

Performance of Naked Neck versus Normally Feathered Coloured Broilers for Growth, Carcass Traits and Blood Biochemical Parameters in Tropical Climate

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ABSTRACT : A population segregating for the naked neck (Na) gene was used to evaluate its effect on fast growing broilers at heat stress. An experimental stock comparable to those of modern broilers was established by backcrossing to colour synthetic male and female lines. Matings between heterozygous (Na/na) males and females produced normally feathered (na/na), heterozygous (Na/na) and homozygous (Na/Na) chicks for the present study. Day old to seven week old coloured broilers of three genotypes viz. normally feathered (na/na), heterozygous naked neck (Na/na) and homozygous naked neck (Na/Na) were compared for heat dissipation, growth performance, body conformation traits, blood biochemical parameters and carcass traits in tropical climate. In hot climate, naked neck broilers had significantly less body temperature and better heat dissipation capabilities as compared to normal broilers. The naked neck broilers had significantly higher body weight and better feed conversion ratio than na/na broilers. The Na/Na or Na/na broilers exhibited higher giblet yield, blood loss and lower feather mass compared to na/na broilers. The results indicated that the reduction in feather coverage in Na/Na and Na/na broilers facilitates better heat dissipation with lower body temperature, more body weight gain, better FCR and carcass traits compared to normal broilers. (*Asian-Aust. J. Anim. Sci. 2002, Vol 15, No. 12 : 1776-1783*)

Key Words : Naked Neck Broilers, Body Weight, FCR, Carcass Traits, Blood Cholesterol Parameters and Heat Dissipation

INTRODUCTION

In advancement of poultry industry in the recent era, interest has been increased towards the utilization of major genes in tropical climate. Since most of the layer and broiler breeds or strains have originated and been developed under temperate climate so they are more prone to tropical climatic stress in our country, due to which there is decrease in feed consumption, feed efficiency accompanied with heavy mortality during summer. Especially broilers suffer more in dissipating the body heat due to their faster metabolism. In this context, the naked neck gene (Na) has been found to be associated with improved heat tolerance (Yahav et al., 1998) without negatively affecting growth rate that could be achieved by genetically reducing the body insulation and increasing heat dissipation through reduced feather coverage. The naked neck gene (Na) reduced feather mass (Merat, 1986; Cahaner et al., 1993) by 20 and 30 per cent in the heterozygous (Na/na) and homozygous naked neck (Na/Na) birds, respectively as compared with normally feathered (na/na) counterpart.

A higher growth rate (Cahaner et al., 1993) and meat yield (Barua and Howlider, 1991) has been observed in naked neck broilers than normally feathered counterparts when reared at a high or moderate ambient temperature. Reduction in plumage coverage facilitates better heat

dissipation through convection of internally produced heat resulting in improvement of the thermoregulation under high (30°C) or moderate (22°C) ambient temperature which is reflected by lower body temperature (BT) and better feed conversion ratio (FCR) (Herremans et al., 1988).

Measurement of BT and especially of body temperature change (BTC) following an alteration in environment provides rapid measurement for heat tolerance of broilers.

Reduction of plumage causes gains of 1.5 to 2.0 and 2.5 to 3.0 per cent in slaughter yields (Khan, 1998) of two genotypes. (Na/na and Na/Na) respectively. There is also an increase in meat yield of dressed carcasses. The advantage of Na/na over na/na in this respect was varied from 1.8 to 7.1 per cent in males and 0.78 to 5.1 per cent for females in different populations studied (Khan, 1998). This resulted from a higher proportion of muscle (Zein-El-Dein et al., 1984b) in naked neck broilers in the pectoral region.

Body fat content measured by abdominal fat thickness or plasma cholesterol and triglycerides level has been found to be negatively correlated with heat tolerance (Macleod and Hocking, 1993). The naked neck bird has been found to have lower proportion of subcutaneous and intramuscular fat (Zein El. Dein et al., 1984a). However, most of the studies on production profiles of naked neck versus normally feathered broilers have been undertaken in constant high/low ambient temperature. The studies on the effect of naked neck gene under cyclic/seasonal tropical climate are limited and need to be investigated.

In context of the above, the present study was, therefore, planned to determine the effect of the Na gene on body temperature change, growth, feed efficiency, feed conversion ratio, blood biochemical parameters and

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slaughter traits like dressing percentage, cut up parts, giblets and ratio of meaty to bony cuts in comparison with normally feathered coloured broilers.

