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Climate Action and the Impact of Heat Stress on Poultry Production in Fiji

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Abstract

One of the significant reasons for monetary misfortunes in the animal market is climate change, including high ambient temperature or Heat Stress. The poultry industry is an essential aspect of the livestock market. Yet, it faces adverse losses due to heat stress. An increment within the natural temperature is unfavorable for the livestock market worldwide, thus, affecting the poultry industry. The meat derived from poultry sustains a low number of saturated fatty acids and contains many vitamins, minerals, and proteins. Likewise, poultry eggs are the most available source of animal protein. However, heat stress leads to numerous changes in the physiology of the chicken body, such as immunological responses and oxidative stress, resulting in mortality, reduced feed efficiency, feed intake, and many more. Heat stress also affects the process and production of eggs and their quality on laying hens while reducing the growth rate in broilers. Thereby, strategies with a degree of effectiveness have been established to mitigate heat stress in poultry. Nutritional techniques like dual feeding, wet feeding, restrictions in the feed time, vitamins, minerals and electrolytes, and proper ventilation area with adequate housing and environment have been found to minimize the devastating effects of heat stress.

Keywords: *High ambient temperature, livestock, egg and poultry, strategies.*

Introduction

Being one of the Pacific Countries, Fiji is highly pruned to climatic changes, such as sea-level rise, cyclones, heat stress, increase in precipitation, and many more. Climate change is one of the most crucial challenges identified in this century for the Pacific Region, such as Fiji (Igbal, 2022). Agriculture is one of the significant sectors in Fiji, contributing around 10.4% to the total GDP of Fiji (Fiji – Agriculture Sector, 2021). However, it is the primary sector affected by climate change adversely. Not only crops in the agriculture sector but the livestock industry is also highly involved, and this review will mainly focus on the poultry industry. In 2012, 15 million FJD was invested in expanding poultry production in Fiji to achieve self-sufficiency. As a result, Fiji was 97% self-sufficient in meat poultry and 100% in egg production, with the few big companies that dominated the market, such as Ram Sami and Sons Ltd (egg market), Goodman Fielder and Rooster chicken (broiler companies), (Fiji Times Online, 2014). In 2020, the primary egg production increased to 8,156 tons, while meat production was 25,867 tons (Knoema, 2020). Though Fiji's poultry industry has been growing over the past years, it is still affected drastically by climatic changes like heat stress.

An increment within the natural temperature is unfavourable for the livestock market worldwide. Poultry is one of the critical sectors that accounts for high-quality protein manufacturing. The improved nutritional status and extensive selection of genes have made the meat-type of chickens reachable to market age within 35 days, while chicken with egg-type can produce 200 eggs a year. However, heat stress reduces production performance. High ambient heat is the main stress factor in the poultry production system. Heat/temperature stress usually occurs due to a negative balance among the released energy in terms of production by the system (Goel, 2021). Besides this, heat stress, becoming one of the significant environmental challenges, can be costly in finance for the poultry industry. Detrimental consequences of

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heat stress stretch from feed intake, reduced body weight gain, and a rise in the conversion ratio of the feeding of live birds, to substandard quality of meat (Awad et al., 2020).

Based on the exposure duration, heat pressure can be delegated as short-term (acute) and long-term (chronic or cyclic) (Awad et al., 2020; Barrett et al., 2019). Heat stress is also intensified through relative humidity in the atmosphere. The occurrence of effects like feed intake, lower egg production and quality, and increased mortality is channelized over different modifications that take place in the body. Therefore, identifying these modifications is very important to overcome the distress (Barrett et al., 2019; Franco-Jimenez et al., 2007). Improvements, such as adjusting or adapting to the surrounding environment, bird density, nutritional management, and ventilation system, reduce poultry exposure to heat stress (Dayyani and Bakhtiari, 2013). Not only this, environment and housing, breeding selection and feeding strategies are all methods that can help mitigate the heat stress on poultry.

Therefore, this review will reveal the heat stress conditions that adversely affect the poultry production in Fiji, with the solutions that will help Fiji better adapt to this kind of climatic change in the livestock sector.

Discussion

Signs of Heat Stress in Poultry Production

According to (Nardone et al., 2010; Dayyani and Bakhtiyari, 2013), **"The signs of heat stress in poultry are panting with open mouth, elevated their wings and squatting near to the ground, droopy acting, slowness and lethargic closed eyes, lying down, increased water intake, decreased appetite, drop in egg production, reduced egg size, poor eggshell quality, reduced body weight, and increased cannibalism"**. Generally, panting with an open mouth is regarded as normal behaviour and response to heat in the atmosphere; however, as the heat increases, the panting rate also increases (Nienaber et al., 2007). Below is a picture (Figure 1) demonstrating the panting with the open mouth of birds.

Figure 1: Panting with the mouth open in response to too much heat in the environment.

Source: (Dayyani and Bakhtiyari, 2013), Heat stress in poultry: Background and Affective Factors.

The birds might eventually die if heat production becomes more significant than 'maximum heat loss' either through long periods (chronic stress of heat) or intensity (acute heat stress). When there is too much heat, the birds mostly try to lose heat by changing positions of their feathers, panting or sometimes gasping, losing water in their breathing and bracing by evaporation over the lung's surface. When chickens face heat stress conditions, they spend less time during the feeding process and more time panting and drinking. Likewise, heat stress causes the birds to move or walk less and take more time to rest. These conditions help the poultry farmers to determine that the birds are going through extreme heat stress (Mack et al., 2013).

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The efficiency of broiler production and its meat quality is highly affected by heat stress. Temperature-Humidity Index (THI) value and high environmental temperature above the critical thresholds can lead to reduced intake of food, lower body weight, and lower efficiency of feed conversion (Sohail et al., 2012). (Sohail et al., 2012) A study planned to observe the effects of prebiotic and probiotic additions on the Performance of the chicken (broilers) when reared under chronic heat stress. The results showed that chickens/birds had poor growth when exposed to chronic heat stress and increment in the concentrations of corticosterone (corticosterone is the fundamental glucocorticoid, engaged with the guideline of **energy, safe responses, and stress reactions of numerous species** like birds, reptiles, and rodents). However, under the 'Heat Stress Controlled Group', the prebiotic and probiotic treatments had increased growth performance and reduced corticosterone concentration, even though the comparison was not always apparent. The two table below (Table 1 & 2) shows the results obtained during the study process.

Table 1: Summary of Feed Consumption, Body Weight and Feed Conversion Ratio in Broilers Reared under Heat Stress Conditions or Normal Temperature.

	Treatment Group				
Day	CONT	HS-CONT	HS-MOS	HS-PM	HS-SYN
BW gain(g)					
21	$825.8^{a} \pm 8.77$	$698.4^{c} \pm 6.33$	$754.6^{b} \pm 26.35$	$728.2^{bc} \pm 10.20$	$714.9^{bc} \pm 5.80$
42	$2{,}411.3^{a} \pm 30.66$	$1{,}626.3^{c} \pm 143.89$	$1{,}906.7^{b} \pm 38.10$	$1{,}726.0^{bc} \pm 90.84$	$1{,}744.3^{bc} \pm 47.01$
Feed consumption (g)					
21	$1{,}082.8^{a} \pm 17.11$	$908.6^{c} \pm 25.51$	$990.6^{bc} \pm 31.55$	$1022.1^{ab} \pm 19.72$	$984.2^{bc} \pm 31.92$
42	$3{,}214.5^{a} \pm 94.87$	$2{,}688.8^{b} \pm 73.99$	$2{,}658.3^{b} \pm 82.37$	$2{,}769.7^{b} \pm 107.13$	$2{,}618.7^{b} \pm 40.56$
Feed conversion ratio (g of feed/g of weight gain)					
21	$1.31^{a} \pm 0.04$	$1.30^{a} \pm 0.02$	$1.31^{a} \pm 0.04$	$1.40^{a} \pm 0.04$	$1.37^{a} \pm 0.08$
42	$1.33^{c} \pm 0.05$	$1.67^{a} \pm 0.10$	$1.39^{bc} \pm 0.04$	$1.60^{ab} \pm 0.04$	$1.50^{abc} \pm 0.05$
Mortality (%)					
21	4.44	1.11	1.11	2.22	2.22
42†	5.56	10.00	1.11	7.78	2.22

Source: (Sohail et al., 2012), Effect of supplementation of prebiotic mannan-oligosaccharides and probiotic mixture on growth performance of broilers subjected to chronic heat stress.

The above table shows summary of the reared broilers, whereby, $^{(a\text{-}c)}$ means ± SE inside the row lacking a common superscript differ (P (probability) < 0.05) and (†) represents percentage values difference (P < 0.05) at $^{(d)}$ 42(gain). The CONT is same as 'control'; HS = heat stress; MOS = mannan-oligosaccharide (abstract); PM = probiotic mixture; SYN = synbiotic.

Table 2: Concentrations of Corticosterone (pg./mL) in broilers reared under heat stress conditions or average temperature.

	Treatment group				
Day	CONT	HS-CONT	HS-MOS	HS-PM	HS-SYN

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21	90.7^{b} ± 22.56	877.4^{a} ± 185.70	233.3^{b} ± 75.50	93.4^{b} ± 17.79	250.7^{b} ± 86.52
42	51.8^{b} ± 10.07	278.0^{a} ± 87.48	81.5^{b} ± 58.41	167.4^{ab} ± 45.81	125.8^{ab} ± 27.14

Source: (Sohail et al., 2012), Effect of supplementation of prebiotic mannan-oligosaccharides and probiotic mixture on growth performance of broilers subjected to chronic heat stress.

The above table shows summary of the reared broilers on Corticosterone concentrations, whereby, (a, b) means ± SE within a row lacking a common superscript difference ($P < 0.05$). in here, the CONT = control; HS = heat stress; MOS = mannan-oligosaccharide; PM = probiotic mixture; SYN = synbiotic.

Exposure to chronic heat stress can cause adverse effects on the quality of the meat being produced and the deposition of fats in broilers (Lu et al., 2007). According to (Dai et al., 2012; Imik et al., 2012), exposing birds to higher solar radiation is biformed with chemical composition depression and meat qualities in the broiler industry. Similarly, when the broilers are exposed to higher temperatures during their growing phase, the meat characteristics are poor with a loss of quality (Lu et al., 2007; Zhang et al., 2012). Moreover, heat stress exposure during birds' transportation from production farms to the processing centre leads to losses in meat quality (Dadgar et al., 2010). Below are the detailed impacts of heat stress on the poultry industry.

