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Full length research paper

Feeding value of Prosopis juliflora Pod Flour in the concentrate diet of lactating cross bred (F1 Boran x Friesian) dairy Cows

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The experiment was conducted at Holetta Agricultural Research Center with an objective to assess the performance of early lactating crossbred cows (50% Friesian-Boran) fed natural pasture hay supplemented with increasing levels of flours from *P. juliflora* pods replacing wheat bran in a formulated dairy concentrate mix. Five cows with same genetic make-up except for parity were arranged randomly in 5x5 Latin Square Design to receive the control diet i.e., dairy concentrate mix with 0% *P. juliflora* + Natural pasture hay (T_1) ; *P. juliflora* replacing 10% wheat bran + *adlib* Natural pasture hay (T_2) ; *P. juliflora* replacing 20% wheat bran + *adlib* Natural pasture hay (T_3) ; *P. juliflora* replacing 30% wheat bran + *adlib* Natural pasture hay (T_4) ; *P. juliflora* pod flour replacing 50% wheat bran in the mix + *adlib* Natural pasture hay (T_5). Partial replacement of *P. juliflora* for wheat bran up to 50% level of supplementation didn't influence ($P>0.05$) daily basal feed and total dry matter intakes (TDMI) relative to the control groups. Nutrient intakes except for Neutral Detergent Fibre (NDF). Cows supplemented the pod at 10% replacement (T_2) produced higher daily milk yield ($P<0.05$) than cows on the remaining treatments. It can be recommended that the pods' flour from prosopis can be used as alternative energy diet to replace up to 30% of wheat bran in a concentrate mix for lactating crossbred cows.

Key words: Prosopis juliflora pod, basal feed, concentrate mix, wheat bran, nutrient intake.

INTRODUCTION

Attempts in improving dairy productivity and intensifications under Ethiopian situation are currently facing a major challenge due to high feed cost, poor quality and availability. In response to scarcity of feed resources there is a tendency to invoke the prospects for non-conventional feed resources. The alternative approach could be the development of dietary formulations which allow locally available ingredients to be used. Such an approach would reduce feed cost as well as the dependency to imported food and feed materials. Therefore, the search for alternative feed resource has become urgent and in this context, *P. juliflora* pod flour is worthy of consideration. *P. juliflora* is a leguminous tree native to arid and semi-arid regions of North America,Central America and the Caribbean. Although the exact date and source of *P. juliflora* introduction to Ethiopia had not been documented, it was believed to be introduced from India in 1970s by the ministry of Agriculture for conservation purposes (HDRA, 2005). It has green-brown twisted stem, flexible branches and produce flattened, multi-seeded curved pods with hardened pericarp *P. juliflora* pods have been used in livestock diets and produced encouraging results with various animal species in many countries. Studies in Brazil showed that *P. juliflora* pod flour could replace up to 600g/kg of wheat flour in ration of lactating cows and that TDMI, weight gain and milk production increased with an increasing proportion of pod flour (Habit and Saavedra,1988). Preliminary study on chemical composition and animal response using goat under Ethiopian condition suggest that *P. juliflora* contains: Crude protein (CP) 14.8%, Metabolisable Energy (ME) 10.13MJ/kg DM, Ash 4.3%, NDF 43.08%, Acid Detergent

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Table 1. Chemical compositions and *in-vitro* digestibility of feed ingredients used in the study (% DM).

