EFFECT OF FEEDING VARYING LEVELS OF PALM KERNEL CAKE ON PRODUCTION PERFORMANCE AND CHANGES IN BLOOD METABOLITES OF LACTATING CROSSBRED DAIRY CATTLE

Z. Iqbal[1*], M. A. Rashid[1*], T. N. Pasha[1] and J. A. Bhatti[2]

[1,2] Department of Animal Nutrition, [2]Department of Livestock Production, University of Veterinary and Animal Sciences, Pattoki, Lahore, Pakistan

*Corresponding Authors' email: drafzal@uvas.edu.pk; zahidzizi@gmail.com

ABSTRACT

The objective was to evaluate the effects of increasing level of palm kernel cake (PKC) in concentrate feed on dry matter intake (DMI), body weight (BW), milk production, milk composition and blood metabolites of dairy cows. Twenty one crossbred cows with average BW 410 ± 52.6 kg, producing 12 ± 3.2 kg of milk daily were blocked by their BW, previous lactation yield and days in milk (DIM). The animals were assigned to dietary treatments in a randomized complete block design (RCBD) with n=7 cows per treatment. Dietary treatments were: Control (C), PKC 20 and PKC 40 containing 0%, 20% and 40% PKC in concentrate diets, respectively. The duration of experiment was 70 days (d). Commonly used agro industrial by-products wheat bran and rice polishing were replaced with PKC. Body weight and body condition score (BCS) were measured at the start and then on a bi-weekly basis; whereas, feed intake and milk yield were recorded daily. Milk samples were collected twice a week (wk) and blood samples were taken weekly. Increasing level of PKC in concentrate diet had no effect ($p>0.05$) on DMI, fecal score, milk production and composition, BW and BCS gain as well as milk production efficiency. However, milk fat and total solids (TS) increased linearly ($p<0.05$) with increasing level of PKC. Plasma glucose, blood urea nitrogen (BUN) and non-esterified fatty acids (NEFA) concentrations were similar ($p>0.05$) among treatments. Inclusion of PKC at 40% increased milk fat and TS contents without affecting DMI, milk production, BW and BCS in crossbred dairy cows. It is concluded that PKC up to 40% can successfully replace wheat bran and rice polishing in dairy concentrate diet for crossbred cows.

Key words: Palm kernel cake; Dairy cow; Milk production; Milk composition

INTRODUCTION

Countries with high livestock number are facing challenge in feed supplies due to increase in prices of indigenous feed resources. A recent survey revealed a gap of 19.4%, 37.2% and 38% between supply and demand of dry matter (DM), crude protein (CP) and metabolizable energy (ME) respectively in Pakistan (Habib et al., 2016). An increasing trend towards efficient utilization of alternate agro-industrial by-products in livestock is gaining popularity among nutritionists and dairy farmers.

Palm kernel cake (PKC), non-conventional feed ingredient, is a co-product of palm kernel oil extraction industry constituting approximately 50% of the kernel. In the market, PKC available is brown in colour and obtained after the oil extraction from screw pressing of palm kernel. Palm kernel cake is known for its medium energy, moderate protein and high fiber contents. Palm kernel by-products have been used for ruminants' feeding as less expensive source of protein and other digestible nutrients (FAPRI, 2005, Silva et al., 2013). Digestibility values for acid detergent fiber (ADF) and neutral detergent fiber (NDF) contents of PKC are higher in cattle (73.1%) compared to small ruminants (53.0 %) and therefore make it a more suitable ingredient for cattle (Alimon, 2004). Annually about 54,000 tons of PKC is imported to Pakistan (MPOC, 2013). To date several investigators have evaluated the inclusion of palm extraction by-products in ruminants' feeding trials. Zahari and Alimon (2004) recommended an inclusion level of 30 to 50% for dairy cattle. In an earlier work, inclusion of palm kernel meal (PKM) and corn distillers dried grains (CDG) was evaluated in silage based diets of dairy cows (Carvalho et al., 2006). Feeding of solvent-extracted palm kernel meal at 15% in the diet decreased feed costs without detrimental effects on productive responses and tended to increase milk protein content.

