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Effect of feeding detoxified *Jatropha curcas* meal on carcass characteristics and meat quality in lambs

S S PATIL[1], K SHARMA[2], NARAYAN DUTTA[3], A K PATTANAIK[4] and S K MENDIRATTA[5]

Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh 243 122 India

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ABSTRACT

Lambs (24) of about 3 to 4 months of age with an average body weight of 15.76±1.92 kg were divided randomly into 4 groups of 6 each as per completely randomized design and allocated to 4 dietary treatments dJM-0, dJM-12.5, dJM-25 and dJM-37.5. Lambs in dJM-0 were fed with concentrate mixture containing soybean meal as the major protein source, while those from the rest of the 3 groups were fed concentrate mixtures containing detoxified jatropha meal (dJM) replacing soybean meal of control at 12.5, 25.0 and 37.5% level, respectively, on iso-nitrogenous basis. The lambs were scarified after 180 days of experimental feeding. The voluntary feed intake of lambs did not differ significantly among the dietary treatments. Pre-slaughter weight (PSW), carcass yield, carcass length and loin eye area of lambs were similar between control and treatment groups. Similarly, yield of wholesale cuts, edible and non-edible visceral organs were comparable among groups. Chemical composition, physico-chemical properties and phorbol esters concentration of *Longissimus dorsi* (LD) muscle did not differ significantly among groups. Organoleptic scores and tenderness of pressure cooked LD muscle samples with salt (1.5% w/w) were also comparable among the treatment groups. It may be concluded that soybean meal cake can be replaced with detoxified jatropha meal up to 37.5% in the diet of growing lambs without any apparent adverse impact on carcass yield and meat quality.

Key words: Carcass characteristics, Detoxified jatropha meal, Jatropha, Lambs, Meat quality, Phorbol esters

Jatropha (*Jatropha curcas*) meal is having high CP value (58–60%) with good amino acid profile. Despite good nutrient profile of jatropha meal, its use as feed supplement for ruminants is limited by the presence of the toxin phorbol esters (Makkar and Becker 1999). Ahmed and Adam (1979b) studied the sequential development of the clinical signs and lesions in the organs of desert sheep and Anglo-Nubian goats dosed with jatropha and reported that diarrhoea, reduced water consumption, dehydration, sunken eyes, inappetence and loss in condition were the important signs of poisoning in the sheep and goats. The adverse effects of phorbol esters can be reduced by extraction of the meal using aqueous ethanol or methanol and alkali treatment (Rakshit *et al.* 2008, Elangovan *et al.* 2013, Guedes *et al.* 2014). In view of above, the present study was aimed at assessment of feeding detoxified jatropha meal (dJM) on carcass characteristics and meat quality attributes in lambs.

Present address: [1]Assistant Professor (drsrpatt@gmail.com), Department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, Junagadh, Gujarat. [2]Formerly ADG (HRD) (ksharma52@gmail.com), Flat No 05073, Ats Greens Paradiso, Sector Chi 04, Greater Noida 201310. [3,4]Principal Scientist (dutta65@gmail.com, akpattanaik1@gmail.com), Centre of Advanced Faculty Training in Animal Nutrition; [5]Head (mendiratta_65@yahoo.co.in) Department of Livestock Product Technology.

MATERIALS AND METHODS

Experimental animals and diets: Lambs (24) of about 3 to 4 months of age with an average BW 15.76±1.92 kg were randomly divided into 4 equal groups as per completely randomized design and allocated to 4 dietary treatments dJM-0, dJM-12.5, dJM-25 and dJM–37.5. Lambs in dJM-0 were fed with concentrate mixture containing soybean meal as a major protein source, while those from the 3 groups were fed concentrate mixtures containing dJM to replace soybean meal of control at 12.5, 25 and 37.5% level, respectively, on iso-nitrogenous basis (Table 1). The detoxified jatropha meal was procured as a partner of the project. All the lambs were dewormed prior to experiment and reared under uniform managemental conditions throughout the experimental period of 180 days.

