ISSN: 2754-477X

Journal of Food Technology & Nutrition Sciences

Research Article

Open Access

Effects of Fungus (*Aspergillus niger*) Treated Castor seed Cake on the Performance and Egg Quality of Japanese Quail (*Coturnix coturnix japonica*)

Belewu Moshood Adewale[1]*, Ling Shing Wong[2], Geetha Subramaniam[2], Belewu Kafayat Yemisi[3], Ganiyu Akeem Owolabi[4], Aliyu Karimat Imam[5], Abdulsalam Somrat Adeola[6], Akanmu Habib Olajide[5] and Ibiwoye Adesewa Abigeal[1]

[1]Department of Animal Production, Nigeria

[2]Faculty of Health & Life Sciences, INTI, University, Malaysia

[3]Department of Agricultural Economics and Farm Management, University of Ilorin, Ilorin, Nigeria

[4]Department of Dairy Science, Nigeria

[5]Department of Animal Science, Nigeria

[6]Department of Fisheries Aquaculture and Wildlife, University of Abuja, Nigeria

ABSTRACT

Castor seed cake (CSC) has been recognized as a potential protein source for livestock due to its high Protein and amino acids profile. However, the cake contains some anti-nutrients and toxic compounds that may prevent its full utilization in Livestock feed. The present study was conducted to investigate the effect of partial substitution of Groundnut cake with Fungus (*Aspergillus niger*) treated Castor seed cake (FCSC) on performance characteristics, egg quality and biochemical blood parameters of Japanese quail. Seventy-two quail chicks used for this experiment were subjected to three dietary treatments: Control diet (A, 0% FCSC), B (30% FCSC) and C (60% FCSC). The birds were randomized against the diets with three replicates, and with eight birds each. Feed and water were administered *ad-libtum*. The experiment which lasted for six weeks in a Complete Randomized design model revealed significant differences($p<0.05$). in the weight gain and feed conversion ratio of the Control diet (A) compared with Diets B and C Feed intake of Diets A and B was similar ($p>0.05$) but significantly different from C. Additionally, the egg weight of Diets A and C was also similar ($p>0.05$) while the Haugh unit of the three Diets were significantly different but highly acceptable according to USDA. However, the hen-day production of the Control diet (A) was highly significantly different from B and C having 70%, 50% and 30% respectively. Conclusively, Fungus treatment of Castor seed cake is essential to eliminate hepatotoxic and nephrotoxic effects and inclusion of 60% *Aspergillus niger* treated Castor seed cake in the diet of Japanese quail which have no effect on the performance characteristics, egg quality and health status of the birds is recommended.

***Corresponding author**
Belewu Moshood Adewale, Department of Animal Production, Tel +234 803 581 7941, Nigeria.

Received: August 16, 2024; **Accepted:** August 23, 2024; **Published:** September 25, 2024

Keywords: Aspergillus Niger, Castor Seed Cake, Performance Characteristics, Egg Quality and Quantity, Japanese Quail

Introduction

Poultry offers the greatest scope for increasing the quantity and quality of animal protein hence; Poultry production should be given high priority because the animal has a better energy and protein conversion ratio with high net return on investment than any other animal species. Initial investments costs are low for the Japanese quail production, reason being that they are hardy birds and small sized. Japanese quail, *Coturnix japonica* which is a ground living species that tends to stay within dense vegetation areas in order to take cover is one of the domesticated poultry species which is mainly distributed in East Asia, Russia and Africa. The plumage of Japanese quail is sexually dimorphic which allow differentiating of different sexes from each other and the animal has behaviour to closely follow photoperiods in their feeding habit, i.e. they eat at the beginning and end of the day. Quails which are best raised for good conversion of feeds into meat and eggs can lay all year-round if photoperiod is maintained. Additionally, the animal has a remarkable resistance to disease at six weeks and ready for consumption at four to five weeks of age [1-4].

