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Full Length Research

Nutritional value of soybean milk residue and nutrient intake in Red Sokoto goats

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ABSTRACT: This study is designed to evaluate the proximate composition, fibre fractions, mineral assay and phytochemical properties of soybean milk residue for livestock and was carried out in the Science Laboratory and the Teaching and Research Farm of Federal Polytechnic, Bali B ward, Bali Local Government Area (LGA) of Taraba state, Nigeria. Air-dried soybean milk residue was crushed and a subsample taken to the laboratory for analyses. The soybean milk was also used to formulate diets having varying levels of its inclusion as replacement for soybean meal. These diets were fed to the bucks for a period of 90 days. During the last 7 days, feacal samples were collected and analyzed before calculating the nutrient intake. Results were presented using simple tables. Analysis carried out showed that soybean milk residue contains 89.53% dry matter, 10.47% moisture, 5.13% ash, 32.19% crude protein, 5.46% ether extract and 4.78% crude fibre. Fibre fractions were 31.97% nitrogen free extract, 10.63% acid detergent fibre, 21.51% neutral detergent fibre, 2.00% acid detergent lignin, 8.28% cellulose and 10.89% hemicellulose. Metabolizable energy was 3138.22 Kcal/kg. The mineral profile of soybean milk residue indicates 2.11% potassium, 0.28% calcium, 0.62% phosphorus, 0.27% magnesium, 0.17 ppm sodium, 155.22 ppm iron, 38.72 ppm manganese and 55.17 ppm zinc. Phytochemicals found in the soybean milk residue were phenolic (0.12%), saponins (0.18%), phytate (0.34%), tannins (0.03%), lectins (0.05%), oxalates (0.27%), alkaloids (0.01%) and flavonoids (55.17%). In the second experiment, 25 weaned bucks weighing 8.40 kg were used to evaluate the nutrient intake of diets (T_0, T_{25}, T_{50}, T_{75} and T_{100}) formulated with varying levels of soybean milk residue as a replacement for soybean meal. Total crude protein intake increased across the treatments with T1 (55.46 g) and T5 (59.63 g) having the least and highest value respectively. Higher values were recorded in total dry matter intake was higher for T3 (358.00g), total crude protein intake for T5 (59.63g), total ether extract intake for T5 (7.97g), total crude fibre intake for T1 (58.55g) and total nitrogen free extract intake for T3 (182.82g). Total crude fibre intake and total ether extracts intake were significantly affected ($p<0.05$) by the dietary treatments while total dry matter intake, total crude protein intake and total nitrogen free extract intake were not. It was concluded that soybean milk residue contains a good nutrient profile in quantities that are required for goats. T_{50} and T_{100} supplementation gave good nutrient intake.

Keywords: Fibre fractions, minerals, nutrient intake, phytochemicals, proximate, soybean milk residue.

INTRODUCTION

High productivity is usually attained when alternative feedstuffs (which are less expensive) with low human food preference and low industrial usage are utilized as feed (Akinmutimi, 2004). The current trend tends to source alternative feed ingredients, which are not only cheap but readily available and capable of supplying the nutrients required by the animal for optimal growth and productivity.

Soybean milk residue is the residue (sludge) remaining after extracting juice from ground soybeans. It is rich in protein (27%) but usually dumped on refuse sites after soymilk extraction (Shuhong *et al*., 2013). Its production throughout Nigeria has greatly increased, making it readily available and cheap in towns and villages where cheese is widely produced and eaten (Iyeghe-Erakpotobor, 2010). A conscious effort to properly channel this seemingly good quality feedstuff for feeding ruminants like goats will enhance additional production value. Although soybean milk residue is processed in wet form which cannot be stored for long, it is usually sun-dried to enhance greater storability and acceptability by the animals. Emmanuel *et al*. (2021) noted that soybean milk residue is nutritious and can be used to reduce the cost of production. Rahman *et al.* (2014) reported lower dry matter intake, feed conversion ratio and feed cost per kilogram of body weight for goats fed supplemental soybean milk residue. But Priyanto *et al.* (2017) reported good performance in terms of final body weight, average daily gain, dry matter intake and feed efficiency when cattle were fed 70% of soybean milk residue. This study is, therefore, designed to evaluate the proximate composition, fibre fractions, mineral assay and phytochemical properties of soybean milk residue. Soybean milk residue is well accepted by rabbits (Iyeghe-Erakpotobor, 2010; Emmanuel *et al*., 2021), birds and hogs (Shuhong et al., 2013), goats (Rahman *et al*., 2014) and cattle (Priyanto *et al*., 2017).

Therefore, this study sought to investigate whether the composition of soybean milk contains sufficient nutritional value or energy in livestock nutrition.

