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Nutritional Evaluation of Sheabutter Fat in Fattening of Yankasa Sheep

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Abstract: Fifteen Yankasa rams, balanced for their weight, were used to evaluate the effects of feeding basal diet of *Pterocarpus erinaceus* forage supplemented with Sheabutter Fat (SBF) based concentrate diets on performance, nutrient digestibility and economic benefit. The rams were submitted to four supplemental diets containing: 0 g/kg SBF (control), 50 g/kg SBF and 100 g/kg SBF in a completely randomized design for 56 days. Average Daily Gain (ADG), intakes of Ether Extract (EE) and Crude Protein (CP), Feed Conversion Ratio (FCR), digestibility coefficients of EE and Organic Matter (OM), digestible OM, digestible and metabolizable energy concentrations and net benefit improved ($p<0.05$) with increasing levels of SBF supplementation. While forage intake was reduced ($p<0.05$) in SBF diets, the reverse was the case for the concentrate ($p<0.05$). Dry Matter (DM) intake and intake as the percentage of live weight, CP, OM and Crude Fibre (CF) intakes and CF digestibility were similar among the treatments. SBF diets improved ($p<0.05$) digestibilities of DM and CP compared to the control. OM intake was higher ($p<0.05$) in 50 g/kg SBF than in the control which compared with 100 g/kg SBF. Cost of feed consumed/sheep was lower ($p<0.05$) for 100 g/kg SBF compared to the control and 50 g/kg SBF. Feed cost/kg of mutton decreased ($p<0.05$) progressively from the control to 100 g/kg SBF. Differential and relative benefits were more ($p<0.05$) for 100 g/kg SBF than for 50 g/kg. 100 g/kg SBF supplementation improved the performance, nutrient digestibility and economic benefit.

Key words: Sheabutter fat, performance, digestibility, economic benefit, yankasa sheep

INTRODUCTION

Fat is an important energy component in the diet of ruminants and over the last decade fat supplementation has become a common practice to increase the energy density of the diet for high producing dairy cows. Recent advances have renewed the interest in dietary fats and lipid metabolism. Primary sources of lipid in the ruminant diet are forages and concentrates, although the lipid content can be increased by the use of fat supplements. Fat supplements that are by-products of rendering and vegetable oil refining industries contain the lipid predominantly as triglycerides whereas rumen-protected supplements of Ca-salts are comprised of free fatty acids. There are, however, conflicting reports on the beneficial effect of fat supplementation in livestock. For example, Chilliard (1993) observed that dietary fat did not affect gain in body weight or body condition score after peak lactation but tended to increase body weight loss during early lactation and body fat deposition in growing cattle but increased body fat in growing pigs and decreased body weight loss in lactating sows. The extent to which added fat improves the efficiency of the diet varies with the amount of supplementation, livestock species and age of the animal (Ironkwo and Oruwari, 2004).

Sheabutter Fat (SBF), obtained from sheabutter seed, is a readily available and cheap cooking ingredient in the northern parts of the country where the tree grows virtually everywhere. Sheabutter tree (*Vitallaria paradoxa*) is a wild plant species thriving abundantly in the guinea and derived savanna woodland zones of Nigeria, especially on poor soil. It belongs to the family sapotaceae and was named *Butryospermum paradoxa* until recently when the name was changed to *Vitallaria paradoxa* (Keay, 1989). Several authors (Hilton, 1982; Lovell, 1989; Watanabe, 1982 and Desilva *et al*., 1995) indicated that the sheabutter lipid is digested with ease and so serves as a better energy source for protein sparing than carbohydrate as well as sources of essential fatty acids. There are no published reports on the feeding value of sheabutter fat for ruminants. This study therefore aimed at assessing the effects of feeding concentrate containing graded levels of SBF as supplement to basal forage of *Pterocarpus erinaceus* on the performance, nutrient digestibility and economy of production of Yankasa sheep.

MATERIALS AND METHODS

Experimental site, design and animal management: This study was carried out at the goat unit of the Teaching and Research Farm of Federal College of Wildlife Management, New Bussa, Niger state. The building is of open sided type that permits cross-ventilation in the animal house, with a concrete floor and zinc-roofing sheet. It is located between latitude 70 80´ and 100 00´N longitude 40 30´ and 40 33´E. The temperature and relative humidity averaged 34°C and 60% during the period of the study.

