

EFFECT OF HOUSING TEMPERATURE AND COCONUT WATER ON SERUM FERRITIN AND TOTAL IRON BINDING CAPACITY (TIBC) OF BROILER CHICKENS

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Abstract

The poultry industry, particularly in developing nations, faces significant challenges from climate-related stressors, notably heat stress in broiler chickens. Heat stress significantly disrupts physiological balance, leading to oxidative damage and impacting iron metabolism. This interplay can result in poor performance and increased mortality, particularly as iron metabolism parameters like serum ferritin and Total Iron Binding Capacity (TIBC) are affected by stress and oxidative stress. This study investigates the effects of housing temperature and coconut water on serum ferritin and TIBC of broilers chicken. A total of 600 Broiler chicken (Mashall Breed) were purchased for the experiment, 200 birds were allocated for each housing condition: Cold (CHT, 18.3- 22.1°C), Natural (NHT, 26.3- 26.6°C), and Hot (HHT 34.9 – 36.1°C). Each housing temperature was demarcated into 5 treatment group: Ordinary water as control (T1), 0.5g of vitamin C / litre of water, (T2) 0.5% CW / liter of water, (T3)1% CW / liter of water (T₄) and 1.5% CW / liter of water (T₅). Each treatment was replicated four times with 10 birds per replicate. The treatment duration was three weeks, at the expiration of the investigation the birds were bled and serum was harvested for laboratory analysis on Serum Ferritin and TIBC. Housing temperature and coconut water has significant effect ($P < 0.05$) on Serum Ferritin and TIBC of the broiler chicken. For ferritin, the broiler chickens under natural housing temperature administered with vitamin C had the highest value (36.84 $\mu\text{mol/L}$) across the three housing condition, while birds under hot housing temperature administered vitamin C had lowest value (8.56 $\mu\text{mol/L}$). Birds under hot housing temperature recorded (34.70 $\mu\text{mol/L}$, 30.68 $\mu\text{mol/L}$ respectively) and cold (18.26 $\mu\text{mol/L}$ and 24.89 respectively) administered with coconut water at 1% and 1.5% recorded highest value. Also, Coconut water and vitamin C showed significant effects ($P < 0.05$) on total iron binding capacity of the broiler chicken. Administration of 1.5% coconut water under cold housing temperature recorded the highest value of (0.081 $\mu\text{mol/L}$) while birds offered vitamin C recording lowest value (0.029 $\mu\text{mol/L}$). Therefore, the research work revealed that administration of coconut water could assist in iron metabolism, reduction in oxidative stress in broiler production.

Keywords: Ferritin, Iron, Broiler, Vitamin C, Coconut water.

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Introduction

Iron is a vital trace element that performs essential roles in oxygen transport, DNA synthesis, and cellular respiration. Likewise Ferritin and TIBC are critical biomarkers employed in evaluating iron status in animals under clinical and research settings. Accurate knowledge on the interrelationship between serum iron, ferritin, and TIBC is crucial for diagnosing and managing conditions like iron deficiency anemia, some fatal diseases, and iron overload disorders (Cook *et al.*, 2003).

Iron deficiency is a universal problem which is responsible for one of the serious public health challenges called anaemia. Nutritional anemia is an acquired problem due to inadequate consumption of diet rich in iron and also insufficient bio-available of essential nutrients to meet the need for hemoglobin and red blood cell synthesis (Koperdanova and Cullis, 2015). Iron is one of trace element out of many that are required in minimal quantity usually present in serum. Other trace elements are: Zinc, Copper, Cobalt, Iodine, Selenium and Manganese. Among the others, iron is most prevalence in serum than the rest up to 1.0 to 2.0ppm (Suttle, 2010 and Radostits *et al.*, 2007). Iron plays vital roles in animals such as sustaining health and welfare of the animals, it also helps in physiological and biochemical processes like protein, enzymes and hormonal synthesis. Others are immune function, growth, reproduction and production (Gressley, 2009 and Mohd, 2013). This crucial element is one of component of antioxidant such as catalase, peroxidase and cytochrome oxidase which plays vital roles in mediating oxidative stress (Elisa and Elgabaly, 2010; Mohd *et al.*, 2013).

