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Influence of Turmeric and Garlic Fortified Sorghum Diets on Body Temperature and Sexual Maturity of Japanese Quails

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ABSTRACT

This study was carried out to ascertain the influence of fortifying sorghum, which replaces maize, with turmeric and garlic on the attainment of sexual maturity and temperature indices in quails. Nine hundred and sixty (960), one-week old unsexed Japanese quail chicks were used in the study which lasted for a period of sixteen (16) weeks. The birds were randomly assigned in a completely randomized design into 16 different dietary groups of sixty (60) birds per group and each was sub-divided into three (3) replicates of twenty (20) birds each with a factorial arrangement. The groups consisted of two basal diets: Maize diet as positive control (Ma) and Sorghum diet (T1). To fortify the sorghum-based diet, turmeric and garlic meals were combined at five (5) different levels of 0, 0.25, 0.50, 0.75 and 1.00 %, and three (3) (0, 0.50 and 1.00%) levels, respectively, hence making a total of 15 combination groups (1 + 3 x 5). Body and rectal temperatures were measured weekly. In females, the onset of puberty was assessed as the first day of egg production and female calling while in males, the first day of foam production from the cloacal gland and crowing were indicated as the onset of puberty. The mean body and rectal temperatures ranged between 38º – 41°C and 40º – 43°C, respectively. The onset of puberty was accelerated in females on the positive control (Maize) earlier compared to those on the negative control (Sorghum) by one day. Foam production was initiated earlier in male quails fed Maize (positive control) than those fed sorghum (negative control) by 3 (three) days whereas, at levels of 0.50 – 1.00%, garlic, and turmeric supplementation synergistically affected foam production in male Japanese quails. Results revealed that supplementation of garlic and turmeric did not affect the onset of puberty and sexual maturity in females. From our findings, the temperature obtained indicated that the birds had normal body temperature and were not under heat stress conditions while onset of puberty was accelerated in females on the positive control (Maize) earlier compared to those on the negative control (Sorghum) by one day. Initiation of puberty in female Japanese quails on T10 ($G_{0.50}T_{1.00}$), T11 ($G_{1.00}T_{0}$), T12 ($G_{1.00}T_{0.25}$), T13 ($G_{1.00}T_{0.50}$) and T15 ($G_{1.00}T_{1.00}$) was similar to that of control (Maize), whereas puberty was delayed by 1 (one) to 4 (four) days in quails on other treatments. Japanese quails on T10, T12 and T15 had their onset of foam production hastened when compared with maize based diet (positive control). Sexual maturity in Japanese quails was enhanced by sorghum diets – T11 and T13 and was similar to the maize diet. Hence, substituting maize for sorghum and fortifying it with turmeric and garlic did not show any adverse effect on temperature and sexual maturity of quails and can be incorporated in quail diet.

KEYWORDS: Quails, maize, sorghum, body temperature, sexual maturity

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INTRODUCTION

The increase in the production and consumption of poultry products (meat and eggs) has been on an unswerving rise for years and cannot be abated due to the rapid growth in the population worldwide (Mardoia, 2016). This constant rise in demand for poultry products can be attributed to the accessibility and affordability of its animal protein and noncomplicated cholesterol content (Thea *et al.*, 2018). In recent years, the continuous increase in demand for animal protein has compelled the broadening of the poultry industry, which can be achieved by rearing fast-growing and highly adaptable birds such as the quail (*Coturnix coturnix*) (Mnisi *et al.*, 2023) apart from broilers and turkeys.

Mahesh and Prabhakar, (2018) reported that quails possess a more robust immune system and are less susceptible to bacterial infections than chickens. However, their immune systems still need to be boosted. Antibiotic supplementation in a regular diet reduces morbidity and mortality (Mahesh), but, its utilization may show an adverse effect on public health by developing antibiotic-resistant microflora (Gouda and Bhandary, 2018; Islam *et al*., 2014), thus, its ban. The development of alternative synthetic antibiotics is a constant challenge for animal nutritionists, and the quest for alternative feed supplements has intensified. Hence, medicinal herbs have received a lot of interest as possible antibiotic alternatives (Ibrahim *et al*., 2005). Enhancing quails' growth performance and health through innovative feeding strategies is crucial for meeting this demand. Some alternatives involve the incorporation of natural additives like turmeric (*Curcuma longa*) and garlic (*Allium sativum*), which are recognized for their potential health benefits and growth-promoting properties.

Turmeric contains curcumin, a compound known for its anti-inflammatory and antioxidant effects. These effects can improve feed efficiency and enhance immune response in poultry (Mishra *et al.*, 2015). Similarly, garlic is noted for its antimicrobial properties and ability to improve gut health, which can lead to better nutrient absorption and overall performance (Sunanta *et al.*, 2023). When combined in a diet, these additives may synergistically enhance the health benefits and growth and reproductive performance of quails.

Onset of puberty (age at onset of first egg lay and female calling and age at first foam production and male crowing) and sexual maturity (age at which the females lay their first 10 eggs collectively) are critical landmarks in birds (El-Deen *et al*., 2015). Developmental landmarks are indicators of the physiological age of a growing animal (Ottinger and Brinkley, 1979), as well as the stage of maturation (Touart, 2005). Several authors (Saraswati *et al*., 2013; Saraswati and Tana, 2016; Oko *et al*., 2017; Al-Shammari *et al*., 2019) have studied the onset of puberty and sexual maturity extensively. Saraswati *et al*. (2013) reported that spices such as turmeric and garlic can improve physiological conditions as well as reproductive and egg performances in quails. Turmeric was reported to contain phytoestrogens which affects the growth of ovarian follicles, causing ovulation, thus, accelerating the age at sexual maturity to 43 days against control's 45 days (Saraswati and Tana, 2016).

It has been observed that sexual maturity of animals is delimited by several influences, such as genetics, nutrition, and environment. Of late the scientists in the area of reproductive biology have sought to determine the relationship between sexual maturity and nutrition. The sexual maturity in animals is a highly energy-sapping process; hence it is firmly influenced via nutritional status and energy metabolism within the body (Yin *et al.*, 2023).

