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Effect of the Naked Neck Gene (*Na*) on Marketability, Carcass Traits, Haematological and Serum Biochemical Indices of Cockerels

by

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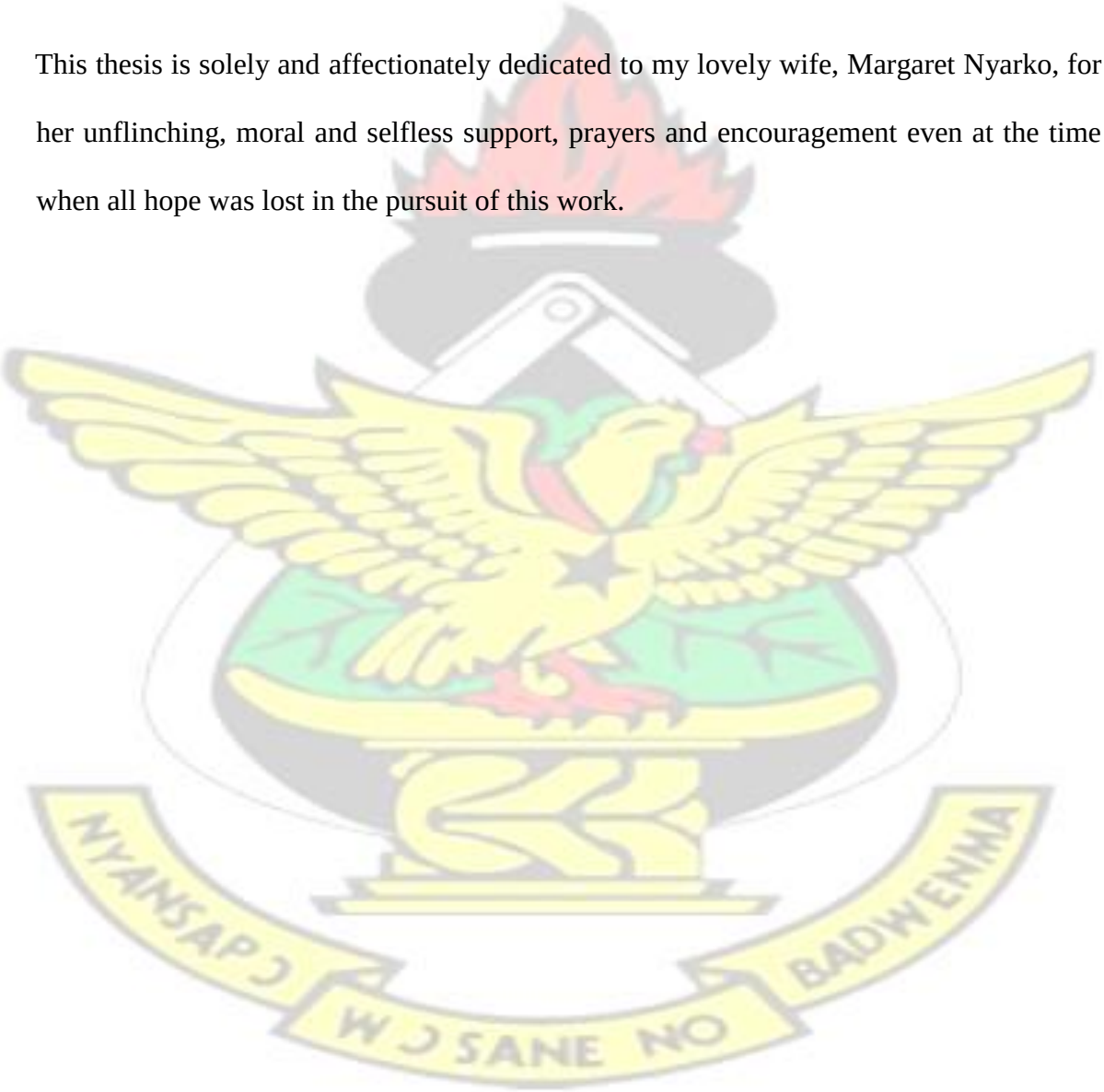
DEDICATION

This thesis is solely and affectionately dedicated to my lovely wife, Margaret Nyarko, for her unflinching, moral and selfless support, prayers and encouragement even at the time when all hope was lost in the pursuit of this work.



DECLARATION

I hereby declare that this submission is my own work towards the Master of philosophy (Animal Breeding and Genetics) degree and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text

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ABSTRACT

A research comprising of two phases; a survey and an experimental work was conducted: the survey comprised mainly of interviewing market women and supplying birds to them for sale in order to find answers to questions related to marketability or otherwise of the naked neck, frizzled- naked neck and normal feathered cockerels whiles the experiment was carried out to evaluate the effect of the three genotypes namely: (i) *NanaFf*, (ii) *Nanaff* and (iii) *nanaff* on carcass characteristics, haematological/ serum biochemical parameters and marketability of cockerels. The birds used were the fourth generation (F4) offspring of crosses between local heterozygous naked neck (*Nana*) and heterozygous frizzled (*Ff*) males and hybrid commercial Lohmann females. Three hundred (300) eleven-week old crossbred cockerels (hundred each of the three genotypic groups) were randomly housed in fifteen (15) opensided deep litter pens with twenty (20) cockerels in each pen in a Completely Randomized Design for nine weeks and their haematological/ serum biochemical indices and carcass characteristics evaluated. The birds were provided with grower mash *ad lib* throughout the experimental period. Blood was taken from 3 birds from each genotypic group when the birds were 18 and 20 weeks old. At the end of the trial, 15 cockerels from each of the three genotypic groups were randomly selected and slaughtered to determine the carcass parameters. Burgers were prepared from the breast muscle of the carcass for sensory evaluation. The results from the survey indicated that majority (91.7%) of the respondents admitted they would readily accept to sell the naked neck cockerels. Also, at almost all the sales points the *Nanaff* was first to be sold out followed by the *nanaff* feathered with the *NanaFf* being the last both before and during the major seasons‟ sales. On the other hand, the results from the experiment indicated that except for total cholesterol, spleen and neck weight, there was no significant genotypic effect ($p>0.05$) on haematological, serum biochemical and carcass parameters measured. The *nanaff* genotype birds had significantly higher ($p<0.05$) cholesterol levels than both *Nanaff* and *NanaFf* genotype birds, both of which did not differ significantly. The *Nanaff* had significantly ($p<0.05$) higher spleen and neck weight than both the *nanaff* and *NanaFf*. The latter two did not differ significantly ($p>0.05$). Also, haematological and serum biochemical assays of all the birds were within normal range. The results from the sensory evaluation indicated that the burgers from *nanaff* and *NanaFf* birds had significantly ($p<0.05$) lower acceptability levels than those from the *Nanaff* birds. In conclusion, the naked neck gene had a positive effect on cockerel meat and cockerel marketability.

TABLE OF CONTENTS

Table of Contents

LIST OF TABLES AND FIGURES

CHAPTER ONE

1.0 INTRODUCTION

The local chickens, according to Njue (2002) form part of the many local assets of underprivileged people living in the rural areas, which may perhaps be harnessed and exploited for poverty alleviation. Ibe (1995) stated that the environment of the tropical zone is typified by stress factors, remarkable among which is high ambient temperature, which can result in heat stress and thus, influence the performance of birds. High ambient temperature and high amount of feather covering chickens decrease the rate of heat dissipation. Chickens therefore dissipate heat through their respiratory system (panting) and via morphological body surfaces such as combs, wattles and shanks (Ibe, 1995).

According to Zulkifli *et al*. (1994), stress from the environment may slow down the immune function of birds by hindering antibodies production and effective cell-mediated immunity. Guo *et al.* (1998) in consonance with the above statement stated that the development of organs of the immune system of broilers were restricted as a result of high ambient temperature. In addition to these, research has revealed that an increase in body temperature has an undesirable effect on semen quality (McDaniel *et al*., 1995, 1996). It is therefore advisable for farmers to use management practices that may reduce heat stress in their facilities. However, the depression of chicken growth due to high temperature cannot be completely eliminated by such management practices. Moreover, these practices aimed at alleviating heat stress are for most part quite expensive and hence not economically feasible in rural areas of developing countries. Yahav *et al*. (1998) reported that chickens suffer under high ambient temperature because their feather covering impedes the dissipation of internal heat, resulting in soaring body temperatures. In order to evade a dangerous rise in body temperature, chickens reduce endogenous heat generation by reducing feed intake, with a consequent decrease growth and

yield. Reduced feather covering ought to improve and boost heat dissipation and accordingly ameliorate the heat stress on chicken raised in hot climates (Galal *et al*., 2007). A considerable amount of gene complexes and/or major genes have been found in the gene pool of native chicken populace in the tropics and incorporation of these genes into the commercial strain could in part or completely help solve the heat tolerance problem (Peters *et al*., 2002). Prominent among them are the naked-neck, *Na* (feather distribution) and the frizzled, *F* (feather structure) genes (Hassan, 1989). It has been established that these genes (*Na, F*) are highly tolerant to the tropical condition and can produce high number of good quality eggs and carcass with low production and handling costs (Stadelman, 1977). Hernandes *et al.* (2002) reported that these distinctive genes (*Na, F*) reduced heat stress in the tropics and boosted the performance of individuals carrying them. Gowe and Fairfull (1995) mentioned the sex-linked recessive gene for dwarfism (*dw*) as another gene that is also responsible for heat tolerance.

Although these indigenous breeds perform better under high levels of management than under village conditions, Gowe and Fairfull (1995) reported that these indigenous breeds still do not perform competitively under commercial conditions. Some researchers have added that most indigenous strains lack the productive capacity of the commercial stock (Horst, 1988, 1999).

Saxena and Ketelaars (1993) stated that it might be worthwhile to examine the possibility of combining good performance ability with the capacity to tolerate warm environmental temperatures. Therefore, crossing the local strains which have better adaptability with the commercials with better productive capacity becomes imperative.

Galal *et al.* (2007) stated that heterozygous naked neck *(Nana*) hens had significantly heavier body weights compared to their normal (*nana*) feathered counterparts, confirming an earlier report by El-Safty *et al*. (2006) who also reported that the *Na* gene significantly increased body

weight, shank length and keel length of laying hens compared to normal feathered ones. As reported by Bordas and Merat (1984) the homozygous naked neck (*NaNa)* genotype at high temperatures significantly had higher egg numbers, higher average egg weight, and higher egg mass than their normal feathered counterparts.

Thus, to improve the productivity and efficiency of the indigenous birds within their local environments, it is necessary to preserve desirable genes, for example disease resistance genes, and advance them (Sonaiya *et al.*, 2002). In the light of this, it is imperative to evaluate the immune response capabilities of the local chicken. Kral and Suchy (2000) reported that important information is provided by serum biochemical and haematological parameters on the immune status of animals and this type of information is required for diagnostic and management function and could equally be integrated into breeding programmes for the genetic advancement of native chickens.

Islam *et al.* (2004) stated that critical examination of normal haematological parameters of birds is especially vital in diagnosing the diverse metabolic and pathological disorders and as a diagnostic tool, it can be used to evaluate the health status of an individual and /or a flock. Characteristically, haematological changes are useful for the determination of various conditions of the body and also for the determination of environmental stress, pathological and /or nutritional factors and due to these factors, in recent years scientists, researchers and veterinarians as well as poultry farmers have found avian physiology to be of great importance (Islam *et al.*, 2004). Dukes (1955) stated that haematological parameters of chickens are affected by sex, age, breed, season, climate, geographical location, time of day, day length, nutritional status, life habit of species, present status of individuals and such other physiological factors.

