Indian Journal of Animal Sciences **94** (3): 258–265, March 2024/Article
https://doi.org/10.56093/ijans.v94i3.127396

Effect of heat stress on growth, carcass and sensory parameters in synthetic broiler and native cross chicken

KADIMETLA SNEHA[1], SHAKTI KANT DASH[1✉], PREM PRAKASH DUBEY[1], O P MALAV[1] and PUNEET MALHOTRA[1]

Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab 141 012 India

Received: 26 August 2022; Accepted: 17 January 2024

ABSTRACT

Poultry production in the tropics is mainly affected by environmental stressors, viz. temperature and humidity. The present investigation aimed to study the growth, carcass and meat quality of the two different genetic groups of chicken under control (spring season) and heat stress conditions (summer). During the spring season, the mean temperature of the poultry house was found to be 23.68±0.39°C, while it was 34.41±0.52°C during summer. Under both conditions, the body weights of both the genetic groups were recorded at 0, 7, 21 and 42 days of age. The carcass traits were recorded after 6 weeks of age and sensory evaluation was done by meat product preparation. The results showed no significant difference in the growth performance, carcass traits and sensory parameters of control and heat stress groups of native cross birds which might be due to better adaptability and heat tolerance potential, however, the synthetic broiler variety IBL80 was significantly affected by heat stress causing a 16.82% reduction in marketable weight as compared to the control group. According to the findings of the current study, native cross chickens had a higher capability for heat tolerance even if fast-growing synthetic broilers were superior in terms of growth performance and carcass production.

Keywords: Carcass traits, Growth performance, Meat quality, Temperature Humidity Index

Climate change has become a major global concern, leading to extreme climatic variations throughout the globe. In tropics, warmer climatic conditions along with the global warming are causing havoc on the overall health of livestock and affecting their productivity. Poultry farming too is significantly affected by environmental stressors such as high temperature and humidity (Nawab *et al*. 2018). Heat stress can be defined as the combined effect of environmental parameters producing conditions that are higher than the temperature range of the animal's thermal neutral zone (Buffington *et al.* 1981). Optimum environmental conditions are required for the birds to perform up to their maximum potential. When the temperatures are above the thermo-neutral zone, the birds exhibit distress to dissipate the heat, affecting various physiological, biochemical, immunological, behavioural, reproductive, productive performances (Pawar *et al.* 2016). Zaboli *et al.* (2012) reviewed the three mechanisms that affect the meat quality in chicken under heat stress; firstly, panting increases the exhalation of carbon dioxide causing metabolic acidosis in skeletal muscle, secondly, release of corticosteroid hormones increases the catabolism of protein and accelerates the reactive oxygen species (ROS), which leads to oxidative stress that disrupt the calcium regulation in sarcoplasm of the muscles and finally, higher temperature of the muscle before and during slaughter results in rapid decline of *p*H, causing the denaturation of sarcoplasmic proteins resulting in low water holding capacity (WHC). Due to their faster growth rate and heavier body, the present-day commercial broiler poultry have decreased thermoregulatory potential, thus are more susceptible to changes in the environment. Sohail *et al.* (2012) postulated that heat stress causes severe economic losses with decrease in marketable weight due to reduced feed intake in broilers. Despite the lower growth and egg production potential of the native chicken, it is their smaller body size, hardiness and natural immunity to common diseases, which helps them to survive better in the tropical climatic conditions (Padhi 2016). In Xueshan yellow feathered broilers, the carcass traits along with meat quality parameters are also affected by heat stress (Shao *et al.* 2018). The present-day focus is on developing chicken varieties with native chicken bloodline, as these varieties are most suitable for backyard poultry farming. The native chicken is considered to be climate resilient and the broiler varieties with native chicken inheritance, though are slower growing in comparison to commercial broiler varieties, but due to their native genetics they are more climate resilient, require lower input and fetch higher premium. Thus, the present study was designed to have

Present address: [1]COVS, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab. ✉Corresponding author email: shaktikant07@gmail.com

a comparative evaluation of synthetic broiler and native cross poultry under heat stress on the basis of production performance and sensory parameters.

MATERIALS AND METHODS

Experimental design, bird housing and feeding: The experimentation was conducted in the poultry farm of Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India. At this poultry farm different parent lines are being maintained, viz. PB1 and PB2. Punjab Brown is a parent line developed by *ex situ* selection of Punjab Brown native chicken, which is native breed of Punjab and birds of IBL80 which is a fast-growing synthetic broiler variety and native cross chicken variety were chosen for this study. The IBL80 is a cross of PB1 and PB2 parent lines, which have been under selection for improved growth for more than five decades under the AICRP broiler breeding project (Naik *et al.* 2019). Whereas the native cross, was developed as low input dual purpose poultry variety, by crossing between males of PB1 line and females of Punjab Brown line, which is a native poultry breed found in the Gurdaspur district of Punjab. The chicks of each treatment group were raised under heat stress (during the summer months, i.e. April and May) and control conditions (during spring season of February and March) for a period of 42 days (6 weeks). 40 one day old chicks of each of the four treatment groups were raised in pens of dimension 11.148 sq. meter. Each treatment had 5 replicates with 8 chicks per replicate. The pens were properly disinfected before arrival of the day-old chicks. Rice husk was used as the bedding material and equipment's such as chick drinkers, linear feeders, and light bulbs were used as per standard requirements (23 h constant light at an intensity of 40 lux with 1 h of darkness). The birds were fed with chick ration (ME and 20% CP) as per the ration formulation of the AICRP project (Table 1), with *ad lib.* feeding and watering at chick stage.