Fifteen male sheep of Yankasa breed with average initial weight Body Weight (BW) of 25.2±1.51 kg were used. The animals, which were balanced for the weight, were purchased from villages located within 15 km of the College. On arrival, the sheep were given prophylactic treatment and a Vitamin B complex, at the dosage of 1 ml/10 kg body weight of the animal. They were also drenched with albendazole to control endoparasites and dipped in diazintol solution against ectoparasites. Housing of the animals was in individual pens, which were cleaned and distinfected with izal solution before the animals arrived. The feeding trial lasted for 8 weeks, preceded by 3 weeks of adaptation to the pen and experimental diets. Records of initial and weekly live weight and daily feed intake were kept and the nutrient intake and feed conversion efficiency were calculated.

Experimental diets: The animals were assigned to 3 isocaloric and isonitrogenous dietary treatments containing 0, 50 and 100 g/kg sheabutter fat in a completely randomized design. The diets were formulated such that the total dietary fat level did not exceed the 70 g/kg dietary dry matter (Jenkins, 1993, Chalupa *et al.*, 1996, NRC, 2001) which has been reported to adversely affected rumen microbial fermentation. Ingredient composition of the experimental diets is given in Table 1. The basal diet was wilted forage of *Pterocarpus erinaceus* which was offered *ad libitum* while the concentrate diet was fed at 30 g/kg BW. Feeding was twice in a day at 08.00 and 15.00 h. Water supply in the pens was regular throughout the experimental period.

Digestibility trial: This was carried out immediately after the growth trial by collecting the faecal samples. The quantity of feed offered, feed residue and faeces were determined for the 7 days collection period. Ten percent of the faeces collected daily were pooled over the 7-day period and then taken for laboratory analysis.

Economic analysis: Cost effectiveness of SBF supplementation was assessed using prevailing market prices to cost the concentrate diet and mutton. The cost of the basal diet was estimated by computing the cost of labour for lopping the foliage of the plant which was naira 5/kg as at 2004. The cost of the feeds consumed and the value of the weight gain by the animals throughout the feeding trial was computed for each sheep to quantify accruable net benefits.

Chemical analysis: Feed and faecal samples were analysed according to the official methods of analysis (AOAC, 1990). The neutral detergent fibre and acid detergent fibre components of the basal forage were determined by methods of Van Soest *et al.* (1991).

Table 1: Composition of the experimental diets (g/kg)

	Sheabutter Fat (SBF) (g/kg)		
Ingredient	0	50	100
Cassava meal	740.0	495.0	290.0
Maize offal	60.0	272.0	465.0
Groundnut cake	90.0	100.0	60.0
Blood meal	100.0	73.0	75.0
Sheabutter Fat (SBF)	-	50.0	100.0
Salt	5.0	5.0	5.0
Premix	5.0	5.0	5.0
Total	1000.0	1000.0	1000.0
Calculated content			
Crude protein	157.2	155.6	154.9
ME (MJ/kg)	14.27	14.31	14.35

ME, metabolizable energy

Table 2: Chemical composition of the basal and experimental diets (g/kg)

	Basal forage	Sheabutter Fat (SBF) (g/kg)		
	Pterocarpus erinaceus	0	50	100
Dry matter	306.0	921.8	919.2	920.7
Crude protein	151.0	165.0	164.1	163.7
Crude fibre	273.0	61.6	95.7	100.7
Ether extract	24.0	24.1	52.2	70.3
Ash	78.0	65.1	54.2	48.3
NFE	473.0	674.2	633.8	618.0
Organic matter	228.0	856.7	865.0	872.4
NDF	524.1	ND	ND	ND
ADF	396.0	ND	ND	ND

ND, not determined

Statistical analysis: Generated data were subjected to analysis of variance using completely randomized design (Steel and Torrie, 1980) and significant means were separated using Duncan's multiple range test (Duncan, 1955). Differences among treatment means were considered significant at the $p<0.05$ level.

RESULTS

The chemical compositions of the basal and experimental diets are presented in Table 2. Intake of forage was significantly ($p<0.05$) higher for the animals on the control diet compared to those animals on sheabutter fat based diets (Table 3). In contrast to the forage intake, concentrate intake was more ($p<0.05$) in sheabutter based diets. Dry Matter Intake (DMI) and DMI expressed as a percentage of live weight and in g/kg$W^{0.75}$ were not significantly ($p>0.05$) affected by the dietary treatments. Crude protein and crude fibre intakes (g/kg$W^{0.75}$/day) were similar among the diets. Organic Matter Intake (OMI) (g/kg$W^{0.75}$/day) was higher ($p<0.05$) in 50 g/kg SBF than in the control which compared with 100 g/kg SBF. Ether Extract Intake (EEI) (g/kg$W^{0.75}$/day) significantly ($p<0.05$) varied among the diets in this order: 100 g/kg SBF > 50 g/kg SBF > 0 g/kg SBF. Sheep on 100 g/kg SBF supplementation had the best FCR, followed by 50 g/kg SBF and 0 g/kg SBF supplementation (control) least. Average daily gain

