Asian Science Bulletin

OPEN ACCESS

Effect of Partial Replacement of Groundnut Cake with Baobab Seed Cake on Milk Production and Quality of Desert Goats

[1]Dalia, Abdelrahman Mohammed Al Basheir and [2]Ibrahim, Bushara

[1]Department of Animal Biotechnology. Faculty of Animal Production, University of East Kordofan, Sudan

[2]Department of Animal Production, Faculty of Natural Resources and Environmental Studies, University of Kordofan El-Obied, Sudan

ABSTRACT

Background and Objective: Baobabs trees are widespread all over the hot, drier regions of Sudan. Baobab seeds are rich in protein and contain the amount of energy and crude protein which can be used as animal feeds. With scarcity of range with folders there is needed to search for another source of feeding. This study, therefore, investigated to study the effect of grazing desert goats fed varying levels of baobab seed cake (BSC) on milk yield and composition. **Materials and Methods:** This experiment was conducted in Al-Newala Village South ELObied town, Sheikan locality in North Kordofan State, Sudan. Twenty four adult pregnant doe's of desert goats were randomly allotted to four dietary treatments with six animals per replicate in a completely randomized design to determine the quantity and quality of milk produced. The experiment goats were separated into four supplementary feeding groups. Group A was used as a control, the second group B was supplemented with a diet of 65% (BSC), group C with a diet of 55% (BSC) and group D was supplemented with 45% (BSC). All goats were released for free grazing. **Results:** The results revealed that feeding with (BSC) had a highly significant ($p<0.05$) effect on milk yield on 60 days, total milk and daily milk yield. Group B recorded highest significantly ($p<0.05$) more milk (106.67 kg) than those in groups C and D at 93.75 and 82.58 kg, respectively. Group A showed the lower milk (77.17 kg). Daily milk yield indicated that the goats supplemented with (BSC) produced significantly ($p<0.01$) more milk than control groups. The data indicated that supplementation had exerted a significant ($p<0.05$) effect on fat during 1-15 and 30-45 days with higher fat percentage in group C in 45-60 days. Protein showed a significant ($p<0.05$) effect on 15-30 and 30-45 days. Lactose and ash content secure non-significant affected by baobab seed cake supplementation. **Conclusion:** Supplementation with baobab seed cake diet to Sudanese desert goats during the dry season improved milk production and inclusion of baobab seed cake at 65% in the diet of desert goats gave the highest milk yield.

KEYWORDS

Desert goat, supplementation, baobab seed cake, milk production, groundnut cake

INTRODUCTION

Goat production plays an important role in the livelihood of rural populations in Sudan[1]. It significantly improves health and family nutrition. Sales of animals and their products help to stabilize household income and are used as a source of food security. Milk from ruminants is a good alternative to augment

ISSN: 1813-0070 (Online)
https://doi.org/10.3923/asb.2024.272.279

Received: 05 Nov. 2023
Accepted: 29 Mar. 2024
Published: 30 Sep. 2024

animal protein intake[2]. Increased awareness of the importance of milk in tropical areas has led to increased demand for milk and its products[3]. With the increased population, there is increased demand for milk and its products in the tropics, which has informed the need to raise goat milk, even outside their natural environment[4,5]. Milk quality and quantity is very dependent on the type of feed used in dairy farming[6]. Milk production from small ruminants in the tropics is often limited by poor nutrition and inadequate energy, protein, mineral and vitamin intake by the animals[4]. In order to maximize opportunities presented for milk production by goats, there is a need to improve the nutrition of the milking goat.

The desert goat is an indigenous goat breed found in Western Sudan. Records of its dairy performance in the natural environment it produces a low quantity of milk when compared with other goat breeds[7]. In Sudan, the traditional ruminant livestock feeding system mainly depends on the use of forage, native grasses, legumes and field grass originating from the surrounding environment with low nutritional quality affect productivity. In the extensive systems, livestock production is facing problems such as scarcity and fluctuating quantity and quality of the year-round feed supply during the dry summer[8,9].

