Pakistan J. Zool., vol. 50(2), pp 429-435, 2018. **DOI**: http://dx.doi.org/10.17582/journal.pjz/2018.50.2.429.435

An Assessment of the Growth and Profitability Potential of Meat-Type Broiler Strains under High Ambient Temperature

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Article Information
Received 17 March 2017
Revised 04 May 2017
Accepted 24 May 2017
Available online 25 January 2018

Authors' Contribution
ZR conducted the study, NC designed the study and RUK edited and corrected the paper. SK and MSQ designed the study.

Key words
Broiler strains, High ambient temperature, Thermoneutral zone, Growth performance.

ABSTRACT

The present study was planned to study the performance and potential profitability of four commercial broiler strains in two different temperature zones *i.e.,* thermoneutral zone (TN) and high ambient temperature zone (HAT) group. Day-old broiler chicks (n=242) of four different commercial strains (Ross, Hubbard, Cobb and Arber Acer) were placed in brooding room for the first two weeks and then chicks were divided into two groups: TN and HAT. Chicks in TN group were housed at constant room temperature (25ºC ± 2ºC and RH 65 ±5%) while chicks in HAT group were kept at high ambient temperature. In the TN zone, significantly (P< 0.05) higher feed intake and weight gain were recorded on day 21, 28, 35 and 42. Feed intake in TN zone was 3.02, 9.79, 9.74 and 12.14 % higher than feed intake recorded on the corresponding days in HAT while weight gain in thermoneutral zone was 9.28, 15.25, 17.48, and 15.62 % higher than weight gain recorded on the corresponding days in HAT. On day 21, 28, 35 and 42 significantly (P<0.05) lower (good) FCR was recorded in TN zone as compared to HAT zone. Higher mortality was recorded in HAT zone as compared to thermoneutral zone. Significantly (P< 0.05) higher net return per chick was recorded in TN zone as compared to HAT zone. Ross and Arber Acer performed better in terms of feed intake, weight gain, FCR and are more economical to be reared in hot summer season in tropical climates of Pakistan, while Cobb and Hubbard strains performed better in TN environment.

INTRODUCTION

Broiler strains most commonly reared in Pakistan are Ross, Hubbard, Cobb and Arber Acre. Various performance traits of these strains such as production potentials, resistance to various diseases and adaptability of these strains in high environmental temperature may adversely affect the farmer's preferences. The information about the performance and management of these strains in the literature of breeder's company not necessarily apply to regional environmental conditions of any particular country (Farran *et al*., 2000).

High ambient temperature (HAT) is a life-threatening factor for commercial broiler production particularly in hot climates, where poultry producers cannot afford expensive artificial control of high temperature in broiler shed (Deeb and Cahaner, 2001; Khan *et al*., 2014). High temperature causes economic losses in broiler production due to the poor performance, lower weight gain, and poor feed efficiency (Zhang *et al*., 2012; Chand *et al*., 2016). These adverse effects of high ambient temperature are more prominent in chicken genotype having higher body weight and rapid growth than in those with slower growth and lower body weight (Razuki and Al-Rawi, 2007). Different broiler strains respond differently to different environments. The rearing of unsuitable genotype in hot area may result in large economic losses due to the reduced growth, decreased protein gains and higher mortality (Razuki and Al-Rawi, 2007; Berrong and Washburn, 1998).

The testing of different broiler strains in hot climate may provide more useful information relating to specific broiler strains that can produce well in hot and thermo neutral (TN) climates. In view of the above consideration, the present study was conducted to investigate the economic suitability of four commercial broiler strains (Ross, Hubbard, Cobb and Arber Acer) reared in thermo neutral and high ambient temperature (summer season).

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0030-9923/2018/0002-0429 $ 9.00/0

MATERIALS AND METHODS

The trial was conducted in a completely randomized design with two temperature zones and four broiler strains. A total of 240 day old broiler chicks of four commercial broiler strains (Ross, Hubbard, Cobb and Arber Acres) of the same age and size were used for the study. In first two weeks, chicks were placed in brooding room and then divided into two groups: thermo neutral zone (TN) and high ambient temperature (HAT). Chicks were fed standard ration as shown in Table I and the chemical composition is given in Table II. Chicks in TN group were housed at constant room temperature (25ºC ± 2ºC and RH 65 ±5%) while chicks in HAT group were kept at high ambient temperature as shown in Table III. Both the groups were kept in two different rooms which were identical in term of size, construction materials and equipment. Chicks in each group were further divided into four sub groups *i.e.,* TN-Ross, TN-Hubbard, TN-Cobb, TN-Arber Acer and HAT-Ross, HAT-Hubbard, HAT-Cobb, HAT-Arber Acer. Each sub group was further subdivided into four replicates having ten chicks per replicate. Feed and water was provided ad libitum.

