

NEEM (*Azadirachta indica*) SEED CAKE/KERNEL AS PROTEIN SOURCE IN RUMINANTS FEED

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ABSTRACT

Ruminant production that is very popular in Nigeria livestock production faces series of problems, chief among them is the shortage of protein supply in adequate amount for optimum performance of the animals. The forages, which constitute the bulk of the source of feed for these animals, fluctuate in supply with poor nutrient content especially during the dry season of the year. The convectional protein concentrates which boost the protein supply faces intense competition from man. It has become imperative for intensive effort to be made at making the unconventional source of protein available to the farmers. Neem seed cake/ kernel cake fits as one of the unconventional protein supply in view of the high level of the protein content and balancing of the amino acids. It is capable of offering a big relief to these protein shortages. The neem seed is readily available in the northern part of Nigeria that is the home to the largest of number of ruminants in the country. However, they are not readily acceptable to the animals due its pungent smell and bitterness caused by the active principles present. This paper reviewed availability of neem seed in Nigeria, antinutritional factors and limitation, methods of processing and debitterizing the cake, nutritional quality, palatability, nutrient digestibility and performance, effect on haematological and biochemical characteristics; and the economics of use of the cake. The paper concluded that neem seed cake/kernel could readily serve as safe source of protein to the ruminants with appropriate treatment to remove active principles.

Keywords: Neem kernel cake, Alkali treated neem kernel, haematological, biochemical and Uda Lambs.

1. INTRODUCTION

Ruminant production in Nigeria is popular among the rural farmers. They are widely distributed in among rural, urban, and peri-urban areas representing about 63.7% of the total grazing domestic animals in Nigeria (1). It supplies a great proportion of meat consumption. According to (2), the average Nigerian consumes only 3.245g of animal protein per day, out of the 34g recommended by FAO. According to (3), cattle still contribute over 50% of the national meat supply, while other

38 classes of livestock contribute the remaining 40-45%. Of this, 35% are from small ruminants and
39 about 10% from poultry (3). The level of domestic livestock production still falls short of demand,
40 in 1997 and 1998; demand for beef was 554,000 and 627,000 tonnes, respectively. However, the
41 domestic supplies were 376,000 and 391,000 tonnes for the years 1997 and 1998, respectively
42 (4). The most important factor responsible for the gap in the relationship between the demand
43 and supply of ruminants in Nigeria is the supply of feed both in quantity and quality. The main
44 feed resources for small ruminants are natural pastures consisting of legumes and browse
45 species (5). These pastures depend on rainfall which fluctuates especially in the northern part of
46 the country where the largest percentage of the animals are raised.

47 According to (6), the scarcity of energy and protein feedstuffs during dry season is a major
48 setback to ruminant livestock production in the tropics. During this period, the available forages
49 are dry, protein content of which is very low and there is marked decrease in voluntary intake and
50 digestibility by the animal (7; 8). The nutritional problems of ruminants have been increased by
51 competition between man and the animals for the scarce grains and the protein concentrates
52 feed making it difficult to meet up with nutritional requirements of the animals at affordable cost.

53 Some of the factors which contributed to the increasing cost of feed are under-production of
54 various ingredients used in feed formulation, high inflation rates and competition in consumption
55 of these ingredients by other animal species including man. The increase in human population
56 further worsens the situation because of pressure placed on the available land for grazing,
57 competition for grains and other crops that are consumed by man but do not have a
58 commensurate increase with that of human population and inappropriate employment of
59 technology for improved production.

60 The commonest protein supplement for livestock feed in Nigeria in periods of low yield and
61 availability of poor quality herbage are groundnut cake (GNC) and cotton seed cake (CSC). The
62 prices of GNC and CSC products have been rising thereby increasing the cost of production.
63 Researchers therefore considered the use of alternative source of feed ingredients in order to
64 reduce the cost of production. One of the promising materials under consideration is the neem
65 kernel cake. However, despite its availability and the derivable benefits from the use of the cake,
66 its use is still beleaguered by series of problems.

67 The main objective of this study is to create awareness on the potentials of the use of neem seed
68 cake in Nigeria. The study will further dwelt on the nutritional and antinutritional components; and
69 the different methods of debitterizing the cake.