It is desirable to be acquainted with the normal physiological values under local conditions for proper management, breeding, feeding, prevention and treatment of disease, but information on normal haematological values of the local birds is scarcely existing in the literature as research in this area has hardly ever been carried out under local conditions (Islam *et al.*, 2004). Coupled with the fact that prominent farmers have exercised restraint and fear in the use of the local birds as commercial birds for sale in Ghana, due to some perception and beliefs that people have on the consumption of their meat; the main objective of the present study was to determine the effect of the naked neck gene (Na) on marketability, haematological and serum biochemical indices, carcass traits and consumer acceptability of cockerels. The specific objectives of the study were to:

- examine haematological parameters such as Packed Cell Volume (PCV), Haemoglobin (Hb) concentration, Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular Hemoglobin Concentration (MCHC) of the naked neck, normal and frizzled-naked neck birds.
- evaluate the haematological and serum biochemical parameters of the naked neck, frizzled-naked neck and their normal feathered counterparts.
- compare the carcass composition and carcass quality of the naked neck and frizzlednaked neck with their normal feathered counterparts.
- determine the taste preference for the three genotypes i.e. naked-neck, frizzled-nakedneck and normal feathered birds.
- assess the level of acceptance of the naked-neck and frizzled-naked neck birds as commercial birds in Ghana.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Performance of Animals

The performance of an animal gives an indication of the extent to which the genes possessed by it are expressed under a given set of environmental circumstances (Falconer, 1989). Thus, the performance or the phenotype of an animal is the sum of the effects of the animal‟s genotype and the environment in which it finds itself as well as how the environment reacts with the genotype (Falconer, 1989). The animals‟ own genotype or heredity sets the upper boundary to its potential (Etgen and Reaves, 1978; Lasley, 1987). Even the provision of the best possible environment will not cause that animal to exceed this upper limit unless this limit can be identified and altered through the use of hormones or radiations or chemicals (Lasley, 1987) or genetic engineering. The environment provides the opportunity for the animal to perform (Etgen and Reaves, 1978). In the absence of genotype – environment interaction, the best expressed genotypes in one environment will be the best in another environment. As a result of this genotype – environment interaction, mating outstanding animals does not guarantee that a resulting offspring will also be outstanding unless similar environments are provided to it. The probability of the offspring being superior, however, is greater than when one of the parents is of low genetic merit (Leaver, 1983). In addition, an animal of certain genotype may perform more satisfactorily in one environment than in another. Thus, it is important to have the right strain or breed for a particular environment.

The purpose of an animal breeding programme, therefore, is to improve the animal‟s genetic ability economically for higher performance in the traits of importance as rapidly as possible. To accomplish this, the measurability, profitability or economic value of the trait, presence of variations in the trait and the level of its heritability must be taken into consideration. Other

factors to consider are the association of this trait with other traits and the effect of a number of traits selected for concurrently (Etgen and Reaves, 1978; Leaver, 1983).

2.1.1 Performance of naked-neck Birds

In a research carried out by Merat (1990) on birds reared under high temperatures, about 30°C or above, the homozygous (*Na/Na*) or the heterozygous *(Na/na)* naked-neck birds showed a heavier average weight gain than their normally feathered counterparts. Improvement in the carcass yield for the heterozygous genotypes was also observed. In another study Patra *et al.* (2002) and Yalcin *et al.* (1997) also observed that under high temperatures, birds possessing the naked-neck gene had heavier breast weight, higher growth rate, and superior feed conversion ratio and carcass traits. Eberhart and Washburn (1993) stated that naked-neck chickens had significantly larger body size than their normal feathered birds when subjected to chronic heat stress although the two genotypes segregated from the same parents.

Merat (1986) in a study of naked-neck and normal feathered broilers reared at three different temperatures (20ºC, 25ºC and 30ºC) observed that at 20ºC or lower, the differences between the normally feathered and the naked-neck birds in terms of body weight and weight gain was almost the same. At 24 – 25ºC growth and feed efficiency between the naked-neck and the normal feathered genotypes were negligible. Near 30ºC or higher, the naked-neck birds were heavier and had superior feed efficiency than the normal feathered birds. On carcass yield, the study by Merat (1986) revealed that the reduction of plumage by 30 percent for the heterozygote and 40 percent for the homozygote resulted in gains of 1.5-2.0% and 2.5-3.0% in slaughter yield of the two genotypes respectively. An increase in meat yield of dressed carcasses by as much as 5.5 percent and 4.0 percent for males and females respectively was also observed. This was evident in the higher proportion of muscles in naked-neck birds in the

pectoral region. There was also a lower percentage of intramuscular and subcutaneous fat in the naked-neck chickens in comparison to the normal feathered ones (Merat, 1986). Fayeye *et al.* (2006) observed that among the indigenous birds surveyed in some selected villages in Nigeria, those expressing the naked-neck trait were recognized to be superior in adult body weight. Horst (1988) worked on Dahlem Red stocks showing the naked-neck gene and reported that those genotypes expressing the gene were superior in egg production and body weight as compared to genotypes that were not expressing the gene. It has been reported that the heterozygous naked-neck (*Na/na*) genotype recorded an improved humoral and cellular response than their normal feathered (*na/na*) and homozygous naked-neck (*Na/Na*) genotypes (Alvarez *et al.*, 2002). Again, it was reported that the *Na/na* hens had a significantly higher dermal swelling (cell mediated) compared to the normal feathered ones (El-safty *et al*., 2006).

Furthermore, heterozygous naked-neck hens had a lower culling and mortality rate than the normal plumage hens. Galal and Fathi (2001) concluded that the naked-neck gene was connected with higher feed intake compared to its homozygous recessive allele under high ambient temperature. These authors also observed that the *Na* allele had a positive effect on feed conversion ratio, where the *Na/na* genotypes had significantly lower feed conversion ratio when compared to the *na/na* ones. Under moderate ambient temperature (34^0C) Alvarez *et al.* (2002) observed 2.42 feed conversion ratios for *na/na*, 1.84 for *Na/na* and 1.92 for *Na/Na* hens. Jianxia (2002) recorded 6.0% increase in feed intake on the average for male broilers with frizzled and naked-neck genes when compared to the normal feathered broilers.

Under high temperature, it had been reported that the reduction of feather coverage offers relative heat tolerance to birds and therefore, heterozygous naked-neck chickens are superior to their normal feathered counterparts (Cahaner *et al.*, 1993).

In hot environments, the *Na* gene has been linked with increased laying rate, egg size and egg mass (Younis and Galal, 2006; Garces *et al., 2*001). Abdel-Rahman (2000) researched into the effect of the *Na* gene on the egg production performance of sharkasi chickens under subtropical conditions and reported that the naked-neck hens showed significant increase in egg production, 90-day egg number and egg mass by 9.0, 17.80 and 13.30% for *Na/na,* and 3.70, 7.30 and 7.30% for *Na/Na* compared with the *na/na* genotype. The naked-neck birds also significantly matured sexually earlier than the normal feathered birds by about 5 days. The naked-neck birds were also heavier at 24, 40 and 72 weeks than normally feathered birds. During the laying season the average mortality rate was less in naked-neck chickens than the normal feathered (*na/na*) ones; however, the differences were not significant. AbdelRahman (2000) stated that the *Na* gene also reduced feed intake by 12.40 and 13.60% respectively in *Na/na* and *Na/Na* genotypes. The naked-neck chickens had a significantly superior feed conversion than *na/na* genotypes. The *Na* gene resulted in a significant reduction in egg yolk and shell percentages. Eggs produced from naked-neck hens had a lower breaking strength and egg shell thickness compared with the *na/na* genotypes. Other effects of this gene on productivity noted by other researchers (Ladjali *et al.,* 1995) include lessened effect of high ambient temperature on fertility, body weight loss under heat stress, better levels of heat shock protein, Hsp70 (Hernandes *et al.,* 2002).

Lowest incidence of diseases such as cloacal cyst, ascites, prolapsed, Coccidiosis, Marek‟s disease, Osteodystrophy and Salmonellosis was similarly observed by Fraga *et al*. (1999) in the naked-neck birds. According to Yushimura *et al*. (1997) among the indigenous chickens, the naked-neck is found superior in terms of egg production and size and body weight in a hot and humid environment. Other positive effects associated with this gene on broiler stocks are increased body weight and meat yield, higher body weights, lower fat content and better feed

efficiency (Merat, 1986). A study by Njenga (2005) in coastal Kenya on productivity and socio-cultural facets of local poultry phenotypes showed that the *Na* phenotypes had significantly higher body weights in contrast to the normal feathered counterparts. Egg weight ranged from $38 \pm 2.9g$ $to 45 \pm 4.5g$, with the *Na* phenotypes producing the highest. The mean egg shell thickness for the chickens was 0.31mm. Among the other four phenotypes the *Na* phenotype gained the highest average daily gain. The author made a conclusion that the *Na* phenotype is better in productivity as compared to the other four phenotypes. Barua *et al.* (1998) showed that among the indigenous chickens of Bangladesh, the naked-neck fowl performed better in terms of egg and meat production, and were more resistant to diseases than their fully feathered counterparts. They observed that the crosses between the indigenous naked-neck fowl and the exotic standard breeds performed better than similar crosses using fully feathered indigenous fowl.

2.1.2 Performances of frizzled Birds

There is much less information on the effect of the *F* gene on productivity as compared to the naked-neck gene. Nevertheless, there is evidence to indicate that for stocks that have to perform under hot humid conditions this gene may be useful (Gowe and Fairfull, 1995). Merat (1990) showed that the frizzling gene resulted in an increase in egg number and egg mass, alongside reducing death rate under hot and humid environment. According to Horst (1988) the *F* gene is associated with increase in egg number, egg mass and reduction in mortality when the birds are raised under hot and humid conditions. Hauanshi *et al.* (2002) worked on the effect of the *Na* and *F* genes on immunocompetence in chickens and reported that there were significantly higher haemolytic complement levels in serum observed for the frizzled feathered birds than the normal feathered sibs. Younis and Cahaner (1999) suggested that when reared at high ambient temperature (32%), birds with frizzled genes perform in terms of weight gain from 4-

7 weeks than their counterparts which are normally feathered. The results indicated that the reduced feather coverage by the frizzled gene provided relatively heat tolerance; therefore, in the hot climates the *F/f* broilers were superior to their normal feathered birds. They suggested that frizzled birds must be preferred in hot climates. Nwachukwu *et al.* (2006) also observed that the birds with the frizzled gene outperformed their sibs which were either naked-neck or normal feathered in body weights and most of the egg traits evaluated, thus indicating that the frizzled gene may be advantageous in poultry production in the humid tropics. Frizzled birds have increased basal metabolism, leading to increased production of thyroid and adrenal grand hormones (Benedict *et al*., 1932 and Boas and Landauer, 1933). They again found an increased oxygen consumption, heart rate, volume of circulating blood and feed intake. As a result of this, frizzled birds are expected to have enlargement of the spleen, heart, gizzard and alimentary canal.

2.2 Origin of Poultry

The term "poultry" is generally used as a name for a diversity of domesticated birds which are reared mainly for their meat and eggs, for example, ducks, chickens, turkeys, guinea fowls, geese, swans, pigeons, etc. Collectively, they are probably the most economic converters of locally available feed such as grains and grain by- products into high quality sources of animal protein in the form of meat and table eggs (Tweneboah, 2002).

According to Crawford (1990), the interest in the origin and history of poultry species to the present has always been mostly academic. Little improvement has been made through the use of wild ancestors or primitive relatives of modern stocks, as pertains in crop breeding. In spite of this, the knowledge of origins and history of chickens will have a practical use, considering the rapid development in genetic engineering. According to modern ornithology, there are four

(4) species of the jungle fowl, but the red jungle fowl (*Gallus gallus)* is found to be a major contributor or an ancestor to the domestic fowl (Crawford, 1990). Conventionally it is thought that all the other three wild species (*G. lafayettei, G. sonnerati and G. various)* interbred with *Gallus gallus* and those domestic stocks owe some of their inheritance to all of these species. From which various species have arisen domestic hens of various types. Some, known as the fancy breeds" are of little direct commercial value. The fancy breeds such as the Cornish red and the white rock have been very important contributor to the strains that now produce our modern strains of broilers. Smith (1990) stated that it is very important that these breeds are maintained in the future as (gene banks) because they may contain useful genes that could be exploited commercially. The genome of the domestic chicken has a haploid number of thirty-nine (39) chromosomes, one (1) pair of sex chromosome (*z* and *w*), eight (8) pairs of macro chromosomes and thirty (30) pairs of micro chromosomes. The size of the chicken genome is projected to be 1.2 ×109 BP (Groenen *et al.,* 2000; Olofeson and Bernardi, 1983). Like other avian species, chickens differ from mammals in that the male is the homogametic sex (*ZZ*) and the female is the heterogametic sex (*ZW*), the *Z* and *W* chromosomes showing heteromorphism (Singh, 2000).