Performance measurement

Chicks were weighed initially and weekly at seven days interval for six weeks and total body weight gain (BWG) was calculated at the end of trial. Daily feed intake was calculated by subtracting the quantity of feed left from offered. Feed conversion ratio (FCR) was determined on weekly basis. Mortality was recorded during experiment. Economics of each strain used in this trial was calculated in terms of feed cost, gross return and net income. Total expenditure including feed cost per chick plus day old chick price and cost of medicine were included in the total cost per chick. Gross return per chick was computed on per kg (live weight basis) basis according to the market price. Net return was measured by subtracting cost per chick from gross return per chick.

Statistical analysis

Data was subjected to two-way analysis of variance with zone of temperatures and strain as the main effects. The following model was used:

$$Yjkm = \mu + \beta j + \alpha k + \gamma l + ejklm$$

Where, μ is population mean, βj is treatment effect (treatment comprise thermo neutral (TN) zone and high ambient temperature (HAT) zone), αk is the strain effect (four commercial broiler strains Ross, Hubbard, Cobb and Arber Acres), γl is the strain by temperature zone interaction, eijklm is the random error associated to k^{th} chicks and j^{th} is treatment in experimental unit.

Least significant test was used to compare the differences among treatment means. All statistical analysis was carried out using statistical package SAS (1992).

Table I.- Ingredients of starter and finisher diets (%).

Ingredient name	Starter	Finisher
Corn	35	35.5
Wheat	0	7
Rice	22	20
Rice polishing	2	4
Canola meal	10	10
Sun flower meal	2	1.75
Rapeseed meal	3.5	2
Fish meal	11	7
Maize gluten meal 60%	7.5	6
Di calcium phosphate	2	1.35
Molasses	3	3.5
Vitamin mineral premix	1	1
DL Methonoine	0.20	0.23
Lime stone	0.60	0.5
Sodium chloride	0.20	0.17
Total	100	100

Table II.- Chemical composition of starter and finisher ration.

Parameter	Starter	Finisher
Crude protein (%)	22.96	20.50
Crude fiber (%)	4.75	5.30
Either extract (%)	4.28	4.17
Calcium (%)	1.27	8.90
Phosphorus (%)	0.85	1.26
Lysine (%)	1.26	0.85
Methionine and Cysteine (%)	0.77	1.26
Tryptophan (%)	0.21	0.63
Metabolizable energy (Kcal/kg)	2935	2918

RESULTS

Mean feed intake per chick of four different broiler strains reared in TN and HAT zone is given in Table IV. On day 28, in TN zone, significantly higher (P< 0.05) feed intake was found in Hubbard and Cobb strains, while in HAT zone, higher (P< 0.05) feed intake was recorded in Ross and Arber Acer. On day 35, similar trend was recorded in TN and HAT zones. On day 42, in TN zone, no significant difference was found in feed intake. On day 42, in HAT zone, higher feed intake was recorded in Ross followed by Arber Acer and Cobb, while lowest feed intake was recorded in Hubbard. In TN zone, over all feed intake was significantly (P<0.05) higher in Cobb and Hubbard,

Table III.- Temperature (°C) of high ambient temperature group during experimental period.

Age (Weeks)	Temperature (°C)								RH%	
	08:00 am	12:00 pm	4:00 pm	8:00 pm	12:00 am	04:00 am	Min	Max	Min	Max
1	35	35	35	35	35	35	35	35	43	58
2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	38	62
3	31	37.5	33.76	31.44	30.37	28	28	37.5	45	64
4	29	35	31	29	28.11	27.8	27.8	35	43.56	62.22
5	27.66	32.2	30.9	28.71	27.11	26.5	26.5	32.2	55.66	71.67
6	30	36.77	32.95	29.35	28.66	27.4	27.4	36.7	42.44	61.33

Table IV.- Feed intake of different broilers strain reared under thermo neutral and high ambient temperature zones.

