CARCASS CHARACTERISTICS AND IMMUNE STATUS OF NAKED NECK AND NORMALLY FEATHERED CHICKEN GENOTYPES

A. Galal[1], M.Y. Mahrous[1], A.M.H. Ahmed[1] and Amira E.M. El-Dlebshany[2]

1- Department of Poultry Production, Faculty of Agriculture, Ain Shams University, Cairo, Egypt, 2- Department of Poultry Production, Faculty of Agriculture, Alexandria University, Egypt

SUMMARY

Carcass measurements and some immunocompetence parameters were investigated in naked neck (NaNa & Nana) and normally feathered (nana) genotypes under summer season conditions of Egypt. Two hundred and ten broiler chicks (70 of each genotype) were reared under similar environmental, managerial and hygienic conditions. The feed and water were provided ad libitum. The average high and low ambient temperatures recorded during the experimental period were 32.5 and 28.7°C, respectively. At 6 weeks of age, 150 chicks (50 each genotype) chicks were randomly chosen for carcass evaluation. The present result indicated that the presence of Na gene in a double state significantly increased body weight, relative breast muscle weight and meat yield compared to normally feathered birds. However, the Nana genotype was intermediated in most cases. Concerning immunocompetence parameters, the presence of naked neck gene in a single manner significantly increased relative lymphoid organs weight compared to normally feathered genotype. Similar trend was not observed for homozygous naked neck genotype. With respect to cell-mediated immunity, the present result indicated that the NaNa and Nana genotypes was hyper responder to PHA-P injection compared to nana birds. In conclusion, under summer conditions of Egypt, broiler carcass composition could be improved by incorporating naked neck (Na) gene for increasing relative breast muscles and relative meat yield and decreased relative abdominal fat weight. Moreover, the naked neck birds had higher immune response compared to normally feathered ones.

Keywords: carcass measurements, immunocompetence, naked neck gene, chicken

INTRODUCTION

In developing countries, poultry production is facing many challenges. Diseases, unfavorable circumstances and bad management are major factors resulting in economic loss either in egg or broiler production. Poor results, as an expected, would be obtained when birds are raised in open-houses under high ambient temperatures. It appears that broiler stocks bred for high growth rate and meat yield under optimal environments, are not able to fully express their genetic potential when reared in hot climates, unless their selection programs include breeding for heat tolerance.

Whereas studies on alleviation of heat stress have focused on costly management adjustments, however, genetic improvement of heat tolerance may provide a low-cost solution, particularly attractive to developing countries with hot climates. The importance of the potential use of naked neck and frizzle genes is accentuated (Lina *et al*., 2006). Chickens suffer under high ambient temperature because their feathers coverage hinders internal heat dissipation, leading to elevated body temperature (BT) (Yahav *et al*., 1998). Reduced feather coverage should improve and enhance heat dissipation and consequently alleviate the effects of heat on chickens reared in hot climates. In addition, reduced feathering saves on the amount of protein required to form feathers. Such protein that would have been used to form feather would now be used for meat tissues (Cahaner *et al*., 1987). Under normal temperature, Cahaner *et al*. (1993) reported that the naked neck broiler chicks had relatively higher growth rate and meat yield than normally feathered counterparts. Moreover, the gene effect is more pronounced in high temperature. The presence of Na gene in a single or double state resulted in heavier body weight, higher feed efficiency and lower body temperature (Patra *et al*., 2002 and Galal *et al*., 2007). Moreover, the Na allele can increase breast meat production (Deeb and Cahaner, 1999). The fat deposit in breast muscle is also decreased in naked neck chickens compared to normal type (Raju *et al*., 2004).