Ingredient	DM	Ash	OM	CP	NDF	ADF	Lignin	DOMD
Wheat bran	88.97	6.77	95.23	16.37	39.78	12.83	3.62	70.89
Noug seed cake	91.69	8.93	91.07	32.28	33.48	25.52	7.16	60.19
Powdered P. *juliflora*	88.42	5.45	94.55	14.59	41.27	27.98	8.81	61.50
Natural pasture hay	89.17	8.58	91.42	5.65	72.41	43.47	7.55	46.66

Fibre (ADF) 27.19%, Total tannin 0.1% and condensed tannins 0.09% and *P*. *juliflora* has a potential to replace about 25% of concentrate ration in fattening goats (Getachew Gebru, personal communication). *P*. *juliflora* is rapidly invading the traditional agro-and silvo-pastoral range lands of the Afar, Oromia, Dire Dawa and Somali regions. The use of crushed pod as livestock feed would definitely contribute to the control strategy. There is limited information on the potential use of *P*. *juliflora* pod flour in dairy rations under Ethiopian situation. This study was thus aimed to assess the performance of crossbred lactating cows when fed with increasing levels of flours from *P*. *juliflora* seed pods replacing wheat bran as an energy source in a formulated dairy concentrate mix.

MATERIALS AND METHODS

Experimental Animal Management, Treatments and Measurements

The study was carried out at Holetta Research Center. A total of 5 lactating 50% F_1 crossbred cows (Boran x Fresian) from same stage of lactation (early lactation, that is on the 5^{th} day after parturition), having similar body weight (350$\pm$30 kg) but differing in parities (1-5) were selected and individual fed experimental diets for an adaptation period of 14 days between subsequent periods and actual measurement of 14 days. All the cows were weighed and drenched with broad-spectrum anti-helminthics (Albendazole 500mg) prior to the start of the experiment. Experimental rations were formulated from wheat bran, Noug seed cake, *P. Juliflora* pod flour, salt and natural pasture hay to the nearest iso-nitrogenous with 18% CP to meet the nutrient requirements of lactating crossbred cows with an initial daily milk yield of 13 kg and 4% butter fat according to ARC (1990). The experimental animals were then randomly allotted to one of the five dietary treatments that consisted of : T_1 = Dairy concentrate mix with 0% *P*. *juliflora* pod flour + Natural pasture hay (control); T_2 = *P*. *juliflora* pod flour replacing 10% wheat bran in the mix + *adlib* Natural pasture hay; T_3 = *P*. *juliflora* pod flour replacing 20% wheat bran in the mix + *adlib* Natural pasture hay; T_4 = *P*. *juliflora* pod flour replacing 30% wheat bran in the mix + *adlib* Natural pasture hay; T_5 = *P*. *juliflora* pod flour replacing 50% wheat bran in the mix + *adlib* Natural pasture hay. The basal feed was offered *adlibtum* at 8:00 am daily while provision for water and factory made mineral blocks were made free of choice. The concentrate mix was offered in equal portions at 5:00 am and 5:00 pm during the morning and evening milking at the rate of 0.5 kg/kg of daily milk produced. Feed offer and refusal samples were taken daily per cow, bulked on a weekly bases and oven dried at 65^{o} C for 48hs to determine daily feed, nutrient intake and digestibility. Samples were then ground to 1 mm sieve size using Cyclo-Tec sample mills for lab analysis. Similarly, the daily milk yield of individual cows were recorded and about 100ml of thoroughly mixed composite morning and evening milk samples at the beginning and the end of each period were used to determine percentage of fat, protein and total solids.

Sample Analysis

All samples of feed offer, refusals and faeces were analyzed for DM, OM, and CP according to AOAC (1990) procedures. NDF, ADF and permanganate lignin were determined by the methods of Van Soest and Robertson (1985). *In vitro* organic matter digestibility of feed offer and refusals were determined using procedures outlined by Tilley and Terry (1963). On the other hand, milk compositions (Fat, Protein and total solids) were determined using NIR-Infrared milk product analyzer (Ver. 1.1, 2000).

