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NUTRI-ECONOMIC EFFECTS OF TIGER-NUT (CYPERUS ESCULENTUS) COMPOSITE MEAL ON EGG OUTPUT, QUALITATIVE ATTRIBUTES AND ORGANOLEPTIC PROPERTIES OF JAPANESE QUAILS

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ABSTRACT

In a seven-week feeding trial, one hundred and eighty (180) 18-week-old uniform female Japanese quails were divided in a completely randomized design into five dietary groups, with four replicates of nine birds each to evaluate the nutritional and economic suitability of tiger-nut composite meal on egg output, external and internal egg quality parameters, and sensory properties. In the diets, tiger-nut composite meal was used to substitute maize at 0.00% (control), 12.50%, 25.00%, 37.50%, and 50.00%. The tiger-nut composite meal contained 9.68% crude protein, 3.24% ether extract, 9.75% crude fibre, 8.62% ash and 2707.44 kcal/kg metabolizable energy according to proximate analysis. The feed intake and feed cost per kg were significantly influenced ($p < 0.05$) while other aspects of egg production were unaffected. The eggshell weight and percentage, yolk weight, height, length, colour, index, albumen percentage, yolk: albumen ratio and haugh unit were significantly different ($p < 0.05$). The yolk color, egg taste, texture, residue, and overall acceptability were all significantly different ($p < 0.05$) when sensory properties were analyzed. The use of up to 50.00% tiger-nut composite meal reduced the feed costs and did not adversely affect the profit, albumen percentage, and haugh unit but reduced the yolk weight, colour, shell weight, and overall acceptability. However, 25.00% replacement for maize is most appropriate for sensory properties.

KEY WORDS

Cyperus esculentus, egg quality, quail, production, sensory, cost-benefit.

The tiger-nut *(Cyperus esculentus*), is a little-known crop grown for its nutritious edible nut with medicinal values is found in southern Europe, Africa, the Middle East, and India (Bamishaiye *et al.* 2010). The plant is considered a weed in many locations due to inadequate nutritional information (Sánchez-Zapata *et al.* 2012). The nutritional benefits (Adejuyitan *et al*. 2009; Adejuyitan *et al*. 2011 and Nina *et al*., 2019) accrued to the nut has awakened interest in the use of the products, especially the drink.

The proximate composition of the nut showed that the crude fibre ranges from 6.5-15% (Adel *et al.* 2015 and El-Naggar, 2016), 6.23-9.8% crude protein (El-Naggar, 2016 and Nina *et al*. 2019), 19.79-22.05% ether extract (Oladele *et al*. 2007), and 47-62% carbohydrate (Adel *et al*. 2015; Nina *et al*., 2019). It had been reported to be high in potassium, low in sodium (Oladele *et al*. 2007 and Ndubuisi, 2009) while other elements found in the nut include iron, calcium, zinc, copper, manganese, magnesium and phosphorus (Nina *et al*. 2019). The high dietary fibre content had been reported to be effective against gastrointestinal disorders (Adel *et al*. 2015). The crude protein is higher than tubers like cassava and potato. The ether extract is higher than that of pigeon pea (Abioye *et al*. 2018) but low when compared to oil seeds like Jatropha kernel or cashew kernel (Ojediran *et al*. 2014 and Ojediran *et al*. 2021).

The milk-like drink made from Tiger-nut which could either be purely from the nut or composite is becoming popular apart from consumption in the raw form either processed dried or roasted. The natural vegetable drink is a nutritive, healthy drink that is less expensive and also suitable for people with cow milk allergy (Rehman *et al*. 2007 and Orhevba and Bankole, 2019). The tiger-nut milk drink without the addition of sugar is reported to be appropriate for diabetic patients. The potential of the drink as being helpful to those who seek to lower cholesterol or lose weight (Beniwal, 2004) and Mohamed *et al*. (2005) observed its anti-arteriosclerosis capacity.