70 **2. METHODOLOGY**

71 Secondary materials obtained from published journals and reports were for review of this
72 study.

73 **3. DISCUSSION**

74 **3.1 Neem Seed Availability**

75 Neem tree is planted in many states in Nigeria (9). According to (10), about 3,500 hectares of
76 land is under cultivation in Kebbi, Sokoto and Zamfara states, with a density of about 1,200 trees
77 per hectare. In Nigeria, neem form about 90% of forestry established in 12 states within the
78 savanna zone under the aforestation programme (11). The neem tree does well in well drained
79 deep soil, sandy loams with ground water level at 3.05 metre depth or more. The Neem tree
80 (*Azadirachta indica*) is an evergreen of the tropics and subtropics. It is native to India but widely
81 planted and naturalized throughout Asia, Africa, Australia, the Caribbean and several Central
82 American countries (12). It may grow up to 15m tall under ideal conditions and is reported to live
83 up to 200 years (12). The tree has the ability to withstand frost due to a very suberised back layer
84 and can easily survive desert conditions of temperature above 50⁰C and takes about five years to
85 produce the first fruit crop but can produce a good yield in the third year (13). The tree has the
86 advantage of growing on marginal lands (14). Neem tree can perform well in dry soils that are
87 poor in nutrients (130mm) (15). Neem tree flowers between February and May with profuse
88 clusters of small white flowers. The fruits are drupes, turning golden yellow on maturity, which
89 occurs during June, to August in India. The tree begins bearing fruit after 3 to 5 years and
90 produces about 50kg fruits annually when mature in India. The fruits are about 1.5cm long (12).
91 According to (13), the seeds are about 2cm long and 1.5cm diameter, kernel of about 1.5cm
92 length containing about 30 to 40 percent oil and 5 to 6 years old tree can yield 20kg kernels.
93 However, Radwanski (15) reported that fruit yield is extremely variable ranging from 10 to 50kg
94 per tree with an average of 20kg. The yield of 20.5kg fresh fruit for a fully grown neem tree was
95 reported by NARICT (9) in Nigeria while (16) reported an average yield of 17.71kg in Sokoto and

its environ. The large number of the neem trees and its yield in the northern part of Nigeria is an advantage for its use.

3.2 Anti-nutritional Factors and Limitation of Neem Seed Cake as Feed Ingredient

The possibility of using NSC in livestock ration was explored by Christopher (17) using the feeding practice of local farmers in Southern India. However, NSC pungent odour and the bitter taste caused by the active principles isolated from different parts of the plant namely azadirachtin, meliacin, gedunin, salanin, nimbin, valassin and many other derivatives of these principles constitute the hindrances to its use. Paul *et al.* (18) reported that despite the high CP content, its incorporation in animal diets was discouraged due to their adverse effect on production traits because of the presence of bitter and toxic triterpenoids mainly nimbin, nimbidin, azadrachtin and salanin. The triterpenoids: azadirone, nimbin and salanin have impacted the pungent smell and bitter taste of this cake (19).

Biologically active principles isolated from different parts of the plant include: azadirachtin, meliacin, gedunin, salanin, nimbin, valassin and many other derivatives of these principles. (20) reported the presence of toxic triterpenoids, azadirone, nimbin and salanin in neem seed cake. Meliacine forms the bitter principles of the neem oil; the seed also contain tignic acid (5-methyl-2-butanic acid) responsible for the distinctive odour of the oil (21, 22,23, 24). Neem seed cake is very unpalatable due to the presence of salanolide meliacin which has been found to be one of the active principles of neem seed oil (25). These compounds are natural products called triterpenoids or more specifically, linonoids and they are concentrated in the seed despite their presence in other parts of neem tree.

Neem seed is bitter and pungent in odour. The bitter taste and pungent odour resulting in poor palatability discourage animals from eating it. These compounds influence the palatability of the NSC. NSC has been found to be unpalatable in calves (26), cross-breed bulls(27) and sheep (28). The active principles are slightly hydrophilic but freely lipophilic and highly soluble in organic solvents like hydrocarbon, alcohols, ketones and esters (22,21). (29) reported that poor palatability was accompanied by either poor weight gain or loss of body weight along with lowered nutrient digestibility in crossbred calves fed concentrate mixture containing NSC that contributed 12.5, 25, or 50% of DCP requirement. The author suggested that NSC was unsuitable for animal feeding even for maintenance. (30) observed a gradual decline in growth rate of rams with higher levels of NSC in concentrate ration. This then makes the processing of the cake

127 before being fed to animals very important. The processing of the neem seed into palatable seed
128 cake poses a challenge to its use as animal feed.

