

Nutritional potential and utilization of processed Roselle (*Hibiscus sabdariffa* L.) seed meal by grazing Red Sokoto bucks in Semi-Arid Nigeria

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Abstract

Two studies were conducted to explore the utilization of roselle seed meal (RSM) as a feedstuff in small ruminant feed. In study one, the effect of processing methods on the proximate compositions, mineral contents and anti-nutritional factors of roselle seed were evaluated. Four different processing methods were evaluated as treatments, T1 = was control (untreated roselle seed), T2 = fermented roselle seed, T3 = hot water treated roselle seed, and T4 = lye water treated roselle seed. The prepared samples were subjected to laboratory analysis. In the second study, feeding trial was conducted to assess the performance of grazing red Sokoto bucks supplemented with diets containing processed roselle seed meals. Four experimental diets were formulated using wheat offal, sorghum husk, rice husk, salt, bone meal and processed RSM (T1 = Untreated RSM; T2 = Fermented RSM; T3 = Hot water treated RSM and T4 = Lye water treated RSM) as treatments. The bucks were supplemented the diets for 84 days, after six hours grazing in a 50 hectares' rangeland daily. Sixteen red sokoto bucks, four bucks per treatment with average weight of 11.69 ± 0.32 kg were used in a completely randomized design, water was provided ad libitum. Data were generated on feed intake, weekly weight changes and feed conversion ratio. Results obtained in study one indicated that processing methods had no significant ($P > 0.05$) effect on the proximate compositions of roselle seed except on ether extract and dry matter contents. The mineral compositions of the roselle seed obtained showed that there were significant ($P < 0.05$) differences in the values of Potassium (K), Sodium (Na) and Copper (Cu). Lye water treated roselle seed (T4) was statistically superior to others in terms of K and Na, while fermented roselle seed (T2) was statistically superior in Cu. The result obtained in the analysis of anti-nutritional factors revealed that all the parameters were significantly ($p < 0.05$) different. The values of tannin, saponin, Pytate, cyanide and oxalate ranged from 0.38-0.87mg/g, 13.21-22.57mg/g, 33.13-50.79mg/g, 6.51-10.34mg/g and 2.12-4.36mg/g respectively. Results from the second study showed that there was significant ($P < 0.05$) difference in the mean values of total weight gain, average feed intake and total feed intake. In conclusion, processing methods substantially reduced the effect of anti-nutritional factors in roselle seed which can serve as a good source of feedstuff for small ruminant production. Also, supplementation of roselle seed meal can significantly improve the performance of goats without any detrimental effect.

Keywords: Nutritive values, Roselle seeds meal, processing, bucks

La Potentiel nutritionnel et L'utilisation de la farine de graines transformée de Roselle (*Hibiscus sabdariffa* L.) par pâturage des mâles Sokoto rouges dans le zone semi-aride au Nigeria

Résumé

Deux études ont été menées pour explorer l'utilisation de la farine de graines de roselle (le

