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Full Length Research Paper

Partial substitution of cumin seed meal by Jatropha meal as a potential protein source for feed

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This study was carried out to evaluate the effect of incorporating the *Jatropha curcas* meal in place of black cumin seed meal (*Nigella sativa*) as a new source of protein on nutrients digestibility, feeding value, growth performance and economic efficiency of growing Demeshgi goats rations. Feeding trial which lasted for 90 days was conducted using 12 growing Demeshgi goats (average 23.26 kg live body weight and 6 to 8 months old). The animals were randomly divided into four groups and fed at 3% of live body weight on four experimental rations. The first group received control ration consisting of feed mixture (40% yellow corn grains; 20% cumin seed meal; 17% wheat bran; 20% bean straw, 2.0% lime stone and 1.0% salt). In the second, third and fourth rations, cumin seed meal (CSM) was replaced with 10.0, 20.0 and 30.0% Jatropha seed meal (JSM), respectively. The chemical composition, digestibility coefficients, nutritive values, daily gain, feed conversion and economical efficiency were determined. The results indicated that digestion coefficients of all nutrients and nutritive value were not significant in four tested rations. The highest value of average daily gain ($p < 0.05$) was recorded for goats fed on R1 and R2 compared with those fed R3 and R4. Feed conversion as a kg DMI/kg gain was significantly ($p < 0.05$) better for G1 and G2 (7.10 and 7.04) than 7.35 for G3 and 8.05 for G4. Total feed cost was decreased for R4 and R3 (577.73 and 580.66 L.E./h) compared with 593.16 and 592.01 L.E./h for R1 and R2, respectively. On the other hand, the economic efficiency of animals fed rations containing 10 and 20% JSM was higher (16.04 and 15.66%) than those fed 0 and 30% JSM (14.47 and 14.0%), respectively. Similar trend was noticed for relative economic efficiency value (110.85 and 108.22%) recorded for R2 and R3 compared with 100 and 96.75% for R1 and R4, respectively. This study therefore recommend that further researches may be required to study the effect of increasing the level of JSM used in goat rations than 30%, which did not cause any adverse effect on the animals.

Key words: Jatropha meal, cumin meal, chemical composition, digestibility, goat performance and economic efficiency.

INTRODUCTION

Bioresource technology involves the exploitation of natural substances and/or biotechnological approaches in production processes. The utilization of various parts of *Jatropha curcas*, combines these targets, thus potentially improving the economic situation of various tropical countries. *J. curcas* is a drought-resistant shrub or tree belonging to the genus Euphorbiaceae, which is cultivated in Central and South America, Southeast Asia, India and Africa (Schmook and Seralta-Peraza, 1997).

The toxic and anti-nutritional components in the kernel and the press cake include phytase, saponins, lectin and trypsin inhibitor (Makkar et al., 1997; Areghore et al., 2003). The seed cake can be a protein source for livestock after inactivation of trypsin inhibitors and lectins by heat treatment or defatted for the removal of the phorbol esters. Through laboratory analysis, *J. curcas* seed meal free of shells has been found to have high nutritive value comparable to that of soybean meal because it is rich in protein (27 to 33%) (Makkar et al., 1998; Abou-Arab and Abu-Salem, 2010; Abdel-Shafy et al., 2011). Nasr et al. (2011) indicated that the administering of Jatropha seed meal (JSM) at 2.5%

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Table 1. Feed ingredients (%) of experimental rations.

Item	R1	R2	R3	R4
Yellow corn grains	40	40	40	40
Cumin seed meal (CSM)	20	18	16	14
Jatropha seed meal (JSM)	0	2.0	4.0	6.0
Wheat bran	17	17	17	17
Bean straw	20	20	20	20
Lime stone	2.0	2.0	2.0	2.0
Salt	1.0	1.0	1.0	1.0

R1, Control ration contained 0% JSM; R2, second experimental ration (replaced CSM with 10% JSM); R3, third experimental ration (replaced CSM with 20% JSM); R4, fourth experimental ration (replaced CSM with 30% JSM).

normal diet was not toxic in rabbits, while 5 or 7.5% JSM exhibited slight adverse sero-biochemical and histo-pathological alteration; although 10% JSM exhibited some sero-biochemical and histopathological alteration in liver and kidney functions.

The plant is adaptable to extreme growing conditions, tolerates high temperature and is resistant to drought. The seeds contain 30 to 32% protein and 60 to 66% oil (Aderibigbe et al., 1997). The protein rich cake could be used as a potential livestock feed after detoxification (Areghore et al., 2003; Chivandi et al., 2004; Rakshit and Bhagya, 2006).

