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Effect of Feeding Deoiled Palm Kernel Cake on Nutrient Utilization, Mineral Balance and Rumen Nitrogen Dynamics of Murrah Buffalo Bulls

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ABSTRACT

Background: Palm kernel cake is a high-fibre and medium-grade protein feed available at a cheaper price. Determining the optimum quantity of palm kernel cake inclusion levels could help in designing sustainable livestock-feeding systems. The studies related to its use in buffaloes are scarce. Considering the indispensable role of buffaloes in enhancing the Indian economy, the current study is aimed at finding the optimum level of palm kernel cake inclusion in rations of buffaloes.

Methods: In a 4×4 LSD, four graded Murrah buffalo bulls (4 yrs; 329±10.4 kg) were fed maintenance rations comprising Super Napier and concentrate mixture. A concentrate mixture with 20% CP was prepared using conventional feed ingredients and is used as control. De-oiled palm kernel cake (DPKC) is incorporated at 0, 15, 30 and 45 per cent level to study the effect of feeding DPKC on nutrient utilization, mineral (calcium, phosphorus and nitrogen) balance and rumen fluid parameters (TVFA and nitrogen dynamics).

Result: The DPKC diets did not affect nutrient intakes; however, decreased the nutrient digestibility coefficients. The nitrogen outgo was higher and the N retention and per cent absorbed was lower for DPKC-included diets. No effects were observed on the calcium and phosphorus balance of diets. A linearly decreased pattern of TVFA and total nitrogen was observed with increased levels of DPKC. Further, the diets did not affect food and protozoal N and residual N of rumen liquor.

Key words: Agro-industrial byproducts, Nutrient digestibility, Ruminants, Rumen physiology.

INTRODUCTION

The rapid growth in the world economy fueled the increased demand for palm oil, making it the world's leading vegetable oil. The palm berry yields 43% crude palm oil yielding 57% press cake, consequently producing palm kernel cake (PKC) at an extensive scale. Palm Kernel Cake is one of the unconventional feed ingredients that can be utilized in livestock rations to reduce feed cost. The PKC is low in crude protein content compared with soybean meal and groundnut cake; however, it could supply a substantial part of the maintenance requirements of livestock. Further, it is viewed as an attractive replacement for traditional protein supplements (Abdeltawab and Khattab, 2018). In this regard, several studies on cattle found no deleterious effects of PKC inclusion at varied proportions.

The Krishna and Godavari zones of Andhra Pradesh, India, contributes to 67% of the total country's oil palm farming and produces 136.2 mt palm kernel cake per annum (Raju *et al.*, 2017). Designing location-specific feeding strategies using locally available non-conventional feed resources aids in sustainable and profitable livestock farming (Adegbeye *et al.*, 2020). Besides, the rapid hike in feed prices and shortage of feed grains and traditional protein supplements necessitate exploring unconventional feed resources. Hence, the current study was intended to study the effect of inclusion of Deoiled Palm Kernel Cake (DPKC) in the maintenance ration on nutrient utilization, mineral profile and rumen nitrogen dynamics of Murrah buffalo bulls.

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MATERIALS AND METHODS

The experiment was carried out at Livestock farm complex, NTR College of Veterinary Science, Sri Venkateswara Veterinary University, Gannavaram, Andhra Pradesh, India.

In a 4 × 4 LSD, four graded Murrah buffalo bulls (4 yrs.; 329 ±10.4 kg) were randomly allotted to four dietary treatments and fed green fodder (Super Napier) and concentrate mixture containing DPKC at 0 (DPKC 0), 15 (DPKC 15), 30 (DPKC 30) and 45 (DPKC 45) per cent level as per ICAR (2013) requirements. The Vit-Min premix added to the diet was prepared according to the prevailing mineral status within the study location (Swaroop *et al*., 2017).

A Metabolism trial was conducted where in each period of a Latin square consisted of a 21-days preliminary period and 7-days collection period. The buffalo bulls were offered respective concentrate mixtures daily at 9:00 AM and 3:00 PM throughout the experimental period. Daily feed intake, feed refusals if any as well as faeces and urine voided were recorded daily. Rumen fluid was collected on the 28th day of each rotation for four consecutive switchovers during the trial. The hours of collection include 1 hour before feeding (0 h) and 2, 4, 6 and 8 h post-feeding. The strained rumen liquor was transferred to a 100 ml anaerobic polythene bottle followed by adding 1 ml saturated mercuric chloride to cease the microbial activity.