129 **3.3 Methods of Processing and Debitterizing of Neem Seed Cake**

130 Single seeded mature neem fruit contains 23.8% skin, 47.5% pulp, 18.6% shell and 10.1% kernel
131 (31). The decortications of depulped seed yields about 26% kernel, which gives 45 to 50% oil
132 leaving the rest as neem kernel cake (NKC).Neem seed cake could not earn favour as a good
133 livestock feed due to its pungent smell and bitter taste imparted by the presence of toxic
134 triterpenoids: azadirone, nimbin and Salanin (20). The impact of the effect of the toxic substances
135 in NSC has over time place so much emphasis on the processing of the seed for these toxic
136 substances to be removed. The removal of the anti-nutritional factors of neem seed can be done
137 through different methods of processing.

138 According to (20), before oil extraction, neem fruits should be soaked in water for 3-4 days and
139 depulped using depulper machine. The seeds decorticated using a winnowing machine and then
140 crushed after further drying for 3 days. The ripe fruits were dried by spreading them in the sun for
141 fifteen days and ground to produce the neem fruit cake. The ripe fruits were dried, soaked in
142 water for three days and then depulped. The depulped seeds were washed and sun dried for a
143 period of ten days. The dry seeds were decorticated, further dried for five days, crushed and the
144 oil removed manually to produce the neem kernel cake. (16) prepared by spreadingthe ripe fruits
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146 cake. The ripe fruits were dried, soaked in water for three days and then depulped. The depulped
147 seeds were washed and sun dried for a period of ten days. The dry seeds were decorticated,
148 further dried for five days, crushed and the oil removed manually to produce the neem kernel
149 cake while (32) reported that collected seeds were sun dried to constant weight.The dried seeds
150 were soaked in water in an open basin for 72 h. The seed were poured into a jute bag to drain the
151 water and later sun-dried to constant weight. Then, the water soaked and untreated seeds were
152 taken to the mill separately for oil extraction. Cake obtained from the oil-extraction was then
153 ground in a hammer mill to pass through 2 mm sieve.

154 There are various methods of removing the oil from the neem seed cake. For the expeller neem
155 seed cake, the crushed kernel will be steamed and the oil is pressed out using expeller machine.
156 The hydraulic press neem seed cake processing is devoid of heat. The milled kernel was cold-
157 pressed using the hydraulic press machine until the oil content of the residue (cake) is minimal.
158 To reduce the oil content of the cake, it is further defatted using hexane. Attempts have been
159 made at removing hte bitter principles or debitterizing the cake for improved palatability. (33) and

(34) adopted the solvent extraction method in which the oil from the crushed neem kernel or cake is extracted using organic solvent of high polarity mixed with water and filtered. alcohol treatment (35), alkali (0.8% NaOH, wt/wt), boiling (1:2.5wt/vol) of cake followed by water washing and draining off after washing (36). Of the several methods tried to detoxify NKC, for example water washing (37), hexane extraction (38), alkali treatment of neem kernel cake (38) and water washing which was found to be most effective despite the loss of 22% dry matter (39). However, to avoid this dry matter loss from water washing, alkali treated (20g NaOH/kg cake, wt/wt) NKC was tried and found to be palatable to adult cattle and buffalo (40), proved promising in the feeding of buffalo calves (41) and Uda lambs and rams (16). (42) also used the simple method for debitterization through alkali soaking or urea ammoniation without water washing because there is loss of nutrient in washing. Such alkali (2.5%, wt/wt NaOH) soaked and urea (3.5%, wt/wt) ammoniated NKC at 30 parts of inclusion in the concentrate mixture of buffalo calves for 150 days feeding revealed comparable feed intake and nutrient utilization.

3.4 Nutrient Digestibility and Performance

Feeding neem seed cake/kernel without treatment has been shown to have negative effect on nutrient digestibility and performance of ruminants. (43) fed 27% neem seed cake as a replacement to groundnut cake with consequent poor growth in cattle. (44) reported poor palatability accompanied by either depressed weight gain or loss of body weight along with lowered nutrient digestibility in crossbred calves fed concentrate mixture containing NSC to contribute 12.5, 25.0 and 50.0% of digestible crude protein requirement suggesting that the NSC as such was unsuitable for animal feeding even for maintenance. (45) reported lowered rumen protozoan count along with reduced enzyme activity in calves fed NSC.