Zone	Strain	Day 21	Day 28	Day 35	Day 42	Total
TN zone	Ross	688.22±4.08	815^{b}±12.87	978.5^{b}±10.2	1103.5^{a} ±18.13	3585.2^{b}±20.05
	Hubbard	694.77±3.32	857.5^{a}±5.67	1019^{a}±9.85	1123.8^{a} ±5.54	3695^{a} ± 14.78
	Cobb	672.0±9.62	862.5^{a}±3.06	1027.3^{a} ±8.75	1143.5^{a}±18.31	3705.3^{a}±21.92
	Arber Acer	649.03±14.88	819^{b}±3.08	987.2^{b}±7.99	1087.8^{ab}±17.93	3543^{b} ± 20.38
HAT zone	Ross	640.62±10.40	773.75^{c}±4.47	917^{c} ±8.65	1032^{bc}±15.29	3363.4^{c}±17.05
	Hubbard	675.2±13.40	737.5^{d}±4.78	886^{d}±9.99	915^{e}±29.01	3213.8^{d}±28.74
	Cobb	652.12±8.12	742.5^{d}±11.086	895^{cd}±11.22	957.8^{de}±27.68	3247.4^{d}±32.74
	Arber Acer	654.44±8.78	772^{c} ±13.44	923.2^{c}±9.41	1012.6^{cd}±19.04	3362.3^{c}±29.59

Mean with different superscript in the same column are significantly different (P<0.05)

Table V.- Weight gain of different broilers strain reared under thermo neutral and high ambient temperature zones.

Zone	Strain	Day 21	Day 28	Day 35	Day 42	Total
TN zone	Ross	372.9± 9.06	458^{b}±9.84	463.75^{b}±6.77	433.5^{b}±3.66	1728.2^{b} ± 13.5
	Hubbard	393±17.03	495.5^{a}±7.84	495.25^{a}±7.85	454.3^{ab}±11.12	1838.1^{a}± 15.7
	Cobb	373.5± 11.63	489.1^{a}±6.14	501.75^{a}±4.76	460.8^{a}±8.93	1825.3^{a} ± 5.40
	Arber Acer	361.5±12.41	448.5^{b} ±5.90	474.5^{b}±8.21	439.4^{ab} ±5.52	1723.9^{b}± 16.7
HAT zone	Ross	336.94± 7.29	415.0^{c}±3.10	405.5^{c}±6.54	404^{c}±5.84	1561.4^{c}± 7.61
	Hubbard	341.5±3.77	381.75^{d}±3.70	385^{d}±5.64	352^{d}±11.40	1460.3^{d}±11.12
	Cobb	340.7± 3.96	383.5^{d}±2.95	393.75^{cd}±7.64	359^{d}±7.68	1477.5^{d}± 3.92
	Arber Acer	342.75±10.12	422.2^{c} ±6.79	412.7^{c}±7.10	393.25^{d}±4.98	1571^{c} ± 21.9

Mean with different superscript in the same column are significantly different (P<0.05).

while in HAT zone, significantly higher (P< 0.05) overall feed intake was recorded in Ross and Arber.

Mean weight gains per chick of four different broiler strains reared in TN and HAT zone is given in Table V. Temperature zone significantly (P< 0.05) affected weigh gain in different broiler strains on all recorded stages except day 28. On day 28, in thermo neutral zone, significantly higher (P<0.05) weight gain was recorded in Cobb and Hubbard strains followed by Ross and Arber Acer. On day 28, in HAT zone, higher (P< 0.05) weight gain was found in Arber Acer and Ross followed by Cobb and Hubbard strains. On day 35, in TN zone, significantly (P< 0.05) higher weight gain was found in Cobb and Hubbard. On day 35, in HAT zone, significantly (P< 0.05) higher weight gain was recorded in Arber Acer and Ross followed by Cobb. On day 42, in TN zone, weight gain was higher in Cobb followed by Hubbard and Arber Acer, while lowest weight gain was recorded in Ross. On day 42, in HAT zone, significantly (P< 0.05) higher weight gain was recorded in Ross, while it was lower in all other strains. Total weight gain was significantly (P< 0.05) higher in Hubbard and Cobb in thermo neutral zone, while higher total weight gain was recorded in Ross and Arber Acer in HAT zone (Table V).

Table VI.- Feed conversion ratio (FCR) of different broilers strain reared in thermo neutral and high ambient temperature zones.

Zone	Strain	Day 21	Day 28	Day 35	Day 42	Total
TN zone	Ross	1.84±0.034	1.78^{cd}±0.02	2.11^{b} ±0.02	2.54^{ab}±0.02	2.07^{c}±0.013
	Hubbard	1.77±0.071	1.73^{d}±0.016	2.05^{b} ±0.01	2.47^{b}±0.059	2.01^{d}±0.015
	Cobb	1.80±0.10	1.76^{cd}±0.02	2.04^{b} ±0.01	2.48^{b} ±0.06	2.03^{cd}±0.010
	Arber Acer	1.79±0.046	1.82^{b}±0.03	2.08^{b}±0.02	2.46^{b} ±0.059	2.05^{cd}±0.029
HAT zone	Ross	1.90±0.058	1.86^{ab}±0.023	2.26^{a}±0.01	2.55^{ab}±0.022	2.15^{ab}± 0.006
	Hubbard	1.97±0.060	1.93^{a}±0.007	2.30^{a} ±0.01	2.60^{ab}±0.043	2.20^{a}± 0.012
	Cobb	1.91±0.033	1.93^{a}±0.036	2.27^{a} ±0.01	2.66^{a}±0.03	2.19^{a} ± 0.022
	Arber Acer	1.91±0.040	1.82^{bc}±0.038	2.23^{a} ±0.01	2.57^{ab} ±0.03	2.14^{b}± 0.030