2.3 Indigenous Poultry Production in Developing Countries

Commercial poultry production, although fairly well developed, continues to develop rapidly in Africa and other areas of the world. Much less attention has been given to the progress of the family poultry systems (Kitalyi, 1998). The promotion of rural poultry is appropriate and actively practiced in order to improve the economic and nutritional security of the people living in tribal, rural and inaccessible areas in a sustained manner (Branckaert *et al*., 2000). One of the outstanding features of poultry husbandry in tropical countries is that in few places it is a specialized industry and rarely does it form the sole means of livelihood or even a major source

of income. Many tribes and people consider poultry husbandry degrading or at least, not worth the attention of men of standing in the community. Eggs as a form of food are taboo to some African tribes, and eggs as well as poultry flesh are forbidden to strictly vegetarian peoples (Williamson and Payne, 1964). Despite this, practically, every family whether nomadic or settled own some form of poultry in varying numbers so that, in the aggregate, the total poultry population in most tropical countries is impressively large (Taylor and Ralph, 1988). Although the contribution of poultry to human nutrition in the tropics is already appreciable, it is but a small fraction of what it would be if optimum human requirements could be satisfied (Williamson and Payne, 1978). Although, with the exception of the poorest of the poor, poultry are minor to other agricultural activities, they have an essential role in providing the indigenous population with high-quality protein and income (Tweneboah, 2002)

2.4 Rural Chicken Management System in Ghana

The rural chicken is unremarkable and has assumed names based on the researcher. These birds appear to be genetically heterogeneous with no specific colour pattern (Ladokun *et al.*, 2008). There appears to be no uniformity in the terminology used for the description of the rural chicken and has been named as the indigenous chicken, the native chicken, the local chicken, the village chicken, the scavenging chicken, the traditional chicken, the family poultry, the free –range chicken and the backyard chicken (Minga *et al*., 2004). Traditional village – scavenging poultry make up a significant fraction of poultry in the continent or national flock in developing countries (Scanes, 2007). The rural chicken populace is very large; it makes up 80% of the total chicken population in the world. There are over 300million chickens in Africa and more than 80 percent are rural chickens (Gue‟ye, 1988). In developing countries village poultry plays a very significant socio-economic role for farmers. Village poultry provide regular household

income and are used for starting capital for young people, gift and sacrifices (Sonaiya *et al.*, 1999; Gue‟ye, 1998; Guarantne *et al.*, 1993).

Village chicken products are often the only source of animal protein for resource –poor households and therefore they offer a source of high-quality protein (Minga *et al.*, 2006). Development programmes of traditional poultry production in developing countries were either deficient or limited in scope, and due to that, village poultry production is not adequately understood in connection with existing farming systems (CNRST, 1995). Additionally, village chicken system is low at farm level in relation to off take (consumption or sale).

It is reported that a lot of researches have been made to better the performance of indigenous chickens, either by improved feeding or cross –breeding however, the impact of these studies is barely felt in practice. The native domestic fowl (*Gallus gallus*) reared in the African rural areas have been described with names like "African chicken, „bush chicken‟ or „runner chicken‟ by various investigators (Gueye and Bessei, 1997; Kaunta, 1991; Sonaiya, 1990; Oluyemi, 1989; Berte, 1987). Gue‟ye (1998) reported that village chickens appear to be well tailored to the conditions of their environment for instance cold or hot weather, rain and sporadic feed scarcity.

Poultry –keeping systems in Africa have evolved over time. The earliest were the farmyard operations, in which small flocks of birds had almost complete freedom of movement. There has been most development work on systems for hens, but many systems are used for various poultry. Diverse systems have been reported by a number of investigators together with Aini (1990) and Cumming (1992) however, in point of fact there is generally no accepted definition of rural poultry production system. The systems described by these authors are typify as

consisting of undersized flocks, with minimal or no inputs, low outputs and sporadic damage of the flocks by diseases. In these systems, birds are possessed by individual households and they are sustained under a free range system, with no or little inputs for feeding, housing or healthcare. Characteristically, these flocks are small in quantity where each flock contains birds from each age group, with an average of 7-10 growers of various age groups. Sonaiya (1990) also stated that family poultry in Africa consisted of birds ranging from 5-10 on average. The village poultry production system is also defined by Tadelle and Ogle (1996) as being distinguished by lowest amount of inputs, and with birds roaming freely in the backyard, and no expenses beyond the cost of the starting stock, a handful of grain almost every day and probably simple perches at night. Family poultry in Africa has been classified into four (4) broad production systems by Bessei (1987), that is; intensive, semi-intensive, backyard extensive and free range extensive systems.

2.4.1 Free Range Extensive System

Under this system, the birds are not confined and can roam freely in search of feed over an extensive area. Simple shelters and perches could be made available, but these possibly will or will not be used. The flock usually contains birds of different species and of varying age groups (Bessie, 1987).

2.4.2 Backyard Extensive System

Under this system, the birds are allowed to roam free during the day but are kept in pens at night (Bessie, 1987). The most important involvement is in the region of water and feed supplementation, during the night accommodation and, to a much less important extent, medication. According to Chrysostome *et al.* (1995), supplementation comprises administration of wastes from household or cereal grains, normally inside the morning or late into the afternoon in accordance with the capability of the farmers. The supplementary rations

are usually offered to the birds in the mornings and evenings when they have returned from scavenging. Under this system, production of meat cannot be separated from production of egg or chick, and due to that a very much broody, low body weight or bird with low feed requirement is best for endurance in this condition (Kitalyi, 1998). In this system hens brood their own chicks for incessant rebirth of the flock as there is little reproductive control of hens.

2.4.3 Semi-Intensive System

According to Bessei (1987) the semi-intensive system is a combination of the extensive and the intensive systems where birds are confined to a certain area with access to shelter. It is commonly found in urban and peri-urban and sometimes in rural situations. In the "run" system, the birds are confined in an enclosed area outside during the day and housed at night. Feed and water are available in the house to avoid wastage by rain, wind and wild animals. The semi-intensive system is generally observed in Asian countries. In this system, the chickens are fed with formulated diets either bought commercially or produced from feed mills (Aini, 1990). Flock size varies between 50 and 500 birds on average (Sonaiya *et al*., 1999). Roberts (1999) suggested the use of specialized birds in this type of system rather than indigenous animals.

2.4.4 Intensive System

This system is used by medium to large scale commercial ventures. It becomes a backyard intensive when used at the household level under small scale. The birds are completely limited either in pens or houses. Under the intensive system, birds are completely dependent on their owners for all their necessities and capital expenditure is very high.

Cost of producing birds in this system is also relatively higher than the extensive and the semi-intensive systems. The birds are either kept in the deep litter or the battery cage system under

the commercial production system. The system requires a high starting principal injection and is mostly restricted to large scale commercial egg laying business (Bessie, 1987).

2.5 Ownership and Management of Rural Chicken

In most African societies possession of rural chickens is a function of cultural and social factors. Even though rural birds roam freely about the entire village area, they are linked to a definite family unit (Kitalyi, 1997). The bond between the chickens and the owner‟s household is exceptional and has directed some investigators to describe rural chickens as component of the family unit, frequently sharing identical shelter (Kitalyi, 1997). For example, in Ghana, Williams (1990) found out that chickens move about with farmers between fields and homesteads. In West Region of Cameroon, the whole family generally own the chickens, however with detailed possession patterns, majority of the women owned the birds (52.7%), children (26.9%) and men (20.3%) followed contrary to what pertains in various part of Borno state in Nigeria where chickens is principally possessed by men (55.5%), women (38.8%) and children (5.55%) followed.

Abu-Bakr *et al*. (2007) and Njenga *et al.* (2005) also supported this finding and mentioned that men possess the majority of village chickens, in the proportion of 6:10:13 for children, women and men respectively. The reason for this trend in ownership in Nigeria was ascribed to the prearranged function men play in terms of making decision on issues relating to management of poultry and other family issues (Ekue *et al*., 2002), whereby the decision of the husband as the family head is at all times final (Abu-Bakr *et al.*, 2007). Similar trends in the assigning of duties towards poultry management were observed by Abu-Bakr *et al.* (2007) and Ekue *et al*. (2002).

Maintenance of hygiene and feeding were noticed to be the joint responsibility of both children and women and that the latter are the appropriate group through which development policy could be directed. Rural chickens are in the field of women according to the general school of thought but as mentioned by Kitalyi (1996) there exists variations within and this is because of the closer connection of women with other domestic activities. Therefore the women were noted to have extra information on the chickens. In the daily administration of poultry activities women provide extra labour (Njenga *et al.*, 2005).

The attachment of the local chicken to the household and the difference in intra household relations within Africa result in different system of rural chicken production. In some rural community, the blending of flocks between family units is limited to searching periods only (Abu-Bakr *et al.*, 2007). In others there is a more prominent relationship of herds from various family units, which can stretch out to sharing asylum and lodging (Kitalyi, 1997). Kitalyi (1997) further clarified that the administration of village chickens is confused by the nearness of multi-stage groups in the same run. Where additional nourishing and water is made available, the holders utilized are too deep for the chicks to get to the contents. Disease, poor administration, inadequate breeding and nourishment are seen as significant parts influencing village poultry generation. The administration issue additionally leads to the disappointment or poor execution of health control. Health and feeding enhancement projects may be effective if this circumstance is given due thought to guarantee that the diverse age groups are covered (Kitalyi, 1997).

2.6 Constraints to Village Chicken Production

Village chicken production (Rural poultry keeping) is an essential farming activity of nearly every rural society in Africa and will continue to remain prominent in African villages, despite

the introduction of exotic high-yielding chicken breeds since the 1920"s (Kitalyi, 1998). Nthimo (2004) explained that this is largely due to the fact that farmers are not able to afford the higher input requirement of these high-yielding exotic breeds. Under the free range system, it is estimated that about 80% of these poultry are reared in the villages, (Alders and Spradbrow, 2001) thus, making available meager animal protein in the form of eggs and meat and also being a dependable supply of paltry cash. In Africa, most village chicken production systems are based on the native or indigenous domestic fowl (*Gallus domesticus*) and are differentiated by a less amount of input and output (Awuni, 2002). In spite of these inherent positive potentials, there are challenges that militate against the full expression of their potential (Kitalyi, 1998). The constraints identified are as follows;

2.6.1 Socio – Cultural Constraints

For any meaningful improvement on the performance of the village chicken, there is the need to appraise the socio – cultural factors existing in the village. This is because these variables add to the wide assortment of reaction of rural poultry attendants even under indistinguishable monetary conditions. In some communities, there is a ban on duck keeping since they are alleged to be filthy and dangerous to drinking water supplies (Kitalyi, 1998).

Another socio –cultural limitations to poultry advancement, as indicated by Kitalyi (1998), is the worth set on poultry for use at observances and celebrations or even as an origin of food or as a regular source of income. The high value placed on crop production at the expense of livestock production is also a major constraint to poultry generation. This influences the eagerness to put in much time, cash and endeavors into the domesticated animals segment.

Robbery which results in loss of flock is also an immense limitation because farmers who have lost all their birds through burglary might be unwilling to start all over again. Kitalyi (1998) concluded that the social norm that determines the ownership of livestock can militate against the development of rural poultry. Unlike crop farming which is mainly a man‟s business, keeping livestock and poultry is perceived to be a supplementary source of employment and therefore relegated to women and children hence the low investment in that sector.

2.6.2 Marketing Constraints

As indicated by Kitalyi (1998) the sale of local chickens and its products (meat and eggs) is not well organized. The birds are traded live to meet family needs and the majority of the deals happen at home. The age groups which are first to be sold are the young males, followed by the cockerels while most of the females are kept for breeding purposes. Sale and consumption of birds and eggs, according to Kitalyi, (1998), peak during the festive periods such as Christmas and Easter. The eggs produced by the hen are hardly sold or consumed as they are mainly used for hatching. The marketing and product utilization aspect of village chicken must be taken seriously. A study by Rushton (1996) demonstrated that chicken and egg utilization levels in village communities are low, with mean family consumption levels of one (1) chicken and eight (8) eggs for each month in Ethiopia. The levels recorded in the Gambia from the same study were observed to be lesser than that in Ethiopia. He in this manner suggested the need, particularly in Africa for vivacious advancement of the utilization of chicken meat, eggs and chicken – derivative products among village communities. A range of chicken product preparation technique, either from customary or foreign dishes, or utilization of eggs in manufacturing snack foods should be incorporated into instructional courses, especially where women's groups are included.

2.7 Socio- Economic Importance of Village Chicken Rearing

As indicated by Crawford (1990) the local chicken involves indigenous unimproved, undistinguished poultry strains generally found in developing nations. These breeds incorporate mixed (unspecified) ones coming about because of uncontrolled mating (Kalube, 1990).