However, there were reports of improvement in the digestibility and performance of ruminants when fed treated neem seed cake/ neem kernel cake. (39) attempted water washing of NKC after overnight washing in NaOH (0.8%, wt/wt) followed by repeated draining off with two or three times water washing. Such water washed NKC (WWNKC) when incorporated after sun drying at 45% level in the concentrate mixture for bull calves for 273 days resulted in significantly lower growth rate and comparable DM intake, nutrient digestibility, balance of Ca, P, N and TDN intake with the control. (36) observed significantly lower DM digestibility, but higher N-balance and faster growth of buffalo calves fed 40% WWNKC than in those on control diet. (46) reported no significant variations in milk yield, milk fat content, and sensory evaluation of milk, dry matter intake and digestibility when water washed neem kernel cake was incorporated at 40% level in the concentrate diet of dairy cow for 300 days. The reports of (47) showed that treatment of neem kernel meal with alkali improved the growth performance, and that of (48) showed improvement in growth when goats were fed urea ammoniated neem kernel cake. (49) reported comparable performance between the growth performance of Uda lambs fed alkali treated neem kernel cake.

3.5 Nutritional Quality of Neem Seed Cake

Neem (*Azadirachta indica*) seed cake (NSC), a by-product of neem oil industry, is a non-conventional feed ingredient with great potential for livestock feeding (50, 33). Neem seed cake has been noted as a rich protein source with 34% - 38% CP (20) and; 33.20% and 32.90% for ATNKC and NKC respectively (16). Deoiled neem seed cake is rich in essential amino acids, crude protein, fibre contents, sulphur and nitrogen (23). Neem seed cake balanced in minerals as shown in Table 1. It is balanced in Ca, P but exceptionally high kernel Fe.

Table 1: Mineral profile of certain neem products (DM)

Product	%					ppm						
	Ca Pb	P	Mg	Na	K	Cu	Zn	Fe	Co	Mn	Cr	
Neem leaves	0.72	0.27	0.77	0.56	1.85	30	15	777	8	59	0.5	30
Neem fruits	0.29	0.36	0.54	0.36	0.74	10	16	775	3	12	0.2	7.8
Neem seed	0.77	0.31	0.37	0.47	1.94	18	26	970	1.3	34.5	-	14.3
Neem cake	0.96	0.30	0.44	0.40	0.98	19	19	2705	1.5	70	1.0	10.6
FFNSM	0.07	0.01	0.10	0.59	1.52	10	60	300	-	20	-	-

Source: 51

FFNSM: Full fat neem seed meal

The gross protein value of variously processed neem seed meal (NSM) ranged from 55 to 59% (51). The undecorticated NSC contained 6.5 to 11.6% digestible crude protein (27). (20) reported crude protein percentage of 23.19%, 22.69%, 23.06% and 22.5% for raw neem seed meal, hydraulic press neem seed cake, solvent extracted Neem seed cake and expeller neem seed cake respectively. The protein quality of neem kernel cake is comparable to that of peanut meal (PNM) (52). Neem cake consists of all essential and non-essential amino acids including sulphur containing ones, but with fewer amounts of histidine, lysine and tyrosine (52).

Chemical composition of neem seed cake is shown in Table 2 and varied considerably depending on the method of processing. The crude protein (CP) varied from 12.35% in neem seed cake (NSC) to 40.91% in urea treated neem kernel cake (UANKC). The crude fibre was highest in full fat neem seed meal of 40.50% as reported by (53). (38) reported the lowest value in neem kernel

cake of 11.40%. The ether extract (EE) varied from 0.38% in deoiled neem seed cake (54) to 27% in full fat neem seed meal (52). The nitrogen free extract was the lowest in full fat neem seed meal (18) with 14% and highest in neem seed cake (26) with 52.52%. UANKC (42) seemed to be the best because of high crude protein of 40.91% and relatively low crude fibre of 11.43%.

Alkali treated neem kernel cake consisted of 33.76% crude protein and 13.77% crude fibre (41). The authors also reported that alkali treated neem kernel cake can be a wholesome substitute for pea nut meal in terms of performance. Water washing was found to be an effective method of detoxifying neem seed cake but there was loss of dry matter of about 22% (39). In addition, some enzyme stimulating factors are also washed out as indicated by Agrawal *et al.* (55). Alkali treatment was adopted to avoid the water loss and was found to be palatable to adult cattle and buffalo (41) and buffalo calves (40).