Impact of Heat Stress on Egg Production

Generally, the poultry industry's primary objectives are to produce larger quantities of healthy, intact, and good quality eggs. Yet, increased temperature or heat stress drastically affects the poultry farm performances and processes, with the first manifestation being declined feed consumption (Kirunda et al., 2001; Jones, 2006; Deng et al., 2012), followed by decreased levels of calcium and plasma protein and higher (Kirunda et al., 2001). Eventually, all these lead to reduced egg production and quality (Jones, 2006; Deng et al., 2012; Abbas et al., 2017). (Vercese et al., 2012) conducted research on the Performance and egg quality of Japanese quails in the stage after egg production peak, submitted to cyclic heat stress. The results showed that increased temperature up to 36oC caused a decline in egg production, its quality, and less level of saleable eggs contrasted with those at an agreeable 21^{o}C temperature level in poultry. The table below shows the results:

Table 3: Summary Showing Egg production (E.P.), Feed intake (F.I.), percentage of saleable eggs (S.E.), egg weight (E.W.), egg mass (E.M.), feed conversion ratio per dozen (FCR/dz) and per kg (FCR/kg) of egg produced by Japanese quails submitted to cyclic heat stress.

Temp (°C)	FI (g/bird/day)	EP (%)	SE (%)	EW (g)	EM (g/bird/day)	FCR/dz	FCR/kg
21	30.9	83.06	80.80	12.28	10.36	0.45	2.98
24	30.1	83.64	81.00	12.05	10.09	0.43	3.00
CV (%)	4.54	4.10	4.88	2.45	4.47	5.62	6.01
21	28.2A	81.47	76.12	12.02A	9.79A	0.42A	2.90
27	26.0B	80.71	75.54	11.41B	9.20B	0.39B	2.81
CV (%)	4.11	4.06	5.20	1.93	3.95	5.84	5.12
21	28.4A	79.96	75.56	12.14A	9.71A	0.43A	2.92A
30	25.0B	79.91	75.00	11.42B	9.12B	0.38B	2.74B
CV (%)	4.48	4.85	5.21	1.40	4.36	5.70	5.92
21	27.6A	80.76	74.97	12.03A	9.71A	0.41A	2.84
33	23.0B	77.25	71.21	11.19B	8.64B	0.36B	2.66
CV (%)	8.52	5.17	7.05	2.93	5.42	9.37	9.09
21	28.3A	79.04A	72.84A	12.32A	9.74A	0.43A	2.93
36	22.2B	73.77B	62.40B	10.85B	8.01B	0.36B	2.79
CV (%)	6.96	5.28 7	7.03	2.51	6.53	8.60	9.29

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Source: (Vercese et al., 2012), Performance and egg quality of Japanese Quails submitted to cyclic heat stress

In the above table, the (A, B) means followed by various capital letters in the same column surrounded by each temperature cycle are different by the test.

Moreover, panting with an open mouth reduces the hydrogen carbon and carbon dioxide in the chicken's blood (Renaudeau et al., 2012). It boosts respiratory alkalosis, which leads to a decline in the quantity of calcium required by the uterus for eggshell formation, causing cracked egg production since the eggshells become weak (Ma et al., 2014; Santos et al, 2015).

Impacts of Heat Stress on Meat Production

Reduced feed intake, the efficiency of feed conversion, lower calcium concentration and plasma protein are all caused by heat stress (Sohail et al., 2012). In addition, broilers gain lots of body weight since they reduce their movements during higher temperature levels and spend most of their time panting (Sahin et al., 2001; Imik et al., 2012). Heat stress also causes an increase in the consumption of water (Jahejo et al., 2016), adrenal hormone and mortality (Sohail et al., 2012). During the growth stage of broilers, heat stress leads to reduced meat quality, muscle growth, the chemical profile of the meat and metabolism of fats (Lu et al., 2007; Babinszky et al., 2011; Dai et al., 2012; Zhang et al., 2012). Quality of meat parameters such as; water holding capacity, colour, stability of oxidation, tenderness, paleness and softness are all affected due to increased temperature, resulting in changed body appearance, taste and purchaser acknowledgment (Imik et al., 2012; Fouad et al., 2016).

Impact of Heat Stress on Meat Quality During Transportation

From production to processing sites, poultry birds can be highly exposed to several stressors during their transportation, but the temperature level beyond the thermoneutral zone is more critical. It results in poor quality of meat (Dadgar et al., 2010; Barbut, 2015) and a higher mortality rate associated with safety concerns (Warriss et al., 2005; Vecerek et al., 2016). During transportation, the birds are more prone to mortality with those with more bodyweight than those with lower body weight under heat stress (Caffrey et al., 2017). In the summer months (June, July and August), the poultry transportation reduces the efficiency of physiological and behavioural thermoregulatory mechanisms (Warriss et al., 2005). Moreover, the quality of meat characteristics is more affected by distance and seasons (Santos et al., 2017).

Effect of Heat Stress on Poultry Reproduction and Growth

Effects on Poultry Reproduction

Heat stress with high relative humidity has more potential to harm the reproductive system of animals. For instance, the White Leghorn Hens (The **Leghorn** is an intelligent and resourceful bird and will find much of its food if allowed to the range) when exposed to high temperature, it causes a decline in the reproductive activities, leading to failure of the reproduction and poor quality of egg production (Ebeid et al., 2012). Furthermore, breeder and layer hens with too much heat had adverse Effects on the ovulation rate leading to declined reproductive Performance (Obidi et al., 2008; Ayo et al., 2011; Ebeid et al., 2012) and a reduction in the fertility rate (Banks et al., 2005; Oguntunji and Alabi, 2010) as well as hatchability (Lin et al., 2006; Yousaf et al., 2017).

Heat stress also reduces the development of oocyte and follicular and maturation rate of yolk resulting in problems like infertility (Abidin and Khatoon, 2013; Kala et al., 2017). According to (Sahin et al., 2009; Ma et al., 2014; Cheng et al., 2015; Alagawany et al., 2017), higher temperature levels in quails, laying hens and ducks result in oxidative damage to the ovaries, small yellow follicles and oviducts, whereby, it eventually diminishes the weights of oviducts and ovaries and quantity of large follicles. Thus, it evokes reduced performances of egg production, and in adverse cases, there could be an occurrence of infertility. Furthermore, heat stress affects male breeders in terms of infertility more than female breeders (Bonato et al., 2014). In the early phases, the increased heat stress regulates the growth of the testicular with increased

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volume and concentration of semen; however, further increase of heat stress results in suppression of the capacity of reproductive capacity in poultry production (Obidi et al., 2008).

Effects on Poultry Growth

Poultry selection for more growth rate and better efficiency of feed conversion is directly or indirectly related to many undesirable factors, which eventually enhances its susceptibility to heat stress. High-temperature levels also lead to a depressed growth rate because of reduced voluntary intake of food (Sahin et al., 2001). Likewise, poor Performance of growth rate is observed in broilers exposed to more heat load due to over-production of hormones stimulating stress (Niu et al., 2009; Attia et al., 2011; Ghazi et al., 2012). The development of growth rate in birds (poultry) enhances metabolic heat production, reducing the bird's capacity to tolerate higher environmental temperatures (Zumbach et al., 2008; Dikmen and Hansen, 2009).

Furthermore, chronic heat stress empowers impaired embryo growth, the development of retarded post-hatch chickens and defects in the birth rate (Lourens et al., 2007; Noiva et al., 2014). According to (Yalcin et al., 2001), "The slow-growing broiler lines had low mortality and body temperature compared to fast growers". Impacts of heat stress were also observed in the internal organs since the reduced weight in the spleen, liver (Felver-Gant et al., 2012) and thymus (Ghazi et al., 2012) was noticed in laying hens that were exposed to protracted heat burden. A study was taken out by (Felver-Gant et al., 2012). The main temperature impact was examined in which hens exposed to heat stress displayed elevated body temperature compared to the respective controls. The table below shows the summary of heat stress on the examined hens.

Table 4: The effects of heat stress on Body Weight (B.W.), spleen weight (S.W.), heart weight (H.W.), liver weight (L.W.), and core body temperature.

Treatment	BW (kg)	SW (g)	HW (g)	LW (g)
Wk 1				
C-DXL	1.49 ± 0.03	1.91 ± 0.09	7.64 ± 0.44	43.1 ± 1.1
H-DXL	1.40 ± 0.03	1.45 ± 0.09**	6.73 ± 0.43	28.3 ± 1.1**
C-KGB	1.43 ± 0.03	1.32 ± 0.09	7.21 ± 0.43	34.3 ± 1.1
H-KGB	1.37 ± 0.04	1.09 ± 0.10	6.75 ± 0.5	32.1 ± 1.3
Wk 2				
C-DXL	1.45 ± 0.03	1.70 ± 0.09	7.44 ± 0.44	36.7 ± 1.2
H-DXL	1.33 ± 0.03#	1.32 ± 0.09**	7.10 ± 0.44	31.2 ± 1.2**
C-KGB	1.51 ± 0.04	1.14 ± 0.10	7.10 ± 0.49	35.4 ± 1.3
H-KGB	1.34 ± 0.04**	1.03 ± 0.10	5.54 ± 0.48*	30.8 ± 1.3*
P-value				
Temperature	0.0007	0.0004	0.0228	0.0001
Strain	0.9068	0.0001	0.0847	0.0513
Temperature × strain	0.7549	0.0864	0.5639	0.0002
Wk1 C-DXL vs. H-DXL	0.1373	0.0019	0.1584	0.0001
Wk1 C-KGB vs. H-KGB	0.3185	0.1090	0.4954	0.2118
Wk2 C-DXL vs. H-DXL	0.0501	0.0099	0.5763	0.0023
Wk2 C-KGB vs. H-KGB	0.0073	0.4734	0.0339	0.0184

Source: (Felver-Gant et al., 2012), Genetic variations alter physiological responses following heat stress in 2 strains of laying hens.