The residue could be put to economic use because it could cause environmental and ecological pollution if not properly managed. Tiger-nut meal had been fed to various livestock (Oladele *et al*. 2010) including broilers and fishes (Agbabiaka *et al*. 2013), goats (Belewu *et al*. 2007) and pigs (Imam *et al*., 2013) but there has been no documentation on using of tiger-nut composite meal for Japanese quails.

The aim of this feed trial was to evaluate the nutritional and economic suitability of tiger-nut composite meal on egg output, external and internal egg quality parameters, and sensory properties.

MATERIALS AND METHODS OF RESEARCH

The experiment took place at the Teaching and Research Farm, Poultry Unit, Ladoke Akintola University of Technology, Ogbomosho, Nigeria. Latitudinal on 8º 08' North and longitudinally on 4º 15' East at about 347 m above sea level. It is a humid tropical region in derived savannah zone with a mean rainfall of about 1244 mm and 27.3ºC temperature annually.

Tiger-nut composite meal (TNCM) sourced locally from a reputable vendor was sundried and hammer milled into smaller particles with 250µm sieve. Tiger-nut seeds were soaked in water for two days and deseeded date nut and coconut were added at ration 7: 2: 1 respectively. It was then grounded and sieved to remove the milk. The shaft was sundried to reduce the moisture level. The resulting meal was referred to as TNCM used to formulate the experimental diet for the Japanese quails as a replacement for maize. 180 laying Japanese quails were chosen from a 126 day-old flock (18 weeks) and divided in a completely randomized design into five diet groups, each with four replicates of nine birds each in a seven-week investigation. In diets, the Tiger-nut composite meal replaced the maize at 0 % (control), 12.5 %, 25.00 %, 37.50 % and 50.00 % respectively as shown in Table 1.

Table 1 – Gross composition of the experimental diet

Ingredients	Tiger-nut composite meal, %				
	0, control	12.50	25.00	37.50	50.00
Maize	52.00	45.50	39.00	32.50	26.00
Tiger-nut	0.00	6.50	13.00	19.50	26.00
Fish meal	1.50	1.50	1.50	1.50	1.50
Soya bean meal	20.00	20.00	20.00	20.00	20.00
Groundnut	7.00	7.00	7.00	7.00	7.00
Kernel cake	3.70	3.70	3.70	3.70	3.70
Wheat over	10.00	10.00	10.00	10.00	10.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	2.00	2.00	2.00	2.00	2.00
Lysine	0.12	0.12	0.12	0.12	0.12
Methionine	0.18	0.18	0.18	0.18	0.18
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated nutrients					
ME (Kcal/kg^{-1})	2864.78	2772.43	2725.00	2677.47	2583.52
Crude Fibre	3.70	4.20	4.70	5.21	5.71
Ether Extract	3.82	3.77	3.72	3.67	3.62
Lysine	1.03	1.02	1.00	0.98	0.97
Calcium	1.62	1.59	1.59	1.59	1.58
Available Phosphorus	0.55	0.54	0.53	0.53	0.52
Methionine	0.49	0.48	0.47	0.46	0.45
Crude protein (%)	19.99	20.09	20.18	20.22	20.30
Cost/Kg (₦)	134.23	125.31	120.80	119.15	116.21

Note: ME = Metabolizable energy.

The TNCM was analyzed using the AOAC, (2012) methods for proximate analysis while the energy was calculate using the model of Pauzenga (1985). The egg production indicators of feed ingested, total eggs output, hen-day-production, egg weight, egg mass, and total feed intake to total egg produced were all recorded. Feed price per kilogram, daily intake per crate of egg output, feed price per egg crate, profit per egg crate, and egg: feed production ratio are among the economic indices parameters.

As described by Ojediran *et al*. (2018), eggs were weighed on a kerro (BL 30001E) digital scale and 10 eggs were used to assess the eggs' external and internal parameters. Egg length and width were measured using a digital vernier caliper (Ohaus 150mm LCD). Each egg was carefully cracked and poured onto a flat plate. A tripod micrometre (Apex SC, Ambala) was used to measure the albumen and yolk heights. A digital vernier calliper was used to measure the length of the yoke. The eggshell was weighed after being dried with tissue paper. A micrometre screw gauge (Baxlo, spain) was used to measure eggshell thickness as well as shell membrane thickness. An electronic digital scale was used to weigh the egg, yolk, albumen, and shell. The yolk was scored with Roche's color fan.