In another investigation, inclusion level of PKC in concentrates for goats was evaluated and no difference in total DMI as percent of BW was observed for PKC inclusion up to 55%; however, a decrease in digestibility for DM, CP and fiber was noticed in the goats fed 45-50 % PKC in the same concentrate diet (Chanjula et al., 2010). Recent work by Van Wyngaard et al. (2015) evaluated the inclusion level in the concentrate supplement of Jersey cows grazing on rye grass pasture. The palm kernel expeller (PKE) was included in concentrates at 0, 200, and 400 g/kg, respectively and partially substituted some of the maize and soybean in the concentrate. The study concluded that inclusion of PKE up to 400 g/kg in the concentrate of grazing dairy cows did not have any negative impact on milk production, BW and BCS change. However, the authors recommended that inclusion at 200 g/kg was more applied approach for grazing Jersey cows. Pimentel et al. (2015) evaluated the effects of feeding 5%, 10% and 15% PKC in diet DM of crossbred dairy cows and reported no effects on behavioural activities as well as feed efficiency at up to 15% inclusion level. Oliveira et al. (2015) carried out an experiment to study the effect of feeding PKC on nutritional profile of milk and cheese. Authors observed no effects on total milk production, total fat and other components of milk as well as cheese; however, PKC increased the proportion of saturated fatty acid. To date, most of published work on inclusion of PKC in ruminant diets involved the replacement of grains with PKC; however, limited information is available on inclusion of PKC in place of conventional agro industrial by-products. Therefore, the objective of this experiment was to determine the appropriate inclusion level of PKC in dairy concentrate as substitute of wheat bran and rice polishing and to evaluate its effect on performance of lactating crossbred cows. It was hypothesized that feeding PKC in concentrate up to 40% would not affect production and health of crossbred dairy cows.

MATERIALS AND METHODS

Animal care: The experiment was approved by institutional Animal Care and use Committee (ACUC) University of Veterinary and Animal Sciences (UVAS), Lahore (DR/727).

Experimental design and animal husbandry: The experiment was carried out at Military Dairy Farm Renala, District Okara, Punjab, Pakistan from January to March 2017. Twenty one crossbred (Sahiwal x Holstein) multiparous lactating cows with an average BW 410 ± 52.6 kg, 43 ± 11.4 d in milk and producing 12 ± 3.2 kg of milk daily were selected. The animals were blocked by their BW, previous lactation yield as well as DIM and assigned to three dietary treatments under RCBD (7 blocks, n=3 cows/block) with n=7 cows per treatment. Dietary treatments were: 1) Control (C); containing 0% PKC, 2) PKC 20; containing 20% PKC and 3) PKC 40; containing 40% PKC in concentrate diets on dry matter basis. Formulated concentrate diets were iso-nitrogenous and fed twice daily as TMR (Table 1). To ensure consistent composition of diets through entire feeding period, PKC was purchased as a single shipment through Organon Feeds (Private., Limited Lahore Pakistan).

The duration of experiment was 70 d including a 14 d adaptability period and 56 d of data collection. During the adaptability period, all cows were fed a common TMR diet already in practice at the farm and then shifted to experimental diets gradually. Diets were fed as TMR containing (DM basis) 50% concentrate feed, 45% corn silage and 5%

Table 1. Ingredients mean chemical composition of concentrate[1] feeds containing increasing level of palm kernal cake, corn silage and wheat straw (DM basis).

Ingredients	C	PKC 20	PKC 40	Corn Silage	Wheat Straw
Maize grain	28.0	30.0	32.0	-	-
Rice polishing	15.0	7.5	-	-	-
Wheat Bran	25.0	12.5	-	-	-
Sugar cane molasses	5.0	5.0	5.0	-	-
Corn gluten 30%	7.0	5.0	3.0	-	-
Palm kernel cake[2]	-	20.0	40.0	-	-
Canola meal	15.0	15.0	15.0	-	-
Urea	1.0	1.0	1.0	-	-
Mineral mixture[3]	1.0	1.0	1.0	-	-
Lime stone ground	2.0	2.0	2.0	-	-
$NaHCo_3$	1.0	1.0	1.0	-	-
Chemical Composition (%DM)					
DM (% as fed)	92.9	91.6	92.61	30.0	94.0
ME, Mcal/kg DM[4]	3.0	3.0	2.9	-	-
CP	20.0	20.0	20.0	8.5	3.3
Fat	5.7	5.4	5.4	3.6	1.4
NDF	25.6	32.1	38.6	57.0	70.6
ADF	10.2	16.6	23.1	46.0	57.0
NFC[5]	46.8	43.1	39.4	-	17.5
Ash	11.1	10.0	8.9	7.0	7.5
Ca	1.2	1.3	1.3	0.3	0.3
P	0.6	0.6	0.6	0.3	0.1