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The above table depicts; 2C-DXL = control Dekalb XL (DXL) hens; H-DXL = heat-stressed DXL hens; C-KGB = control kind gentle bird (KGB) hens; H-DXL = heat-stressed KGB hens. (**) is P < 0.01; (*) is P < 0.05; and (#) is 0.05 < P > 0.01 compared with respective controls.

Below is another table (Kumar et al., 2021) showing the summary of heat stress on poultry production, reproduction, and growth.

Table 5: Impacts of Heat Stress on Reproduction, Growth and Production Performance of Poultry.

Breed	N	Exposure Temperature		Egg prod. (%)	Egg wt. (%)	Daily feed intake (%)	Body wt. (%)	Body wt. gain (%)	FCR (%)	References
		Control (◦C)	Treatment (◦C)							
W-36 parent-line (2 wk after HS)	407	23	35	− 6.30	–	− 46.33	− 3.9	–	+99.51	Barrett et al. (2019)
W-36 parent-line (4 wk after HS)	407	23	35	− 4.99	–	− 38.78	− 5.5	–	+72.34	Barrett et al. (2019)
Hy-Line brown commercial laying strain	856	26	33	− 6.12	− 10.05	-13.63	–	–	–	Zhang et al. (2017)
Hy-Line commercial laying strain	200	20–26	22–36	–	−3.25	–	–	–	–	Allahverdi et al. (2013)
Isa Brown layer	222	22	31.15–34.11	− 25	− 2.78	− 16.26	− 3.74	− 50.0	+9.87	Kilic and Simsek (2013)
White Leghorn	40	20–22	30–33	–	− 3.24	–	–	–	–	Ebeid et al. (2012)
Ross-708 strain (21 days)	450	22	35 ± 2	–	–	− 16.09	− 15.43	–	+0.67	Sohail et al. (2012)
Ross-708 strain (42 days)	450	22	35 ± 2	–	–	− 16.4	− 32.6	–	+25.6	Sohail et al. (2012)
Rhode Island Red	60	21	37	− 36.4	-3.41	− 31.6	–	–	–	Star et al. (2009)
Japanese quails	240	22	34	–	–	–	− 10	− 14.5	–	Sahin et al. (2005)
Japanese quails	240	22	34	–	–	–	− 9.1	− 11	–	Onderic et al. (2005)
Commercial laying strain	180	23.9	35	− 28.8	–	− 34.7	− 19.3	–	–	Mashaly et al. (2004)
Japanese quails	240	22	34	− 23.3	-14.3	–	− 7.7	–	–	Sahin et al. (2004)
Single-comb White Leghorn (Expose to heat stress 8–14 days)	80	10–24	37	− 13.2	–	–	–	–	–	Farnell et al. (2001)
Single-comb White	80	10–24	37	− 26.4	–	–	–	–	–	Farnell et al. (2001)

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Leghorn (Expose to heat stress 30–42 days)										
Single-comb White Leghorn (Expose to heat stress 43–56 days)	80	10–24	37	–57.0	–	–	–	–	–	Farnell et al. (2001)

Source: (Kumar et al., 2021), Climate change and heat stress: Impact on production, reproduction and growth Performance of poultry and its mitigation using genetic strategies

In the above table, N= Number of observations, FCR= Feed conversion ratio and the references are given in the last column from where the data and results were collected.

Effect of Heat Stress on Poultry Production on Behavioral and Physiological Responses

Thermoregulation, controlled by metabolic, central and endocrine systems, plays an essential role in homeostasis maintenance. The body's morphological, mass and confirmation parameters, such as the colour of fur, are associated with the rate of basal metabolism and can use adjustments in the behaviour (Cooper et al., 2008). The thermoregulatory system's capabilities are adaptive in making the animal survive in adverse environmental conditions. Under heat stress, birds alter their physiological and behavioural responses to retain their body temperature by probing thermoregulation. Birds who experience heat stress usually spend less time feeding, more in panting, drinking and elevating wings, and moving closer to more excellent surfaces (Mack et al., 2013). In adverse conditions, homeostasis is maintained in birds by the exchange of heat between the air sac and the environment through convection, perspiration, evaporating heat, and vasodilation (Mutaf et al., 2009).

Furthermore, it is essential to know that increase in panting under heat stress can lead to higher carbon dioxide levels and higher blood pH (i.e., alkalosis), which results in hampering the blood bicarbonate availability for the mineralization of eggshell and induces boosted availability of organic acid, also reducing free levels of calcium in the blood. This process is critical in laying hens and breeders, as it highly affects the quality of eggshells. In addition, heat stress changed the neuroendocrine systems activities of poultry, leading to hypothalamic-pituitary-adrenal (HPA) axis activation and elevated plasma corticosterone concentrations (Garriga et al., 2006; Star et al., 2008; Quinteiro-Filho et al., 2010; Quinteiro-Filho et al., 2012).

Some of the significant physiological changes other than panting that takes place in the heat-stressed birds are:

Oxidative Stress

ROS (reactive oxygen species) are free peroxides, and radicles produced typically during regular metabolism within the cells. They are essential for several cellular processes like cytokine transcription, ion transportation and immunomodulation. Physiological detoxifying mechanisms eliminate these ROS produced in the cells. At the thermoneutral condition, the transcriptional factor activation causes extra combination of a gathering of cell reinforcement particles, which manages the expanded reactive oxygen species within the cell. (Surai et al., 2019). Yet, the imbalances in these systems, either through decreased antioxidant defence system effectiveness or higher ROS production, the cells get exposed to oxidative stress (Betteridge, 2000; Mishra and Jha, 2019). Free radicles that are excessively produced during oxidative stress devastate all the cell components involving lipids, protein and DNA (Figure 2). Oxidative stress effects depend on its range and severity, from minor reversible alterations to apoptosis and death of the cell in the case of severe stress of oxidant.

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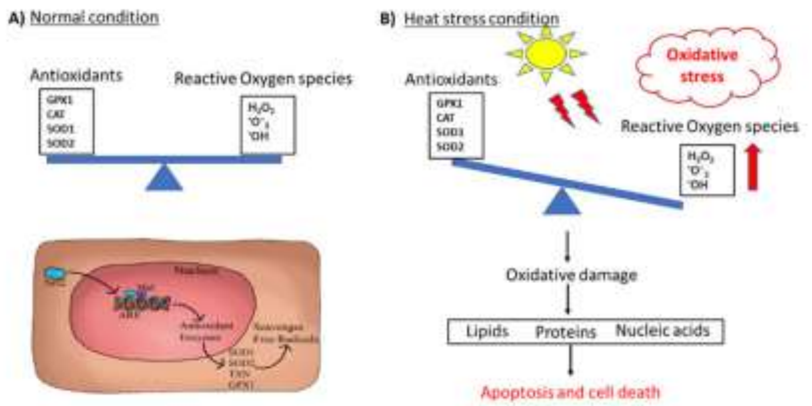
Figure 2: Simplified Diagram Depicting the Redox System

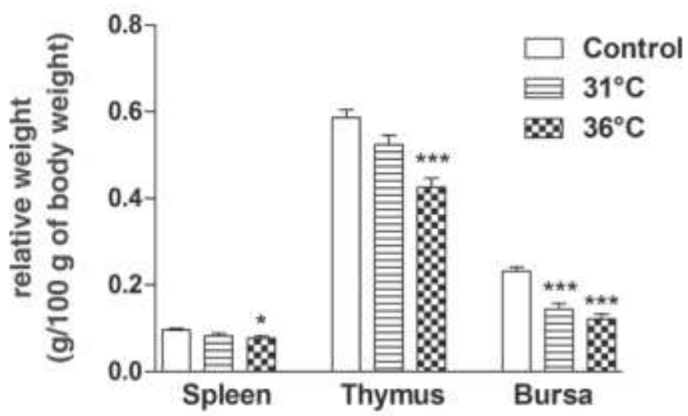


Source: (Wasti et al., 2020), Impact of heat stress on poultry health and performances, and potential mitigation strategies.

Heat Stress Effects on Immunological Responses

The adverse effects of heat stress on the bird's health status lead to alterations in metabolism, physiology, immune and hormonal systems. According to (Zulkifi et al., 2000), heat stress can highly reduce the production of antibodies. Heat stress had a significant decline in antibody production. A robust immune system is required to have better production performances since it directly relates to healthy chickens (Awad et al., 2020; Deng et al., 2012; Mashaly et al., 2004). The thymus, bursa of Fabricius and spleen (lymphoid organs) are the critical immune organs declining under heat stress in chickens (Quinteiro-Filho et al., 2010). In the study (Quinteiro-Filho et al., 2010), the broiler chickens were noticed for wellbeing status and conduct, whereby the lymphoid organs were tested. The graph below summarizes the results obtained during the study.

Graph 1: Effects of heat stress on Lymphoid Organs (Thymus, Bursa of Fabricius and Spleen)



Source: (Quinteiro-Filho et al., 2010), Heat Stress impairs performance parameters, induces intestinal injury, and decreases macrophage activity in broiler chickens.

The above graph (1) shows the relative weight at different temperature levels. (31 ± 1 and 36 ± 1°C) heat stress effects for 10 h/day from experimental d 35 to 42 on the relative weights of lymphoid organs. Data are represented as the means ± SEM (n = 10/group). *P < 0.05 and ***P < 0.001 compared with the control group.

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Intestines' permeability arising because of heat stress enables pathogen penetrations through the gastrointestinal tract. The enhancement in the intestinal pathogenic bacteria proportions such as Salmonella sp., Clostridium sp., and Escherichia coli decreases immune performances in heat-stressed chickens (Goel, 2021). According to (Khatlab et al., 2019), "Challenging the birds with harmful bacteria results in inflammatory responses and oxidative stress in the intestine". Thus, evaluating immune systems' adaptive response can clarify the ability of chickens to respond to heat stress.

Does Heat Stress Impact Food Safety?