Table 3: Feed intake and weight gain parameters of Yankasa sheep supplemented with sheabutter fat diet

	Sheabutter Fat (SBF) (g/kg)			
Parameter	0	50	100	SEM
Initial weight (kg)	25.2	25.3	25.2	
Final weight (kg)	31.70^{b}	34.60^{ab}	37.30^{a}	0.81
Total weight gain (kg)	6.50^{c}	9.37^{b}	12.00^{a}	0.56
Average daily gain (kg)	116.07^{c}	167.32^{b}	214.29^{a}	13.12
DM intake (g/day)				
Forage	951.33^{a}	910.40^{b}	916.33^{b}	5.87
Concentrate	445.62^{b}	494.40^{a}	503.67^{a}	15.35
Total	1396.95^{a}	1404.80^{a}	1420.00^{a}	60.64
DMI (% live weight)	4.91^{a}	4.70^{a}	4.54^{a}	0.23
DM intake (g/kgW$^{0.75}$/day)	113.39^{a}	109.84^{a}	107.33^{a}	6.78
CP intake (g/kgW$^{0.75}$/day)	17.55^{a}	16.91^{a}	16.62^{a}	1.16
OM intake (g/kgW$^{0.75}$/day)	48.59^{b}	49.69^{a}	49.00^{ab}	0.34
CF intake (g/kgW$^{0.75}$/day)	23.31^{a}	23.13^{a}	22.74^{a}	0.78
EE intake (g/kgW$^{0.75}$/day)	2.72^{c}	3.73^{b}	4.37^{a}	0.20
Feed conversion ratio	12.04^{a}	8.40^{b}	6.63^{c}	0.65

^{a,b,c}means with different superscripts along the same row differ significantly (p<0.05)

Table 4: Apparent of digestibility and energy concentrations of Yankasa sheep supplemented sheabutter fat diet

	Sheabutter Fat (SBF) (g/kg)			
Apparent digestibility	0	50	100	SEM
Dry matter	72.24^{b}	80.15^{a}	84.75^{a}	2.50
Crude protein	70.03^{b}	79.56^{a}	77.87^{a}	3.20
Crude fibre	72.42^{a}	69.91^{a}	74.65^{a}	5.41
Ether extract	51.08^{c}	62.12^{b}	71.98^{a}	4.03
Organic matter	71.15^{c}	80.89^{b}	87.65^{a}	2.51
Digestible OM	77.15^{c}	88.42^{b}	96.47^{a}	2.66
Energy concentration (MJ/kg)^{a}				
Digestible energy	14.66^{c}	16.80^{b}	18.33^{a}	0.48
Metabolizable energy	11.57^{c}	13.26^{b}	14.47^{a}	0.41

^{a,b,c}means with different superscripts along the same row differ significantly (p<0.05), ^{a}Determined by MAFF (1984 equation)

(ADG) was more (P < 0.05) pronounced in 100 g/kg SBF compared to 50 g/kg SBF which was superior (p<0.05) to the control.

DM matter digestibility was superior (p<0.05) for sheep fed 50 and 100 g/kg shea butter fat compared with those on the control diet (Table 4). However, there were no differences (p>0.05) among the treatments in the digestibility CF. CP digestibility was higher (p<0.05) in 50 and 100 g/kg SBF than in the control. EE and OM digestibilities and digestible OM followed a similar trend to the EEI, with 100 g/kg SBF highest, 50 g/kg SBF intermediate followed by 0 g/kg SBF lowest (all p<0.05). Similarly, SBF markedly (p<0.05) varied the digestible and metabolizable energy in this order: 100 g/kg SBF > 50 g/kg SBF > 0 g/kg SBF (Table 4). Total cost of feeding were higher (p<0.05) in the control and 50 g/kg SBF compared to 100 g/kg SBF. Cost of feed/kg mutton was lowest (p<0.05) for 100 g/kg SBF, highest (p < 0.05) with 0 g/kg SBF and intermediate (p<0.05) with 50 g/kg SBF. Value of mutton and economic net benefit were lowest for sheep fed 0 g/kg SBF, intermediate for 50 g/kg and highest with 100 g/kg (all p<0.05). Differential and relative benefits were lower (p<0.05) for 50 g/kg than 100 g/kg SBF.