Increase in human population, income improvements and urbanization are some of the factors governing the increased demands for foods of animal origin in developing countries. Hence, increase demand for protein of animal origin has helped in combating malnutrition which is a problem in Africa and this resulted to increase in the production of animal protein with consequential increasing demands of ingredients which have high protein and energy values. Most feed ingredients given to poultry are also eaten by human and this has led to food-feed competition between man and his livestock in developing countries [5-7].

The major challenge facing the poultry industry is how to produce sustainable poultry products that is capable of bridging the protein supply gap in future. Protein supplements become costly as a result of the habitual decrease in the production of these conventional ingredients like Groundnut cake.

Groundnut cake is one of the conventional protein supplements in poultry ration but due to its limited supply and seasonal availability, there has been increase in its cost. As a result of the digestive system in quail, very high-quality protein is required to meet their protein requirement which is more similar to what human need. Castor oil seed (*Ricinus communis*) has been found as an alternative to partially substitute for groundnut cake. Castor seed cake production can be obtained after the extraction of oil from milled Castor seed either by mechanical or chemical methods and about a tonne of processed castor oil seed will yield 550kg of castor cake. It is noteworthy that Castor seed cake can be used as protein supplement for poultry, ruminants and pigs but with some limitations [8-11].

The limitation in the direct use of Castor seed cake is the presence of anti-nutritional factors like ricin, ricinine, allergen and chlorogenic acid. Several methods of detoxification are well documented in literature without encouraging results. Therefore, the thrust of this study was to evaluate the efficacy of *Aspergillus niger* treated Castor seed cake on the performance characteristics and egg quality of Japanese quail [12-15].

Materials and Methods

Site of Experiment

This experiment was conducted at the Department of Animal Production Poultry unit, University of Ilorin, Ilorin, Kwara State of Nigeria. University of Ilorin is located at latitude 8.4820, longitude 4.320 and elevation of 330m [16].

Fungus

Fungus (*Aspergillus niger*) was obtained from the Department of Microbiology, University of Ilorin, Nigeria into a bijour bottle. The fungus was sub-cultured by inoculating and maintained on Potato Dextrose Agar (PDA) containing in Petri-dishes.

Collection and Processing of Castor (Ricinus communis) Seed

Mature seeds of *C. Ricinus* were collected around Ilorin metropolis, Nigeria. The debris and stones in the seeds were handpicked and later cleaned, weighed and decorticated individually to remove the kernels. The kernels were milled using grinder and defatted using hydraulic press while petroleum ether was used as cool extraction so as to remove the residual oil from the cake. The cake was then autoclaved at 1210C, 15psi for 30minutes so as to eliminate microbes present in the cake and later cool in readiness for fungus inoculation [17].

Inoculation of the cake

The cooled autoclaved *Ricinus communis* cake was inoculated using *Aspergillus niger* at the rate of 107 spore / ml [18].

Animal Management

A total of seventy-two (72) Japanese quail birds averaging 8g initial weight at day old were used for the experiment. The birds were kept under standard and similar environmental, hygienic and management conditions in line with care guidelines while all birds were brooded for a week in a brooding cage. Newly constructed cage having nine faces (60m x 40m) was labelled randomly (having three treatments replicated three times) and electrified to supply light for the birds. The chicks were randomized against three dietary ttreatments containing fungus treated Castor seed cake at 0%(A), 30%(B) and 60%(C) in replacement of Groundnut cake while other ingredients were of fixed proportions (Table 1). Each Treatment had 24 chicks while feeding and watering were supplied *ad libitum* throughout the experimental periods and cleaning of feeders, drinkers, and cages were practiced daily [19].

Table 1: Presents the Composition of the Experimental Diet, Formulated to Meet the Nutrient Requirements of Japanese Quail [19].