MATERIALS AND METHODS

The experiments were designed and conducted systematically during summer with high temperature and humidity in the month of May to August, 2000. All the experimental procedures and analytical techniques followed in present study are described below:

Breeding stock

Coloured naked neck population denoted NNCP, available at Experiment Broiler Farm, CARI, Izatnagar were utilized for the present study. The naked neck coloured line had been developed by crossing non-breed specific naked neck (body weight of approximately 400-500 g at 6 week age) and synthetic broiler lines CSML. Henceforth it had been backcrossed for five generations with synthetic broilers with aim to obtain a fast growing naked neck broiler.

In the present study, chicks were produced by crossing of 28 CPNa/na (Coloured plumage heterozygous naked neck) males parent line with 168 CPNa/na female parent line of coloured plumage line. Artificial insemination was done at 5 days interval at 1:6 ratio (male:female) in individual cages, using same particular male for six particular numbers of females for the collection of pedigree eggs.

The day old chicks were identified as homozygous naked neck (Na/Na), heterozygous naked neck (Na/na) and normally feathered (na/na). The na/na chicks were easily identified by their complete feather cover over the neck. The Na/na chicks were differentiated by the presence of semi-circular tuft of feathers on the ventral side of neck while Na/Na chicks were completely devoid of feathers on the neck. Also the Na/Na chicks lacked feathers on the abdomen and around the keel bone.

All the chicks were wing banded and then divided in equal numbers over different pens. They were provided 24 hours light per day throughout the experimental period and paddy husk was used as litter. A scientific broiler diet, supplied by Feed Process Unit, CARI and water were provided *ad libitum*. The standard and uniform management practices were followed for all the chicks.

Measurement of production traits

Chicks were weighed individually at day old to seventh week of age. Total feed consumption (FC) was measure for each pen, and corrected for mortality. Feed conversion ration (FCR) was calculated as the ratio between total FC to total body weight of all birds in each pen. Body temperature

(BT) was measured on a random sample birds from each genotype at 6 week age at normal and on-feed condition. The clinical thermometer (Basemed Digital, Made in Taiwan) was inserted about 3 cm deep into cloaca and held for 60 sec. All the 6 week aged birds sampled for off-feed BT measurements were killed by cervical dislocation, weighed, scaled for 2 min at 60°C, pluck mechanically, and reweighed to calculate feather weight by subtraction. The birds were manually eviscerated. Head, shanks and abdominal fat around cloaca, under viscera and gizzard fat were removed and ready to cook carcasses were individually weighed. Breast including meat, bone and skin were weighed for each bird. Feather mass, shrinkage loss, bleeding loss, evisceration yield, giblet yield and abdominal fat yield were expressed as percentage of body weight after 24 h without feed. Cut up parts yield was calculated as percentage of evisceration weight for breast, thigh, drumstick, back, wing and neck. The total and HDL serum cholesterol were estimated according to one step method of Wybenga and Pileggi using reagent kits from Span Diagnostic. The triglycerides concentration was measured according to enzymatic (GPO/Trinder), end point colorimetry, and single reagent chemistry with lipid clearing factor (LFC) using the reagent kit supplied by Autospan. The VLDL cholesterol concentration was measured by dividing triglycerides concentration by 5. The LDL cholesterol concentration was measure by subtraction of VLDL and HDL cholesterol concentration from total cholesterol concentration.

Statistical analysis

All the data collected were analyzed by a DCM PS /386 type computer. All the statistical analysis was performed according to Snedecor and Cochran (1980) with the help of pre-prepared programs in Fortran package. Wherever more than one hatch data were used, the hatch effect was corrected using least squares analysis (Harvey 1979). The differences between means were tested Tukey's Honestly Significant Difference method.

RESULTS

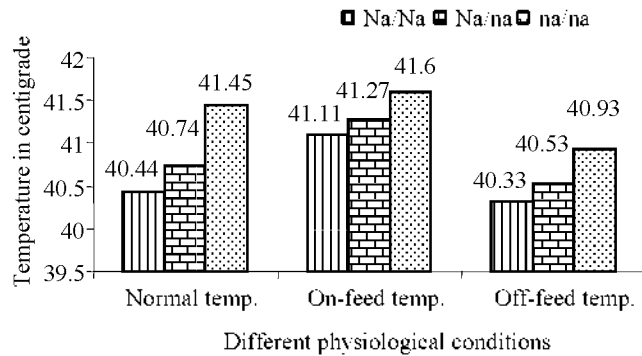
Body temperature

The significantly ($p < 0.05$) lower normal cloacal temperature of homozygous naked neck (-1.01°C or -2.43%) and heterozygous naked neck (-0.71°C or -1.71%) as compared to normal broilers are presented in the Table 1 and Figure 1 for normal body temperature (40.44 ± 0.07 , 40.74 ± 0.06 , $41.45 \pm 0.05^{\circ}\text{C}$), of these genotypes, respectively. When the birds kept "on-feed", the average increase in BT was also significantly ($P < 0.05$) lower in Na/Na (-0.49°C or -1.17%) and also significantly lower for Na/na (-0.33°C or -0.79%) than na/na genotypes. Similarly