As a valued venture of every household, the rearing of village chicken plays an important role in the developing world, and the absence of a backyard chicken in a rural household is a sure sign of poverty (Nalugwa, 1996). Family poultry is therefore defined as small scale poultry keeping by households using family labour and, wherever possible, locally available feed resources (Kitalyi, 1998). These birds may range freely in the household compound and find much of their own food, getting supplementary amounts from the householder. According to Sonaiya (1990) rural poultry represents a significant part of the rural economy. Sonaiya (1990) also defined rural poultry as a flock of less than 100 birds, unimproved or improve, raised in either extensive or intensive farming system. It has become extremely difficult to determine the most important purpose of raising birds in the rural areas because it is impossible to compare the spiritual benefit of sacrifice with the financial benefit of a sale. Rural poultry keeping is rarely the sole means of livelihood for the family but is one of a number of integrated and complementary farming activities contributing to the overall wellbeing of the household (Kitalyi, 1998). Prominent among the benefit derived from this enterprise is the provision of food in the form of meat and eggs. Apart from increased quantitative production of animal protein in rural households, chicken meat and eggs provide the needed protein of a higher biological value than that of red meat (Kitalyi, 1998). The meat and eggs from chicken are reported to complement staple diets of rural Africa due to the higher nutrient concentration. The village chicken is reported to provide readily harvestable animal protein to rural

households and as a result, in some part of Africa, is raised to meet the obligation of hospitability to honoured guest (Kitalyi, 1998). Kuit *et al*. (1986) in their study conducted in Mali found that the main function of village chickens from the farmers‟ perspective is the provision of meat and eggs for home consumption.

According to Alam (1997) and Branckaert and Gue‟ye (1999), in low income, food – deficient countries, meat and eggs from family poultry are estimated to contribute 20 to 30% of the total animal protein supply. Another important benefit derived from local poultry is income. Income generation is seen to be an important goal of family poultry keeping. The eggs produced can provider regular, though small income, while the sale of live birds provides a more flexible source of cash as required. According to Rauen *et al.* (1990) in the Dominican Republic, family poultry contributes 13% of the income from animal production.

Ouandaogo (1990) reported that in Burkina Faso, about 25 million rural poultry produce 15, 000 tones of meat, out of which 5000 tones are exported to Cote d‟Ivoire, at a value of 19.5 million us dollars. In Kenya, it has been reported that the poultry population is about 29.8 million chickens consisting of 21.8 million local chickens, 4.4 million broilers and 2. 9 million layers (Mbugua, 1990). According to Njue (2002) the local chicken is the main source of income for 90% of the rural households, which comprise 80% of the population. He therefore suggested that there is the need to harness and utilize the local chicken for poverty alleviation because these birds are among the many local resources of poor people living in rural areas. Poultry products have social and spiritual benefits and play an important role in rural economies. In many customs of indigenous people, poultry is used for ceremonies, sacrifices, gifts and as savings in the village. Chickens are given or received to show or to accept good relationship or to say thanks for a favour or help (Sonaiya *et al.*, 2002).

Poultry can serve as a unit of exchange in societies where there is no circulation of money (Gue‟ye, 1998). For example, in Gambia; five adult hens can be bartered for one sheep and 25 hens for one herd of cattle. Under normal conditions, birds are sold when the household is in need of money. The income from the sale of chickens is additional revenue to earnings from cash crops from the field (Sonaiya *et al.*, 2002).

Tadelle and Ogle (1996) revealed that the main objective of keeping poultry is for the production of eggs for hatching (51.8%), sale (22.6%), and home consumption (20.2%) and the production of birds for sale (26.6%), sacrifice for healing ceremonies (25%). In some cases, farmers give live birds (8.6%) and eggs (5.4%) as gifts and invite special guests to partake of the popular dish “doro watt” which contains both chicken meat and egg and are considered to be one of the most exclusive dishes in Ethiopia. According to Sonaiya *et al*. (1999), in Nigeria the sale of birds and eggs take place in the villages market. Prices fluctuate during the year being low during the hungry season when the granaries are empty and the crops are still growing and everybody needs ready cash. At such times, traders come to buy and to resell in big cities. Sometimes middle men are involved. Poultry products contribute about 15% of the annual financial income of the household (Sonaiya *et al.*, 1999). Similarly, Tadelle and Ogle (1996) indicated that farmers sell live birds and eggs, particularly during holidays and festivals; they also sell at the onset of local disease outbreak to prevent expected financial loss. In such circumstances prices fall dramatically due to the high supply of bird‟s relative to demand.

Other important benefits that can be derived from rural poultry are as a source of sacrificial offerings in traditional worship and as insurance against crop failure or lean harvest (Kitalyi, 1998). According to Gondwe *et al.* (2005) rural poultry can serve as a means of payment of

fines to settle disputes. Veluw (1987) and Sonaiya (1990) have also reported that rural poultry play a significant role through their contribution to the cultural and social lives of rural people.

2.7.1 Use of Local Genomes and Major Genes

The utilization of sole or combined dominant genes for feather constraint (naked –neck, *Na*) and feather arrangement (frizzled, *F)*, as well as sex – linked recessive gene for reduced body size (Dwarf, *dw*), has been observed to influence biological efficiency in chickens in the tropics (Haaren –Kiso *et al.,* 1995; Horst, 1989). A research by Fayeye *et al*. (2006) showed that birds that possessed thermoregulatory genes (Na and F) had a higher adult body weight than their normally feathered counterparts. According to Kitalyi (1998) in an FAO paper on breed improvement, there are seven known possible valuable major genes, namely, naked – neck (*Na*), dwarf (*dw*), slow feathering (*K*), Fayoumi (*Fa*), frizzled (*F*), silky (*H)*, and fibro – melanosi (*Fm*). Once the phenotypic effects of these genes on physiological and anatomical traits are characterized, it would be easy to incorporate these genes into crossbreeding programmes by establishing paternal breeding lines with dominant and or sex – linked major genes. Aside the major genes identified, Kitalyi (1998) also found other morphological features that permit improved heat dissipation. These consist of huge combs, huge wattles and long legs. Coding of gene for these traits, which are not major genes but the result of multiple genes and their interactions, could also be considered for integration into the development of high performing indigenous chickens for the tropics.

2.7.2 Relevance of Heat Tolerant Genes in Chicken

Siegel and Dunnington (1997) expressed that the hereditary make – up of an individual is settled at fertilization and, with the exception of mutation, does not change. The hereditary piece of populaces is dynamic and deal with groups of persons and hereditary incident on a

populace level both inside and crosswise over generations. Stressors normal to poultry generation comprise great temperatures, infection, handling, beak trimming, immunizations, swarming and deficient ventilation. These frequently happen simultaneously with different stressors. The body temperature of local fowls is kept up inside a thin range that is normally reflected by the upper and lower breaking points of a circadian rhythm under high temperature in healthy birds that are neither dissipating heat to the earth nor picking up warmth from nature (Aengwanich, 2008). The upper and lower breaking points of the circadian beat are respectively 41^{o}C and 40.5^{o}C (Saxena and Ketelaars, 1993).

One of the real worries in the poultry business is heat stress in fowls, since it causes high death and/or low profitability, particularly amid the hot season. Physiologists and geneticists have indicated enormous attention for a particular reaction seen in every single live organism when submitted to any sort of stress. The vulnerability of chickens to excessive heat results in an issue of monetary significance to the poultry business. Since little can be done to enhance heat resistance in chickens by administration, the hereditary advancement of chickens with inborn heat resilience would be of worth (Mazzi, 1998). The principle trademark amid this particular reaction to stress is the expanded articulation of the so –called stress protein (Hsps), particularly Hsps 70, which has been revealed to be one of the most preserved stress proteins. Saxena and Ketelaars (1993) mentioned that continuous panting resulting from accelerated respiration rate causes the excretion of large amounts of carbon dioxide by the lungs, resulting in respiratory alkalosis, which means an abnormal increase in blood pH, with unwanted consequences such as soft shelled eggs.

2.7.3 Major Genes Influencing Heat Tolerance and Their Effects on Productivity

One of the principle hurdles to proficient poultry generation in tropical nations is the high ecological temperature, which decreases feed intake and increases energy required for heat output via the respiratory tract, thereby leading to a drop in performance (Cahaner and Deeb, 2001). The indigenous chickens are among the numerous local assets of needy individuals living in the villages, which could be exploited and used for poverty mitigation (Njue *et al*., 2002).

There are several genes found in the indigenous chicken that improve the mechanism of insensible heat loss in poultry among rural chickens in the tropics. According to Ndegwa *et al.* (1998) there are high populations of indigenous birds carrying genes for dwarfism, frizzling, naked – neck, silkiness, crest feathering and slow feathering. The fuse of these qualities could be noteworthy in the advancement of suitable strains and breeds for smallholder poultry creation in the tropics (Kitalyi, 1998). Genetic resistance to heat stress could come about because of decreased feather covering of broilers. The naked-neck gene diminishes total feather covering by 20% to 40%.

In high surrounding temperatures, naked neck broilers displayed higher development rate and meat yield than their normal feathered partners. Field experiment in Egypt, Israel, Turkey, India and Vietnam have exhibited the pragmatic point of preference of the naked – neck gene in hot atmospheres (Cahaner *et al*., 1993). The naked – neck (Na) influences the characteristic straightforwardly by decreasing feather spread. The sex –linked recessive gene for dwarfism (dw) decreases body size accordingly reducing metabolic heat yield (Gowe and Fairfull, 1995). The frizzling (F) gene notwithstanding, brings about the contouring of the feathers. In contemporary breeding systems, major genes are economically attractive (Islam and Nishibori,

2009) as they go about as sex marker genes and infections resistant variables (e.g avian leucosis)

2.7.3.1 The naked neck (*Na*) Gene

The source of the strange looking naked neck chicken is disputed (Nthimo, 2004). The naked neck chicken is thought to have originated from Malaysia and spread all over the world by Dutch East Company in the course of trading around the 17th century (Remsey *et al.*, 2000).

The *Na* gene was first researched by Davenport in 1914, but the gene symbol was assigned by Hertwig in 1933 (Somes, 1990). Several names have been given to this gene due to its uniqueness example; Turkens, Transylvania naked-neck, Bare –neck, Hackleless and Rubberneck. It is single autosomal dominant gene. It is an incompletely dominant gene with the heterozygote (*Na/ na+)* showing an isolated tuft of feather on the ventral side of the neck above the crop, while the homozygote dominant (*Na / Na*) birds either lack this tuft or it is decreased to just a few pinfeathers or small feathers.

The resulting bare skin becomes reddish; mostly in males as they approach sexual maturity (Somes, 1990). The feather tracks of these birds are either absent or reduced in areas resulting in a reduced feather cover. There is a 30% increase in the lateral pelvic apteria width of *Na/Na* chicks compared to *Na/na*$^{+}$ chicks. The reduction in feather cover is less in the heterozygote than the homozygote (22% and 27%*for Na/ na*$^{+}$ males and females respectively and 33% and 41% for the *Na/Na* males and females respectively).

The dorsal and ventral cervical tracks of these birds are also absent. The dorso- pelvic, dorsal, caudal and pectoral tracks are all markedly reduced in area. The feather follicles are also missing from the head and neck except around the comb, the anterior spinal track and two small

patches on each side above the crop. The naked – neck gene which controls the naked – neck trait is located near the middle of chromosome 3. It is a single autosomal incomplete dominant allele symbolized „*Na*". The Homozygous dominant (*Na/Na*) or heterozygous (*Na/na*$^{+}$) birds exhibits the naked –neck characteristic, though the heterozygote exhibit less reduction (20%) in feathering (Somes, 1990).

Horst (1988) advocated the introduction of the naked – neck gene into the local birds in the tropics for higher productive adaptability. Due to the naked – neck birds" alertness and fighting characteristics, they seems to be capable to defend themselves and their baby chicken from being preyed on. They have been found to do well under heat stress and high humidity. According to Merat (1986) the naked –neck trait is present in several regions of the World, especially in the tropics where the climate is hot and humid. Due to their fewer feathers, they require less protein resulting in a reduced incidence of feather pecking and cannibalism. The reduced feather cover helps the birds to receive more solar radiation, which may well help higher vitamin D production and in turn add to better egg shell quality.

Major heat – tolerant genes like naked – neck are of economic interest in current breeding frameworks because they act as sex marker genes and disease resistant factors (e.g. avian leucosis). In recent times, research results have confirmed that naked – neck genes can influence productive adaptability to tropical and management conditions (Islam and Nishibori, 2009). These major genes are also related to better feed intake, productivity and survivability under heat stress conditions.

As indicated by Islam and Nishibori (2009) the "*Na*" gene and its impact on heat dispersal positively influence appetite. This occurs for two contradicting reasons; in cool atmospheres,

because of higher vitality requests, and in hot atmospheres, due to an increase in body temperatures.