During the growth period, heat stress in broilers has been related to undesirable characteristics of meat and loss of quality (Lu et al., 2007; Zhang et al., 2012; Sandercock et al., 2001). Likewise, broiler transportation from farms to processing site under heat stress conditions have resulted in meat quality losses (Debut et al., 2005; Dadgar et al., 2010). According to (Bozkurt et al., 2012; Mashaly et al., 2004), heat stress in laying hens negatively affects the quality and production of eggs. Over the past years, food safety following egg and poultry production has become a significant issue in the food system. Food safety has been considered an essential part of the modern concept of food quality. Colonization of foodborne pathogens in birds, such as Salmonella and Campylobacter, and their consecutive dissemination associated with the food chains of the human race has been a significant public health and economic concern in the production of eggs and poultry. Handling and consuming undercooked products from poultry creates familiar sources of foodborne illness (Gantois et al., 2009; Newell et al., 2010; Eisenberg et al., 2012; Domingues et al., 2012). Environmental stress has also been a factor that could lead to farm animal colonization by microorganisms, expanded shedding of faecal and transmission horizontally, and, therefore, boosted risk of contamination in animal products (Humphrey, 2006; Rostagno, 2009; Verbrugghe et al., 2012). These aspects infecting animals have been associated with the effects of stress-related mediators and hormones in the immune system (usually due to immunosuppression). Thus, it is essential to know that heat stress can change host-pathogen interactions.

The gastrointestinal tract is principally responsible for stressors that can cause various changes, involving the alteration of protective microbiota and declined sincerity of the epithelium in the intestine (Collins et al., 2012; Dinan and Cryan, 2012). According to (Wei et al., 2013), poultry's intestinal tract harbours a dynamic ecosystem of the microbiome, which can be affected by various factors. Not much o the work has been published on the environmental stress effects on the ecosystem of the microbial intestine of poultry. However, according to (Tajima et al., 2007; Uyeno et al., 2010), heat stress affects the composition of microbes and the concentration of fatty acids (short-chained) in the rumens, which is a relatively larger microbial system compared to the intestinal microbiome of poultry. Thus, it is acceptable to assume that high ambient temperature would likewise influence the gastrointestinal microbial populaces of poultry.

Excessive Heat Burden Triggers Metabolic Stress that Affects Meat Quality

Excessive Production of ROS (reactive oxygen species) Impairs Meat Quality

Modifications in genes used for rapid growth in broiler chickens have made the broilers more susceptible to environmental stressors (Altan et al., 2003; Sihvo et al., 2014). Among the ecological stressors, oxidative stress is significant, which can refrain chicken growth, bringing severe effects on the meat quality of broilers. Increased liberation of ROS is damaging since it provokes muscle ageing, degradation of protein and inactivates nuclear proteins, involving RNA (**ribonucleic acid**) and DNA (**Deoxyribonucleic acid)**. In addition, heat stress activates ROS production by impairing the function of mitochondria, leading to declined aerobic metabolism of glucose and fat and glycolysis, which eventually results in poor quality of meat expressed by low pH and higher drip loss (Estévez, 2015).

The living tissues possess several antioxidants to adapt to oxidants; assuming that the cell reinforcements and oxidants adjusting alters and the oxidants exceed a limitation within the body, this situation demonstrates oxidative stress. Generally, the oxidants are produced at cellular metabolism inside the living cells' mitochondria. Not only cellular metabolism is the only place of oxidants, but some other external sources, such as oxidized fats and lipids comprised to make feed, are responsible for reactive oxygen species

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production (Cadenas and Davies, 2000). According to (Mujahid et al., 2007), the electron leakages from the respiratory mitochondria chain during phosphorylation of oxidants are the ultimate source of ROS. Heat stress boosts ROS production by compromising the electron transport chain functions, which are needed to produce energy in the muscles (Elisabeth et al., 2010). ROS alters the calcium sensitivity by oxidizing the thiol groups in the ryanodine receptor and devastates an enzyme sarcoendoplasmic reticulum Ca+2 –(**adenosine triphosphatase**) ATPase, (SERCA). This enzyme keeps the calcium balance within the sarcoplasmic reticulum by removing extra calcium. Due to ROS, the calcium control system collapses, resulting in contractions of muscles, culminating in muscle dystrophy (Küchenmeister et al., 2005; Zissimopoułos et al., 2006).

Way Forward

The main strategies that many farmers have used to control or reduce the harmful effects of heat stress on poultry are discussed in this review.

Environment and Housing

Numerous systems for rearing have been applied to regulate poultry species' health, welfare, and production performances. Litter rearing system (LRS), cage rearing system (CRS) and perforated plastic slate rearing system (PSRS) are the most commonly used rearing systems (Abo Ghanima et al., 2020). According to (Wang et al., 2015), the growth performance was not affected and was noticed to be likely when the chickens were reared in LRS and CRS. However, when comparing these systems with PSRS, they were preferred for the Performance of the growth and yield of carcass under heat stress. CRS is yet a higher cost rearing system for installation. Thus, LRS is more commonly used in developing countries for broiler rearing. LRS rearing systems also have better responses to the immune system and have lower chances of pathogen infections (Abo Ghanima et al., 2020; Farghly et al., 2018). (Wang et al., 2015) experimented on the chickens performed under the rearing systems, whereby the effects of the rearing system on the growth performance were shown, presented in the table below. At the time of 21-(d) intervals and overall period of the experiment, gained weight, FCR and mortality were not affected by three different rearing systems. Yet, treatment with LRS showed a lower intake of feed than the other two groups from (d) 0-21 (P<0.05).

Table 6: The Rearing System effects on the growth performance in male broilers.

Item	CRS	LRS	NRS	SEM
d 0 to 21				
Weight gain (g)	804	805	809	6
Feed intake (g)	1122[a]	1100[b]	1120[a]	6
FCR	1.403	1.368	1.385	0.001
d 21 to 42				
Weight gain (g)	1849	1900	1889	43
Feed intake (g)	3917	3921	3990	65
FCR	2.110	2.066	2.088	0.047
Overall				
Weight gain (g)	2654	2739	2752	46
Feed intake (g)	5027	5023	5164	79
FCR 1	1.856	1.834	1.882	0.040
Mortality (%)	7.56	5.78	6.61	1.44

Source: (Wang et al., 2015), Effects of different rearing systems on growth performance, nutrients digestibility, digestive organ weight, carcass traits, and energy utilization in male broiler chickens.

The [a,b] means – the same row with different superscripts differ (P<0.05); n=10. [c] CRS=multilayer cage rearing system; LRS=litter rearing system; NRS=plastic flat net rearing system, FCR=feed conversion ratio, SEM=standard error of the mean.

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Breeding Stock Selection

The selection of genes is a method of choosing good quality to give the subsequent progeny. Different aspects like immunity and growth have been utilized as a parameter. The main issue with meat-type chickens is related to deprived feed intake under heat stress (Awad et al., 2020). Prolonged selection in the past years aimed at fast growth in broilers. But, they are more affected under heat stress since they possess lower heat tolerance than broilers that grow slower (Deeb & Cahaner, 2002). Performances of egg production are the major priority for rearing laying hens. Heat stress adversely harms egg production by reducing its quality (Barrett et al., 2019). Fine-mapping associated with quantitative trait loci (QTL) is also adequate for the veiling of tolerant birds towards high heat stress. Based on the capacity of heat tolerance for enhancing performance parameters, select animals should be followed for progeny improvement.

Manipulation of the Embryo

The priority of embryonic life has adversely boosted due to the decline of marketable age in chickens. Conditions in the hatchery involve minimal handling, proper sanitation and minor disturbance during the incubation period. Therefore, it is essential to sustain an appropriate humidity and temperature at incubation. The temperature inconstancy acts as stress that can agitate the stable development of the embryo in the chicken (Yalcin & Siegel, 2003). But, the establishment of programmed embryonic temperature has helped in overcoming the post-hatch heat stress effectively (Al-Zghoul & El-Bahr, 2019; Piestun et al., 2008).

Modification of Surrounding Environment

Relative humidity and environmental temperature influence the evaporative mechanism of cooling in birds. In high temperatures, the evaporative heat loss increases relatively with the speed of the wind; however, it declines during increased humidity (Lin et al., 2005; Sinha et al., 2017). Fans, cooling pads, curtains, foggers with fans, thermostats and static pressure controllers are all used to control the surrounding environment. The adaptation of insulation, building and roof overhang dramatically influences the temperature inside the poultry house. The movement of air inside the house is very critical for proper ventilation. The use of a fogger with a fan and sprinkler reduces the inside temperature on hot days or climatic conditions (Sinha et al., 2018). Fans and exhaust fans in the building produce air movement and a mechanical ventilation system that controls the environment.

Ventilation System

It is vital to have a sound ventilation system for heat pressure control. It eliminates the air stacked with moisture from the poultry house and enters an equal quantity of fresh air outside. The ventilation system should be at its maximum as the movement of air assists in removing carbon dioxide, moisture, and ammonia from the poultry house and entering fresh oxygen from outside (Butcher and Miles, 2012). Ventilation houses properly made can add consistent airflow patterns. The ventilation system of tunnels attaches moving demeanor of working from inlets to debilitate fans, regulating the higher airflow speed. The fast movement of air boosts convective loss of heat, declining the body temperature in birds. The velocity of air in tunnel ventilation is almost 350 feet/minute. Evaporative cooling pads perform on the same cooling principle as foggers; the air is frigid within the house when it goes through the cooling pads. Circulation fans are suggested for convenient ventilation in a properly ventilated place for maximized air movement through the birds to boost convective cooling (Daghir, 2008).

Feeding Strategies

Feeding is essential for all animals to maintain their health and keep a robust immune system (Igbal, 2021). However, feed is highly affected by heat stress on poultry; thus, below are some strategies that can help overcome these situations.

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a. **Restriction of Feed** – feed restriction has become a standard method in poultry production during the hotter periods of the day. In this method, the intake of food is reduced by refraining from feeding for a specific time (usually 8 am-5 pm) to lower the rate of metabolism in birds (Wasti et al., 2020). Furthermore, according to (Uzum et al. 2013), refraining the feed to 8 hours per day during hotter periods has improved feed efficiency and lowered tonic immobility, a measure to regulate fearfulness in which the chickens are placed on its back for examining the right reflex.

b. **Dual Feed Regime** – restriction of feed leads to rush and overcrowding during the re-feeding period resulting in additional mortality. Therefore, the double-feed regime has been established to ensure that birds have access to food throughout the day. Feed limitation brings about congestion and rush at a re-taking care of time, bringing about extra mortality. Subsequently, the double taking care of system has been concocted to guarantee birds approach feed over the course of the day (Wasti et al., 2020).

c. **Wet feeding** – at the time of heat stress, the chickens lose a high level of water through the respiratory tract, leading to increased water intake to retain the balance of the thermoregulator. In addition, wet-feeding regulates pre-digestion, improves nutrient absorption from the gut and stimulates digestive enzyme action on the feed. They are adding water to the food assists in boosting the water intake and lowers viscosity in the heart leading to fast passage for feed (Syafwan et al., 2011).