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'RSM') comme aliment dans l'alimentation des petits ruminants. Dans la première étude, l'effet des méthodes de traitement sur les compositions immédiates, les teneurs en minéraux et les facteurs anti-nutritionnels de la graine de roselle ont été évalués. Quatre méthodes de traitement différentes ont été évaluées comme traitements, T1 = était témoin (graine de roselle non traitée), T2 = graine de roselle fermentée, T3 = graine de roselle traitée à l'eau chaude et T4 = graine de roselle traitée à l'eau de lessive. Les échantillons préparés ont été soumis à une analyse en laboratoire. Dans la deuxième étude, un essai d'alimentation a été mené pour évaluer les performances des mâles Sokoto rouges au pâturage complétés par des régimes contenant des farines de graines de roselle transformées. Quatre régimes expérimentaux ont été formulés en utilisant des abats de blé, des balles de sorgho, des balles de riz, du sel, de la farine d'os et du 'RSM' transformé (T1 = le 'RSM' non traité ; T2 = le 'RSM' fermenté ; T3 = le 'RSM' traité à l'eau chaude et T4 = le 'RSM' traité à l'eau de lessive) comme traitements. Les mâles ont été nourris pendant 84 jours, après six heures de pâturage quotidien dans un pâturage de 50 hectares. Seize mâles sokoto rouges, quatre mâles par traitement avec un poids moyen de $11,69 \pm 0,32$ kg ont été utilisés dans une conception complètement aléatoire, de l'eau a été fournie ad libitum. Des données ont été générées sur la consommation alimentaire, les changements de poids hebdomadaires et le taux de conversion alimentaire. Les résultats obtenus dans la première étude ont indiqué que les méthodes de traitement n'avaient pas d'effet significatif ($P > 0,05$) sur les compositions proches de graines de roselle, sauf sur l'extrait d'éther et la teneur en matière sèche. Les compositions minérales de la graine de roselle obtenues ont montré qu'il y avait des différences significatives ($P < 0,05$) dans les valeurs de Potassium (K), Sodium (Na) et Cuivre (Cu). La graine de roselle (T4) traitée à l'eau de lessive était statistiquement supérieure aux autres en termes de K et de Na, tandis que la graine de roselle fermentée (T2) était statistiquement supérieure en Cu. Le résultat obtenu dans l'analyse des facteurs anti-nutritionnels a révélé que tous les paramètres étaient significativement différents ($p < 0,05$). Les valeurs de tanin, saponine, pytate, cyanure et oxalate variaient respectivement de 0,38 à 0,87 mg/g, 13,21 à 22,57 mg/g, 33,13 à 50,79 mg/g, 6,51 à 10,34 mg/g et 2,12 à 4,36 mg/g. Les résultats de la deuxième étude ont montré qu'il y avait une différence significative ($P < 0,05$) dans les valeurs moyennes du gain de poids total, de la prise alimentaire moyenne et de la prise alimentaire totale. En conclusion, les méthodes de transformation ont considérablement réduit l'effet des facteurs anti-nutritionnels dans les graines de roselle qui peuvent servir de bonne source d'alimentation pour la production de petits ruminants. En outre, la supplémentation en farine de graines de roselle peut améliorer considérablement les performances des chèvres sans aucun effet néfaste.

Mots clés: Valeurs nutritives, farine de graines de roselle, transformation, dollars

Introduction

Available forages do usually contain low energy and protein content and this affects voluntary intake and digestibility leading to loss of weight amongst the animals, as dry season grow longer. In addition, the competition between man and monogastric also stand as a militating factor to the realization of the full potential of small ruminant production (Uguru, 2014; Nyako,

2015; Ogunbosoye *et al.*, 2015). The above prevailing conditions justify efforts towards sourcing for alternative and locally available means of feeding ruminants to increase their productivity while contending with the problem of insufficient conventional feed resources (Ogunbosoye *et al.*, 2015; Abdurrahman *et al.*, 2017). However, one of the feed ingredients that can be used as protein supplement with little or no cost is *Hibiscus sabdariffa* (roselle)

seeds (Maffo *et al.*, 2014). *Hibiscus* belongs to the *Malvaceae* family (Sahar *et al.*, 2017), and it is quite large, containing several hundred species that are native to warm-temperate, subtropical and tropical regions throughout the world. Roselle seeds are byproduct that is left behind during processing of roselle products (Nyam *et al.*, 2009). Furthermore, Roselle seeds have been found to contain high amount of protein, dietary fiber, lipids, and minerals (Toukara *et al.*, 2011). Preliminary studies also show that the raw roselle seed contains 22% crude protein, 89% Dry matter, 20% crude fibre, 21% lipid and 6.4% ash content (Maffo *et al.*, 2014). This plant is cultivated in thousands of hectares in Jigawa state but the potential of its seeds in small ruminant production is yet to be explored. However, despite the high nutritional value of this seed, it contains anti nutritional factors such as tannin, saponin, cyanide, oxalate and Pytate. Anti nutritional factors are substances which interfere with feed utilization and affect the health and production of animal or which act to reduce nutrient intake, digestion, absorption and utilization and may produce other adverse effects (Akande and Fabiyi, 2010; Yacout, 2016). But the effect of these anti nutritional factors can be reduced by various processing methods (Maffo *et al.*, 2014). Therefore, this research work was aimed at providing information on the best processing method in reducing the effects of anti nutritional factors found in the roselle seed for small ruminants' production.