Table 1. Ingredients composition of the birds' diet

Ingredient (g/kg ration)	Quantity
Maize	600
Soya bean [44% Crude Protein]	310
De-oiled rice polish	46.55
Dicalcium Phosphate[a]	20
Limestone Powder	15
Vitamin-Mineral Premix[b]	1.35
DL-Methionine (99.0%)	1.80
L-Lysine (99.0%)	2.80
Sodium Chloride	2.50
Coccidiostat	0.0005
Calculated analysis	
ME MJ/kg	11.93
Crude Protein%	20
Ca%	1
P%	0.45
Digestible lysine%	1
Digestible Methionine%	0.52
Choline Chloride%	0.10
Sodium Chloride%	0.40

[a]Dicalcium Phosphate contained 18% phosphorous, 23% calcium. [b]kg of vitamin-mineral premix per ton of feed supplied each kg of diet with Vit. A, 12000 IU; Vit. D3, 1000 IU; Vit. E., 25 mg; Vit. H, 5 mg; Vit. B9, 5 mg; Ca, 225 g; Co, 20 mg; Mg, 60 mg; Fe, 30 mg; Cu, 2 mg; Mn, 2 mg; Zn, 2 mg; K, 20 mg; Choline chloride (50% choline), 50 mg; I, 1 mg; Se, 0.1 mg; ethoxyquin, 3000 mg.

To assess the in-house ambience, the temperature and humidity of the poultry shed were recorded thrice daily i.e., morning, afternoon and evening with the help of Manson's wet and dry bulb hygrometer (Zeal make). Temperature Humidity Index (THI) was calculated with the help of formula:

$$THI = 0.85t_{db}+0.15t_{wb} \text{ (Tao and Xin 2003)}$$

where, t_{db} , dry bulb temperature and t_{wb}, wet bulb temperature in degree centigrade (°C).

Variables recorded: Birds were individually weighed at 1st, 7th, 21st and 42nd day. Average daily gain up to 3 weeks (ADG3), average daily gain up to 6 weeks (ADG6) of age, average daily gain from 3rd to 6th week (ADG 3-6) were calculated. At the end of the experimental period at 6 weeks, the birds were slaughtered following scientific procedure, for evaluating the meat parameters. Live weight, carcass yield (as proportion to live weight), and the weight of carcass cuts: neck, wings, breast, drumstick, and giblets (liver, gizzard, and heart) were recorded. Sensory parameters of meat products, viz. appearance, flavour, and texture, cooking loss, juiciness and overall acceptability were assessed.

Meat product preparation: Deboned meat from 6 randomly selected birds from each group was used for the preparation of chicken nuggets. The procedure for the preparation of the chicken nuggets was similar to Rindhe *et al.* (2018) with slight modifications (i.e. without the addition of wheat bran and egg albumin). After collection, the meat was stored at -18°C and partially thawed overnight at 4°C, the day before the preparation of meat product. The thawed meat was double minced in meat mincer (Mado Eskimo Mew-714, Mado, Germany) using 4 mm plate. Meat emulsion was prepared in a bowl chopper (Seydelmann K20, Ras, Germany). The pre-weighed meat was chopped for 2 to 3 min by the addition of salt, sodium tripolyphosphate and sodium nitrite, chilled water. Refined vegetable oil was slowly incorporated while chopping, till it was completely dispersed in the batter. The remaining ingredients were added and chopped till the desired consistency of emulsion was achieved. Meat emulsion of about 200 g was filled into the stainless-steel moulds and cooked at 121°C for 15 min. The weight of the meat block was recorded after cooking to estimate the cooking loss. The cooking loss was calculated and expressed as percentage by a formula:

$$[(\text{Weight of raw meat emulsion} - \text{Weight of cooked product}) / \text{Weight of raw meat emulsion}] \times 100.$$

Table 2. 8-point scale used for evaluation of Sensory attributes of meat product (nugget)

Attribute	Scores							
	8	7	6	5	4	3	2	1
Colour and Appearance	Excellent	Very good	Good	Fair	slightly poor	Moderately poor	Very poor	Extremely Poor
Flavour	Extremely desirable	Very desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Moderately undesirable	Very undesirable	Extremely undesirable
Juiciness	Extremely juicy	Very juicy	Moderately juicy	Slightly juicy	Slightly dry	Moderately dry	Very dry	Extremely dry
Texture	Extremely desirable	Very desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Moderately undesirable	Very undesirable	Extremely undesirable
Overall acceptability	Extremely acceptable	Very acceptable	Moderately acceptable	Slightly acceptable	Average acceptable	Moderately unacceptable	Very unacceptable	Extremely unacceptable