Table 1: Composition of the experimental diets (%)

Ingredients Diets	Diets		
	A	B	C
	0%	30%	60%
Maize	52.00	51.00	50.00
Groundnut Cake (GNC)	28.80	20.10	11.40
Fungus treated Castor seed cake	0.00	8.64	17.28
Wheat bran	10.00	11.00	12.00
Fish meal	2.50	2.50	2.50
Bone meal	2.00	2.00	2.00
Oyster shell	2.00	2.00	2.00
Palm kernel cake	2.00	2.00	2.00
Salt	0.25	0.25	0.25
Methionine	0.10	0.10	0.10
Lysine	0.10	0.10	0.10
Premix	0.25	0.25	0.25
Total	100.00	100.00	100.00

Sample Collection

Average Weekly Feed Intake (AWFI) was calculated as the difference between the feed offered and the feed refused as shown below:

AWFI= Quantity of feed offered – Quantity of feed refused

Average Weight Gain (AWG) was calculated as follows:

$$AWG\ (t1, t2) = (t_1, t_2) = \frac{W(t2) - W(t1)}{t2 - t1},$$

Where: t_1= initial time (week); t_2= final

time (week); W (t_2) = final body weight (g); w (t_1) = initial body weight (g).

Feed Conversion Efficiency was Obtained as Follows:

Feed Conversion Efficiency=

$$\frac{Average\ weight\ gained\ (\frac{g}{week})}{Average\ amount\ of\ feed\ consumed\ (g/week)}$$

Eggs produced were collected daily at maturity during the study. Egg production was expressed as Hen-day production.

$$\text{Hen Day Production} = \frac{number\ of\ eggs\ produced}{number\ of\ hen-days} \times 100$$

Number of hen-day = number of hens×number of days in lay.

Egg Quantity and Quality Assessment

The number of eggs of each unit was recorded daily and eggs were weekly weighed to obtain average egg weight. Quail reach maturity at six weeks of age and two eggs per replicate were collected during three consecutive days throughout the experimental period. The eggs were taken to the laboratory, weighed using precision weighing scale (0.01). The eggs were accessed for both internal and external qualities. The egg parameters measured were: Egg weight (g), egg shell percentage, Albumen height (mm), Haugh unit, Shell thickness (mm), Yolk height (mm), Yolk width (cm), Yolk index (Y.I.), Albumen weight (gram) and Egg shape index.

Albumen Height (mm)

Three weighed egg samples were collected at random per treatment. The eggs were broken on a flat non-absorbent surface. The thick albumen was measured as its widest part at a position half between the yolk and the outer margin using a spyrometer. Albumen height was converted into Haugh unit based on the calculation of [20]. Thus:

$$\text{H. U.} = \frac{100\log\ (H-\sqrt{G}(30w^{0.37}-100+1.9)}{100}$$

H. U. = Haugh Unit;
H = Albumen height in mm
G = 32.2; W = Weight of the whole egg in grams.

Egg shape index $= \frac{Weight}{Width} \times 100$

Yolk Index (Y.I.)

This was calculated by dividing the yolk height with the yolk width.

$$\text{Yolk index} = \frac{Weight\ of\ yolk}{Width\ of\ yolk}$$

Gross Energy: It was determined Using the Formular of Carpenter and Clegg [21].

Chemical Analysis

The Proximate Analysis of the Feed and faeces were determined using [22].

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using Completely Randomized Design model (CRD). Significant means of the treatment were separated using Duncan Multiple Range Test [23].

Result and Discussion

Table 2: Proximate analysis of Fungus Treated Castor seed cake

Parameters (%)	Aspergillus niger treated Castor seed cake
Dry matter	92.71
Crude protein	29.52
Crude fibre	3.96
Ether extracts	15.27
Ash	5.03

Table 3: Proximate Analysis of the Experimental Diets

Parameters (%)	Diets		
	A (0%)	B (30%)	C (60%)
Dry Matter	88.21	87.98	89.16
Ether Extracts	10.82	10.32	11.57
Ash	7.63	8.32	10.21
Crude Protein	21.16	20.09	20.12
Crude Fibre	5.42	6.84	7.92
NFE	45.03	45.58	49.82
Gross energy (K.cal/Kg)	476.99 ..	432.67	1435.67

Table 3: Performance Characteristics of Quail Fed with Fungus Treated Castor Seed Cake

