



Chemical composition and anti-nutritional factors of underutilized (*Delonix regia*) seeds processed with different methods for sustainable ruminant production

*Lamidi, A. A. and Evien, E.E.

Department of Animal Science, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria

Abstract

*Nutrients and anti-nutrients profile of *Delonix regia* seeds subjected to different processing methods for sustainable ruminant production in Niger Delta, Nigeria was studied. Eight different experimental treatments were adopted, namely T1 (raw/control); T2 (roasted); T3 (soaked in water for 24hrs); T4 (soaked in water for 48hrs); T5 (soaked in rumen liquor for 24hrs); T6 (soaked in rumen liquor for 48hrs); T7 (parboiled); T8 (cooked), replicated three times in a Complete Randomized Design (CRD). Results shows no significant difference ($P>0.05$) in all the parameters considered for proximate composition of *Delonix regia* seeds except crude fibre (CF), T4 had least significant ($P>0.05$) value (2.97%) of CF among the treatments. Calcium content varied ($P<0.05$) from 0.07 – 0.10%, while K and Mg value ranged ($P<0.05$) from 0.32 – 0.38% and 0.13 – 0.14% respectively. Sodium, P, Fe and Zn had similar ($P>0.05$) content across the treatments. Phytate content were similar ($P>0.05$) across the treatments. Significant ($P<0.05$) difference was observed for oxalate, tannin and saponins across the treatments. Tannin was higher ($P<0.05$) in T7 and T8, while the least ($P<0.05$) values was observed in T3. The T2 (roasted) treatment promoted higher contents of Ca, K and Mg, while the T3 (24 hrs. water soaked) seeds had least phytochemical properties. T3 can be recommended for the effective process of *Delonix regia* seeds for sustainable ruminant production.*

keywords: *Delonix-regia*-seeds, Nutrients, Phytonutrients, Ruminant, Sustainable production

Introduction

Availability of feed is one of the greatest constraints to the expansion of the ruminant production in Nigeria. Apart from the limited production and the high and fluctuating costs, some of the ingredients used in finished feeds, notably cereal grains, are in high demand for human consumption, industrial use and know bio-fuel production, these resulted to serious feed resources competition. In view of these challenges, there is the need to investigate alternative feed resources from agro-industrial by-products, food wastes, farm wastes and other unconventional feed resources that are available and of no economic value in human nutrition. However, alternative feed resources, particularly of plant origin are noted to contain high level of anti-nutrients and other phytochemicals which could limit the use of these potential feed resources in livestock feed formulation.

Delonix regia (Caesalpinidae) is a tree, which is about 12m high with a slightly flat or curving crown. It is an ornamental, leguminous plant, which produces tones of pods containing seed in the fruiting season (Keay, 1967; Lamidi and Ojo, 2018). These seeds are left unutilized since they are neither consumed by any animal nor utilized for any other medical purposes. Its seeds contain 20.50% crude protein (CP), 4.18-4.23% ether extract (EE), 4.45-6.84% crude fibre (CF) and secondary compounds of condensed tannins and saponins at 90-95 mg · 100 g⁻¹ and 10-15%, respectively (Alemede *et al.*, 2010; Kaga, 2011). This study examined the nutrients composition and phytonutrients profile of *Delonix regia* seeds subjected to different processing methods for sustainable ruminant production.

Materials and Methods

Collection of experimental materials

*akeem.lamidi@uniport.edu.ng

2348055219133 / 08103142367

The study was carried out in the Faculty of Agriculture Teaching and Research Farm, University of Port Harcourt, Port Harcourt, Rivers State. Port Harcourt is a coastal city located in the Niger Delta region of Nigeria within latitudes 6° 58' – 7° 60' E and longitudes 4° 40' – 4° 55' N (Lamidi and Ogunkunle, 2016).

Matured *Delonix regia* fruits were harvested from *Delonix regia* trees within the University of Port Harcourt community, Port Harcourt, Rivers State. The collected pods were sun-dried for three days and dehulled to obtain the seeds, also discarded seeds was also being gathered.

Experimental treatments

Eight (8) different processing methods was used and they are as follows:

(T1) Raw: Raw *Delonix regia* seeds (Untreated seeds).