Materials and methods

Experimental area

The study was conducted at Federal University Dutse Teaching and Research Farm. Dutse is the capital city of Jigawa State. The site is located latitude 11°N 13°N and longitudes 8°E 10°35'E, at an altitude of 485m above sea level. Jigawa state has an

estimated land size of 23,154 km² (Google Earth, 2012). The state is situated within the Sudan Savannah vegetation zone, but there are traces of Guinea savannah in the southern part of the state. The regions are characterized by a long dry season of 7-8 months. The region is characterized by mean annual rainfall ranges from 600 to 1000mm with a peak in August. The average minimum and maximum temperature and relative humidity ranges are 12 and 40°C, 40 and 78% respectively. Lowest temperatures occur during the harmattan (November - February) and highest from March to June (Olofin, 2008).

Experimental materials

The Roselle seed that was used in the research was collected from federal university Dutse teaching and research farm. The collected seeds were cleaned by winnowing and hand picking of stones and debris. The cleaned Roselle seeds were subjected to four processing methods: Untreated Roselle seed (control) (T₁), Fermented Roselle seed (T₂), Hot water treatment Roselle seed (T₃), Lye treatment Roselle seed (T₄).

Processing methods of Roselle seeds

Fermentation

Roselle seed was placed in a muslin cloth and soaked in clean water completely for 3 days under air-tight condition. The water was drained on the 3rd day and the fermented seed was sun-dried as described by Ari *et al.* (2012a). The Fermented Roselle seed represents treatment T₂.

Hot water treatment

The method adopted by Ari *et al.* (2012b) was used. The cleaned seeds were poured into aluminum tower pot containing 1liter of clean water in a batch of 1 Kg. The Roselle seeds sample was allowed to boil at 100°C for 20 minutes before cooling by spreading on jute bags until stable weight was attained at room temperature. The parboiled Roselle seed represents treatment T₃.

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Lye treatment

Lye water was prepared by passing water over gray ash in a barrel. The ash was sieved to remove pieces of charcoal and other impurities. The sieved ash was then placed (without compaction) in a plastic container with holes plugged with sieved cloth at the base of the plastic. Hot water was poured on the ash and a brown liquid dripped at base of the container. This brown liquid represents the lye water that was used in this study. Roselle seed was placed in a muslin cloth and then soaked in the lye for 18hrs. It was removed and then sun-dried for 7days (Akande *et al.*, 2011). This sample represents treatment T₄.

Laboratory analysis

Determination of proximate composition

Samples of the roselle seeds, differently processed roselle seeds and experimental supplements were collected for proximate analysis. Dry matter, crude protein, crude fibre, ether extract, Nitrogen free extract and ash, were analyzed according to AOAC (2013).

Determination of mineral composition

Atomic Absorption Spectrometer was used to determine the content of the macro minerals of the Roselle seed such as Calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na), while dietary micro minerals iron (Fe), copper (Cu), zinc (Zn) and manganese (Mn) were **determine according to the procedures described by AOAC (2013).**

Determination of anti-nutritional factors

The presence of anti-nutritional factors, Tannin, Oxalates and Cyanide were determined according to AOAC (2013), Phytate according to Stewart (1974) and Saponin according to Peng *et al.* (1995).

Feeding and management of animals

A total of sixteen red sokoto bucks with average weight of 11.69±0.32kg were used to evaluate feed intake and growth

performance in this study. Prior to the commencement of the experiment, the pens were thoroughly washed with detergent and disinfectant. The animals were dewormed with albendazole (2ml/10kg body weight) and were given tetracycline long active (TLA) antibiotic injection at (1ml/10kg body weight) against bacterial infections. While ecto-parasites was checked using Ivermectin (Ivomec) at (1ml/50kg body weight). The animals were allotted to four (4) dietary treatments with four (4) animals per treatment, in a Completely Randomized Design. The animals were housed individually in an open-sided, well-ventilated pens and each pen was equipped with feed and water troughs. The animals were moved for grazing in a 50 hectares' rangeland of the University farm from 8.00am to 1.00pm and returned for watering and rest. They were then moved out from 3.00pm to 5.00pm. While returning from second grazing, the experimental animals were sent to their individual pens and supplement was offered to them according to treatment allocated. Equally, they spent the night in their individual pen.