Representative samples of complete feeds, faeces andurine were collected and analyzed for proximate principles (AOAC, 2007) and fibre fractions (Van Soest *et al*., 1991). The calcium and phosphorus in feed and faeces were analyzed as per Talapatra *et al*. (1940) while those in urine samples were estimated according to the methods described by Ferro and Ham (1957), Fiske and Subba Row (1925), respectively. The TVFA concentration of rumen liquor was determined by using the procedure of Barnett and Reid (1957). The total nitrogen content was analyzed through kjeldahl procedure, while residual nitrogen and food and protozoal nitrogen were determined as per the protocols of Singh *et al*. (1968).

Statistical analysis

The experimental error was reduced by using animals as replicates. The data of intakes, nutrient digestibility coefficients, minerals balance and rumen function parameters were analyzed by using PROC GLM procedure using the model:

$$Y_{ij} = \mu + T_i + A_j + e_{ij}$$

Where

Y_{ij} = Observation.

μ = Overall mean.

T_i = Effect of treatment (i=4).

A_j = Random effect of animal.

e_{ij} = Residual error.

The linear and quadratic coefficients were generated using PROC IML with ORPOL function. The interactions of rumen function parameters with time (hour) of sampling were measured using repeated measure analysis according to the model:

$$Y_{ijkl} = \mu + T_i + H_j + A_k + (T \times H)_{ij} + e_{ijkl}.$$

Where

Y_{ijkl} = Observation.

μ = Overall mean.

T_i = Effect of treatment (i=4).

H_j = Effect of hour (j=5).

$(T \times H)_{ij}$ = Interaction between treatment.

e_{ijkl} = Residual error.

The optimum percent inclusion level was arrived by conducting post-hoc analysis using Tukey's honestly significant difference (Tukey-HSD) Test. The differences among treatments were considered significant at $P<0.05$. All analyses were performed using the SAS 9.4 (Statistical Analysis System Institute, Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

The ingredient and chemical composition of the DPKC diets are provided in Table 1. Although the diets are iso-nitrogenous, the NDF and ADF fractions were markedly higher in DPKC 45 diets. Similar pattern of higher fiber fractions with DPKC inclusion was reported by van Wyngaard and Meeske (2017). The higher fibre per cent of DPKC-included diets is attributed to the significant proportion of fibre-rich pericarp (35%) within the expeller cake (Pickard, 2005).

The nutrient intake and digestibility coefficients are presented in Table 2. Despite the higher fibre content and lower palatability compared to cotton seed cake, the DPKC diets did not affect intakes of DM, DCP and TDN on gm per $Kg^{0.75}$ body weight basis. Contrary to these results, few authors reported decreased nutrient intakes on feeding PKC diets (Silva *et al*., 2013). In the current study, the negative effects of PKC on intakes might be masked by limited feeding (maintenance ration) as per the standard requirements, instead of feeding ad libitum. Moreover, mixing DPKC with other palatable feed ingredients such as rice, de-oiled rice

Table 1: The ingredient and chemical composition of the DPKC diets.

Ingredient composition	De-oiled palm kernel cake			
	0	15	30	45
Maize	33	26	23	21
De-oiled rice bran	39	35	25	17
Cotton seed meal	25	21	18	14
De-oiled palm kernel cake	0	15	30	45
Vit-Min premix[1]	3	3	3	3
Nutrient composition				
DM	93.82	94.04	92.68	94.40
OM	90.73	90.59	90.39	89.68
CP	20.00	20.01	19.98	20.03
EE	2.20	2.14	2.24	2.38
TA	9.27	9.41	9.61	10.32
NDF	61.57	62.22	65.91	69.62
ADF	32.52	36.84	42.36	48.51
Hemi-cellulose	29.05	25.38	23.55	21.11
Cellulose	23.53	27.48	31.12	36.29
ADL	6.99	7.37	9.28	10.12
Silica	1.38	1.65	1.99	2.68

bran and cotton seed meal might have ameliorated the anti-palatability nature of DPKC.