(T2) Roasted: Dry sand (1kg) was heated to 100-110°C in a pan using a kerosene stove as source of heat. Thereafter, 1kg of the seed was poured into the pan and the content was stirred repeatedly to ensure uniform roasting and prevent charring. The seeds was considered roasted when change in seed colour from brown to dark brown is observed and change in aroma. The seeds were removed from the sand and spread out to cool, grinded, stored and labeled in an air-tight container until required for laboratory analyses.

(T3 and T4) Soaked in water: 1kg of seed was soaked in 1.5litre of distilled water at varying durations 24hrs and 48hrs, respectively. Thereafter, seeds were removed from the water and air-dried until no appreciable weight difference was observed.

(T5 and T6) Soaked in rumen liquor: 1kg of seed was soaked in 1.5litre of rumen liquor for 24hrs and 48hrs, respectively. Thereafter, seeds were removed from the rumen liquor and air-dried.

(T7) Parboiled: Water was boiled and later poured into the seeds and was allowed to cool and air dry. (T8) Cooked: The seeds were put in a pot and cooked with water using a kerosene stove, allowed to cool and air dry. The seeds then air dried for three days, ground and sieved into 2mm.

Chemical analysis

The proximate composition of the silage was determined according to AOAC (2000), while neutral detergent fibre (NDF) was determined according to Van Soest et al. (1991). Non-fibre carbohydrate was calculated as NFC = 100 – (CP + Ash + EE + NDF). Mineral composition of the samples was carried out using the Atomic Absorption Spectrophotometer of AOAC (1990). Tannin and saponin contents were determined according to the methods described by Rosales *et al.* (1989). Oxalate was according to Munro (2000) while phytate was determined as describe by Prokopet and Unlenbruck (2002).

Experimental design statistical analysis

The study was conducted using a completely randomize design (CRD). All the data collected were subjected to a one-way analysis of variance (ANOVA) using SAS (2002) Statistical package. Significant treatment means were compared using Duncan's New Multiple Range Test.

Results and Discussion

Table 1 shows the proximate composition of *Delonix regia* seeds treated with different methods of processing. There was no significant ($P > 0.05$) difference in all the parameters considered for the proximate composition of treated *Delonix regia* seeds (DM, CP, EE, CF, ASH and NFE) except crude fibre (CF). The value for the DM, CP, EE, Ash and NFE ranged from 86.82 - 89.51%, 20.27 - 21.45%, 2.24 - 3.05, 4.25 - 4.89 and 54.87 - 58.53%, respectively. The CF were similar ($P < 0.05$) in T1, T2, T3, T5, T6, T7 and T8.

However, T4 had least significant ($P>0.05$) value (2.97%) of crude fibre among the treatments.

Table 1: Proximate composition of (%) *Delonix regia* seeds treated with different methods of processing

Treatments	Parameters							
	DM	CP	EE	CF	ASH	NFE	NDF	ADF
1	88.41	20.59	2.24	3.38 ^a	4.25	58.37	39.78	25.18
2	89.03	21.28	2.59	3.47 ^a	4.36	58.33	39.85	25.27
3	89.22	20.78	2.46	3.42 ^a	4.29	58.27	39.43	25.14
4	86.82	20.27	3.05	2.97 ^b	4.54	54.87	39.67	25.38
5	89.14	20.59	2.37	3.29 ^a	4.33	58.53	39.72	25.33
6	89.41	21.09	2.79	4.48 ^a	4.67	56.38	38.89	25.47
7	89.35	21.17	2.75	4.54 ^a	4.73	56.16	39.69	25.41
8	89.51	21.45	2.84	4.59 ^a	4.89	55.70	39.64	25.29
SEM	0.63	0.83	0.11	1.81	0.26	0.73	0.76	0.37

^{a, b} Means value with different superscripts within a column significantly different ($P<0.05$), SEM= Standard error of mean T1= (Raw seeds/control); T2= Roasted; T3= water soaked for 24hrs; T4= water soaked for 48hrs; T5= Rumen liquor soaked for 24hrs; T6= Rumen liquor soaked for 48hrs; T7= parboiled; T8= cooked

