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Effect of dietary antioxidant supplementation on growth and carcass traits of Vanaraja birds under heat-stress

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Abstract

Background: The impact of heat-stress on growth and carcass traits of Vanaraja birds along with subsidiary evaluation of heat-stress ameliorative (antioxidant) properties of *Oxycure*®, a mineral and vitamin supplement was studied.
Methods: A total of 120, five-week old birds were divided into four groups (BF and OX groups were controls fed basal feed and supplemented with *Oxycure*®, respectively while BFHS and OXHS were corresponding heat exposed groups). Treatment birds were subjected to heat-stress (38 °C and 40% RH; THI=86), for 4 hours daily for a period of 5 weeks in an environment-controlled walk-in humidity chamber. The mean ambient temperature and RH in the poultry house were 24.6 °C and 54%, respectively (mean THI= 71.53) during the study period.
Result: Significant ($P \leq 0.01$) negative impact of heat-stress was observed on feed intake, weight gain, FCR and carcass traits of Vanaraja birds, and *Oxycure*® supplementation has significantly ($P \leq 0.01$) improved the feed intake, weight gain, FCR and carcass traits of heat-stressed birds.

Keywords: Antioxidants, carcass traits, FCR, Growth, heat-stress, *Oxycure*®, temperature-humidity index (THI), Vanaraja

Introduction

Poultry farming is an important activity throughout the world contributing to 32.48% of global meat production (FAO, 2016) [14]. It is one of the efficient animal protein production systems with minimal carbon footprint. Rapid increase in demand for poultry products resulted in intensive farming wherein stressors have substantial negative impact on productivity. With climate change becoming a reality, heat stress emerged as a major concern in poultry industry (IPCC, 2007) [21]. This is further aggravated by modern poultry genotypes which are fast growing with higher metabolic activity and sensitivity to temperature changes (Settar *et al*., 1999 and Deeb and Cahaner, 2002) [37, 11].

Although accurate data on economic losses incurred by Indian poultry industry due to heat-stress are not available, studies suggest that these losses are alarming and require immediate and comprehensive approach to deal with. Also, it is imperative to begin focusing on climate resilient agriculture systems to minimise the effects of heat-stress and climate change and ensure fair productivity even under environmental adversities.

Heat stress in birds leads to altered behavioural, physiological and immunological responses which generally result in decreased productivity and immune competence (Lara and Rostagno, 2013; Shakeri *et al.*, 2018 and Wang *et al.*, 2018) [23, 38, 41]. There is a concomitant loss of appetite and weight with drop in egg production and quality (Dayyani and Bakhtiari, 2013) [10]. Broiler chickens subjected to heat-stress tend to have lowered dressing percentage, breast meat and leg quarter yield owing to reduction in muscle protein accretion (Mendes *et al.*, 1997) [27].

Higher environmental temperatures alter the activity of the neuro-endocrine system of poultry, resulting in malfunctioning of the thyroid (Elnagar *et al*., 2010) [13] and the activation of Hypothalamic-Pituitary-Adrenal (HPA) axis, with elevated plasma corticosterone concentrations (Garriga *et al.*, 2006; Star *et al.*, 2008; Quinteiro Filho *et al.*, 2010, 2012) [16, 40, 31, 32]. These changes stimulate lipid accumulation through increased *de novo* lipogenesis, reduced lipolysis, and enhanced amino acid catabolism.

In this investigation, the relevance of using *Oxycure*®, a dietary antioxidant mixture, in ameliorating the negative effects of heat-stress in Vanaraja birds, was tested.

Vanaraja is a multi-colored, dual-purpose variety of backyard chicken, developed by the ICAR-Directorate of Poultry Research, to suit the free-range farming conditions of rural India and are known to perform well during environmental adversities. However, the performance of these birds needs to be reviewed regularly owing to the dynamic nature of climate change. Unlike the commercial varieties, these birds can perform well on diets poor in Metabolizable Energy (ME) and protein, provided they are given balanced feed during the initial 6 weeks of age (Rama Rao *et al*., 2005) [33].

Material and Methods

The study was conducted at ICAR- Directorate of Poultry Research, Rajendranagar in 2018.