In such situations feed intake goes high, bringing about enhanced body weight, egg sizes and livability. A definite effect of this gene is identified with enhanced vitality and decreased liver fatness. Islam and Nishibori (2009) again recorded that because of the dominant nature of the *"Na*" gene, physiological enhancement are firmly identified with the seriousness of the ecological stress circumstance. The gene is evidently expressed under adverse conditions, for example, higher ambient temperatures and mugginess, small diurnal or seasonal variation and under poor administration conditions. Vulnerability of the *"Na*" gene to heat resistance was observed to be not exactly as found in commercial birds (N'dri *et al*., 2007). Normal feathered (na/na) chickens are more powerless to heat stress than naked –neck chickens, in light of the fact that the last have fundamentally more noteworthy dermal swelling ability contrasted with their 'na/na' partners in high encompassing temperatures.(El – Safty *et al*., 2006). As for the bare – neck gene, the Na chickens have gotten more noteworthy consideration for poultry generation, on account of their relationship with the decrease in feather covering, enhanced warmth resilience and improved adaptability at high ambient temperatures (Merat, 1986).

2.7.3.1.1 Effect of the naked – neck (*Na*) Gene on Broiler Production

The primary objective of the farmer is high body weight at slaughter. Elements that impact broiler flock performance are for the most part feeding and environment (Tona *et al.*, 2004). Development rate, sustain productivity and meat yield are fundamentally diminished when broilers are raised at high encompassing temperature (Younis and Cahaner, 1999).It has been proposed that high surrounding temperature contrarily influence broilers enormously particularly those with higher hereditary potential for development rate than those with lower development rate (Cahaner and Leenstra, 1992). An analysis was directed by Eberhart and

Washburn (1993) to assess the execution of the twofold heterozygous *NanaFf* (BW at 7WK= 1, 5 6 2) at 32ºC and contrasted it and that of *nana* (BW at 7Wk= 1, 390) ones. Dressing rates and aggregate meet yield of local naked neck, and local completely feathered chickens were 57 – 63 and 30 - 37, and 53 – 61 and 25 – 30 respectively (Islam and Nishibori, 2009). Even when local naked neck is crossed with foreign chicken to enhance meat yield characteristics, dressed, dim and add up to meat yield of crossbred of local naked neck with white leghorn was higher than the crossbred of indigenous naked neck X Rhode Island Red. They recommended the rearing of meat – type birds carrying the Na gene and even when grown in a warm environment (usually over 30ºC)usually have larger body weight, better feed efficiency, a lower percentage of feathers, slightly more fleshing, higher viability and sometimes a lower rate of cannibalism (Cahaner and Deeb, 2001) in comparison with their normal feathered partners.

2.7.3.1.2 Effect of the *Na* Gene on Growth, Feed Efficiency and Meat Yield

The significance of the naked – neck quality in the tropics depends on its relationship with thermoregulation. The decrease in feather covering of around (30-40) % in these birds encourages better warmth dissipation bringing about a superior relative warmth resilience under hot atmospheres. In a study did By Merat (1990) on birds raised under high temperatures, around 30ºC or higher, the homozygous (Na/Na) or the heterozygous (Na/na) naked – neck fowls demonstrated a better mean weight gain than their normal feathered partners. There was likewise an enhancement in the carcass yield for the heterozygous genotypes.

There was however an increase in embryonic mortality found in the Na/Na and Na/na chickens. Yalcin *et al.* (1997) and Patra *et al.* (2002) likewise found out that under high temperatures, chickens possessing the naked –neck gene had higher breast weight, better development rate,

and better feed conversion proportion and carcass traits. Eberhart and Washburn (1993) reported that naked –neck birds were essentially bigger than normal feathered fowls when subjected to endless warmth stress in spite of the fact that the two genotypes isolated from the same parents.

Fayeye *et al.* (2006) observed that among the indigenous birds surveyed in some selected villages in Nigeria, those expressing the naked – neck trait was found to be superior in adult body weight. Horst (1988) worked on Dahlem Red stocks showing the naked – neck gene and reported that those genotypes expressing the gene were superior in egg production and body weight as compared to genotypes that were not expressing the gene. It was observed that the heterozygous exposed – neck (Na/na) genotype had a superior cell and humoral reaction than their normal feathered (na/na) and homozygous naked – neck (Na/Na) genotypes (Alvarez *et al.*, 2002). Likewise, El-Safty *et al*. (2006) recorded that the Na/Na hens had an altogether more prominent dermal swelling (cell intervened) contrasted with the normal feathered ones.

Furthermore, the normal plumage hen has a higher death and culling rate than heterozygous naked –neck hens. Another examination work by Mahrous *et al*. (2008) on the effect of naked – neck and frizzled genes on development performance and immune competence in chickens demonstrated that the presence of the *Na* gene in the single state fundamentally enhanced feed conversion ratio.

2. 7. 3.1.3 Effect of the *Na* Gene on Haematologlcal and Biochemical Indices of Chicken

Blood is a complicated liquid veins and capillaries of man and animals (Kronfield and Mediway, 1975), and its essential capacity is to convey oxygen from respiratory organs to body cells (Duke, 1975), circulating nutrients and chemicals to cells and diverting waste items (Baker and Silverton, 1982) consequently keeping up homeostasis of the inner environment

(Bentrick, 1974). The different functions of the blood are made conceivable by the individual and aggregate activities of its constituent –the biochemical and hematological parts. Blood science studies are normally done to build up the indicative baselines of blood qualities for routine administration practices of farm animals (Tambuwal *et al*., 2002; Onyeyilli *et al*., 1992, Aba – Adulugba and Joshua, 1990).

Hematological values of chickens are affected by sex, age, breed, atmosphere, land area, season, time of day, day length, habit of species, health status, life, present status of individual and such other physiological variables (Dukes, 1955). Investigation into the hematological and biochemical measures in indigenous chickens is particularly key in diagnosing the different neurotic, and metabolic, parasitic clutters which can be utilized as symptomatic device as a part of request to assess the wellbeing status of an individual and/or a herd (Fudge, 2000).

Pollock *et al.* (2001) demonstrated that packed cell volume (PCV) and Hemoglobin (Hb) ought to go between 23 – 55% and 7 .0 – 18.6 g/dl respectively. They said that a value under 7g/dl in Hb content could be an indication of paleness in the individual animal **(Table 2.1).**

Table 2.1 Normal Haematological and Serum Biochemical Values of Chicken

Haematological Component	**Value**
Packed cell volume (%)	23 – 55
Red blood cell (10^6/µl)	1.3 – 4.5
White blood cell (10^3/µl)	9 - 32
Haemoglobins (g /dl)	7.0 – 18. 6

Serum biochemical Component	Value
Total protein (g /dl)	3.3- 5.5
Albumin (g /dl)	1.3- 2.8
Globulin (g / dl)	1.5- 4.1
Total cholesterol (mg / dl)	86- 211

Source: Pollock *et al*. (2001)

Total serum protein has been reported as an indication of the protein retained in the animal body (Akinola and Abiola, 1991; Esonu *et al.*, 2001). Ladokun *et al.* (2008) in a study of the haematological and serum biochemical indices of *NaNa* and normally feathered (*nana*) cockerels realized that the nana feathered bird had higher (not significant) value of total protein albumin, globulin, and cholesterol. Normal feathered (1.53 g/dl) cock however, had significantly ($p<0.05$) higher globulin content than *NaNa* (1.15 g/dl) counterpart **(Table 2.2)**.

Tables 2.2 Mean Serum Biochemical Indices of *Nana* And *nana* Feathered Nigerian Indigenous Cockerels.

Genotype	Total protein (g/ dl)	Albumin (g/dl)	Globulins (g/dl)	Cholesterol (mg /dl)
NaNa	4 .63	3. 48	1. 15[b]	31. 30
Nana	4 .81	3. 28	1.53[9]	32.45

SEM: standard error of means ab means within column bearing different superscript differ significantly (P<0.05%). **Source: Ladokun *et al*. (2008).**

The explanation given was that the higher value obtained for serum parameter were important in the proper maintenance of osmotic pressure between the circulating fluid and the fluid in the

tissue spaces so that exchange of material between the blood and cells could be facilitated. El-Safety *et al.* (2006) stated that the heterozygous naked neck had higher haematocrit (PVC) than their normal feathered counterpart although the different was not statistically significant. Galal *et al.* (2007) also recorded a higher total plasma protein in normal body–size heterozygous naked neck. (8.85 $\pm$0.89) birds as compared to normal feathered (9.19 $\pm$ 0.13g/dl) ones but the difference was not significant. The result might be attributed to the acute phase of an immune response (hyper active of immunity system), where the liver cells produce and secrete acute phase protein (APP), which gives protection to birds against infection or any invasion. El-Safty *et al*. (2006) reported higher haematocrit value for the heterozygous naked neck (*Nana*) genotype and indicated that a higher haematocrit may have enhanced oxygen delivery to the tissues at a lower temperature. Again, they mentioned that the Nana females had a higher average haematocrit value, which is an indication of enhanced oxygen delivery to the tissues especially at lower temperature. They also reported a slightly higher level of plasma total protein for the Nana females at higher ambient temperature.

The high plasma total protein shows the important role of globulins in terms of immunity. Galal *et al.* (2007) indicated that dwarf naked neck (*dw – Nana*) birds had significantly higher plasma albumen compared to their dwarf (*dw*) and naked neck (*Nana*) genotypes.

El–Safty *et al. (*2006) stated that the heterozygous naked neck had a significantly higher (1.57 $\pm$ 0.20 mg/100m/) globulin concentration than their normal feathered genotypes. Globulins are composed of three fractions, designated alpha, beta and gamma. The alpha – globulins are a group of proteins manufactured almost entirely by the liver.

Normally, these proteins increase with acute nephritis, severe active hepatitis, active usually systemic inflammation, malnutrition and in nephritis syndromes (Margaret, 2001). Also, serum

parameters contribute to the viscosity and maintenance of normal blood pressure and pH. The higher globulin levels in normal plumage cockerels aids in better cell – mediated immune response (Ladokun *et al.,* 2008). Albumen concentration was indicated to be different between normal feathered birds and their counterparts carrying the naked neck gene although not significant (El- safty *et al*., 2006). Galal *et al.* (2007) also stated that higher albumen levels serve as a major reservoir of protein and was involved in colloidal osmotic pressure, acid – phase balance and that it acted as a transport carrier for small molecules such as vitamins, minerals, hormones and fatty acids (Margaret, 2001).

Homozygous naked neck (*NaNa*) cockerels had a higher average PCV (41. 00 Vs 35. 90%), RBC (4. 84 Vs 4. 21 $\times 10^6$/m/) and Hb (13. 6b Vs 11. 60g/d/) values which differed significantly from the normal (*nana)* feathered ones **(Table 2.3)**.

Table 2.3 Mean Haematological Values of Nigerian Indigenous Cockerels

Genotype	**PCV**	**Hb**	**RBC**	**WBC**
	(%)	(g/dl)	($x10^6$/ml)	($x10^3$/ml)
naked neck, *NaNa*	41.00^a	13.68^a	4.48^a	4.32
normal, *nana*	35.90^b	11.60^b	4.21^b	4.07
SEM	1.16	0.41	0.17	0.26

SEM: Standard error of means, ab means within columns bearing different superscripts differ significantly (p< 0.05%) **Source: Ladokun *et al.* (2008)**

Both El- Safty *et al.* (2006) and Galal *et al.* (2007) reported that the higher values in PCV recorded by the *NaNa* gene were due to the heavier body weights as a result of a reduction in heat load. This could be a boost to the growth and productive life of the *NaNa* birds. Galal *et al.* (2007) stated that the cholesterol level in normal size – normal feathered normal size –

naked neck and dwarf –naked neck were 201.5 ±5.69, 119.50±6. 50 and 117, 50 ±7.33 mg/ 100d/) respectively. Ladokun *et al.* (2008) stated that the cholesterol levels in normal feathered and homozygous naked neck birds were 32.45 and 31.30 mg/dl respectively.

2.7.3.2. Frizzled Gene

According to Horst (1989) the frizzled condition is caused by a single incompletely dominant autosomal gene, symbolized, *F*. This gene was first described by Aldrovandi in 1600, but it was Davenport who first suggested that it is a dominant gene in 1906 (Somes, 1990). The frizzled gene which controls the frizzling is located on chromosome 6. The gene is occasionally restricted by an autosomal recessive modifier (mf). As described by Somes (1990), in unmodified homozygous birds, the rachises of all feathers are extremely curved.