Iron appears in the body from five different sources, comprising transport, storage, oxygen carrying, functional and low molecular weight iron. Transferrin, ferritin, haemoglobin, myoglobin, iron dependent enzymes and small transporting iron chelates respectively (Min and Ahn, 2005). Serum transferrin which is the most significant

functional source of iron is a glycoprotein produced in the liver and jointly with ferritin binds fundamentally all circulating plasma iron. Ferritin is an iron storage protein within the cell which is an indicator of iron stores. Basically, all living organism synthesis this protein (ferritin) including algae, bacteria, complex plants and animals. In human being, it safeguards against iron shortage and iron surplus. Ferritin is mostly found in all the tissue as a cytosol protein, but lesser amount are released into the blood serum where it functions as an iron carrier. Iron insufficiency can be detected through low ferritin level. Elevated levels of ferritin recurrently signify iron overload triggered by impaired hepatocytes; inflammatory disorders; liver disease; alcohol excess; or malignancy (Koperdanova and Cullis, 2015). Iron binding capacity is the forte of transferrin to bind with iron (Arjum and Shiva, 2023). Total iron-binding capacity (TIBC) is a vital resource used for assessing iron deficiency anemias and other syndromes of iron metabolism. Housing temperature has negative effects on productivity in broilers chickens most especially in the tropical areas of the world (Dawkins *et al.*, 2004). But controlled housing temperature is confirmed to give room for maximum and higher production performance in broilers (Kao *et al.*, 2011) the health and performance of poultry (Estevez, 2007). High housing temperature is also known to lead to heat stress in broiler chickens (DEFRA, 2005). Coconut water is a source of antioxidant as it comprises a diversity of nutrients including vitamins, minerals, amino acids, enzymes, growth factors, and other nutrients. Coconut water is a good source of the most important minerals like potassium, calcium, and magnesium. According to BacicVrca *et al.*, (2014) vitamin C and A has been said to influence ferritin and TIBC in birds. Likewise Abegunde *et al.*, (2023) after experimenting coconut water on immune regulatory potentials of broilers chicken exposed to varying housing temperature recommended

coconut water in immune regulation. Therefore, this work designed to evaluate the influence of housing temperature and coconut water as source of antioxidant on serum ferritin and TIBC.

Materials and Methods

Experimental site

This research work was carried out at the poultry unit of Federal University of Agriculture farm, Abeokuta, Ogun State, Nigeria with latitude 7° 13'49.46"N; longitude 3°26'11.98"E and altitude 76 metres above sea level (Google Earth, 2015). The climate of the experimental site is humid, located in the rain forest vegetation zone of western Nigeria.

Meteorological observations

The daily temperatures and relative humidity of the pen were monitored using digital thermohygrometer all through the trial period.

Experimental birds and management

Six hundred *Oba Marshal* broiler chickens were procured. Proper disinfection and fumigation of the poultry house was done ahead of brooding. Brooding was carried out for a period of two weeks. The birds were vaccinated and given prescribed medication. At the end of the 4th week, the birds were weighed and randomly allotted to five (5) different treatments and three housing units with 200 birds per housing temperature: Cold (CHT, 18.3-22.1°C), Natural (NHT, 25.2-33.5°C), and Hot (HHT, 34.9-36.1). Each housing temperature was partitioned into five treatment groups: ordinary water (T₁), 0.5g of vitamin C/ litre of water (T₂), 0.5% CW/ litre of water (T₃), 1% CW/ litre of water (T₄) and 1.5% CW/ litre of water (T₅), with four replicates and 10 birds per replicate. The hot and cold housing condition was achieved by total covering of the pen with polythene nylon, then heat or cold source installed. Each treatment was replicated four times under each housing condition with 10 birds per replicates and placed on treatment till 7 weeks of age. All

through the brooding phase, birds were reared in deep litter inside the open sided poultry house. Broiler finisher was fed to them for the 3 weeks of the experiment *ad-libitum*. Descriptions of different housing condition used in this experiment are shown below:

Hot housing temperature (34.9 - 36.1°C). This was maintained with the use of charcoal.

Natural open-sided pen (25.2-33.5°C). Kept open-sided with temperature cycling.

Cold housing temperature (18.3-22.1°C). Housing temperature was maintained within the thermo-neutral zone of the birds with the use of air-condition housing.

Source and processing of coconut water

The coconut seed, source of coconut water used for this research work was procured from Towobowo market, Igboora, Ibarapa North local government Oyo state of Nigeria. Coconut water was collected by breaking the coconut shell, then sieved after which it was served fresh to the experimental birds. The coconut seeds used were matured one.

Treatments

The treatments used during the duration of this experiment were as follows: T1 Ordinary water without vitamin C or coconut water (negative control) T2: 0.5g of vitamin C in 1 liter of water (positive control), T3: 0.5% of coconut water in 1 liter of water, T₄, 1% of coconut water in 1 liter of water, T₅ 1.5% of coconut water in 1 liter of water.

