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Economic Analysis of *Melia dubia* Cav. Drupe Pulp as New Alternate Feed for Small Ruminants

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Abstract: An experiment was conducted to evaluate the effect of replacing basal diet of goat kids with 20% and 40% of *Melia dubia* Cav. drupe dry pulp to ascertain its effect on body weight, dry matter intake (g day^{-1}), and growth rate, feed conversion ratio and economics of feeding. Twenty four goat kids (average 121 days old and 6.49 kg live weight) were assigned randomly to 0%, 20%, or 40% *M. dubia* dry pulp diets (8 kids diet^{-1}). The study lasted for 90 days. Total mixed rations (TMRs) replaced by *M. dubia* drupe pulp (BF; Basal feed, 20% and 40% *M. dubia* drupe pulp) did not have any significant effect on body weight, dry matter intake, growth rate and feed conversion ratio by the kids of all groups. Inclusion of *M. dubia* drupe pulp in different TMRs of kids reduced the cost of feeding. Replacement up to 40% of normal ration with *M. dubia* drupe pulp was most economical. The investigation divulged that feeding is economically beneficial without any difference in growth performance and hence *M. dubia* drupe dry pulp could be a good alternative feed source.

Keywords: *Melia dubia*, Pulp, Feed, Goat kids, Alternate feed, Small ruminants

Agro-industrial by-products and/or alternate feeds may be economically advantageous in reducing feeding costs and can play an important role in feeding of sheep and goats. These include industrial by-products, agro-by-products, horticulture and vegetable wastes, local grasses, tree leaves, tree pods and tree fruit pulps, weeds and other non-conventional feed resources (Andrade-Montemayor et al 2011, Anon. 2012, Obeidat and Shdaifat 2013, Sirohi et al 2017). The interest in search for alternative/additional food and feed ingredients is of paramount importance mainly because of the global demand for grains which has exceeded the production and stiff competition between man and the livestock industry for existing food and feed material (McCalla 2009). Numerous tree species have been evaluated for their leaf fodder or pod feed quality and their effect on livestock and are advocated to reduce cost of feed by replacing the concentrates (Gunasekaran et al 2014, Gebeyew et al 2015, Navale et al 2017, Sirohi et al 2017). Apart from tree leaves and twigs, pods and fruits also being looked as alternate energy rich feed sources for small ruminants and cattle. However, a meager research has been done on fruit pulp of trees for nutritive value and their potential to be utilized as top feeds. Moreover, the use of alternative feed resources which are adaptive to long dry seasons is important for livestock production in arid areas globally (Gusha et al 2015).

There are a number of lesser-known and under-utilized plants that adapted to local, harsh conditions and have tremendous potential as livestock feed. *Melia dubia* Cav. is one such species, drupes of which could be utilized as top feed. It originates from the Meliaceae family. The species is indigenous to Western Ghats region in India, it is found in Bangladesh, Myanmar, Thailand, Mexico, Sri Lanka, Malaysia, Java, China, America, Philippines and Australia (Thakur et al 2018). It is valued for its high-quality termite and fungus resistant timber, used for furniture, agricultural implements and house construction, as alternative pulp wood species, fuel wood and leaf used as a fodder (Parthiban et al 2009). *M. dubia* is being planted under industrial agroforestry models and is reported to be a amenable agroforestry ideotype (Thakur et al 2018, Bhusara et al 2018) without any allelopathic effect on under-storey crops (Kumar et al 2017, Parmar et al 2018). It's fruit pulp possess many beneficial biological activities (Susheela *et al.* 2008, Sukumaram and Raj 2010). Studies suggest that the apart from possible top feed source the drupe pulp could be a good supplement for various ailments in small ruminants and livestock. While collecting the fruits for seed extraction for commercial seedling production, we observed that deer, goats and cattle browse fallen drupe of *M. dubia* from naturally growing trees in the northern Western Ghats parts in Gujarat, India. After having insight in to the literature no scientific report was encountered regarding feeding studies (either on small ruminants or livestock) of dupe pulp of this species. Hence,

we took this study to evaluate the effect of feeding drupe pulp on growing kids of goat to find out possibilities of it as economic alternative feed resource during lean period..