DISCUSSION

The chemical composition of the Pterocarpus foliage was similar to the report of Ouédraogo-koné *et al.* (2008). The higher forage intake by sheep fed the control diet could possibly be attributed to the fact that they consumed less of the concentrate diet which was more consumed by the animals on the sheabutter diets. Consumption of more concentrate diet by the sheep fed sheabutter fat based diets could be due to improved palatability and reduced dustiness of the concentrate diets, which were in mash form, as a result of lipid supplementation since the diets were isocaloric. The result confirms the earlier reports (Ironkwo and Oruwari, 2004; Bamgbose *et al.*, 2008) who indicated fat supplementation improves the physical consistency of mash-type diet and reduces dustiness, enhances dispersion of micro ingredients, palatability and feed intake. Similar results were found by Nguyen and Mai (2004) who reported that groundnut oil improved feed intake in cattle. Though higher for sheep fed sheabutter fat supplemented diets, total DMI was not significant obviously because the sheep on the control diet consumed more of forage to make up for the reduction in the concentrate intake. This is in consonance with the report of Phengvilaysouk and Wanapat (2008) who indicated that supplementation with coconut oil (6% of the diet DM) did not affect total DM intake but contradicts the reports of Lough *et al.* (1993) and Bessa *et al.* (2005) who observed a depression in intake when forage fed lambs were supplemented with lipids. The conflicting reports on effect of lipid supplementation of feed intake may be due to differences in lipid energy concentration of the experimental diets or a metabolic effect of the increase of lipid intake (Palmquist, 1994). DMI as percent of the body weight was higher than the value of 1.5-2.8% reported by Undi *et al.* (2001) for sheep on maize stover/legume diets. Variations in the diet, age and breed of sheep used possibly account for the difference. The significantly increasing EEI as levels of SBF supplementation increased appears logical since the EE content of the diets increased progressively and was within the recommended threshold level. The superior FCR of SBF diets indicated that sheep on these diets were able to digest and convert the diets into body tissue with the higher degree of efficiency than those on control diet. Similarly, Nguyen *et al.* (2008) reported better FCR for cattle drenched with oil. While diet 100 g/kg SBF improved ADG by 28 and 85% compared to 0 and 50 g/kg SBF diets, respectively, 50 g/kg SBF enhanced ADG by about 44% in relation to 0 g/kg SBF. The lowest ADG recorded for the sheep fed the control diet (0 g/kg SBF) could be due to lower efficiency of

Table 5: Economic evaluation of sheep supplemented with diets containing shea butter fat

	Sheabutter Fat (SBF) (g/kg)			
Parameter	0	50	100	SEM
Cost/kg concentrate feed (Naira)	22.70	21.23	19.20	
Forage consumed, kg	53.27	50.98	51.31	0.33
Concentrate consumed (kg)	24.95	27.69	28.20	0.86
Cost of forage consumed (Naira/sheep)	213.08[a]	203.92[a]	205.24[a]	7.83
Cost of concentrate consumed (Naira/sheep)	566.36[ab]	587.86[a]	541.44[b]	14.52
Total cost of feed consumed Naira/sheep)	779.44[a]	791.78[a]	746.68[b]	16.87
Total weight gain (mutton) (kg)	6.50[c]	9.37[b]	12.00[a]	0.56
Cost/kg of mutton (Naira)	400	400	400	
Cost of feed (Naira) / kg of mutton	119.91[a]	84.50[b]	62.22[c]	6.63
Value of mutton (Naira)	2600[c]	3748[b]	4800[a]	90.80
Net benefit (Naira)	1820.56[c]	2956.22[b]	4053.32[a]	52.54
Differential benefit (Naira)	-	1135.66[b]	2232.76[a]	47.21
Relative benefit (%)	-	62.38[b]	122.64[a]	10.84

[a,b,c]Means with different superscripts along the same row differ significantly ($p<0.05$), Naira = Nigerian's unit of currency; $ 1.00 = Naira 120.00