Sensory evaluation: A panel consisting of seven experienced and semi-experienced judges, included faculty and postgraduate scholars of Department of Livestock Products and Technology (LPT), College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, evaluated the samples for sensory attributes like colour and appearance, flavour, juiciness, texture and overall acceptability. An 8-point hedonic scale for product evaluation (ranging from 8 = excellent and 1= extremely poor) was prepared in reference to Keeton 1983 and was used by the panellists (Table 2). The samples were suitably coded and presented to the panellists and water was served for rinsing the mouth between the samples.

Statistical analysis: For studying the significant difference between the two varieties of birds under two different environmental conditions, data pertaining to different growth, carcass and sensory variables, were analysed using a two factor ANOVA with interaction effect by GLM procedure of SAS 9.3 software package. The statistical model used was:

$$Y_{ijk} = \mu + B_i + THI_j + BxTHI_k + e_{ijk}$$

where, Y_{ijk} , independent variable; B_i , main effect of breed; THI_j , main effect of THI and $BxTHI_k$, interaction effect of breed and THI on growth, carcass and sensory variables. Sensory variables were analysed using parametric statistics, with reference to Adegbeye *et al.* (2020). Prior to analysis, the square root transformation of the sensory data was done to approximate normal distribution.

RESULTS AND DISCUSSION

Temperature-Humidity Index (THI): Based on experiential observations of weather conditions in the place of study, the two groups of poultry (native cross and IBL80 broiler) were raised during February to March (spring season) and May to June (summer months). The t_{db} during February to March, in the poultry house ranged from 19°C to 24°C, whereas for summer season it ranged from 28°C to 40°C. During the spring season, the mean temperature of the poultry house was found to be 23.68±0.39°C, while it was 34.41±0.52°C during summer. The THI and t_{db} in summer season were extremely high indicating the stressful conditions as compared to ambient season. As the t_{db} of the spring season was within the thermo-neutral zone birds raised during this period were considered as control group. The mean in-house THI of the control group was 22.45±0.37 and HS group was 32.87±0.46. Hence, the birds reared in summer season were naturally subjected to heat stress and constituted the heat stress group. The results of the present investigation regarding THI differences between control and heat stress seasons, substantiate the findings of Behura *et al.* (2016), who conducted the study on broiler breeder pullets in Odisha, India and reported that the mean effective THI during winter was 22.48, during which the maximum t_{db} was within the thermo-neutral zone (TNZ; 18°C to 24°C). Vale *et al.* (2010) observed decreased performance and high mortality in broilers older than 31 days at THI above 30.6. Purswell *et al.* (2012) observed a reduction in the performance of heavy broilers when the THI exceeded 20.8. Moura *et al* (2015) did meta-analysis aiming to study the effect of heat stress on growth in broilers at 1 to 42 days of age and reported a 36.5% reduction of body weight gain in broilers when the mean values for dry-bulb and wet-bulb temperatures were higher than 32°C and 25.7°C, respectively with average THI at 23.3.

Growth parameters: Table 3 shows the effect of different factors on growth and average daily gain (ADG) variables in native cross and synthetic broiler chicken. The effect of breed was significant (P<0.05) on all body weight and average daily gain variables. IBL80 broiler was superior in growth performance in comparison to native cross for all the growth variables. The average daily gain (ADG) analysis in two cross bred indicated that the IBL80 had higher ADG. The overall average feed conversion ratio (FCR) of IBL80 birds was higher (1.9) in comparison to native cross variety (3.3).

THI was found to have significant effect (P<0.05) on majority of weight and ADG variables, excepting the variables day old body weight and BWT7. There was marked reduction in the performance of the poultry birds that were raised under heat stress as compared to control group. The poultry birds raised under control THI period were 15.63% and 9.64% times superior in comparison to birds under heat stress with respect to BWT21 and BWT42 respectively. The average FCR of the poultry birds,

Table 3. Mean and standard error estimates indicating the effect of genotype, THI and their interaction on growth and average daily gain (ADG) variables in native cross and synthetic broiler

