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NONRUMINANT NUTRITION

Performance and egg qualities of laying japanese quails fed yam peel meal based diets with enzymes complex + yeast supplementation

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ABSTRACT. A 10-week experiment was conducted to evaluate the combined effect of enzyme complex + yeast (Maxigrain®, MXG®) supplementation of sun-dried yam peel meal (YPM) based diet of laying Japanese quails (*Coturnix coturnix japonica*) on performance and egg quality. A total of 240, seven-weeks old quails were distributed in a completely randomize design with four dietary treatments and five replicates of 12 quails each. Diet 1 served as the control diet without YPM while diet 2, 3, and 4 contained 25, 50, and 75% YPM with MXG® supplementation (1g per kg), respectively. MXG® supplementation in YPM diets improved ($p < 0.05$) egg mass and feed conversion per egg. Increasing levels of YPM with MXG® supplementation did not show any effect ($p > 0.05$) on internal and external egg quality attributes except for eggshell weight and thickness which was higher ($p < 0.05$) in quails fed 75% YPM diet. It was concluded, therefore, that the utilization of YPM as an alternative dietary ingredient with MXG® supplementation can be tolerated in the diets of laying Japanese quails up to 75% inclusion level without any negative effect on productive and egg quality performance.

Keywords: yam peel meal; egg atributes; feed aditives; laying performance; poultry.

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Introduction

The inadequate supply of traditional feed ingredients is considered a major challenge facing the growth of the poultry industry, especially in many developing countries, triggering the search for other viable alternative feed resources to provide the bird's required nutrients (Anaeto & Adighibe, 2011; Apata & Babalola, 2012; Thirumalaisamy et al., 2016; Abdel-Hafeez, Saleh, Tawfeek, Yousef, & Abdel-Daim, 2018). The incorporation of these alternative feedstuffs in poultry rations would help to mitigate the problem of feed shortages and extortionate prices resulting from seasonal production and high demand for traditional feedstuffs such as maize and soybean due to strong rivalry between humans, livestock and industries for their use (Agbabiaka, Madubuike, Ekenyem, & Esonu, 2013; Abd El-Hack, Alagawany, Farag, & Dhama, 2015). Thus, research interest in optimizing the use of fairly inexpensive and readily accessible agro by-products, such as yam peel to formulate poultry feeds, has been intensified in an attempt to minimize feed production costs (Edache, Yisa, & Okpala, 2012; Olajide, 2014; Aguihe, Kehinde, Ilaboya, Abidoye, & Iyayi, 2015; Diarra, 2018).

Yam peel (*Dioscorea rotundata*) is a basic by-product obtained from yam processing and production activities especially during cooking for human consumption. The peels have been reported to be integrated into poultry diets as a cheap untraditional and alternative feedstuff as a source of energy for partial replacement of corn, when properly processed to minimize inherent anti-nutritional factors (Akinmutimi & Onen, 2008; Ezieshi & Olomu, 2011; Edache et al., 2012). Nevertheless, higher amounts of crude fiber in form of non-starch polysaccharides (NSP) have been deemed a limiting factor for the use of yam peels by poultry birds (Abdel-Hafeez et al., 2018; Diarra, 2018). Accumulative data suggests that NSP has anti-nutritional activity in most monogastric species, such as poultry, because it is not readily degraded by digestive enzymes in poultry birds that disrupt gastrointestinal tract functions (Ravindran, 2013; Amerah, 2015, Aftab & Bedford, 2018). Luckily, based on the current biotechnology advances in feed additive, extensive studies have been conducted to increase the utilization of untraditional feed ingredients as a tool for lowering the economics of production in feed industry (Blake & Hess, 2013; Al-Harthi, 2017; Aguihe, Kehinde, Abdulmumini, Ospina-Rojas, & Murakami, 2017; Aftab & Bedford, 2018).