The immune system of birds consists of three basic sub-systems, the humoral, cellular and phagocytic. It is of interest to know that the genetic control of these components may be independent from each other (Cheng and Lamont, 1988; Sarker *et al.*, 2000; Li *et al*., 2001 and Yunis *et al*., 2002). T-cell mediated immune response of chicken has significant variation among birds of different genetic lineage (Lamont and Smyth, 1984; Cheng and Lamont, 1988). Successful divergent selection of chickens for various T-cell functions suggests that many of these functions are highly heritable, and are often negatively correlated with body weight (Yamamoto and Okado, 1990 and Afraz *et al.*, 1994). The difference among lines for response to PHA-P injection could be attributed to the lymphoblastogenic response to PHA-P is presumed to be polygenic. Major genes are believed to confer not adaptability to the tropical climate, but also resistance to diseases. Significantly higher cell-mediated immune (CMI) estimate were observed in NaNa and Nana broilers as compared to nana ones (Patra *et al.*, 2004). Haunshi (1999) reported that the naked neck and frizzle genes did not significantly effect cell-mediated immunity (CMI) response to Concanavalin A (Con-A). Inversely, Alvarez *et al.* (2002) found that the heterozygous naked neck (Nana) genotype had a better cellular and humoral response than their normally feathered (nana) and homozygous naked neck (NaNa) genotypes. Also, Alvarez *et al.* (2003) showed that the Nana chickens are the most resistant to *Salmonella Gallinarum* (SG) infection and the best responder to vaccination with SG antigens compared to NaNa and nana sibs. The aim of this work was to improve the carcass measurements and immunocompetence traits of broiler chicks under summer conditions of Egypt by introducing the naked neck (Na) gene.

MATERIALS AND METHODS

Genetic flocks and husbandry

Heterozygous naked neck (Nana) Hubbard females were artificially inseminated with heterozygous naked neck (Nana) males. According to the previous mating, three

genetic groups were obtained; normally feathered (nana), heterozygous naked neck (Nana) and homozygous naked neck (NaNa) broiler chicks. All chicks were wing-banded and brooded in electrical brooding batteries from hatch to 3 weeks of age. The birds, then, were transferred to a floor pen. All genetic groups were reared under similar environmental, managerial and hygienic conditions. Feed and water were supplied *ad libitum*. They were fed a commercial diet containing 21% CP and 2900 kcal ME/kg diet. Average high and low ambient temperatures recorded during the experimental period were 32.5 and 28.7°C, respectively.

Measurements and observations

Productive parameters

Body weights and body measurements (keel length, shank length and breast angle) were determined individually at 6 weeks of age. Also, at 6 weeks of age, 150 chicks (50 of each genotype) were slaughtered for carcass assessment. Birds were individually weighed before slaughtered. They were slaughtered by severing the carotid artery and jugular vein, and reweighed to calculate blood weight by difference. Feathers were manually removed after scalding at 60°C for approximate 2 min. Then, the birds were reweighed to calculate feathers weight by difference. The birds were processed by removing the head and shank and eviscerated by removing the viscera without disturbing the fat pad along the abdominal wall. The heart, liver, gizzard and spleens were dissected from the viscera and the gizzard was cut open and rinsed of its contents. Then, the carcasses were immersed in cold water. The carcass, breast thigh and drumstick muscles were weighed. Each organ and muscle was expressed as a proportion of the live body weight.

***In vivo* cell-mediated immunity**

A phytohemagglutinin-P (PHA-P) injection assay (Cheng and Lamont 1988) was used to evaluate in vivo T-cell-mediated immune response of broiler chicks. Birds were injected intradermally in the toe-web with 0.5 mg of PHA-P (Sigma Chemical Co., St. Louis, Missouri) in 0.1 ml of phosphate buffered saline (PBS) after marking the injection site. The thickness of toe-web was measured (to nearest 0.01mm) at 0, 24, 48 and 72hrs after PHA-P injection. Toe-web swelling was calculated as the difference between the thickness of the toe-web prior to and after injection of PHA-P.

