AGRO PRODUCTIVIDAD

Colegio de Postgraduados

Nutrient content and *in vitro* degradability of the palm kernel meal produced in the state of Chiapas, Mexico, as feed for ruminants

Escobar-España, José C.[1]; **Bárcena-Gama, José R.**[2*]; **Ley-De Coss, Alejandro**[3]; **Crosby-Galván, María M.**[2]

[1] Facultad de Ciencias Agrícolas Campus IV, Universidad Autónoma de Chiapas (UNACH). Entronque Carretera Costera y Pueblo de Huehuetán, Huehuetán, Chiapas, México, C. P. 30660.

[2] Colegio de Postgraduados Campus Montecillo. Programa de Recursos Genéticos y Productividad-Ganadería. Carretera Federal México-Texcoco km 36.5, Montecillo, Estado de México, México. C. P. 56230.

[3] Facultad de Ciencias Agronómicas Campus V, Universidad Autónoma de Chiapas (UNACH), Carretera Ocozocoautla-Villaflores km 84.5, Villaflores, Chiapas, México, C. P. 30470.

* Correspondence: rbarcena@colpos.mx

ABSTRACT

Objective: The objective of this study was to determine the nutritional content of palm kernel meal (PM) produced in the state of Chiapas, Mexico, as feed for ruminants.

Design/Methodology/Approach: The following were determined: content of dry matter (DM), total protein (TP), ethereal extract (EE), ash, neutral detergent fiber (NDF), acid detergent fiber (ADF), amino acids, long chain fatty acids (LCFA), minerals, polyphenols, and the in vitro degradability of DM (IDDM), of the NDF (IDNDF), and of the ADF (IDADF).

Results: The contents were: DM 92.23%, TP 10.56%, EE 7.2%, ash 3,09%, NDF 76,56% and ADF 57,20%. The PM had low concentration of lysine (0.3%), methionine (0.228%) and tryptophan (0.095%), and high contents of lauric acid (50.49%), palmitic acid (10.92%), stearic acid (19.725%), oleic acid (13.56%), copper (23.3 mg kg^{-1}), iron (230.5 mg kg^{-1}), zinc (78.47 mg kg^{-1}) and total phenols (7.8 mg g^{-1}), although the IDDM (46.02%), IDNDF (29.91%) and IDADF (27.61%) were low.

Findings/Conclusions: The PM, as byproduct of the oil agroindustry, has some important nutritional characteristics to be used as feed for ruminants. It is recommended to conduct a chemical analysis of this byproduct before including it in balanced meals to have an adequate balance of nutrients.

Keywords: palm kernel meal, chemical composition, degradability, byproduct.

Citation: Escobar-España, J. C., Bárcena-Gama, J. R., Ley-De Coss, A., & Crosby-Galván, M. M. (2022). Nutrient content and *in vitro* degradability of the palm kernel meal produced in the state of Chiapas, Mexico, as feed for ruminants. *Agro Productividad*. https://doi.org/10.32854/agrop.v15i5.2235

Academic Editors: Jorge Cadena Iñiguez and Libia Iris Trejo Téllez

Received: February 27, 2022.
Accepted: May 4, 2022.
Published on-line: June 6, 2022.

Agro Productividad, 15(5). May. 2022. pp: 125-131.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a plant from which oil is extracted from its fruit, primarily for human consumption, whether from pressing or using solvents (Stein *et al.*, 2015). During the extraction process, byproducts are generated that can be an alternative to be used in animal feed (Pang *et al.*, 2018), such as the palm kernel meal (PM; Figure 1).