Supplementation of enzyme complex and yeast has been shown to improve the efficiency of utilization of poor quality or highly fibrous feed stuffs in poultry production (Al-Mansour, Al-Khalf, Al-Homidan, & Fathi, 2011; Zamani, Loh, Foo, Samsudin, & Alshelmani, 2017; Ludke et al., 2018, Woyengo, Bogota, Noll, & Wilson, 2018). Supplementation of multi-enzymes is believed to promote the dissolution of starch, cell walls and endogenous proteins, thus enhancing energy use; and thus reducing the detrimental impact of non-starch polysaccharides (NSPs) in poultry (Adeola & Cowieson, 2011; Suresh et al., 2019; Attia, Al-Khalaifah, Abd El-Hamid, Al-Harthi, & El-Shafey, 2020). In addition, multiple experiments have shown that yeast has a positive effect on poultry efficiency by enhancing the microbial composition of the intestines, synthesizing vitamins, activating the digestive enzyme, utilizing indigestible carbohydrates, encouraging nutrient digestion and absorption, and increasing defense against pathogenic microbial toxins (Salianeha, Shirzadb, & Seifi, 2011; Yalçın et al., 2015; Wang, Ren, Li, Yue, & Guo, 2017; Kumar et al., 2019).

Japanese quails (*Coturnix coturnix japonica*) are small-sized, sturdy; simple to handle, fast growing, and high-rate egg productive poultry animals (Moraes et al., 2016; Weslane et al., 2017). They lay their first eggs between the 6th and 7th week of age and their eggs are low in cholesterol (Musa, Haruna, & Lombin, 2008; Kaankuka, Alu, Carew, & Tuleun, 2012), which is of public health benefit. In addition, improving the egg production and quality traits through cost-effective nutritional strategies are utmost vital in creating significant savings to the industry and poultry farmers in an increasingly competitive environment. Therefore, based on these statements, the objective of this study was to investigate the effects of dietary inclusion of multienzymes complexes and yeast supplement in Japanese quails fed diets containing graded levels of yam peel meal on performance and egg quality traits.

Material and methods

Study area

The study was carried out at the Poultry Unit of Teaching and Research Farm of the Department of Animal Production Technology, Federal College of Wildlife Management, New Bussa, Niger State, Nigeria.

Source and processing of yam peel meal

Fresh yam peels were collected from several commercial processing centers in New Bussa, Nigeria. The fresh peels were processed by soaking for 72 hours and thereafter sun-dried for 48 hours to reduce activity of inherent anti-nutritional factors (Akinmutimi & Onen, 2008; Ezieshi & Olomu, 2011). The sun-dried peels were milled in a heavy-duty high rotation hammer mill to pass through 1 mm mesh sieve, producing fine particles into meals to obtain the yam peel meal (YPM). The sample of YPM was subjected to proximate analysis according to AOAC (2011) procedure (Table 1).

Table 1. Proximate composition of sun-dried yam peel meal.

Nutrients	% Composition
Dry matter	94.40
Ash	8.15
Crude protein	10.52
Crude fibre	13.25
Ether extract	1.11
Nitrogen free extract	66.97
*Energy (kcal kg^{-1} ME)	2856.70

*Calculated from Pauzenga (1985: ME (kcal kg^{-1}) = 37 x % CP + 81.1 x % EE + 35.5 x % NFE.

Experimental birds and management

The experimental procedures of this current study complied with the provisions of the Ethical Committee on the use of animals of the Federal College of Wildlife Management for biometric research. A total of two hundred and forty (240), seven-weeks old Japanese quails were used in the experiment. They were randomly allocated to four treatment groups and each group was further divided into five replicates of 12 quails each in completely randomize design. The birds were raised and managed under a deep litter system with wood shavings serving as litter material and housed in a typical tropical open-sided and well-ventilated poultry facility.