The present study aimed to evaluate the effect of incorporating the Jatropha meal (0, 10, 20 and 30%) in place of the black cumin seed (Nigella sativa) meal as a new source of protein on nutrients digestibility, feeding value, growth performance and economic efficiency of growing Demeshgi goats' rations.

MATERIALS AND METHODS

This study was carried out at the Nubaria Experimental Station, El-Hussein Village, Nubaria Governorate and in the Laboratories of Animal Production Department, National Research Center, Dokki, Giza, Egypt, during the period of February to April, 2009.

Preparation of Jatropha meal

J. curcas (Linnaeus), which belongs to the family Euphorbiaceae, was used as a seed meal after the extraction of its oil using hexane as solvent (Hawash et al., 2008).

Feeding trials

Twelve growing Demeshgi goats aged 6 to 8 months and weighed in average 23.26 kg, were randomly allocated into four similar groups (3 animals in each). Jatropha seed meal (JSM) was incorporated into the experimental feed mixtures to replace 0, 10, 20 and 30% of the black cumin seed meal (CSM) as a new source of protein. The formulation and the chemical composition of the feed mixtures; black CSM and JSM are shown in Tables 1 and 2. The experimental feed mixtures were fed at 3% of the goat body weight in two parts daily at 8.0 a.m. and 4.0 p.m., and fresh water was freely available to animals all time. The feeding trial lasted for incorporating the Jatropha meal (0, 10, 20 and 30%) in place of the black cumin seed (*Nigella sativa*) meal as a new source of protein on nutrients digestibility, feeding value and growth performance. 90 days during which animals body weight and feed intake were recorded weekly and the feed intake was adjusted for each animal.

Digestibility trials

At the middle of the experimental period (45 days), for all animals of each group, a grab sample method was used to determine the nutrients digestibility and nutritive value of the tested rations using acid insoluble ash (AIA) as a internal marker as described by Van Keulen and Young (1977). The digestibility coefficient was calculated according to the formula of Gallups et al. (1945) and Forbes and Garrigs (1948).

$$\text{Digestibility (\%)} = 100 - \left(100 \times \frac{\text{Indicator in feed} \times \text{Nutrient in feces}}{\text{Indicator in feces} \quad \text{Nutrient in feed}} \right)$$

Proximate composition

The moisture content of the samples was determined by oven-drying to a constant weight at 105°C. Crude protein, ether extract, crude, fiber and ash content were determined in accordance with the standard methods of AOAC (1990). Carbohydrates (nitrogen free extract) were determined by difference.

Amino acid analysis

Amino acid content was determined as described by Spackman et al. (1958) and Moore et al. (1958). The analysis was performed in Central Service Unit, National Research Center, Egypt, using LC 3000 amino acid analyzer (Eppendorf-Biotronik, Germany). The technique was based on the separation of the amino acids using strong cation exchange chromatography followed by the ninhydrin colour reaction and photometric detection at 570 nm. Samples were hydrolyzed with 6 N HCl at 110°C in Teflon-capped vials for 24 h. After vacuum removal of HCl, the residues were dissolved in a lithium citrate buffer, pH 2.2. 20 µl of the solution were loaded onto the cation exchange column (pre-equilibrated with the same buffer), then four lithium citrate buffers with pH values of 2.2, 2.8, 3.3 and 3.7, respectively, were successively applied to the column at flow rate 0.2 ml/min. The ninhydrin flow rate was 0.2 ml/min at a

Table 2. Chemical composition of the experimental rations and two sources of protein (on dry matter (DM) basis).

Item	DM	Chemical composition (%) on DM basis					
		OM	CP	CF	EE	NFE	Ash
Ration 1	92.43	92.08	15.32	11.17	7.60	57.99	7.92
Ration 2	92.67	91.46	15.67	10.73	7.69	57.37	8.54
Ration 3	92.63	92.57	15.59	11.50	6.66	58.82	7.43
Ration 4	92.33	91.43	15.62	14.39	6.71	54.71	8.57
Cumin seed meal (CSM)	90.57	92.05	28.85	13.31	16.14	33.75	7.95
Jatropha seed meal (JSM)	93.35	91.39	26.25	31.85	4.84	28.45	8.61

DM, Dry matter; OM, organic matter; CP, crude protein; CF, crude fiber; EE, ether extract; NFE, nitrogen free extract.

pressure of 0 to 150 bar. The pressure of buffer was from 0 to 50 bar and reaction temperature was 130°C.

Statistical analysis

The data of feeding and digestibility trials were statistically analyzed using general method of statistical analysis system (SAS, 1996). Duncan multiple range test (Duncan, 1955) was used to separate differences among means.