Animals were fed supplement diet, at 2% of their body weights. The treatments that were evaluated are T₁ = diet containing untreated Roselle seed meal (control), T₂ = diet containing fermented Roselle seed meal, T₃ = diet containing hot water treated Roselle seed meal and T₄ = diet containing lye water treated Roselle seed meal. Clean drinking water was provided to the animals' daily *ad libitum*. The experiment lasted 84 days after 7 days adjustment period.

Statistical analysis

The data generated from these studies were analyzed using One-way Analysis of Variance (ANOVA), Procedure of Statistical Analytical system (SAS, 2013). Significant treatment means were separated using least significant difference (LSD) at 5% level of significance.

Table 1: Experimental diets

Ingredients (%)	Treatments: Roselle Seed Meal Processed by Different Methods			
	T1	T2	T3	T4
Processed Roselle seed meal	35.60	35.60	35.60	35.60
Wheat offal	13.65	13.65	13.65	13.65
Sorghum husk	20.00	20.00	20.00	20.00
Rice husk	30.00	30.00	30.00	30.00
Common salt	0.25	0.25	0.25	0.25
Bone meal	0.5	0.5	0.5	0.5
Total	100	100	100	100
Calculated analysis				
Crude Protein	15.00	15.00	15.00	15.00

Results

Effect of processing methods on proximate composition of the processed roselle seed meal

The results of proximate compositions of the processed roselle seed meals were presented in Table 2. It shows no significant ($P>0.05$) different among the treatments on parameters evaluated except for % DM and ether extract. The values of % DM obtained range from 95.72% in T2 to 96.72% in T1. %EE obtained in T3 (4.10 %) was statistically superior ($P<0.05$) to other treatments.

Effect of processing methods on antinutritional factors in the roselle seed

Table 3 shows the anti-nutritional factors of the processed roselle seeds. It reveals that all the anti-nutritional factors analyzed were significantly ($p<0.05$) different across the treatments. The value of tannin obtained in this study ranges from 0.38mg/g in T3 to 0.87mg/g in T1. The value of saponin obtained in this study ranges from 13.21mg/g in T4 to 22.57mg/g in T1. The pyrate obtained in this study ranges from 33.13mg/g in T3 to 50.79mg/g in T1. Cynide obtained in the PRS ranges from 6.51mg/g in T2 to 10.34mg/g in T4. The value of oxalate obtained here ranges from 2.12mg/g in T1 to 4.36mg/g in T4.

Effect of processing methods on some mineral composition of roselle seed

Table 4 shows the mineral composition of various processed roselle seed. The result of

this study indicates that among the macro minerals analyzed, potassium (K) and sodium (Na) were found to be significantly ($p<0.05$) different across the treatments. However, Copper (Cu) was found to be significantly ($p<0.05$) different among the micro minerals. All other minerals analyzed apart from those mentioned above were not significantly ($p>0.05$) different among the treatment groups. The values of K ranges from 639.85ppm in T1 to 773.92ppm in T4. The value of Na analyzed in this study ranges from 120.61ppm in T2 to 160.80ppm T4. The value of Cu ranges from 13.63ppm in T4 to 44.27ppm in T2. The value of calcium obtained in this study ranges from 500.50ppm in T2 to 651.50ppm in T3 and T4. Mg value obtained ranges from 254.90ppm in T1 and T4 to 352.94ppm in T3. The value of Zn analyzed was 7.49ppm across all the treatments. Mn was found in the range of 12.26ppm in T1 to 18.95ppm in T2 and T3.

Effect of processing methods on feed intake and growth performance of grazing red sokoto bucks

Results from feed intake and growth performance of grazing red Sokoto bucks supplemented with diets containing PRSM presented in Table 5, reveals that there was significant ($P<0.05$) difference in values of total weight gain, average feed intake and total feed intake. However, there was no significant ($p>0.05$) different in values of final weight gain and FCR.