STATISTICAL ANALYSIS

Data from milk yield and compositions, voluntary DM and nutrient intakes and digestibility were subjected to analysis of variance (ANOVA) procedure using the model for simple 5x5 Latin Square Design and Statistical software SAS, 2002. Treatment means were separated using Duncan multiple range test. The model used was:

$Y_{ijkl} = \mu + C_i + P_j + T_k + E_{ijkl.}$ Where; Yijkl = The observed response, μ = Overall mean, C_i = Cow effect (parity), P_j = Period effect, T_k = Treatment effect, E_{ijkl} = random error

RESULT AND DISCUSSIONS

Chemical Compositions of Experimental Feed Ingredients

Chemical compositions and *in-vitro* digestibility fractions of feed ingredients used in the experiment are shown below in

.

Table 2. Daily feed dry matter, nutrient intake and apparent digestibility of experimental cows.

	Intake (Kg/day)					Mean	CV%	SEM	Pr>F
	T1	T2	T3	T4	T5				
Hay intake	7.40[a]	7.58[a]	7.87[a]	7.49[a]	7.34[a]	7.54	17.56	1.32	<0.0001
TDMI	12.46[a]	12.61[a]	12.44[a]	12.66[a]	12.17[a]	12.47	11.55	1.44	<0.0001
CPI	1.384[a]	1.385[a]	1.316[b]	1.320[b]	1.314[b]	1.36	11.22	0.15	<0.0001
Concentrate	5.08*	4.98*	4.47*	4.74*	4.51*	4.76			
EMEI	109.04[a]	109.34[a]	106.13[ab]	104.74[ab]	102.72[b]	107.19	11.05	11.84	<0.0001
NDFI	7.16[a]	7.33[a]	7.42[a]	7.44[a]	7.49[a]	7.37	13.07	0.96	<0.0001
ADFI	3.97[b]	3.97[b]	4.24[a]	4.26[a]	4.27[a]	4.14	14.13	0.59	<0.0001

* Not analyzed, TDMI=Total dry matter intake, CPI=Crude protein intake, EMEI= estimated metabolisable energy intake as described by McDonald et al. (2002) i.e. ME (MJ/kg) = 0.016 DOMD, NDFI= neutral detergent fiber intake, ADFI= acid detergent fiber intake,[a-b-c] Means with same superscript in the same row do not significantly differ each other (P>0.05).

Table 3. Daily milk yield (kg/day) and compositions (%) of experimental cows.

	T1	T2	T3	T4	T5	Mean	CV%	SEM	Pr>F
Milk yield,	11.02b	11.45a	10.81b	10.99b	10.28c	10.95	6.07	0.66	<0.0001
Fat%	4.16a	4.44a	4.28a	4.14a	4.10a	4.22	6.54	0.28	0.0689
Protein%	2.63a	2.71a	2.77a	2.81a	2.97a	2.78	9.77	0.27	0.0408
Total solids	11.20b	11.94ab	12.84a	12.56ab	11.72ab	12.04	7.98	0.96	0.340

[a-b-c] Means with same superscript in the same row do not significantly differ each other (P>0.05).

Table1 Most of the concentrate diets for ruminant in Ethiopia constitute wheat bran as energy and noug seed cake as protein sources. These conventional supplements can't easily been found and in most cases are far beyond the economic reach of the poor dairy farmer. The condition is quite worsens under pastoral setting where the use of these supplements can't be justified both from the economic as well as biological point of view. As can be seen from Table 2 above the likelihood of replacing wheat bran with pod flours from *P. juliflora* as energy source would seem very high. There exist strong resemblance for most proximate and detergent fractions between wheat bran and *P. juliflora* pods except for ADF fraction. The higher ADF fraction coupled with a relatively higher lignin constituent influenced the *in-vitro* organic matter digestibility of prosopis compared to wheat bran. Associated to its digestible carbohydrate contents, *P. juliflora* pods are palatable feeds and serve as a good source of energy to replace part of the concentrate rations for ruminants. Pod composition is quite variable and pods from India and Africa appear to have lower levels of desirable carbohydrates and higher levels of unwanted fibre than pods from Peru and Brazil (Pasiecznik *et al*., 2001). In general, the observed result for chemical compositions and fiber fractions from the current trial could either slightly agree or fall within reported ranges by several authors. Sawal *et al*., (2004) indicated 10-15 % DM of crude protein while Getachew Gebru. (2008) reported 13% crude protein content for the whole pod. Recent study conducted in ILRI by Joe (2007) as cited by Getachew Gebru (2008) on nutritional value of Prosopis pods (green on the tree, ripe on the tree and ripe on the ground) in four districts of Kenya also showed some degree of similarity with values in table 2 above in the current study. Reported values for DM, NDF, ADF, CP, Lignin and ash were 87.81%, 42.01%, 29.85%, 11.68%, 7.7%, 5.28%, respectively.