Blood collection

At the last day of experiment which was day 49 five ml of blood was collected from 2 birds in each replicate via the brachial vein using 5ml hypodermic syringe and needle. Blood was collected into plain bottles. The blood samples were spun for 5 minutes at 4000 revolutions per minute (r.p.m) to separate the serum.

Determination of serum Ferritin and Total

Iron Binding Capacity

Fortress kits factory-made in UK were used for chemical analysis of both ferritin and total iron binding capacity (TIBC). The results were then calculated by automated spectrophotometer (Dixon, USA, Model AS1234).

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) in a factorial arrangement (3×5) using SAS (2003). The model for the experiment was:

$$Y_{ijk} = \mu + T_i + C_j + (TC)_{ij} + E_{ijk} \dots \dots \dots$$

Meteorological observations

Average value of meteorological parameters observed throughout the investigational period is shown in Table 1. The temperature recorded in cold housing temperature range between 18.3 and 21.1°C, while relative humidity ranges between 73.3 and 77.3%. In natural housing environment which is an open sided pen, the temperature range between 25.2 and 33.5°C while relative humidity range between 76 and 86.3%. In hot housing temperature range between 34.9 and 36.1°C, while relative humidity range was between 81 and 83.3%.

Table 1: Average values of meteorological parameters observed during the experimental period

Parameter	Temperature (° C)		Relative humidity (%)	
Housing Temperature	08.00hr	16.00hr	08.00hr	16.00hr
Cold	18.3	22.1	73.3	77.3
Natural	25.2	33.5	76	86.3
Hot	34.9	36.1	81	83.2

Result

Interactive effect of housing temperature and diluted coconut water on ferritin and TIBC of broiler chicken

Interactive effect of housing temperature and diluted coconut water on ferritin and total iron binding capacity of broiler chicken is presented in fig 1 and 2. Fig 1 shows the interactive effect housing temperature and diluted coconut water on ferritin. Ferritin level was significantly ($P < 0.05$) influenced across the experiment. Broiler chickens under natural environmental condition administered with vitamin C had the highest value (36.84

µmol/L) across the three housing condition, while birds under hot environmental condition administered vitamin C had lowest value (8.56 µmol/L). Now, analyzing the result under each environmental condition the result is as follows: under the hot environmental condition birds served with coconut water at various levels recorded the highest values (1.0% CW recorded 34.70 µmol/L, followed by birds under 1.5% CW 30.68 µmol/L then those supplemented with 0.5% CW recorded 14.98 µmol/L) followed by birds supplied with water only (16.09 µmol/L while vitamin C has the least. Under natural housing temperature significant ($P < 0.05$) effect was noticed in birds

offered vitamin C and ordinary water, recording 36.84 $\mu\text{mol/L}$ and 26.16 $\mu\text{mol/L}$ respectively, while coconut water recorded lesser values ranges from 10.51 $\mu\text{mol/L}$ to 20.75 $\mu\text{mol/L}$. For birds under cold housing temperature, coconut water was also significant ($P < 0.05$) at 1.5% coconut water supplementation with 24.89 $\mu\text{mol/L}$, while vitamin C recorded 14.38 $\mu\text{mol/L}$. Fig 2 shows the interactive effect housing temperature and diluted coconut water on iron binding capacity. For TIBC significant effect was ($P < 0.05$) was noticed across the treatments, birds under cold housing temperature offered 1.5% CW had the highest value (0.071 $\mu\text{mol/L}$) while the least value (0.029 $\mu\text{mol/L}$) for TIBC was recorded in birds offered vitamin C. TIBC increased significantly ($P < 0.05$) in HHT with birds given 1.0% CW (0.077) and 1.5% CW (0.067) followed by birds given ordinary water (0.036 $\mu\text{mol/L}$), then the one with vitamin C (0.029 $\mu\text{mol/L}$). Under NHT and CHT all level coconut water administers recorded higher TIBC value followed by ordinary water then vitamin C.

Significant ($P < 0.05$) effect of diluted coconut water on total iron binding capacity (TIBC) was also noticed, birds offered 1.5% CW had the highest value (0.071 $\mu\text{mol/L}$) across the three housing condition, while birds administered vitamin C under hot housing condition recorded the lowest value (0.039 $\mu\text{mol/L}$). Under hot housing temperature, total iron binding capacity significant increase ($P < 0.05$) was recorded with bird given 1% and 1.5% CW with 0.077 $\mu\text{mol/L}$ and 0.06 $\mu\text{mol/L}$ respectively while vitamin C has the least value 0.029 $\mu\text{mol/L}$. In birds under natural environment at administration of 1% coconut water significant ($P < 0.05$) increase in TIBC was also noticed while, likewise in cold housing temperature significant effect ($P < 0.05$) of coconut water on TIBC was recorded at 0.5% CW, 1.0% CW and 1.5 % CW administration with these ascribed values respectively 0.070 $\mu\text{mol/L}$, 0.077 $\mu\text{mol/L}$ and 0.065 $\mu\text{mol/L}$, with vitamin C recording the

lowest value of 0.041 $\mu\text{mol/L}$. Finally, Coconut water showed significant effect on TIBC recording 0.081 $\mu\text{mol/L}$ with vitamin C recording the lowest value of 0.050 $\mu\text{mol/L}$.