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Table 2: Proximate compositions of various processed *Hibiscus sabdariffa* L. seeds

Parameter (%)	T1	T2	T3	T4	SEM	LOS
DM	96.72 ^a	95.72 ^b	95.78 ^b	96.02 ^{ab}	0.13	*
CP	21.16	20.83	21.00	19.07	0.63	NS
CF	21.44	22.21	23.73	22.61	0.58	NS
NFE	49.67	48.86	46.97	49.91	0.97	NS
EE	3.30 ^b	3.53 ^{ab}	4.10 ^a	3.67 ^{ab}	0.18	*
ASH	4.43	4.57	4.23	4.75	0.11	NS

DM-Dry matter, CP-Crude protein, CF-Crude fibre, EE-Ether extract NFE-Nitrogen free extract, SEM - Standard Error of means, LOS-Level of significance, *-Significant, NS- not significant.

Table 3: Anti Nutritional factors of various processed Roselle (*Hibiscus sabdariffa*) seeds

Parameter (Mg/g)	T1	T2	T3	T4	SEM	LOS
Tannin	0.87 ^a	0.63 ^b	0.38 ^c	0.42 ^c	0.06	*
Saponin	22.57 ^a	20.53 ^b	19.85 ^b	13.21 ^c	1.07	*
Pytate	50.79 ^a	46.22 ^b	33.13 ^d	39.69 ^c	2.01	*
Cyanide	7.06 ^c	6.51 ^d	8.41 ^b	10.34 ^a	0.45	*
Oxalate	2.27 ^b	4.25 ^a	2.12 ^b	4.36 ^a	0.32	*

SEM- Standard Error of means, LOS-Level of significance, *-Significant.

Table 4: Some macro and micro mineral composition of various processed Roselle (*Hibiscus sabdariffa*) seeds

Minerals (ppm)	T1	T2	T3	T4	SEM	LOS
Macro						
Ca	606.1	500.0	651.5	651.5	45.84	NS
Mg	254.90	274.51	352.94	254.90	27.89	NS
K	639.85	645.95	749.54	773.92	22.33	*
Na	140.70	120.61	140.70	160.80	6.43	*
Micro						
Zn	7.49	7.49	7.49	7.49	0.92	NS
Mn	12.26	18.95	18.95	17.83	1.33	NS
Cu	30.30	44.27	36.36	13.63	4.19	*

SEM- Standard Error of means, LOS-Level of significance, *-Significant, Ca-Calcium, Mg-magnesium, K-Potassium, Na- sodium, Zn-Zinc, Mn-manganese, Cu-Copper.

Table 5: Feed intake and growth performance of Red Sokoto Bucks fed Roselle seed meal

Parameter	T ₁	T ₂	T ₃	T ₄	SEM	LOS
Initial body weight (kg)	12.03	11.06	11.66	12.00	0.32	NS
Final weight (kg)	13.90	14.10	14.33	14.53	0.41	NS
Total weight gain (kg)	1.87 ^c	3.04 ^a	2.67 ^b	2.53 ^b	0.29	*
Average feed intake (kg)	1.27 ^b	1.42 ^a	1.50 ^a	1.47 ^a	0.05	*
Total Feed intake (kg)	10.19 ^c	11.32 ^b	11.95 ^a	11.75 ^a	0.38	*
Feed conversion ratio	5.91	3.40	4.01	4.99	0.42	NS

T₁ = diet containing untreated Roselle seed meal (control), T₂ = diet containing fermented Roselle seed meal, T₃ = diet containing hot water treated Roselle seed meal and T₄ = diet containing lye water treated Roselle seed meal, Means with different superscript within the same row differed significantly at P<0.05, SEM= standard error mean, LOS-Level of significance, *-Significant, NS- not significant

Discussion

Proximate composition of the processed roselle seed

The dry matter contents of the seed obtained in this study (95.72% to 96.72%) agreed with 94.34% for pre-treated roselle seed flour reported by Karma and Chavan (2017) and (95%) dry matter reported by Mariod *et al.* (2013). Lye water treatment (T4) has slightly reduced the crude protein content of the seed to (19.07% CP) which implies that lye water treatment has negative effect on protein. With the exception of T4, all other crude protein obtain in the current study were in agreement to those reported by Mariod *et al.* (2013) for RSM subjected to different treatments; but lower than (27.78%) reported by previous researchers (Nzikou *et al.*, 2011). The ether extract was slightly increased in T3 compared to other treatments which indicates that hot water has a positive effect on EE. In the present study, the EE contents (3.30 to 4.10%) were found to be lower than (21.85%) as reported by Nzikou *et al.* (2011). The crude fibre (21.44 to 23.73 %) and ash (4.23 to 4.75) recorded in this study were similar to those reported by Maffo *et al.*, (2014). NFE of the seed was higher than the values (27.27%, 27.80% and 13.87%) earlier reported by Nzikou *et al.* (2011); Mariod *et al.* (2013) and Karma and Chavan (2017), respectively.