Including DPKC in the maintenance rations decreased the nutrient digestibility coefficients of dry matter, organic matter, crude protein, ether extract, crude fibre, nitrogen free extract, neutral detergent fibre, acid detergent fibre, hemi-cellulose and cellulose. The reduced digestibility coefficients could be attributed to the increased fibre content of diets included with DPKC, especially at higher levels (45%).

The rapidly fermentable N fraction of PKC is low with less effective degradability of protein compared to traditional protein sources, consequently reducing CP digestibility coefficient. Besides, the heat applied during oil extraction may cause Maillard reaction, rendering some portion of protein unavailable for rumen microbes. Similar results were reported on including PKC as high as 55% (Silva *et al*. 2013) or 75% (Chanjula *et al*. 2011) or 210 g/kg DMI (Cruz *et al*., 2018) of the ruminants' ration. On contrary, Carvalho *et al*. (2006) observed no effect on nutrient digestibility coefficients of hay substituted with PKC at 15%, 30% and 45% level. Interestingly, Cunha *et al*. (2013) revealed higher EE and NDF digestibility coefficients on feeding lactating dairy cows with PKC at 113, 228 and 342 g/kg DM. These inconsistencies could be connected to the roughage source.

Table 2: Intake and nutrient digestibilities of the buffalo bulls fed DPKC diets.

Parameters	Deoiled palm kernel cake				SEM	P value	
	0	15	30	45		L	Q
Intakes (g/WKG$^{0.75}$)							
DM	88.58	88.61	88.69	88.62	0.26	0.940	0.821
DCP	6.50	6.41	6.01	5.84	0.07	0.162	0.787
TDN	35.11	34.68	33.40	30.66	0.60	0.101	0.253
Nutrient digestibility coefficients							
Dry matter	60.62	58.59	55.71	52.17	0.85	0.001	0.425
Organic matter	69.09	67.86	64.02	61.07	1.30	0.001	0.527
Crude protein	65.05	64.18	61.22	59.81	0.92	0.048	0.797
Ether extract	76.93	75.73	74.87	70.54	1.89	0.045	0.451
Crude fibre	64.19	62.46	60.47	58.01	2.20	0.050	0.494
Nitrogen free extract	69.28	68.81	66.18	64.85	1.65	0.002	0.118
Neutral detergent fibre	64.62	64.49	61.81	60.50	2.45	0.042	0.627
Acid detergent fibre	59.75	57.67	54.89	51.07	2.00	0.001	0.442
Hemi-cellulose	72.48	69.91	68.80	67.78	2.17	0.049	0.477
Cellulose	63.78	61.99	60.94	58.12	2.90	0.046	0.421
Plane of nutrition							
DCP (%)	7.33	7.23	7.15	6.95	0.08	0.048	0.585
TDN (%)	39.63	39.15	37.96	35.05	0.69	0.013	0.311

Table 3: Mineral balance of the buffalo bulls fed DPKC diets.

Parameter	Deoiled palm kernel cake				SEM	P value	
	0	15	30	45		L	Q
Nitrogen (g/d)							
Intake (g/d)	130.82	130.82	130.82	130.82	0.35	1.000	1.000
Outgo (g/d)	77.36	80.56	81.34	87.26	1.49	0.023	0.614
Retention (g/d)	53.46	50.26	49.48	43.56	1.39	0.013	0.570
% absorbed	68.36	64.14	63.74	59.18	1.20	0.007	0.929
Calcium (g/d)							
Intake (g/d)	46.35	46.62	46.90	47.09	0.15	0.421	0.889
Outgo (g/d)	29.96	31.67	31.99	32.31	0.77	0.878	0.754
Retention (g/d)	16.39	14.95	14.91	14.78	0.83	0.999	0.751
% absorbed	65.37	65.94	62.05	61.62	2.34	0.851	0.729
Phosphorous (g/d)							
Intake (g/d)	36.27	36.36	36.55	36.74	0.10	0.923	0.523
Outgo (g/d)	16.67	17.49	18.92	19.87	0.75	0.126	0.965
Retention (g/d)	19.61	18.87	17.63	16.86	0.78	0.151	0.963
% absorbed	71.49	71.14	69.43	69.12	2.53	0.485	0.946

Supplementing unconventional protein sources to poor quality roughages may ameliorate the negative effects of the supplements, thereby masking the adverse effects (Reddy *et al*., 2021). However, the buffalo bulls in the current study were fed high quality Super Napier fodder source.