MATERIALS AND METHODS

Experimental location

The research was carried out in the Science Laboratory and the Teaching and Research Farm of Federal Polytechnic, Bali B ward, Bali Local Government Area (LGA) of Taraba state, Nigeria. The Polytechnic covers a total land area of about 1000 m^2 and extends between latitude 8° 35'00" North of the equator and 10° 46' 00" East of the Greenwich Meridian (Taraba State Government, 2020).

Source and preparation of experimental material

Soybean milk residue (SBMR) was sourced from soybean milk vendors within Bali town. Wet form was bagged in jute bags and pressed again using heavy stones to reduce moisture content after which it will be spread over a concrete floor to sun-dry properly to avoid moulding. When all the residues were properly dried, they were crushed using a hammer mill. These were then bagged and a subsample was taken to the laboratory for analysis. The bagged SBMR were crushed and used to formulate diets designated as T_0, T_{25}, T_{50}, T_{75} and T_{100} according to levels of inclusion to replace soybean meal as seen in Table 1. The soybean meal used in this study is the waste generated after the extraction of oil from full-fat soybeans. Bucks were housed in individual compartments with 5 bucks representing a treatment and each buck, a replicate. Bucks were fed the respective diets for 90 days. The last 7 days were used to collect faecal samples which were analyzed and used to calculate the nutrient intake.

Chemical analysis

Samples of the soybean milk residue were analyzed for dry matter, crude protein, crude fibre, ether extract and ash using AOAC (2005) procedure while acid detergent fibre (ADF), acid detergent lignin (ADL) and neutral detergent fibre (NDF) were analyzed using Van Soest *et al*. (1991) procedure. Cellulose and hemicellulose were calculated as differences between ADF and ADL, and NDF and ADF respectively. The dry matter content of the samples was determined by oven-drying to a constant weight at 105°C for 24 hours.

$$W = W1 - W2 \times 100$$

Where W1 = weight of sample + petri dish before drying; W2 = weight of sample + petri dish after drying; W = weight of sample

% Dry matter = 100 - moisture (W)

Nitrogen Free Extract (NFE) was determined for each sample subtracting the percentage of moisture, crude protein, crude fibre, ether extract and ash from 100.

NFE = 100-(% CF+ %CP + %EE + % Ash)

The energy content of feed and faeces was calculated using the equation below as modified by Carew *et al*. (2016) from Pauzenga (1985):

$$\text{Metabolizable Energy (KCal/kg)} = 37 \times \%\text{CP} + 81 \times \%\text{EE} + 35.5 \times \%\text{NFE} + 35.5 \times (0.22)\%\ \text{CF}$$

Minerals were determined using an atomic absorption spectrophotometer as described by Thomas *et al.* (2015). Phytochemicals were determined using a standard method (AOAC, 1990).

Statistical analysis

All data collected in this study were presented using simple tables.

Table 1. Composition of experimental diet.

Ingredients	Experimental diet				
	T_0	T_{25}	T_{50}	T_{75}	T_{100}
Maize	5.00	5.00	5.00	5.00	5.00
Sorghum chaff	10.00	10.00	10.00	10.00	10.00
Maize offal	57.74	57.74	57.74	57.74	57.74
SBMR	0.00	6.06	12.13	18.20	24.26
SBM	24.26	18.20	12.13	6.06	0.00
Bone ash	2.00	2.00	2.00	2.00	2.00
Common salt	1.00	1.00	1.00	1.00	1.00
Total	100	100	100	100	100
Calculated analysis %					
Crude protein	18.00	16.31	14.62	12.92	11.23
Crude fibre	7.11	7.30	7.49	7.69	7.84
Ether extract	3.26	3.39	3.53	3.66	3.79
Ash	4.63	4.46	4.29	4.12	3.95
NFE	67.00	68.60	70.07	71.67	73.19
ME (Kcal/kg)	2477.50	2401.37	2325.12	2248.84	2172.71

SBMR= soybean milk residue, SBM=soybean meal, NFE= nitrogen free extract, ME= metabolizable energy. T_0= 0% SBMR and 100% SBM. T_{25}= 25% SBMR and 75% SBM. T_{50}= 50% SBMR and 50% SBM. T_{75}= 75% SBMR and 25% SBM. T_{100}= 100% SBMR and SBM.