Table 1. Body temperature kinetics (Environmental temperature=30°C) for different genotypes

Genotype	Normal temp. (°C) [mean±SE]	Deviation from na/na (°C)	On-feed temp. (°C) [mean±SE]	Deviation from na/na (°C)	On-feed temp. (°C) [mean±SE]	Deviation from na/na (°C)	Range of heat tolerance (°C)
Na/Na	40.40±0.07 ^{a**}	-1.01 (-2.43%)	41.11±0.06 ^{a**}	-0.49 (-1.17%)	40.33±0.04 ^{a**}	-0.60 (-1.46%)	0.78
Na/na	40.74±0.06 ^{b**}	-0.71 (-1.71%)	41.27±0.07 ^{ab**}	-0.33 (-0.79%)	40.53±0.03 ^{b**}	-0.40 (-0.98%)	0.74
na/na	41.45±0.05 ^{c**}		41.60±0.07 ^{c**}		40.93±0.08 ^{c**}		0.67

Figures bearing no common superscript (column wise) between genetic groups differ significantly. (** Denote p<0.01).

**Figure 1.** Body temperature kinetics for different genotypes

during "off-feed" condition the average decrease in BT was significantly lower for *Na/Na* (-0.60°C or -1.46%) and *Na/na* (-0.40°C or -0.98%) as compared to *na/na* broilers.

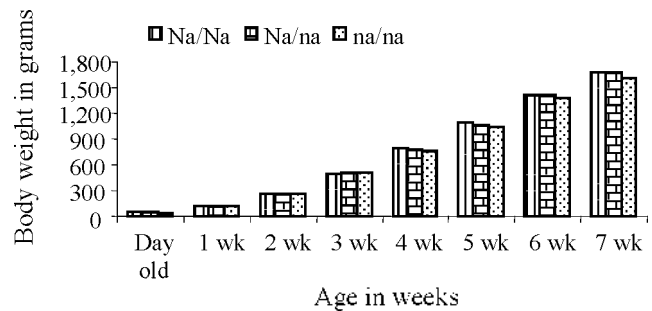
Body weight

The homozygous and heterozygous naked neck broilers exhibited significantly higher body weight (Table 2 and Figure 2) than *na/na* broilers on day old (44.2±0.4 g) and fifth week (1088.3±16.0 g) of age. Relative to the *na/na* broilers, the *Na/Na* or *Na/na* broilers had higher body weight for the rest of the periods except at third week of age.

The *Na/Na* broilers had 4.6% higher body weight than *na/na* broiler at fifth week of age.

Feed consumption and feed conversion ratio

The homozygous naked neck (*Na/Na*) broilers consumed (Table 3 and Figure 3) higher amount of feed upto 20.5% at 5-6th week and also in most of the weeks compared to *na/na* broilers during their higher growth rate. Similarly, the *Na/na* broilers had better feed conversion ratio (Table 4 and Figure 4) up to -30.70 percent and the *Na/Na* broilers had up to -21.25 per cent over *na/na* broilers. In most of the cases the *Na/na* broilers had better FCR

**Figure 2.** Mean body weight at different weeks for various genotypes**Table 2.** Mean±SE (grams) of body weight at different weeks for various genotypic groups