Mineral balance of the buffalo bulls fed DPKC diets is presented in Table 3. The diets did not affect calcium and phosphorus balance. The calcium and phosphorus outgo in healthy ruminants depends on their intake levels; hence, the unaffected calcium and phosphorus balance could be related to their similar estimates in all the four replacement diets (Reddy *et al*., 2019a and b). The experimental buffalo bulls were in positive nitrogen balance indicating that the DPKC diets met the digestible protein requirements. Nevertheless, the nitrogen outgo was higher and the N retention and per cent absorbed was lower for DPKC included diets. The higher nitrogen wastage is presumably instigated by low degradative ability of DPKC included diets.

The TVFA concentration and rumen nitrogen dynamics (total N, food and protozoal N and residual N) are presented in Table 4 and Fig 1. The TVFA concentration showed a linearly decreased pattern with increased DPKC inclusion levels (Fig 1a). Similarly, Chanuja *et al*. (2010) reported a decreased TVFA concentration with increased DPKC inclusion from 15% to 55% of the diet. The decreased TVFA proportion could be connected to the decreased digestibility coefficients of organic matter and nitrogen free extract. Further, the ruminal nitrogen dynamics revealed decreased total nitrogen levels (Fig 1b) without affecting food and protozoal N (Fig 1c) and residual N (Fig 1d). The reduced rumen nitrogen content could be attributed to the decreased CP digestibility. A significant diet × time interaction was observed for all the rumen function parameters estimated. Overall, the post-hoc analysis revealed 30% as the optimum inclusion levels as the inclusion levels at 45% decreased dry matter digestibility, nitrogen retention and rumen nitrogen (Fig 2).