Experimental Birds, Feeding and Management

Vanaraja birds were used in this study. All the birds were given standard Maize-Soya based basal diet (Table 1a) supplemented with *Oxycure*® (a dietary antioxidant; Table 1b) in certain treatments. A total of 120 five-week old birds, divided into four groups *viz.* BF and OX fed with basal feed and *Oxycure*® supplemented basal feed, respectively and BFHS and OXHS which were corresponding groups subjected to heat stress were reared in battery cages at the rate of 5 birds per cage. Feed and water were provided *ad libitum*. The mean ambient temperature and RH in the poultry house were 24.6 °C and 54%, respectively (mean Temperature-Humidity Index, THI = 71.53) during the study period. Groups BFHS and OXHS were subjected to heat stress by exposing them to 38°C temperature and 40% RH (THI= 86) for 4 hours daily from 6 to 10 weeks of age in an environment controlled 'walk-in' humidity chamber (Model: NLWH1856MI) as shown in the figure 1.

Fig 1: Treatment birds during heat-stress exposure (Inside the chamber)

Table 1a: Basal Feed Composition

Ingredient	%
Maize	61.742
Soya DOC 45%	30.82
De-oiled Rice Bran	3.08
Di-calcium Phosphate	1.6166
LSP-Powder	1.7198
Salt	0.3838
DL-Methionine	0.194
L-Lysine HCL	0.1108
L-Threonine	0.0242
Trace Mineral Mixture	0.1002
AB_2D_3K	0.015
B Complex	0.01
Choline Cl	0.06
Toxin Binder	0.1002

Table 1b: Oxycure® Composition

Ingredient	% of Feed
Quantum Blue®	0.025
Betaine	0.07
Salicylic Acid	0.02
Vitamin C	0.02
Vitamin E	0.02
Organic Zinc	0.004
Organic Selenium	0.0000151

Table 2: Mean weekly feed intake, weight gain (g) and FCR in Vanaraja birds

Treatment	Week 6	Week 7	Week 8	Week 9	Week 10
Feed intake (P)	0.27	0.00**	0.00**	0.00**	0.00**
BF	534.07 ± 15.05	628.10 ± 6.09ᵃ	621.44 ± 7.87ᵃ	659.27 ± 13.21ᵃᵇ	669.17 ± 7.38ᵇ
BFHS	509.03 ± 7.72	529.99 ± 6.69ᶜ	540.55 ± 11.76ᵇ	591.36 ± 3.46ᶜ	571.57 ± 8.63ᵈ
OX	540.15 ± 15.88	646.75 ± 10.49ᵃ	617.20 ± 3.20ᵃ	685.81 ± 13.78ᵃ	695.62 ± 9.43ᵃ
OXHS	512.51 ± 12.20	596.04 ± 2.89ᵇ	547.30 ± 15.68ᵇ	635.48 ± 9.27ᵇ	630.67 ± 9.96ᶜ
Weight gain (P)	0.01**	0.00**	0.00**	0.00**	0.00**
BF	214.62 ± 4.21ᵃ	235.65 ± 5.83ᵃ	231.70 ± 2.53ᵃ	230.38 ± 3.12ᵇ	227.66 ± 2.28ᵇ
BFHS	196.68 ± 2.50ᵇ	186.44 ± 2.31ᶜ	174.98 ± 3.43ᶜ	183.07 ± 2.52ᵈ	163.28 ± 2.22ᵈ
OX	219.89 ± 6.95ᵃ	235.91 ± 6.75ᵃ	228.12 ± 2.39ᵃ	254.61 ± 3.66ᵃ	236.35 ± 2.58ᵃ
OXHS	206.88 ± 0.91ᵃᵇ	206.94 ± 2.28ᵇ	189.10 ± 5.67ᵇ	209.71 ± 3.66ᶜ	202.76 ± 3.22ᶜ
FCR (P)	0.13	0.01**	0.00**	0.00**	0.00**
BF	2.49 ± 0.04	2.67 ± 0.05ᵇ	2.68 ± 0.03ᶜ	2.86 ± 0.02c	2.94 ± 0.01ᶜ
BFHS	2.59 ± 0.02	2.84 ± 0.04ᵃ	3.09 ± 0.04ᵃ	3.23 ± 0.04ᵃ	3.50 ± 0.03ᵃ
OX	2.46 ± 0.02	2.75 ± 0.05ᵃᵇ	2.71 ± 0.02ᶜ	2.69 ± 0.04ᵈ	2.94 ± 0.02ᶜ
OXHS	2.48 ± 0.06	2.88 ± 0.03ᵃ	2.90 ± 0.07ᵇ	3.03 ± 0.02ᵇ	3.11 ± 0.00ᵇ