MATERIAL AND METHODS

The present investigation was carried out in Livestock Research Station, Vanbandhu College of Veterinary Science and Animal Husbandry, Navsari Agricultural University (NAU), Navsari, in 2018. Twenty four goat kids of average 121 days old and 6.49 kg live weight were selected. These kids were distributed for three treatments (representing male and female in each treatment). The kids allotted to each treatment were statistically tested as per CRD design and were found statistically at par in age and body weight within three groups.

Three treatments were arranged in a Complete Randomized Design (CRD) with 8 repetitions. The feeding treatments were according to Indian Council of Agricultural Research, New Delhi, India (ICAR, 1998) feeding standard. Treatments were Control (Basal feed; FB), MDDP20-replacement of basal feed (Sumul dan- pelleted compound cattle feed manufactured in cattle feed factory of Sumul Co-operative Dairy at Chalthan, Surat Gujarat, India by *M. dubia* drupe pulp @ 20%) and MDDP40-replacement of basal feed with *M. dubia* drupe pulp @ 40%. Other fodders fed to experimental kids are given in Table 1 and 2. The feeding period was of 105 days. The first 15 days of the experiment were considered as preliminary period to provide adaptation time to kids for new ration. Mature fresh *M. dubia* drupes were collected from naturally growing trees in Southern Gujarat region, falling in northern Western Ghats of India. Drupes were de-pulped manually and shade dried up to constant weight. Course grounded dry pulp was stored properly. For daily feeding pulp was weighed according to feeding schedule and individually offered to kids of each treatment/group (described later) and after feeding left over was weighed. At the time of feeding of experimental feed kids were shifted in cages individually.

Dry matter intake (DMI g day^{-1}): The feeds and fodders as per the feeding schedule were weighed before feeding and offered separately to the experimental kids. Daily refused dry fodder of each kid was collected. The DMI Kg/100Kg body weight (BW) was calculated by considering body weight of animals during respective observation. The pooled observations pertaining to DMI were worked out by averaging all fortnight observations.

Body weight (BW) and growth rate: The animals were weighed at fortnight intervals, in the morning before feeding on Weigh Bridge. Fortnightly average daily gain (ADG) was calculated for all experimental kids by working out the difference of particular fortnight observation with previous observation of body weight divided by number of days between these two observations. Likewise the pooled ADG was calculated by working out the differences in body weight from first and last observation divided by number of days between first and last observation. The raw data of ADG (fortnightly and pooled) were subjected to statistical analysis.

Feed conversion ratio (FCR): FCR was calculated at the end of the experiment as per procedure described by Mamta and Sharma (2008) using the formula, FCR=Feed consumed (kg)/Gain in live weight.

Economics of feeding: All the day to day records regarding fodders, feeds and supplements supplied to experimental kids were maintained. However, the total quantity of feed ingredients for all individual experimental kids was worked out by considering feed intake/day multiplied by duration of experiment (90 days). The price of farm grown green and dry fodder fixed by Directorate of Research, Navsari Agricultural University, Navsari, Gujarat, India, was used to work out the feed cost. The actual purchase price for Sumul dan from the source was used to calculate the feed cost. The cost of feed ingredients consumed during experimental period was worked out by multiplying it with unit price of particular ingredients (Table 4). Thus, the total cost of ration for whole experimental period was calculated for every kid.