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231 **Table 2: Chemical composition of various types of neem cake/meal (%DM)**

Neem cake/meal	CP	EE	CF	NFE	Ash	Ca	P	Reference
NSC	12.35	3.3	17.9	52.52	13.93	-	-	(26)
NSC	17.85	3.62	25.90	46.20	5.5	0.72	0.58	(17)
Neem fruit lake	14.97	2.40	26.95	40.92	15.17	1.65	0.31	(56)
NKC	33.50	10.40	11.40	29.70	15.00	-	-	(39)
NSM	35.51	9.14	11.89	28.48	14.98	0.77	0.69	(57)
Hexane Exp. NSM	38.31	1.06	13.46	29.02	18.15	1.05	1.08	(57)
Alcohol NSM	Exp.	40.35	0.71	13.92	26.02	19.00	1.12	1.11 (57)
NSC		20.90	14.80	19.20	29.50	15.50	0.14	0.81 (47)
FFNSM		16.80	22.80	34.61	23.10	2.7	-	- (10)
FFNSM		14.20	27.00	40.50	14.00	14.30	0.07	0.01 (53)

DNSC	18.37	0.381	30.12	34.97	16.16	0.97	0.16	(54)
ATNKC	33.76	5.39	13.77	27.28	19.90	-	-	(41)
UANKC	40.91	4.44	11.43	28.10	15.12	-	-	(42)
ATNKM	36.01	4.80	15.60	27.80	15.80	0.78	0.50	(58)
UANKM	40.06	4.90	15.30	24.12	15.62	0.74	0.45	(58)

232 **NSC: Neem seed cake; NKC/NKM: Neem Kernel Cake/Meal; WWNKC: Water wash NKC; NSM: Neem**
233 **seed meal; FFNSM: Full fat NSM; DNSC: Deoiled NSC; ATNKC/ATNKM: Alkali treated NKC/NKM;**
234 **UANKC/UANKM: Urea-Ammoniated NKC/NKM; Exp: Expeller.**

235 **Palatability of Neem Seed Cake/Kernel**

236 Neem seed cake is unpalatable due to the presence of salanolide meliacin which has been found
237 to be one of the active principles of neem seed oil (25). The seed contains Tignic acid (5-methyl-
238 2-butanic acid), which is believed to be responsible for the distinctive odour of neem oil. These
239 compounds are natural products called triterpenoids or more specifically linonoids and they are
240 concentrated in the seed despite their presence in other parts of neem tree. The compounds
241 influence palatability of the NSC. NSC has been found to be unpalatable in calves (26), cross-
242 breed bulls, (27) and sheep (28). However, the palatability of the NSC can be improved with
243 appropriate treatment to remove the active principles. According to (59), NSC palatability
244 improved when NSC was fed to sheep along with barley, molasses and peanut meal but
245 consumption of concentrate mixture was reduced from 79 to 39% when NSC levels increased
246 from 59% to 90% respectively. Yearling sheep could completely consume concentrate mixture
247 comprising 75 parts NSC and 25-part maize (28). However, the consumption was reduced to one
248 third when NSC was fed alone. Buffalo calves though continued to relish even after enhancing
249 NSC from 5 to 15 parts when fed along with 7 and 20 parts of molasses and peanut meal
250 respectively, the consumption was reduced to half on withdrawal of molasses (60). Depression of
251 60% feed intake could be corrected by curtailing NSC to provide digestible crude protein
252 requirement from 25 to 12.5% in the ration of buffalo calves (26). (49) reported improved
253 palatability when neem kernel cake was treated with an alkali (NaOH).

254 **3.6 Effect on Haematological and Biochemical Characteristics**

255 The use of treated neem seed cake/neem kernel cake in the feed of ruminants has been proven
256 to be safe for their consumption. (16) reported that feeding of alkali treated neem kernel cake to
257 lambs up to 20% level has no significant effect on the haematological and biochemical

characteristics. (60) reported that neem bitterness and toxicity can be inactivated by alkali treatment. This was also supported by (42) in his report that alkali treated neem kernel cake can convert neem kernel cake to a wholesome vegetable protein supplement for growing buffalo calves. According to (61), inclusion of water washed neem kernel cake in the concentrate mixture of male kids at 15 and 25 parts for 180 days of feeding led to comparable intake and utilization of nutrients, besides normal balance of nitrogen, urinary creatine, blood haemoglobin, cholesterol and activities of Glutamate oxalo acetate transaminase (GOT), Glutamate pyruvate transaminase (GPT) and alkaline phosphates with significantly lowered blood glucose, urea and total protein.