Supplementation of Vitamins, Minerals, and Electrolytes

Below is a table (7) shows the beneficial impacts of minerals, vitamins and electrolytes on poultry suffering from heat stress.

Table 7: Summary of Vitamins, minerals, osmolytes and phytochemicals (electrolytes) having beneficial effects in heat-stressed poultry.

Supplements	Beneficial Effects on Heat-Stressed Birds
Vitamin E	➢ prevent liver damage, facilitate the synthesis and release of vitellogenin; ↑ egg production in laying hen ➢ ↓ liver and serum MDA concentration; ↑ increased serum and liver vitamin E and A concentration in broilers
Vitamin A	➢ ↑ egg weight in laying hens ➢ ↑ live weight gain improved feed efficiency and ↓ serum MDA concentration in broilers
Vitamin C	➢ improved growth rate, nutrient utilization, egg production and quality, immune response, and antioxidant status in poultry ➢ ↓ the serum concentration of MDA, homocysteine, and adrenal corticotrophin hormone in Japanese quail ➢ improved body weight gain and FCR in broilers
Zinc	➢ improved body mass growth, ↓ level of the lipid peroxide, ↑ activity of SOD in broilers ➢ improved live weight gain, feed intake, and hot and chilled dressing percentage in quails ➢ ↓ MDA concentration, ↑ serum vitamin C and vitamin E level, ↑ egg production in Japanese quail ➢ improved eggshell thickness and mitigated the eggshell defects in laying hens
Chromium	➢ ↑ body weight, feed intake, and carcass quality; ↓ level of serum corticosterone concentration; ↓ serum glucose and cholesterol concentration; ↑ serum insulin level in broilers.

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	➢ improved cellular and humoral immune responses in broilers ➢ ↑ immune response, egg quality, Haugh unit ➢ ↓ serum glucose, cholesterol, and triglyceride concentration
Selenium	➢ improved live weight and FCR ➢ improved egg production, egg weight, Haugh unit and eggshell strength in laying hens ➢ increased feed intake, body weight and egg production in quails
Sodium Bicarbonate	➢ improved eggshell quality in laying hens
KCL	➢ improved FCR in broilers
Lycopene	➢ ↑ cumulative feed intake and body weight; ↓ FCR in broilers ➢ ↑ antioxidant level enzymes (SOD, GSH-Px) and ↓ MDA concentration in broilers ➢ ↑ oxidative status of laying hens, enhanced vitamin levels in the egg; improved egg oxidative stability and yolk colo
Resveratrol	➢ ↑ average daily gain, ↓ rectal temperature, ↓ corticosterone, adrenocorticotropin hormone, cholesterol, and malonaldehyde; ↑ triiodothyronine, glutathione, total superoxide dismutase, catalase, and glutathione peroxidase in yellow-feather broilers ➢ improved microbial profile, villus-crypt structure, and expression of the tight junction related genes in broilers ➢ ↑ muscle T-AOC and activity of antioxidant enzymes (catalase, GSH-Px) ➢ ↓ total serum cholesterol and triglycerides, ↓ egg cholesterol content, ↑ antioxidant activity, and ↑ egg sensory scores
Epigallocatechin gallate (EGCG)	➢ ↑ body weight, feed intake, and level of serum total protein, glucose, and alkaline phosphatase activity in broilers ➢ improved in level of antioxidant enzymes (GSH-Px, SOD, and catalase) in the liver and serum in broilers ➢ ↑ feed intake, egg production, hepatic SOD, catalase, and GSH-Px activity; ↓ hepatic MDA level in quails
Curcumin	➢ ↓ mitochondrial MDA level; ↑ activity of Mn-SOD, GSH-Px, GSST in broilers ➢ ↑ gene expression of thioredoxin two and peroxiredoxin-3 in broilers ➢ improved the laying performance, egg quality, antioxidant enzyme activity, and immune function during heat stress in laying hen
Betaine	➢ improvement in the feed intake, weight gain, and FCR; lower H/L ratio; improvement in the dressing percentage in broilers ➢ improved digestive function and carcass traits in indigenous yellow-feathered broilers
Taurine	➢ improved expression of heat shock proteins and body weight in broilers ➢ improved jejunal morphology, ↓ concentrations of serum ghrelin, ↑concentrations of somatostatin and peptide Y.Y. in the duodenum; ↑ expression of appetite-related genes

Source: (Wasti et al., 2020), Impact of heat stress on poultry health and performances, and potential mitigation strategies

In the above table, MDA means Malondialdehyde; FCR means feed conversion ratio; SOD means superoxide dismutase; GSH-Px means Glutathione peroxidase; T-AOC means Total Antioxidant Capacity; and GSST means Glutathione S-transferase

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Conclusion

Thus, this review depicts the effects of heat stress on poultry production. Poultry is an important sector in the livestock industry, and climatic changes such as heat stress have already affected its processes from the farm to the market site. High ambient temperature occurs due to a negative balance among the energy released, thus, affecting the production system. Heat stress is classified as long-term (chronic heat stress) and short-term (acute heat stress). Both can severely affect poultry production, like lower egg quality and production, lower feed intake and increased mortality. Panting with an open mouth is one of the most common signs of heat stress where chickens start to take long breaths by opening their mouth, causing more resting and less movement, which affects their metabolism.

Thus, it is essential to overcome these stressors to retrieve good production in the poultry industry. Solutions like rearing systems, ventilation, feeding strategies, breeding selection and providing supplemental vitamins, minerals and electrolytes can adversely help retain poultry production. Yet, it should be done with utmost care and time since fluctuating feeding times and providing vitamins and minerals at the wrong time can harm the birds. Hence, practising the solutions discussed above can assist in increasing the production and profitability of the poultry industry.

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References

Abbas, I. M., Schwaar, T., Bienwald, F., & Weller, M. G. (2018). Predictable peptide conjugation ratios by activation of proteins with succinimidyl iodoacetate (SIA). Methods and Protocols, 1(1), 1–14. https://doi.org/10.3390/mps1010002

Abidin, Z., & Khatoon, A. (2013). Heat stress in poultry and the beneficial effects of ascorbic acid (vitamin C) supplementation during periods of heat stress. In World's Poultry Science Journal (Vol. 69, Issue 1, pp. 135–152). https://doi.org/10.1017/S0043933913000123

Abo Ghanima, M. M., Abd El-Hack, M. E., Othman, S. I., Taha, A. E., Allam, A. A., & Eid Abdel-Moneim, A. M. (2020). Impact of different rearing systems on growth, carcass traits, oxidative stress biomarkers, and humoral immunity of broilers exposed to heat stress. Poultry science, 99(6), 3070–3078. https://doi.org/10.1016/j.psj.2020.03.011

Alagawany, M., Farag, M. R., Abd El-Hack, M. E., & Patra, A. (2017). Heat stress: Effects on productive and reproductive Performance of quail. World's Poultry Science Journal, 73(4), 747–755. https://doi.org/10.1017/S0043933917000782

Allahverdi, A., Feizi, A., Takhtfooladi, H. A., & Nikpiran, H. (2013). Effects of heat stress on acid-base imbalance, plasma calcium concentration, egg production and egg quality in commercial layers. Global Veterinaria, 10(2), 203–207. https://doi.org/10.5829/idosi.gv.2013.10.2.7286

Altan, Ö., Pabuçcuoğlu, A., Altan, A., Konyalioğlu, S., & Bayraktar, H. (2003). Effect of heat stress on oxidative stress, lipid peroxidation and some stress parameters in broilers. British Poultry Science, 44(4), 545–550. https://doi.org/10.1080/00071660310001618334

Al-Zghoul, M. B., & El-Bahr, S. M. (2019). Basal and dynamics mRNA expression of muscular HSP108, HSP90, HSF-1 and HSF-2 in thermally manipulated broilers during embryogenesis. BMC Veterinary Research, 15(1). https://doi.org/10.1186/s12917-019-1827-7

Attia, Y. A., Hassan, R. A., Tag El-Din, A. E., & Abou-Shehema, B. M. (2011). Effect of ascorbic acid or increasing metabolizable energy level with or without supplementation of some essential amino acids on productive and physiological traits of slow-growing chicks exposed to chronic heat stress. Journal of Animal Physiology and Animal Nutrition, 95(6), 744–755. https://doi.org/10.1111/j.1439-0396.2010.01104.x

Awad, E. A., Najaa, M., Zulaikha, Z. A., Zulkifli, I., & Soleimani, A. F. (2020). Effects of heat stress on growth performance, selected physiological and immunological parameters, caecal microflora, and meat quality in two broiler strains. Asian-Australasian Journal of Animal Sciences, 33(5), 778–7787. https://doi.org/10.5713/ajas.19.0208

Ayo, J. O., Obidi, J. A., & Rekwot, P. I. (2011). Effects of Heat Stress on the Well-Being, Fertility, and Hatchability of Chickens in the Northern Guinea Savannah Zone of Nigeria: A Review. ISRN Veterinary Science, 2011, 1–10. https://doi.org/10.5402/2011/838606

Babinszky, L., Halas, V., & Verstegen, M. W. A. (2011). Impacts of Climate Change on Animal Production and Quality of Animal Food Products. www.intechopen.com

Banks, S., King, S. A., Irvine, D. S., & Saunders, P. T. K. (2005). Impact of a mild scrotal heat stress on DNA integrity in murine spermatozoa. Reproduction, 129(4), 505–514. https://doi.org/10.1530/rep.1.00531

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https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.4761
Barbut, S. (2015). The Science of Poultry and Meat Processing. Retrieved from http://download.poultryandmeatprocessing.com/v01/SciPoultryAndMeatProcessing%20-%20Barbut%20-%20v01.pdf

Barrett, N. W., Rowland, K., Schmidt, C. J., Lamont, S. J., Rothschild, M. F., Ashwell, C. M., & Persia, M. E. (2019). Effects of acute and chronic heat stress on the Performance, egg quality, body temperature, and blood gas parameters of laying hens. Poultry Science, 98(12), 6684–6692. https://doi.org/10.3382/ps/pez541

Betteridge, D. J. (2000). What Is Oxidative Stress?