Discussion

Heat stress results in oxidative stress in broiler chickens. During this period, free radicals attack protein and lipids in cells thus causing cell lysis (Alves, 2006). Iron is released from blood ferritin during this period, and thereby increasing the number of circulating iron which in turn react with hydrogen peroxide to produce ferric oxide ion to combat ROS generated. Housing temperature did affect ferritin levels of broiler chickens in this study this is so because of low ferritin level recorded in birds offered ordinary water and vitamin C under hot housing temperature which is the critical housing condition out of them all in this experiment. The main reason for this is that heat stress triggers oxidative stress, disrupting iron balance by releasing iron from its storage sites and increasing the levels of free iron. This excess free iron can drive ferritin reactions, resulting in additional oxidative damage (Lin *et al* 2006). Lin *et al.*, (2006) also added that broilers birds exposed to prolonged heat stress showed increase in serum ferritin. This result is in line with the findings of Sahin and Kucuk (2003) who stated that birds exposed to high temperature had low ferritin values when compared to those in thermo-neutral conditions but his assertion contradicted the result of this study. This is so because under cold housing temperature, ferritin levels of birds under control followed the same pattern. Significant effect of antioxidant of vitamin C and coconut water on ferritin in this research work is seen vividly as ferritin levels in all housing conditions greatly influenced. Antioxidants are known to play crucial role in maintaining cellular structures from oxidative damage due to heat stress. These antioxidants could be enzymatic in nature (e.g., superoxide dismutase, glutathione peroxidase) or non-

enzymatic (e.g., vitamins E and C, selenium, polyphenols). Supplementing broiler with these antioxidants has proved to improve the adverse effects of heat stress on parameters such as: performance and physiological functions (Sahin *et al.*, 2003). So, the ferritin level jack up because coconut water mitigate against the effect of heat stress on the birds as coconut water contain appreciable amount of vitamin C and other electrolyte like manganese, zinc, iron, potassium and others. Kidd, (2004) also added that antioxidants prevent the oxidation of iron and reduce inflammation, thereby stabilizing serum ferritin and TIBC levels. In contrast, Sahin and Kucuk (2003) stated that birds offered zinc (an antioxidant) had lower ferritin values.

Often, serum iron concentration and TIBC reveals the iron status of the body. TIBC indirectly measures transferrin specific carrier protein, which increase as serum iron concentration (and stored iron) decreases (Aparna and Dhiraj, 2014). Lin *et al.*, (2006) stated that broilers exposed to prolonged heat stress shows decreased TIBC, indicating inflammatory responses and impaired iron metabolism. This is true as the result of this study confirm the same. Under the hot housing

environment, it could be noticed that birds under control treatment and the one given vitamin C together with 0.5% coconut were defected in iron binding capacity. Reason for the low recorded TIBC could be attributed to inflammatory responses and impaired iron metabolism caused by prolonged heat stress. Total iron binding capacity was influenced by 1.0% CW and 1.5% CW only in this study. The increase in TIBC signify that 1.0% CW and 1.5% CW modulating influenced on iron binding capacity of the experimental birds. This observation is an suggestion that coconut water at this level (1.0% and 1.5%) contain antioxidant properties which influences iron transport mechanism, this also is in accordance to report of Basic Vrca *et al.*, (2014) who reported that vitamin C and A has influence on ferritin and total iron binding capacity of in bird. Inability of vitamin C to modulate the influence of heat stress here could probably be ascribed to the use of vitamin C alone without synergism effect with other vitamins like vitamin E and A. For instance Basic Vrca *et al.*, (2014) and Sahin *et al.*, (2003) administer vitamin C and A, and vitamin E and A together as antioxidant to boost the ferritin under heat stress.