Heterophils / lymphocytes ratio

At 6 week of age, blood samples were obtained from each genotype for heterophil (H) and lymphocyte (L) enumeration based on the procedures of Gross and Siegel (1983). Briefly, one drop of blood being smeared on each of glass slides. The smears were stained using Wright's stain. Two hundred leukocytes, including granular (heterophils) and nongranular (lymphocytes) ones, were counted on different microscopic fields representing 200 cells, and the heterophil to lymphocyte ratio was calculated.

Statistical analysis

Data were subjected to one-way analysis of variance with genotype effect using the General Linear Models (GLM) Procedure of SAS User's Guide, 2001.

RESULTS AND DISCUSSION

Productive parameters

Body weight and body measurements

Body weight and body measurements of broiler chicks as affected by naked neck gene are presented in Table (1). It is apparent that the homozygous naked neck (NaNa) broiler chicks had significantly heavier marketing body weight by about 8.1% compared to normally feathered sibs. Similar trend, but not statistically significant, was observed in heterozygous naked neck (Nana). The heavier body weight associated with Na gene, especially in homozygous state, could be attributed to the feather reduction associated with this gene, consequently saving more protein for muscle weight. This observation is similar to that of Mérat (1986); Yalcin *et al*. (1997) and Galal *et al*. (2007). With respect to body measurements, it could be noticed that the presence of Na gene in homozygous state significantly increased keel length, shank length and breast width by about 2.95, 3.0 and 2.3%, respectively compared to normally feathered genotype. However, the breast angle did not significantly affected by naked neck gene. It seemed that the Na gene had a favorable effect on keel bone length.

Table 1. Body weights and body measurements (Mean±S.E) of naked neck (NaNa & Nana) and normally feathered (nana) broiler chicks (n=70/genotype)

Trait	Genotype			Gene effect		
	NaNa	Nana	nana	Prob.	NaNa	Na-
Body weight, g	1957.4^{a}±43.52	1896.8^{ab}±35.26	1811.2^{b}±41.12	0.05	+8.07	+4.73
Keel length, cm	10.81^{a}±0.81	10.66^{ab}±0.67	10.50^{b}±0.71	0.01	+2.95	+1.52
Shank length, cm	10.61^{a}±0.43	10.55^{ab}±0.49	10.30^{b}±0.52	0.02	+3.01	+2.43
Breast angle	107.42±1.25	107.39±1.40	107.21±2.13	NS	+0.20	+0.17

[a and b] Means within row with different letters are significantly different NS: not-significant
Gene effect was calculated as a deviation from normally feathered (nana) genotype

Carcass characteristics

Data summarized in Table (2) showed that the effect of naked neck gene in a heterozygous or homozygous state on carcass characteristics of broiler chicks. The present result indicated that the blood percentage of NaNa genotype was significantly higher than that of nana ones. However, the Nana genotype was intermediated. The higher proportion of blood percentage in naked neck genotype was probably due to higher hemoglobin concentration and packed cell volume associated with the naked neck gene (Luger *et al*., 1998; Raju *et al*., 2004 and Galal *et al*., 2007) as a consequence of greater oxygen demand. Also, the higher blood volume associated with this gene may be due to the higher blood supply to organs and muscles (Galal and Fathi, 2001 and Galal, 2007). Concerning relative feather weight, the presence of Na gene in a heterozygous or homozygous manner significantly reduced feather coverage by about 25.2 and 38.0%, respectively compared to normally feathered genotype. Bordas *et al.* (1978) stated that the naked neck gene, Na, is a genetic mutant with approximately 40% reduced feather covering in homozygous (NaNa) and approximately 30% reduced covering in heterozygous (Nana). The reduced feathering associated with Na gene results in increased flexibility in regulating their body temperature at high ambient temperature. The main effect of naked neck gene is the reduction of the whole feather percentage especially in neck and breast areas by about 30-40% as compared with the normal chickens (Mérat, 1986 and Horst and

Rauen, 1986). Accordingly, naked neck chickens can tolerate low dietary protein level more than normal chickens (Monnet *et al*., 1979). It could be observed that the NaNa broiler chicks had significantly higher dressing percentage by 2.8% compared to nana genotype. The same trend, but the difference was not statistically significant, was observed in Nana genotype.