Bonato, M., Malecki, I. A., Rybnik-Trzaskowska, P. K., Cornwallis, C. K., & Cloete, S. W. P. (2014). Predicting ejaculate quality and libido in male ostriches: Effect of season and age. Animal Reproduction Science, 151(1–2), 49–55. https://doi.org/10.1016/j.anireprosci.2014.09.015

Bozkurt, M., Küçükyilmaz, K., Çatli, A. U., Çinar, M., Bintaş, E., & Çöven, F. (2012). Performance, egg quality, and immune response of laying hens fed diets supplemented with mannan-Oligosaccharide or an essential oil mixture under moderate and hot environmental conditions. Poultry Science, 91(6), 1379–1386. https://doi.org/10.3382/ps.2011-02023

Butcher, G. D., & Miles, R. (2012). Heat Stress Management in Broilers 1. https://edis.ifas.ufl.edu

Cadenas, E., & Davies, K. J. A. (2000). Lars Ernster Commemorative Issue.

Caffrey, N. P., Dohoo, I. R., & Cockram, M. S. (2017). Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. Preventive Veterinary Medicine, 147, 199–208. https://doi.org/10.1016/j.prevetmed.2017.09.011

Cheng, C. Y., Tu, W. L., Wang, S. H., Tang, P. C., Chen, C. F., Chen, H. H., Lee, Y. P., Chen, S. E., & Huang, S. Y. (2015). Annotation of differential gene expression in small yellow follicles of a broiler-type strain of Taiwan country chickens in response to acute heat stress. PLoS ONE, 10(11). https://doi.org/10.1371/journal.pone.0143418

Collins, S. M., Surette, M., & Bercik, P. (2012). The interplay between the intestinal microbiota and the brain. In Nature Reviews Microbiology (Vol. 10, Issue 11, pp. 735–742). https://doi.org/10.1038/nrmicro2876

Cooper, C. E., & Geiser, F. (2008). The "minimal boundary curve for endothermy" as a predictor of heterothermy in mammals and birds: A review. In Journal of Comparative Physiology B: Biochemical, Systemic, and Environmental Physiology (Vol. 178, Issue 1, pp. 1–8). https://doi.org/10.1007/s00360-007-0193-0

Dadgar, S., Lee, E. S., Leer, T. L. V., Burlinguette, N., Classen, H. L., Crowe, T. G., & Shand, P. J. (2010). Effect of microclimate temperature during transportation of broiler chickens on quality of the pectoralis major muscle. Poultry Science, 89(5), 1033–1041. https://doi.org/10.3382/ps.2009-00248

Dai, S. F., Gao, F., Xu, X. L., Zhang, W. H., Song, S. X., & Zhou, G. H. (2012). Effects of dietary glutamine and gamma-aminobutyric acid on meat colour, pH, composition, and water-holding characteristic in broilers under cyclic heat stress. British Poultry Science, 53(4), 471–481. https://doi.org/10.1080/00071668.2012.719148

Dayyani, N., & Bakhtiari, H. (2013). Heat stress in poultry: background and affective factors. In International journal of Advanced Biological and Biomedical Research (Vol. 1, Issue 11). http://www.ijabbr.com

Debut, M., Berri, C., Arnould, C., Guemené, D., Santé-Lhoutellier, V., Sellier, N., Baéza, E., Jehl, N., Jégo, Y., Beaumont, C., & le Bihan-Duval, E. (2005). Behavioural and physiological responses of three chicken breeds to pre-slaughter shackling and acute heat stress. British Poultry Science, 46(5), 527–535. https://doi.org/10.1080/00071660500303032

Deeb, N., & Cahaner, A. (2002). Genotype-by-Environment Interaction with Broiler Genotypes Differing in Growth Rate. 3. Growth Rate and Water Consumption of Broiler Progeny from Weight-Selected Versus Nonselected Parents under Normal and High Ambient Temperatures. http://ps.oxfordjournals.org/

Deng, W., Dong, X. F., Tong, J. M., & Zhang, Q. (2012). The probiotic Bacillus licheniformis ameliorates heat stress-induced impairment of egg production, gut morphology, and intestinal mucosal immunity in laying hens. Poultry Science, 91(3), 575–582. https://doi.org/10.3382/ps.2010-01293

Dikmen, S., & 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 Science, 92(1), 109–116. https://doi.org/10.3168/jds.2008-1370

Dinan, T. G., & Cryan, J. F. (2012). Regulation of the stress response by the gut microbiota: Implications for psychoneuroendocrinology. In Psychoneuroendocrinology (Vol. 37, Issue 9, pp. 1369–1378). https://doi.org/10.1016/j.psyneuen.2012.03.007

Domingues, A. R., Pires, S. M., Halasa, T., & Hald, T. (2012). Source attribution of human salmonellosis using a meta-analysis of case-control studies of sporadic infections. In Epidemiology and Infection (Vol. 140, Issue 6, pp. 959–969). https://doi.org/10.1017/S0950268811002172

Ebeid, T. A., Suzuki, T., & Sugiyama, T. (2012). High ambient temperature influences eggshell quality and calbindin-D28k localization of eggshell gland and all intestinal segments of laying hens. Poultry Science, 91(9), 2282–2287. https://doi.org/10.3382/ps.2011-01898

Eisenberg, J. N. S., Trostle, J., Sorensen, R. J. D., & Shields, K. F. (2012). Toward a systems approach to enteric pathogen transmission: From individual independence to community interdependence. In Annual Review of Public Health (Vol. 33, pp. 239–257). https://doi.org/10.1146/annurev-publhealth-031811-124530

Estévez, M. (2015). Oxidative damage to poultry: From farm to fork. Poultry Science, 94(6), 1368–1378. https://doi.org/10.3382/ps/pev094

Farghly, M. F. A., Mahrose, K. M., Cooper, R. G., Ullah, Z., Rehman, Z., & Ding, C. (2018). Sustainable floor type for managing Turkey production in a hot climate. Poultry Science, 97(11), 3884–3890. https://doi.org/10.3382/ps/pey280

Volume: 3, No: 8, pp. 705 – 724
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.4761
Farnell, M. B., Moore, R. W., Mcelroy, A. P., Hargis, B. M., & Caldwell, D. J. (2001). Effect of Prolonged Heat Stress in Single-Comb White Leghorn Hens on Progeny Resistance to Salmonella enteritidis Organ Invasion. In Source: Avian Diseases (Vol. 45, Issue 2).

Felver-Gant, J. N., Mack, L. A., Dennis, R. L., Eicher, S. D., & Cheng, H. W. (2012). Genetic variations alter physiological responses following heat stress in 2 strains of laying hens. Poultry Science, 91(7), 1542–1551. https://doi.org/10.3382/ps.2011-01988

Fiji - Agriculture Sector. (2021). Fiji – Country Commercial Guide. Retrieved from https://www.trade.gov/countrycommercialguides/fijiagriculturesector#:%7E:text=Th%20agriculture%20sector%20accounts%20for,percent%20of%20Fiji' s%20ruralpopulation.

Fiji Times Online. (2014). Fijian Project Opens Doors to Poultry Farming. Retrieved from https://www.thepoultrysite.com/news/2014/07/fijian-project-opens-doors-to-poultry-farming

Fouad A.M, W. Chen, D. Ruan, S. Wang, W.G.Xia and C.T.Zheng, (2016). Imapct of Heat Stress on Meat, Egg Quality, Immunity and Fertility in Poultry and Nutritional Factors That Overcome These Effects: A Review. International Journal of Poultry Science, 15: 81-95 Doi: https://dx.doi.org/10.3923/ijps.2016.81.95

Franco-Jimenez, D. J., Scheideler, S. E., Kittok, R. J., Brown-Brandl, T. M., Robeson, L. R., Taira, H., & Beck, M. M. (2007). Differential effects of heat stress in three strains of laying hens. Journal of Applied Poultry Research, 16(4), 628–634. https://doi.org/10.3382/japr.2005-00088

Gantois, I., Ducatelle, R., Pasmans, F., Haesebrouck, F., Gast, R., Humphrey, T. J., & van Immerseel, F. (2009). Mechanisms of egg contamination by Salmonella Enteritidis: Review article. In FEMS Microbiology Reviews (Vol. 33, Issue 4, pp. 718–738). https://doi.org/10.1111/j.1574-6976.2008.00161.x

Garriga, C., Hunter, R. R., Amat, C., Planas, J. M., Mitchell, M. A., & Moretó, M. (2006). Heat stress increases apical glucose transport in the chicken jejunum. Am J Physiol Regul Integr Comp Physiol, 290, 195–201. https://doi.org/10.1152/ajpregu.00393.2005.-In

Ghazi, S., Habibian, M., Moeini, M. M., & Abdolmohammadi, A. R. (2012). Effects of different levels of organic and inorganic chromium on growth performance and immunocompetence of broilers under heat stress. Biological Trace Element Research, 146(3), 309–317. https://doi.org/10.1007/s12011-011-9260-1

Goel, A. (2021). Heat stress management in poultry. In Journal of Animal Physiology and Animal Nutrition (Vol. 105, Issue 6, pp. 1136–1145). John Wiley and Sons Inc. https://doi.org/10.1111/jpn.13496

Huff Lonergan, E., Zhang, W., & Lonergan, S. M. (2010). Biochemistry of postmortem muscle - Lessons on mechanisms of meat tenderization. In Meat Science (Vol. 86, Issue 1, pp. 184–195). https://doi.org/10.1016/j.meatsci.2010.05.004

Humphrey, T. (2006). Are happy chickens safer chickens? Poultry welfare and disease susceptibility. In British Poultry Science (Vol. 47, Issue 4, pp. 379–391). https://doi.org/10.1080/00071660600829084

Igbal, M. R. (2021). Bovine Mastitis in Fiji: Economic Implications and Management—A Review. Journal of Agricultural Science, 13(10), 162. https://doi.org/10.5539/jas.v13n10p162