Genotype	Sex	Obs.	Weeks of age							
			Day old	1st	2nd	3rd	4th	5th	6th	7th
<i>Na/Na</i>	Male	60	44.6±0.5	119.0±2.5	268.2±6.1	510.0±12.6	803.0±16.7	1114.4±21.6	1482.8±23.5	1754.1±37.2 (27)
	Female	36	43.6±0.7	116.7±3.5	259.1±6.2	490.4±10.1	758.4±12.9	1003.5±14.8	1297.9±18.4	1544.7±37.4 (15)
	Combined	96	44.2±0.4 ^{bc}	118.2±2.0	264.8±4.5	502.7±8.6	786.3±11.7	1088.3±16.0*	1413.5±18.6	1679.3±31.3 (42)
<i>Na/na</i>	Male	155	44.8±0.4	121.7±1.3	276.4±3.1	521.9±6.9	802.3±9.4	1121.3±12.3	1512.7±13.9	1800.2±26.7 (51)
	Female	119	44.2±0.4	119.4±1.6	259.2±3.6	483.2±5.7	727.9±7.5	970.9±9.4	1268.8±10.3	1482.0±16.8 (35)
	Combined	274	44.6±0.3 ^{bc}	120.7±1.0	268.9±2.4	505.1±4.7	770.0±6.6	1056.0±9.2 ^{abc}	1406.8±11.6	1670.7±24.1 (86)
<i>na/na</i>	Male	61	43.4±0.5	120.9±1.8	271.9±3.9	534.0±8.9	815.1±14.6	1133.9±15.1	1511.1±18.2	1786.3±39.4 (20)
	Female	68	43.6±0.5	117.0±2.1	251.9±3.9	480.8±7.1	721.3±9.5	956.1±10.7	1243.3±11.5	1461.7±21.8 (23)
	Combined	129	43.5±0.3 ^a	118.8±1.4	261.4±2.9	506.0±6.1	765.6±9.5	1040.2±12.0*	1369.9±15.9	1612.7±32.9 (43)

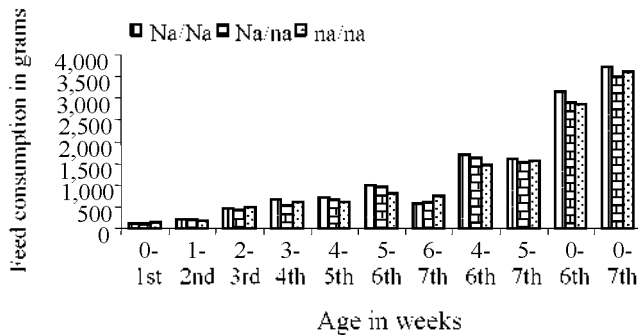
Figures bearing no common superscript (column wise) between genetic groups differ significantly.

* p<0.05. ** p<0.01.

Table 3. Feed consumption (gram) for various genotypes at different weeks of age

Genotype	Hatch	0-1st	1-2nd	2-3rd	3-4th	4-5th	5-6th
Na/Na	Ist	116.7 (-21.7%)	218.5 (16.55%)	450.9 (-6.6%)	662.5 (8.9%)	692.2 (14.52%)	1,000.0 (20.5%)
Na/na	Ist	106.9 (-28.2%)	198.9 (6.2%)	437.9 (-9.3%)	545.2 (-10.4%)	688.8 (14.0%)	939.5 (13.2%)
na/na	Ist	148.9	187.2	482.7	608.5	604.3	830.0
Genotype	Hatch	6-7th	4-6th	5-7th	0-6th	0-7th	
Na/Na	Ist	578.9 (-21.1%)	1,692.2 (18.0%)	1,578.85 (1.0%)	3,140.7 (9.8%)	3,719.6 (23.5%)	
Na/na	Ist	589.2 (-19.7%)	1,628.3 (13.5%)	1,528.8 (-2.2%)	2,917.2 (1.9%)	3,506.4 (-2.5%)	
na/na	Ist	733.3	1,434.3	1,563.3	2,861.7	3,595.0	

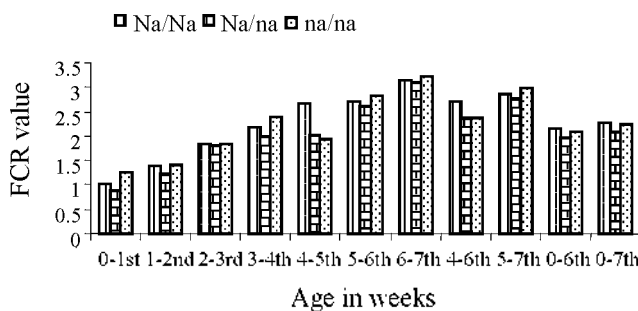
Figures in the parenthesis indicate the deviation from na/na broilers.

**Figure 3.** Feed consumption for various genotypes at different weeks

compared to Na/Na and na/na broilers, respectively.