Feed DM and Nutrient Intake of Experimental Diets

Voluntary feed dry matter intakes

The result of the effect of *P. juliflora* pod supplementation on feed DM and nutrient intakes of lactating crossbred cows is presented in Table 2 below. Partial replacement of pod flour from *P. juliflora* for wheat bran at any level of supplementation did not influenced (P>0.05) daily basal feed and total dry matter intakes relative to the control groups. Differences were also noted to be non-significant (P<0.05) among the prosopis supplemented groups that received the prosopis at various levels of replacements. When expressed as a proportion of body weight, the basal feed was consumed on average at the rate of 2.1% while average TDMI was calculated to be 3.5%.

Compared to the control groups intake for both TDMI and hay intake for the remaining dietary treatments seem to be un affected implying the condition for ruminal fermentation in the rumen was ideally met across all dietary treatments . Moreover, higher daily energy and CP intakes that were actually above the requirement of the animals across all dietary treatments, perhaps, contributed to the improved daily feed intake. In general, it can be said from Table 2 above that the wheat bran in the concentrate mix can safely be replaced by up to 50% prosopis without considerable drop (P>0.05) in daily TDM d hay intake. This is in line with those reports by (Silva *et al*., 2007; Camara *et al*., 2009). Inclusion of prosopis above 50% in concentrate mix may help in reducing cost of daily feeding but according to previous research works this can also result in several health complications to the animal due to pods contents of cytotoxic alkaloids that may cause intoxications to cattle, horses, sheep and goats (Silva *et al*., 2007; Camara *et al*., 2009). A study in India by Anon (1981) as cited by Mathur and Bohra (2003) also reported deleterious effects on the health of livestock eating excessive *P. juliflora* pods as well as dry leaves mainly attributed to indigestion and impaction. This effect was caused by the regression of rumen bacterial cellulose activity due to the high sugar content (30%) of the pods. Pods should not also be given as the sole ration to animals because such feed has occasionally fatal constipating effects. Secondly, even animals offered higher levels of pods should be supplemented with phosphorus rich feeds such as wheat bran and cakes. Even though not analyzed, owning to the increase in fibre intake with an increase in the level of prosopis pod in the concentrate mix it can be seen from the table 3 above that the amount of concentrate intake per day on average was slightly decreasing for levels of prosopis replacement beyond 10%. There are, however, reports that negate this substitution and advocate a boost in feed intake when inclusion and/or replacement level of prosopis in the concentrate ration exceed 50%. A study by Habit and Saavedra (1988) in Brazil showed that *P. juliflora* pod flour could replace up to 60% of wheat flour in rations for lactating cows and that DM intake have been increased with increasing proportion of pod flour in the concentrate mix.