Igbal, M. R. (2022). The Economic Impact of Climate Change on the Agricultural System in Fiji. Journal of Agricultural Science, 14(2), 144. https://doi.org/10.5539/jas.v14n2p144

Imik, H., Atasever, M. A., Urcar, S., Ozlu, H., Gumus, R., & Atasever, M. (2012). Meat quality of heat stress exposed broilers and Effect of protein and vitamin E. British Poultry Science, 53(5), 689–698. https://doi.org/10.1080/00071668.2012.736609

Jahejo, A. R., Rajput, N., Leghari, I. H., Kaleri, R. R., Rajput, M., Mangi, R. A., Sheikh, M. K., & Pirzado, M. Z. (2016). • Heritability Estimates for Some Growth Traits of Dhatti Camel Breed in Tharparkar View project Production Performance of Thari cattle View project Effects of Heat Stress on the Performance of Hubbard Broiler Chicken. https://www.researchgate.net/publication/321026821

Jones, D.R. (2006). Conserving and monitoring shell egg quality. Australian Poultry Science Symposium.18:198-205

Kala, M., Shaikh, M. V., & Nivsarkar, M. (2017). Equilibrium between antioxidants and reactive oxygen species: a requisite for oocyte development and maturation. In Reproductive Medicine and Biology (Vol. 16, Issue 1, pp. 28–35). John Wiley and Sons Ltd. https://doi.org/10.1002/rmb2.12013

Khatlab, A. D. S., del Vesco, A. P., de Oliveira Neto, A. R., Fernandes, R. P. M., & Gasparino, E. (2019). Dietary supplementation with free methionine or methionine dipeptide mitigates intestinal oxidative stress induced by Eimeria spp. challenge in broiler chickens. Journal of Animal Science and Biotechnology, 10(1). https://doi.org/10.1186/s40104-019-0353-6

Kilic and Simsek. (2013). The Effects of Heat Stress on Egg Production and Quality of laying hens.

Kirunda, D. F. K., Scheideler, S. E., & Mckee, S. R. (2001). The Efficacy of Vitamin E (DL-α -tocopheryl acetate) Supplementation in Hen Diets to Alleviate Egg Quality Deterioration Associated with High Temperature Exposure. http://ps.oxfordjournals.org/

Knoema. (2021, December 21). Fiji Production of poultry meat and egg, 1961–2021. Retrieved from https://knoema.com/atlas/Fiji/topics/Agriculture/Live-Stock-Production-Production-Quantity/Production-of-poultry-meat

Küchenmeister, U., Kuhn, G., & Ender, K. (2005). Preslaughter handling of pigs and the Effect on heart rate, meat quality, including tenderness, and sarcoplasmic reticulum Ca2+ transport. Meat Science, 71(4), 690–695. https://doi.org/10.1016/j.meatsci.2005.05.020

Kumar, M., Ratwan, P., Dahiya, S. P., & Nehra, A. K. (2021). Climate change and heat stress: Impact on production, reproduction and growth Performance of poultry and its mitigation using genetic strategies. In Journal of Thermal Biology (Vol. 97). Elsevier Ltd. https://doi.org/10.1016/j.jtherbio.2021.102867

Lin, H., Jiao, H. C., Buyse, J., & Decuypere, E. (2006). Strategies for preventing heat stress in poultry. In World's Poultry Science Journal (Vol. 62, Issue 1). https://doi.org/10.1079/WPS200585

Lin, H., Zhang, H. F., Jiao, H. C., Zhao, T., Sui, S. J., Gu, X. H., Zhang, Z. Y., Buyse, J., & Decuypere, E. (2005). Thermoregulation Responses of Broiler Chickens to Humidity at Different Ambient Temperatures. I. One Week of Age. http://ps.oxfordjournals.org/
Lourens, A., van den Brand, H., Heetkamp, M. J. W., Meijerhof, R., & Kemp, B. (2007). PHYSIOLOGY, ENDOCRINOLOGY, AND REPRODUCTION Effects of Eggshell Temperature and Oxygen Concentration on Embryo Growth and Metabolism During Incubation. http://ps.oxfordjournals.org/
Lu, Q., Wen, J., & Zhang, H. (2007). ENVIRONMENT, WELL-BEING, AND BEHAVIOR Effect of Chronic Heat Exposure on Fat Deposition and Meat Quality in Two Genetic Types of Chicken 1.
Ma, X., Lin, Y., Zhang, H., Chen, W., Wang, S., Ruan, D., & Jiang, Z. (2014). Heat stress impairs the nutritional metabolism and reduces the productivity of egg-laying ducks. In Animal Reproduction Science (Vol. 145, Issues 3–4, pp. 182–190). Elsevier. https://doi.org/10.1016/j.anireprosci.2014.01.002
Mack, L. A., Felver-Gant, J. N., Dennis, R. L., & Cheng, H. W. (2013). Genetic variations alter production and behavioral responses following heat stress in 2 strains of laying hens. Poultry Science, 92(2), 285–294. https://doi.org/10.3382/ps.2012-02589
Mashaly, M. M., Hendricks, G. L., Kalama, M. A., Gehad, A. E., Abbas, A. O., & Patterson, P. H. (2004). Effect of Heat Stress on Production Parameters and Immune Responses of Commercial Laying Hens 1. http://ps.oxfordjournals.org/
Mishra, B., & Jha, R. (2019). Oxidative stress in the poultry gut: Potential challenges and interventions. In Frontiers in Veterinary Science (Vol. 6, Issue MAR). Frontiers Media S.A. https://doi.org/10.3389/fvets.2019.00060
Mujahid, A., Akiba, Y., Warden, C. H., & Toyomizu, M. (2007). Sequential changes in superoxide production, anion carriers and substrate oxidation in skeletal muscle mitochondria of heat-stressed chickens. FEBS Letters, 581(18), 3461–3467. https://doi.org/10.1016/j.febslet.2007.06.051
Mutaf, S., Seber Kahraman, N., & Firat, M. Z. (2009). Intermittent partial surface wetting and its Effect on body-surface temperatures and egg production of white and brown domestic laying hens in Antalya (Turkey). British Poultry Science, 50(1), 33–38. https://doi.org/10.1080/00071660802592399
Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M. S., & Bernabucci, U. (2010). Effects of climate changes on animal production and sustainability of livestock systems. Livestock Science, 130(1–3), 57–69. https://doi.org/10.1016/j.livsci.2010.02.011
Newell, D. G., Koopmans, M., Verhoef, L., Duizer, E., Aidara-Kane, A., Sprong, H., Opsteegh, M., Langelaar, M., Threfall, J., Scheutz, F., der Giessen, J. van, & Kruse, H. (2010). Food-borne diseases - The challenges of 20years ago still persist while new ones continue to emerge. International Journal of Food Microbiology, 139(SUPPL. 1). https://doi.org/10.1016/j.ijfoodmicro.2010.01.021
Nienaber, J. A., & Hahn, G. L. (2007). Livestock production system management responses to thermal challenges. International Journal of Biometeorology, 52(2), 149–157. https://doi.org/10.1007/s00484-007-0103-x
Niu, Z. Y., Liu, F. Z., Yan, Q. L., & Li, W. C. (2009). Effects of different levels of vitamin E on growth performance and immune responses of broilers under heat stress. Poultry Science, 88(10), 2101–2107. https://doi.org/10.3382/ps.2009-00220
Noiva, R. M., Menezes, A. C., & Peleteiro, M. C. (2014). Influence of temperature and humidity manipulation on chicken embryonic development. BMC Veterinary Research, 10(1). https://doi.org/10.1186/s12917-014-0234-3
Nuhad J. Daghir. (2008). POULTRY PRODUCTION IN HOT CLIMATES Second Edition.
Obidi J.A, B.I. Onveanusi J.O. Ayo, P.I. Rekwot and S.J. Abdullahi, (2008). Effect of Timing of Artificial Insemination on Fertility and Hatchability of Shikabrown Breeder Hens. International Journal of Poultry Science, 7: 1221-1226. Doi: https://dx.doi.org/10.3923/ijps.2008.1224.1226
Oguntunji, A. O., & Alabi, O. M. (2010). Influence of high environmental temperature on egg production and shell quality: A review. In World's Poultry Science Journal (Vol. 66, Issue 4, pp. 739–750). https://doi.org/10.1017/S004393391000070X
Onderci, M., Sahin, K., Sahin, N., Cikim, G., Vijaya, J., & Kucuk, O. (2005). Effects of Dietary Combination of Chromium and Biotin on Growth Performance, Carcass Characteristics, and Oxidative Stress Markers in Heat-Distressed Japanese Quail. In Biological Trace Element Research (Vol. 165).
Piestun, Y., Shinder, D., Ruzal, M., Halevy, O., Brake, J., & Yahav, S. (2008). Thermal manipulations during broiler embryogenesis: Effect on the acquisition of thermotolerance. Poultry Science, 87(8), 1516–1525. https://doi.org/10.3382/ps.2008-00030
Quinteiro-Filho, W. M., Gomes, A. V. S., Pinheiro, M. L., Ribeiro, A., Ferraz-de-Paula, V., Astolfi-Ferreira, C. S., Ferreira, A. J. P., & Palermo-Neto, J. (2012). Heat stress impairs Performance and induces intestinal inflammation in broiler chickens infected with Salmonella Enteritidis. Avian Pathology, 41(5), 421–427. https://doi.org/10.1080/03079457.2012.709315
Quinteiro-Filho, W. M., Ribeiro, A., Ferraz-de-Paula, V., Pinheiro, M. L., Sakai, M., Sá, L. R. M., Ferreira, A. J. P., & Palermo-Neto, J. (2010). Heat stress impairs performance parameters, induces intestinal injury, and decreases macrophage activity in broiler chickens. Poultry Science, 89(9), 1905–1914. https://doi.org/10.3382/ps.2010-00812
Renaudeau, D., Collin, A., Yahav, S., de Basilio, V., Gourdine, J. L., & Collier, R. J. (2012). Adaptation to hot climate and strategies to alleviate heat stress in livestock production. Animal, 6(5), 707–728. https://doi.org/10.1017/S1751731111002448
Rostagno, M. H. (2009). Can Stress in Farm Animals Increase Food Safety Risk?
Sahin, K., Onderci, M., Sahin, N., Gursu, M. F., Vijaya, J., & Kucuk, A. O. (2004). Effects of Dietary Combination of Chromium and Biotin on Egg Production, Serum Metabolites, and Egg Yolk Mineral and Cholesterol Concentrations in Heat-Distressed Laying Quails (Vol. 101).