[1]Concentrate diets: C = 0% PKC: PKC 20= PKC included at 20% (DM basis): PKC 40= PKC included at 40% (DM basis). Crossbred dairy cattle were offered as total mixed ration containing (DM basis) concentrates 50%, corn silage 45% and wheat straw 5%. [2]PKC chemical composition on DM basis: CP, 17.67%; either extract, 8.69%; ash, 4.8%; NFC, 11.8%; NDF, 56.98 %; ADF, 37.63 %; ME/kg, 2.9 Mcal; Ca, 0.28%; P, 0.70%. [3]Dairy premix composition, di-calcium phosphate, 70.8%; sodium chloride, 18.9%; magnesium sulfate, 8.6%; ferrous sulfate, 0.86%; manganese sulfate, 0.5%; zinc sulfate, 0.2%; copper sulfate, 0.03%; potassium iodide, 0.009%; cobalt chloride, 0.009%; sodium selenate, 0.0015%.

[4]Metabolizable energy calculated according to (NRC, 2001) using the values of analyzed feeds. [5]Non fibrous carbohydrates= 100-(%NDF+%CP+%EE+%ASH) (NRC, 2001).

wheat straw. Individual feeding was carried out at 07:00 and 17:00 hour (h) twice daily. Daily feed allowances were adjusted to ensure *ad libitum* intake with 10% refusal. Animals were housed in individual pens bedded with sand and provided with individual free choice water during the entire experimental period.

Measurements, sampling and analysis: At start and then on bi-weekly basis, Weighing and BCS were performed for two consecutive days 4 h post a.m. feeding. Body condition score was performed by the same person using a 1 to 5 scoring system in 0.25 increments (Wildman et al., 1982). Body weight was measured on an electronic digital weighing scale. Milking was carried out twice daily at 06:30 h and 16:30 h with a portable milking machine (De Laval; Sweden), and milk yield was recorded on daily basis. Fecal scoring was performed daily using 1-5 scoring system with 1 being loose and 5 being firm (Hutjens, 2010).

Feed samples were collected weekly and oven dried at 55 ºC for 48 h for further analysis. Dried samples were ground to a 2 mm particle size using a Wiley mill (Arthur H. Thomas Co., Philadelphia, PA), and to 1 mm particle size in an ultracentrifuge mill (Pulverisette 14.Fritsch Industries Idar-oberstein, Germany). Fine ground feed samples were analysed at Animal Nutrition Laboratory Ravi Campus UVAS according to procedures of AOAC (2000). Briefly; DM contents were determined using a hot air oven at 105 ºC for 3 h; CP contents by using Kjeldahl apparatus as N x 6.25 (Gerhardt Kjeldatherm, Germany), and ash contents were determined in a muffle furnace at 550°C for 4 h. Fat contents were determined by ANKOM^{XT15} (ANKOM Technology USA) using petroleum ether extraction system (AOAC 2000). An α - amylase treated filtration analytical methods were used for sequential determination of NDF by using Ankom 2000 fiber analyzer and AOAC based filtration method was used for determination of ADF (Van Soest et al., 1991, AOAC, 2000).