Feeding procedure: All the lambs were housed in well ventilated shed having provision for individual feeding. The reference and test concentrate mixtures were offered daily in the morning at 9.30 AM to meet the nutrient requirements of lambs for maintenance and growth as per Kearl (1982). All the lambs were offered a basal diet of wheat straw *ad lib*. and 100g green (oat/ maize) was given to each animal per day to meet their vitamin A requirement. Fresh water was offered *ad lib.* twice daily to all the animals. The body weights of the lambs were recorded fortnightly in the morning, before feeding and watering. The amount of concentrate and roughage offered and residue left after 24 h was measured to find out the dry matter intake of feed. The ration schedule was adjusted fortnightly after recording the body weights of each animal.

Carcass studies: After 180 days of experimental feeding, all lambs were fasted overnight with free access to water and slaughtered by standard procedures in the experimental abattoir of the Institute after recording pre slaughter weight (PSW). The carcass length (cm) was recorded. Weights of carcass (before and after evisceration), gastro-intestinal tract (full and empty), vital organs, viz. thyroid, liver, kidneys, lungs with trachea, heart and spleen were recorded. The carcass was divided into 7 primal wholesale cuts as per ISI (1963). Loin eye area (cm^2) was determined by tracing on the cut section of *longissimus dorsi* (LD) muscle between the 10^{th} and 11^{th} rib using a butter paper. Weight of edible and non-edible offals were recorded and expressed as g/kg PSW. The LD muscle from left side of the carcass from each animal in respective treatment was pooled and deep frozen for organoleptic evaluation later. The LD muscle from the other side of carcass was individually preserved by deep freezing (–20°C) until further analysis.

Analysis of samples: The samples of feed offered and residues left were analysed for proximate principles (AOAC 2000) and fibre fractions (Van Soest *et al.* 1991). The phorbol esters concentration (%) of raw and detoxified feed samples was determined by using HPLC as per Makkar *et al.* (1997). Representative samples of thawed and minced LD muscle were analysed for chemical composition (AOAC 2000), pH value using digital pH meter and water holding capacity (WHC) by centrifugation technique. The phorbol esters, concentration (%) of vital organs viz. liver, kidney and muscle samples were determined (Makkar *et al.* 1997) by using tissue extracts made by tissue homogenization.

Organoleptic evaluation: Pooled LD muscle samples from each treatment group were pressure cooked with salt (1.5% w/w) and subjected to organoleptic evaluation. The sensory attributes, viz. appearance, flavour/taste, texture/tenderness, juiciness and overall acceptability of cooked meat samples were assessed by 8 panelists, using an 8 point Hedonic scale (Piggott 1984).

Statistical analysis: The data obtained were subjected to analysis of variance using SPSS 11.0 software and treatment means were ranked using Duncan's multiple range tests. Significance of treatments with respect to different characters was declared at $P<0.05$ unless otherwise stated. All the statistical analysis procedures were done as per Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

Chemical composition: The proximate composition and fiber fractions of wheat straw and concentrate mixtures are given in Table 1. All the concentrate mixtures were iso-nitrogenous and comparable with respect to their proximate composition and fibre fractions. The chemical composition of concentrate mixtures and wheat straw offered as basal feed was within normal range and comparable to values reported by earlier workers (Dubey *et al*. 2012). Phorbol esters content was non-detectible in all the concentrate mixtures.

Voluntary feed intake: The mean dry matter intake did not differ significantly ($P>0.05$) among the dietary treatments (Table 2). The intake of concentrates, greens and wheat straw also followed the same trend. Dry matter intake by lambs ranged from 62.5–65.7 g/ kg $W^{0.75}$ and was within the normal range (Kearl 1982); this clearly indicated that all the experimental diets were palatable and non-pungent. The daily intakes (g/kg $W^{0.75}$) of digestible crude protein (DCP) and total digestible nutrients (TDN) were also comparable among the treatment groups. It is understandable because phorbol esters were completely removed from detoxified jatropha meal and could not induce any adverse effect on voluntary feed intake. Phorbol esters are the major culprit in jatropha meal causing toxicity to animals. The clinical signs of toxicity include inappetence, irritant of gastro-intestinal tract leading to diarrhoea (Ahmed and Adam 1979a, b) could not be noticed.