Mean with different superscript in the same column are significantly different (P<0.05).

Table VII.- Mean (±SE) mortality (%), cost (Rs.), gross income (Rs.) and net income (Rs.) of different broilers strain reared under thermo neutral (TN) and high ambient temperature (HAT) zones.

Zone	Strain	Overall mortality	Cost/chick	Gross income / chick	Net income / chick
TN zone	Ross	5^{bc}±0.027	222.90^{a}±3.24	276.50^{a}±2.83	53.59^{ab}±3.68
	Hubbard	2.50^{c}±0.01	211.92^{bc}±3.26	273.12^{a}±2.83	61.19^{a}±0.73
	Cobb	0.00^{c}±0.00	227.55^{a}±2.97	285.99^{a}±2.87	58.43^{a}±2.77
	Arber Acer	5^{bc}±0.04	219.91^{ab}±1.65	274.45^{a}±3.28	54.53^{ab}±4.11
HAT zone	Ross	7.50^{bc}±0.13	208.42^{C}±5.65	252.99^{b}±8.0	44.57^{b}±2.96
	Hubbard	12.50^{ab}±0.04	188.42^{d}±1.74	219.16^{c}±3.70	26.28^{c}±2.74
	Cobb	17.50^{a}±0.01	190.52^{d}±2.89	214.70^{c}±5.71	28.63^{c}±5.82
	Arber Acer	7.5^{bc}±1.11	206.87^{C}±3.36	251.93^{b}±6.86	45.05^{b}±8.02

Mean with different superscript in the same column are significantly different (P<0.05).

Mean FCR per chick of four different broiler strains reared inTN zone and HAT zone is given in Table VI. On day 28, in TN zone, significantly (P< 0.05) lower FCR was recorded in Hubbard. On day 28, in HAT zone, significantly (P< 0.05) lower FCR was recorded in Arber Acer. On day 35, FCR was significantly lower and the same in all strains in TN zone, while it was significantly (P<0.05) higher and the same in all the four strains in HAT zone. On day 42, in TN zone significantly (P<0.05) lower FCR was recorded in difference were recorded in FCR. On day 42, in HAT zone, no significant difference was recorded in mean FCR. Overall FCR in TN zone was significantly lower (good) in Hubbard followed by Cobb and Arber Acer, while overall FCR in TN zone was the poor (high) in Ross.

In HAT zone, the lowest overall FCR was recorded in Arber Acer followed by Ross, Hubbard and Cobb. Overall FCR was also significantly (P< 0.05) lower (good) in TN zone as compare to HAT zone. Overall mortality of four different broiler strains reared in TN and HAT zone is presented in Table VII. In TN zone, no significant difference was found among the strains. In HAT zone, higher (P< 0.05) mortality was recorded in Cobb followed by Hubbard, Ross and Arber Acer.

Economics of the experimental chicks in terms of feed price, gross return and net return per chick is given in Table VII. In TN zone, significantly (P< 0.05) higher feed price was recorded for Ross and Cobb followed by Arber Acer and Hubbard. Feed cost of Arber Acer in TN zone was not different from Ross and Cobb. In HAT zone, significantly (P< 0.05) higher feed cost per chick was recorded in Ross and Arber Acer. Gross return per chick was significantly higher and same in all the four strains in TN zone. In HAT zone, significantly (P< 0.05) higher gross return per chicks was recorded in Ross and Arber Acer. In TN zone, significantly higher net return per chick was recorded in Hubbard and Cobb. In HAT zone, significantly (P< 0.05) higher net income per chick was recorded in Ross and Arber Acer. Net return per chick for Hubbard strain in HAT zone was not different from Cobb.