Parameters	Diets				
			Dietary Treatments		
	A (0%)	B (30%)	C (60%)	±SEM	P<0.05
Feed Intake (g/bird/day)	21.82^b	22.21^b	25.57^a	0.4004	0.0023
Weight Gain (g/bird/day)	13.50^a	11.63^b	10.32^c	0.3434	0.0038
Feed Conversion Ratio	1.62^c	1.92^b	2.49^a	0.0647	0.0050

Means along the row with different superscripts are significantly different at p<0.05

Table 4: Egg External and Internal Qualities of Quail fed with Fungus treated Castor seed cake

Parameters	Dietary Treatments				
	A (0%)	B (30%)	C (60%)	±SEM	P<0.05
Egg Weight (g)	8.82^a	7.14^b	8.68^a	0.3475	0.0460
Egg Length (mm)	2.83^a	2.60^b	2.80^a	1.3720	0.0350
Egg Width (cm)	2.23^a	2.15^a	2.23^a	0.0265	0.1190
Egg shell %	0.69	0.56	0.68		
Shell Thickness (mm)	0.16^b	0.13^b	0.25^a	0.0220	0.0350
Shell Weight (g)	0.91^b	0.99^b	1.36^a	0.0795	0.0290
Albumen Height (cm)	3.40^b	4.45^a	3.60^b	0.1360	0.0070
Yolk Weight (g)	2.48^a	1.90^a	2.81^a	0.3205	0.1240
% York	28.12	26.61	32.37		
Yolk Height (mm)	5.50^b	7.40^{ab}	8.25^a	0.5255	0.0460
Yolk Diameter (cm)	2.10^a	1.75^a	2.10^a	0.0925	0.0940
Albumen Diameter (cm)	3.13^a	2.65^a	3.05^a	0.1349	0.1419
Albumen Weight (g)	4.43^a	3.88^a	3.85^a	0.2000	0.2130
% Albumen	50.23	54.34	44.35		
Egg Index	0.79b	0.83^a	0.80^b	0.0055	0.0130
Yolk Index	2.60^b	4.27^a	3.93^a	0.2141	0.0070
Haugh Unit	85.68^b	93.11^a	87.00^b	0.9735	0.0070

Means along the row with different superscripts are signif icantly different at p<0.05

Table 5: Hen-Day Production

Diets Castor %	Parameter Hen-Day Production
A (0%)	70.33a
B (30%)	51.00b
C (60%)	32.33c
±SEM	2.07
P-value	0.05 <.0001

Means with different superscripts are significant at p<0.005

Results and Discussion

Proximate Composition

The Proximate composition of the experimental Diets is shown in Table 2. The dry matter, Crude protein and Crude fibre contents reported in this study agreed with the reported values of Roseli et al. Contrarily the Crude Protein, Crude fibre and Ether extract contents reported herein were higher than the value noted by Annongu et al. and this could be attributed to the addition of microbial protein synthesized by the fungus as well as the method of fat extraction from the cake. Allied with the above points it may also be due to the higher inclusion levels of the Fungus (Aspergillus) treated Castor seed cake in the total diet. However, the Ether extracts reported by Annongu et al.was higher than 15.27% noted in this study and this may be due to the lipolytic action of the fungus and/or the differences in ether extracts might be due to the combination of mechanical and chemical methods of oil extraction in this study [24,25].

Additionally, the low Crude fibre content could probably be due to the fungus treatment (which they could have used the fibre for their body own growth). The high percentages of ash in both diets B and C connotes that the Fungus treated Castor seed cake was not deficient of minerals that is needed directly for shell formation in laying birds.

The performance characteristics of the experimental Animals are shown in Table 3.

Feed Intake

It was observed that the feed intake increased as the level of Fungus treated Castor seed cake inclusion increases (p<0.05) in this study and this contradicts the reported values in literature who reported low feed intake as the castor seed cake inclusion level increased. The variation in the results could be due to the fungus treatment of Castor seed cake used in this study. The above authors fed raw/ or chemically treated Jatropha cake. The highest feed intake was recorded for birds on Diets C > B and A respectively. The higher inclusion and tolerance levels of the fungus treated Jatropha kernel cake could be due to its treatment by fungus which could have detoxified the cake to tolerance level compared to the reports in literature who fed raw, heat and chemical treated Jatropha meal [26-31].