Means with different superscripts within each column under each trait differ significantly; ** Significant ($P \leq 0.01$)

Table 3: Means of Carcass characteristics in 10-week old Vanaraja birds

Treatment	Weight (g)							
	Live	Carcass	Breast	Abdominal Fat	Gizzard	Heart	Liver	Spleen
BF	1750.70 ± 19.69ᵃ	1151.96 ± 12.96ᵃ	268.64 ± 3.02ᵃ	19.78 ± 0.22ᶜ	55.15 ± 0.62ᵃ	10.85 ± 0.12ᵃ	35.19 ± 0.40ᵃ	1.93 ± 0.02ᵃ
BFHS	1487.37 ± 23.16ᶜ	953.40 ± 14.84ᶜ	203.27 ± 3.16ᶜ	32.87 ± 0.51ᵃ	46.85 ± 0.73ᶜ	9.22 ± 0.14ᶜ	29.90 ± 0.47ᶜ	1.64 ± 0.03ᶜ
OX	1788.53 ± 15.35ᵃ	1176.85 ± 10.10ᵃ	274.44 ± 2.36ᵃ	20.21 ± 0.17ᶜ	56.34 ± 0.48ᵃ	11.09 ± 0.10ᵃ	35.95 ± 0.31ᵃ	1.97 ± 0.02ᵃ
OXHS	1636.82 ± 6.63ᵇ	1077.03 ± 4.36ᵇ	240.39 ± 0.97ᵇ	25.04 ± 0.10ᵇ	51.56 ± 0.21ᵇ	10.15 ± 0.04ᵇ	32.90 ± 0.13ᵇ	1.80 ± 0.01ᵇ
P	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**

Means with different superscripts within each column differ significantly; ** Significant ($P \leq 0.01$)

Temperature-Humidity Index (THI)

The ambient temperature and relative humidity (RH) inside the shed were recorded daily using a Traceable® Thermometer/Clock/Humidity Meter (*Cat. No. 4040*). Ambient temperature and RH readings were used to calculate the THI as per Moraes *et al*. (2008) [29].

Feed Consumption, Weight Gain and FCR

Cage-wise (group of 5) feed intake and body weights of all the groups were recorded weekly from 6th to 10th week of age (*i.e.* during heat exposure period) with an electronic weighing balance. Feed conversion ratio (FCR) was calculated. Data were analysed using one-way ANOVA and significant differences were further compared using Duncan's Multiple Range Test (DMRT) as modified by Kramer (1957) [22].

Carcass Traits

At the end of 10th week, 24 birds in total (6 birds per group) were humanely slaughtered to study the effect of heat stress on carcass traits such as weight of carcass, abdominal fat and giblets. The data obtained were subjected to one-way ANOVA and Duncan's Multiple Range Test (DMRT).

Results and Discussion

Heat-stress diminishes feed intake, weight gain, carcass quality, mineral balance (Abidin and Khatoon, 2013 [1]; Alhenaky *et al.*, 2017) [3]. Birds exposed to heat stress showed significantly lower feed consumption except during the first week of heat-stress exposure. Several authors have also reported significant reduction in feed intake in both broilers and layers subjected to heat-stress (Mujahid *et al.*, 2009 [30]; Quinteiro Filho *et al.*, 2010 [31]; Quinteiro Filho *et al.*, 2012 [32]; Sohail *et al.*, 2012 [39]; Abidin and Khatoon, 2013 [1] and Awad *et al.*, 2018) [6]. Lower feed consumption is more likely due to the involuntary attempt by birds to reduce heat load as digestion process is associated with increased heat production in the body (Daghir, 2008) [9]. However, this reduction in feed intake is not the only contributing factor to reduced growth during heat-stress. Heat stress is also known to increase mineral excretion and decrease serum vitamins such as C, E and A. However, among the heat-stressed birds, those fed on *Oxycure®* supplemented feed showed higher feed consumption. This may be due to the presence of vitamin E in *Oxycure®*, which has been shown to increase the feed intake in poultry (Sahin and Kucuk, 2001 [34]; Sahin *et al.*, 2002 [35] and Metwally, 2003) [28].