(16) reported that the Serum glutamate oxalo acetate transaminase (SGOT) and Serum glutamate pyruvate transaminase (SGPT) values in the control and test diets Uda lambs fed alkali neem treated kernel cake were comparable. He also showed that the Bilirubin total, Bilirubin Conjugate and Bilirubin unconjugate values in the study were normal and conformed to the report of (62) and (63). These values were within the range of 14-123u/l for SGOT and 15-44u/l for SGPT reported by (63). These indicate that inclusion of ATNKC is not toxic to the liver. (64) reported that SGPT and SGOT were excellent markers of liver damage caused by exposure to toxic substances. (65) reported that incorporation of NSC up to 20% did not alter GOT and GPT activities in the blood. The urea nitrogen level of lambs fed alkali treated neem kernel cake and control in the report of (16) were not significantly different from each other and were all within the normal range reported for sheep by (63) and (62). The authors also showed that the Sodium and Potassium level obtained the blood of Uda lambs fed alkaline treated neem kernel cake were normal and within the range of 142-160mmol/l for Sodium and 4.3-6.3mmol/l for potassium reported by (63) and that of (66) of 153mmol/l and 4.7mmol/l for Sodium and Potassium respectively. This indicate that ATNKC inclusion up to 20% level did not interfere with the renal functions of the animals.

3.7 Economics of use

Neem seed cake has proven to be economical in the feed of ruminants. (67) in the study conducted with Uda lambs and rams as shown in tables 3 and 4 showed that the use of treated neem seed cake in the feed of ruminants as shown compares favourably in cost of feed gain, cost of feed consumed and cost of feed per live weight gain.

Table 3: Cost of feed/kg liveweight of Uda lambs

Parameter	Treatments					
	A	B	C	D	E	±SE
Cost of Feed (₦/kg)	43.98	43.59	43.20	43.59	41.72	-
Cost of feed consumed (₦/kg)	30.48 ^{ab}	37.32 ^a	24.75 ^b	28.13 ^b	28.83 ^{ab}	2.72
Cost of feed/kg live weight gain (₦/kg)	418.85 ^a	356.28 ^{ab}	268.24 ^b	286.27 ^b	427.10 ^a	36.24

288 Means not followed by the same superscripts are significantly different ($P < 0.05$) along the row.

289 **Table 4: Cost of feed/kg liveweight of Uda ram**

Parameter	Treatments				
	A	B	C	D	±SE
Cost of feed (₦/kg)	39.11	35.93	34.47	31.06	
Cost of feed consumed (₦/day)	49.72	40.14	34.41	31.79	1.38
Cost feed per live-weight gain (₦/kg)	351.69	240.85	259.84	267.81	19.51

290 Means not followed by the same superscripts are significantly different ($P < 0.05$) along the row.

291

292 (50) also reported 20% lower cost per weight gain when he replaced deoiled peanut with urea
 293 ammoniated neem kernel meal in goats. (20) reported that hydraulic pressed neem seed cake
 294 had the least cost per kg liveweight gain among dietary treatments including the control in rabbits.
 295 (68) reported that the cost of feed per kg liveweight gain was less for diets with inclusion of
 296 detoxified neem seed cake than with the conventional feed in Nellore sheep.

297 **4.0 CONCLUSION**

298 Neem seed is readily available in Nigeria especially in the northern part. It can easily be
 299 converted to neem seed cake/kernel cake. The active principles present in the seed have
 300 resulted in bitterness and pungent smell which have impacted negatively on the palatability and
 301 the consumption. However, with appropriate method of preparing the cake and removing the
 302 active principles, its palatability and the consumption has been found to improve resulting in
 303 comparable performance in animals fed treated neem seed cake/ kernel cake and the control
 304 diets without any adverse effect on the haematological and biochemical parameters. Treated

305 neem seed cake/kernel cake can readily fit in as replacement for the convectional protein
306 sources.

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