DISCUSSION

Under high ambient temperature, there is heat exchanged between the birds and their surrounding environment (Al-Fataftah and Abu-Dieyeh, 2007). Birds lose heat to their surrounding environments mostly by evaporative heat loss and gain heat from environment at the same time. In addition, heat is produced by feed metabolism. The birds use their physiological mechanism to reduce heat stress during high environmental temperature. Our results are in line with findings of Lara and Rostagno (2013) who found that birds kept under high ambient temperature, consumed 16.4% less feed compared with TN group at 42 days of age. Similarly, Quinteiro-Filho *et al*. (2010) reported decreased feed consumption in broilers kept at high ambient temperature. Niu *et al*. (2009) reported decreased feed consumption in broilers subjected to cyclic heat stress (23.9 to 38°C) which is in support to our findings. Al-Fataftah and Abu-Dieyeh (2007) found that increasing temperature decreased feed consumption after four weeks trial by 4.0, 12.4 and 28%, respectively as compared to feed consumption in TN zone (24-28°C).

Under optimum condition, Iqbal et al. (2012) reported that Hybro PN consumed significantly less feed compared to Arber Acer, Ross and Hubbard strains. Similarly, Razuki et al., (2011) reported that Hubbard strain consumed more feed then Cobb, Ross and Lohmann strains in heat stress.

The depression in body weight gain at high environmental temperature might be due to decreased feed consumption, inefficient digestion (Hai et el., 2000), decreased concentrations of growth hormones (T3 and T4) in hot environments (Elnagar *et al*., 2010), reduced enzymatic activities of amylase, trypsin and chymotrypsin (Abu-Dieyeh, 2006), decreased plasma amino acid and energy supply (Temim *et al*., 2000). At high ambient temperature protein synthesis is reduced (Geraert *et al*., 1996) and metabolism is impaired (Farrell and Swain, 1978), which might be responsible for reduced growth rate at HAT zone.Strains that perform better at optimum ambient temperature may not maintain their superiority for growth in HAT (Razuki and Al-Rawi, 2007). Moreover, differences between strains in their growth at high ambient temperature are related to their genetic potential for feed intake and growth rate (Razuki *et al*., 2011) which may be responsible for better performance of Ross and Arber Acer under high temperature zone. Tawfeek *et al*. (2014) reported 35.47% less body weight for birds kept under high ambient temperature as compared with thermo neutral group at 42 days of age which is supported to our findings. Similarly, Lara and Rostagno (2013) reported 32.6% less weight gain under high ambient temperature as compared with thermo neutral group. Ruzaki and Al-Rawi. (2007) reported that strains that performs better in optimum temperature cannot maintain superiority for growth in high ambient temperature.

The decreased body weight may not only be due to the lower feed intake, but also to a direct effect of environmental temperature on broiler physiology and metabolism (Tawfeek *et al*., 2014). Our results are in line with findings of Lara and Rostagno (2013), Quinteiro-Filho *et al*. (2010), Niu *et al*. (2009), Al-Fataftah and Abu-Dieyeh (2007) and Abu-Dieyeh (2006). The results of present findings are in agreement with those Razuki *et al*. (2011), who reported that Ross strain exhibited better FCR than Cobb, Hubbard and Lohmann strains in heat stress. Similarly, Farran *et al*. (2000) reported that Arber Acres has significantly lower feed conversion than Ross and Lohman at 49 days of age.

In the present study, mean mortality and economics of four different broiler strains reared in TN and HAT zone are significantly affected by temperature zone. In hot environment, high mortality in broiler may be due to inefficient evaporative cooling which increase of heat inside the body. When temperature of the body reaches dangerous level, due to continue accumulation heat, the birds' dies from heat prostration (Al-Fataftah and Abu-Dieyeh, 2007). The death from heat prostration may be due to adrenal cortical insufficiency or cardiovascular failure or imbalance of ions (potassium, calcium, sodium, chloride, phosphate, magnesium and sulphate) in the blood (Deaton *et al*., 1978). Our results are similar to the findings Quinteiro-Filho *et al*. (2010), Al-Fataftah and Abu-Dieyeh (2007) and Abu-Dieyeh *et al*. (2006).

Iqbal *et al*. (2012) reported that mortality in Hubbard strains was significantly lower (4.4%) than Hybro PN, Ross 308 and Arbor Acres-strains in optimum conditions. Similarly, Razuki *et al*. (2011) reported lower mortality in Hubbard strains compared to Rose, Cobb and Lohmann.

CONCLUSION

Ross and Arber Acer performed better in terms of feed intake, weight gain, FCR and are more economical to be reared in hot summer season in tropical climates of Pakistan, while Cobb and Hubbard strains are more suitable in thermo neutral environment.

ACKNOWLEDGMENTS

The authors are thankful to Higher Education Commission (HEC) of Pakistan for funding this work under indigenous scholarship scheme.

Statement of conflict of interest

Authors have declared no conflict of interest.

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