RESULTS AND DISCUSSION

Proximate and fibre fractions of soybean milk residue

Table 2 shows the proximate and fibre fractions of the test ingredient used in this study. A high dry matter percentage (89.53%) in soybean milk is an indication of good storage ability and nutrient absorption. The crude protein (CP) of 32.19% reported for soymilk residue in this study is similar to the 33.4% reported by Prestamo *et al*. (2007) and Mateos-Aparicio *et al.* (2010c) but higher than the 27.00% reported by Shuhong *et al.* (2013) and 19.99% reported by Darunee and Wichai (2014). Emmanuel *et al*. (2021) reported a CP of 24.06%. This variation might be due to the type of soybean cultivar used or the method adopted in processing the soybean milk. However, the CP obtained was within the recommended requirement for goats (McDonald *et al*., 2022). The ether extract value of 5.46% is lower than the 8.5% reported by Mateos-Aparicio *et al*. (2010c) but similar to the 4.98% reported by Sompong and Pirote (2008) and higher than the 2.52% reported by Emmanuel *et al*. (2021). The crude fibre value of 4.78% is similar to the 5.61% reported by Darunee and Wichai (2014) but lower than the 12% reported by O'Toole (1999), 14.81% (Emmanuel *et al*., 2021) and lower than 9.80% reported by Odeyinka *et al*. (2014). 5.13% ash is a bit higher than the 3.7% ash content reported for soybean milk residue by Mateos-Aparicio *et al*. (2010c). Soybean milk residue is a good dietary fibre; rich in cellulose and accounts for approximately 50% of the dry weight in soybean with very few calories (Shuhong *et al*., 2013). The nitrogen free extract value of 31.97% is lower than the 45.50% reported by Odeyinka *et al*. (2014), 48.87% (Emmanuel *et al*., 2021) and 53.6% (Muroyama *et al*., 2006). The acid detergent fibre (ADF) value of 10.63% is slightly lower than the 13.86% reported by Amao *et al*. (2021). Neutral detergent fibre was 21.51%. This is lower than the 29.63% reported by Amao *et al*. (2021). Acid

Table 2. Proximate and fibre fractions of soybean milk residue.

Proximate (%)	Soybean milk residue
Dry matter	89.53
Moisture	10.47
Ash	5.13
Crude protein	32.19
Ether extract	5.46
Crude fibre	4.78
Fibre fractions (%)	
Nitrogen free extract	31.97
Acid detergent fibre	10.63
Neutral detergent fibre	21.51
Acid detergent lignin	2.00
Cellulose	8.24
Hemicellulose	10.89
Metabolizable energy (Kcal/Kg)	3138.22

detergent lignin (ADL) was 2.00%. Cellulose content was 8.24% and hemicellulose 10.89%. However, Amao *et al*. (2021) reported higher values for ADL (2.35%), cellulose (11.5%) and hemicellulose (15.85%). Dust *et al*. (2004) reported 2.3% ADL, up to 49.3% ADF and 17.7% for hemicellulose in soybean hulls. The variations in the various proximate and fibre fractions of soybean milk residue could be due to soybean cultivars, soil type where the soybean was planted, harvesting time of the soybean, the method used to process the soybean milk, post-production treatment and laboratory analysis. The proximate (%dry matter) composition of the soybean milk residues shows their potential as an alternative feed resource for goats. Metabolizable energy (3138.22 Kcal/kg) is comparable to the 2837.04 Kcal/kg reported by Emmanuel *et al*. (2021) when soybean milk residue was used to formulate feed for rabbits and within the 2310-2970 Kcal/kg calculated by AFRC (1998), Luo *et al*. (2004) and Sahlu *et al*. (2004) for growing goats.

Mineral profile of soybean milk residue

Mineral analysis as shown in Table 3 indicated that soybean contains potassium (2.11%), calcium (0.28%), phosphorus (0.62%), magnesium (0.27%), sodium (0.17 ppm), iron (155.28 ppm), manganese (38.72 ppm) and zinc (55.17 ppm). This is similar to the report of Mateos-Aparicio *et al*. (2010c) who recorded potassium (1.35%), calcium (0.32%), sodium (0.03 ppm), and magnesium (0.13%), with lower values of iron (62.00 ppm), manganese (21.00 ppm), and zinc 29.00 ppm). The levels of minerals in the soybean milk residue may be attributed to its low ash content (5.13%). However, soybean milk residues in the diets contain very important minerals. The mineral contents were within the requirements for goats as outlined by Mamoon (2008).

Phytochemical composition

Phytochemical screening as presented in Table 4 revealed the presence of phenolic (0.12%), saponins (0.18%), phytate (0.34%), tannins (0.14%), oxalates 0.38%), alkaloids (0.01%) and flavonoids (55.17%) in the soybean milk residue. This report is in line with the report of Amao *et al*. (2021) who reported glucoside (0.10%), saponins (0.13%), phytate (0.01%), phytosterol (0.01%), trypsin inhibitor (2.66%) and polysaccharide (0.11%). Dourado *et al*. (2011) reported the presence of phytate, protease inhibitors, lectins, tannins and calcium oxalate which are reduced greatly by soaking the soybean used in the processing of the residues. Soybean milk residue is rich in isoflavone glucoside which forms the major phenolic compounds and performs several health-promoting functions (Kim *et al*., 2006). Alkaloids are naturally occurring antioxidants which have analgesic, anti-protozoa

Table 3. Mineral profile of soybean milk residue.