Intakes of major nutrients from experimental diets

The result for intake of major nutrients from the total mixed ration of experimental cows is displayed in Table 2 above. Except for NDF, nutrient intakes however were significant (P<0.05) among dietary treatments both when comparisons were made between the control and prosopis supplemented groups and/or among prosopis supplemented groups. Experimental cows that were on the control diet (T_1) and T_2 consumed superior amount of CP (P<0.05) per day over the remaining cows. Moreover, cows on T_2 consumed an extra gram per day of 69, 65 and 71 CP over those cows maintained on dietary treatments 3, 4 and 5. Similarly, while same groups of cows (T_1 and T_2) consumed same amount of ME/day (P>0.05) the amount consumed by both were statistically higher (P<0.05) over cows maintained on dietary T_5. This means that they were consuming an extra energy amounting to 6% per day over these cows (T_5). Experimental cows followed same trend for NDFI (P>0.05) as for the basal and TDMI. However, differences among and between dietary treatments for daily ADFI were statistically detectable (P<0.05) with cows on higher levels of prosopis replacements (T3, T4 and T5) consuming on average substantial amount of ADF equivalent to an extra daily intake of 6.8% compared to their counter parts cows in T1 and T2.

The CP and ME intakes of experimental cows from this trial were adequate and even more than an estimated CP & ME intake requirements (928.5 g/d CP and 102.5 MJ/d ME; ARC, 1990) for the average daily milk produced i.e. 10.95kg from the experimental cows in the current trial. Taking this mean daily milk yield all experimental cows were in general on positive CP and ME in take balance. This can also be calculated to an extra daily extra CP intake of 456, 457, 388, 392, 386 gram and ME intake of 6.54, 6.84, 3.63, 2.24, 0.22 MJ were recorded for T1, T2, T3, T4 and T5, respectively. The reason why these extra intakes didn't happen to boost daily milk yield per cow over and above than that expected during the initial designing of this experiment was not clear. The observed NDFI for all dietary treatments tended to be very high owning to the improved basal feed, CP and ME intakes. NDFI alone consisted on average over more than 59.10% of the daily TDMI implying the majority of the nutrients required for the current milk production and maintenance requirements sourced from the cheaper and fibrous basal feed resource, i.e. hay. Needless to say that the higher ADFI (P<0.05) for prosopis supplementation at a rate above 20% replacements were expected because prosopis pod had higher ADF value than wheat bran (Table 2). In other words, the increasing trend in fibre intake (even though not significant for NDF) with an increase in the proportion of prosopis pod in the concentrate diet has something to do with the higher NDF and ADF contents of prosopis pod. The finding from the current trial for feed DM and NDF intakes conform well to non-significant values reported earlier by Muwalla *et al*., (2010) for kids' supplemented prosopis up to 20% in a concentrate mix replacing barley grain. It would, however, completely disagree with non significant values reported for CP intake in the same study. Similarly, in another study with kids supplemented increasing levels of *prosopis juliflora* pods and sesame hulls Muwalla *et al.,* (2010) indicated substantial improvement in DM, CP, NDF intakes for lower prosopis supplemented groups, even though, this holds true alone for CPI in the present study and as opposed to the finding from the current study higher ADF intakes were reported for lower prosopis supplemented groups. All Variations with previously findings in this regard can be explained by the difference in the species of experimental animal, basal feeds used and the type and level of concentrate feed that prosopis has replaced either in the total ration or concentrate diet.

Milk Yield and Compositions of Experimental Cows

Daily milk yield

Daily milk yields and compositions of experimental cows fed on the different dietary treatments are presented below in Table 3.Differences in daily milk yield of experimental animals for the various dietary treatments were found to be statistically significant (P<0.05) with cows supplemented the prosopis pod at the rate of 10% replacement (T_2) producing higher daily milk yield than cows on the remaining treatments. Inclusion of prosopis pod flour at 50% level of replacement has been observed to significantly (P<0.05) reduce daily milk yield relative to cows receiving the control diet and to those supplemented the pod flour at various levels of replacements. Daily milk yield differences of cows on the different dietary treatments can be presented in the order T2 > T_1 = T3 = T_4 > T_5. Experimental cows on T_2 were producing an extra daily milk yield of 0.43, 0.64, 0.46 and 1.17kg over those cows maintained on dietary treatments 1, 3, 4, and 5, respectively.