The yolk index was estimated by dividing the yolk height by the yolk width. Using the egg weight and albumen height, a Haugh unit grade was calculated. The Haugh unit values for individual eggs were calculated using the following formula (Monira *et al*. 2003):

$$HU = 100\, log_{10}(H - 1.7\ \times EW^{0.37} + 7.6)$$

Where: H = Albumen height and EW = Egg weight.

Ten unskilled panel members who had been usual egg consumers took part in the sensory test. The eggs were stored for three days before each test. These eggs were heated in water medium of 150 ml per egg for 15 minutes at 97°C, water-cooled, served coded to panel members. A nine hedonic numeric rating was used (Ojediran *et al*. 2018).

Using the SPSS v16 software package, all data were complete randomized, analyzed by one way ANOVA, and means were separated using Duncan's (Duncan, 1955) multiple range test.

RESULTS AND DISCUSSION

The tiger-nut composite meal’s proximate composition is shown in Table 2. The observed chemical composition of tiger-nut composite meal showed that it crude protein compared favourable with maize and sorghum but higher in crude fibre and ash (Ojediran *et al*., 2018b and Nina *et al*. 2019) The crude protein was higher than cassava root meal but lower in comparism to dried cassava vinnase (Ojediran *et al*., 2019). The ether extract is lower than that of tiger-nut seed (Oladele *et al*. 2007), pigeon pea (Abioye *et al*., 2018), Jatropha kernel and cashew kernel meal (Ojediran *et al*. 2014 and Ojediran *et al*. 2021).

Table 2 – Proximate analysis and metabolizable energy of Tiger-nut composite meal

Parameters (%)	Sample	SD±
Crude protein	9.68	0.007
Ether extract	3.24	0.014
Moisture	9.16	0.003
Crude fibre	9.75	0.021
Ash	8.62	0.006
Metabolizable. Energy (Kcal/kg)	2707.44	0.023

Table 3 revealed the egg output of layering quails offered different levels of tiger-nut composite meal. The total and daily feed intakes were both significantly influenced ($p < 0.05$) unlike other parameters ($p > 0.05$). The dietary groups had 1.35, 1.32, 1.45, 1.54 and 1.45kg total feed intake values respectively. Birds fed diets 12.50 % and 37.50 % were significantly different ($p < 0.05$). However, birds fed control and 12.50 %, then 25.00%-50.00% had a similar values. The least total intake value per bird was seen in dietary group 12.50 % while birds given diet 37.50 % recorded the highest.

Observation on feed intake agreed with Akinola and Sese (2012) that there was significantly increased feed consumption in the birds given low energy diets. The graded addition of TNCM resulted in reduced metabolizable energy in the diets which caused increased feed intake. This is because quails will consume to meet their energy need. Costa *et al*. (2004) concluded that dietary protein levels do not affect feed intake contrary to the observation of Dumont *et al*., (2017) for bird fed low protein levels. Unlike the observation of Shanaway, (1994) that low energy diets resulted in reduced egg production, this experiment was contrary. However, Ojediran *et al*, (2018a) established that dietary protein, synthetic amino acid or both in feed could influence egg production and hen day production if not balanced. Manju *et al*. (2015) linked insufficient quantity of amino acid at 16% CP with reduced egg production, although, Bunchasak *et al*. (2005) reported such at 14% CP with reduced egg weight and mass. However, a normal quail egg weighs round 9.3g (Bawa *et al.* 2011). This study further established that adequate protein in the diet of laying quails would not adversely affect egg production indices, weight and mass of egg.