Minerals (%)	Soybean milk residue
Potassium	2.11
Calcium	0.28
Phosphorus	0.62
Magnesium	0.27
Sodium (ppm)	0.17
Iron (ppm)	155.22
Manganese (ppm)	38.72
Zinc (ppm)	55.17

ppm = part per ml.

Table 4. Phytochemical composition of soybean milk residue.

Phytochemicals (%)	Soybean milk residue
Phenolic	0.12
Saponins	0.18
Phytate	0.34
Tannins	0.03
Lectins	0.05
Oxalates	0.27
Alkaloids	0.01
Flavonoids	55.17

and anti-fungal activities (Jiwuba *et al*., 2020). Trypsin inhibitors (which are mostly destroyed by cooking), saponins and agglutins are also found in soybean milk residues (Shuhong *et al.,* 2013). These compounds have various physiological and therapeutic functions such as antioxidant capacity, prevention of cardiovascular diseases, and effective chemo-preventive agents for certain types of cancer (Quitain *et al*., 2006).

Nutrient Intake

Table 5 shows the nutrient intake (g/day) of Red Sokoto goats fed diets containing varying levels of soybean milk residue with *Ficus lyrata* as basal diet. Total dry matter (TDMI), total crude protein (TCP) and total nitrogen free extract (TNFE) were not affected ($p>0.05$) by the level of soybean milk residue inclusion in the diets of Red Sokoto goats. However, total ether extract (TEE) and total crude fibre (TCF) varied significantly ($p<0.05$) among the treatment diets. Total crude protein intake and total ether extract intake increased as the level of soybean milk residue inclusion in the diets increased from 55.46-59.63% and 7.18-7.97%, respectively. Crude fibre intake was reduced ($p<0.05$) due to the dietary inclusion of soybean milk residue. Total nitrogen free extract (TNFE) was least in T4 (178.93%) and highest in T3 (182.82%). High TDMI (358.00%), TCP (58.90%) and TNFE (182.82%)

Table 5. Nutrient intake (g/day) of Red Sokoto goats fed diets containing varying levels of soybean milk residue with *Ficus lyrata* as basal diet**.**

Parameters	Treatments					SEM	P- value
	T_0	T_{25}	T_{50}	T_{75}	T_{100}		
Total dry matter	349.28	353.04	358.00	349.14	353.48	6.37	0.8566
Total crude protein	55.46	56.11	58.90	59.10	59.63	1.36	0.1353
Total ether extract	7.18^{b}	7.36^{b}	7.47^{ab}	7.49^{ab}	7.97^{a}	0.12	0.0033
Total crude fibre	58.55^{a}	56.93^{ab}	57.26^{ab}	53.73^{bc}	52.78^{c}	0.98	0.0018
Total NFE	180.46	180.95	182.82	178.93	180.49	3.26	0.9444

^{abc}Means with different superscript within the same row differ significantly ($p<0.05$)**.**

were recorded among goats receiving 50% soybean milk residue inclusion in their diets. This may be due to increased palatability. Total crude protein intake in T2 (56.11%) and T4 (59.10%) did not translate into a better final body weight of goats in T2 (13.82kg) and T4 (13.86kg). According to McDonald *et al*. (2022), some of the proteins not utilized may have been converted to urea and excreted in the urine. Nutrient intake is in line with Mamoon (2008) and Teixeira *et al*. (2024).

Conclusion

Soybean milk residue contains nutrients in quantities that are required for a good goat ration and reliable fibre fraction that can support good ruminal activities and enhance good performance in Red Sokoto goats. Soybean milk residue contains safe levels of phytochemicals for goats which can serve as antioxidants and also fight cancers. Supplementation of soybean milk residue up to 50% ensured the best dry matter, crude fibre and nitrogen free extract intakes. 100% replacement resulted in the highest crude protein and ether extract intakes.

Recommendation

Soybean milk residue can be used as a feed ingredient in the diet of goats. However, attention should be paid to how the soybean milk residue is processed to avoid the build-up of aflatoxins. Goats can absorb more nutrients from soybean milk residue when supplemented up to 100% as a replacement for soybean meal.

CONFLICT OF INTEREST

The authors declare that they have no conflict interest.

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