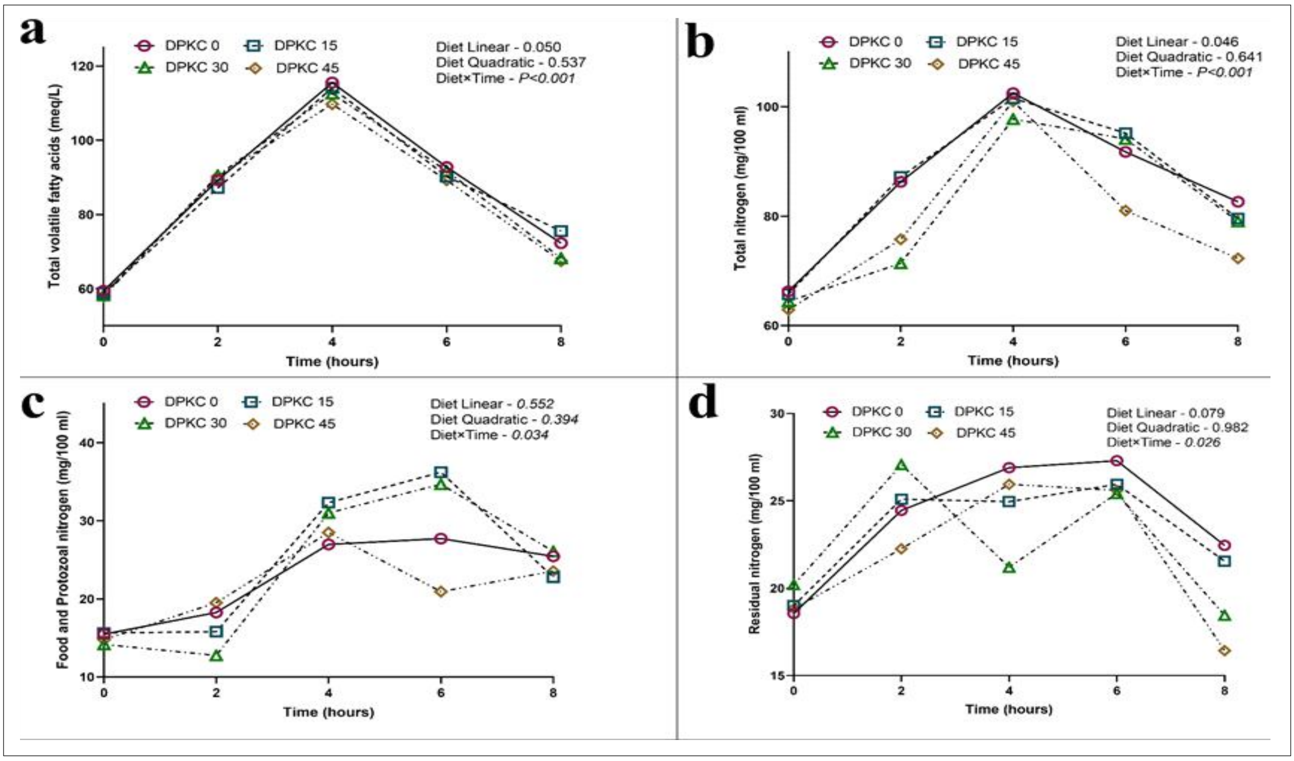

Fig 1: Rumen function parameters of the buffalo bulls fed DPKC diets.

Table 4: Rumen function parameters of buffalo bulls fed DPKC diets.

Parameter	Deoiled palm kernel cake				SEM	Diet		Time	Diet *
	0	15	30	45		L	Q		time
Total volatile fatty acids (meq/L)	78.44	77.64	76.88	75.52	0.51	0.05	0.537	0.038	<0.001
Total nitrogen (mg/100 ml)	85.88	85.84	81.35	78.59	0.68	0.046	0.641	0.001	<0.001
Food and protozoal nitrogen (mg/100 ml)	22.78	24.55	23.14	21.45	1.04	0.552	0.394	0.253	0.034
Residual nitrogen (mg/100 ml)	23.93	23.34	22.45	21.80	0.49	0.079	0.982	0.045	0.026

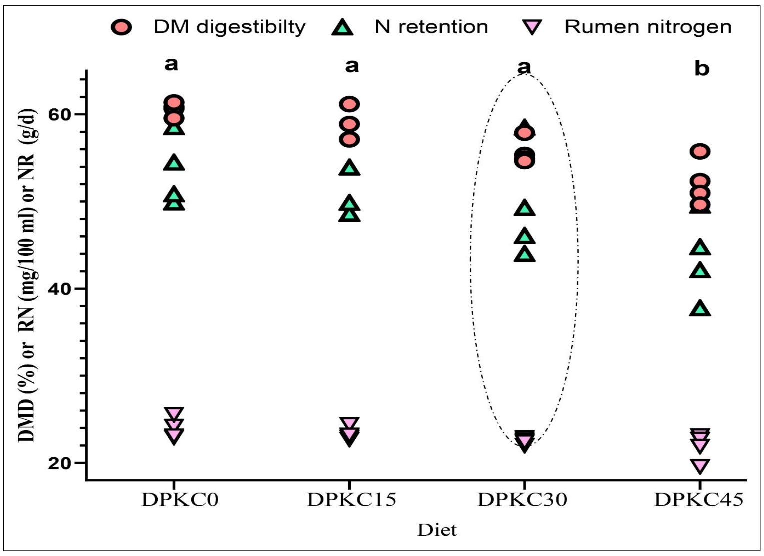

Fig 2: Scatter plot of individual mean values of dry matter digestibility, rumen nitrogen and nitrogen retention.
DMD - Dry matter digestibility, RN - Rumen nitrogen, NR - Nitrogen retention.
[ab]Graph columns bearing different superscripts differ significantly (*P*<0.05).

CONCLUSION

The present study concluded that including the de-oiled palm kernel cake at higher level (45%) in maintenance ration limit the nutrient digestibility coefficients, nitrogen retention and rumen nitrogen concentration without affecting the nutrient intake and calcium and phosphorus balance. Hence, the inclusion percent of de-oiled palm kernel cake in buffaloes' rations should be limited up to 30% to prevent negative effects on the digestibility coefficients and nitrogen dynamics of buffaloes.

Conflict of interest: None.

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