These feathers are easily broken and therefore the birds appear quite bare. The modifying gene lessens the extreme aspect of the homozygote so that some birds are almost indistinguishable from the wild –type (Crawford, 1990). The unmodified heterozygotes have their feather shafts and barbs of contour feathers curved, to a much less extent than the homozygote. These birds have body feathers, the shafts of which are recurred so that the feathers curd toward the head or have their apices pointed outward in planes roughly perpendicular to the surface of the body. The action of the frizzling gene has been shown to be localized in the feather follicle and does not result from a metabolic disorder (Somes, 1990). He further stated that the modifying gene modifies the heterozygote‟s making them less different from the normally feathered ones. Frizzled birds have increased basal metabolism, leading to increased production of thyroid and adrenal gland hormones (Benedict *et al.*, 1932 and Boas and Landauer, 1933). They again found an increased feed intake, oxygen consumption, heart rate, and volume of circulating blood. As a result of this, frizzled birds are expected to have enlargement of the heart, spleen, gizzard and alimentary canal.

2.7.3.2.1 Effect of the frizzled Gene on Productivity

In an experiment conducted by Mahrous (2003), it was observed that normally feathered birds had higher (28. 25g) but not significant day old body weight compared to frizzled birds (28.0g). However, at 12 weeks of age the frizzled birds recorded significantly heavier body weights (1, 036. 77g) compared to the normally feather birds (965.66g). The higher body weight at 12 weeks old was due to the tolerance of the frizzled birds to heat stress. However, Nthimo (2004) stated that male frizzled birds had significantly higher matured body weight (1.5kg) than female frizzled (1.2kg). Egg weight was however significantly higher in (Ff) (58.7g) birds compared to their normal feathered (57.3g) ones. The greater egg weight of the frizzled layers was associated with its heavier body weight rather than an increase in synthesis of egg components. Peters *et al*. (2008) carried out a study involving indigenous frizzled and naked neck as well as their normal feathered counterparts. They reported that the frizzled feather sire group produced the highest percentage of fertile eggs (82.13 +7.1) followed by the normal feathered genetic group (82.13±7.1) and naked neck (80.62± 6.1).

No significant difference was observed between the frizzled birds and their normal feathered counterparts. However, significant difference occurred between frizzled and naked neck birds. Fayeye (2006) indicated that frizzled birds were also superior to their naked neck counterparts in all body size parameters except for body length and body girth. The better performance of the frizzled (Ff) is associated with positive adaptive gene influence of the frizzled feather trait significantly affecting thermoregulatory ability (Horst, 1989).

With respect to body measurements, Mahrous *et al*. (2008) stated that frizzled birds had longer shanks (10.2cm) as compared to naked neck (9.7cm) and heterozygous frizzled naked neck

(9.7cm) ones, and observed a similar trend for shank diameter (mm). Minga *et al*. (1989) also stated 10.9cm for shank length among Tanzanian chickens. Nwachukwu *et al.* (2006) reported significant difference in shank length measurement between naked necks (8. 35. ± 0.15cm), normal feathered (8.16 ± 0.18cm) and frizzled genotype (7.12+ 0.19cm) in his local X exotic crossbreds at 18 weeks of age under a humid tropical environment. Fayeye and Oketoyin (2006) stated that shank length and diameter of adult female Nigerian chickens were (8.90 + 1.13cm and 0.20 + 0.12cm) respectively.

Table 2.4 Body Weight of Chickens as affected by naked neck (*Na*), frizzled (*F*) and double (*NanaFf*) segregation genes.

Parameter	*Nana*	*F*	*Nana Ff*
Shank length, cm	9.7	10.2	9. 7
Shank diameter, mm	13.4	13.6	13. 5
Body weight gain (4-12 wks)	776.5	761.3	691. 3

Sources: Mahrous *et al*. (2008)

2.7.4 Other Genes Influencing Heat Tolerance

2.7.4.1 Dwarf (*dw)* Gene

The dwarf gene (*dw*) causes a reduction in body size and is an important factor of acclimatization to warm environments through heat loss by radiation on one hand and endogenous heat production on the other (Gowe and Fairfull, 1995).

Dwarfism can be both sex –linked dwarfism, with three different genes (*dw*, $dw^B dw^M$) and autosomal dwarfism, *(a dw*). The sex – linked dwarfism, *dw*, is a recessive gene closely linked to the gold – silver and slow –feathering loci (Somes, 1990). Bantam dwarfism (dw^B) is a size

reducing sex linked recessive gene, closely related to the sex – linked feathering observed for sex – linked dwarfism. It reduces the female size by (5- 11) % when compared to normal (*dw*) females (Njenga *et al*., 2005). Heterozygous males *(Dw –dw^R*) are reduced by about 5% while the homozygous dwarf males (*dwdw*) are reduced by 14%, when compared to normal size birds. MacDonald dwarfism (*dw^M*) gene is a single sex – linked recessive gene belonging to the same locus as *dw,* is different from the *dw^B*, as the *dw^B* gene only reduces females body weight by 10%, shank length by 5%,, with birds generally appearing normal

(Njenga *et al*., 2005). The *dw^M*gene reduces females‟ body weight by 13.5% shank length by 9%, with birds being definitely distinguishable from the normal by their smaller sizes. The dominance relationship between the *dw^M* and the other two recessive alleles is unknown

(Somes, 1990). Gowe and Fairfull (1995) indicated that the main effect of the dwarf gene (*dw*) is to reduce the body weight of homozygous males by about 43% and that of homozygous females by 26 to 32%. Galal *et al.* (2007) stated that the presence of the *dw* gene significantly (P< 0.01) reduced egg mass, egg number and egg weight of sexual maturity. However, the presence of the *dw* gene in a single manner or combined with naked neck gene exhibited better effect on feed conversion ratio. The effect of the dwarfing gene on growth is clearly expressed by 6 weeks of age, when the dwarfs are reduced in weight compared with their normal but heterozygous sibs. The dwarfing gene significantly reduces body weight, shank length and keel length compared with normal feathered hens. The reduction in these body measurements was due to physiological and biochemical effects of the gene. Galal *et al*. (2007) discovered that the concentration of triiodthyronine (*T3*) circulating in the plasma of the dwarf hens is significantly lower than nana size birds. Due to this they recommended the introduction of the *Na* gene into dwarfing stock in order to improve body weight particularly at high environmental temperature for the improvement of egg production.

2.7.4.2 The Interaction Between The naked – neck (Na) And frizzled (F) Genes

According to Gowe and Fairfull (1995) some major genes like naked –neck and frizzling are used to improve heat tolerance and are often implemented in breeding programmes with local chickens to increase poultry production. Studies by Younis and Cahaner (1999) have shown that combining the naked –neck allele with another heat tolerant gene like frizzling resulted in a favourable additive effect on various productive parameters.

Horst and Mathur (1992) reported that the three genes *Na*, *F* and *dw* interact so that the combined effects of one or two genes are lower than the sum of their individual gene effects. Mukherjee (1992) observed a positive additive effect on performance when Dahlem Red naked –neck strains were crossed with Dahlem White frizzleds strains. Horst (1988) also advocated the use of the naked –neck and frizzling genes in combination to develop stock specifically for the hot and humid environments. It is therefore clear that the use of the double heterozygote (*Na/naFf*) is very advantageous especially for stocks that are to be reared in hot humid environments. For a favourable egg laying performance under hot and humid conditions, that is, above 30^0C, Horst (1989) and Haaren-Kiso *et al.* (1988) proposed the use of the double heterozygous condition of naked –neck and frizzling. Younis and Cahaner (1999) suggested the incorporation of the naked – neck and frizzled genes in birds that are to be reared under high ambient temperature conditions due to the positive additive effects of the two thermoregulatory genes on body weights and growth rates.

The advantage of heterozygous naked –neck (*Na/na*) broilers over their normally feathered (*na/na*) counterparts under heat stress was only one –half of that of homozygous (*Na/Na*) ones (Cahaner *et al*., 1993), but producing *Na/Na* broilers is not commercially feasible because of their poor hatchability (Merat, 1986). Therefore, instead of reducing feather number from 20% (*Na/na*) to 40% (*Na/Na*), the insulation efficiency of the feather coverage of *Na/na* birds could

be further reduced by the frizzled gene (*F*). The *F* gene curls the feathers and reduces their size, thus increasing the heat conductivity of the feather coverage

(Somes, 1990). The effects of frizzled feathers on the performance of layers were reported by Harren –Kiso *et al*. (1995); thus, combining the two genes at the heterozygous state (*Na/Na Ff*) resulted in a better heat tolerance compared with that of fully feathered birds and with that of birds heterozygous only for one of these genes (Pech – Waffenschmidt, 1992). When layers of the four genotypes (*na/ naf/f, na / naF/f, Na/naf/f, and Na/naF/f)* were exposed to a constant high ambient temperature of 34^0C the double heterozygous birds (*Na/na F/f*) exhibited the highest feed consumption body weight and egg production among the four genotypes. According to a work by Mahrous *et al*. (2008), it was observed that the naked – neck frizzled (*Na/na F/f)* genotypes attained sexual maturity earlier than that of normally feathered females by about 4. 3 while the age at sexual maturity was not significantly affected by the frizzled gene. The presence of naked –neck frizzled genes in combination significantly increased egg mass, egg number and egg weight compared to the fully –feathered genotype. Egg albumen percentage and Haugh units of Na*/na f/f,na /na F/f* and *Na/naF/f* genotypes were higher than that of *na/naF/f* ones. Haematocrit level, plasma calcium and phosphorus of *Na/na F/f*, *na/ na F/f* and *Na/ na F/f* genotypes were significantly higher than that of *na /na f/f* birds. They concluded that combining the two alleles in a heterozygous state (*Na/na F/f)* resulted in a better performance of laying hens compared to normally feathered (*na/na F/f*) birds and birds heterozygous only for one of these gene (*Na/na f/f and na/na F/f).*

2.8 Blood Composition and Function

Blood is a specialized body fluid that delivers necessary substances such as nutrients and oxygen to the body‟s cells and transports waste products away from the same cells. The functions performed in blood have been summarized as follows:

- Supply of oxygen to tissues (bound to haemoglobin)
- Supply of nutrients such as glucose, amino acids and fatty acids
- Removal of waste substances (CO_2, urea and lactic acid)
- Immunological functions, including circulation of white blood cells
- Messenger functions, including the transport of hormones and the signaling of tissue damage.
- Coagulation (ie. blood clotting after an open wound in order to stop bleeding)
- Thermoregulation of body temperature and
- Hydraulic function
- Maintenance of pH balance inside the body (Wikipedia, 2010)

Blood is mainly composed of red blood cells (RBC), white blood cells (WBC) and platelets. The RBCs constitute 45% of total blood by volume, containing haemoglobin which gives blood its red colour. The principal function is to deliver oxygen to different tissues of the body. High RBCs count does not necessary imply something harmful as age and sex play a part in the red blood cell count in the blood stream, but low RBC is considered as unhealthy (Pollock *et al*., 2001).

The WBCs is 1% by volume of total blood. They protect the body against pathogens and infectious diseases. A high count indicates infection, inflammatory and tissue injury. On the other hand, low WBC indicates low viral infections, low immunity and bone marrow failure. The platelets are also known as thrombocytes. The most important function of platelets is blood coagulation (blood clotting) and fighting infection. Low count of platelets may cause excessive bleeding while a high count is an indication of infection (Pollock *et al.*, 2001).

2.8.1 Effect of Nutrition on Blood Composition

The blood, consisting of blood cells and plasma, fulfills transport, regulatory, protective and homeostatic functions (Nasyrova *et al.*, 2006) as cited by Eze *et al.* (2010). Haematological profiles are important indicators of health and disease in animals and have become indispensible in the diagnosis, treatment or prognosis of many diseases (Mbanasor *et al*., 2003). The determination of the packed cell volume, erythrocyte count and haemoglobin can give an idea of the level of disease conditions (Eze *et al*., 2010). Haematological and serum biochemistry assay of animals suggest the physiological disposition of the animals to nutrition (Madubuike and Ekenyem, 2006). Esonu *et al*. (2001) had stated that haematological constituents reflect the physiological responsiveness of the animals to its internal and external environment. The effects of various feed on the haematology and serum biochemistry of livestock have been studied by many scientists (Annongu and Folorunso, 2003; Awosanya *et al.*, 1999; Iyayi, 2001 and Olayeni *et al.*, 2006) and concluded that feed affects animal physiology (Madubuike and Ekenyem, 2006). According to Machebe *et al*. (2010), the quality and quantity of ration given to an animal affects its physiological condition.