Statistical analysis: All respective observations pertaining feeding experiment were analyzed as per standard statistical procedure using Complete Randomized Design (CRD) as experimental design described by Snedecor and Cochran

Table 1. Proximate composition and mineral matter of tree fodder fed *ad libitum* to experiment kids during study period

Tree Species	CP	EE	CF	NFE	TA	P	Ca
Azadirachta indica	17.04	2.74	29.41	46.27	8.44	0.22	1.90
Leucaena leucophala	23.33	1.92	12.83	55.77	6.15	0.30	1.90
Ziziphus mauritiana	13.10	3.90	40.27	59.81	6.7 0	0.21	1.20
Hardwickia binata	10.80	3.80	27.5	47.3	10.50	0.16	2.86
Pithecellobium dulce	20.20	7.20	24.2	38.10	10.30	0.35	0.96
Samanea saman	24.70	5.90	29.2	35.00	5.20	0.26	1.28

Source: Gaikwad et al (2017); https://www.feedipedia.org/content/feeds?category=13594, accessed on 02/07/2018
CP=Crude protein; EE=Ether extract; CF=Crude fibre; NFE=Nitrogen free extract TA=Total ash; P=Phosphorous; Ca=Calcium

(1980). The means in different treatments were tested for statistical significance using Duncan's multiple range tests with significance difference of P≤0.001.

RESULTS AND DISCUSSION

Effect of feeding of *M. dubia* drupe pulp on goat kids: The findings of investigation evinced that, body weight (BW kg kid^{-1}), dry matter intake (DMI g day^{-1}), growth rate (GR g day^{-1}) and feed conversion ratio (FCR) of Surati goat kids and dry matter intake did not vary significantly (P≤0.001) among groups either fed entirely on basal feed (BF group) or 20% (MDDP20 group) or 40% (MDDP40 group) replacement with *M. dubia* drupe pulp throughout the feeding period (Table 3) after 15 (initial) and 90 days (final) of feeding.

Sirohi et al (2017) replaced standard concentrate mixture with *Prosopis juliflora* pods and found that average daily dry matter intake (DMI)/100 kg body weight did not differ among the groups. They also reported that, goats were not adversely affected in terms of growth performance. Similarly, Obeidat et al (2008) reported that final body weight, average daily weight gain (ADG) and FCR in Awassi male lambs were not affected when *P. juliflora* pods (PJP) were included at rates of 0, 10 and 20% (replacing barely grains) in lamb diets. Similarly, PJP diets offered *ad libitum* to replace the barley grain, fed to nursing Awassi ewes and their lambs, did not showed differences ($P > 0.05$) in dry matter (DM), organic matter (OM), crude protein (CP), and metabolizable energy (ME) intake among groups (Obeidatand Shdaifat 2013). Kushwaha and Rai (2011) fed babul pods *(Acacia nilotica)* to crossbred (Alpine x Beetal) lactating goats, and concluded that feeding of babul pods to the extent of 16.5% in TMR equivalent to 3% tannin in diet could be safely incorporated in the diet of lactating goats without affecting their performance. In present study also there was no effect of feeding *M. dubia* drupe pulp on growth rate of Surati goat kids due to inclusion of dried pulp up to 40%. Ratan and Sawal (2005) found that grounded siris (*Albizia lebbeck*) pod incorporated in feeding diet of rams can be moderate source of protein and energy without adversely affecting live weights and wool production of sheep.

Similar to present finding, Kaur et al (2016) supplemented wheat straw with either conventional concentrate mixture (control) or 40% KMW (kinnow mandarin (*Citrus nobilis* Lour x *Citrus deliciosa* Tenora*)* waste (KMW)) containing concentrate mixture (Treatment) in diet of local goats (age= 8-10 months; BW= 23.00 kg). The mean body weights of the animals were similar throughout the feeding trial irrespective of the diet or period indicating that nutrient supply from KMW was sufficient for maintaining the body weight of the animals. They concluded that KMW could be incorporated up to 40% level in the concentrate mixture without any effect on intake, nutrient digestibility and

Table 2. Composition (%) of concentrate, green fodder, dry fodder and drupe pulp of *M. dubia* offered to experimental kids