Table 2. Carcass characteristics of (Mean±S.E) naked neck (NaNa & Nana) and normally feathered (nana) broiler chicks (n=50/genotype)

	Genotype				Gene effect	
Trait	**NaNa**	**Nana**	**nana**	**Prob.**	**NaNa**	**Na-**
Blood, %	5.22^{a}±0.18	4.85^{b}±0.21	4.76^{b}±0.17	0.01	+9.66	+1.89
Feather, %	5.10^{c}±0.13	6.15^{b}±0.18	8.22^{a}±0.22	0.001	-38.00	-25.18
Dressing, %	68.35^{a}±1.10	67.24^{ab}±1.14	66.51^{b}±1.21	0.01	+2.77	+1.10
Gizzard, %	2.11^{a}±0.05	1.95^{ab}±0.04	1.82^{b}±0.07	0.02	+15.93	+7.14
Heart, %	0.53^{a}±0.05	0.51^{ab}±0.03	0.48^{b}±0.02	0.03	+10.42	+6.25
Liver, %	2.45±0.11	2.34±0.10	2.30±0.013	NS	+6.52	+1.74
Giblets, %	5.09^{a}±0.54	4.80^{ab}±0.51	4.60^{b}±0.43	0.05	+10.65	+4.35
Breast muscle, %	15.10^{a}±0.64	14.70^{b}±0.71	13.62^{c}±0.54	0.001	+10.87	+7.93
Edible meat parts, %	73.44^{a}±0.84	72.04^{b}±0.95	71.11^{c}±1.10	0.01	+3.28	+1.31
Abdominal fat, %	1.25^{c}±0.09	1.92^{b}±0.11	2.45^{a}±0.14	0.001		

[a , b and c] Means within row with different letters are significantly different NS: not-significant
Gene effect was calculated as a deviation from normally feathered (nana) genotype
Giblets: gizzard + liver + heart Edible meat parts: dressing + giblets

The NaNa genotype had significantly higher relative gizzard and heart weights compared to the nana genotype. The Nana genotype was intermediated. However, the relative liver weight did not significantly affected by genetic groups. The presence of Na gene in a double manner significantly increased giblets percentage compared to normally feathered genotype. This is important for slaughtering yield; because of the added to sellable parts, especially in the developing countries. With respect to breast muscles, it could be concluded that the NaNa and Nana genotypes had significantly higher relative breast muscles weight compared to the nana genotype. The increased percentage of muscles in the pectoral region associated with the Na gene may be due to the availability more dietary protein for muscle development and lower protein requirements for plumage growth (Mérat, 1990). Therefore, incorporating Na gene in broiler strains could be improving carcass quality. Finally, the presence of Na gene significantly increased relative meat yield compared to normally feathered counterparts. According to Singh *et al.* (2000); Galal and Fathi (2001) and Deeb and Cahaner (2001), the Na allele increased meat yield compared to normally feathered counterparts. Several mechanisms appear to be responsible for higher meat yield in chickens with reduced plumage. Mérat (1986) summarized three of them as follows; (1) less feather production leaves more protein for the synthesis of other tissue, mainly muscle (meat); (2) the more rapid dissipation of heat results in less appetite depression and consequently better growth under high ambient temperatures; and (3) lower carcass fat content resulting from a higher proportion of lipids being used for thermoregulation.