2.9 Factors Affecting Meat Quality attributes and Sensory Characteristics

Meat quality is an essential trait in meat –producing animals. Meat quality describes the attractiveness of meat to consumers, which includes colour, tenderness, and water holding capacity, marbling and flavour (Shi- Zheng and Su-Mei, 2009).

Studies have shown that intramuscular fat (IMF) content is one of the most important trait influencing eating quality characteristics (Verbeke *et al.*, 1999). The IMF refers to the chemically extractable fat from a muscle especially from adipocytes and myocytes (Shi-zheng and Su-Mei, 2009). Consequently, research on IMF deposition in the muscles of pigs

and other meat producing animals is currently one of the most important fields of study in meat (quality) science. Major factors influencing carcass characteristic are genetic, nutritional, non-nutritional and environmental factors.

Resource-poor farmers generally rely on chicken meat to meet their dietary protein requirements (Mwale & Masika, 2009). These farmers keep indigenous chickens, and to a large extent, crossbred chickens produced from the indiscriminate crossbreeding of imported fast growing birds and the local hens. Due to the increasing demand for natural or organic meat that has been produced with minimal use of additives and chemicals, the relevance of indigenous chickens, which can be produced without any supplementary feeding and are highly tolerant of local diseases and parasites (Muchenje *et al.*, 2008a), has increased. To promote the production of indigenous chickens, even on a large scale, information on the carcass characteristics, weight of organs (e.g. liver, heart, intestines) that are commonly consumed within the households and extent of acceptability of the meat is relevant. The information could lead to the identification and development of niche markets for the meat from indigenous chickens. The quality attributes of food products, including poultry meat, have been attracting an increasing interest in recent years. Modern consumers are often aware of the relationship between meat quality and safety and animal welfare (Hermansen, 2003; Grunert *et al*., 2004), and many of them believe that organic food products have superior sensory properties and report that they "taste better" (Latter-Dubois, 2000).

"Quality is the composite of those characteristics that differentiate individual units of a product and which have significance in determining the degree of acceptability of that unit to the user" (Groom, 1990). Kauffman *et al*. (1990) explain that quality as perceived by meat eaters means "nutrition, convenience, wholesomeness, appearance, health image and naturalness, and yes,

palatability – and perhaps even price. It is the meat that looks good, smells good and tastes good, and is affordable. It must be repetitiously consistent, be price competitive, and be available and convenient". Of course, price is part of the customer's appraisal of what is offered in the market place and sometimes it is the all-important feature (Groom, 1990). British research nominates price as the most important attribute of meat followed by quality (Farrell, 2001).

"Price seemed to be the key factor influencing these consumers" product choices. It provided the boundaries for both the type and cut of meat they could consider buying; then they would look for the piece of meat which best met their own quality standards. Within these pricing boundaries, however, the quality of the meat was more important than price." (Institute of Grocery Distribution, 2000). The above quotes show the importance of both price and quality to consumers. The price-quality relationship melds with many other attributes of a product such as the degree of doneness (Cox *et al*., 1997). In other market places demand massively exceeds supply and distribution is the main marketing concern. If the product has no genuine appeal, then price will certainly be the key feature (Groom, 1990). At a recent International Meat Conference in the UK it was suggested that, at least in affluent markets, a formula which describes' the current situation is:

$$\textit{Value perception} = \frac{\textit{Perceived benefits}}{\textit{Price}}$$

To determine the acceptance of meat or food products, consumers consider several characteristics, such as its sensory characteristics, its nutritional value and its impact on health (Muchenje *et al*., 2008b; Muchenje *et al*., 2009). Chicken meat is considered better than red meat because of comparably low levels of fat, cholesterol and high levels of iron (Jaturasitha *et al.*, 2008). In addition, chicken meat is relatively lowly priced, packaged in typically convenient portions, and lack religious restrictions against its consumption (Jaturasitha, 2004).

Sensory assessments of meat have been shown to be influenced by various factors. For example, Sveinsdóttir *et al*. (2009) have established that availability and familiarity of food affect sensory scores. Easy access, frequency of purchase of a product and ethnicity has been shown to influence sensory attributes of meat (Prescott, 2001). Sañudo *et al.*, (2007) also showed differences in perception of sensory attributes between consumers of different countries. In chickens, as well as other types of meat, meat colour, method of processing, exposure to chemicals, method of storage, and method of cooking influence sensory characteristics (Barbut, 2001; Fletcher, 2002). Understanding factors that affect carcass characteristics and the quality of chicken meat is important in a poultry enterprise. Unfortunately, knowledge on such factors in resource-limited poultry production systems is low. Although trained panels are preferred to assess sensory characteristics of meat, it has been demonstrated that consumers can describe products in a reliable and repeatable way (Worch *et al.*, 2010).

Five main characteristics contribute to the overall eating quality of meat. These are taste, texture, juiciness, appearance and odor. Among these characteristics, texture is probably considered to be the most important attribute by the average consumer (Dransfield, 1994; Chrystall, 1994). Mechanical factors (tenderness) and juiciness (succulence) contribute to different meat textures. The tenderness of meat is the sum total of the mechanical strength of skeletal muscle tissue and its weakening during the post-mortem aging of meat. The former depends on species, breed, age, sex and individual skeletal muscle tissue of animals and fowls (Takahashi, 1996).

Meat tenderness originates in structural and biochemical properties of skeletal muscle fibres, especially myofibrils and intermediate filaments, and of the intramuscular connective tissue, the endomysium and perimysium, which are composed of collagen fibrils and fibers. Attractive appearance to consumer of indigenous chicken meat is performed by its carcass conformation, skin or meat color which might be related to chicken genotypes, feeds, rearing system or even processing condition. There are many intrinsic and extrinsic factors including genotype or breed, age, rearing system, feeds, chemical composition, structure, and properties of muscle and processing condition which can influence on different quality characteristics of chicken meat.

2.9.1 Genotype

Genotype (the breed and strain) of chickens plays a major role in carcass fatness and meat quality (Jaturasitha *et al*., 2008). The quality of meat from different indigenous chicken breeds, such as the common Southern Thai native, Naked-neck, Kai Dang, Blackboned and the Northern Thai native chicken, were studied (Od-Ton *et al*., 2004; Wattanachant *et al*., 2004a; 2004b; Adulyatham *et al*., 2006; Wattanachant *et al*., 2007; Jaturasitha *et al*., 2008). Naked-neck chicken breast and thigh muscles had slightly higher fat content but were lower in shear value and a* and b* value compared to those of the Southern Thai native chicken. The difference in muscle color profile between both chicken breeds contributed to significantly lower sensory scores on color preference of Naked-neck chicken (Adulyatham *et al*., 2006). The slightly darker meat of Black-boned chicken and the higher redness of Northern Thai native chicken muscle have been reported by Jaturasitha *et al*. (2008). Among the Thai indigenous chicken breeds studied, collagen content in their muscles was similar except for those of the Black-bone and Northern Thai native chicken. The difference in this collagen content could perhaps be attributed to the differences in the analytical method used by

researchers. Indigenous chicken muscles had shear force value in ranges of 1.8 - 2.7 kg for breast muscle and 2.4 - 4.2 kg for thigh muscle which were higher than those of commercial broiler chicken muscles (Wattanachant *et al*., 2004a; Chuaynukool *et al*., 2007; Wattanachant and Wattanachant *et al*., 2007). The high shear value relating to high collagen content of native chicken meat results in lower sensory score on tenderness and juiciness of cooked meat compared to broiler (Adulyatham *et al*., 2006). Water holding capacity of breast and thigh muscle of indigenous chicken was not different among genotypes which were in consistent with cooking loss quality**.** There were no difference in sensory score evaluation on color, juiciness, flavor, and tenderness between cooked naked-neck and Thai indigenous chicken meat (Adulyatham *et al*., 2006). All data obtained show that different genotypes has more influence on typical color characteristic of raw Thai chicken meat when compared at the same age of chicken.

2.9.2 Rearing and Feeding Systems

Generally, backyard or village production systems (the extensive system) are preferred for producing indigenous chicken by homesteads since the production costs are very low. The chickens are allowed to scavenge on their own for resources around the homestead during the day and this is supplemented with concentrated feeds in the evening when they come back to roost and sheltered at night. However, this system cannot certify the quality of the chicken, especially the chicken live weight, the carcass percentage, the quality of the meat, and meat safety. In intensive rearing systems the chicken were kept in houses and provided with concentrated pellet feeds as the main diet, and given other supplements such as rice bran or chopped herbaceous banana stalks. This system provided the higher carcass percentage (Wattanachant *et al*., 2002; Od-Ton *et al*., 2004). Wattanachant and Wattanachant (2007) found that the indigenous chicken reared under the intensive farming system had a higher percentage

of breast muscle when the age of chicken was older than 14 weeks. Rearing systems (intensive and extensive) did not affect the proximate composition of the chicken muscle. However, rearing under the intensive system resulted in a lower shear value of the raw and cooked indigenous chicken muscles and higher L*, a*, and b* value for skin color of the indigenous chicken. Therefore, rearing chickens with full feeding supplements provided chickens with high percentages of breast muscle, which was tenderer and of a better quality of muscle protein, than muscle obtained from the extensive system.

2.9.3 Age

Animal age has been known to affect chemical composition, properties and structure of muscle which could all contribute to the quality of meat (Lawrie, 1991). Changes in composition, structure, properties of muscle protein, and meat quality of indigenous chicken from Thai during growth from 6 to 24 weeks have been studied by Wattanachant and Wattanachant (2007). During the growth of the indigenous chicken, moisture content in muscle decreased from 77.8 to 71.6%, whereas protein and fat content increased from 21.5 to 24.0% and 1.35 to 3.90%, respectively. Total collagen was unchanged with the age of chicken while soluble collagen slightly decreased and this was not correlated to the shear value of chicken muscles (Nakamura *et al*., 1975; Wattanachant and Wattanachant, 2007). The tenderness of chicken meat decreased during muscle growth (Nakamura *et al*., 1975; Wattanachant and Wattanachant, 2007) probably because of the structural changes of collagen (Nishimura *et al*., 1996; Fang *et al*., 1999; Nakamura *et al*., 2004). The breast muscle skin color L*, a* and b* increased while b* value of muscle decreased with increasing age. Wattanachant and Wattanachant, 2007 stated that the appropriate age for indigenous chickens to possess economical live weight and high meat quality was in the range of 16 - 18 weeks of age.

However, the indigenous chicken shows an appropriate age for consumption between 16 - 20 weeks, with 1.2 - 1.5 kg live weight in commercial terms.

2.9.4 Meat pH

Meat pH has been shown to be primarily related to the biochemical state of the muscle at time of slaughter and following the development of rigor mortis. This affects both the light reflectance properties of the meat as well as the chemical reactions of the myoglobin (Fletcher, 1999a). Muscle pH and meat color are highly correlated. In a survey of five commercial broiler processing plants, breast meat colors were found to range with lightness values (L*) from 43.1 to 48.8 with a strong negative correlation with muscle pH (Fletcher, 1995). As mentioned by Fletcher (1999a, b), higher muscle pH is associated with darker meat whereas lower muscle pH values are associated with lighter meat. In the extremes, high pH meat is often characterized as being dark, firm and dry (DFD) and the lighter meat as being pale, soft and exudative (PSE). The effect of pH on meat color is complex. One effect, as noted earlier, is that many of the haem-associated reactions are pH dependent. In addition, muscle pH affects the water binding nature of the proteins and therefore directly affects the physical structure of the meat and its light reflecting properties. In addition, pH affects enzymatic activity of the mitochondrial system thereby altering the oxygen availability for haem reactivity (Fletcher, 1999a). The muscle pH of indigenous chicken from Thai was 5.80

- 5.93 for pectoralis muscle and 5.85 - 6.06 for biceps femoris muscle as reported by Wattanachant *et al.* (2004a) and Chuaynukool *et al.* (2007). The latter researcher found higher muscle pH for both muscles of the indigenous chicken which was related to the lower L* value of the muscles. Higher muscle pH is associated with darker meat than that of lower pH (Allen *et al*., 1998; Fletcher, 1999a, b). The low ultimate pH in indigenous chicken muscles compared

to broilers, especially in biceps femoris muscle, has been reported by Wattanachant *et al.* (2004a) and Chuaynukool *et al*. (2007).