Attributes	Concentrate*	Green fodder**	Dry fodder*	*M. dubia* drupe pulp**
Dry matter	90.05	25.00	90.00	29.95
Organic matter	93.20	98.20	89.5	93.66
Crude protein	19.60	2.20	6.00	7.63
Crude fibre	11.20	8.00	39.00	8.31
Ether extract	2.80	0.80	1.00	5.11
Total ash	6.80	1.80	10.5	6.34
NFE	59.60	12.20	43.50	72.60

*Specifications given on Sumul Dan packaging, Sukhadiya (2018), **Sukhadiya et al (2021)

Table 3. Initial and final (After 90 days) body weight (BW), dry matter intake (DMI), growth rate (GR) and feed conversion ratio (FCR) of Surati goat kids fed on different total mixed rations (TMRs) replaced (basal feed Sumul Dan) with *M. dubia* drupe dry pulp

Feeding treatments	Body weight (BW kg/kid)		Dry matter intake (DMI g/day)		Growth rate (GR g/day)		Feed conversion ratio (FCR)	
	Initial*	Final**	Initial*	Final**	Initial*	Final**	Initial*	Final**
BF	7.01^{a}	10.13^{a}	333.098^{a}	375.63^{a}	35.83^{a}	65.00^{a}	20.01^{a}	8.23^{a}
MDDP20	7.27^{a}	10.67^{a}	334.205^{a}	377.47^{a}	47.50^{a}	57.25^{a}	9.49^{a}	8.13^{a}
MDDP40	7.20^{a}	10.58^{a}	334.161^{a}	376.29^{a}	39.17^{a}	83.83^{a}	10.33^{a}	6.24^{a}
SE(m)	0.47	0.78	2.46	2.01	8.93	16.41	4.29	1.32

BF- Basal feed; MDDP20=20% basal feed replaced by *M. dubia* drupe pulp; MDDP40=40% basal feed replaced by *M. dubia* drupe pulp; Same superscript letter in vertical columns denotes non-significant difference according to Duncan's multiple range test (P ≤ 0.001); *After 15 and **90 days of feeding

nitrogen balance. In present study, *M. dubia* pulp up to 40% did not showed any negative effect on growth performance of Kids. Vijay et al (2016) fed male crossbred (Black Bengal x Beetal) kids wheat bran of control ration replaced with tamarind seed meal and found that daily DM intake of kids, body weight and average daily body weight gain between groups did not varied significantly. The results indicated that there was no adverse effect of replacement of wheat bran with tamarind seed meal in the ration of kids.

Economics of total mixed rations (TMRs): The study evinced that the cost (Table 4) of feeding was reduced due to inclusion of *M. dubia* drupe pulp in different TMRs of goat kids. 20% replacement of basal feed with *M. dubia* drupe pulp reduced total cost of TMR to Rs. 492.56 and 40% replacement reduced the feed cost to Rs. 1012.33/group (8 kids). Hence, the investigation suggests that feeding small ruminants could be economically beneficial without any difference in growth performance.

The economics of feeding small ruminants with industrial by-products, agro-by-products, horticulture and vegetable wastes, tree pods and tree fruit pulps, weeds and other non-conventional feed resources have been found economically beneficial when included in feed replacing the costlier concentrates without any effect on growth performance, production (meat, milk, wool etc.) in small ruminants and cattle. Studies on inclusion of mixed grass hay, milled and whole *Acacia tortilis* pods of pastoral goats in the arid rangelands (Lengarite et al 2014); feeding fattening Awassi lambs with diets containing PJP 200 g kg^{-1} of diet (Obeidat et al 2008) and PJP as a feed ingredient for nursing awassi ewes (Obeidat and Shdaifat 2013) have been reported to potentially reduce the cost of feed without compromising with growth and milk production.

