36**	199	216	267	211	51
DM	119^{a}	145^{ab}	173^{b}	15**	133	143	157	154	24

** $P < 0.01$. ^{ab}Means without letter in common in the same row differ significantly ($P < 0.05$).

TABLE III

FAECAL DIGESTIBILITY OF NUTRIENTS IN PIGS FED MULBERRY LEAF MEAL AND CRUDE PALM OIL / DIGESTIBILIDAD APARENTE EN CERDOS ALIMENTADOS CON HARINA DE FOLLAJE DE MORERA Y ACEITE CRUDO DE PALMA

	Mulberry leaf meal (%)				Crude palm oil (%)				
	0	10	20	SE ±	0	3	6	9	SE ±
Digestibility (%)									
Dry matter	88.15^{a}	85.51^{a}	82.72^{b}	1.53**	86.93	85.80	84.41	84.72	2.07
Ash	47.13	51.36	53.86	5.10	53.95	51.68	50.18	49.99	7.05
Organic matter	82.12^{a}	80.20^{b}	78.98^{c}	0.72**	80.48	80.51	81.77	81.65	1.28
NDF	68.49^{a}	62.97^{b}	60.12^{b}	4.22*	67.23	62.80	62.33	63.08	5.98
N	87.59^{a}	83.49^{ab}	78.21^{b}	1.90**	84.67	83.24	81.47	81.68	2.91
Energy	86.74^{a}	83.60^{a}	79.98^{b}	1.92**	85.35	84.07	82.20	82.12	2.92

* $P < 0.05$. ** $P < 0.01$. ^{abc}Means without letters in common in the same row differ significantly ($P < 0.05$).

plain these differences in results. In fact, mulberry leaf meal prepared at Chamcar Daung (Cambodia) had a high and low N and NDF content respectively, as compared to the chemical composition of the mulberry foliage employed in the current study. Nevertheless, this is not an abnormal condition, taken into account the studies of Pérez [16], who claimed that energy digestibility in diets for pigs, decreases in 1.03 units in response to the increase of one percent of NDF content in the feed. In this connection, it should be very important to establish the role of the large intestine in digestive processes of pigs fed mulberry leaves and foliage, the nature of the cultivar utilized, and the influence of leaves, petioles and stems on digestibility of the diet.

In the case of crude palm oil, Chhay and Ly [3] and Prak [17] observed that pigs fed increasing levels of this type of oil in the ration, showed a depression in total tract digestibility of ash and ether extract, thus suggesting the formation of insoluble salts from fatty acids in the intestinal lumen. This hypothesis could not be tested in the current investigation, but in fact ash digestibility tended to be low with increasing levels of crude palm oil in the diet.

There was a strong indication that either N digestibility was highly correlated (r = - 0.822; P < 0.001) to the NDF digestibility of the diet, thus suggesting that an important proportion of the N could be linked to the cell walls. In this connection, Trigueros and Villalta [21] reported that 56.6% of total N was linked to the cell wall in the mulberry foliage meal used in their trial at Izalco. In the current investigation, the relationship found was the following:

N digestibility, % = 52.91 – 0.47 NDF digestibility,
(S_{yx} = ± 3.32)

Estimates of nutrient digestibility indices of mulberry leaf meal are listed in TABLE IV.

There were no significant differences between digestibility indices for mulberry leaf meal in the case where the leaves were included in the diet. Therefore, all data were pooled (n = 32), and the resulting average values for DM, ash, organic matter, NDF, N and energy digestibility were 61.35, 85.13, 64.65, 19.98, 43.65 and 52.81% respectively. Estimated digestible energy value for mulberry leaf meal was 9.41 kjoule/g DM. As to be expected, N digestibility of mulberry leaf meal was low if compared to that reported previously [12], as a probable consequence of the differences in the chemical composition of the mulberry used in both experiments.