Temperature and relative humidity are major factors that affect livestock productivity (Caurez and Olo, 2013). Heat stress is the combined effect of high ambient temperature and relative humidity on the bird, which are responsible for increased body and rectal temperatures (Ajakaiye *et al*., 2011). Ajakaiye *et al*. (2011) reported 18 - 24º C as the thermo-neutral zone for birds; body and rectal temperatures of 38 – 41 ºC and 40 - 43º C, and a body temperature of 41.5º C for poultry. Raharjo, *et al*. (2018) on the other hand, reported a thermo-neutral zone of 18–25º C for poultry, and a temperature and humidity of 25-27 ºC and 60-70 percent, respectively for quails.

Within these temperature ranges, sensible heat loss is adequate to maintain the bird's normal body temperature of 41°C. Animals exposed to heat stress are prone to physiological changes such as thermal imbalance or disrupted homeostasis which may lead to increased body temperature and respiratory rate, decreased physical activity, decreased live weight, growth rate, feed consumption and efficiency as well as decreased egg productivity and quality (Ajakaiye *et al*., 2011; Lallo *et al*., 2018). These negative effects of thermal stress on poultry may result to significant economic losses (El-Tarabany, 2016). Comparison of the values of THI used for larger animals with that of smaller animals shows that smaller animals tolerate higher climatic stress than larger animals. This may be due to the smaller animal's higher body temperature (Habeeb *et al*., 2018).

Temperature-humidity index (THI) is one of the indices used to measure heat stress. It integrates the effects of temperature and humidity with different weightings for different species (Hahn *et al.*, 2009); and has proven to be a useful tool for gauging livestock productivity response as a function of climate (Dikmen and Hansen, 2009). The comparative usefulness of various THI formulations has been used to examine animals' physiological state by several authors (Silva *et al*., 2007; Marai and Habeeb, 2010). Normal THI ranges have been reported by several authors for poultry (Tao and Xin, 2003; Moraes *et al*., 2008; Ajakaiye *et al*., 2011; El-Tarabany, 2016 and Habeeb *et al*., 2018); broilers (Purswell *et al*., 2012 and Aluwong *et al*., 2017); layers (Ghanem *et al*., 2017); and Quails (El-Tarabany, 2016).

Since there is dearth of information regarding the combination of turmeric and garlic, thus this necessitated this study. Moreover, there is the need to understand the interactions between temperature, sexual maturity and dietary components which are essential for optimizing the use of sorghum in quail diets, particularly when enhanced with turmeric and garlic. By elucidating these relationships, we aim to provide insights, of appropriate interaction that contribute to the development of more effective and sustainable feeding strategies, thereby enhancing quail production in an increasingly competitive market.

MATERIALS AND METHODS

Location of the study

The field study was carried out at the Poultry Unit of the Teaching and Research Farm, University of Calabar, Calabar, Cross River State, Nigeria. Calabar is located within the tropical rain forest zone of Nigeria and has a land area of 406 m^2. Calabar lies between latitude 4.96^0 N of the Equator and longitude 8.34^0 E of the Greenwich meridian. Its relative humidity is between 55 and 90 % with an elevation above sea level of 62.30 meters (Google Earth, 2020; Ewona and Udo, 2011). The annual temperature and rainfall ranges between 25^0 and 30^0C and 1260 and 3500 mm respectively (Okon and Njoku, 2017).

Sourcing, processing of test ingredients and experimental diets

Turmeric (*Curcuma longa*) rhizomes and garlic (*Allium sativum*) bulbs were purchased from Watt market in Calabar South Local Government Area of Cross River State, Nigeria. Turmeric rhizomes were washed, cut into pieces and sun dried till they became crispy. Subsequently, they were milled using a manual grinder and sieved with a 1mm mesh to obtain turmeric rhizome powder.
Garlic bulbs were cut into very thin pieces and sun dried to constant weight for three days. They were thereafter oven dried at 180^0C (SAISHO S-196 model hot oven) until very crispy and then milled immediately using a manual grinder while still hot to enable grinding due to its sticky nature, to form the garlic powder. The milled samples of turmeric and garlic meals were then stored in dry, airtight containers to avoid contamination and infestation by molds until needed for feed formulation. The proximate composition of turmeric and garlic were determined using the AOAC (2006) method.
Experimental diets were formulated to meet the nutrient requirements of Japanese quails, such that:

i. Two basal diets were formulated: Maize diet as positive control and Sorghum diet as test diet (Table 1) to compare the replacement value of maize by sorghum at 100% level.
ii. To fortify the sorghum-based diet for improved utilization, and determine its efficacy in quails, turmeric and garlic meals were combined at five (5) different levels such as 0, 0.25, 0.50, 0.75 and 1.00 %) and three (3) (0, 0.50 and 1.00%) levels, respectively, and added with the sorghum diet consisting of 15 combination groups as follows:

Ma: Positive control basal diet (Maize);
T1: Negative control basal diet (Sorghum)
T2: T1 Diet + 0.25% turmeric
T3: T1 Diet + 0.50% turmeric
T4: T1 Diet + 0.75% turmeric
T5: T1 Diet + 1.00% turmeric
T6: T1 Diet + 0.50% garlic
T7: T1 Diet + 0.50% garlic & 0.25% turmeric
T8: T1 Diet + 0.50% garlic & 0.50% turmeric
T9: T1 Diet + 0.50% garlic & 0.75% turmeric
T10: T1 Diet + 0.50% garlic & 1.00% turmeric
T11: T1 Diet + 1.00% garlic
T12: T1 Diet + 1.00% garlic & 0.25% turmeric
T13: T1 Diet + 1.00% garlic & 0.50% turmeric
T14: T1 Diet + 1.00% garlic & 0.75% turmeric
T15: T1 Diet + 1.00% garlic & 1.00% turmeric

Therefore, a total of 16 dietary groups were studied. The experimental diets were formulated to meet the nutrient requirement of Japanese quails during the growth and laying phases according to NRC (1994). Feed and water were offered *ad libitum.*