Fifty per cent replacement of concentrate mixture similar to that of the standard concentrate mixture of PJP0 (no *Prosopis juliflora* pods) with crushed and entire PJP have been found to make diets economical by Rs. 471.50 and 521.50/quintal basis in PJPG and PJPE, respectively (Sirohi et al 2017). Vijay et al (2016) also reported that among three diets *i.e.* T_1 (concentrate feed without tamarind seed meal), T_2 and T_3 (wheat bran in concentrate feed replaced with a tamarind seed meal at the rates of 1/3rd and 2/3rd (w/w) the cost of concentrate mixture per quintal for T_1 (Rs.1540.00) was maximum followed by T_2 (Rs. 1529.00) and T_3 (Rs. 1515.00) and the cost of feed per kg live weight gain remained non-significant among three groups. They concluded that replacement of wheat bran with tamarind seed meal reduced the cost of concentrate feed. *Albizia lebbeck* pods have been found as a cheaper feed in the arid tropics and can be incorporated as moderate source of

Table 4. Cost and economics of feeding (up to 90 days) Surati goat kids fed on basal feed, and 20 and 40 per cent basal feed replaced with *M. dubia* drupe pulp

Cost of feed ingredients

Item	Cost (Rs. kg^{-1})	Source
Concentrate (Sumul Dan)	16.00	Sumul Co-operative Dairy at Chalthan, Surat Gujarat, India
Green fodder	3.00	As fixed annually by Directorate of Research, NAU, Navsari, Gujarat India
Dry fodder	4.00	
M. dubia pulp	3.00	Considered equal to legume straw, As fixed annually by Directorate of Research, NAU, Navsari, Gujarat, India

Quantity (per group, n=8) of total mixed rations (TMRs) fed to experimental kids during entire feeding experiment

Treatments (kid group)	Concentrate (kg)*	Green fodder (kg)	Dry fodder (kg)	*M. dubia* pulp (kg)	Total (kg)
BF	93.15	169.63	133.89	0.00	396.67
MDDP20	63.18	125.53	101.27	83.25	373.23
MDDP40	34.10	58.71	82.23	157.30	332.34
Total	190.43	353.96	317.39	240.55	1102.33

Cost (INR) of feeding different TMRs fed to experimental Surati goat kids during study period

Treatments (kid group)	Concentrate (Sumul dan)	Green fodder (Tree leaves)	Dry fodder (Gotar)	*M. dubia* drupe pulp	Total	Cost reduction over basal feed
BF	1490.42	508.89	535.55	00.00	2534.86	-
MDDP20	1010.90	376.59	405.07	249.74	2042.30	492.56
MDDP40	545.57	176.13	328.92	471.91	1522.53	1012.33
Total	3046.90	1061.61	1269.55	721.65	6099.70	-

BF - Basal feed; MDDP20=20% basal feed replaced by *M. dubia* drupe pulp; MDDP40=40% basal feed replaced by *M. dubia* drupe pulp

protein and energy, substituting up to 40 % in the concentrate supplements without adversely affecting live weights and wool production of sheep (Ratan and Sawal 2005). Mlambo et al (2002) suggested that *Dichrostachys cinerea* pods can be used by smallholder farmers in place of expensive commercial products, with only inputs required are milling of the pods and storage. These investigations indicate that there are alternative unexplored feed sources which could as good as costlier concentrates. Similarly, *M. dubia* pulp could be a good energy rich cheap alternative feed supplement for goats in semiarid regions rangelands considering its acceptable nutritional characteristics. It can alleviate nutritional constraints in the dry season.

CONCLUSION

The results showed that *M. dubia* drupe dry pulp has a good nutrient content indicating the possibility of using it at up to 40% in goat kids diets to replace basal feed without any negative effect on growth performance. Further, inclusion of *M. dubia* drupe pulp in different TMRs of Surati goat kids reduced the cost of feeding. The *M. dubia* drupe is a good alternative/agro-industry by-product (pulp extracted from drupes to raise seedlings) as a feed source for small ruminants.

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