As a result, animals consume a higher quantity of less palatable species and protein content, which consequently results in loss of body weight and low milk production. Using concentrate rations to improve low-quality dry season feeds is limited by high cost and competition with humans. This high competition for the consumption of conventional protein sources between human beings and the animal industry has resulted in a declining supply of proteins. Feeding ruminant livestock generally becomes a challenge to farmers during the dry season but due to their small herds, the small-scale farmers are the hardest hit given the high feed costs, especially energy and protein sources. So it is significant to improve the quality of feed and provide adequate good-quality feed and explore new kinds of feed sources to increase the quality of milk and maintain their productivity while mitigating climate change[10].

The problem of feed shortage can be addressed by the use of locally produced good quality alternative non-conventional feed materials that are nutritious and affordable[11,12]. Therefore, research on low-cost and locally available indigenous protein sources is very important, especially those that do not attract competition with human beings. Utilization of local indigenous multipurpose tree products and by-products, such as oil seed cakes and leaf meals is one such possible alternative. Use of non-conventional feed ingredients especially when it encourages a shift to other ingredients that are not edible to man but readily available will minimize the cost of feed and maximize the returns from goat's production[9].

Many researchers have indicated that one of the best potential low-cost and locally available protein sources in goat diets is baobab seed cake[13]. Baobab trees are widespread all over the hot, drier regions of tropical Africa are prevalent in Sudan and are commonly considered as an African symbol[13,14]. Baobab seeds are rich in protein and contain a substantial amount of energy[13,15]. Baobab seed cake (BSC) has a crude protein content of about 17%[16], which is inadequate for it to be used as a sole protein source in mid-lactating dairy cows. The supplementation of animal rations with a protein source is necessary to meet the protein and amino acid requirements of the animal for better performance.

Many studies have evaluated the effect of baobab seed cake (BSC) on cows and ewes. To our knowledge, there are few published studies on the effects of baobab seed cake (BSC) on the lactating goat. However, there is limited information about the feeding value of Adansonia digitata seedcake as feed for goats in Sudan. Furthermore, no studies have investigated the effect of the incorporation of baobab seed cake (BSC) and ground nut cake mixture in the goats' diet. This study aims to evaluate the effects of diets supplemented with baobab seed cake (BSC) on desert goat milk production performance and quality in North Kordofan State, Sudan.

MATERIALS AND METHODS

The experiment was conducted in Al-Newala Village (Longitudes 30.34-30.05° N, Latitudes 12.93-13.34° E), about 35 km South of EL-Obied town, Sheikan locality in North Kordofan state. Average temperature varies between 30-35°C during most of the year with peaks of above 40°C during April, May and June. The rainy season extends from July to October with maximum rainfall in August. Long-term average annual rainfall is about 280 mm.

Experimental design and duration: The study involved three experimental groups and one control group, which made a total of four treatments. A completely randomized design was used for the experiment, with six replicates of pregnant doe's desert goats per treatment. Animals were randomly distributed to 4 treatments. The experiment was carried out from June 2021 to August 2021 and lasted for 97 days (7 days for pre-experimental period, 30 days for last month of gestation period and 60 days for lactation period).

Experimental animals and feeding management: The study was carried out on 24 adult pregnant doe desert goats were used from the last month of pregnancy until 60 days of lactation. The goats were collected from small-scale farmers in Al Newala Village. The doe's were of different in age with a range of >1 year to three years of age. The target goats were ear tagged, weighed and randomly divided into four groups A, B, C and D each group component of 6 doe's according to body weight. All groups were treated against endo-and ectoparasites and vaccinated against food and mouth disease, Anthrax and Hemorrhagic Septicemia. All goats were housed in partially shaded pens, constructed from local materials of woods and were equipped with clean water troughs.

All goats depended on pasture to maintain their roughage and they were daily turned to grazing from 8.00 a.m. to 6.00 p.m. These goats were fed experimental diets containing different levels of baobab seed cake in a formulated diet (Table 1). Group A was used as a control and managed according to the prevailing traditional system which relies mainly on grazing with no supplementation. Group B, besides being allowed to graze similar to the control group was managed with a ration of 1. Group C, was managed with grazing and supplementing with ration 2, last group D was managed with grazing and supplement with ration 3. Supplementation of groups B, C and D was performed during the night after grazing time at a rate of 200 gm/head/day. Animals were hand milked twice daily.

Milk production: Milk yield collected from each lactating doe started 7 days after kidding to let kids intake colostrums. Milking was done manually twice daily at 7 am and 5 pm for 60 days. Suckling by kids for 5 min was used to stimulate milk let-down. The milk was weighed using a precision scale. To estimate milk intake by Kids, kids were weighed before and immediately after suckling. Kids were separated from their mothers after milking. Total milk yielding was calculated as the summation of milk off-take and intake by the kid.