Table 1: Gross composition of sorghum and maize basal diets for Japanese quails

	Chick diet		Grower diet	
Ingredient (%)	Maize	Sorghum	Maize	Sorghum
Maize	41.00	0.00	40.00	0.00
Sorghum	0.00	41.00	0.00	40.00
Soya bean	42.00	42.00	38.00	38.00

Wheat offal	6.00	6.00	7.00	7.00
Crayfish dust	2.00	2.00	2.00	2.00
Palm kernel cake	4.00	4.00	8.00	8.00
Palm oil	1.00	1.00	1.00	1.00
Dicalcium phosphate	3.00	3.00	3.00	3.00
Limestone	0.00	0.00	0.00	0.00
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated nutrients (%)				
Crude protein	25.05	25.87	24.08	24.88
Crude fibre	5.94	3.89	6.22	4.22
Calcium	1.24	1.25	1.24	1.25
Energy (Kcal/Kg)	3116.20	3075.20	3056.90	3016.90

Vitamin premix=Vitamin A 12,000,000 i.u., Vitamin D3 2,500,000 i.u., Vitamin E 30,000 i.u., Vitamin K 2,000mg, Vitamin B1 2,250mg Vitamin B2 6,000mg, Vitamin B6 4,500mg, Vitamin B12 15mg, Niacin 40,000mg, Pantothenic Acid 15,000mg, Folic Acid 1,500mg, Biotin 50mg, Choline chloride 300,000mg, Manganese 80,000mg, Zinc 50,000mg, Iron 20,000mg, Copper 5,000mg, Iodine 1,000mg, Selenium 200mg, Cobalt 500mg and Antioxidants 125,500mg

Experimental animals and management

Nine hundred and sixty (960), one-week old unsexed Japanese quail chicks purchased from the National Veterinary Research Institute (NVRI), Vom in Plateau State, Nigeria were used in the study which lasted for a period of sixteen (16) weeks for growth study while the temperature and sexual maturity lasted from weeks 4 to 6. The birds were managed on deep litter system according to the Federation of Animal Science Societies' Principles of Animal Care in experimentation set (Craig and Muir, 1996) and no prophylactic therapy was administered throughout the research period. For the feeding trial, there were sixteen (16) groups of sixty (60) birds each. Each group was sub-divided into three (3) replicates of twenty (20) birds each.

Temperature measurement

Body and rectal temperatures were measured weekly, before weighing the birds. Body temperature was measured by placing the thermometer under the wings of the birds while the rectal temperature was measured using a digital clinical thermometer ($\pm 0.1^0$C accuracy; model (MC-246 Omron) inserted 3 cm into the rectum and left until a constant reading followed by a repeated beeping tone was reached. The thermometer was wiped using fresh clean cotton wool moistened with methylated alcohol between subsequent measurements to prevent possible cross-infection among birds with the birds in inverted position.

Meteorological measurements

Meteorological measurements were recorded daily during the growth phase. Ambient temperature (db^0C) and relative humidity (RH) (%) were recorded automatically twice a day for 3 weeks using Thermometer-hygrometer data loggers (On Computer Corporation, Po asset, MA, USA). The recorded temperature and relative humidity data were used to estimate the temperature humidity index (THI) as follows:

$THI = db^0C - [\{0.31 - 0.31\ (RH/100)\}\ (db^0C - 14.4)]$ (El-Tarabany, 2016)

Where THI is the temperature humidity index; db^0C is the ambient temperature and RH is the relative humidity.

Onset of puberty and age at sexual maturity

These are developmental landmarks that were monitored from days 28 to 42 of the feeding trial. On day 28 of the experiment, 10 quails were picked from each treatment, separated, and housed in individual cages at room temperature, on a long-day photoperiod (16L: 8D; where natural lighting and supplementation with artificial lighting were used to stimulate the birds' reproductive systems) to monitor these landmarks. In females, the onset of puberty was assessed as the first day of egg production and female calling while in males, the first day of foam production from the cloacal gland and crowing were indicated as the onset of puberty. The cloacal gland is an androgen-sensitive secondary sex character in Japanese quail and an external index of sexual maturity. In females, age at sexual maturity was determined as the age at which the females produced their first 10 eggs (El-Deen *et al*., 2015).

RESULTS AND DISCUSSION

Body and rectal temperature indices

The mean weekly body and rectal temperatures are shown in Figures 1 and 2. The body and rectal temperatures ranged between 38º – 41°C and 40º – 43°C, respectively.