Table 3 – Egg production of layering quails offered varying levels of tiger-nut composite meal

Parameters	Tiger-nut composite meal, %					SEM	P-value
	0, control	12.50	25.00	37.50	50.00		
TFI (kg/b)	1.35^{bc}	1.32^{c}	1.45^{ab}	1.54^{a}	1.45^{ab}	0.025	0.01
ADFI (g/b)	27.59^{bc}	27.00^{c}	29.57^{ab}	31.46^{a}	29.56^{ab}	0.51	0.01
TEP (d)	6.18	6.14	6.19	5.62	5.20	0.21	0.51
HDP (%)	77.30	76.70	77.38	70.24	65.05	2.58	0.51
Egg weight (g)	9.92	11.04	10.73	10.24	10.81	0.32	0.85
Egg mass	7.70	8.47	8.30	7.21	6.98	0.35	0.67
TFI: TEP	39.94	40.13	43.23	47.70	48.55	1.56	0.25

Note: ^{abc} *= means in the same row with different superscript are significantly different (p < 0.05); TFI kg = Total Feed intake; TFI kg/b = Total feed intake kilogramme per bird; ADFI gb = Average daily feed intake; TEP = Total egg production; HDP % = Hen day production percentage; TEP d = Total Egg production per day.*

Table 4 showed the economic outlook of layering quails offered varying levels of tiger-nut composite meal. Feed consumed per crate, feed cost per egg crate, profit per crate, and egg: feed production ratio were not significant (p > 0.05). Conversely, feed cost lowered significantly (p < 0.05) across the dietary groups control-50.00% (those given control diet had the costliest price unlike those offered diet 50.00% having the least. The feed cost reduced as the level of tiger-nut composite meal increased. This showed that the cost of production could be reduced with the use of tiger-nut composite meal. This is in agreement with the findings of Agbabiaka *et al.* (2013) and Obidinma, (2009) when tiger-nut meal and spent grain were fed to finisher broilers beyond 50% dietary level respectively. This correspond with Shittu *et al*. (2016) result when biscuit dough was used as an alternative to maize. The non-significant feed consumed per crate and feed cost per crate showed that the tiger-nut composite meal was tolerated. This study also revealed that the profit and egg-feed production ratio were not affected by the use of tiger-nut composite meal.

Table 4 – Economic outlook of layering quails offered varying levels of tiger-nut composite meal

Parameters	Tiger-nut composite meal, %					SEM	P-value
	0, control	12.50	25.00	37.50	50.00		
Feed cost / kg	134.23^{a}	125.31^{b}	120.80^{bc}	119.15^{bc}	116.21^{c}	1.88	0.00
Feed consume / 30 (g)	1198.25	1203.87	1296.92	1430.99	1456.48	46.75	0.25
Feed cost / 30 (₦)	160.83	150.19	156.47	170.45	169.39	4.81	0.61
Profit / 30 (₦)	239.17	249.81	243.53	229.55	230.61	4.81	0.61
E: FPR	2.54	2.69	2.56	2.35	2.40	0.07	0.67

Note: ^{abc} *= means in the same row with different superscripts are significantly different (p < 0.05); Feed cost / 30 = Feed cost per crate; E : FPR = Egg : Feed production ratio.*

External egg qualities of layering quails offered different levels of tiger-nut composite meal are shown in Table 5. The eggshell weight and eggshell percent were different (p < 0.05). Birds offered control diet differ significantly (p < 0.05) with higher values from other diets. Observation on eggshell percentage was similar to that observed for eggshell weight. Observation on egg spatial dimensions, shell thickness and shell index were contrary to the finding of Ojediran *et al*. (2018a) during which laying Japanese quails consumed low protein feeds enhanced with lysine. One of the essential quality parameters of an eggshell is the thickness and protection it gives the internal content of the egg. Dietary energy and protein had no direct impact on shell calcification but calcium and phosphorus does. The slight decrement in calcium and phosphorus amount in the diets (Table 1) was observed in the shell weight and percentage as incorporated quantity of tiger-nut increased in the formulation. Consequently, tiger-nut composite meal had low level of calcium and phosphorus.