Milk composition: Milk samples (20 mL) were taken in sterile containers every 15 day's intervals for chemical analysis to the end of experiment. The samples were kept in a refrigerator adjusted at 5°C pending the analysis for chemical composition. The analysis has been done according to methods of AOAC[17]; the crude protein, fat content and ash were determined as described by AOAC[17]. Crude fiber determination was carried out using trichloroacetic acid (TCA) method. Lactose and solids, not fat contents, were determined by difference. Analysis was done in the laboratory of Animal Production of EL-Obied Agricultural Research Station, North Kordofan state, Sudan.

Chemical composition of supplementation rations and feeds: Proximate composition of the ingredients used in concentrated ration formulation, supplemented diets (ration 1, 2 and 3) and some grasses in wet and dry season samples were analyzed following standard procedures, according to Official Methods of Analysis of AOAC International, Horwitz and AOACI[18] (Table 1 and 2).

Table 1: Ingredients of the experimental feedstuffs

Components (%)	Ration 1 (group B)	Ration 2 (group C)	Ration 3 (group D)
Sorghum grains	5	5	5
Baobab seed cake	65	55	45
Groundnut cake	20	30	40
Wheat bran	9	9	9
Lick salt	0.25	0.25	0.25
Common salt	0.75	0.75	0.75
Chemical composition of the experimental feed stuffs			
DM	96.40	96.40	96.30
CP	30.57	28.20	26.30
CF	31.48	28.45	23.64
EE	6.20	6.00	5.07
NFE	48.28	25.68	35.66
Ash	5.30	5.04	5.00

DM: Dry matter, CP: Crude protein, CF: Crude fiber, EF: Either extracts and NFE: Nitrogen free extracts

Table 2: Chemical composition of some forage stuff during study period

Plant species	DMI	CP	CF	EE	NEF	Ash	ME (Mj/kg)
Wet season							
Dactyloctenium aegyptium	89.6	12.44	6.9	1.4	62.3	10.4	10.99
Echinochloa colonum	88.5	5.00	9.55	2.8	68.5	9.65	11.54
Eragrostis tremula	95.5	6.00	12.89	2.3	69.11	4.51	15.57
Cenchrus biflorus	90.1	10.5	9.2	1.8	62.5	9.9	11.88
Schoenefeldia gracilis	92.8	10.5	10.3	3.1	57.3	11.6	11.32
Zornia glochidiata	90.2	10.75	9.65	1.7	46.6	9.8	8.82
Dry season							
Cenchrus biflorus	88.9	3.3	73.7	29	11.3	11.1	5.93
Eragrostis termula	93.3	2.9	80.5	0.8	9.00	6.8	5.95
Schoenefeldia gracilis	93.3	2.2	79.2	0.8	11.1	6.7	6.03
Cenchrus setigerus	96.3	4.7	80.8	1.0	9.8	3.7	6.29

DMI: Dry matter intake, CP: Crude protein, CF: Crude fiber, EF: Either extracts, NFE: Nitrogen free extracts and ME: Metabolize energy

Statistical analysis: The experimental design adopted for this study was a completely randomized design. All data collected were subjected to analysis of variance procedure at $p<0.05$ using the General Linear Model (GLM) applicable to the experimental design and significant means were separated by Duncan's multiple range tests, following the procedures of SPSS[19].

RESULTS

Effect of supplementation of baobab seed cake on milk yield: The weekly milk yield of the goats for the 8 weeks of lactation is in Table 3. The supplementation with baobab seed cake had a highly significant ($p<0.05$) effect on milk production in 60 days, total milk production and daily milk yield. Milk production was significant during all study periods 0-60 days. Milk yield increased steadily from the first week of lactation to the eighth week (60 days) and then dropped for all groups. The peak for the weekly milk yield was recorded at the 4th week (30 days) of lactation for all the treatments.

The does in group B registered highest significance ($p<0.05$) and had more milk (106.67 kg) than those in groups C and D 93.75 and 82.58 kg respectively. The least milk was produced by the A group (control) of (77.17 kg) which was significantly less than supplemented groups ($p<0.05$). The daily milk production indicated that the does supplemented with baobab seed cake yielded significantly ($p<0.01$) than control groups.