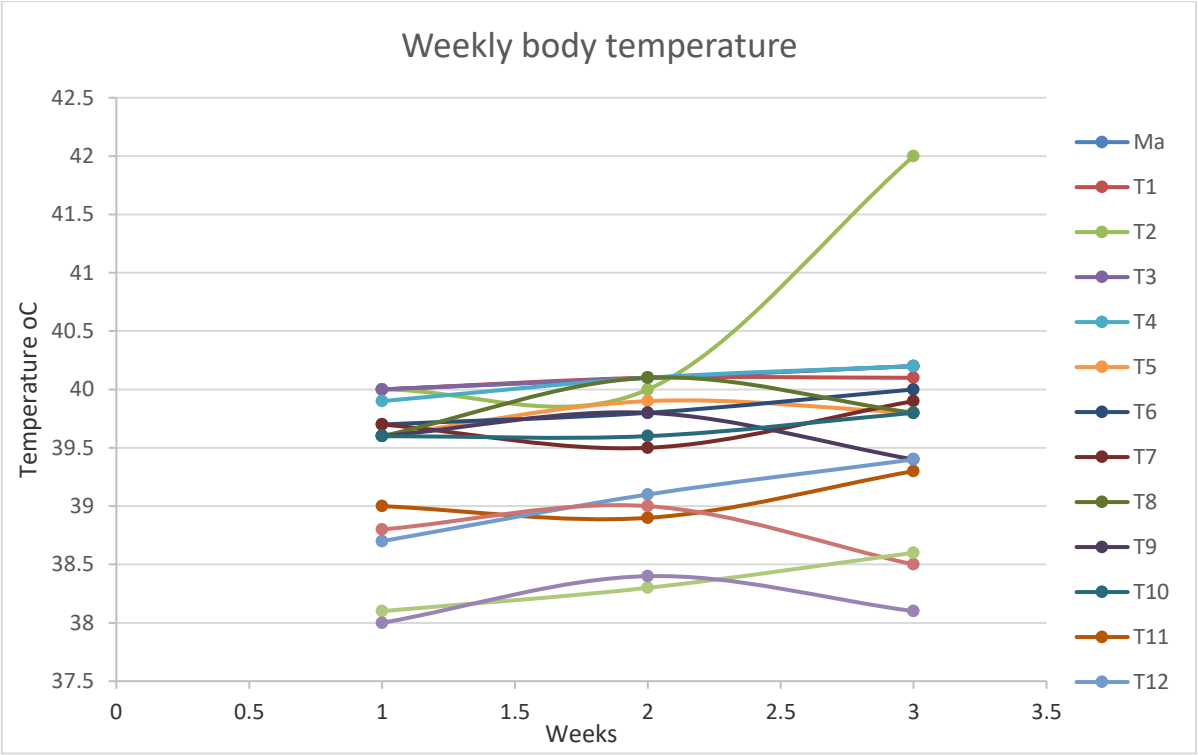

Figure 1: Mean weekly body temperature

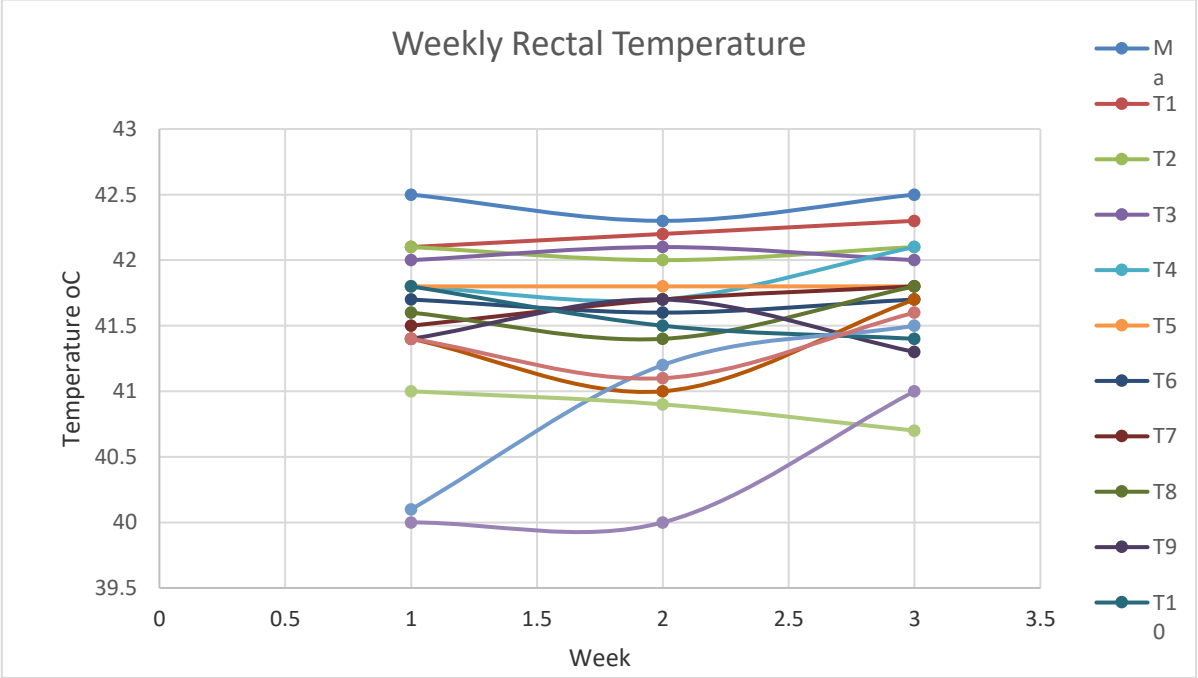

Figure 2: Mean weekly rectal temperature

These ranges were within normal temperatures (38 – 39.9ºC body temperature and 42 – 42.2°C rectal temperature) for quails (Hubrecht and Kirkwood, 2010). The poultry body temperature normally varies between 41º and 42°C but will fluctuate depending on the temperature of its environment. The established thermoneutral zone for birds reared in the tropical regions ranges between 18º and 24°C (Ajakaiye *et al*., 2011). The temperature obtained indicated that the birds had normal body temperature and might not be under heat stress conditions.

Japanese quails thrive at a temperature and humidity of 25º – 27ºC and 60 – 70 percent, respectively (Raharjo, 2018). High environmental temperature may have negative effects on the health and performance of laying hens and cause behavioral changes. These effects include decrease in egg size and production as a result of the decreased consumption of nutrients (especially energy and protein) in poultry. The high temperature makes quails stressed, so the energy for egg production is being used to overcome the stress (Raharjo, 2018). The behavioral changes as a result of stress include; rapid breathing and gasping, eating less food, remaining prostrated and opening of wings in an attempt to dissipate body heat. High environmental temperatures result in decline in quail productivity (El-Tarabany, 2016).

Temperature humidity index

Table 2 presents the ambient temperature (AT), relative humidity (RH), and temperature humidity index of the flock. The mean ambient temperature (AT) and relative humidity (RH) were 28.77 and 43.60%, respectively. The temperature humidity index (THI) was established to be 26.26 implying that heat stress was absent in the flock. This index is in line with Habeeb *et al*. (2018) who reported a THI of <27.80 for poultry. El-Tarabany (2016) however, reported a THI of <75.00 for quails.