Anti-nutritional factors of various processed roselle seed

Anti-nutritional factors (ANF) are natural agents in feed that limits the bioavailability of nutrients (Kumar *et al.*, 2017). The ANFs analyzed in this research were tannin, saponin, Pytate, cyanide and oxalate. It was observed that hot water treatment (T3) reduced the different anti-nutritional factors more than other treatments. Tannin was significantly reduced by Hot water treatment as compared to other treatments. The tannin contents of the seed obtained in this study was similar to (0.16mg/g)

reported by Anhwange (2006) but statistically inferior than (17%) extracted from dried calyces of *Hibiscus sabdariffa* using solvent extraction method by Okereke *et al.*, (2015). According to Ramchadra *et al.* (2019), more than 4% concentration of tannin has been reported to be harmful to ruminants. Condensed tannins have more profound digestibility-reducing effect than hydrolysable tannins, whereas, the latter may cause varied toxic manifestations due to hydrolysis in rumen (Akande *et al.*, 2010; Smitha Patel. *et al.*, 2013). In the present study, saponin contents of the seed ranged from 13.21-22.57mg/g. The various treatments that were carried out in this study has slightly reduce the saponin content of the roselle seed with lye water treatment (T4) having the highest effect (13.21mg/g) as for other treatments. Apart from T4 that was lower than the earlier findings (2.2%) tannin contents, all other treatments were similar to the report Anhwange *et al.*, (2006). High concentration of saponin in feed reduces the bioavailability of nutrients; decreases enzyme activity, affects protein digestibility by inhibiting various digestive enzymes such as trypsin and chymotrypsin (Liener 2003; Gemede *et al.*, 2014). However, despite the negative effect of saponin in diet of animals, it also has some beneficial effects of biological importance as antibacterial and anti-protozoal (Avato *et al.*, 2006; Kumar *et al.*, 2017). Phytate content of the seed was highly reduced to 33.13mg/g in hot water treatment (T3) which implies that T4 was more effective compared to other treatments, but all values of phytate obtained in the current work were much higher than (2.58mg/g and 5.90mg/100g) reported Karma and Chavan (2017) and Anhwange *et al.* (2006). Phytate works as a highly negatively charged ion and its presence in the diet has a negative impact on the bioavailability of divalent and trivalent mineral ions in non ruminants

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(Yilkal, 2015). In areas of the world where cereal proteins are a major and predominant dietary factor, the associated phytate intake is a cause for concern (Gemedede *et al.*, 2014). Fermented roselle seed has least cyanide content (6.51mg/g) as compared to other treatments. The values of cyanide (0.29mg/100g) obtained by Anhwange *et al.* (2006) in roselle seed and 0.21mg/g to 0.36mg/g reported by Abdurrahaman *et al.* (2017) for nutritional potential of *Piliostigma reticulatum* (dc) Hotchst pods in semi arid zone of Nigeria were lower than the current values. Generally, only plants that produce more than 20mg HCN/100g fresh weights are considered toxic (Okoli *et al.*, 2003; Njidda, 2010). According to Ramchandra *et al.* (2017), ruminants are more susceptible to hydro cyanide toxicity than non-ruminants such as horses and pigs. High consumption of feed containing large amount of hydro cyanide usually causes reduced growth; poor feed efficiency and resultant death in large ruminant such as cattle and buffaloes which are more susceptible than small ruminants. The lethal dose of HCN for cattle and sheep is 2.0-4.0 mg per kg body weight (Kumar *et al.*, 2017). Higher oxalate observed in T2 and T4 indicated that both fermentation and lye water treatment tends to increase the oxalate content of the seed. The oxalate content of the seed (2.12mg/g to 4.36mg/g) observed in this study were very low when compared with 19.28% reported by Alwandawi (2015) in roselle seed pod. However, hot water treatment can be considered as the best processing method for reducing the effect of anti-nutritional factors found in the seeds. Oxalates react with calcium to produce insoluble calcium oxalate thereby reducing calcium absorption as well as causing a disturbance in the absorbed calcium: phosphorus ratio (Kumar *et al.*, 2017). The effect of oxalate poisoning in animals varies with species as ruminants adapted to diets with high oxalate content can tolerate oxalate levels that are