Effect of supplementation with baobab seed cake on milk composition: The effect of supplementation and parity order on the milk chemical composition of experimental goats is illustrated in Table 4. The data indicated that supplementation had exerted a significant ($p<0.05$) effect on fat during 1-15 and

Table 3: Effect of supplementation on milk production/kg

Variables	N	0-15 days	15-30 days	30-45days	45-60 days	Total milk	Daily milk
Group A	6	10.08^{b}	13.42^{c}	9.08^{c}	5.75^{b}	77.17^{c}	1.28^{c}
Group B	6	13.67^{a}	18.17^{a}	13.67^{a}	8.17^{a}	106.67^{a}	1.78^{a}
Group C	6	12.75^{a}	16.00^{b}	11.33^{b}	6.42^{a}	93.75^{b}	1.56^{b}
Group D	6	10.58^{b}	14.50^{bc}	10.33^{bc}	5.92^{b}	82.58^{c}	1.38^{c}
Overall Mean±SE	24	11.77±0.53*	15.52±0.52**	11.10±0.44**	6.56±0.41*	90.04±2.35**	1.50±0.04**

^{abc}Values in same column with different superscripts differ at p<0.05, *p<0.05 and **p<0.005

Table 4: Effect of supplementation on milk composition (%)

		Fat				Crude protein			
Variables	N	1-15	15-30	30-45	45-60	1-15	15-30	30-45	45-60
Animal group									
Group A	6	3.33^{b}	3.30	3.35^{ab}	3.62	3.30	3.40^{ab}	3.47^{b}	3.48
Group B	6	3.55^{ab}	3.30	3.45^{ab}	3.50	3.30	3.45^{ab}	3.50^{b}	3.55
Group C	6	3.55^{ab}	3.38	3.25^{b}	3.75	3.45	3.25^{b}	3.82^{a}	3.77
Group D	6	3.60^{a}	3.11	3.65^{a}	3.52	3.32	3.65^{a}	3.52^{ab}	3.60
Overall Mean±SE	24	3.51±0.10*	3.28±0.17	3.43±0.11*	3.60±0.10	3.43±0.18	3.44±0.11*	3.58±0.10*	3.60±0.10
		Lactose				Ash			
Variables	N	1-15	15-30	30-45	45-60	1-15	15-30	30-45	45-60
Animal group									
Group A	6	4.32	4.16	4.24	4.19	0.79	0.78	0.75	0.73
Group B	6	4.42	4.36	4.42	4.36	0.80	0.75	0.81	0.79
Group C	6	4.37	4.40	4.45	4.48	0.78	0.80	0.78	0.77
Group D	6	4.65	4.30	4.37	4.28	0.79	0.77	0.78	0.78
Overall Mean±SE	24	4.44±0.21	4.30±0.18	4.37±0.15	4.33±0.15	0.79±0.03	0.77±0.04	0.79±0.03	0.76±0.03

^{abc}Values in same column with different superscripts differ at p<0.05 and *p<0.05

30-45 days with a higher fat percentage in group C in 45-60 days. Protein showed a significant (p<0.05) effect on 15-30 and 30-45 days. Lactose and ash content secured non-significant effected by baobab seed cake supplementation. Besides this supplemented groups showed higher lactose and ash content compared with the control group.

DISCUSSION

Feed composition, feed intake by animals and the energy balance and energy reserve of the animal affected milk production and composition. Total milk production in this study was 90.04±2.35 kg, with 1.50±0.04 kg per day in a lactation period of 60 days, this level of production was the same as that reported by Bushara *et al.*[20] and lower than that reported by previous studies[5,7,21] and higher than that reported by Ojoawo *et al.*[6] for West African Dwarf Goats offered *Moringa oleifera* Herbage supplement. Milk production increased during early lactation and reached its peak at the 4th week of lactation and subsequently decreased until the 60th day of lactation. The trend of lactation curve of desert in this study was similar to the report by previous studies[5,7,22]. While peak yield of milk generally occurs during early lactation, it is more desirable to shift it toward mid-lactation in order to sustain a fairly high milk production throughout lactation. This appears to be a genetic trait and may not be easily influenced by nutrition as reported by Marete *et al.*[22] where peak yield tended towards early lactation for local goats.