Onset of puberty, foam production, and sexual maturity

The effects of dietary treatments on the onset of puberty (the first day of egg production in females and foam production in males) and sexual maturity (collective laying of first 10 eggs in each group) are illustrated in Figures 3 - 5. The onset of puberty was accelerated in females on the positive control (Maize) earlier compared to those on the negative control (Sorghum) by one day (Figure 3). Initiation of puberty in female Japanese quails on T10 ($G_{0.50}T_{1.00}$), T11 ($G_{1.00}T_{0}$), T12 ($G_{1.00}T_{0.25}$), T13 ($G_{1.00}T_{0.50}$) and T15 ($G_{1.00}T_{1.00}$) was similar to that of control (Maize), whereas puberty was delayed by 1 (one) to 4 (four) days in quails on other treatments.

Table 2: Mean ambient temperature, relative humidity, and temperature humidity index of the poultry house

Week	Ambient temperature (^{0}C)	Relative humidity (%)	THI
4	29.50	39.00	
5	27.90	45.00	26.26
6	28.90	46.80	
Total	86.30	130.80	
Mean	28.77	43.60	

THI = 26.26; THI = db^{0}C – [{0.31 – 0.31(RH/100)} (db^{0}C – 14.4)] (El-Tarabany, 2016)
THI: Temperature humidity index; db^{0}C: Ambient temperature of the poultry house
RH: Relative humidity; THI <27.80 signifies the absence of heat stress; THI >30.00 signifies heat stress

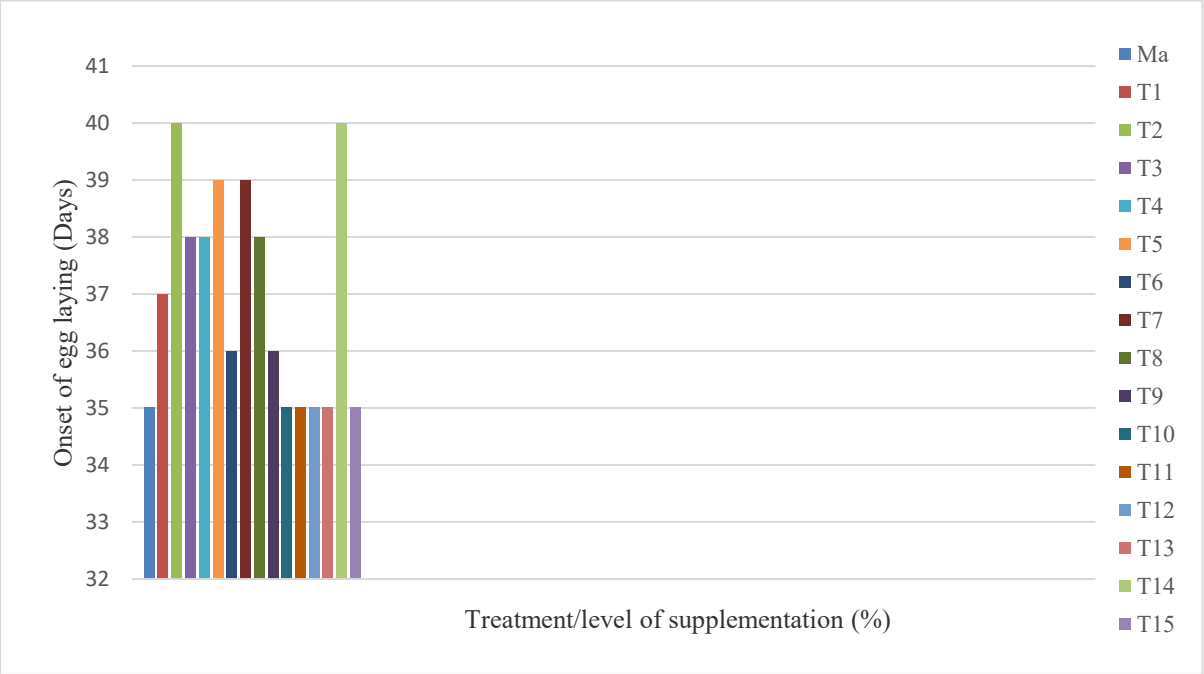

Figure 3: Effect of turmeric-garlic supplementation on the onset of egg laying in Japanese quails

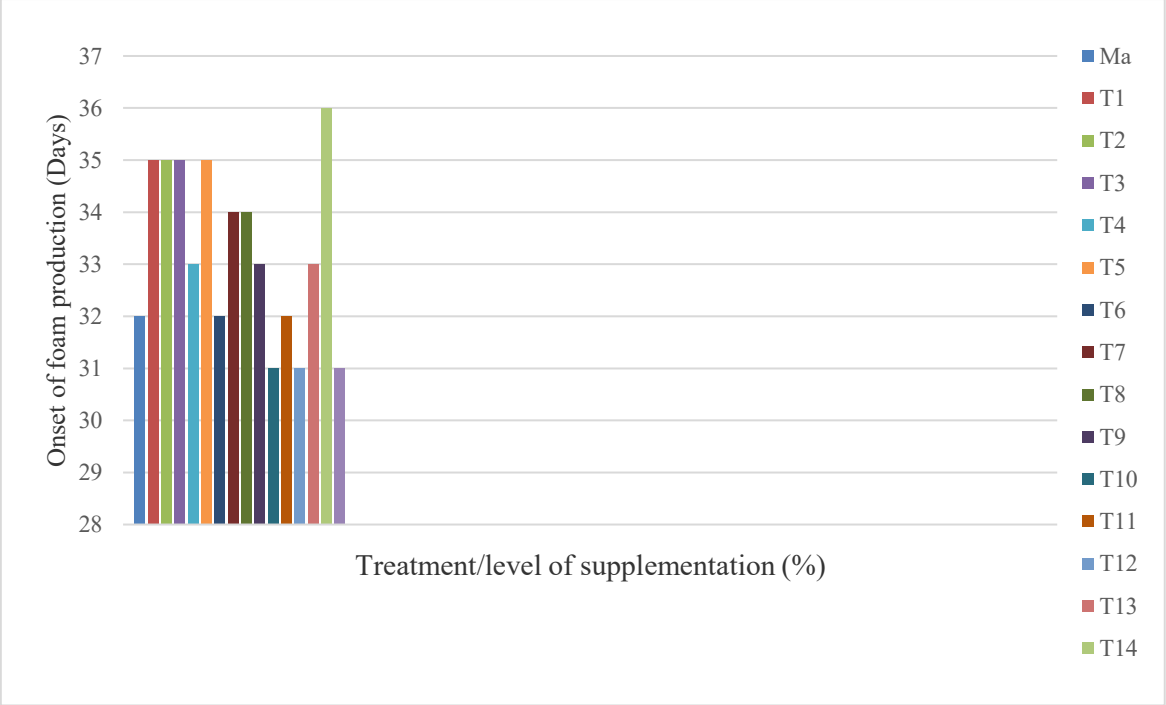

Figure 4: Effect of turmeric-garlic supplementation on the onset of foam production in Japanese quails