Significantly lowered weight gains were recorded in heat-stressed birds while supplementation of *Oxycure®* improved their weight gain. However, this improvement was not comparable to that recorded in control birds, which showed better weight gain. The observed lower weight gain in heat-stressed birds is well correlated with lower feed consumption due to heat-stress (Quinteiro Filho *et al.*, 2010 [31]; Attia *et al.*, 2011 [5]; Ghazi *et al.*, 2012 [18]; Quinteiro Filho *et al.*, 2012 [32]; Sohail *et al.*, 2012 [39]; Abidin and Khatoon, 2013 [1]; Alhenaky *et al.*, 2017 [3]; Awad *et al.*, 2018) [6]. Lowered growth rates may be attributed to decreased total body proteins, decreased protein utilization (Geraert *et al.*, 1996; Cheng *et al.*, 1997) [17, 8] and increased protein degradation (Lin *et al.*, 2006) [24] during heat stress. The presence of vitamins C and E and other minerals in *Oxycure®* may be the reason behind better weight gains observed in this study (Ibrahim and Mobarak, 2002 [20]; Sahin *et al.*, 2002 [35]; Lohakare *et al.*, 2005 [25]; Maini *et al.*, 2007 [26]; Ali Raza Jahejo *et al.*, 2016) [4]. Vitamin E is known to be a lipid component of biological membranes and is considered as a chain breaking antioxidant (Halliwell and Gutteridge, 1999) [19] and protects cells and tissues from oxidative damage induced by free radicals (Gallo-torres, 1980) [15]. Overall, *Oxycure®* supplementation appears to mitigate the negative effects of heat stress by providing necessary minerals and vitamins thus improving feed consumption and body weight.

The calculated values of FCR followed the same trend as that of feed intake and body weight gain. In general, heat-stressed birds showed significantly higher FCR values. However, *Oxycure*® supplemented birds under heat-stress displayed significantly lower FCR values during latter weeks of heat-stress period. Dietary supplementation of vitamin E in heat-stressed chicken increases feed conversion efficiency (Sahin *et al.*, 2002 [35] and Maini *et al.*, 2007) [26] and improves FCR (Metwally, 2003) [28]. Also as reported in the Annual Report of ICAR-DPR, 2017-18, a significant improvement in FCR was observed in Vanaraja chicks fed on *Oxycure*® supplemented feed during summer.

The influence of heat-stress in this study was not only limited to weight gain and FCR but has also extended to carcass traits. Heat-stressed chicken usually yield reduced breast meat and leg quarters as a result of decreased muscle protein synthesis and accretion (Mendes *et al.*, 1997) [27]. Deterioration of meat quality due to heat-stress occurs because of high rate of lipid peroxidation and electrolyte imbalance (Sandercock *et al.*, 2001; Babinszky *et al.*, 2011 and Zhang *et al.*, 2012) [36, 7, 42]. Presence of vitamin C, apart from other antioxidants, in the feed may be the most probable reason for improved carcass traits observed in *Oxycure*® fed heat-stressed chicken (Lohakare *et al.*, 2005 [25]; Abidin and Khatoon, 2013 [1]; Abo *et al.*, 2014) [2].

Conclusions

The study indicated a negative impact of heat stress on feed consumption, growth rate and carcass traits in Vanaraja birds. Reduction in the growth performance under heat-stress can be attributed to behavioural, metabolic and physiological changes observed in response to high ambient temperatures (Awad *et al.*, 2018) [6]. This negative impact could be contained to a certain extent by dietary supplementation of *Oxycure*®.

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