Image by tk tan at Pixabay

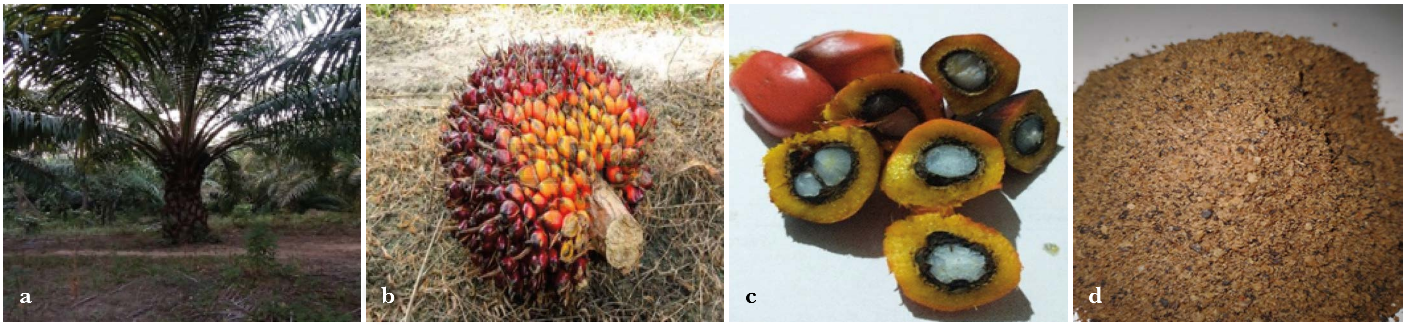

Figure 1. a) Oil palm, b) Bunch of fruits, c) From fruits, d) Palm kernel meal.

In Mexico, the total surface sown is 82,150.60 ha, located primarily in the states of Chiapas, Tabasco, Campeche and Veracruz, and 54,600.52 ha are harvested; Chiapas is the main producer, with a surface sown of 43,468.17 ha and 34,215.05 ha harvested (SIAP, 2015). It is estimated that the production of PM is 13,169.37 t per year, approximately (García and Yañez, 2010), which represents an important source of nutrients for the animal diet. The PM has been used in production systems as an ingredient in diets for birds, pigs (Zumbado *et al.*, 1992; Kperegbeyi and Ikperite, 2011), sheep (Freitas *et al.*, 2017), goats (Ebrahimi *et al.*, 2012), cattle (Oladokun *et al.*, 2016), and fish (Mazón *et al.*, 2018). However, the results reported are inconsistent mainly due to the variation in the content and the availability of nutrients. The ethereal extract (EE) can be higher than 6% (Oliveira *et al.*, 2015), raw protein (RP) varies from 10 to more than 14% (Freitas *et al.*, 2017), and there are contents of neutral detergent fiber (NDF) higher than 60% (Stein *et al.*, 2015), acid detergent fiber (ADF) higher than 40% (Sulabo *et al.*, 2013) and lignin (Lig) over 20% (Fereira *et al.*, 2012), which means that the digestibility of the PM can be low and that it would be a more appropriate food for ruminants. It is important to highlight that Shahidi and Nazck (2006) consider that the PM can also be a natural source of antioxidants in meat, since there are high contents of polyphenols. Presently, in Mexico, PM is a byproduct with high demand for the diet of animals due to its low cost, and it is commercialized primarily for ruminants. The scientific information on the nutrient content of PM is scarce in Mexico, and the results are quite variable. It is important to generate information about the chemical composition of the PM to include it in balanced meals and to have an adequate balance of nutrients for animals. Therefore, the objective of this study was to determine the nutritional content (DM, RP, EE, ash, NDF, ADF, lignin), long chain fatty acids, content of amino acids, minerals, total phenols, and *in vitro* degradability of the DM (IDDM), of the NDF (IDNDF), and of the ADF (IDADF) of the PM as byproduct of the oil industry in the state of Chiapas, Mexico.