RESULTS AND DISCUSSION

Chemical composition

Chemical analysis of JSM, black CSM and experimental feed mixtures are shown in Table 2. The data indicated that the crude protein (CP) (28.85%) and ether extract (EE) (16.14%) contents were higher in CSM than the JSM (26.25 and 4.84% for CP and EE, respectively). The high content of EE recorded for CSM was mainly due to the incomplete extraction of oil from cumin seed during processing of meal. These results are in agreement with those obtained by Khalifa (1995), Zeweil (1996), El-Ghamry et al. (1997), Abd El-Ghani (2003), Aboul Ela et al. (2004), Abd El-Rahman (2008) and Abdel-Shafy et al. (2011). They noticed that black CSM has considerable amounts of CP and EE. On the other hand, JSM contained high content of crude fiber (CF = 31.85%) than the CSM (13.31%). The chemical composition was some what similar in the four experimental rations.

Results in Table 3 demonstrated the amino acids concentration (g/100 g sample) in JSM and CSM. The major amino acid in JSM was glutamic acid (4.72%). Others were cysteine (2.77%), arginine (2.52%), aspartic acid (2.25%), leucine (1.89%), alanine (1.40%) and phenylalanine (1.36%). These results had high concentrations than those obtained by Apiwatanapiwat et al. (2009). On the other hand, the major amino acid in CSM was glutamic acid (6.22%), followed by 5.28, 3.24, 2.97, 2.44, 1.74, 1.69 and 1.69% for cystine, arginine, aspartic acid, leucine, alanine, tyrosine and phenylalanine, respectively. In general, amino acids composition had high concentration in CSM than those in JSM.

Digestion coefficient and nutritive values

The results in Table 4 showed the digestion coefficient of experimental rations. It can be noticed that there were no significant differences between the experimental rations for dry matter (DM), organic matter (OM), Crude protein (CP), crude fiber (CF),ether extract (EE) and nitrogen free extract (NFE). The same results were obtained by Zeweil (1996), Zaki et al. (1998) and El-Gaafarawy et al. (2003), with sheep fed different levels of *N. sativa* cake as a new source of protein. The nutritive value as total digestible nutrients (TDN) of all experimental rations were similar, but digestible crude protein (DCP) of goats fed ration 4 followed by R2 and R3 were slightly higher than those fed control diet due to the high trend CP digestibility of their rations. The same trend was obtained by Zaki et al. (1998). These results are in agreement with those obtained by Abd El-Salam and Draz (2005), which indicated that most of nutrients digestibility coefficients and feeding values as TDN and DCP were not affected by increased levels of Canola meal as a source of protein in rations.

Growth performance and economic evaluation

Data of growth performance of the animals fed experimental rations are presented in Table 5. Body weights of the four animal groups were similar at the start of the trial (23.15, 23.30, 23.23 and 23.38 kg for control, G2, G3 and G4, respectively). However, at the end of the experimental period, G2 that fed 10% JSM as a source of protein recorded the highest (34.35 kg) final body weight. The highest values of average daily weight gain ($p < 0.05$) were recorded as 122.80 g/h/d for goats fed 10.0% JSM and 120.0 g/h/d for control diet compared with those

Table 3. Amino acids concentration (g/100 g sample) in Jatropha and cumin seed meals.

Amino acid	Jatropha seed meal	Cumin seed meal
Essential amino acid		
Threonine	0.85	1.45
Valine	Not detected	0.04
Methionine	0.32	0.55
Isoleucine	0.97	1.42
Leucine	1.89	2.44
Phenylalanine	1.36	1.69
Histidine	0.84	1.42
Lysine	0.99	1.48
Arginine	2.52	3.24
Non essential amino acid		
Aspartic acid	2.25	2.97
Serine	1.04	1.35
Glutamic acid	4.72	6.22
Glysine	0.78	1.28
Alanine	1.40	1.74
Cystine	2.77	5.28
Tyrosine	0.67	1.69

Table 4. Digestion coefficients and nutritive value of experimental rations.

Item	Experimental ration (%) on DM basis				SE
	R1	R2	R3	R4	
Apparent digestibility (%)					
DM	69.78	69.48	70.78	69.55	2.28
OM	71.18	71.16	70.88	71. 98	0.49
CP	66.95	67.96	67.87	69.15	0.59
CF	62.10	61.47	61.30	62.15	0.28
EE	75.59	75.29	75.04	76.82	0.45
NFE	71.56	71.48	71.50	71.86	0.24
Nutritive value (%)					
TDN	71.82	70.76	70.94	70.66	0.26
DCP	10.49	10.65	10.58	10.80	0.25

DM, Dry matter; OM, organic matter; CP, crude protein; CF, crude fiber; EE, ether extract; NFE, nitrogen free extract; TDN, total digestible nutrients; DCP, digestible crude protein.

fed 20.0% JSM(115.0g/h/d) or 30.0% JSM (106.10 g/h/d).