Blood biochemical parameters

The Na/Na or Na/na broilers had non-significantly lower concentration (Table 5 and Figure 5) of Total Cholesterol, HDL, Triglycerides, VLDL and LDL cholesterol than na/na broilers in most of the cases except

**Figure 4.** Feed conversion ratio for different genetic groups.**Table 4.** Feed conversion ratio for different genetic groups

Genotype	Hatch	0-1st	1-2nd	2-3rd	3-4th	4-5th	5-6th
Na/Na	Ist	1.00 (-21.25%)	1.37 (-2.14%)	1.83 (0.00%)	2.18 (-8.78%)	2.66 (37.11%)	2.70 (-3.91%)
Na/na	Ist	0.88 (-30.70%)	1.23 (-12.14%)	1.82 (-0.84%)	2.01 (-15.89%)	2.02 (4.12%)	2.60 (-7.47%)
na/na	Ist	1.27	1.40	1.83	2.39	1.94	2.81
Genotype	Hatch	6-7th	4-6th	5-7th	0-6th	0-7th	
Na/Na	Ist	3.14 (-2.18%)	2.69 (13.98%)	2.85 (-4.68%)	2.16 (3.84%)	2.27 (1.33%)	
Na/na	Ist	3.11 (-3.11%)	2.35 (-0.42%)	2.77 (-7.35%)	1.96 (5.76%)	2.09 (-6.69%)	
na/na	Ist	3.21	2.36	2.99	2.08	2.24	

Figures in the paranthesis indicate the deviation from na/na broilers.

HDL of Na/Na and LDL of Na/Na broilers.

The Na/Na broilers exhibited lowest values in most of the cases except HDL cholesterol, followed by Na/na broilers in all the cases except LDL cholesterol compared to na/na broilers. Though the males had higher values of above biochemical parameters than females in most of the cases, the differences were non-significant between the sexes.

Carcass traits

Comparative studies on various carcass traits indicated (Table 6 and Figure 6) the superiority of naked neck (Na/Na and Na/na) broilers compared to na/na for some important economic traits. For evisceration yield all the three genotypes exhibited close values with non-significant differences. The Na/Na or Na/na had higher percentage of breast, thigh and wing yield than na/na. Naked neck broilers had significantly higher percentage of giblet and significantly lower percentage of feather mass and the higher amount of blood loss. The Na/Na or Na/na broilers had non-significantly lower percentage of neck yield and shrinkage loss. All the three genotypes were having same values for the ratio of meaty to bony cuts. The Na/na broilers have non-significant lower abdominal fat per centage than na/na, the Na/Na broilers.

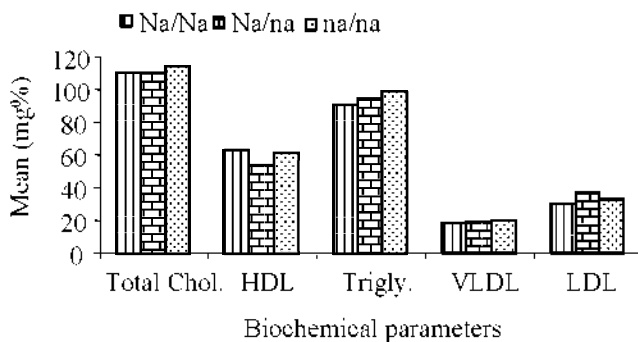
DISCUSSION

Body temperature change

The significantly lower normal body temperature (Table 1 and Figure 1) for both the 'on-feed' and 'off-feed' groups in Na/Na and Na/na broilers as compared with na/na broilers were in accordance with the finding of Merat (1986) which might be due to reduction in feather mass by

Table 5. Mean±SE (mg%) of various blood biochemical parameters in different genetic groups of naked neck and normally feathered broilers

Genotype	Sex	Observation	Total cholesterol	HDL	Triglycerides	VLDL	LDL
Na/Na	Male	9	115.3±8.0	67.7±4.9	95.9±9.5	19.2±1.9	28.4±4.0
	Female	9	105.6±7.8	57.3±4.5	85.0±8.0	17.0±1.6	31.4±3.3
	Combined	18	110.4±5.5	62.5±3.4	90.4±6.2	18.1±1.2	29.9±2.5
Na/na	Male	9	106.1±7.9	51.833±4.3	96.5±9.5	19.3±1.9	35.0±6.3
	Female	9	114.7±8.7	56.3±3.3	90.5±9.3	18.1±1.9	40.3±6.0
	Combined	18	110.4±5.8	54.1±2.7	93.5±6.6	18.7±1.3	37.7±4.4
na/na	Male	9	116.5±6.6	68.8±5.6	99.1±10.3	19.8±2.1	27.8±3.5
	Female	9	110.0±7.5	52.634±4.3	96.7±8.3	19.3±1.7	38.0±3.2
	Combined	18	113.2±4.9	60.7±3.9	97.9±6.4	19.6±1.3	32.9±2.6