lethal to non-adapted animals (Ramchandra *et al.*, 2019).

Mineral composition of various processed roselle seed meal

Lye water treatment has significantly increases the K and Na contents of the seed, but the values of K and Na in this study were lower than (1329 ±1.47mg/100g and 659 ±1.58mg/100g) reported by Nzikou, (2011) and (16.86-20.71mg/g and 0.90-2.90mg/g) reported by Sanoussi *et al.* (2013) for seeds of three Roselle ecotypes from Niger. This variation can be as a result of differences in the geographical location in which the seeds were obtained and the effect of processing methods. The highest value of Cu was obtained in fermented roselle seed (T2) which was very low compared to (72±3.75 mg/g) revealed by Sanoussi *et al.* (2013). The Ca contents of the various roselle seeds were also lower than (4.70mg/g to 5.10mg/g) and (647±1.21mg/100g) reported by Sanoussi *et al.* (2013) and Nzikou *et al.* (2011). The values of magnesium obtained in this research were found to be lower than the previous findings made by Nzikou *et al.* (2011). The zinc contents of the seed were not affected across the treatments, but all the values of zinc were lower than the early findings of previous researchers (88±3.88, 97±4.61 and 75±2.65 µg/g) in the seeds of three ecotypes (E3, E7 and E9 respectively) of roselle from Niger (Sanoussi *et al.*, 2013). The values of manganese obtained in the present study increased across the treatments with untreated seed having the least value. Similarly, the values (75 ±2.65µg/g to 88 ±3.88µg/g) for Zinc obtained by Sanoussi *et al.* (2013) were higher than the current values.

Growth performance of grazing of red sokoto bucks

The final weigh obtained ranged from 13.90kg in T1 to 14.55kg in T4. These values were slightly higher than 11.30kg to 13.12kg reported by Hassan *et al.* (2016) in red sokoto bucks fed graded levels of lablab

hay as a supplement to maize stover basal diet. The fermented roselle seed treatment had the highest weight gain (3.04kg) compared to other treatments. These treatments were numerically higher than the control (T1). Also, weight gain in this study was in agreement with the report of previous scientists (Hassan *et al.*, 2016; Makun *et al.*, 2016). However, values obtained by Jibrin *et al.* (2018) were higher than the current values. The result obtained for feed intake in the current study was lower than the values (19.82-22.74kg) obtained by Yashim *et al.* (2016) from their study on growth performance, nutrient digestibility and nitrogen Balance in red sokoto bucks fed irish potato (*solanum tuberosum L.*) peels as a replacement for maize offal. The highest FCR (5.91) was recorded from untreated roselle seed (T1), this means that the processing methods have significantly reduced the FCR of the animals. More so, previous researchers (Hassan *et al.*, 2011; Ikyume *et al.*, 2018; Jibril *et al.*, 2018) reported higher FCR (3.40-5.91) than obtained in this study.

Conclusion

The study revealed that processing methods had no effect on the proximate composition of the processed roselle seed, except in the mean values of dry matter and ether extract but substantially reduced the effect of anti-nutritional factor in roselle seed and can serve as a good source of protein for small ruminant production. It is concluded that supplementation of roselle seed meal in as a diet can successfully improve the performance of goats without any detrimental effect.

Recommendation

Based on the outcome of this research, hot water treatment is suggested for reducing anti-nutritional factors in seed.

Roselle seed meal either processed or unprocessed can surely be fed to our

ruminant animals with a good resultant weight gain as obtained in this study. Further studies may be conducted on feeding diets containing processed roselle seed meal on nutrient digestibility and nitrogen balance to ruminants.

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