Total yield and daily milk yield between goats subjected to different nutritional supplements with baobab seed cake were highly significant differences. The superiority of milk production in group (B) goats over the goats in other supplemented groups, may be the high milk attributed to the higher level of energy and protein fed to group B. This study corroborated with findings of Sultana *et al.*[21] with Bengal does fed concentrate supplement, Khalifa *et al.*[23] and Ojoawo *et al.*[6] in West African Dwarf Goats offered *Moringa oleifera* Herbage supplement. Milk yield of goats in this study increased with the addition of baobab to the diet and was directly proportional to protein intake by the animals. This agreed with the findings of

Okunlola *et al*.[3,5] that the milk yield was significantly affected ($p<0.05$) with supplementation of Baobab seed cake. Also Ojoawo *et al*.[6] showed that nutrition improvement with multipurpose trees could be a means of increasing milk yield. Contrary to the current results Madzimure *et al*.[24] found inclusion of baobab seed cake in the diets of lactating cows reduces milk quality and quantity.

The dietary concentrate level and forage feed during wet and dry seasons impact the level of milk production and characteristics of milk[25]. Goats in control group had lower milk yield compared with supplemented groups, this may be due to fewer nutrients available during the lactation period to meet mammary growth and milk production. Goats in the control flock began to mobilize their reserve more than goats in the supplemented group. Confirm results obtained by Gargouri *et al*.[26] who reported that supplementing goats with ration content of high energy and protein will increase milk production which was observed in supplemented groups due to sufficient energy intake, this matched with the findings of AL-Dabbas and Hawari[27].

The non-concurrent values in these studies could be due to the effect of breed and management systems. It is thereby inferred that nutrition impacts milk yield and that baobab seed cake supplement improved milk production in desert does, which agreed with Ojoawo *et al*.[6]. Also the difference in milk yield could be due to the composition of the diet, type of livestock and study area was responsible for the variations with the finding in this study, or may be attributed to feed intake and varying inclusion levels of baobab seed cake in the experimental diets.

Milk composition and quality are most important attributes that determine the nutritive value and consumer acceptability. The composition of the milk was largely affected by the dry matter intake of the animals which increased as the level of baobab seed cake in the diet increased. The mean fat content of milk varied from 3.51-3.60% while protein varied from 3.43-3.60%. Lactose and ash content of the milk also varied from 4.44-4.33% and 0.79-0.76%, respectively. Milk composition of fat and protein content had significant differences ($p<0.05$) among trial diets and lactation stages. The protein and fat content of the milk increased with higher levels of baobab seed cake in the diet. This was influenced by the higher protein intake of goats as the level of baobab fruit increased in the diet, which agreed with study of previous researches[3,5,23,24,28], also these results were confirmed by Póti *et al*.[29]. They reported that different feeding strategies have a different impact on the chemical composition of goat milk. Contrary to the current results many researchers found no significant effect ($p>0.05$) of protein and fat[10,30,31].

There were no significant differences in ash or lactose content of the milk in goats fed different levels of baobab in the diet which on harmony with, Ahamefule *et al*.[4], Arief *et al*.[10] and Ibeawuchi *et al*.[32] whom reported that it has been noted that lactose concentration in milk is not easily altered by nutrition. The variability of milk chemical composition during the lactation period is linked to the "dilution effect" because milk production is negatively correlated with milk composition as fat and protein[31].

Baobab seed cake is a promising non-conventional protein source that has the good potential to limit the costs of animal production. However, precaution is needed for sustainable harvesting of baobab to avoid negatively impacting the environment or upsetting ecosystems especially wild animals that feed on the fruits.

CONCLUSION

The addition of baobab seed cake to the diet of desert goats increased the milk yield of the lactating goats. Protein and fat content of goat milk increased while ash and lactose content was not altered with the addition of baobab seed cake to the diet. Baobab seed cake enhanced milk production in desert goats.

SIGNIFICANCE STATEMENT

Milk yield and composition are important attributes that determine the nutritive value and consumer acceptability of milk. The rising demand for milk and its products in the Sudan has made it imperative to find means to increase goat milk yield. Protein and energy are considered basic feed components that belong to the abnormally high-cost concentrate feeds of ruminants, because of the continuous increase in their prices. Therefore, this study was designed to compare the milk yield, compositions and minerals using cheap protein sources of non-conventional (baobab seed cakes) as supplemented ration to lactating desert goats.