The experimental treatment T4 had the least significant effect on the crude fiber compared to other treatments, this result might be different from the findings of previous study on the proximate composition, due to different processing methods and the strategies adopted in the present study. The dry matter recorded (88.41 - 89.51 %) in this study is within the range of dry matter catalogued (89.26 - 89.88 %) by Lamidi and Ogunkunle (2015) for ruminant feedstuffs in South west Nigeria. The range of CP value (20.59 – 21.45%) obtained in this study similar to 20.50% CP reported by Kaga, (2011), differed from 12.77 – 16.44% reported for the same seeds by Falola et al, (2017). The different might be different in ecological and edaphic factors Lamidi and Aina (2013). However, CP contents recorded across the experimental treatments was higher than crude protein referred for ruminant animal nutrition. Gaterby (2002) indicated 10 - 12% CP as a moderate level for ruminant production. Therefore, the *Delonix regia* seeds irrespective of the experimental treatments (processing methods) would provide the adequate nitrogen requirement for the rumen

microorganisms to maximally digest the main components of dietary fibre leading to the production of volatile fatty acids (Trevaskis *et al.*, 2001; Lamidi and Ogunkunle, 2016) which in turn facilitate microbial protein synthesis (Lamidi and Aina, 2013).

Similar content of NFE was recorded for all the experimental treatments. The NFE is an indicator of carbohydrate content of feedstuff or ingredient that is soluble or easily digested and available for animal. It implies that the soluble carbohydrate could support the production of volatile fatty acids in the rumen during fermentation (Blummel *et al.*, 1997).

Higher levels of NDF and lignin have been reported to have negative effect on DM intake and DM digestibility (Bakshi and Wadhwa, 2004). Meanwhile, the NDF (38.89 – 39.85%) contents recorded in this study were less than 60% which is considered safe for acceptable intakes of forage in ruminants (Meissner *et al.*, 1991).

Mineral profile of *Delonix regia* seeds treated with different methods of processing was indicated in Table 2. Significant ($P<0.05$) difference in the mineral content of Ca, K and Mg was observed. Calcium content varied ($P<0.05$) from 0.07 – 0.10%, while K and Mg value ranged ($P<0.05$) from 0.32 – 0.38% and 0.13 – 0.14 respectively. Sodium, P, Fe and Zn had similar ($P>0.05$) content across the experimental treatments. Meanwhile Fe and Zn content ranged from 62.90 - 66.20 mg/kg and 8.10 - 9.50 mg/kg respectively.

Table 2: Mineral profile of *Delonix regia* seeds treated with different methods of processing

Treatments	Parameters						
	Ca (%)	P (%)	Na (%)	K (%)	Mg (%)	Fe (mg/kg)	Zn (mg/kg)
1	0.70 ^c	3.70	1.00	3.40 ^b	1.30 ^d	63.40	8.40
2	1.00 ^a	4.00	1.10	3.80 ^a	1.40 ^a	66.20	9.50
3	0.80 ^{ab}	3.90	1.00	3.40 ^{bc}	1.30 ^{cd}	63.70	8.70
4	0.80 ^{ab}	3.90	1.10	3.30 ^{bc}	1.40 ^{ab}	64.30	8.10
5	0.90 ^{ab}	3.80	1.10	3.30 ^{bc}	1.40 ^{ab}	62.90	8.50
6	0.90 ^{ab}	3.70	1.00	3.50 ^b	1.30 ^{abcd}	64.60	9.10
7	0.80 ^{bc}	3.80	1.00	3.20 ^c	1.30 ^{cd}	65.40	8.87
8	0.80 ^{bc}	3.80	1.00	3.30 ^b	1.30 ^{abcd}	66.50	9.30
SEM	0.01	0.11	0.10	0.11	0.10	0.63	0.18

^{a, b, c, d} Means value with different superscripts within a column significantly different ($P<0.05$) SEM= Standard error of mean T1= (Raw seeds/control); T2= Roasted; T3= water soaked for 24hrs; T4= water soaked for 48hrs; T5= Rumen liquor soaked for 24hrs; T6= Rumen liquor soaked for 48hrs; T7= parboiled; T8= cooked

Table 3: Anti-nutritional factors of *Delonix regia* seeds treated with different methods of processing