Contrary to what occurred with the foliage examined in the present study, when energy digestibility of crude palm oil was estimated by difference, the obtained values were extremely variable. Average values were 43.0, 33.2 and 44.7% if the oil was included at a rate of 3, 6 and 9% in the diet. The observed variability was from more than 100% to negative values for energy digestibility in the crude palm oil. A similar situation was encountered previously by Seijas *et al.* [19] when crude palm oil was included in diets for pigs fed *trichanthera* foliage. The high variability in energy digestibility for crude palm oil could be a consequence of the relatively low level of inclusion of the oil in the diet. Nevertheless, although not significantly (P > 0.05), energy digestibility of the diets decreased with either crude [19] or refined [3] palm oil included in the feed for pigs.

TABLE IV
NUTRIENT DIGESTIBILITY OF MULBERRY LEAF MEAL ESTIMATED BY DIFFERENCE / DIGESTIBILIDAD ESTIMADA POR DIFERENCIA DE NUTRIENTES DE HARINA DE FOLLAJE DE MORERA

Digestibility (%)	Mulberry leaf meal in diet (%)		SE ±
	10	20	
Dry matter	61.71	61.02	1.17
Ash	89.43	80.84	5.23
Organic matter	62.91	66.40	0.47
NDF	13.30	26.65	3.61
Nitrogen	46.60	40.73	3.09
Energy	55.32	50.30	2.60

Nutrient digestibility of palm oil has not been extensively studied, and data related to its nutritive value are conflicting [7, 11]. On this matter, Seijas *et al* [19] found a value as low as 56.5% for ether extract digestibility of crude palm oil, and it was attributed to the influence of the high palmitic acid content of palm oil [10]. This fact merits further research.

CONCLUSIONS

It is suggested that if mulberry leaf meal is introduced up to 20% in diets for growing pigs, a decreasing effect on total tract digestibility indices should be encountered. The use of crude palm oil up to 9% can contribute to maintain the energy density of the diet. However, due to the relatively low digestibility of crude palm oil, methods should be investigated in order to improve its nutritive value.

ACKNOWLEDGMENTS

The authors thank gratefully to the staff of the Pig Unit of the School of Agronomy of the Universidad Central de Venezuela. Similar gratitude is expressed to the librarians of the Swine Research Institute of Cuba for helping in the localization and organization of the bibliography herein mentioned.

BIBLIOGRAPHIC REFERENCES

[1] ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (AOAC). **Official Methods of Analysis.** 15th Ed. K. Helrick (Ed). Arlington 1230 pp. 1990.

[2] CHHAY, T. Palm (*Elaeis guineensis*) oil and ensiled cassava leaves as feed resources for growing pigs. Swedish University of Agricultural Sciences. Uppsala (Master Thesis). 86 pp. 2003.

[3] CHHAY, T.; LY, J. Rasgos de comportamiento e indices digestivos de cerditos alimentados con ensilado de hojas de yuca y aceite de palma. En: **VII Encuentro Regional de Nutrición y Producción de Animales Monogástricos.** Mérida, México 2-3 Mayo. 68-69 pp. 2003.

[4] CHIV, P.; PRESTON, T.R.; LY, J. Mulberry (*Morus alba*) leaves as protein source for young pigs fed rice-based diets: digestibility studies. **Livestock Research for Rural Development.** Fundación CIPAV. En: http://www.cipav.org.co/lrrd/lrrd15/1/phiny151.htm. 2003.

[5] CRAMPTON, E.W.; HARRIS, L.E. Applied Animal Nutrition. The use of feedstuffs in the formulation of livestock rations. W.H. Freeman (Ed). San Francisco. 753 pp. 1969.

[6] D'MELLO, J.P.F. Nutritional potentialities of fodder trees and fodder shrubs as protein sources in animal nutrition. In*:* Legume Trees and other Fodder Trees as Protein Source for Livestock. A. Speedy and P.L. Pugliese (Eds). **FAO Animal Production and Health Paper 102.** Rome 115-127 pp. 1992.

[7] EEKHOUT, W.; FONTAINE, G; DESCHRIVER, R. Energy value of vegetable fats for pigs and poultry. In: Fat quality in lean pigs. **Meat Research Institute Special Report** No. 2. 88-97 pp. 1983.

[8] GONZÁLEZ, D.; GONZÁLEZ, C.; DIAZ, I.; VECCHIONACCE, H. Determinación en cerdos de la digestibilidad de nutrientes de dietas de follaje de yuca amarga (*Manihot esculenta Crantz*) y aceite de palma (*Elaeis guineensis Jacq.).* **Rev. Comp. Prod. Porcina**. 6(1):40-48, 1999.