With respect to relative abdominal fat weight, the NaNa and Nana genotypes had significantly lower relative abdominal fat weight by about 49.0% and 21.6%, respectively compared to nana counterparts. The decrease of abdominal fat weight

may be due to the varied insulation effects due to less plumage cover. Chickens carrying Na gene appear to spend a higher proportion of the ingested energy on thermoregulation, thus lessening their fat deposition (Mérat, 1986). Also, this result is in agreement with Mahrous (2003) and El-Attar and Mérat (1985). They found that the presence of Na gene, in a single state, significantly reduced abdominal fat percentage compared to normally feathered genotype. Younis *et al*. (1998) stated that the Na gene had more pronounced effects on carcass traits through reducing total fat percentage. Galal (2003) showed that the Na, F and double segregation genes significantly decreased abdominal fat percentage compared to normal type under low ambient temperature. Conversely, Lou *et al.* (1992) and Hussein (2000) showed an increase in abdominal fat in Nana genotype compared with nana one.

Immunocompetence measurements

Relative lymphoid organs weight and some hematological parameters

Effects of naked neck (Na) gene on relative lymphoid organs weight and some hematological parameters of broiler chicks are presented in Table (3). The bursa of Fabricius is a key lymphoid organ that is responsible for the development and maturation of B-lymphocytes, and the humoral antibody response is dependent on this central organ (Zhang *et al.*, 2006 and Cheema *et al.*, 2007).The present results showed that the presence of Na gene, in a heterozygous state, significantly increased relative bursa weight by about 34.6% compared to normally feathered genotype. As for the relative thymus and spleen weights, it could be noticed that the relative thymus and spleen weights was not significantly affected by the presence of the Na gene in a homozygous state. Inversely, the heterozygous naked neck genotype had significantly higher relative thymus and spleen weights compared to normal type. The size of the spleen of avian species may be influenced by genotype (Ubosi *et al*., 1985). It could be concluded that the presence of naked neck gene in a single state increased the relative lymphoid organs weight in chicken. Similar trend was not observed in the presence of Na gene in a homozygous state.

Table 3. Relative lymphoid organs weight and some hematological parameters (Mean±S.E) of naked neck (NaNa & Nana) and normally feathered (nana) genotypes (n=50/genotype)

	Genotype				Gene effect	
Trait	**NaNa**	**Nana**	**nana**	**Prob.**	**NaNa**	**Na-**
Lymphoid organs						
Bursa, %	0.26^{b}±0.09	0.35^{a}±0.03	0.26^{b}±0.08	0.01	0.00	+34.62
Thymus, %	0.34^{b}±0.05	0.41^{a}±0.04	0.32^{b}±0.06	0.01	+6.25	+28.13
Spleen, %	0.26^{b}±0.04	0.31^{a}±0.05	0.25^{b}±0.07	0.01	+4.0	+24.00
Hematological traits						
Hematocrit	34.12^{b}±0.85	35.10^{a}±0.91	33.18^{c}±0.72	0.01	+2.83	+5.79
Plasma total protein, g	6.20^{ab}±0.12	6.53^{a}±0.15	6.12^{b}±0.18	0.05	+1.31	+6.70
Albumin, g	3.32±0.10	3.18±0.08	3.23±0.09	NS	+2.78	-1.55
Globulin, g	2.98^{ab}±0.12	3.35^{a}±0.09	2.89^{b}±0.11	0.01	+3.11	+15.92

$^{a, b \text{ and } c}$ Means within row with different letters are significantly differed

NS: non-significant

Gene effect was calculated as a deviation from normally feathered (nana) genotype

Hematocrit of Nana genotype was significantly higher than those of NaNa and nana ones. The similar trend was observed when NaNa genotype was compared to the nana birds. The presence of Na gene in a single state significantly increased both plasma total protein and globulin level compared to the nana genotype. The NaNa genotype was intermediated. There was no significant difference among genotypes for plasma albumin.