Breed effect	NC	IBL80		
Day Old (g)	36.71[a]±0.43 (80)	38.58[b]±0.43 (80)		
BWT7 (g)	53.69[a]±1.22 (78)	69.38[b]±1.21(76)		
BWT21 (g)	175.99[a]±4.19 (77)	236.31[b]±4.23 (73)		
BWT42 (g)	962.29[a]±16.66 (77)	1430.05 [b]±16.76 (73)		
ADG 0-3 (g)	6.63[a]±0.19 (77)	9.42[b]±0.20 (73)		
ADG 3-6 (g)	15.41[a]±0.27 (77)	23.71[b]±0.27 (73)		
ADG 0-6 (g)	22.03[a]±0.39 (77)	33.13[b]±0.27 (73)		
THI Effect	Control	Heat Stress		
Day Old (g)	37.98±0.41 (80)	37.31±0.44 (80)		
BWT7 (g)	62.65±1.17 (78)	60.43±1.25 (75)		
BWT21 (g)	221.09[a]±4.05 (77)	191.21[b]±4.35 (73)		
BWT42 (g)	1251.17[a]±16.08 (77)	1141.18[b]±17.31 (73)		
ADG 0-3 (g)	8.72[a]±0.19 (77)	7.33[b]±0.20 (73)		
ADG 3-6 (g)	20.17[a]±0.26 (77)	18.95[b]±0.28 (73)		
ADG 0-6 (g)	28.89[a]±0.38 (77)	26.28[b]±0.41 (73)		
Breed × THI	IBL80 Control	IBL80 Heat Stress	NC Control	NC Heat Stress
Day Old (g)	38.96±0.67 (40)	38.19±0.42 (40)	36.99±0.42 (40)	36.43±0.79 (40)
BWT7 (g)	68.31±1.33 (39)	70.44 ± 2.52 (37)	56.98±1.49 (39)	50.41±0.96 (39)
BWT21 (g)	265.91[a]±6.45 (38)	206.71[b]±4.18 (35)	176.27±4.42 (39)	175.71±7.18 (38)
BWT42 (g)	1588.69 [a]±28.21 (38)	1321.41[b]±18.24 (35)	963.65±15.56 (39)	960.95±29.39 (38)
ADG 0-3 (g)	10.81[a]± 0.29 (38)	8.03[b] ± 0.192 (35)	6.63 ± 0.19 (39)	6.63 ± 0.37(38)
ADG 3-6 (g)	24.90 [a]± 0.51 (38)	22.53[b] ± 0.328 (35)	15.43 ± 0.23 (39)	15.38 ± 0.43 (38)
ADG 0-6 (g)	35.71[a] ± 0.67 (38)	30.56[b] ± 0.43 (35)	22.06 ± 0.37 (39)	22.01 ± 0.69 (38)

Mean±Standard error (sample size); NC, Native cross; THI, Temperature humidity index; Means with different superscript between rows differ significantly at $P<0.05$; Values in parenthesis indicate number of observations.

belonging to both the varieties, was superior under control condition (2.6) in comparison to heat stress (2.7).

Breed×THI interaction, which indicated the genotype environment interaction, was found to be significant on all variables excepting day old body weight. Within breed analysis revealed that in case of native cross there was no significant difference between the mean values of birds maintained under control and heat stress conditions, with the birds under control THI having marginally superior mean values. In case of IBL80 broiler, the birds maintained under heat stress conditions had significantly lower mean estimates for all growth and ADG variables, excepting day old body weight. The estimates for FCR indicated better results under control conditions for both varieties in comparison to heat stress conditions. FCR the estimates were 3.0, 3.6, 1.7 and 2.1 for native cross control, native cross heat stress, IBL80 control and IBL80 heat stress groups, respectively.

Heat stress had significant effect on the body weight in poultry. The broilers under heat stress showed reduced feed intake and body weight gain as compared to control group birds which was similar to the results of Sohail *et al.* (2012) and Zuo *et al.* (2015). The reduction in body weight gain might be due to decreased appetite and lowered feed intake, a defensive mechanism for less metabolic heat production. The broilers selected for growth consume more feed leading higher metabolic heat production, thus there is greater reduction in feed intake during high temperatures (Rosa *et al.* 2007). So, in agreement with this IBL80 feed intake might be reduced greatly than native cross chicken, resulting in significant reduction of body weight in IBL80 under heat stress. The decreased body weight and increased water-to-feed ratio was observed in selected broilers under high ambient temperatures due to genotype-environment interaction (Deeb and Cahaner 2002).

Our results indicated that the effect of heat stress was detrimental on growth performance and feed conversion of IBL80 broiler in comparison to native cross poultry. The decreased body weights resulting in the poorer performance was also observed in the earlier studies (Attia *et al.* 2011, Sohail *et al.* 2012, Rimoldi *et al.* 2015). The native cross variety showed greater adaptability to stressful climatic conditions. The native cross performed well even under the heat stress conditions although the body weights were less under heat stress as in comparison to the control group, no significant difference were noticed. The results were similar to the study in China that native chickens were not significantly affected by heat stress as compared to broilers (Lu *et al.* 2007). In contrast to this, Bueno *et al.* (2020) observed that the overall performance of the slow growing broiler was better than the fast-growing broiler under cyclic heat stress. This may be due to the resistance and adaptation to altering environmental changes in slow growing birds.