Volume: 3, No: 8, pp. 705 – 724
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.4761
Sahin, K., Sahin, N., Kucuk, O., Hayirli, A., & Prasad, A. S. (2009). Role of dietary zinc in heat-stressed poultry: A review. In Poultry Science (Vol. 88, Issue 10, pp. 2176–2183). Poultry Science Association. https://doi.org/10.3382/ps.2008-00560

Sahin, N., Sahin, K., & Küçük, O. (2001). Effects of vitamin E and vitamin A supplementation on Performance, thyroid status and serum concentrations of some metabolites and minerals in broilers reared under heat stress (32 degrees C). Veterinární Medicína, 46(No. 11–12), 286-292. doi: 10.17221/7894-vetmed

Sahin, N., Sahin, K., Onderci, M., Gursu, M. F., Cikim, G., Vijaya, J., & Kucuk, O. (2005). Chromium picolinate, rather than biotin, alleviates Performance and metabolic parameters in heat-stressed quail. British Poultry Science, 46(4), 457–463. https://doi.org/10.1080/00071660500190918

Sandercock, D. A., Hunter, R. R., Nute, G. R., Mitchell, M. A., & Hocking, P. M. (2001). Acute Heat Stress-Induced Alterations in Blood Acid-Base Status and Skeletal Muscle Membrane Integrity in Broiler Chickens at Two Ages: Implications for Meat Quality.

Santos Dos, V. M., Dallago, B. S. L., Racanicci, A. M. C., Santana, P., & Bernal, F. E. M. (2017). Effects of season and distance during transport on broiler chicken meat. Poultry Science, 96(12), 4270–4279. https://doi.org/10.3382/ps/pex282

Santos, R. R., Awati, A., Roubos-van den Hil, P. J., Tersteeg-Zijderveld, M. H. G., Koolmees, P. A., & Fink-Gremmels, J. (2015). Quantitative histo-morphometric analysis of heat-stress-related damage in the small intestines of broiler chickens. Avian Pathology, 44(1), 19–22. https://doi.org/10.1080/03079457.2014.988122

Sihvo, H. K., Immonen, K., & Puolanne, E. (2014). Myodegeneration With Fibrosis and Regeneration in the Pectoralis Major Muscle of Broilers. Veterinary Pathology, 51(3), 619–623. https://doi.org/10.1177/0300985813497488

Sinha.R, Madan Lal Kamboj, & Ashish Ranjan. (2017). Effect of modified housing on behavioural and physiological responses of crossbred cows in hot humid climate. Retrieved 11 February 2022, from https://www.researchgate.net/publication/320857336_Effect_of_modified_housing_on_behavioural_and_physiological_responses_of_crossbred_cows_in_hot_humid_climate

Sinha.R, Madan Lal Kamboj, Surendra Singh Lathwal and Ashish Ranjan. (2018). Effect of housing management on production performance of crossbred cows during hot-humid season. Retrieved 11 February 2022, from https://arccjournals.com/journal/indian-journal-of-animal-research/B-3316

Sohail, M. U., Hume, M. E., Byrd, J. A., Nisbet, D. J., Ijaz, A., Sohail, A., Shabbir, M. Z., & Rehman, H. (2012). Effect of supplementation of prebiotic mannan-oligosaccharides and probiotic mixture on growth performance of broilers subjected to chronic heat stress. Poultry Science, 91(9), 2235–2240. https://doi.org/10.3382/ps.2012-02182

Star, L., Decuypere, E., Parmentier, H. K., & Kemp, B. (2008). Effect of single or combined climatic and hygienic stress in four layer lines: 2. Endocrine and oxidative stress responses. Poultry Science, 87(6), 1031–1038. https://doi.org/10.3382/ps.2007-00143

Star, L., Juul-Madsen, H. R., Decuypere, E., Nieuwland, M. G. B., de Vries Reilingh, G., van den Brand, H., Kemp, B., & Parmentier, H. K. (2009). Effect of early life thermal conditioning and immune challenge on thermotolerance and humoral immune competence in adult laying hens. Poultry Science, 88(11), 2253–2261. https://doi.org/10.3382/ps.2008-00373

Surai, P. F., Kochish, I. I., Fisinin, V. I., & Kidd, M. T. (2019). Antioxidant defence systems and oxidative stress in poultry biology: An update. In Antioxidants (Vol. 8, Issue 7). MDPI. https://doi.org/10.3390/antiox8070235

Syafwan, S., Kwakkel, R. P., & Verstegen, M. W. A. (2011). Heat stress and feeding strategies in meat-type chickens. In World's Poultry Science Journal (Vol. 67, Issue 4, pp. 653–674). https://doi.org/10.1017/S0043933911000742

Tajima, K., Nonaka, I., Higuchi, K., Takusari, N., Kurihara, M., Takenaka, A., Mitsumori, M., Kajikawa, H., & Aminov, R. I. (2007). Influence of high temperature and humidity on rumen bacterial diversity in Holstein heifers. Anaerobe, 13(2), 57–64. https://doi.org/10.1016/j.anaerobe.2006.12.001

Uyeno, Y., Sekiguchi, Y., Tajima, K., Takenaka, A., Kurihara, M., & Kamagata, Y. (2010). An rRNA-based analysis for evaluating the Effect of heat stress on the rumen microbial composition of Holstein heifers. Anaerobe, 16(1), 27–33. https://doi.org/10.1016/j.anaerobe.2009.04.006

Uzum, M., & Toplu, H.D. (2013). Effects of stocking density and feed restriction on Performance, carcass, meat quality characteristics and some stress parameters in broilers under heat stress. Retrieved from https://www.semanticscholar.org/paper/Effects-of-stocking-density-and-feed-restriction-on-Uzum-Toplu/fbb88c8c7a5c09fca58eec39b3c2a7152c4d1b39

Vecerek, V., Voslarova, E., Conte, F., Vecerkova, L., & Bedanova, I. (2016). Negative trends in transport-related mortality rates in broiler chickens. Asian-Australasian Journal of Animal Sciences, 29(12), 1796–1804. https://doi.org/10.5713/ajas.15.0996

Verbrugghe, E., Boyen, F., Gaastra, W., Bekhuis, L., Leyman, B., van Parys, A., Haesebrouck, F., & Pasmans, F. (2012). The complex interplay between stress and bacterial infections in animals. In Veterinary Microbiology (Vol. 155, Issues 2–4, pp. 115–127). https://doi.org/10.1016/j.vetmic.2011.09.012

Vercese F, G. E. S. J. P. S. A. de P. F. A. B. D. M. A. de B. P. K. (2012). 38 Performance and Egg Quality of Japanese Quails Submitted to Cyclic Heat Stress. https://doi.org/https://doi.org/10.1590/S1516-635X2012000100007

Wang, Y., Ru, Y. J., Liu, G. H., Chang, W. H., Zhang, S., Yan, H. J., Zheng, A. J., Lou, R. Y., Liu, Z. Y., & Cai, H. Y. (2015). Effects of different rearing systems on growth performance, nutrients digestibility, digestive organ weight, carcass traits, and energy utilization in male broiler chickens. Livestock Science, 176, 135–140. https://doi.org/10.1016/j.livsci.2015.03.010

Warriss, P. D., Pagazaurtundua, A., & Brown, S. N. (2005). Relationship between maximum daily temperature and mortality of broiler chickens during transport and lairage. British Poultry Science, 46(6), 647–651. https://doi.org/10.1080/00071660500393868

Journal of Ecohumanism
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Wasti, S., Sah, N., & Mishra, B. (2020). Impact of heat stress on poultry health and performances, and potential mitigation strategies. Animals, 10(8), 1–19. https://doi.org/10.3390/ani10081266

Wei, S., Morrison, M., & Yu, Z. (2013). Bacterial census of poultry intestinal microbiome. Poultry Science, 92(3), 671–683. https://doi.org/10.3382/ps.2012-02822

Yalçin, S., & Siegel, P. B. (2003). Exposure to Cold or Heat During Incubation on Developmental Stability of Broiler Embryos. http://ps.oxfordjournals.org/

Yalcin, S., Özkan, S., Türkmut, L., & Siegel, P. B. (2001). Responses to heat stress in commercial and local broiler stocks. 1. Performance traits. British Poultry Science, 42(2), 149–152. https://doi.org/10.1080/00071660120048375

Yousaf, A., Jabbar, A., & Ditta, Y. A. (2017). Effect of Pre-Warming on Broiler Breeder Eggs Hatchability and Post-Hatch Performance. Journal of Animal Health and Production, 5(1), 1–4. https://doi.org/10.14737/journal.jahp/2017/5.1.1.4

Zhang, P., Yan, T., Wang, X., Kuang, S., Xiao, Y., Lu, W., & Bi, D. (2017). Probiotic mixture ameliorates heat stress of laying hens by enhancing intestinal barrier function and improving gut microbiota. Italian Journal of Animal Science, 16(2), 292–300. https://doi.org/10.1080/1828051X.2016.1264261

Zhang, Z. Y., Jia, G. Q., Zuo, J. J., Zhang, Y., Lei, J., Ren, L., & Feng, D. Y. (2012). Effects of constant and cyclic heat stress on muscle metabolism and meat quality of broiler breast fillet and thigh meat. Poultry Science, 91(11), 2931–2937. https://doi.org/10.3382/ps.2012-02255

Zissimopoulos, S., & Lai, F. A. (2006). Redox regulation of the ryanodine receptor/calcium release channel.

Zulkifli, I., Che Norma, M. T., Israf, D. A., & Omar, A. R. (n.d.). The Effect of Early Age Feed Restriction on Subsequent Response to High Environmental Temperatures in Female Broiler Chickens. http://ps.oxfordjournals.org/

Zumbach, B., Misztal, I., Tsuruta, S., Sanchez, J. P., Azain, M., Herring, W., Holl, J., Long, T., & Culbertson, M. (2008). Genetic components of heat stress in finishing pigs: Development of a heat load function. Journal of Animal Science, 86(9), 2082–2088. https://doi.org/10.2527/jas.2007-0523