In terms of the amount of daily consumed feed, milk productions per kg DM were 0.88, 0.92, 0.87, 0.85 and 0.84kg while the amount produced per kg concentrate was 2.17, 2.56, 2.21, 2.28 and 2.28kg for T_1, T_2, T_3, T_4 and T_5, respectively. This implies for the same amount of feed DM and concentrates consumed per kg daily milk yield cows on dietary treatment two were relatively producing higher milk with less daily investments made in feed. If not for the higher soluble sugar and ether extract contents of prosopis, the higher daily milk yield for cows on T_2 can't be justified since proximate and detergent fraction in Table 2 above are more in favor of wheat bran. Secondly, the improved average daily milk yield from cows on dietary T_2 may be speculated to the combining effect of flours from *P. juliflora* with concentrate mix and efficient utilisation of dietary fibrous feed resources used in the experiment. Globally several authors advocated the feed value of prosopis but with varying degree of replacements for conventional dairy concentrates. According to Van der Maesen and Oyen (1997) the most economic ration for lactating cows in Hawai, Peru, Chile, Argentina, Uruguay and Brazil was when the pods were used in concentrate rations of dairy cows at a ratio of 40-60%. The result from this study can also be matched to previous research reports in India where inclusion of up to 30 % pods in the diet maintained dairy performance (Talpada and Shukla, 1988; Pandya *et al*., 2005). Possible reason for inconsistencies in the level of recommendations can be linked to variations in nutritional quality of the pods used to make up the dairy concentrate mixes, the method of pod processing, other experimental ingredients in the basal and concentrate ration, the breed used and stage of lactations.

Milk Compositions

Except for total solids dietary treatment effects were non-significant (P>0.05) for milk composition. Prosopis supplemented groups in general were better for total solids with cows particularly receiving the prosopis at the rate of 20% replacement levels producing significantly (P<0.05) higher amount of total solids than cows on the control diet. Even though, numerical, an increasing trend in milk protein content observed with an increase in the level of prosopis replacement in the concentrate diet.

Pandya *et al*. (2005) in a lactation study with crossbred (Jersey x Kankrej and Holstein Friesian x Kankrej) cows fed total mixed rations with 10% and 20% prosopis replacement reported values of 4.01 and 4.05%, respectively for milk fat content both of which can be defined within the range of the present study. In general, similar value for milk fat content over cows receiving the control diet may be associated to higher and better utilization of dietary fibre in the ration leading to more precursors for mammary lipid synthesis. Unlike, Pandya *et al*. (2005) variation among the different dietary treatments for total solids contents of the milk from the present study were significant (P<0.05). The mean value for total solids from this study can safely be compared to the 12.66% value reported by Zelalem Yilma (1999) for crossbred cows maintained under different feeding regimes in the central highlands of Ethiopia. The probable reason for the difference in total solids of prosopis supplemented group (T3) over the control group in the present study while milk fat and protein continents were still non-significant can be attributed to the variations in other milk compositional constituents like solid not fat and lactose which in turn can be influenced by the level of dietary fiber, fat and soluble CHO intakes from the prosopis pod flour. In summary, it can be said that given the data set we have from Table 3 above milk compositions cannot be depressed at any level of prosopis replacement up to 50% compared to cows on the control diet.

CONCLUSIONS AND RECOMMENDATIONS

From the current trial in general, it can be recommend that the pods from prosopis can safely be used as a cheaper feed resource replacing up to 30% of wheat bran in a concentrate mix for lactating cross bred cows without any reduction in the daily milk yield and quality. Unprocessed seeds pass through animals undigested, so the pods should be finely ground before feeding to maximize utilization. Thus changes in the sieve structure needs to be defined to facilitate proper grinding. Research is required to prevent insect attack before collection of pods in the field and during storage before feeding. Studies are also needed to evaluate the relationship between pod maturity, nutrient concentrations and toxin content so that the best harvesting time can be defined for farmers and with minimum insect damage. Experiments need to be conducted to evaluate the extent of Phosphorus supplementation with increased levels of pods in the diet of lactating cows.

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