REFERENCES

1. Idris, A., C. Kijora, F.M. El-Hag, A.M. Salih and S.A.F. Elmola, 2014. Climate change adaptation strategies for sheep production in range land of Kordofan Region. World Essays J., 1: 20-25.
2. Vasta, V., A. Nudda, A. Cannas, M. Lanza and A. Priolo, 2008. Alternative feed resources and their effects on the quality of meat and milk from small ruminants. Anim. Feed Sci. Technol., 147: 223-246.
3. Okunlola, D.O. and O.A. Olorunnisomo, 2016. Influence of baobab fruit in the diet on intake, milk yield and milk composition in Red Sokoto goats. Sci. J. Anim. Sci., 5: 192-198.
4. Ahamefule, F.O., O. Odilinye and E.N. Nwachukwu, 2012. Milk yield and composition of Red Sokoto and Weast African Dwarf does raised intensively in a hot humid environment. Iran. J. Appl. Anim. Sci., 2: 143-149.
5. Okunlola D.O., O.A. Olorunnisomo, A.J. Amuda, H.A. Nuga, A.M. Akinloye and N.O. Balogun, 2015. Milk yield and composition of Red Sokoto goats fed varying levels of baobab (*Adansonia digitata*) fruit meal supplement in the diet. J. Biol. Agric. Healthcare, 5: 121-126.
6. Ojoawo, O.T., J.A. Akinlade, A.A. Akingbade, O.A. Aderinola and D.O. Okunlola, 2021. Reproductive and lactation characteristics of West African Dwarf goats offered *Moringa oleifera* herbage supplement. Iran. J. Appl. Anim. Sci., 11: 789-797.
7. Bushara, I. and F.G.I. Godah, 2018. Effect of supplementary feeding with residual of sesame capsule to lactating desert goat during dry period in North Kordofan State, Sudan. Adv. Biol. Earth Sci., 3: 47-59.
8. Ikyume, T.T., N.N. Eigege, D.T. Bashi, N.P. Oche, A.I. Abdulraheem, M. Ojabo and I.P. Akalika, 2018. Growth performance, blood profile and economics of production of West African Dwarf (WAD) goats fed fermented baobab (Adansonia digitata) seed meal. J. Anim. Husb. Dairy Sci., 2: 30-36.
9. Chilanga, F., F. Chigwa, R. Phoya and M. Chiphwanya, 2022. The potential of *Acacia polyacantha* leaf meal and *Adansonia digitata* seedcake for small ruminant feeding in arid and semi-arid parts of Malawi. EC Vet. Sci., 7: 4-11.
10. Arief, Rusdimansyah, S. Sowmen, R. Pazla and Rizqan, 2020. Milk production and quality of Etawa crossbreed dairy goat that given *Tithonia diversifolia*, corn waste and concentrate based palm kernel cake. Biodiversitas, 21: 4004-4009.
11. Skenjana, A., J.B.J. van Ryssen and W.A. van Niekerk, 2006. *In vitro* digestibility and *in situ* degradability of avocado meal and macadamia waste products in sheep. South Afr. J. Anim. Sci., 36: 78-81.
12. Acheampong-Boateng, O., M.S. Mikasi, K. Benyi and A.K.A. Amey, 2008. Growth performance and carcass characteristics of feedlot cattle fed different levels of macadamia oil cake. Trop. Anim. Health Prod., 40: 175-179.
13. Oloche, J.I., A. Ujor, E.E. Oche and J.J. Oloche, 2020. Performance and toxicological effects of cooked baobab (*Adansonia digitata* L.) seed meal on West African dwarf goats. Niger. J. Anim. Sci., 22: 296-306.
14. Gebauer, J. and E. Luedeling, 2013. A note on baobab (*Adansonia digitata* L.) in Kordofan, Sudan. Genet. Resour. Crop Evol., 60: 1587-1596.
15. Mwale, M., J.F. Mupangwa, C. Mapiye, H. Saina and J. Chimvuramahwe, 2008. Growth performance of guinea fowl keets fed graded levels of baobab seed cake diets. Int. J. Poult. Sci., 7: 429-432.