MATERIALS AND METHODS

Chemical analyses

A homogeneous sample of PM was obtained, which was ground through a 1 mm sieve with a Willey mill (Arthur H. Thomas, Philadelphia, PA). The dry matter (DM), raw protein (RP), ethereal extract (EE) and ash (ash) were determined according to the

AOAC (2005). The contents of NDF, ADF and lignin (Lig) were determined according to Van Soest *et al.* (1991). All the analyses were made by triplicate in the Ruminant Nutrition laboratory of the Livestock program of Colegio de Postgraduados Campus Montecillo. The amino acid profile was determined through the AMINONIR® near infrared technique (Sedghi *et al.*, 2014), in the company Evonik® S. A. de C. V. Measuring the content of calcium (Ca), magnesium (Mg), copper (Cu), iron (Fe) and zinc (Zn) was carried out in a GBC atomic absorption spectrophotometer model SavantAA. Selenium (Se) in a spectrophotometer of coupled plasma in optical emission of brand Horiba Scientific, model Ultima 2 (ICP-OES). Phosphorus (P) was determined in an Ultra-Violeta (UV) spectrophotometer brand Jenway, Model 6715, in the National Laboratory for Research and Agrifood and Forestry Service (Laboratorio Nacional de Investigación y Servicio Agroalimentario y Forestal, LANISAF) at Universidad Autónoma Chapingo, Texcoco, Estado de México.

The long chain fatty acid (LCFA) profile was determined with the methodology of esterification and trans-esterification by Sukhija and Palmquist (1988), modified by Palmquist and Jenkins (2003) and Jenkins, (2010), in a Hewlett Packard 6890 chromatograph with automatic injector, arranged from a silica capillary column (100 m $\times$ 0.25 μm of thickness, Sp-2560, Supelco Brand). The concentration of total phenols was determined according to Makkar (2002) and the phenolic compounds according to Aguiñiga-Sánchez *et al.* (2017).

In vitro degradability of DM, NDF and ADF

The *in vitro* degradability of DM, NDF and ADF of the PM was determined in a Daisy II® ANKOM® incubator model with 25 μm pore. The ruminal liquid from a Holstein bull (550 kg PV) was used as inoculum, with a permanent cannula in the rumen fed with a diet based on oats hay with grain and alfalfa hay. The samples were inoculated and incubated for 3, 6, 9, 12, 24, 48 and 72 h, following the methodology by Curzaynz *et al.* (2020).

RESULTS AND DISCUSSION

The RP content (Table 1) of PM was 10.55%, value lower than 13.24, 15.9 and 19.4% reported by Fereira *et al.* (2012), Abubakr *et al.* (2014) and Tipu *et al.* (2014), respectively. That of EE was 7.27%, value higher than 1.3 and 6.3% reported by Stein *et al.* (2015) and Sulabo *et al.* (2013), respectively, although lower than 9.1 and 12.1% reported by Abubakr *et al.* (2014) and Tipu *et al.* (2014). The content of NDF and ADF was 76.5 and 57.2%, values higher than 77.9 and 49.4% reported by Stein *et al.* (2015), although lower than 72.3 and 47.6% reported by Abubakr *et al.* (2014), respectively (Table 1). The content of amino acids was low, particularly of essential amino acids such as lysine, methionine, threonine, phenylalanine, and tryptophan (Table 1). This indicates that the protein from the PM is of low quality, which could limit its use in diets for non-ruminants. The concentrations of calcium (Ca), phosphorus (P) and magnesium (Mg) are low, compared to other ingredients such as corn, although copper (Cu), iron (Fe) and zinc (Zn) are relatively high (Table 1). These values should be considered when PM is included in balanced meals, since it can be deficient in macronutrients but entail metabolic risks from the excess of Cu and Zn.

Balandrán-Quintana *et al.* (2019) mention that the nutritional value of an oily ingredient is practically given by the extraction method of the oil used, since it can affect the nutrient content. The most frequently used methods are from mechanical extraction or pressing, solvents, and hydrothermal techniques. Extraction from pressing is the one mainly used in Mexico the, which seems to leave more oil and less nutrients in the PM, in contrast with the extraction with supercritical carbon dioxide, which seems to be a more efficient technique for oil extraction and to concentrate more certain nutrients.

The fat from the PM is made up primarily by saturated fatty acids (SFA), mainly lauric, palmitic and stearic, which make up 81% and present low concentration of unsaturated fatty acids (UFA), mainly oleic (Table 2). The presence of phenols in the PM is a very important nutritional characteristic due to their high content and concentration of hydroxybenzoic acid (Table 2).