Table 5 – External egg qualities of laying quails offered different level of tiger-nut composite meal

Parameters	Tiger-nut composite meal, %					SEM	P-Value
	0, control	12.50	25.00	37.50	50.00		
Egg length (cm)	3.35	3.36	3.29	3.30	3.33	0.02	0.67
Egg Width (cm)	1.88	1.87	1.87	1.88	1.89	0.01	0.32
Eggshell weight	1.32^{a}	0.70^{b}	0.66^{b}	0.75^{b}	0.67^{b}	0.09	0.04
Egg ST (mm)	0.14	0.23	0.14	0.14	0.14	0.02	0.48
Eggshell percentage	11.01^{a}	6.47^{b}	6.10^{b}	6.91^{b}	6.09^{b}	0.68	0.04
Eggshell index	56.25	55.45	56.65	56.81	56.85	0.23	0.29

Note: ^{ab} = means in the same row with different superscripts are significantly different ($p < 0.05$); SEM = Standard Error Mean; Av. = Average, EST = Egg Shell thickness.

Table 6 shows internal egg qualities of laying quails offered different level of tiger-nut composite meal. Yolk weigth, heigth, lenght, color, albumen percentage, yolk index, albumen-yolk ratio and Haugh uniit differ significantly ($p < 0.05$). Birds offered control diet had higher yolk weight while birds fed diets 12.50 %-50.00 % had lower values ($p > 0.05$). Diets 0 % - 50.00% were lower ($p < 0.05$) than those offered diet 50.00 % ($p > 0.05$) for yolk length while the reverse was the case for yolk index. Others including yolk weight, height, albumen percentage, yolk:albumen ratio and Haugh unit were influenced significantly in no particular order. The yolk colour reduced linearly from diets 0 % -50.00 % with those offered diet 0 % having highest value.

An egg is proteinous and as such the protein level of feed has impact on internal content of egg (Tuleun *et al*. 2013). Ojediran *et al*. (2018a) observed that reduced CP from 21 % to 15 % though with varying lysine inclusion had effects on all internal egg quality characteristics except albumen height, haugh value, percent yolk/albumen ratio. From this study, tiger-nut composite meal influenced yolk parameters in no definite pattern, although, yolk length was highest for quails fed diet 50.00 % which may be explained that the yolk had reduced firmness at 50% replacement for maize. This explained why the yolk index was least at diet 50.00 %. A linear decrease in yolk colour suggests that tiger-nut composite meal had low carotene level. Although, Gunawardana *et al.* (2008) suggested that dietary protein affected egg yolk colour but that is not applicable in this case. Increased albumen percentage across the dietary groups suggests that tiger-nut composite meal increased albumen production in quails than yolk content which was evident in the yolk: albumen ratio. An increase in haugh unit across the dietary group revealed that tiger-nut composite meal improved the storage ability of the eggs.

Organoleptic properties (egg) of laying quails offered different level of tiger-nut composite meal is shown in Table 7. Yolk color, tastes, texture, residue and acceptability differ significantly ($p < 0.05$), (though in no particular manner) unlike other parameters ($p > 0.05$). Quail eggs had a unique pigmentation unlike chicken, duck, turkey, and guinea fowl eggs which had smooth and uniform colour. This unique egg mottledness was not affected by cooking. The alkalinity of egg upon cooking affects the bindness of albumen and the shell thus giving a smooth peeling (Ojediran *et al*., 2018a). a smooth albumen surface upon peeling gives a visual appeal to the consumer and suggests that the egg was not spoilt (Shittu and Ogunjimi, 2011). This study showed that tiger-nut composite meal did not adversely influence consumer perception on ease of peeling and albumen colour. Colour influence consumers’ judgment and preference because a deviation from normal could cause product rejection (Qiao *et al*., 2001).