Weight Gain

The weight gain recorded in this study collaborates the reported values authors in literature who noted a decreased in the final body weight of birds as the inclusion level of Castor seed cake increased in the diet. The reduction in the performance of the birds as the Castor seed cake inclusion level increases may be due to the presence of residual castor allergen present in the cake. Ani and Okorie reported that the presence of residual ricin in castor seed meal might contribute to growth depression and ricin has been shown to interfere with the digestion and absorption of nutrient in the gastrointestinal tract [12,32-34].

The quantity of feed needed to obtain one gram of body weight increases as the level of fungus castor seed cake increases at $p<0.05$. The higher the feed conversion ratio, the poorer the feed efficiency, low feed conversion ratio recorded especially at 60% (Diet C) inclusion might be due to the effect of the toxin residues still present in the cake. The feed conversion ratio recorded in this study was found to be better and lower compared to the report of Muhammad who noted 2.50 and 2.80 feed conversion ratios in quails fed raw Castor seed cake. This indicates that fungus treatment is still better than feeding raw Castor seed cake [35].

Mortality

In contrast to the reported values in literature there was no mortality recorded throughout this experimental study. The reports of these authors could be due to the inclusion of raw Jatropha meal in their diet as well as the methods of detoxification (chemical method). The treated meal might still be containing some anti-nutrients (anti-trypsin, lectin, curcin, phytate and phorbolester) [26,28].

External and Internal Qualities of Quail Egg

Egg quality

The effect of Castor seed cake on quail eggs qualities and quantity are shown in Table 4. There was no significant difference in egg weight between the Control and Diet C (60%). This might be attributed to late egg production of the birds on 60% Fungus treated Castor seed cake inclusion level (the birds had fully developed for egg production than the control). The age of hen strongly influences the egg size and the proportion of its components. There was significant difference in the shell qualities of the egg by birds on Diet C (60%) with the highest shell thickness compared with other diets. However, the percentage egg shell fell within the reported ranged in literature. Shell thickness is important in handling and marketing of eggs; hence, farmers could embrace diet C for highest egg shell thickness [29-32].

Egg Length and Width

There was no significant difference in the egg width but the Egg length value was least for Diet B while Diets A and C are similar. The values of egg length reported herein fell within the reported values in literature while the egg width was lower that the values of between 2.25 and 2.94 reported by Nowaczewski et al. The egg length and diameter are vital in calculating egg index and both could be used to select for egg and hatch weight [30].

Albumen and Yolk

There were significant differences in the albumen and yolk percentages with Diet C recording higher yolk percentage and Diet B had higher Albumen percentage. The weight of the albumen noted in this study was higher than the reported values of Nowaczewski et al. but lower than the values found by Abd El-Hack et al. Additionally, the report of the yolk weight and yolk percentage of this study were lower than the reported values of Nowaczewski et al.but higher than the value reported by Abd El Hack et al. [1,30].

Haugh Unit

Haugh unit is a parameter used to determine egg quality and freshness. According to the United States Department of Agriculture (USDA), a Haugh unit score of 72 and above is acceptable. This implies the freshness of the egg. Although, there was significant difference in the Haugh unit of the treatments, but acceptability is normal according to USDA [31]. This connotes that as Fungus Castor seed cake inclusion level increases, the freshness and quality of eggs is maintained and not altered. Haugh unit was positively affected by the inclusion levels of the fungus treated Castor seed cake in the following order Diets B> C>A. The result of Haugh unit reported herein was higher than the values noted by Pereira et al. (2016) but fell within the values reported by Abd El Hack et al. and Berto et al. [1,34].