The degradability of the DM was determined traditionally at 24 h because of the daily consumption of the animal. The results show that the IDDM, IDNDF and IDADF and the digestion rate (Kd) of PM were low (Table 3). These results agree with those reported by FEDNA (2015). The degradability of a nutrient allows estimating the nutritional value of a food or a diet and predicting the productive behavior of the animal. The low degradability

Table 1. Chemical analysis for content of amino acids and minerals in palm kernel meal (PM).

Nutrients (%)		Aminoacids (%)		Minerals	
Dry material	92.23	lysine	0.37	Phosphorus (%)	0.16
total protein	10.55	methionine	0.22	Calcium (%)	0.12
Ethereal Extract	7.27	threonine	0.36	Magnesium (%)	0.19
NDF	76.56	tryptophan	0.09	Copper (mg kg^{-1})	23.30
ADF	57.20	Leucine	0.79	Iron (mg kg^{-1})	230.55
Cellulose	23.75	isoleucine	0.42	Zinc (mg kg^{-1})	78.47
hemicellulose	19.75	histidine	0.21		
lignin	31.30	valine	0.63		
ashes	3.09	Phenylalanine	0.52		

NDF: Neutral detergent fiber; ADF: Acid detergent fiber.

Table 2. Long chain fatty acids and phenolic acids in palm kernel meal.

Fatty acid (%)		Phenolic acids	
caprylic	4.34	Totals	7.80±0.50 mg g^{-1}
capric	4.12	gallic	0.007±0.0003 $\mu g\ g^{-1}$
Undecanoic	0.15	ferulic	0.002±0.0001 $\mu g\ g^{-1}$
lauric	50.49	hydroxybenzoic	0.276±0.0228 $\mu g\ g^{-1}$
myristoleic	7.67	protocatechuic	0.008±0.0002 $\mu g\ g^{-1}$
palmitic	10.82		
stearic	19.72		
oleic	13.56		
linoleic	1.95		

Table 3. *In vitro* degradability and digestion rate of the palm kernel meal.

Time Hour	Digestibilidad (% MS)		
	Dry biomass	NDF	ADF
0	1.46	0.00	0.00
3	1.99	0.78	0.81
6	5.60	2.24	1.81
9	6.41	2.75	2.56
18	16.94	7.62	6.77
24	27.94	15.97	13.41
48	32.97	18.79	16.48
72	34.38	20.90	17.34
96	46.02	29.91	27.61
Kd/% h	3.80	4.80	4.30

NDF: Neutral detergent fiber; ADF: Acid detergent fiber.

of the PM is due to the high concentrations of fiber (ADF) and lignin, which is given by the presence of the pit or hard husk that covers the kernel and, also, due to the high fat content that affects the growth of cellulolytic bacteria and ruminal fermentation (Chanjula *et al.*, 2010). Other factors that affect the chemical composition of the PM is the efficiency of oil extraction from the kernel, the residual endocarp, agronomic tasks, and the oil extraction method used (Balandrán-Quintana *et al.*, 2019).

CONCLUSIONS

The palm kernel meal produced in the state of Chiapas is a byproduct with nutritional characteristics that can be used in animal feed, particularly because of its content of protein and fat. However, it should be considered to be a rough food due to its high fiber content and low digestibility, characteristics that make it a more appropriate food to be included in balanced meals for ruminants, although in limited amounts. Due to the variability in the nutritional composition and low digestibility of palm kernel meal, it should be analyzed prior to its incorporation in the diets for animals. It is suggested to research more about its potential as a source of natural antioxidants from its high content of total phenols.