Heterophils and lymphocytes counts

There is a genetic component to heterophil and lymphocyte responses to stressors (Gross and Siegel, 1985) and their ratio has been used as a selection criterion for heat resistance in chickens (Al-Murrani *et al.*, 1997). Data presented in Figure (1) showed that the presence of Na gene, in single or double state manner, significantly decreased heterophils count and significantly increased lymphocytes count compared to normally feathered genotype. In birds, the heterophils are phagocytic cells, its main function is protection against invading microorganisms. Whereas primary functions of lympho-involve cell-mediated and humoral immunity. Heterophils increase and lymphocytes decrease when birds are stressed, so that the ratio between them is an index of response to a stressor (Siegel, 1985).

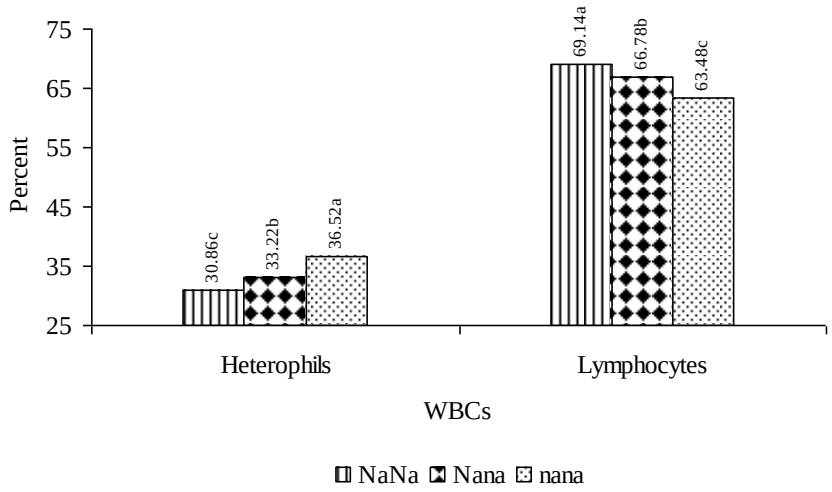

Figure 1. Heterophils and lymphocytes count of naked neck and (NaNa & Nana) normally feathered (nana) genotypes

***In vivo* cell-mediated immunity**

Phytohemagglutinin-P, a T-cell mitogen, induces proliferation in T-lymphocytes. Injection of PHA-P at a selected site in chickens can be considered as an inducer of localized *in vivo* T-lymphoproliferative response (Cheema et al., 2003). This response was measured at 24, 48 and 72h post PHA-P injection into the toe-web, and is presented in Figure (2). It could be observed that the NaNa and Nana genotypes had significantly hyper response to PHA-P injection compared to their normally feathered (nana) counterparts. Similar results were obtained by Fathi *et al*. (2005) and

El-Safty *et al*. (2006). Also, Patra *et al*. (2004) reported that significantly higher cell-mediated immunity (CMI) estimates were observed in Nana and NaNa genotypes compared to their nana counterparts. There was a good indication that cell-mediated immunity plays an important role in controlling and clearing intracellular bacterium (Kougt *et al.*, 1994, 1995). Also, selection for cellular responsiveness might to enhance of resistance to coccidiosis (Parmentier *et al.*, 2001). Therefore, the naked neck birds may be more resistance to coccidiosis than the normally feathered ones.