16. Belewu, M.A., T. Fagbemi, O.O. Dosumu and M.O. Adeniyi, 2008. Physico-chemical and anti-nutritional properties of some lesser known tree and leguminous seeds. Int. J. Agric. Res., 3: 237-242.
17. AOAC, 1990. Official Methods of Analysis of the Association of Official Analytical Chemists. 15th Edn., Association of Official Analytical Chemists, Rockville, Maryland, ISBN: 9780935584424.
18. Horwitz, W. and AOACI, 2000. Official Methods of Analysis of AOAC International. 17th Edn., AOAC International, Rockville, Maryland, ISBN-13: 9780935584677, Pages: 2200.
19. Watanabe, Y., R. Suzuki, S. Koike, K. Nagashima, M. Mochizuki, R.J. Forster and Y. Kobayashi, 2010. *In vitro* evaluation of cashew nut shell liquid as a methane-inhibiting and propionate-enhancing agent for ruminants. J. Dairy Sci., 93: 5258-5267.
20. Bushara, I., M.B. Elemam, O.M.A. Abdelhadi, A.O. Idris and A.M. Abu Nikhiala, 2011. Effect of parity number on the productivity of taggar goats under dry land farming in Western Sudan. Am.-Eurasian J. Agric. Environ. Sci., 10: 515-518.
21. Sultana, S., M.J. Khan, M.R. Hassan and M.A.M.Y. Khondoker, 2012. Effects of concentrate supplementation on growth, reproduction and milk yield of Black Bengal goats (*Capra hircus*). J. Bangladesh Vet., 29: 7-16.
22. Marete, A.G., R.O. Mosi, J.O. Amimo and J.O. Junga, 2014. Characteristics of lactation curves of the Kenya alpine dairy goats in smallholder farms. Open J. Anim. Sci., 4: 92-102.
23. Khalifa, E.I., H.R. Behery, Y.H. Hafez, A.A. Mahrous, A.A. Fayed, H.A.M. Hassanien, 2013. Supplementing non-conventional energy sources to rations for improving production and reproduction performances of dairy Zaraibi nanny goats. Egypt. J. Sheep Goat Sci., 8: 69-83.
24. Madzimure, J., C. Musimurimwa, E. Chivandi, L. Gwiriri and E. Mamhare, 2011. Milk yield and quality in Guernsey cows fed cottonseed cake-based diets partially substituted with baobab (*Adansonia digitata* L.) seed cake. Trop. Anim. Health Prod., 43: 77-82.
25. Goetsch, A.L., S.S. Zeng and T.A. Gipson, 2011. Factors affecting goat milk production and quality. Small Ruminant Res., 101: 55-63.
26. Gargouri, A., G. Caja, R. Casals and I. Mezghani, 2006. Lactational evaluation of effects of calcium soap of fatty acids on dairy ewes. Small Ruminant Res., 66: 1-10.
27. AL-Dabbas, F.M. and A.D. Hawari, 2011. The effect of fat supplementation in Shami goat diets on milk production and composition, does body weight and growth performance of their suckling kids. Pak. J. Biol. Sci., 14: 725-728.
28. Zahraddeen, D., I.S.R. Butswat and S.T. Mbap, 2007. Evaluation of some factors affecting milk composition of indigenous goats in Nigeria. Livest. Res. Rural Dev. Vol. 19.
29. Póti, P., F. Pajor, Á. Bodnár, K. Penksza and P. Köles, 2015. Effect of micro-alga supplementation on goat and cow milk fatty acid composition. Chilean J. Agric. Res., 75: 259-263.
30. Mahouachi, M., N. Atti and H. Hajji, 2012. Use of spineless cactus (*Opuntia ficus indica f. inermis*) for dairy goats and growing kids: Impacts on milk production, kid's growth, and meat quality. Sci. World J., Vol. 2012. 10.1100/2012/321567.
31. El Otmani, S., Y. Chebli, M. Chentouf, J.L. Hornick and J.F. Cabaraux, 2021. Effects of olive cake and cactus cladodes as alternative feed resources on goat milk production and quality. Agriculture, Vol. 11. 10.3390/agriculture11010003.
32. Ibeawuchi, J.A., F.O. Ahamefule and I.A. Ringim, 2003. The influence of lactation stage on the milk constituents of Sahelian goats. Niger. J. Anim. Prod., 30: 259-264.