Table 4. Mean and standard error estimates indicating the effect of genotype, THI and their interaction on carcass variables in native cross and synthetic broiler

Breed effect	Native Cross (N=21)	IBL80 (N=20)		
Live weight (g)	998.60^{a} ± 28.22	1444.80^{b} ± 26.55		
Dressing weight (g)	689.05^{a} ± 20.53	997.19^{b} ±19.31		
Dressing proportion	0.69±0.01	0.69±0.01		
Heart (g)	4.92^{a} ±0.18	4.28^{b}± 0.17		
Liver (g)	29.02^{a} ± 0.99	50.54^{b} ± 0.94		
Gizzard (g)	34.03^{a} ±0.90	49.94^{b}± 0.85		
Thigh (g)	106.82^{a} ± 3.46	157.84^{b}± 3.26		
Drumstick (g)	93.61^{a} ± 3.07	151.73^{b}± 2.88		
Breast (g)	128.37^{a} ±4.11	227.64^{b}± 3.87		
Back (g)	116.49^{a} ± 3.55	178.79^{b}± 3.33		
Wings (g)	55.07^{a} ± 2.02	107.27^{b}± 1.90		
Neck (g)	27.95^{a} ± 0.94	46.01^{b}± 0.88		
THI Effect	Control THI (N=20)	Heat Stress THI (N=21)		
Live weight (g)	1259.00^{a} ± 34.84	1184.403^{b} ± 16.96		
Dressing weight (g)	875.80^{a} ± 25.35	810.44^{b} ± 12.34		
Dressing proportion	0.69±0.01	0.68±0.003		
Heart (g)	7.24^{a} ± 0.23	5.96^{b} ± 0.11		
Liver (g)	43.95^{a} ± 1.23	35.62^{b} ± 0.60		
Gizzard (g)	45.38^{a} ± 1.11	38.59^{b} ± 0.54		
Thigh (g)	132.26 ± 4.28	132.39 ± 2.08		
Drumstick (g)	125.30 ± 3.78	120.04 ± 1.84		
Breast (g)	189.68^{a} ± 5.07	166.33^{b} ± 2.47		
Back (g)	151.78^{a} ± 4.38	143.52^{b} ± 2.13		
Wings (g)	83.66^{a} ± 2.49	78.69^{b} ± 1.22		
Neck (g)	35.46^{a} ± 1.16	38.50^{b} ± 0.56		
Breed × THI	NC Control *(N=10)*	NC HS *(N=11)*	IBL80 Control *(N=10)*	IBL80 HS *(N=10)*
Live weight (g)	996.00± 19.09	1001.20± 10.67	1522.00^{a}± 59.83	1367.16^{b}± 24.03
Dressing weight (g)	695.60±35.84	682.50±20.04	1056.16^{a}±35.84	938.39^{b}±14.40
Dressing proportion	0.69 ± 0.08	0.68 ± 0.04	0.69 ± 0.01	0.69 ± 0.004
Heart (g)	4.99 ± 0.14	4.85 ± 0.08	9.49^{a} ± 0.39	7.07^{b} ± 0.16
Liver (g)	30.19^{a}± 0.57	27.85^{b} ± 0.32	57.69^{a} ± 2.13	43.38^{b} ± 0.86
Gizzard (g)	34.27 ± 0.76	33.78 ± 0.43	56.48^{a} ± 1.83	43.39^{b} ± 0.76
Thigh (g)	101.53^{a}± 2.46	112.11^{b} ± 1.38	163.00 ± 7.32	152.69± 2.94
Drumstick (g)	93.22 ± 2.00	94.00 ± 1.12	157.39 ± 6.51	146.07 ± 2.62
Breast (g)	133.88^{a}± 2.89	122.85^{b} ± 1.62	245.48^{a} ± 8.69	209.81^{b} ± 3.49
Back (g)	111.33^{a} ± 3.52	121.67^{b} ± 1.97	192.22^{a} ± 7.26	165.37^{b} ± 2.92
Wings (g)	54.46 ± 1.46	55.69 ± 0.82	112.86^{a} ± 4.27	101.68^{b} ± 1.72
Neck (g)	27.59± 1.04	28.31 ± 0.58	43.33^{a} ± 1.94	48.68^{b} ± 0.76

NC, Native cross; HS, Heat stress; THI, Temperature humidity index; Means with different superscript between rows differ significantly at P<0.05; Values in parenthesis indicate number of observations.

Carcass traits: Table 4 shows the effect of different factors on carcass variables in native cross and synthetic broiler chicken. General linear model analysis revealed that apart from carcass yield, the effect of breed was significant on all the carcass quality traits. IBL80 being a fast-growing broiler, had significantly higher yield as compared to native cross in all the carcass traits.

THI when considered as a major effect, had a significant effect (P<0.05) on carcass traits. The birds raised under heat stress THI, had lower yield with respect to giblets and meat cutoff variables. However, no significant difference between control and heat stress THI, was observed on carcass yield, thigh and drumstick variables.

Apart from carcass yield and drumstick yield, breed×THI interaction had a highly significant effect (P<0.01) on all carcass traits. In native cross liver, thigh, breast and back had significant differences (P<0.05) in weights, between control and heat stress THI, there was reduction in liver and breast weight and increase in weights of thigh and back meat cuts. In case of IBL80 broiler variety, highly significant (P<0.01) reduction in weight of giblets and meat cutoffs including heart, liver, gizzard, breast, back, wings and increase in neck weight was observed under heat stress.