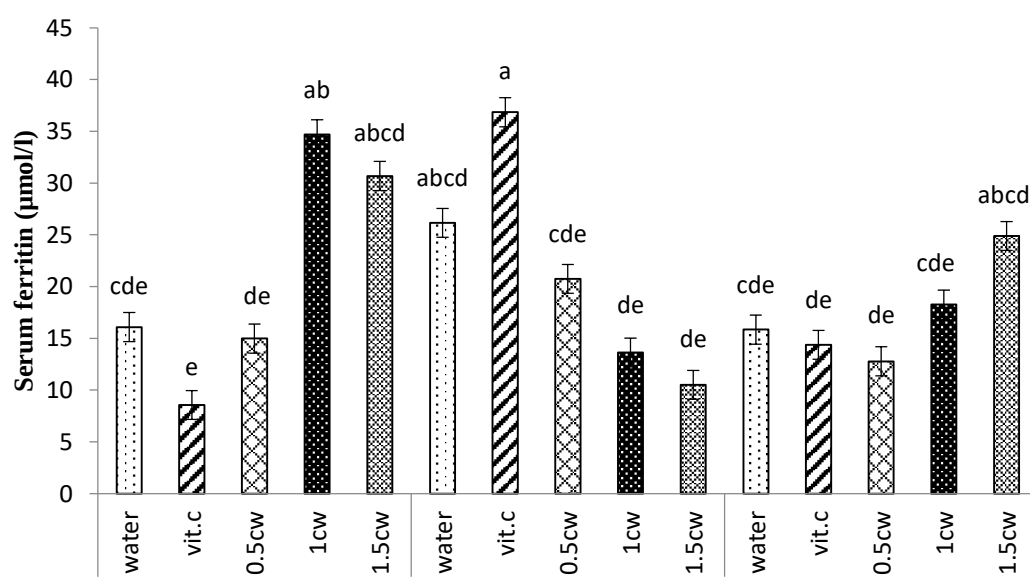


Figure 1: Interactive effect of housing temperature and coconut water on serum ferritin of broiler chickens

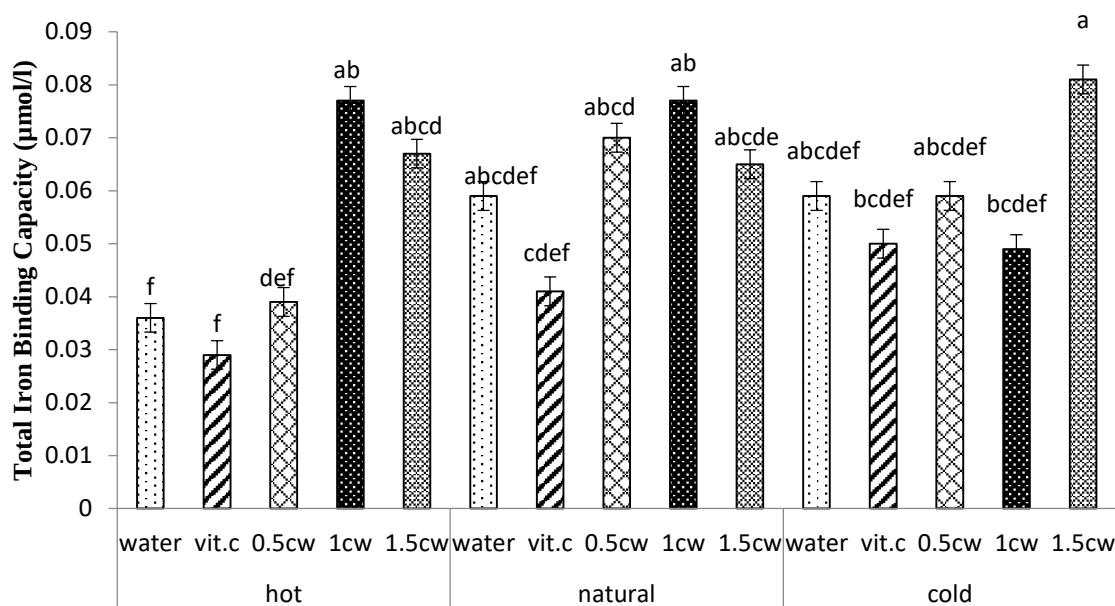


Figure 2: Interactive effect of housing temperature and coconut water on total iron binding capacity of broiler chickens

Conclusion and recommendation

In conclusion serum ferritin and total iron binding capacity were influenced by coconut water under varying housing temperature in this research work. This suggest that coconut supplementation will invariably enhance iron distribution in animal system thereby enhance tissue respiration and well being of the animal. It is therefore, recommended that 1.5% coconut water to be administered to broilers chicken to increase serum ferritin and total iron binding capacity for better performance and rapid growth of the bird. Coconut water at this recommended dose could be employed in broiler production to reduce any source of potential stress.

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