Feed conversion as a kg DMI/kg gain was significantly ($p < 0.05$) better for R2 (7.04), R1 (7.10) and R3 (7.35) than R4 (8.05). The same trend was observed for feed conversion as kg TDN intake or kg DCP intake/kg gain.

These results were in agreement with Awadalla (1997), Gabr et al. (1998), El-Khanawy et al. (1999), El-Ayek et al. (1999), Abd El-Ghani (2003) and Abd El-Rahman (2008), whose results indicated that black CSM as a good new source of protein could be used as a supplement in the diets of ruminants.

Based on the difference in both growth rate and feeding cost per animal, the economic efficiency as affected by using JSM as a source of protein is calculated in Table 6. Total feed cost decreased for R4 and R3 (13.68 and 14.38 $./head, respectively) compared with R2 (17.01 $./head) and R1 (16.52 $./head). This reduction was due to lower price for JSM (54 $/ton) compared with 252 $/ton for CSM. On the other hand, the results showed that total revenue, economic efficiency and relative economic efficiency were best with R2 and R3 (10 and 20% JSM, respectively), followed by R1 and R4. From the

Table 5. Growth performance of kids fed different experimental rations.

Item	Experimental ration				SE
	R1	R2	R3	R4	
Body weight change					
Initial live body weight (kg)	23.15	23.30	23.23	23.38	
Final live body weight (kg)	33.95	34.35	33.58	32.93	
Total body weight gain (kg)	10.8	11.05	10.35	9.55	
Daily body weight gain (g)	120.0[a]	122.80[a]	115.0[b]	106.1[b]	4.178
Feed intake (g/h/d)					
OM	852	855	845	854	2.43
TDN	611.97	605.14	599.34	596.05	0.15
DCP	89.35	91.11	89.39	91.65	3.21
Feed conversion (kg DM intake/ kg gain)					
DM	7.10[a]	7.04[a]	7.35[a]	8.05[b]	0.67
TDN	5.10	4.98	5.22	5.63	0.29
DCP	0.75	0.75	0.78	0.88	0.21

[a, b]Means in the same row with different letters are significantly ($p < 0.05$) different. DM, Dry matter; OM, organic matter; TDN, total digestible nutrients; DCP, digestible crude protein.

Table 6. Economic evaluation of the experimental rations for growth performance*.

Item	R1	R2	R3	R4
Feeding period, day	90	90.0	90.0	90.0
Purchase cost (L.E./head)[1]	439.85	442.7	443.27	444.22
Feed cost (L.E./head)[2]	95.8	91.8	79.9	76.0
Management cost (L.E./head)[3]	57.51	57.51	57.51	57.51
Total cost (L.E./head)[4]	593.16	592.01	580.68	577.73
Selling income (L.E./head)[5]	679.0	687.0	671.6	658.6
Net revenue (L.E./head)[6]	85.84	94.99	90.92	80.87
Economic efficiency (%)[7]	14.47	16.04	15.66	14.0
Relative economic efficiency (%)[8]	100.0	110.85	108.22	96.75

* L.E. = Egyptian pound = 0.18 $ approximately; [1]Initial body weight × price of one kg, [2]Calculated according to the local price in 2008(1250, 1100, 1050, 1000 L.E./ton for R1, R2, R3 and R4, respectively); [3]Include operation and medicinal costs; [4]Include the fixed, management and feed costs; [5]Final body weight × price of one kg at selling; [6]Selling income – total cost; [7]Net revenue/total cost × 100; [8]Economic efficiency for treatment/economic efficiency for control, assuming that relative economical efficiency of the control group equals 100.

economical evaluation of this study, the 10 and 20% of JSM replacement in rations could be recommended.

Conclusion

JSM (up to 30% replacement) could be used safely, economically and successfully as a source of protein for feed, since the percent used in this study in goats feed did not have any adverse effect on digestibility coefficients and nutritive values of rations compared with control. Further investigations are however needed to evaluate the sero-biochemical and histopathological alteration.

Abbreviations

CF, Crude fiber; **FM,** feed mixture; **CP,** crude protein; **DCP,** digestible crude protein; **DM,** dry matter; **DMI,** dry matter intake; **EE,** ether extract; **JSM,** Jatropha seed meal; **LE,** Egyptian pound; **NFE,** nitrogen free extract; **OM,** organic matter; **R1,** control ration contained 0% Jatropha seed meal; **R2,** second experimental

ration replace cumin seed meal with 10% Jatropha seed meal; **R3,** third experimental ration replace cumin seed meal with 20% Jatropha seed meal; **R4,** fourth experimental ration replacecumin seed meal with 30% Jatropha seed meal; **TDN,** total digestible nutrients.

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