Table 5. Mean and standard error estimates indicating the effect of genotype, THI and their interaction on sensory attributes in native cross and synthetic broiler

Breed effect	NC *(N=12)*	IBL80 *(N=12)*		
Colour & Appearance	7.19[a]±0.04	6.98[b]±0.04		
Flavour	7.06±0.04	7.10±0.04		
Juiciness	7.08±0.05	7.09±0.05		
Texture	7.20[a]±0.05	6.95[b]±0.05		
Overall acceptability	7.12±0.03	7.06±0.03		
Cooking loss (%)	4.8[a]	6.8[b]		
THI Effect	Control *(N=12)*	Heat Stress *(N=12)*		
Colour & Appearance	7.22[a]±0.04	6.96[b]±0.04		
Flavour	7.20[a]±0.04	6.95[b]±0.04		
Juiciness	7.21[a]±0.05	6.97[b]±0.05		
Texture	7.23[a]±0.05	6.93[b]±0.05		
Overall acceptability	7.22[a]±0.03	6.96[b]±0.03		
Cooking loss (%)	5.5[a]	7.3[b]		
Breed × THI	NC Control *(N=6)*	NC Heat Stress *(N=6)*	IBL80 Control *(N=6)*	IBL80 Heat Stress *(N=6)*
Colour& Appearance	7.25±0.05	7.13±0.05	7.18[a]±0.05	6.78[b]±0.05
Flavour	7.08±0.06	7.03±0.06	7.31[a]±0.06	6.88[b]±0.06
Juiciness	7.12±0.07	7.05±0.07	7.30[a]±0.07	6.88[b]±0.07
Texture	7.25±0.06	7.15±0.06	7.20[a]±0.06	6.70[b]±0.06
Overall acceptability	7.17±0.04	7.07±0.04	7.27[a]±0.04	6.85[b]±0.04
Cooking loss (%)	4.0[a]	5.5[a]	6.3[b]	7.5[b]

NC, Native cross; PD, Per cent difference; THI, Temperature humidity index; Means with different superscript between rows differ significantly at P<0.05; Values in parenthesis indicate number of observations.

The carcass yield was higher for commercial broiler than the native cross chicken, as these were fast growing broilers which could have resulted in higher yield. Breast weight, carcass weight and carcass yield were higher in commercial broilers whereas drumstick weight was higher in native cross (Pandey *et al.* 2018). Sarsenbek *et al.* (2013) also found that the commercial broilers have greater carcass yields than the native chickens of China. This may be due to high breast muscle proportion of commercial broilers as compared to native chicken. Berri *et al.* (2001) observed that continuous selection of parent birds had led to higher body weight and better carcass yield of broiler varieties than that of unselected birds such as the native chicken, which might also be the reason for higher yield in IBL80 than native cross, studied in the present experiment.

Attia *et al.* (2011) reported that there was significant reduction in carcass yield, liver and giblets weights due to heat stress, however, no significant reduction in heart and gizzard weight. On exposure to heat stress the broilers showed decreased breast, liver, heart weights and increased back and wings yield, without affecting the thigh and drumstick yield (Zeferino *et al.* 2015). The fast-growing broilers showed significant reduction in heart weight under heat stress but no significant reduction in heart weight was observed in slow growing broilers (Zhang *et al.* 2017). Chronic heat stress had decreased the proportion of breast muscle and increased proportion of thigh muscle relative to body weight (Zhang *et al*. 2012). Similar to this finding, we found a significant increase in thigh weight under heat stress in native cross but no such variation was observed in broiler variety. Rosa *et al.* (2007) observed that high ambient temperatures had a greater effect on selected broilers than the unselected broilers.

Sensory attributes: Table 5 shows the effect of different factors on sensory attributes in native cross and synthetic broiler chicken. Sensory attributes of meat products considered for analysis *viz*. colour and appearance, flavour, juiciness, texture, overall acceptability and cooking loss were significantly affected (P<0.01) by the breed of chicken. Meat nuggets prepared from native cross chicken were found to be significantly superior (P<0.01) with respect to colour, texture and cooking loss.

THI had a highly significant effect (P<0.05) on all the sensory parameters and the nuggets prepared from poultry raised under control THI, were superior to those exposed to heat stress.

Breed×THI interaction had a significant effect on all the variables. Within breed analysis revealed that there was no significant difference in the sensory attributes of native cross poultry whether raised under control or heat stress THI conditions. There was significant (P<0.01) reduction in sensory attributes and higher cooking loss in case of products prepared from IBL80 chicken raised under heat stress.