Milk samples were collected twice weekly from a.m. and p.m. milking in sterile 50 mL falcon tubes. Both morning and evening milk samples were composited in equal volumes for each cow by sampling d. Milk samples were analyzed for total solids, fat and protein at Military Dairy Factory Laboratory, Renala using a lactoscan (Milk Analyzer Lactoscan mcc, Milkotronic Ltd, Bulgaria). A 10 mL blood was collected, approximately 4 h post morning feeding, from jugular venipuncture using K3EDTA vacutainers. Blood samples were immediately placed in an ice box and transported to laboratory. Plasma was harvested after centrifugation at 500 x g for 30 min, divided into aliquots, and stored at -20 ºC until further analysis. Plasma samples were analyzed at Physiology Department Laboratory UVAS Lahore for glucose (glucose oxidase kit at 546 nm; Merk Chemical int., USA), BUN (colorimetric kit at 600 nm; Biosystems, Spain) and NEFA (colorimetric kit at 550 nm; Randox Chemicals USA Inc., Richmond VA).

Statistical Analysis; Data were analysed under randomized complete block design. Data of parameters collected over time, including DMI, milk yield, and milk composition were reduced to weekly means and analyzed with repeated measures ANOVA using mix procedures of SAS (SAS, 1999). Model included fixed effects of treatments, wk, treatment x wk and block as random effect. However, BCS change, BW change and production efficiency were analyzed using one way ANOVA. To determine effect of increasing level of PKC in the concentrate diet polynomial orthogonal contrasts were used. Results were considered significant at $p<0.05$ and a trend was reported at $p\leq0.10$.

RESULTS

Intake, milk yield, changes in BW and BCS, and milk composition: Results of average daily DMI, average daily milk yield, energy corrected milk (ECM), manure score, changes in BW, BCS, milk composition and milk production efficiency are presented in Table 2. Average daily DMI was not affected ($p>0.05$) by the dietary treatments. However, a trend for treatment x wk interaction was noticed ($p<0.07$) for DMI. During week seven DMI remained lower for PKC 40 than control. Similarly, changes in BW and BCS were not affected ($p>0.05$) by the treatment.

Milk yield and ECM were not affected by the dietary treatments ($p>0.05$); however, milk fat and TS increased linearly ($p<0.01$) with increasing level of PKC in the diet (Table 2). Treatment x wk interaction was also not significant ($p>0.05$) for milk yield. Other milk components including milk protein and lactose were not affected ($p>0.05$) by the increasing level of PKC in the concentrate diet. However, response of milk protein to PKC levels was not consistent as shown by treatment x wk interaction ($p<0.01$) and protein contents in milk were higher with PKC supplemented diets during the sixth week. Milk production efficiency was not affected ($p>0.05$) by the dietary treatments. However, numerically cows fed on PKC 40 had greater production efficiency as compared to the PKC 20 and C diets. Average daily manure score was similar ($p>0.05$) among all the dietary treatments with no treatment x wk interaction ($p>0.05$).

Glucose, BUN and NEFA: Results of blood metabolites including glucose, BUN and NEFA are summarised in Table 3. Mean plasma glucose, BUN and NEFA concentrations were not affected by the increasing level of PKC in the diets. Similarly, treatment x wk interaction was not significant for any of the blood metabolites.

Table 2. Means ± of DMI, milk production, energy corrected milk yield, manure score, changes in BW, changes in BCS, changes in milk composition (fat, protein, lactose, total solids) and milk production efficiency of crossbred lactating dairy cows fed concentrate diets containing palm kernel cake (PKC) in concentrate diets: control, PKC 20 and PKC 40 including PKC at 0% , 20% and 40%, respectively.

	Treatments[1]				Contrast (*p*-value)		
Variables	**C**	**PKC 20**	**PKC 40**	**SEM**	**Linear**	**Quadratic**	**Treat x wk**
DMI, kg/d	17.6	16.1	14.5	1.36	0.126	0.97	0.065
Milk yield, kg/d	13.7	13.9	13.1	1.19	0.723	0.746	0.243
ECM, kg/d[2]	15.49	15.98	15.87	0.20	0.44	0.49	
Manure score daily[3]	3.71	3.73	3.82	0.097	0.445	0.767	0.421
BW Change, kg[4]	21.0	39.0	33.9	9.827	0.367	0.360	-
BCS change[5]	0.34	0.42	0.38	0.06	0.657	0.393	-
Milk composition							
Fat, %	4.05	4.20	4.67	0.131	0.003	0.324	0.130
Protein, %	3.90	3.90	3.90	0.038	0.982	0.941	0.011
Lactose, %	4.96	4.92	4.99	0.110	0.814	0.673	0.139
Total solid, %	13.4	13.6	14.1	0.18	0.009	0.626	0.536
Milk Production Efficiency[6]	0.89	1.05	1.20	0.131	0.111	0.980	0.121