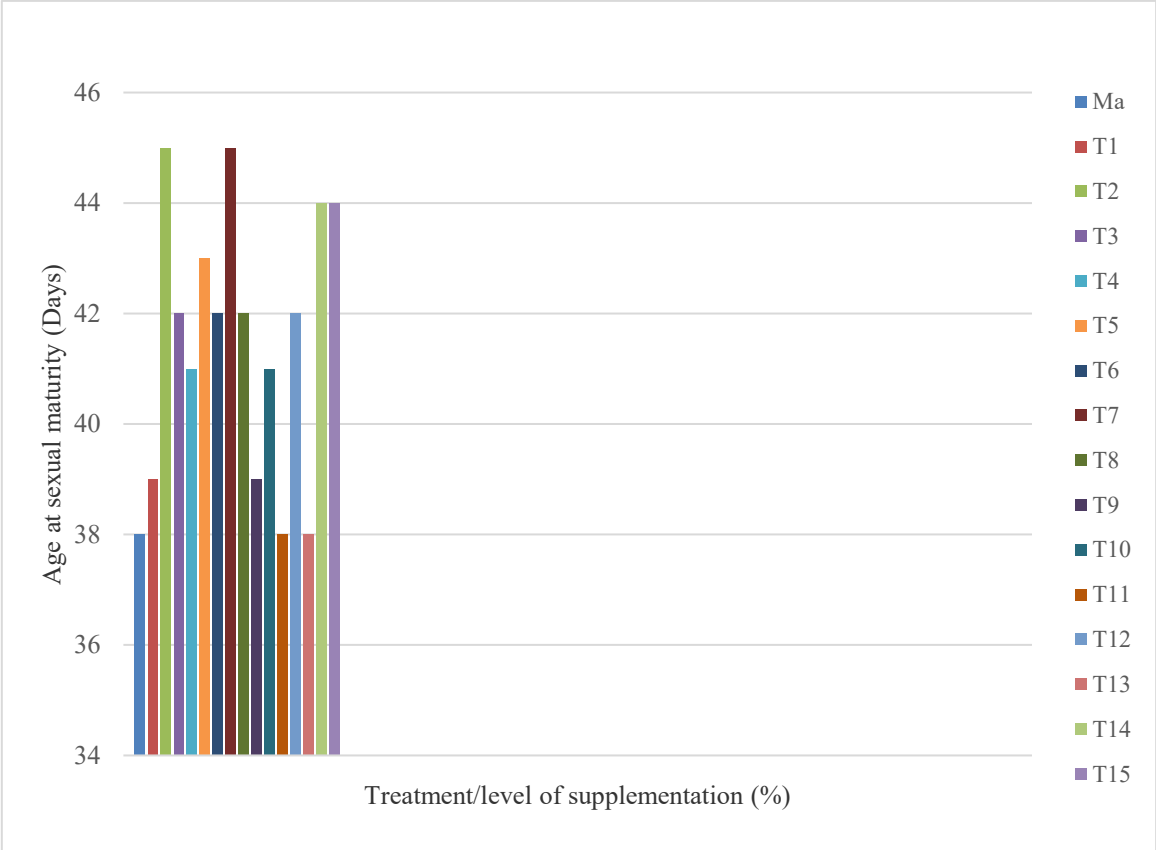

Figure 5: Effect of turmeric-garlic supplementation on the age at sexual maturity in Japanese quails

In the male Japanese quails, foam production (Figure 4) was initiated earlier in quails fed Maize (positive control) than those fed sorghum (negative control) by 3 (three) days. Quails fed 0.50 % garlic + 1.00 % turmeric (T10), 1.00 % garlic + 0.25 % turmeric (T12), and 1.00 % garlic + 1.00 % turmeric (T15) had earlier production of foam by 1 (one) day compared to maize (positive control). Delayed foam production was detected in males on T14 by 5 days. Figure 5 shows the effect of garlic-turmeric supplementation on the age at sexual maturity of female Japanese quails. Birds fed the maize diet (positive control) attained sexual

maturity earlier than those fed the sorghum diet (negative control). Quails on T11 (1.00 % garlic) and T13 (1.00 % garlic +0.50 % turmeric) also attained sexual maturity on the same day as those on positive control.

Results revealed that supplementation of garlic and turmeric did not affect the onset of puberty and sexual maturity in females. However, at levels of 0.50 – 1.00 %, garlic, and turmeric supplementation synergistically affected foam production in male Japanese quails as quails in some treatments attained puberty earlier than the control birds. Zelenka *et al*. (1984) noted that the timing of the transition from somatic to gonadal growth (sexual maturity) is also influenced by the accumulation of energy reserves in the juvenile stage. Therefore, environmental variables that could alter the growth rate will ultimately influence the onset of sexual maturity especially in the female. This, based on literature may also suggest potentially negative impacts on the reproductive performance of the individual birds (Oko *et al*., 2017). Results however revealed higher influences in male rather than female quails following turmeric-garlic supplementation, implying that the male and female quails responded differently to the prevailing environmental conditions. Results were consistent with the findings of Ottinger *et al*. (2005) and Touart (2005) who reported onset of foam production of between 32 and 50 days; and Al-Shammari *et al*. (2019) who reported onset of puberty from 36 – 40 days by female Japanese quails.