Table 6 – Internal egg qualities of laying quail offered different level of tiger-nut composite meal

Parameter	Tiger-nut composite meal, %					SEM	P-Value
	0, control	12.50	25.00	37.50	50.00		
Y + A weight (g)	10.64	10.10	10.21	10.06	10.22	0.10	0.38
Albumen weight (g)	6.88	6.89	6.96	6.69	6.96	0.05	0.48
Yolk weight (g)	3.76^{a}	3.21^{b}	3.25^{b}	3.38^{ab}	3.26^{b}	0.08	0.04
Albumen height (mm)	1.58	1.60	1.69	1.66	1.75	0.03	0.26
Yolk height (mm)	0.83^{ab}	0.84^{b}	0.86^{ab}	0.87^{a}	0.81^{b}	0.01	0.04
Yolk length	2.33^{b}	2.25^{b}	2.19^{b}	2.28^{b}	2.87^{a}	1.44	0.03
Yolk colour	6.62^{a}	5.41^{ab}	5.28^{ab}	4.92^{b}	4.70^{b}	0.24	0.05
Albumen percentage	57.57^{b}	63.83^{a}	64.08^{a}	61.87^{a}	63.98^{a}	0.81	0.02
Yolk percentage	31.42	29.69	29.82	31.22	29.93	0.38	0.48
Yolk index	0.36^{a}	0.37^{a}	0.39^{a}	0.38^{a}	0.15^{b}	0.30	0.02
Yolk : Albumen	0.55^{a}	0.47^{b}	0.47^{b}	0.50^{ab}	0.47^{b}	0.01	0.05
Haugh unit	69.22^{b}	70.78^{ab}	71.44^{a}	71.22^{a}	71.90^{a}	0.33	0.05

Note: ^{ab} = means in the same row with different superscripts are significantly different ($p < 0.05$); SEM = Standard Error Mean; Y + Awt $_{(g)}$ = Yolk + Albumen weight.

Table 7 – Organoleptic properties (egg) of laying quails offered different level of tiger-nut composite meal

	Tiger-nut composite meal, %						P-value
Parameter	0, control	12.50	25.00	37.50	50.00	SEM	
Shell colour	5.10	4.40	4.00	3.70	5.10	0.23	0.20
Ease of Peel	5.00	4.20	4.00	5.00	2.80	0.32	0.19
Albumen colour	6.40	4.80	6.20	6.00	6.80	0.29	0.25
Yolk colour	6.80^{a}	5.50^{b}	6.90^{a}	6.10^{ab}	6.10^{ab}	0.20	0.02
Smell	7.00	5.90	6.00	5.80	5.60	0.23	0.36
Taste	7.60^{a}	6.10^{ab}	6.20^{ab}	4.90^{b}	5.10^{b}	0.27	0.02
Texture	7.10^{a}	5.40^{b}	6.10^{ab}	4.90^{b}	5.10^{b}	0.27	0.04
Residue	5.70^{ab}	3.90^{b}	5.90^{a}	4.60^{ab}	5.80^{ab}	0.29	0.01
Acceptability	7.40^{a}	6.60^{ab}	5.20^{bc}	6.00^{abc}	4.60^{c}	0.29	0.01

Note: ^{abc} = means in the same row with different superscripts are significantly different ($p < 0.05$); SEM = Standard Error Mean.

As observed in the internal egg characteristics for quails fed tiger-nut composite meal that a linear decrease in yolk colour suggests that tiger-nut composite meal had low carotene level. There were no yolk pigment changes during cooking. A decreased taste, texture and overall acceptability showed that tiger-nut composite meal affected the sensory or organoleptic properties of the egg thus consumers' perception of boiled egg from the high inclusion of tiger-nut composite meal in the diet of laying quails was impaired.

CONCLUSION

The result showed that the tiger-nut composite meal reduced the production costs with no undesired effect on egg production and profit. However, the shell weight reduced in all the groups fed tiger-nut composite meal but with higher albumen percentage and Hauge unit. The use of tiger-nut composite meal of up to 50% is recommended for reduced cost of production and higher albumen percentage but not beyond 25.00% replacement for maize if appealing egg taste and texture is desired

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