[1]Concentrate diets: C = 0% PKC: PKC 20= PKC included at 20% (DM basis): PKC 40= PKC included at 40% (DM basis). Crossbred dairy cattle were offered total mixed ration containing (on DM basis) concentrates 50%, corn silage 45% and wheat straw 5%. [2]ECM= Energy corrected milk calculated according to equation described by Guo et al. (2013) and Tyrrell and Reid (1965) ; [(0.327 × kg milk) + (12.95 × kg fat) + (7.2 × kg protein)].
[3]Daily Manure score: was performed using 1-5 scale (Hutjens, 2010). [4]BW Change= Expressed as difference of initial body weight; [5]BCS= Body condition score based on 1 to 5 scoring system with 0.25 increments according to (Wildman et al., 1982). [6] Milk production efficiency = Energy corrected milk /DMI (Guo et al., 2013, Litherland et al., 2013).

Table 3. Means ± SEM of plasma glucose, blood urea nitrogen and non-esterified fatty acids of crossbred lactating dairy cows fed concentrate diets containing palm kernel cake (PKC): control, PKC 20 and PKC 40 including PKC at 0% , 20% and 40%, respectively

	Treatments[1]				Contrast (*p*-value)		
Variables	**C**	**PKC 20**	**PKC 40**	**SEM**	**Linear**	**Quadratic**	**Treat x wk**
Glucose, mg/dL	56.1	56.8	55.3	1.33	0.702	0.533	0.904
BUN, mg/dL	13.73	12.93	12.98	0.51	0.345	0.362	0.389
NEFA, mMol/L	0.522	0.516	0.535	0.013	0.253	0.47	0.435

[1]Concentrate diets: C = 0% PKC: PKC 20= PKC included at 20% (DM basis): PKC 40= PKC included at 40% (DM basis). Crossbred dairy cows were offered diet as total mixed ration containing (on DM basis) concentrates 50%, corn silage 45% and wheat straw 5%.

DISCUSSION

In this experiment, DMI and milk production were not affected by increasing the PKC level up to 40% in the concentrate diet suggesting that this ingredient can successfully replace the conventionally used wheat bran and rice polishing in dairy ration without affecting the animal performance. Our results are in line with Chanjula et al. (2010) who concluded that inclusion of PKC up to 35% in small ruminant concentrate diet caused no changes in daily DMI. Furthermore, Pimentel et al. (2015) reported no change in efficiencies of feeding and rumination in dairy cows fed on TMR containing PKC up to 15% of total diet. However, slight non significant depression in DMI when PKC was used at 40% is in line with previous findings (Macome et al., 2011, Oliveira et al., 2015) which may be due to higher dietary NDF (Table 1) as suggested by Zebeli et al. (2006).

Despite the numerically lower DMI intake in PKC 40 supplemented cows, similar milk production is suggestive of better nutrient utilization through improved milk production efficiency. A slight non-significant decrease in milk yield was noticed in cows fed diet containing highest level of PKC which may be related to high NDF contents as well as lower DMI (Firkins et al., 2001). Further, feeding higher levels of PKC did not result in any BW loss or change in consistency of feces and these observations are in agreement to Carvalho et al. (2006). Lower DMI and better milk production efficiency by feeding higher NDF level found in this experiment are comparable with Ranathunga et al. (2010) who evaluated replacement of starch in diet with agro industrial by-products like DDGS and soy hulls and reported a tendency in increased production efficiency with a decrease in DMI when non-forage fiber ingredients were increased in the diet. In the present study both wheat bran and rice polishing as starch containing ingredients was replaced by the PKC.