Table 1. Ingredients and chemical composition of feeds

Attributes	Concentrate mixture				Wheat straw
	Control	dJM-12.5	dJM-25	dJM-37.5	
Ingredients composition (% as such basis)					
Maize	25	25	25	25	-
Wheat bran	50	50	50	50	-
Soybean meal	22	19.2	16.4	13.6	-
Detoxified jatropha meal	-	2.8	5.6	8.4	-
Mineral mixture	02	02	02	02	-
Salt	01	01	01	01	-
Chemical composition (% DM)					
OM	92.56	91.75	91.62	91.42	94.08
CP	20.32	20.72	20.46	20.14	3.38
Ash	7.44	8.25	8.38	8.58	5.92
NDF	37.26	34.26	34.29	34.20	85.40
ADF	11.65	11.40	11.43	11.71	57.92
Phorbol esters	Nil	Nil	Nil	Nil	-

Table 2. Voluntary feed intake and plane of nutrition in growing lambs fed dJM

Attributes	Treatments				SEM
	Control	dJM-12.5	dJM-25	dJM-37.5	
Intake, g/d					
Concentrate	335.09	323.53	323.29	308.16	30.71
Greens	21.2	21.2	21.2	21.2	0.00
Wheat straw	326.12	349.09	349.66	311.97	32.28
Total DMI	682.41	693.83	694.16	641.33	67.44
DMI,% BW	2.82	2.98	2.97	2.88	0.287
DMI, g/kg $W^{0.75}$	62.55	65.7	65.36	62.57	6.36
DCPI	4.74	5.1	5.02	4.97	0.105
TDNI	41.98	42.68	43.8	40.62	0.932

Table 3. Carcass characteristics and yield of wholesale cuts in lambs fed dJM

Attributes	Treatments				SEM
	Control	dJM-12.5	dJM-25	dJM-37.5	
Carcass characteristics					
Pre slaughter weight (kg)	25.63	25.90	25.00	22.83	0.71
Empty body weight (kg)	17.46	17.40	17.10	15.39	0.52
Carcass weight (kg)	9.82	9.88	9.78	8.64	0.37
Empty carcass weight (kg)	38.22	38.20	38.8	37.76	0.36
Dressed weight (% PSW)	56.24	56.70	56.8	56.02	0.96
Carcass length (cm)	61.00	63.00	61.00	58.25	1.44
Loin eye area (cm^2)	12.87	13.00	12.80	11.39	0.24
Yield of whole sale cuts (% carcass weight)					
Legs	31.64	32.10	31.60	30.00	0.62
Loin	8.35	8.58	8.23	8.26	0.20
Rack	6.94	6.62	6.32	6.30	0.28
Flank	2.92	3.05	2.90	3.07	0.09
Breast and shank	19.59	20.90	20.00	19.50	0.26
Shoulder	21.03	21.00	20.40	20.70	0.34
Neck	9.54	7.79	10.6	12.2	0.26

Carcass characteristics and yield: Plane of nutrition affects mutton production and carcass characteristics of lambs (Palanivel *et al*. 2010). In the present study plane of nutrition (DCPI: 4.7–5.1 and TDNI: 40.6–42.7 g/kg $W^{0.75}$) was comparable irrespective of treatments and did not adversely affect the carcass characteristics of lambs. The carcass length (cm) and loin eye area (cm^2) and the yield of wholesale cuts (7 parts) expressed as percent of carcass weight, the weights of visceral organs and GIT expressed as percent of PSW and edible: non edible ratio were comparable among treatment groups (Tables 3, 4). It has been reported that dressing percentage (% PSW) varies in the range of 49.3 to 51.55 in different breeds of sheep (Snowder *et al*. 1994). The values of carcass characteristics parameters obtained in present study were comparable with reported values of Koyuncu (2008) in Merino breeds. The yield of wholesale cuts (g/kg of carcass weight) was comparable among dietary treatments. Leg contributed maximum to hot carcass followed by shoulder, breast and shank, irrespective of the dietary treatments as recorded in Barbari male kids (Agnihotri and Pal 1997).

Chemical composition and physico-chemical properties of L. dorsi *muscle:* The chemical composition of LD muscle was comparable (P>0.05) among the treatments (Table 5) and the mean moisture, protein, fat and ash contents were comparable to earlier reports (Palanivel *et al*. 2010) in lambs. Physico-chemical properties of *L. dorsi* muscle did not differ significantly (P>0.05) among the dietary treatments. The pH of *L. dorsi* muscle from all the groups ranged from 5.30–5.35, which is in the acceptable range. Water holding capacity (WHC) is one of the most important features of meat quality, and that enables meat to retain its own or added water during application of external forces such as heating, cutting, grinding or pressing (Forrest *et al.* 1975). No significant (P>0.05) difference was observed with WHC of *L. dorsi* muscle irrespective of the dietary groups. There was no significant difference in muscle pigment concentration among treatment groups, though its concentration is influenced by many factors including species, breed, sex, age, type of muscle and muscular activity (Dhanda *et al.* 2003).