[9] GONZALVO, S.; NIEVES, D.; LY, J.; MACIAS, M.; CARON, M.; MARTINEZ, V. Algunos aspectos del valor nutritivo de alimentos venezolanos destinados a animales monogástricos. **Livestock Research for Rural Development.** Fundación CIPAV (Ed.): En: http:// www.cipav.org.co/lrrd/lrrd132/gonz1.32htm. 2001.

[10] JORGENSEN, H.; FERNÁNDEZ, J.A. Chemical composition and energy value of different fat sources for growing pigs. **Acta Agri Scandin. Anim. Sci. Section A.** 50:129-136. 2000.

[11] LEDUC, N. The use of African palm (*Elaeis guineensis*) oil as an energy source for pigs. Swedish University of Agricultural Sciences (Master Thesis). Uppsala 74 pp. 1994.

[12] LY, J.; CHHAY, T.; CHIV, P.; PRESTON, T.R. Some aspects of the nutritive value of leaf meals of *Trichanthera gigantea* and *Morus alba* for Mong Cai pigs. **Livestock Research for Rural Development**. Fundación CIPAV (Ed) En: http://www.cipav.org.co/lrrd/lrrd13/3/ly133.htm. 2001.

[13] MUÑOZ, C.H. Sustitución parcial de alimento comercial por morera (*Morus alba*) en la alimentación de cerdas gestantes. Aspectos técnicos y económicos. Instituto Tecnológico Agropecuario. Conkal. Mérida (México) (Tesis de Maestría). 85 pp. 2003.

[14] NATIONAL RESEARCH COUNCIL (NRC). **Nutrient Requirement of Swine.** National Academy of Science. 9th Ed. National Academy Press. Washington D.C. 210 pp. 1998.

[15] OSORTO, W.A.; LARA, P.E.; SIERRA, A.C.; SANGINES, J.R. Harina de morera como ingrediente de la ración alimenticia de cerdos en crecimiento y engorda. En: **XII Congreso Nacional de Investigación y Desarrollo Tecnológico Agropecuario.** 19-21 Noviembre. Conkal (México) 77 pp. 2003.

[16] PEREZ, J.M. Interet et limites de modèles de prévision de la valeur énergetique des aliments destinés au porc. Université des Sciences et Techniques du Languedoc. Université Montpellier (Doctoral Thesis). 196 pp. 1991.

[17] PRAK, K. Response of pigs fed a basal diet of water spinach (*Ipomoea aquatica*) to supplementation with oil or carbohydrate. Swedish University of Agricultural Sciences (Master Thesis). Uppsala 76 pp. 2003.

[18] Statistical Analysis System Institute. (SAS). Laboratory software user's guide: Statistics. SAS In Company**.** Cary 291 pp. 1992.

[19] SEIJAS, Y.; GONZALEZ, C.; VECCHIONACCE, H.; HURTADO, E.; LY, J. The effect of palm oil on total tract digestibility of pigs fed trichanthera (*Trichanthera gigantea H.B.K. Stend*) foliage meal. **Livestock Research for Rural Development.** Fundacion CIPAV (Ed.) En: http://www.cipàv.org.co/lrrd/lrrd15/5/yelitza155.html. 2003.

[20] STEEL, R.G.D.; TORRIE, J.A. **Principles and Procedures of Statistics: a Biometrical Approach.** McGraw-Hill Book Company. 2nd Ed. Toronto 481 pp. 1980.

[21] TRIGUEROS, R.O.; VILLALTA, P. Evaluación del uso de follaje deshidratado de morera (*Morus alba*) en la alimentación de cerdos de la raza Landrace en etapa de engorde. Centro Nacional de Tecnología Agropecuaria y Forestal. San Salvador, Resultados de Investigación.150-155 pp. 1997.

[22] VAN SOEST, P.J; ROBERTSON, J.B.; LEWIS, B.A. Methods for dietary fiber, neutral detergent fiber and non starch polysaccharides in relation to animal nutrition. **J. Dairy Sci.** 74:3583-3593. 1991.