The trial period lasted 70 days and quails received 18 hours per day lighting programme using 100 watts fluorescent bulbs and natural light. The pens were equipped with cone-shaped drinkers and trough feeders. Feed and clean water were provided *ad-libitum* throughout the experiment. Standard procedures for vaccination and medication were strictly observed throughout the experimental period (Musa et al., 2008). The average temperatures and relative humidity of the environment were determined with the aid of a digital thermo-hygrometer during experimental period. The maximum temperature was 31.07°C and the minimum temperature was 23.89°C. The maximum humidity was 76.50% and the minimum humidity was 68.93%.

Experimental diets and treatment

Four isocaloric (2,900 kcal kg^{-1} ME) and isonitrogenous (20% CP) diets were formulated to meet or exceed all nutrient requirements according to National Research Council [NRC] (1994) management guide of laying quails. Diet 1 contained no yam peel meal (0% YPM) and supplemental MXG®, while diet 2, 3, and 4 contained 25, 50, and 75% graded levels of YPM substituted at the expense of corn meal with Maxigrain® supplementation (1g per kg diet). The multienzymes complexes + yeast supplement (Maxigrain®, MXG®) used in this study is a microbial preparation originated from the bacteria *Asperigillus oryzae* and each gram of MXG® contained mixture of phytase (2,500 FTU), cellulase (10,000 IU), β-glucanase (200 IU), xylanase (10,000 IU), and yeast (*Saccharomyces cerevisiae*, 1 x 10^9 cfu). The inclusion rate of the MXG® in the feed, were performed according to the recommendation of the manufacturer of the supplement product (Table 2).

Table 2. Ingredient composition of yam peel meal based diets with supplemental MXG® for laying quais.

Ingredient	Diet 1 (0% YPM)	Diet 2 (25% YPM)	Diet 3 (50% YPM)	Diet 4 (75% YPM)
Corn	56.50	42.50	28.00	14.50
Soybean	27.35	26.85	26.85	26.35
Yam peel meal	0.00	14.00	28.00	42.00
Wheat offal	3.00	3.00	3.00	3.00
Fish meal	2..00	2.00	2.00	2.00
Vegetable oil	1.50	2.00	2.50	3.00
Di-calcium phosphate	2.00	2.00	2.00	2.00
Limestone	6.50	6.50	6.50	6.00
DL-Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Layer premix*	0.40	0.40	0.40	0.40
Salt	0.25	0.25	0.25	0.25
Maxigrain®	--	++	++	++
Total	100	100	100	100
Calculated composition				
Crude Protein %	20.34	20.49	20.44	20.52
Energy (kcal kg^{-1})	2980.66	2955.54	2937.14	2918.93
Crude fibre %	4.54	6.39	6.85	7.43
Calcium %	3.67	3.74	3.76	3.72
Non-phytate Phosphorus %	0.44	0.45	0.46	0.48

*Premix (Vitamin-mineral mixture) as contained per kg: Vit. A, 8,000 IU; Vit. D3, 1,300 ICU, Vit. E 5 mg; Vit. K, 2 mg; Vit. B1, 0.7 mg; Vit. B2, 3 mg; Vit. B6, 1.5 mg, Vit. B12, 7 mg; Biotin 0.1 mg; Pantothenic acid, 6 g; Niacin, 20 g; Folic acid, 1 mg; Manganese, 60 mg; Zinc, 50 mg; Copper, 6 mg; Iodine, 1 mg; Selenium, 0.5 mg; Cobalt, 1 mg. ++Maxigrain incorporated at 1 g per kg of feed.

Production performance evaluation

Birds were weighed at the beginning of the experiment and then at each 7-day intervals. Egg production (known as hen-day egg production, HDP %) was recorded daily and calculated on a hen-day basis as: total number of eggs collected divided by total number of live hens per day in each pen. Records of the feed intake (FI, g) were taken on weekly basis by the difference between the amount of feed provided and the leftovers. Birds were checked twice daily for mortality; weight of dead birds was used to adjust for feed consumption. To determine egg mass, 30 eggs from each treatment group were used at 14-days interval of the experiment from a 2-day collection of eggs during the week. Egg mass (EM, g) was calculated as a factor of egg weight and hen-day egg production. Feed conversion per egg mass was calculated as the ratio of grams of feed to grams of egg mass (FCEM, g of egg g of $diet^{-1}$) while feed conversion per dozen eggs (FCDZ, g of diet 12 $eggs^{-1}$) was calculated by multiplying the average feed intake by twelve. Viability was calculated as the ratio between the numbers of birds alive at the end of the experiment relative to the initial number of birds per treatment, and expressed as a percentage.