**Figure 5.** Mean of various blood biochemical parameters for different genotypes

the Na gene. The naked neck gene (Na) minimizes the increase in body temperature (BT) under high ambient temperature (AT) with higher rate of heat dissipation from the bare skin than from the feathered surface as reported by Yahav et al. (1998). Deeb and Cahaner (1999) observed that reduction in feather mass prevents an excessive increase in BT caused by eating and digestion at high AT, thus the naked neck gene minimize the negative effect of hot climate on broiler growth and meat yield. Khan (1998) also reported lower cloacal temperature in Na/Na and Na/na than na/na. The lower body temperature in naked neck as compared to normal (Environmental temperature was 30°C) suggests their better thermo-regulatory efficiency and heat tolerance compared to a fully feathered birds.

Body weight

In general, the lower mean body weight (Table 2 and Figure 2) of Na/Na and Na/na than na/na genotypes from first to third weeks of age were in accordance with the findings of Decuyper et al. (1993). The higher mean body weights of Na/Na and Na/na broilers than na/na from four to seven weeks of age were in agreement with the findings of Bordas et al. (1978), Hanzl and Somes (1983) and Zein-El-Dein et al. (1984b).

The magnitude of relative superiority of Na/Na and Na/na genotypes realized over na/na for growth in the

present study for both the lines tends to be increasing with the age. The relative superiority of Na/Na and Na/na over na/na is in agreement with the results of Yalcin et al. (1997b). Better relative advantage of Na/Na and Na/na over na/na is in concurrence with the results of Khan (1998).

Feed consumption, feed conversion ratio

In general, the higher growth rate or feed consumption of the naked neck broilers in most of the cases than normally feathered birds (Table 3 and Figure 3) is yet another manifestation of decreased feathering and thereby having better thermo-regulatory efficiency and increase heat tolerance. The reduction in feather mass prevents an excessive increase in body temperature caused by eating and digestion at high ambient temperature, thus minimizing the negative effect of hot climate on feed consumption, growth and meat yield. The naked neck broilers by virtue of the more exposed skin are able to dissipate heat in a better way and thereby food intake is also more. Bordas et al. (1980), Hammade et al. (1987a,b), Fathi et al. (1993) and Khan (1998) have also reported similar findings.

The higher but non-significant difference in feed efficiency (lower FCR) for naked neck as compared to normal broilers at 86°F ambient temperature has also been reported by Bordas et al. (1978), Monnet et al. (1979), Hanzl and Somes (1983), Horst (1988a,b), Eberhart and Washburn (1993) and Singh et al. (1996) while significantly better FCR for Na/na over na/na has been reported by Yalcin et al. (1997b) and Khan (1998).

Blood biochemical parameters

The total serum cholesterol levels ranging from 110 to 130 mg% (Table 5 and Figure 5) is within the normal range. Mukhopadhyay (1994) reported even wider range (110-204 mg%) of serum cholesterol levels in different crosses. The serum cholesterol levels are directly proportional to muscle cholesterol levels. In the present study, the naked neck genotypes of the coloured lines had non-significantly lower cholesterol levels than normally feathered broilers. Therefore, naked neck broilers are expected to have lower muscle cholesterol concentration.

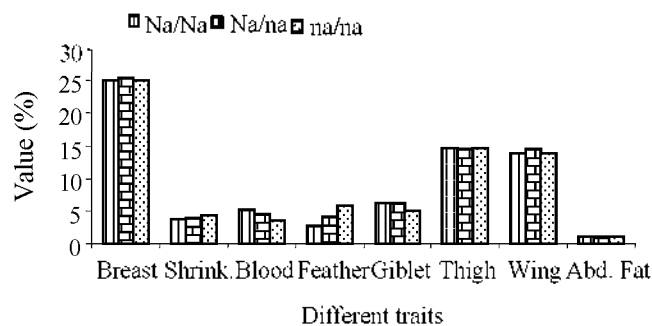
Table 6. Mean±SE (%) of various carcass traits in different genetic groups