REFERENCES

Abubakr, A., Alimon, A. R., Yaakub, H., Abdullah, N., & Ivan, M. (2014). Effect of feeding palm oil by-products based diets on total bacteria, cellulolytic bacteria and methanogenic archaea in the rumen of goats. *PLoS ONE, 9*(4), 1–6. https://doi.org/10.1371/journal.pone.0095713

Aguiñiga-Sánchez, I., Cadena-Íñiguez, J., Santiago-Osorio, E., Gómez-García, G., Mendoza-Núñez, V. M., Rosado-Pérez, J., Ruíz-Ramos, M., Cisneros-Solano, V. M., Ledesma-Martínez, E., de Jesus Delgado-Bordonave, A., & Soto-Hernández, R. M. (2017). Chemical analyses and *in vitro* and *in vivo* toxicity of fruit methanol extract of *Sechium edule* var. *Nigrum spinosum*. *Pharmaceutical Biology, 55*(1), 1638–1645. https://doi.org/10.1080/13880209.2017.1316746

AOAC. (2005). Association of Official Analytical Chemists. In A. of O. A. Chemists. (Ed.), *Association of Official Analytical Chemists*. (18th ed.).

Balandrán-Quintana, R. R., Mendoza-Wilson, A. M., Ramos-Clamont Montfort, G., & Huerta-Ocampo, J. Á. (2019). Plant-Based Proteins. *In*: *Proteins: Sustainable Source, Processing and Applications*. https://doi.org/10.1016/b978-0-12-816695-6.00004-0

Chanjula, P., Mesang, A., & Pongprayoon, S. (2010). Effects of dietary inclusion of palm kernel cake on nutrient utilization, rumen fermentation characteristics and microbial populations of goats fed *Paspalum plicatulum* hay-based diet. *Songklanakarin Journal of Science and Technology, 32*(6), 527–536.

Curzaynz, K., Bárcena-Gama, R., Hernandez, D., Crosby-Galván, M., Escobar-España, J., Santillán-Gómez, E., & Cabañas-Martínez, O. (2020). Corn Based-diets containing corn dried distillers grains with solubles on performance, ruminal fermentation, *in vitro* methane emissions, carcass and meat quality of lambs. *Asian Journal of Research in Animal and Veterinary Sciences, 5*(2), 30–40.

Ebrahimi, M., Rajion, M. A., Goh, Y. M., & Sazili, A. Q. (2012). Impact of different inclusion levels of oil palm (*Elaeis guineensis* Jacq.) fronds on fatty acid profiles of goat muscles. *Journal of Animal Physiology and Animal Nutrition, 96*(6), 962–969. https://doi.org/10.1111/j.1439-0396.2011.01206.x

FEDNA (Fundación Española para el Desarrollo de la Nutrición Animal). 2015. Harina de extracción de palmiste. Recuperado el 30 de abril de 2022, de FEDNA: http://www.fundacionfedna.org/node/440

Fereira, A. C., Oliveira, R. L., Bagaldo, A. R., De Carvalho, G. G. P., Da Silva, R. N. V., & De Oliveira, P. A. (2012). Intake, digestibility and intake behaviour in cattle fed different levels of palm kernel cake. *Revista MVZ Cordoba, 17*(3), 3105–3112.

Freitas, T. B., Felix, T. L., Pedreira, M. S., Silva, R. R., Silva, F. F., Silva, H. G. O., & Moreira, B. S. (2017). Effects of increasing palm kernel cake inclusion in supplements fed to grazing lambs on growth performance, carcass characteristics, and fatty acid profile. *Animal Feed Science and Technology, 226*(February), 71–80. https://doi.org/10.1016/j.anifeedsci.2017.02.009

García N., J. A., & Yañez A., E. E. (2010). Generación y uso de biomasa en plantas de beneficio de palma de aceite en Colombia. *Revista Palmas, 31*(2), 41–48.

Jenkins, T. C. (2010). Technical note: Common analytical errors yielding inaccurate results during analysis of fatty acids in feed and digesta samples. *Journal of Dairy Science, 93*(3), 1170–1174. https://doi.org/10.3168/jds.2009-2509

Kperegbeyi, J. I., & Ikperite, S. E. (2011). The effectiveness of replacing maize with palm kernel. *Journal of Environmental Issues and Agriculture in Developing Countries, 3*(1), 145–149.