Hen Day Production

The Hen-day Production value (Table 5) reported herein was highly significant for the control compared with other Diets (B and C), The poor performance of birds on diets B and C could be attributed to variation in the nutrition (diets B and C had inclusion levels of 30 and 60 % of Fungus Treated Castor seed cake which could still contain some anti- nutrients of Jatropha cake). However, the egg production is slightly in line with the recommended egg production of 300egg per year for quail (i.e. 25 eggs per month). Contrarily the value noted in this study was higher than the values reported by Nowaczewski et al. [30].

Conclusion and Recommendation

In conclusion, inclusion of Fungus treated castor seed cake at 60% replacement of Groundnut cake increased the freshness of quail egg (High Haugh unit) with high egg weight, albumen weight, yolk weight, yolk height, albumen diameter and albumen weight. It is therefore recommended that inclusion of 60% fungus treated Castor seed cake in the diet of Japanese quail has not detrimental effect on the egg quality of Japanese quail.

References

1. Abd ElHack M, Alagawanu M, Sabry Abd El-Gawad El-Sayed, Justin Fowler (2017) Inflfluence of dietary inclusion of untreated or heat-treated Jatropha meal on productive and reproductive performances and biochemical blood parameters of laying Japanese quail. Poultry Science 96: 2761-2767.
2. Buchwalder T, Wechsler B (1997) The effect of cover on the behaviour of Japanese quail (Coturnix japonica). Applied Animal Behaviour Science 54: 335-343.
3. Mills A, Crawford L, Domjan M, Faure J (1997) The Behaviour of the Japanese or Domestic Quail (Coturnix japonica). Neuroscience and Biochemical Reviews 21: 261-281.
4. Steinfeld H (2003) Economic constraints on production and consumption of animal source foods for nutrition in developing countries. J Nutr 133: 4054S-4061S.
5. Abdullah RB, Wan Embong WK, Soh HH (2011) Biotechnology in animal production in developing countries. Proceedings of the 2nd International Conference on Agricultural and Animal Science 88-91.
6. Mengesha M (2011) Climate change and the preference of rearing poultry for the demands of protein foods. Asian J Poult Sci 5: 135-143.
7. Beski R, Swick P (2015) Specialized protein products in broiler chickens' nutrition. A review Anim Nutr 1: 47-53.
8. Azevedo DMP, Lima EF (2001) editor. O Agronegócio da mamona no Brasil. Brasília: Embrapa Informação Tecnológica.
9. Ken BJ, Hawkins CR, Vignolo R (1990) The feasibility of domestic castor production. New International Workshop of Castor Production Sponsored by V.S. Department of Agriculture and Texas and M. University of Plainview, Texas.