Genotype	Sex	Observation	Ev.+Gib.	Eviscer (Ev.)	Breast	Back	Shrinkage	Blood	Feather
Na/Na	Male	7	73.02±0.82	67.51±0.85	25.22±0.91	22.37±0.55	3.81±0.26	4.96±0.20	2.77±0.18
	Female	7	72.37±0.66	66.17±0.86	24.84±0.82	23.02±0.67	3.75±0.20	5.26±0.27	2.81±0.09
	Combined	14	72.69±0.51	66.84±0.61	25.03±0.59	22.69±0.42	3.78±0.16	5.11±0.17 ^{***}	2.79±0.01 ^{***}
Na/na	Male	7	73.21±0.59	67.51±0.62	25.12±0.64	22.10±0.62	3.83±0.18	4.56±0.46	3.66±0.41
	Female	7	73.71±0.41	67.22±0.58	25.86±0.81	21.83±0.43	4.02±0.31	4.46±0.44	4.48±0.31
	Combined	14	73.46±0.35	67.37±0.41	25.49±0.50	21.96±0.36	3.93±0.17	4.51±0.31 ^{ab*}	4.07±0.27 ^{b**}
na/na	Male	7	73.39±0.68	68.49±0.68	25.10±0.86	22.38±0.63	4.09±0.22	3.31±0.65	5.34±0.28
	Female	7	73.24±0.39	68.03±0.50	24.85±0.56	22.18±0.47	4.48±0.35	3.69±0.22	6.11±0.35
	Combined	14	73.31±0.38	68.26±0.41	24.97±0.49	22.28±0.38	4.29±0.21	3.50±0.33 ^{c**}	5.72±0.24 ^{c**}

Genotype	Sex	Observation	Giblet (Gib.)	Thigh	Drumstick	Neck	Wing	Mp/Bp	Abd. Fat
Na/Na	Male	7	6.08±0.21	14.75±0.12	15.73±0.32	6.20±0.36	13.80±0.31	1.31±0.04	1.01±0.19
	Female	7	6.20±0.24	14.71±0.45	15.72±0.51	6.23±0.19	13.94±0.40	1.28±0.04	1.15±0.28
	Combined	14	6.14±0.16 ^{***}	14.73±0.22	15.72±0.29	6.22±0.20	13.87±0.24	1.30±0.03	1.08±0.16
Na/na	Male	7	5.85±0.21	14.67±0.37	15.84±0.16	6.33±0.20	14.22±0.28	1.30±0.03	0.86±0.24
	Female	7	6.49±0.28	14.16±0.26	15.32±0.61	6.26±0.21	14.59±0.55	1.30±0.03	1.04±0.15
	Combined	14	6.17±0.19 ^{ab**}	14.42±0.23	15.58±0.31	6.29±0.14	14.40±0.30	1.30±0.02	0.95±0.14
na/na	Male	7	4.90±0.18	14.67±0.52	15.82±0.46	6.57±0.37	13.28±0.48	1.32±0.04	0.96±0.24
	Female	7	5.91±0.25	14.71±0.33	15.63±0.27	6.56±0.19	14.25±0.46	1.28±0.03	1.01±0.19
	Combined	14	5.06±0.15 ^{c**}	14.69±0.30	15.72±0.26	6.56±0.20	13.77±0.35	1.30±0.02	0.99±0.15

Figures bearing no common superscript (column wise) between genetic groups differ significantly.

* $p < 0.05$, ** $p < 0.01$.

**Figure 6.** Various carcass traits in different genetic groups

The plasma Triglycerides and VLDL are indicators of total body fat (Griffin et al., 1982; Whitehead and Griffin, 1982, 1984). This study revealed lesser triglycerides concentration in coloured naked neck broilers compared to normally feathered broilers, indicating lower total body fat in naked neck broilers. Therefore, it can be postulated that naked neck broilers have less subcutaneous fat depots, which has also been reported by Zein-El-Dein et al. (1984b). In light of the above, it could be stated that the better temperature tolerance of naked neck can be attributed to its lower triglycerides concentration also, which allows better heat dissipation.

Slaughter traits

Shrinkage loss : The lesser shrinkage loss in *Na/Na* and *Na/na* as compared to *na/na* genotypes (Table 6 and Figure 6) led to speculation that naked neck broilers have better resistance to other types of stress in addition to higher

temperature. The finding of Zein-El-Dein et al. (1984b) and Khan (1988) that naked neck suffered lesser losses in body weight as compared to normally feathered birds when subjected to 48 h of starvation supported the speculation. This feature of naked neck is highly desirable particularly in our conditions where birds are subjected to various types of stresses in poorly organized production and marketing channels.

Blood losses : Blood loss of around 3 per cent was in the normal range of values as cited by Veer Kamp (1996). Khan (1998) reported a satisfactory blood loss in all the genotypes. Present study also showed a satisfactory blood loss in *Na/Na* and *Na/na* broilers compared to *na/na* broilers, which is essential for the keeping quality of the meat.