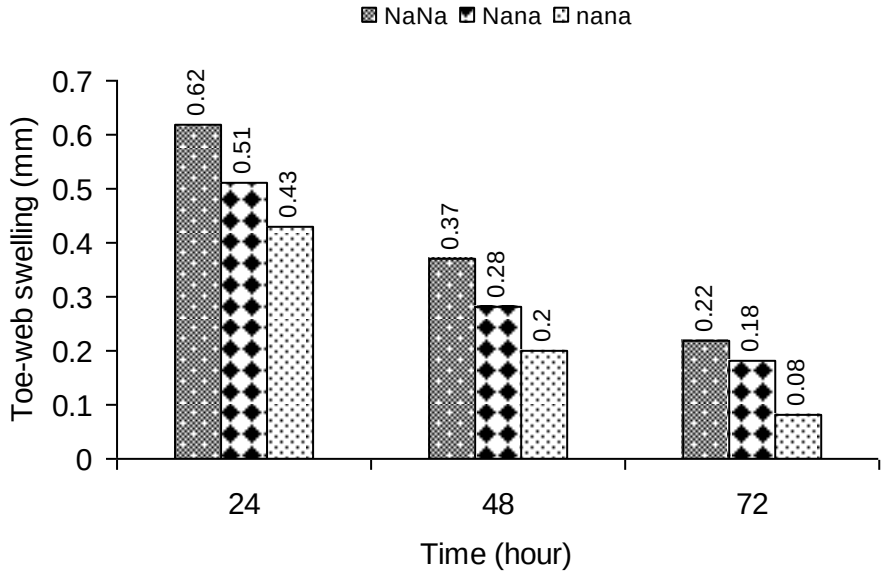

Figure 2. Toe-web swelling of naked neck (NaNa & Nana) and normally feathered (nana) genotypes

	Time (hour)		
	24	48	72
Prob.	0.001	0.001	0.0001

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خصائص الذبيحة والحاله المناعية للدجاج عارى الرقبة وطبيعى التريش

أحمد جلال السيد[١]، محمود يوسف محروس[١]، ايمن محمد حسن[١]، اميرة اسماعيل الدلبشانى[٢]

١- قسم إنتاج الدواجن، كلية الزراعة، جامعة عين شمس، القاهرة، مصر، ٢- قسم إنتاج الدواجن، كلية الزراعة، جامعة الاسكندرية، مصر

صُممت هذه التجربة للمقارنة بين الدجاج عارى الرقبة (الصورة الاصيلة والخليطة) والدجاج طبيعى التريش بالنسبة لخصائص الذبيحة والمقدرة المناعية تحت ضروف فصل الصيف فى مصر. تم رعاية عدد ٢١٠ كتكوت تسمين (٧٠ كتكوت من كل تركيب وراثى) تحت نفس الظروف البيئية والصحية، حيث قدم العلف والماء بصورة حرة، وكان متوسط درجة الحرارة العظمى والصغرى المسجلة خلال الفترة التجريبية ٣٢.٥ و ٢٨.٧ درجة مئوية على التوالى. عند ٦ اسابيع من العمر تم اختيار عدد ١٥٠ طائر (٥٠ من كل تركيب وراثى) عشوائيا وذلك لتقييم صفات الذبيحة. اوضحت النتائج ان وجود العامل الوراثى عرى الرقبة فى صورته الاصيلة ادى الى زيادة معنوية فى وزن الجسم والوزن النسبى لعضلات الصدر وكمية اللحم مقارنة بالطيور طبيعية التريش، بينما سجلت الطيور الخليطة قيم متوسطة فى معظم الحالات. بالنسبة للمقدرة المناعية، ادى وجود عامل عرى الرقبة فى صورتة الخليطة الى زيادة معنوية فى الوزن النسبى للاعضاء الليمفاوية مقارنة بالطيور طبيعية التريش، بينما لم يشاهد نفس الاتجاة فى الطيور علرية الرقبة الخليطة. بالنسبة للمناعة الخلوية، فقد اوضحت النتائج ان الدجاج عارى الرقبة سواء فى الصورة الخليطة أو الاصيلة قد سجل استجابة اعلى معنويا عند الحقن بمادة PHA-P مقارنة بالطيور طبيعية التريش.

الخلاصة، تحت ظروف فصل الصيف فى مصر، امكن تحسين خصائص الذبيحة فى الدجاج عن طريق إدخال عامل عرى الرقبة والذى أدى الى زيادة الوزن النسبى لعضلات الصدر وكمية اللحم بالاضافة الى إنخفاض الوزن النسبى لدهن البطن، علاوة على ذلك زيادة المقدرة المناعية مقارنة بالطيور طبيعية التريش.