Interestingly milk fat contents were highest in cows fed on the PKC 40 diet which may be attributed to to high NDF contents of PKC based diets leading to changes in rumen fermentation end products responsible for the de novo synthesis of milk fat contents in udder. Chanjula et al. (2010) studied the effect of feeding various levels of PKC on rumen fermentation characteristics of goats and reported higher proportion of acetates which might be the reason for high milk fat contents of PKC 40 diet reported in this experiment. Recently Vazirigohar et al. (2018) also found a linear correlation between ruminal acetate proportion and milk fatty acids in cows fed palm fat. Higher NDF contents of non-forage fiber sources stabilize the rumen pH and increases milk fat contents (Allen and Grant, 2000). Other possible explanation for higher milk fat contents could be the rumen inert nature of palm fatty acids resulting in greater by-pass effect of fats and consequent greater direct incorporation of fats in milk. Findings of this experiment are in line with Garnsworthy (1990) who also reported a trend for increase in milk fat % of dairy cows when starchy feed was replaced with higher fiber concentrate. Fat content was the main component which led to higher TS % in PKC fed animals. Greater changes in milk fat and little changes in concentration of milk protein are possible in response to diet (Sutton, 1989, Jenkins and McGuire, 2006). In countries where milk is sold on milk fat basis, increase in milk fat contents can help farmers to fetch better milk prices.

Results of blood glucose, BUN and NEFA were similar across the treatments suggesting no negative impact of dietary treatments on these metabolites. Lack of any significant change in BCS as well as normal range of NEFA concentration on all the three diets indicate absence of negative energy balance and other stress conditions in the experimental lactating cows (Adewuyi et al., 2005).

CONCLUSION: The results concluded that inclusion of PKC at 40% increased milk fat and total solid contents without affecting DMI, milk production, BW and BCS in crossbred dairy cows. Hence, PKC can successfully replace wheat bran and rice polishing in the dairy concentrate diet for crossbred cows up to 40% in DM . Further studies are required to evaluate effective fiber content of PKC and fatty acid profile of milk produced by crossbred cows fed increasing level of PKC.

CONFLICT OF INTEREST: We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

ACKNOWLEDGEMENTS: Authors would like to thank Malaysian Palm Oil Council (MPOC) for funding this project. We are also grateful to Military Farms Directorate, Rawalpindi for permitting our research team to carry out this experiment at Military Dairy Farms Renala. We would like to thank Dr. M Asif Khawaja, Major Tahir and his staff for their support in the successful conduct of this experiment.

REFERENCES

Adewuyi, A., E. Gruys, and F. Van Eerdenburg (2005). Non esterified fatty acids (NEFA) in dairy cattle. A review. Vet. Q. 27(3):117-126.

Allen, D. M. and R. Grant (2000). Interactions Between Forage and Wet Corn Gluten Feed as Sources of Fiber in Diets for Lactating Dairy Cows1. J. Dairy Sci. 83(2):322-331.

Alimon, A. (2004). The nutritive value of palm kernel cake for animal feed. Palm Oil Dev. 40 (1): 12-14.

AOAC. (2000). Official methods of analysis of the Association of Official Analytical Chemists' 17th edn. AOAC International Gaithersburg, MD.

Carvalho, L., A. Cabrita, R. Dewhurst, T. Vicente, Z. Lopes, and A. Fonseca (2006). Evaluation of palm kernel meal and corn distillers grains in corn silage-based diets for lactating dairy cows. J. Dairy Sci. 89(7):2705-2715.

Chanjula, P., A. Mesang, and S. Pongprayoon (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. Sonklanakarin J. Sci. and Tech. 32(6):527-536.

FAPRI. (2005). US and World Agricultural Outlook. Pages ISSN 1534-4533. CARD Staff Report 1-05, Iowa State University: Available from: http://www.fapri.org.

Firkins, J. L., M. L. Eastridge, N. R. St-Pierre, and S. M. Noftsger (2001). Effects of grain variability and processing on starch utilization by lactating dairy cattle. J. Dairy Sci. 79(E. Suppl.):E218–E238.

Garnsworthy, P. (1990). Feeding calcium salts of fatty acids in high-starch or high-fibre compound supplements to lactating cows at grass. Anim. Sci. 51(3):441-447.

Guo, Y., Y. Zou, Z. Cao, X. Xu, Z. Yang, and S. Li (2013). Evaluation of coarsely ground wheat as a replacement for ground corn in the diets of lactating dairy cows. Asian-Australas J. Anim. Sci. 26(7):961.