Pandey *et al.* (2018) studied the sensory attributes of meat in native cross and commercial broiler and found no significant differences and both the meats had good consumer acceptability. In a similar study in China, yielded better results for Chinese native chicken with respect to cooking loss and drip loss, whereas greater carcass yields were achieved in commercial broilers. Sarsenbek *et al.* (2013) proposed that the major factor affecting the quality of meat might be due to varying genetics. Devatkal *et al.* (2019) in a study on slow growing broiler found that sensory attributes of meat and meat products were like that of the commercial broilers. Haunshi *et al.* (2010) observed that the overall acceptability of meat of Miri and Mizo-local native chicken was numerically better than those of fast-growing improved chicken varieties. In agreement with the above studies, the native cross was similar in sensory attributes of broiler whereas superior in colour, texture and cooking loss.

The deterioration of meat quality at higher temperatures has been reported in previous studies. There was reduction in meat quality attributes like pH, colour, water holding capacity, sensory attributes of birds that were raised under high ambient temperatures. This was due to the oxidative stress resulting in lipid and protein oxidations altering the meat quality (Khan *et al.* 2018). Shao *et al.* (2018) observed the reduction in weights and physico-chemical properties in thigh and breast muscles of chicken exposed to heat stress. Chronic heat stress increases the lactate production by accelerating the glycolysis resulting in decline in the *p*H affecting the meat quality (Zahang *et al.* 2012). The results indicated that due to the climate resilient body physiology of the native cross chicken, the sensory attributes of meat were preserved even under stress conditions. Heat stress also had a significant effect on growth, carcass traits and meat quality. Native cross chicken as compared to IBL80 were not significantly affected by heat stress which might be due to their superior adaptability and heat tolerance potential. In the present study, on comparative assessment of the birds raised under heat stress revealed that the sensory attributes of meat products prepared from native chicken were higher than IBL80 chicken.

The results of the present study indicated that though the fast-growing synthetic broilers were superior in their growth performance and carcass yield, it was the native cross chicken which had greater heat tolerance potential. The sensory evaluations of meat products prepared from native cross chicken had higher consumer acceptance and were superior with respect to colour, texture and cooking loss. Comparative assessment of the THI in the spring and summer months revealed that the poultry were exposed to seasonal heat stress during the summer months. In comparison to native chicken in fast growing synthetic broilers, seasonal heat stress had greater effect on the growth performance, carcass yield and sensory properties of the poultry meat.

ACKNOWLEDGEMENTS

Authors are thankful to Directorate Livestock Farms, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India, for providing necessary logistics and support. The research was funded under ICAR7 scheme: 'AICRP on Poultry Breeding Project' and RKVY-9, B-1 scheme: 'Processing of slaughterhouse by-products for the development and storage stability of pet foods.'

REFERENCES

Adegbeye M J, Asaniyan E K, Igbalajobi O A, Damilola S O, Elghandour M M M Y, Salem A Z M and Falade T T. 2020. Influence of selected plant seeds on the performance, carcass characteristics, sensory evaluation, and economics of broiler chicken. *Tropical Animal Health and Production* **52**(3): 1005–12.

Attia Y A, Hassan R A, Tag El Din, A E and 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): 744–55.

Behura N C, Kumar F, Samal L, Sethy K, Behera K and Nayak G D. 2016. Use of Temperature-Humidity Index (THI) in energy modeling for broiler breeder pullets in hot and humid climatic conditions. *Journal of Livestock Science* **7**: 75–83.

Berri C, Wacrenier N, Millet N and Le Bihan-Duval E. 2001. Effect of selection for improved body composition on muscle and meat characteristics of broilers from experimental and commercial lines. *Poultry Science* **80**(7): 833–38.

Bueno J P R, Gotardo L R M, Dos Santos A M, Litz F H, Olivieri O C L, Alves R L O R, Moraes C A and de Mattos Nascimento M R B. 2020. Effect of cyclic heat stress on thyroidal hormones, thyroid histology, and performance of two broiler strains. *International Journal of Biometeorology* **64**(7): 1125–32.

Buffington D, Collazo-Arochu A, Canton G H, Pritt D, Thatcher W W and Collier R J. 1981. Black globe-humidity index (BGHI) as comfort equation for dairy cows. *Transactions - American Society of Agricultural Engineers* **24**: 711–14.

Deeb N and 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 non selected parents under normal and high ambient temperatures. *Poultry Science* **81**(3): 293–301.

Devatkal S K, Naveena B M and Kotaiah T. 2019. Quality, composition, and consumer evaluation of meat from slow-growing broilers relative to commercial broilers. *Poultry Science* **98**(11): 6177–86.

Haunshi S, Doley S and Kadirvel G. 2010. Comparative studies on egg, meat, and semen qualities of native and improved chicken varieties developed for backyard poultry production. *Tropical Animal Health and Production* **42**: 1013–19.

Keeton J T. 1983. Effects of fat and NaCl/phosphate levels on the chemical and sensory properties of pork patties *Journal of Food Science* **48**(3): 878–81.

Khan A Z, Kumbhar S, Liu Y, Hamid M, Pan C, Nido S A, Parveen F and Huang K. 2018. Dietary supplementation of selenium-enriched probiotics enhances meat quality of broiler chickens (*Gallus gallus domesticus*) raised under high ambient temperature. *Biological trace element research* **182**(2): 328–38.