Measurement of egg quality attributes

The various indices of both exterior and interior parts of the egg were measured weekly using 4 eggs per replicate pen basis according to the procedure of Abd El-Hack, Alagawany, Laudadio, Demauro, and Tufarelli (2017). In brief, average weights of eggs were measured using a 0.01g precision digital scale. The egg length and width were equally measured before breaking using a digital caliper. Thereafter, the eggs were carefully broken on a clean glass plate to determine internal and external egg quality attributes. The egg yolks were separated from the albumen. Egg shell was cleaned of any adhering albumen. The albumen weight was determined by subtracting the weight of the egg yolk and eggshell from the whole egg weight. The heights of the yolk and albumen, as well as their diameters were measured using the caliper. Egg shape index was calculated as the ratio of average egg width to the average length and the yolk index is the ratio of yolk height to its average diameter (Funk, Froning, Grottes, Forward, & Kinder, 1958; Awosanya et al., 1998). The Haugh unit was calculated using the formula described by Eisen, Bohren, and Mckean (1962) as: HU = 100 log (H + 7.57 − 1.7 $EW^{0.37}$, where H represents the height of the albumen and EW stands for the egg weight). The eggs were examine for shell quality thickness (with shell membrane) of the eggs and measured using a micrometer, which was obtained as a mean value of measurements taken at three points of the egg shell (air cell, equator, and sharp end) (Abd El-Hack et al., 2017).

Statistical analysis

The General Linear Model procedure of the Statistical Analysis Software of SAS Institute (2012) was applied using one-way analysis of variance (ANOVA) for a completely randomized design. The differences among means were compared utilizing Tukey test. In all analysis, the significance was declared at 5%.

Results and discussion

The effect of dietary treatments on the laying performance recorded for the 70-day feeding period is shown in Table 3. Addition of MXG® supplementation to the graded levels of YPM did not affect ($p > 0.05$) AFI, HDP (laying rate), AEW, FCDZ and live ability of the laying quails. Meanwhile, AWG, EM and FCEM differed significantly ($p < 0.05$) in dietary treatments, due to MXG® supplementation. Values for AFI, HDP, AEW, and FCDZ were similar for the birds in all dietary treatment groups and these results coincided with the findings of Ghazalah, Abd-Elsamee, and Moustafa (2011) and Abd El-Hack et al. (2015), who did not record significant impact on the measured variables, when an enzyme complex was supplemented in the diet of laying hens. Some researchers also observed that egg weight, feed intake and hen-day egg production of hens were not affected by dietary yeast *Saccharomyces cerevisiae* supplementation (Abubakar, Tukur, Sekoni, & Hassan, 2007; Hassanein & Soliman, 2010; Yalçın et al., 2015).

Table 3. Laying performance of quails fed sun-dried yam peel based diets with enzyme complex supplementation.

Parameters	Diet 1 (0% YPM)	Diet 2 (25% YPM)	Diet 3 (50% YPM)	Diet 4 (75% YPM)	SEM
AFI (g day^{-1})	32.27	32.21	32.39	31.98	1.75
AWG (g day^{-1})	24.23^{ab}	23.40^{b}	24.98^{ab}	27.98^{a}	1.83
AEW (g)	9.20	9.32	9.23	9.34	0.11
HDP (%)	83.15	80.20	88.25	88.76	4.09
EM (g day^{-1})	7.65^{b}	7.47^{b}	8.15^{a}	8.29^{a}	0.03
FCEM (g g^{-1})	4.22^{a}	4.31^{a}	3.97^{b}	3.85^{b}	0.65
FCDZ (g dz^{-1})	387.24	386.52	388.68	383.76	5.02
Viability %	95.98	93.08	94.77	94.45	1.87

^{ab}Means with the same superscripts in a row are not significantly ($p < 0.05$) different.