Treatments	Parameters			
	Phytate (%)	Oxalate (%)	Tannin (%)	Saponins (%)
1	0.32	0.189 ^{bc}	0.067 ^d	0.118 ^{cd}
2	0.32	0.198 ^{ab}	0.080 ^{bc}	0.129 ^{abc}
3	0.32	0.187 ^c	0.060 ^d	0.126 ^{bcd}
4	0.33	0.192 ^{bc}	0.075 ^c	0.124 ^{cd}
5	0.32	0.189 ^{bc}	0.070 ^d	0.126 ^{bcd}
6	0.33	0.194 ^{bc}	0.080 ^{bc}	0.122 ^{cd}
7	0.34	0.204 ^a	0.090 ^{ab}	0.136 ^{ab}
8	0.34	0.207 ^a	0.090 ^a	0.139 ^a
SEM	0.01	0.008	0.000	0.001

^{a, b, c, d} Means value with different superscripts within a column significantly different ($P<0.05$) SEM= Standard error of mean; T1= (Raw seeds/control); T2= Roasted; T3= water soaked for 24hrs; T4= water soaked for 48hrs; T5= Rumen liquor soaked for 24hrs; T6= Rumen liquor soaked for 48hrs; T7= parboiled; T8= cooked

Though, roasted seeds (T2) recorded higher ($P<0.05$) contents of Ca, K and Mg while similar value was recorded for P, Na, Fe and Zn for all the treatments, no scientific reasons for this trend. The range of *Delonix regia* seeds in this study is within what Falola *et al*, (2017) catalogued. The range of Ca value (0.70 –

1.00%) in the raw and treated *Delonix regia* seeds was higher than the recommended range (0.20 - 0.26g/100g) for maintenance of growing and lactating sheep (Reuter and Robinson, 1997). The P content (3.7 – 4.0%) was higher than the recommended range (0.15-0.48g/100g) required by ruminants

(McDowell, 1992; 1997). The Na content (0.09 – 1.10%) was also higher than the recommended range of 0.1 - 0.4 g/100g as minimum Na for ruminants (Littledike and Goff, 1987).

Table 3 depicts the anti-nutritional factors of *Delonix regia* treated with different processing methods. The phytate content were similar ($P>0.05$) across the treatments. There was a significant difference ($P<0.05$) in oxalate, tannin and saponin. The highest significant ($P<0.05$) value of oxalate was recorded in T2, T7 and T8. Similar ($P>0.05$) oxalate content was recorded for T1, T2, T4, T5 and T6 vis a vis T3, T4, T5 and T6. The tannin was higher ($P<0.05$) in T7 and T8, while the least ($P<0.05$) values ranges was observed in T3. The value of saponin significantly ranged from 0.115 - 0.139%.

Twenty-four hours' water soaked treatments method (T3) had the least significant difference of oxalate, tannin and saponins among the other treatments, this is in agreement with previous authors, that seed processing substantially reduces and inactivates levels of secondary compounds in the seed.

Feedstuff containing saponin has been shown to be defaunating agent (Fajemisin, 2015) and capable of reducing methane production (Babayemi *et al.*, 2004). The tannin level in *Delonix regia* is below 6.0 % toxic level for small ruminants and it could be an added advantage as a natural additive in the diet of ruminants, since forage or feeds containing tannin have potential of forming complexes with protein as bypass protein in the rumen by diminishing rumen protein digestibility, thus improving on the availability of protein to ruminants at the lower gut. In addition, there is an increasing interest in exploiting tropical plant products as feed additives to solve the problems connected with animal nutrition and

livestock production. A variety of nutritional amendments, such as more grain addition, inclusion of leguminous forages containing condensed tannins and saponins, supplementation of low-quality roughages, readily fermentable carbohydrates and fat, could be promising for CH₄ mitigation (Hristov *et al.*, 2013; Cieslak *et al.*, 2016). In lieu of this *Delonix regia* could be used to mitigate the CH₄ production in ruminant production.

Conclusions and Recommendations

The experimental treatments did not have any significant effects on the proximate composition of the *D. regia* seeds and the nutrients will meet the nutrients requirements of the ruminant animals, T2 (Roasted) promoted higher content of Ca, K and Mg among the other treatments. The T3 and T4 (water soaked 24 and 48 hrs. respectively) had the least value of phytochemical properties compared to other treatments, T7 and T8 (parboiled and cooked methods recorded higher contents of phytochemicals properties. Twenty-four hours (24hrs) Water soaked processing methods (T3) is recommended for proper treatment of *Delonix regia* seeds for effective and efficient utilization for sustainable ruminant production.

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