Lu Q, Wen J and Zhang H. 2007. Effect of chronic heat exposure on fat deposition and meat quality in two genetic types of chicken. *Poultry science* **86**(6): 1059–64.

Moura D J, Vercellino R A, Santos J P A and Vale M M. 2015. Heat stress impact on weight gain in broiler chickens: a meta-analytical study of environmental factor that impact production losses. *ASABE 1st Climate Change Symposium: Adaptation and Mitigation*, Proceedings of the 3-5 May Conference, Chicago Illinois, USA, Published by ASABE St. Joseph Mich. Publication date May 3, 2015. ASABE Publication number: 701P0315usb.

Naik S, Dash S K, Dubey P P, Arora J S, Sahoo S K, Kaur S, Malhotra P and Bansal B K. 2019. AIREML estimation of genetic parameters and study of factors affecting growth and fertility performance of sire line of IBL-80 broiler chicken. *Indian Journal of Animal Research* **53**(10): 1281–86.

Padhi M K. 2016. Importance of indigenous breeds of chicken for rural economy and their improvements for higher production performance. *Scientifica* 1–9.

Pandey S S, Behura N C, Samal L, Pati P K and Nayak G D. 2018. Comparative evaluation of carcass characteristics and physico-chemical and sensory attributes of meat of Native×CSFL crossbred chickens and commercial broilers. *International Journal of Livestock Research* **8**(6): 194–202.

Pawar S S, Sajjanar B, Lonkar V D, Kurade N P, Kadam A S, Nirmal A V, Brahmane M P and Bal S K. 2016. Assessing and mitigating the impact of heat stress on poultry. *Advances in Animal and Veterinary Science* **4**(6): 332–41.

Purswell J L, Dozier III W A, Olanrewaju H A, Davis J D, Xin H and Gates R S. 2012. Effect of temperature-humidity index on live performance in broiler chickens grown from 49 to 63 days of age. *IX International Livestock Environment Symposium (ILES IX)* (p. 3). American Society of Agricultural and Biological Engineers.

Rimoldi S, Lasagna E, Sarti F M, Marelli S P, Cozzi M C, Bernardini G and Terova G. 2015. Expression profile of six stress-related genes and productive performances of fast and slow growing broiler strains reared under heat stress conditions. *Meta Gene* **6**: 17–25.

Rindhe S N, Chatli M K, Wagh R V, Kumar P, Malav O P and Mehta N. 2018. Development and quality of fiber enriched functional spent hen nuggets incorporated with hydrated wheat bran. *International Journal of Current Microbiology and Applied Sciences* **7**(12): 3331– 45.

Rosa P S, Faria Filho D E, Dahlke F, Vieira B S, Macari M and Furlan R L. 2007. Performance and carcass characteristics of broiler chickens with different growth potential and submitted to heat stress. *Brazilian Journal of Poultry Science* **9**(3): 181–86.

Sarsenbek A, Wang T, Zhao J K and Jiang W. 2013. Comparison of carcass yields and meat quality between Baicheng-You chickens and Arbor Acres broilers. *Poultry Science* **92**(10): 2776–82.

Shao D, Wang Q, Hu Y, Shi S and Tong H. 2018. Effects of cyclic heat stress on the phenotypic response, meat quality and muscle glycolysis of breasts and thighs of yellow-feather broilers. *Italian Journal of Animal Science* **18**(1): 301–08.

Sohail M U, Hume M E, Byrd J A, Nisbet D J, Ijaz A, Sohail A, Shabbir M Z and 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): 2235–40.

Tao X and Xin H. 2003. Acute synergistic effects of air temperature, humidity, and velocity on homeostasis of market–size broilers. *Transactions of the American Society of Agricultural Engineers* **46**(2): 491.

Vale M M, Moura D J, Naas I A and Pereira D F. 2010. Characterization of heat waves affecting mortality rates of broilers between 29 Days and market age. *Brazilian Journal of Poultry Science* **12**(4): 279–85.

Zaboli G, Huang X, Feng X and Ahn D U. 2019. How can heat stress affect chicken meat quality? – A review. *Poultry Science* **98**: 1551–56.

Zeferino C P, Komiyama C M, Pelícia V C, Fascina V B, Aoyagi M M, Coutinho L L, Sartori J R and Moura A S A M T. 2016. Carcass and meat quality traits of chickens fed diets concurrently supplemented with vitamins C and E under constant heat stress. *Animal* **10**(1): 163–71.

Zhang Z Y, Jia G Q, Zuo J J, Zhang Y, Lei J, Ren L and 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): 2931–37.

Zhang J, Schmidt C J and Lamont S J. 2017. Transcriptome analysis reveals potential mechanisms underlying differential heart development in fast-and slow-growing broilers under heat stress. *BMC Genomics* **18**(1): 1–15.

Zuo J, Xu M, Abdullahi Y A, Ma L, Zhang Z, Feng D. 2015. Constant heat stress reduces skeletal muscle protein deposition in broilers. *Journal of the Science of Food and Agriculture* **95**(2): 429–36.