Overall, MXG® supplementation to YPM diets at 50 and 75% inclusion numerically recorded maximum HDP over that of the control and 25% YPM diet. Increasing YPM inclusion level with MXG® supplementation resulted in an increase ($p < 0.05$) for AEM and a subsequent decrease ($p < 0.05$) for FCEM. Thus, quails fed 50% and 75% MXG® supplemented YPM diets showed improved AEM and FCEM as compared to the control group. This improvement appears to be as a result of action of multi-enzymes and yeast on decreasing endogenous nutrient loss, and concurrently boosting the involvement of potentially metabolizable nutrients in poultry birds fed fibrous based diets (Woyengo et al., 2018; He et al., 2019; Attia et al., 2020). The incorporation of multi-enzymes may have facilitated reduced viscosity in the digestive tract, thereby promoting the effective digestibility and utilization of nutrients (Sateri et al., 2017; Aftab & Bedford, 2018; Hussein et al., 2019). In the present study, AEM increased ($p < 0.05$) in quails fed MXG® supplemented YPM based diet, which is in accordance with the findings of Khan et al. (2011) and Lee et al. (2014), who reported that egg mass was improved by enzyme complex supplementation. It appears that the improvement ($p < 0.05$) in weight gain, egg mass and feed conversion efficiency by enzyme complex + yeast supplementation could be related to its promoting effects on metabolic processes of digestion and utilization of nutrients as well as stimulation of intestinal mucosa immunity and increasing protection against toxins generated by pathogenic microbes (Al-Mansour et al., 2011; Wen, Wang, Zhou, Jiang, & Wang, 2012; El-Kelawy, El-Shafey, & Ali, 2017; Al-Khalaifah, 2018).

The increase in the release of nutrients due to supplemental MXG® resulted in higher nutrient available for absorption, as demonstrated by the increase in HDP and egg mass of quails fed diets containing higher levels of YPM. Moreover, the improvement in feed conversion (feed consumption/egg mass) of the quails fed MXG® supplemented YPM diets in the presence of the yeast may be a consequence of decreasing microbial colonization in the gut, thereby improving the availability of nutrients for production purposes (Haldar, Ghosh, Toshiwati, & Bedford, 2011; Yalçin, Yalçin, Onbaşilar, Eser, & Şahin, 2014; Ahmed, Abbas, Abdlhag, & Mukhtar, 2015). Also, according to earlier reports (Al-Mansour et al., 2011; Ezema, Ihedioha, Ihedioha, Okorie-Kanu, & Kamalu, 2012), yeast supplementation to diet layers has the ability to decrease pathogenic bacteria prevalence in the gut ecosystem and may also boost digestive tract enzymatic activity leading to increased nutrient utilization.

Table 4 revealed the effect of MXG® supplementation to laying quails fed different levels of YPM based diets on external and internal egg quality parameters. The results showed that inclusion of supplemental MXG® in the diet of laying quails had no significant effect ($p > 0.05$) on the values of internal and external egg quality characteristics except for weight and thickness of egg shell. The relative similarity ($p > 0.05$) of egg quality traits recorded between quails fed control diet and MXG® supplemented YPM diets is an indication that there is no variation in the amount of available dietary nutrients provided by diets.

Table 4. Egg qualities of quails fed sun-dried yam peel based diets with enzyme complex supplementation.