CONCLUSION

The body temperature of the quails was not influenced by the dietary treatments offered neither the environmental heat therefore implying that the animals were not under heat stress. The garlic and turmeric synergy (T10: T1 Diet + 0.50% garlic & 1.00% turmeric; T11: T1 Diet + 1.00% garlic; T12: T1 Diet + 1.00% garlic & 0.25% turmeric; T13: T1 Diet + 1.00% garlic & 0.50% turmeric; and T15: T1 Diet + 1.00% garlic & 1.00% turmeric) accelerated the onset of puberty in females though comparable with those on maize diet. This same synergy (T10, T12 and T15) proved effective in hastening the onset of foam production in Japanese quails. The sorghum fortified diets with garlic and turmeric (T11 and T13) enhanced the sexual maturity of the Japanese quails. Therefore, garlic-turmeric fortification of sorghum has the potentials of replacing maize in quail diets as it did not show any adverse effects.

REFERENCES

1. Ajakaiye, J. J., Perez-Bello, A. and Mollinneda-Trujillo, A. (2011). Impact of heat stress on egg quality in layer hens supplemented with L-ascorbic acid and DL-tocopherol acetate. *Veterinary Archives*. 81: 119-132.
2. Almeida, A. Z., Eyng, C., Garcia, R. G., Nunes, R. V., Sangalli, G. G. and Nunes, K. C. (2020). Dried cassava residue in laying quail feeding. *Braz. J. Poult. Sci*. 22 (1): 1–8. doi: 10.1590/1806-9061-2019-1189.
3. Al-Shammari, K. I. A., Batkowska, J., Drabik, K. and Gryzińska, M. M. (2019). Time of sexual maturity and early egg quality of Japanese quails affected by *in ovo* injection of medicinal plants. *Archives Animal Breeding*. 62(2): 423–430.
4. Aluwong T., Sumanu V. O., Ayo, J. O., Ocheja, B. O., Zakari, F.O. and Minka, N. S. (2017). Daily rhythms of cloacal temperature in broiler chickens of different age groups administered with zinc gluconate and probiotic during the hot-dry season. *Physiological Reports*. 5(12):e13314.
5. AOAC (2006). Official Methods of Analysis. 18th Edition. Association of official analytical chemists, Gaithersburg, MD.
6. Caurez, C. L. and Olo, C. F. (2013). Laying performance of Japanese quail (Coturnix coturnix Japonica) supplemented with zinc, vitamin C, and E subjected to long term heat stress. International Conference on Agriculture and Biotechnology IPCBEE. Volume 60.
7. Craig, J. V. and Muir, W. M. (1996). Group selection for adaptation to multiple-hen cages: Beak-related mortality, feathering, and body weight responses. *Poultry Science*. 75:294–302.
8. Dikmen, S. and Hansen, P. J. (2009). Is the temperature-humidity index the best indicator of heat stress in lactating dairy cows in a subtropical environment? *Journal of Dairy Sciences.* 92:109–116.
9. El-Deen, M. B. Nour, A. A., El-Tahawy, W. S. and Fouad, H. A. (2015). Effect of selection for weight of early eggs on egg production traits in Japanese quail. *Asian Journal of Poultry Science*. 9 (4): 179-190.
10. El-Tarabany, M. (2016). Impact of temperature-humidity index on egg-laying characteristics and related stress and immunity parameters of Japanese quails. *International Journal of Biometeorology*. 60(7).
11. Ewona, I. O. and Udo S. O. (2011). Climatic condition of Calabar as typified by some meteorological parameters. *Global Journal of pure and applied Sciences*. 17(1).
12. Ghanem, H. M., Manaa, E. A. and Saleh, R. M. (2017). Evaluation of egg quality indices, fertility, hatchability % and some biochemical parameters under the effect of some environmental stressors in laying hen. *International Journal of Poultry Science*. 16: 310-316.
13. Google Earth. (2020). Geo Names, Geographical database. Travelling hick for Calabar, Cross River State. Nigeria Time Zone, Latitude, Longitude elevation and map/satellite image.