Habib, G., M. F. U. Khan, S. Javaid, and M. Saleem (2016). Assessment of feed supply and demand for livestock in Pakistan. J. Agric. Sci. Tech. 6:191-202.

Hutjens, M. F. (2010). Manureology 101. Proc Four-State Dairy Nutrition & Management Conference. Dubuque, Iowa:59-61.

Jenkins, T. and M. McGuire (2006). Major advances in nutrition: impact on milk composition. J. Dairy Sci. 89(4):1302-1310.

Litherland, N., D. da Silva, W. Hansen, L. Davis, S. Emanuele, and H. Blalock (2013). Effects of prepartum controlled-energy wheat straw and grass hay diets supplemented with starch or sugar on periparturient dairy cow performance and lipid metabolism. J. Dairy Sci. 96(5):3050-3063.

Macome, F., O. Lopes, B. Regina, G. Garcia Leal A, B. Pires, and M. Costa Alves Da S (2011). Productive performance and carcass characteristics of lambs fed diets containing different levels of palm kernel cake. Revista MVZ Córdoba. 16(3):2659-2667.

Malaysian palm oil council (MPOC), (2013). CPO. Regulatory tariff and fta-efficacy and working. Ministry of plantation industries and commidities Malaysia: Available from: http://www.mpoc.org.

NRC. (2001). Nutrient requirements of dairy cattle, 7th revised edn. The Natl. Acad. Sci. Washingtion DC.

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

Pimentel, L. R., F. F. d. Silva, R. R. Silva, A. R. Schio, E. S. d. O. Rodrigues, and P. A. d. Oliveira (2015). Feeding behavior of lactating cows fed palm kernel cake in the diet. Acta. Sci., Anim. Sci. 37(1):83-89.

Ranathunga, S., K. Kalscheur, A. Hippen, and D. Schingoethe (2010). Replacement of starch from corn with nonforage fiber from distillers grains and soyhulls in diets of lactating dairy cows. J. Dairy Sci. 93(3):1086-1097.

SAS. (1999). User's Guide. Statistics, Version 8.0 Edition. Vol. 2. SAS Institue.

Silva, R. L. N., R. L. Oliveira, O. L. Ribeiro, A. G. Leão, G. G. Carvalho, A. C. Ferreira, L. F. B. Pinto, and E. S. Pereira (2013). Palm kernel cake for lactating cows in pasture: intake, digestibility, and blood parameters. Ital. J. Anim. Sci. 12(2):e42.

Sutton, J. (1989). Altering milk composition by feeding. J. Dairy Sci. 72(10):2801-2814.

Tyrrell, H. and J. Reid (1965). Prediction of the energy value of cow's milk1, 2. J. Dairy Sci. 48(9):1215-1223.

Van Soest, P. v., J. Robertson, and B. Lewis (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74(10):3583-3597.

Van Wyngaard, J., R. Meeske, and L. Erasmus (2015). Effect of palm kernel expeller as supplementation on production performance of Jersey cows grazing kikuyu-ryegrass pasture. Anim. Feed Sci. Technol. 199:29-40.

Vazirigohar, M., M. Dehghan-Banadaky, K. Rezayazdi, A. Nejati-Javaremi, H. Mirzaei-Alamouti, and A. Patra (2018). Effects of diets containing supplemental fats on ruminal fermentation and milk odd-and branched-chain fatty acids in dairy cows. J. Dairy Sci. 101(7): 6133-6141.

Wildman, E., G. Jones, P. Wagner, R. Boman, H. Troutt, and T. Lesch (1982). A dairy cow body condition scoring system and its relationship to selected production characteristics. J. Dairy Sci. 65(3):495-501.

Zahari, M.W. and A. Alimon (2004). Use of palm kernel cake and oil palm by-products in compound feed. Palm oil developments. 40: 5-8.

Zebeli, Q., M. Tafaj, H. Steingass, B. Metzler, and W. Drochner (2006). Effects of physically effective fiber on digestive processes and milk fat content in early lactating dairy cows fed total mixed rations. J. Dairy Sci. 89(2):651-668.