Makkar, H. P. S. (2002). Applications of the *in vitro* gas method in the evaluation of feed resources, and enhancement of nutritional value of tannin-rich tree/browse leaves and agro-industrial by-products. *Animal Production and Health Section, International Atomic Energy Agency*, 23–40.

Mazón, E., Herrera, M., Mazón, M., García, A., Delgado, M., & Guzmán, J. L. (2018). Digestibilidad aparente de dietas con torta de palmiste sobre el rendimiento productivo de la especie nativa *Cichlasoma festae* en la etapa de cría. *Revista Ecuatoriana de Investigaciones Agropecuaria, 2*(2), 28. https://doi.org/10.31164/reiagro.v2n2.4

Oladokun, A. A., Rahman, W. A., & Suparjo, N. M. (2016). Prospect of Maximising Palm Kernel Cake Utilization for Livestock and Poultry in Malaysia: A Review. *Journal of Biology, Agriculture and Healthcare, 6*(13), 107–113.

Oliveira, R., Faria, M., Silva, R., Bezerra, L., Carvalho, G., Pinheiro, A., Simionato, J., & Leão, A. (2015). Fatty acid profile of milk and cheese from dairy cows supplemented a diet with palm kernel cake. *Molecules, 20*(8), 15434–15448. https://doi.org/10.3390/molecules200815434

Palmquist, D. L., & Jenkins, T. C. (2003). Challenges with fats and fatty acid methods. *Journal of Animal Science, 81*(12), 3250–3254. https://doi.org/10.2527/2003.81123250x

Pang, D., Yan, T., Trevisi, E., & Krizsan, S. J. (2018). Effect of grain- or by-product-based concentrate fed with early- or late-harvested first-cut grass silage on dairy cow performance. *Journal of Dairy Science, 101*(8), 7133–7145. https://doi.org/10.3168/jds.2018-14449

Sedghi, M., Golian, A., Kolahan, F., Moussavi, A. H., & Afsar, A. (2014). Broiler diets formulated based on digestible amino acid values as determined by *in vivo* and prediction methods. *Iranian Journal of Applied Animal Science, 4*, 361–366.

Shahidi, F., & Nazck, M. (2006). *Phenolics in Food and Nutraceuticals* (P. CRC (ed.); 5th ed.).

SIAP. (2015). *Servicio de Información Agroalimentaria y Pesquera*. Recuperado el 25 de abril de 2022, de SIAP: https://www.gob.mx/siap/acciones-y-programas/produccion-agricola-33119

Stein, H. H., Casas, G. A., Abelilla, J. J., Liu, Y., & Sulabo, R. C. (2015). Nutritional value of high fiber co-products from the copra, palm kernel, and rice industries in diets fed to pigs. *Journal of Animal Science and Biotechnology, 6*(1), 1–9. https://doi.org/10.1186/s40104-015-0056-6

Sukhija, P. S., & Palmquist, D. L. (1988). Rapid method for determination of total fatty acid content and composition of feedstuffs and feces. *Journal of Agricultural and Food Chemistry, 36*(6), 1202–1206.

Sulabo, R. C., Ju, W. S., & Stein, H. H. (2013). Amino acid digestibility and concentration of digestible and metabolizable energy in copra meal, palm kernel expellers, and palm kernel meal fed to growing pigs. *Journal of Animal Science, 91*(3), 1391–1399. https://doi.org/10.2527/jas.2012-5281

Tipu, M. A., Ahmad, F., Khalique, A., Haque, M. N.,Mirza, R. H., & Tayyab, U. (2014). Replacement of cotton seed cake with palm kernel cake in growing Nili-Ravi buffalo male calves. *The Journal of Animal & Plant Sciences, 24*(Suppl.1): 24–27.

Van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science, 74*(10), 3583–3597. https://doi.org/10.3168/jds.S0022-0302(91)78551-2

Zumbado, M., Madrigal, S., & Marin, M. (1992). Composición y valor nutrimental del palmiste o coquito integral de palma africana (*Elaeis guinensis*) en pollo de engorde. *Agronomía Costarricense, 16*(1), 83–89.