nutrient utilization (Haile *et al*., 2004). The markedly improved ADG of sheep on SBF diets would be a logical consequence of better FCR, DM and OM digestibility coupled with significantly higher energy concentrations of the diets. It could as well be attributed to the protein-sparing action of fat included in the diets thereby making more protein available for tissue synthesis. This result agrees with those of previous workers who reported increased weight gains with fat supplementation (Santos-Silva, 1997; Nguyen and Mai, 2004; Ironkwo and Oruwari, 2004), but disagrees with that of Bessa *et al*. (2005), Lough *et al*. (1994) and Santos-Silva *et al*. (1998) who did not find any effect of lipid inclusion on the growth rate of lambs. The effect of lipid supplementation on growth of forage-fed ruminants is dependent on the forage type, the nature and level of lipid inclusion and the characteristic of the animals used in the experiments, which justifies the difference in the results between trials (Lough *et al*., 1993, 1994; Santos-Silva *et al*., 1998). The results confirm previous reports that fat supplementation enhances the efficiency of feed utilization and causes stimulation of weight gain by animals (Ironkwo and Oruwari, 2004). The pronounced improvement in apparent digestibility of DM, CP and OM of SBF supplemented diets is in agreement with Wanapat *et al*. (2005), who illustrated that digestion coefficients of DM, OM and CP were significantly improved by supplementation with 4% coconut oil plus 2% urea (57.3, 60.7 and 59.1%, respectively). Similarly, Phengvilaysouk and Wanapat *et al*. (2005) noted that it is possible to improve feed intake, digestibility and the feeding value of rice straw with oil supplementation. The higher apparent digestibility of fat observed for 100 g/kg SBF could be attributed to an improved emulsification of fat and its absorption in the sheep intestine. According to Chalupa *et al*. (1996), intestinal absorption of products that contain high amounts of stearic acid can be high if they contain some oleic acid which probably enhances emulsification in the intestine. Though the fatty acid components of SBF were not characterized in this study, it could be that the SBF is high in stearic and oleic acids. Previously, Ranjhan (2001) reported that fat supplementation improves the digestion coefficient of ether extract as the fats are more digestible. The estimated energy concentrations indicate that available energy for nutrients metabolism and utilization increased progressively with increasing levels of SBF supplementation. Phengvilaysouk and Wanapat (2008) earlier reported that lipid supplementation could improve the energy concentration of diets. The beneficial effect of fat supplementation in current study could be explained by the assertion earlier submitted by Church (1976) and Preston and Leng (1987) that adding high levels of fat increased microbial activities. Normally, the fat content of ruminant diets is low (< 50 g/kg) and if it is increased above 100 g/kg the activities of rumen microbes are reduced (McDonald *et al*., 2002). Furthermore, lipid supplementation has been reported to significantly reduce the protozoa population in the rumen (Nguyen *et al*., 2001; Seng *et al*., 2001; Nguyen *et al*., 2005; Wanapat *et al*., 2005) but increase the numbers of bacteria (Nguyen *et al*., 2005; Phengvilaysouk and Wanapat, 2008). The consequence of this is that more propionate, which is glucogenic and acts as an important precursor for gluconeogenesis, will be produced and this will result in provision of copious energy substrate for nutrient utilization since bacterial fermentation is accompanied by preponderance of propionate in the volatile fatty acid proportion (McDonald *et al*., 2002). As reported, supplementation of coconut oil improves rumen fermentation in terms of the fermentation end-products (Wanapat *et al*., 2005) and eliminating the protozoa from the rumen of cattle and sheep has been shown to improve growth rates, as the bacterial population increases and the microbial protein flow from the rumen is increased when the protozoa are absent (Leng, 1989). Since the experimental diets were isonitrogenous and isocaloric, it appears that SBF possesses some qualities or properties which enhance its utilization by the sheep. It thus becomes imperative to characterize the fatty acids of SBF.

Cost of feed per kilogramme of mutton produced showed that 100 g/kg SBF was more economical since animals consumed less amount of feed to produce more flesh. This could be attributed to the fact that the animals consumed the least amount of feed and produced highest quantity of mutton. The higher economic benefits in SBF supplemented sheep over and above that of the control vividly demonstrated the comparative cost advantage and effectiveness of inclusion of SBF in the sheep ration. Differential benefits showed that sheep fed 50 and 100 g/kg SBF supplemented diets had higher benefits of N 1,135.60 and N 2232.76, respectively than the control. Also, SBF supplemented diets resulted in benefits 62.38 and 122.64% higher than the control which implies that benefits as much as 62.38 and 122.64% could be made by feeding 50 and 100 g/kg SBF supplemented diets. However, the significantly higher differential and relative benefits for 100 g/kg SBF than 50 g/kg SBF imply that 100 g/kg SBF is more profitable. Similar results were found by Nguyen and Mai (2004) who reported that groundnut oil supplementation improved profitability.

Conclusions: Animals on 100 g/kg SBF fattened and performed better than the control and 50 g/kg SBF which also fattened more than the control. It is therefore concluded that inclusion of SBF, particularly at 100 g/kg, is beneficial to sheep as it improved the performance, nutrient digestibility as well as accruable economic benefits. Further research is, however, required on characterization of the fatty acid constituents of SBF and using higher levels than that used in the current study.

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