10. Ani A, Okorie AU (2005) The effects of graded levels of dehulled and cooked castor oil bean (Ricinus communis L.) meal on performance of broiler starters. Nig J Anim Prod 32: 54-60.
11. Ani AO, Okorie AU (2008) Response of broiler finishers to diets containing graded levels of processed castor oil bean (Ricinus communis L.) meal. Journal of Animal Physiology and Animal Nutrition 93:157-164
12. Ani AO, Okorie AU (2009) Response of broiler finishers to diets containing graded levels of processed castor oil bean (Ricinus communis L.) meal. J Phy Nutr 9: 157-164.
13. Albertson RC, Powder KE, Hu Y, Coyle P, Roberts RB (2014) Genetic basis of continuous variation in the levels and modular inheritance of pigmentation in cichlid fishes. Mol Ecol 21: 5135-5150.
14. Audi J, Belson M, Patel M, Schier J, Osterloh J (2005) Ricin poisoning: a comprehensive review. Journal of the American Medical Association 294: 2342-2351.
15. Anandan S, Anil K, Ghosh J, Ramachandra KS (2005) Effect of different physical and chemical treatments on detoxification of ricin in castor seed cake. Animal Feed Science and Technology 120: 159-168.
16. (2013) University of Ilorin on the Conservation. Retrieved from https://conservation.com.
17. Belewu M, Tijani AA, Inamette FJ (2013) Synergistic effect of Aspergillus niger and Penicillum chrysogenum on Jatropha cake: influence on performance of Sheep. International Journal of Science and Nature 4: 624-626.
18. Belewu M (2008) Replacement of Fungus treated Jatropha curcass seed meal for Soybean meal in the diet of rat. Green Farming Journal 2: 154-157.
19. (1994) National Research Council. Nutrient requirements of poultry. 9th rev. ed., National Academy Press, Washington, DC, USA.
20. Haugh, R. R. (1937). The Haugh unit for measuring egg quality. US Poult. Mag. 43:552–573.
21. Capeenter KJ, Clegg KM (1956) The metabolizable energy of poultry feedingstuffs in relation to their chemical composition. Retrieved from https/ doi.org/10.1002/jsfa.2740070109.
22. (2010) Association of Official Analytical Chemists International- AOAC. Official methods of analysis of AOAC international. 17th ed. Washington.
23. Duncan DB (1955) Multiple range and multiple f-test 1-42.
24. Roseli SL, Gisete LA, Makishi Hulda, Chambib AM, Bittante QB, et al. (2014) Castor Bean (Ricinus communis) cake protein extraction by alkaline solubiilization: definition of process parameters. Chemical Engineering Transactions 37: 775-780.
25. Annonugu AA, Atteh JA, Joseph JK, Belewu MA, Adeyina AO, et al. (2017) Investing on Biochemically Processed Castor seed meal in Nutrition and Physiology of Japanese Quails. Iranian J Applied Animal Science 7: 501-506.
26. Gross H, G Foidl, N Foidl 1997 Detoxification of Jatropha curcas press cake and oil and feeding experiments on fish and mice. In G. M. Gubitz, M. Mittelbach, and M. Trabi (Eds). Proc. Jatropha 97: International Symposium Biofuel and Industrial Products from Jatropha curcas and Other Tropical Oil Seed Plants. Managua, Nicaragua, Mexico. GrazUniversity of Technology and Karl-Franzens University Graz,Austria 23-27.
27. Agboola AF, Adenuga AA (2015) Performance and organ histopathology of growing Japanese quails (Coturnix coturnix japonica) fed heat treated jatropha seed cake substituted for soybean meal. Trop Anim health Prod 18: 1-8.
28. Barahona E, D´ıaz P, Castellano V, Anad A (2010) Toxicological profile by Jatropha curcas L. Abstracts/Toxicol Lett 196: S287
29. Abdullah, A., Ojedapo, L., Adedeji, T., Olayeni, T., & Adedeji, S. (2003). influence of hens age on egg quality parameters in Bovana Nera Layer strain. Pro28th Annual Conference of Nigerian Society of Animal Production 103-106.
30. Nowaczewski S, Szablewski T, Cegietska Radziejewska R, Stuper Szablewska K, Rudzinska, M, et al. (2021) Effect of age of JapaneseQuail on physical and Biochemical Characteristic of eggs. South Afri J Nimal Sci 51: 120-127.
31. USDA (2012) Egg and Poultry Safety researchUnit: Athens, G.A. [(USDA.ARS (gov)]. Retrieved from https://www.ars.usda.gov.
32. Berto DA, Garcia EA, Mori C, Faaaitarone ABG, Pelicia K (2007) Performance of Japanese Quail fed feeds containing different corn and Limestone particle sizes. Brazillian J Poultry Sci 9: 167-171.
33. Nsa E (2008) Chemical and biological assay of castor oil meal (Ricinus communis) as an alternative source in pullet birds' diets. Umudike, Nigeria: University of Agriculture. https://repository.mouau.edu.ng/work/view/chemical-and-biological-assay-of-castor-oil-meal-ricinus-communis-as-an-alternative-nutrient-source-in-pullet-birds-diet-7-2.
34. Nas E, Ukachukwu S, Akpan I (2010) Growth performance, internal organ development and haematological responses of broiler birds fed diets containing different thermal treated castor oil seed meal (Ricinus communis). Glob J Agric Science 9: 39-44.
35. Muhammad M (2015) The effect of feeding raw castor seed (Ricinus communis) meals, its replacement levels and processing on the productive performance of broilers. Inter J Agric and Biosciences 4: 161-166.