Parameters	Diet 1 (0% YPM)	Diet 2 (25% YPM)	Diet 3 (50% YPM)	Diet 4 (75% YPM)	SEM
Egg weight (g)	9.20	9.32	9.23	9.34	0.11
Egg diameter (mm)	7.52	7.48	7.58	7.60	0.23
Egg width (mm)	2.21	2.36	2.35	2.40	0.10
Egg length (mm)	2.88	2.93	2.91	3.04	0.16
Egg shell weight (g)	1.25[a]	1.15[b]	1.24[a]	1.29[a]	0.03
Egg shell thickness (mm)	0.31[a]	0.22[b]	0.28[ab]	0.33[a]	0.03
Albumen weight (mm)	4.23	3.84	4.29	4.03	0.14
Albumen Height (mm)	0.44	0.51	0.56	0.53	0.66
Yolk weight (mm)	2.97	2.97	3.04	3.18	0.05
Yolk height (mm)	0.59	0.23	0.69	0.73	0.44
Yolk index (%)	0.20	0.23	0.23	0.23	0.01
Egg shape index (%)	0.77	0.81	0.81	0.79	0.01
Haugh Unit (%)	59.66	60.21	60.75	60.31	6.34

[ab]Means with the same superscripts in a row are not significantly ($p < 0.05$) different.

This result is in accordance with previous studies (Kaankuka et al., 2012; Deniz et al., 2013; Yalçin et al., 2015), which has shown that dietary enzyme complex and yeast supplementation did not affect interior and exterior egg quality characteristics of laying birds. Conversely, Ghazalah et al. (2011) and Abd El-Hack et al. (2015) noted that egg quality indices of laying hens were affected by enzyme cocktail supplementation. However, quail birds fed 50 and 75% MXG® supplemented YPM diets were observed to have similar ($p > 0.05$) egg shell weight and thickness with those on control diet but were higher ($p < 0.05$) than those in the group fed 25% YPM diet. The increase in egg shell weight and thickness resulting from the increased level of YPM with added MXG® in diets can be related to the increased availability and use of nutrients, especially energy, calcium and phosphorus, by improving the digestibility of ingested diets, as indicated by previous workers (Abudabos, 2012; Nourmohammadi, Hosseini, Farhangfar, & Bashtani, 2012; Sun & Kim, 2019).

In our study, the observed increase in egg shell quality was expected and this might be attributed to the presence of exogenous phytase (a major enzyme component of MXG®), which was shown to have a direct influence on the strength and thickness of egg shells in laying birds through increased utilization of calcium and phosphorus (Lima et al., 2011; Rossetto et al., 2019). In addition, Shet, Ghosh, Ajith, Awachat, and Elangovan (2018) suggested the increased phosphorus bioavailability triggered by phytate-phosphorus release as a consequence of phytase activity in the gastrointestinal tract, resulted to greater phosphorus and calcium availability needed to maintain egg weight, shell weight and shell thickness of egg producing birds.

In agreement with the present study, some researchers had observed that egg shell weight and thickness of laying hens were improved due to feeding various enzyme complex (Attia et al., 2012) and also yeast supplementation (Chumpawadee, Chantiratikul, & Sataweesuk, 2009; Hassanein & Soliman, 2010; Yalçın et al., 2014); and these authors linked this improvement to the enhancement of calcium and phosphorus absorption and retention associated with the addition of these feed additives. Moreover, MXG® has been identified to optimize the use of unconventional feed ingredients by improving weight gain, feed conversion ratio, litter quality and egg production as well as shell quality (Duru & Dafwang, 2010; Ademola, Egbewande, Lawal, Isah, & Kuranga, 2012).

Conclusion

From the results of this study, the utilization of yam peel meal as a potential untraditional feed ingredient in replacing maize up to 75% inclusion level with MXG® fortification has a positive effect on major parts of egg production and quality characteristics considering egg mass, feed conversion per egg mass, egg shell weight and thickness. Generally, the use of untraditional feed ingredients at higher inclusion levels with combined supplementation of multi-enzymes and yeast (*Saccharomyces cerevisiae*) in laying Japanese quail diets could attract higher production efficiency without any detrimental impact on productive and egg quality performance.

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