Feather loss : The lesser feather loss observed for both homozygous and heterozygous naked neck than normally feathered broilers was a direct consequence of primary effect of naked neck gene reducing the plumage mass. The extent of plumage reduction in terms of percent feather loss was around 1.5 per cent more in *Na/na* and about 2.5 per cent more in *Na/Na* as compared to *na/na* genotypes which is in accordance with the findings of Merat (1986). Howilder et al. (1995) and Khan (1998). It is the reduction of feather mass, which is manifested in terms of gain in evisceration yield and conservation of dietary proteins.

Evisceration yield : Increases in evisceration yield in *na/na* over *Na/na* and *Na/Na* genotype were contradictory with the results of Zein-El-Dein (1984b), El-Athar and Merat (1990), Howilder et al. (1995) and Khan (1998). Similar trend was observed by Pandey et al. (1992) while comparing heavier body weight SDL with a lower body

weight IC-3 broiler lines. The higher body weight line also had higher evisceration percentage. In view of the above, the higher evisceration yield with giblet percentage of Na/na over na/na genotype could also be attributed to its higher giblet weight.

Giblet yield : The significant higher total giblet yields in the naked neck than normally feathered broilers were in accordance with the findings of Howlider et al. (1995). Khan (1998), however, reported higher but non-significant higher yields for naked neck than normally feathered broilers.

Abdominal fat : The results on abdominal fat percentage of about 1% were in the similar range as reported by Mukhopadhyay (1994) and Khan (1998) for various classes of broilers. The non-significant differences in abdominal fat percent between genotypes were in agreement with the observations of El-Athar and Merat (1985) who reported a non-significantly higher abdominal fat in naked neck as compared to normally feathered broilers. But it is contradictory to the findings of Zein-El-Dein et al. (1984b) who reported significantly lower percentage of abdominal fat in naked neck broilers. Moreover, a markedly lower level (1-2%) of abdominal fat in general (irrespective of genotypes) than that (2-6%) reported by Veerkamp (1996) in the broiler is highly desirable from the view points of carcass quality and minimization of wasteful deposition of metabolizable energy (ME).

Cut-up parts : Higher percentage of three meaty cuts (thigh, drumsticks and breast) is yet another desirable trait of naked neck for the poultry processing industry in view of growing demand of such premium cuts by the consumers. The Na/Na had greater percentage of breast yield and wing yield over normal. It has been interpreted as relatively faster development of muscular tissue associated with Na gene (Zein-El-Dein et al., 1984b) especially in thoracic region (El-Athar and Merat, 1985). Results of Somes and Johnson (1982) pointing to better conformation associated with scaleless gene causing a similar but more extreme reduction of the plumage than the Na gene is suggestive of the fact that it might be due to general effect associated with a reduction in plumage. Further, Zein-El-Dein et al. (1984b) have suggested that the effect of the reduction in plumage caused the spare protein being diverted to muscle formation while as Goldspink (1977) stated that number of muscle fiber is one of the factors in determining the future muscle fiber development which are formed during embryonic life. Since fewer feathers are to be formed in naked neck, more protein seems to be available for development of muscle fibers. The better meat yield in the breast of Na/Na as compared to na/na genotype has also been reported by Yalcin et al. (1997b).

The genetic groups differed in body weights with the naked neck broilers having relative advantage over normal depending upon genotypes and age. Generally from fourth week onward the naked neck broilers showed increasing trend in body weight with advancing age. Naked neck broilers showed better heat dissipation and lower body temperature compared to normally feathered broilers. The feed conversion ratio or feed efficiency for heterozygous naked neck showed superiority trend over homozygous naked neck and normally feathered broilers, respectively. Slaughter traits revealed superiority of Na/Na and Na/na over na/na. There were less feather loss more giblet and blood loss in naked neck genotypes than normal. The naked neck genotypes had non significantly more percentage breast yield, wing yield and evisceration yield with giblet (Na/na) as compared to normal. Blood biochemical parameters revealed non-significantly lower total cholesterol levels for naked neck broilers.

In summary the results of the present study clearly indicate that the advantage of naked neck broilers at high ambient temperature (Cahaner et al., 1993) due to their superior ability to dissipate heat. The reduction in feather mass, which prevents an excessive increase in body temperature cause by eating and digestion at high ambient temperature, thus, minimizing the negative effect of hot climate on broiler growth and meat yield. It appears that BTC provides a reliable indication of the level of heat load on broilers and in expected effect on their body weight gain.

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