14. Gouda, M. M. and Bhandary, Y. P. (2018). Natural antibiotic effect of turmeric in poultry management. *Int. J. Poul. Fish Sci.* 2(1):1-3. https://doi.org/10.15226/2578-1898/2/2/00109.
15. Habeeb, A. A., Gad, A. E., EL-Tarabany, A. A. and Atta, M. A. A. (2018). Negative effects of heat stress on growth and milk production of farm animals. *Journal of Animal Husbandry and Dairy Science.* 2 (1): 1-12.
16. Hahn, G. L., Gaughan, J. B., Mader, T. L. Eigenberg R. A. (2009). Chapter 5: Thermal Indices and Their Applications For Livestock Environments. In: DeShazer, J.A (ed.) Livestock Energetics and Thermal Environmental Management. ASABE, MI, USA. Pp. 113–130.
17. Hubrecht, R. and Kirkwood, J. (2010). The UFAW Handbook on the Care and Management of Laboratory and Other Research Animals. John Wiley & Sons. Pp. 655–674.
18. Ibrahim, K. A., Faten, A. M. and Halam, S. A. E. (2005). Comparison of the efficacies of commercial probiotics on growth performance, carcass characteristics and some plasma constituents of broiler chicks. *Suez Canal Vet. Med. J.* 8: 1-18.
19. Islam, M. M., Ahmed, S. T., Kim, Y. J., Mun, H. S., Kim, Y. J. and Yang, C. J. (2014). Effect of sea tangle (*Laminaria japonica*) and charcoal supplementation as alternatives to antibiotics on growth performance and meat quality of ducks. *Asian Australas. J. Anim. Sci*. 27(2): 217-224. https://doi. org/10.5713/ajas.2013.13314.
20. Lallo, C. H., Cohen, J., Rankine, D., Taylor, M., Cambell, J. and Stephenson, T. (2018). Characterizing heat stress on livestock using the temperature humidity index (THI)—prospects for a warmer Caribbean. *Regional Environmental Change*. 18(8): 2329-2340.
21. Mahesh, M. G. and Prabhakar, B. Y. (2018). Natural antibiotic effect of turmeric in poultry management. *Int. J. Poult. Fish Sci.* 2(1): 1-3. https://doi.org/10.15226/2578-1898/2/2/00109.
22. Marai, I. F. M. and Habeeb, A. A. M. (2010). Buffalo's biological function as affected by heat stress—a review. *Journal of Livestock Sciences*. 127:89–109.
23. Mishra, A., Kumar, R., Tyagi, A., Kohaar, I., Hedau, S., Bharti, A. C., Sarker, S. Dey, D., Saluja, D. and Das, B. (2015). Curcumin modulates cellular AP-1, NF-KB, and HPV16 E6 proteins in oral cancer. *E Cancer Medical Science*. 9: 525. 10.3332/ecancer.2015.525
24. Mnisi, C. M., Oyeagu, C. E., Akuru, E. A., Ruzvidzo, O. and Lewu, F. B. (2023). Sorghum, millet and cassava as alternative dietary energy sources for sustainable quail production – A review. *Front. Anim. Sci*. 4:1066388. doi: 10.3389/fanim.2023.1066388
25. Moraes, S. R. P., Junior, T. Y., Oliveira, A. L. R. D., Yanagi, S. M. and Café, M. (2008). Classification of the temperature and humidity index (THI), aptitude of the region, and conditions of comfort for broilers and layer hens in Brazil. (https://api.semanticscholar.org/CorpusID:109480068)
26. Nardoia, M. (2016). Effects of dietary polyphenol-rich grape by-products on growth performance, some physical parameters meat and meat products quality in chickens. Ph.D. thesis, https://iris.unimol.it/handle/11695/66377. Pp. 1–244.
27. NRC. (1994). Nutrient Requirements of Poultry 9th ed. National Academy Press: Washington DC.
28. Odo, B. I. and Nnadi, A. E. (2013). Growth response of quails (*Coturnix coturnix japonica*) to varying levels of cassava tuber meal (*Manihot esculenta*) as replacement for maize (*Zea mays*). *Rev. Cie. UDO Agrí*. 13 (1): 146–149.
29. Oko, O. O. K., Asuquo, O. R., Agiang, E. A. and Osim, E. E. (2017). Neuroendocrine and behavioural responses of Japanese quails to dietary *Aspilia africana* leaf meal and extracts. *Journal of Livestock Science*. 8: 43-51.
30. Okon, I. and Njoku, C. G. (2017). Evaluation of domestic access to pipe-borne water in Calabar Metropolis, southern Nigeria. *Open Access Library Journal* 4: 1-21.
31. Ottinger, M. A. and Brinkley, H. J. (1979). Testosterone and sex-related physical characteristics during maturation of the male Japanese quail (*Coturnix coturnix japonica*). *Biology of Reproduction*. 20: 905-909.
32. Ottinger, M. A., Mobarak, M., Abdelnabi, M., Roth, G., Proudman, J. and Ingram, D. K. (2005). Effects of calorie restriction on reproductive and adrenal systems in Japanese quail: are responses similar to mammals, particularly primates? *Mechanisms of Ageing and Development*. 126(9):967-975. doi: 10.1016/j.mad.2005.03.017. PMID: 15935442.
33. Purswell, J. L., Dozier III, W. A., Olanrewaju, H. A., Davis, J. D., Xin, H. and Gates, R. S. (2012). Effect of temperature-humidity index on live performance in broiler chickens grown from 49 to 63 days of age. Ninth International Livestock Environment Symposium, Valencia, Spain, Paper: ILES12–0265. ASABE, St. Joseph, MI, USA
34. Raharjo, S., Rahayu, E. S. and Purnomo, S. H. (2018). Factors affecting quail egg production under the changing climate at Kulonprogo Regency, Indonesia. IOP Conference Series Earth and Environmental Science. 200(1):012012. Pp. 1-4.
35. Saraswati, T. R., Manalu, W., Ekastuti. D. R. and Kusumorini, N. (2013). The role of turmeric powder in lipid metabolism and its effect on quality of the first quail`s egg. *Journal of Indonesian Tropical Animal Agriculture*. 38: 123–130.

36. Saraswati, T. R. and Tana, S. (2016). Physiological condition of first female and male offspring of Japanese quail (*Coturnix japonica*) whose parents were supplemented by turmeric powder. *Journal of World Poultry Resources*. 6: 59–65.
37. Silva, D. R. G., Morais, D. A. E. F. and Guilhermino, M. M. (2007). Evaluation of thermal stress indexes for dairy cows in tropical regions. *Rev Bras Zootec* 36:1192–1198.
38. Sunanta, P., Kontogiorgos, V., Pankasemsuk, T., Jantanasakulwong, K., Rachtanapun, P., Seesuriyachan, P. and Sommano, S. R. (2023). The nutritional value, bioactive availability and functional properties of garlic and its related products during processing. *Frontiers in Nutrition*. 10:1142784. doi: 10.3389/fnut.2023.1142784
39. Tao, X. and Xin, H. (2003). Acute synergistic effects of air temperature, humidity, and velocity on homeostasis of market-size broilers. *Transactions of the American Society of Agricultural and Biological Engineers*. 46:491–497.
40. Thea, K., Megan, O. M. and Lesley, L. D. (2018). Nanotechnology in the food sector and potential applications for the poultry industry. *Trends. Food. Sci. Technol*. 72: 62– 73. doi: 10.1016/j.tifs.2017.11.015
41. Touart, L. (2005). Final detailed review paper for avian two-generation toxicity test (Washington, DC, USA: The US Environmental Protection Agency).
42. Yin, L., Chen, Q., Huang, Q., Wang, X., Zhang, D., Lin, Z., Wang, Y. and Liu, Y. (2023). Physiological role of dietary energy in the sexual maturity: clues of body size, gonad development, and serum biochemical parameters of Chinese indigenous chicken. *Poultry Science*. 102:103157. https://doi.org/10.1016/j.psj.2023.103157.
43. Zelenka, D. J., Cherry, J. A., Nir, I. and Siegel, P. B. (1984). Body weight and composition of Japanese quail (*Coturnix coturnix japonica*) at sexual maturity. *Growth*. 48:16–28.