Organoleptic evaluation: Organoleptic scores obtained for sensory attributes of pressure cooked meat samples were similar among the treatments (Table 5). The scores obtained

Table 4. Yield of visceral organs and edible: non -edible ratio by lambs fed dJM

Attributes	Treatments				SEM
	Control	dJM-12.5	dJM-25	dJM-37.5	
Yield of visceral organs (% pre slaughter weight)					
Liver	1.45	1.41	1.42	1.43	0.05
Testes	0.53	0.53	0.51	0.55	0.03
Heart	0.41	0.41	0.42	0.41	0.01
Kidney	0.3	0.31	0.32	0.3	0.01
Spleen	0.13	0.14	0.12	0.14	0.01
Pluck	2.82	2.79	2.79	2.83	0.07
Lungs with trachea	1.74	1.73	1.74	1.7	0.04
GI tract.	33.10	33.00	32.69	32.2	0.05
Head	6.98	6.88	6.87	6.6	0.15
Skin	12.4	12.1	11.9	11.9	0.62
Blood	2.48	2.46	2.51	2.41	0.07
Feet	3.46	3.57	3.8	3.53	0.11
Edible: non - edible ratio	2.51	2.79	2.48	2.56	0.16

Table 5. Chemical composition and physico-chemical properties of *Longissimus dorsi* muscle of lambs fed dJM

Attributes	Treatments				SEM
	Control	dJM-12.5	dJM-25	dJM-37.5	
Chemical composition (% on fresh basis)					
Moisture	72.58	72.80	72.60	73.50	0.53
Protein	21.62	22.00	21.80	21.10	0.60
Fat	2.52	2.44	2.26	2.36	0.20
Total ash	2.28	1.77	2.39	2.03	0.75
Physico-chemical properties					
pH	5.35	5.32	5.31	5.35	0.03
WHC (ml 100 g^{-1})	10.18	9.83	9.78	9.83	0.07
Pigments (ppm)	86.17	81.40	76.10	80.00	3.71
Phorbol esters concentration (% DM)					
Liver	ND	ND	ND	ND	ND
Kidney	ND	ND	ND	ND	ND
Muscle	ND	ND	ND	ND	ND

for appearance, flavour, juiciness, texture/tenderness and overall acceptability of mutton of lambs were comparable with values reported by Romero-Bernal *et al.* (2014) who fed male suffolk lambs with different protein sources like fish meal, soybean meal and rape seed meal and did not found significant difference among treatment groups. In the present study, lambs were kept on high plane of nutrition irrespective of dietary treatments and no adverse effect was evident on the carcass characteristics of lambs. As an animal becomes heavier, its muscle fibre diameter usually increases and it develops more intramuscular fat, and both of these are known to decrease meat tenderness, but concurrent deposition of intramuscular fat (marbling) increases juiciness, thereby increasing the perceived tenderness. Tenderness was strongly correlated with juiciness, and both tenderness and juiciness were highly correlated with overall acceptability of meat (Banon *et al*. 2006). In the present study, all the diets were free from any toxic factor (phorbol esters) and consequently did not exert any deleterious effect on organoleptic properties of mutton.

Concentration of residual phorbol esters in vital organs: Phorbol esters are polycyclic compounds in which two hydroxyl groups on neighbouring carbon atoms are esterified to fatty acids. Phorbol esters (Phorbol-12-myristate-13-acetate) have been identified as the major toxic principles in jatropha (Wakandigara *et. al*. 2013). No residual phorbol esters were detected in kidneys, liver and muscle samples, irrespective of dietary treatments as dJM was almost free from the toxin.

On the basis of above results, it may be concluded that soyabean meal can be replaced with detoxified jatropha meal (dJM) up to 37.5% in the diet of the growing lambs without any adverse impact on the carcass yield and meat quality.

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