2.9.5 Chemical Compositions

There are two major aspects of meat quality; "nutrition quality", which is objective, and "eating quality", as perceived by the consumer, which is highly subjective (Bender, 1992). Meat from poultry contains several important classes of nutrients and it is low in calories. The fat contains essential fatty acids; the proteins are good sources of essential amino acids (Mountney and Parkhurst, 1995; Van Heerden *et al*., 2002; Wattanachant *et al.,* 2004a) and also excellent sources of water-soluble vitamins and minerals, such as iron and zinc (Van Heerdin *et al.,* 2002; Boccia *et al.*, 2005). Chicken contains about 16.44 - 23.31% protein, 0.37 - 7.20% fat, 0.19 - 6.52% ash, and 72.8 - 80.82% moisture content (Smith *et al*., 1993; Xiong *et al*., 1999; Abeni and Bergoglio, 2001; Al-Najdawi and Abdullah, 2002; Van Heerden *et al.,* 2002; Wattanachant *et al*., 2004; Chuaynukool *et al*., 2007). The chemical composition of poultry meat has been shown to be related to species, breed, muscle type, sex, age, and method of processing of carcasses (Ngoka *et al*., 1982; Smith *et al*., 1993; Ding *et al*., 1999; Abeni and Bergoglio, 2001; Al-Najdawi and Abdullah, 2002; Van Heerden *et al*., 2002; Wattanachant *et al*., 2004; Boccia *et al.*, 2005; Chuaynukool *et al*., 2007; Wattanachant and Wattanachant, 2007). Ding *et al.* (1999) showed significant differences in fat contents between broiler and local chickens. Wattanachant *et al.* (2002) found that Thai indigenous chicken muscle contained higher protein content but lower fat and ash content compared to broiler muscles. Different breeds and muscle types of Thai indigenous chicken also differ in chemical compositio**.** Much of the value of a protein food is based on its amino acid content whereby the high nutritional value is related to a high presence of essential amino acids

(Bender, 1992). Amino acids represent over 90% of the crude protein in the body of poultry (Hunton, 1995). The amino acid composition of pectoralis and biceps femoris muscles of Thai indigenous chickens was compared to those in other poultry. Both muscles were very high in glutamic acid, arginine, leucine, aspartic acid and lysine. However, no significant differences in the presence of amino acid were observed between broiler and indigenous chicken muscles, with the exception of glutamic acid (Wattanachant *et al*., 2004a). Indigenous chicken muscles contained slightly higher glutamic acid content than broiler muscles ($P < 0.05$). Glutamic acid was found to have a detectable effect on the taste of chicken meat and this may contribute to the differences in flavor between the meats (Farmer, 1999). Glutamic acid is much higher in turkey and goose meat as compared to the meat of broiler and indigenous chicken. Fat content and fatty acid composition of triacylglycerols in muscle are strongly related to meat quality, especially in terms of flavor, juiciness and tenderness (Miller, 1994). Hunton (1995) noted that high unsaturated fat intakes may be preferable for humans; however, unsaturated fatty acids are more prone to oxidation. Wattanachant *et al*. (2004a) reported that indigenous chicken muscle contained a higher percentage of saturated fatty acids ($P < 0.05$) and a lower percentage of polyunsaturated fatty acids ($P < 0.05$) as compared with broiler chicken muscle. However, different results were found by Jaturasitha *et al.* (2008). The fatty acid profile of the indigenous chicken muscles was different in chicken breeds or genotypes. This was also possibly caused by the differences in the feed diets given to the breeds (Cherian *et al.*, 2002). The different fatty acid composition of muscle probably affects the lipid stability and taste. However, there are some reports to indicate that although the chicken received the same feed diet, differences in such meat components as unsaturated fatty acid were observed. These were probably due to differences in eating behavior between breeds. The indigenous chickens tend to scratch while eating and were observed to pick up feed particles more selectively than the broiler (Van Marle-Koster and Webb, 2000). However, Jaturasitha *et al.* (2008) stated that the indigenous chicken

seemed superior in a health point of view because fat and cholesterol contents were low and fatty acid profile was favorable.

2.9.6 Post-mortem Aging

Tenderness of meat is the sum total of the mechanical strength of skeletal muscle tissue and its weakening during post-mortem aging of meat. During refrigerated postmortem storage, improvement in meat tenderness, commonly called meat aging, occurs. The major factor responsible for postmortem improvement in meat tenderness is degradation of muscle proteins. To obtain meat of high quality, post-mortem aging of meat at around 4^{o}C for a certain period is required. Aging periods are usually more than 0.5 - 1 day for chicken. Both tenderness and flavor are improved during this aging time (Takahashi, 1996). Post-mortem changes of Thai indigenous chicken had been studied by Wattanachant (2004). The indigenous chicken meat had a slower pH decline and contained higher lactic acid content, compared to broiler meat, leading to the lower ultimate pH. Broiler meat had a higher degree of proteolysis than indigenous chicken meat as evidenced by a significant increase in TCAsoluble peptides especially early post-mortem. However, no change in soluble collagen in meat of both breeds during the aging period has been reported. Improvement of tenderness of meat by proteolysis required at least 4 h and 6 h post-mortem aging at 4^{o}C for broiler and indigenous chicken carcasses, respectively, have been suggested by Wattanachant (2004).

2.9.7 Processing

Chicken meat can be processed in many forms and is mainly available fresh, chilled or frozen, broiled, roasted, canned, and sometimes in combination with other ingredients and foods. The quality of chicken meat and chicken meat products can be influenced by the way it is processed and the temperature used. The temperature at which poultry is held during chilled storage

determines to large extent its shelf-life (Mountney and Parkhurst, 1995). Chilled poultry stored at 2 - 4^{o}C have a shelf-life of one or two days at maximum before dispatch to retail outlets and may be kept a day or so longer if stored at -1^{o}C (Silverside amd Jones, 1992). Poultry kept in frozen storage at -20^{o}C may be kept for up to 6 months (Mountney and Parkhurst, 1995). During refrigeration or frozen storage, raw or cooked poultry undergoes several changes such as microbial growth, chemical and physical changes that can affect their quality attributes that may result in reduced consumer acceptance (Bustabad, 1999; Kim and Marshall, 1999; Woods and Church, 1999).

Lipid oxidation is one of the most important degradation processes during meat refrigeration. The breast meat of Thai indigenous chicken has been reported to have an increase in TBARS value for 23% within 6 days of chilled storage and 73% at 9 days of chilled storage (Wongwiwat *et al*., 2007). Marinade technique could extent the shelf-life of indigenous chicken meat. Wongwiwat *et al*. (2007) reported that the mixed spices in lemon glass marinade cuisine could retard the lipid oxidation, drip loss and microbial growth in ready-tocook Thai indigenous chicken meat during storage. This process could preserve the chilled indigenous chicken meat product for 12 days. Thermal processing of poultry results in chemical and physical changes that will strongly influence chemical composition, cooking loss, yield and other important quality factors such as texture, juiciness, color, and flavor, which are associated with palatability and consumer acceptance of the final product (Califano *et al*., 1997; Murphy and Marks, 2000; Wattanachant *et al*., 2005). Wattanachant *et al*. (2005) studied the effect of heating temperature on changes in textural properties of Thai indigenous chicken and broiler meat. They found that shear value of indigenous chicken meat slightly increased when heated from 50 to 70^{o}C and dramatically increased at 80^{o}C. No changes in shear value of the indigenous chicken meat were observed when heated at 90 - 100^{o}C. The increase in shear value

with heating up to 80°C might be due to the combination effect of the denaturation of myofibrillar proteins, the shrinkage of intramuscular collagen, as well as the shrinkage and dehydration of the actomyosin (Bailey and Light, 1989). Palka and Daun (1999) pointed out that cooking loss and sarcomere length seemed to be a good indicator of changes in meat during cooking. Wattanachant *et al.* (2005) observed that the greatest shrinkage of the sarcomere in muscle heated to end-point temperature of 70 - 100°C for broiler and 80 - 100°C for indigenous chicken related to the greatest increases in cooking losses of both chicken meats at the same range of heating temperature. With increasing heating temperature, meat tended to be lighter and also turned to a brown-grey hue. The lightening is due to an increased reflection of light arising from light scattering by denatured proteins (Young and West, 2001). The loss of chroma and change in hue result from the changes in myoglobin. Myoglobin is one of the more heat-stable of the sarcoplasmic proteins, which is almost completely denatured between 80 - 85°C (Lawrie, 1991). For this reason, Wattanachant *et al*. (2005) reported that the muscle color of Thai indigenous chicken, lightness (L*) and yellowness (b*), was found to increase significantly with increasing temperature in the range of 50 - 70°C and no changes were observed when heated to higher temperatures (80 - 100°C). However, the redness (a*) of indigenous chicken muscle increased significantly when the muscle was heated to endpoint temperature of 70°C and decreased when heated to higher temperatures.

2.10 Water-Holding Capacity (WHC)

Water-holding capacity of meat is defined as the ability of the postmortem muscle (meat) to retain water even though external pressures (e.g. gravity, heating) are applied to it (HuffLonergan and Lonergan, 2005). In recent years, consumer preference for natural or organic meat produced with no or minimal use of chemicals and livestock supply chains that have a low water footprint is growing rapidly in many parts of the world (Fanatico *et al.*, 2005;

Hoekstra, 2012). The water footprint concept, an indicator used to assess how water-intensive an animal product is and to what extent it relates to water depletion, water pollution or both, is rapidly gaining popularity in some societies and will likely influence consumers‟ purchasing patterns in the future (Doreau *et al*., 2012; Hoekstra, 2012). This shift in consumer preference has increased the demand of local unimproved chickens because of their superior meat flavour and texture, perceived health benefits and relatively low water footprint compared to exotic chickens (Dyubele *et al.*, 2010; Hoekstra, 2012).

Water-holding capacity of fresh meat (ability to retain inherent water) is an important property of fresh meat as it affects both the yield and the quality of the end product. This characteristic can be described in several ways, but in fresh products that have not been extensively processed, it is often described as drip loss or purge (Huff-Lonergan and Lonergan, 2005). The mechanism by which drip or purge is lost from meat is influenced by both the pH of the tissue and by the amount of space in the muscle cell and particularly the myofibril that exists for water to reside (Huff-Lonergan and Lonergan, 2005). Numerous factors can affect both the rate and the amount of drip or purge that is obtained from the product. These factors can include how the product is handled and processed (number of cuts made and size of resulting meat pieces, orientation of the cuts with respect to the axis of the muscle cell, rate of temperature decline after harvest, temperature during storage and even the rate of freezing and temperature of frozen storage). Also of extreme importance is the metabolic state of the live animal at the time of harvest. This can be influenced by the genetic make-up of the animal and by the way the animal was handled. Ultimately, characteristics of the muscle in the live animal can have a strong influence on the amount of moisture that is lost from the resulting meat products. In summary, the entire system of live animal production and handling through initial chilling and

finally storage and handling of the meat all play significant roles in influencing the amount of moisture that is lost from the product.

Muscle contains approximately 75% water. The other main components include protein (approximately 20%), lipids or fat (approximately 5%), carbohydrates (approximately 1%) and vitamins and minerals (often analyzed as ash, approximately 1%) (Offer & Cousins, 1992). The majority of water in muscle is held within the structure of the muscle itself, either within the myofibrils, between the myofibrils themselves and between the myofibrils and the cell membrane (sarcolemma), between muscle cells and between muscle bundles (groups of muscle cells) (Offer & Cousins, 1992). Once muscle is harvested the amount of water in meat can change depending on numerous factors related to the tissue itself and how the product is handled (Honikel, 2004; Honikel & Kim, 1986).

The characteristic of water-holding capacity is not trivial. One of the most prevalent meat quality issues is unacceptably high moisture loss (often described as purge or drip loss) in fresh and minimally processed products. Unacceptably high moisture loss from fresh product as purge or drip has been estimated to occur in as much as 50% of the meat produced (Kauffman *et al*., 1992). Excess purge results in economic losses in numerous ways including reduction in salable product weight and the loss of export customers who demand high quality product with a minimum amount of purge. In addition, valuable water-soluble proteins and vitamins are lost along with moisture (Offer & Knight, 1988a; Offer & Knight, 1988b). Water-holding capacity of meat can also influence processing characteristics. Meat with low water-holding capacity often tends to produce inferior processed products (HuffLonergan and Lonergan, 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

The research comprised of two phases; a survey and an experimental work. The survey comprised mainly of interviewing randomly selected people in some selected market/sales point and supplying birds to them for sale in order to find answers to questions related to marketability or otherwise of the naked neck and frizzled- naked neck birds.

The second phase (experimental work) was a performance evaluation experiment on three feather genotypes namely heterozygous naked neck *(Nanaff*), double heterozygous frizzled naked neck (*NanaFf*) and normal feathered (*nanaff*). It was carried out to determine haematological and serum biochemical factors, as well as carcass characteristics and organoleptic or sensory profile of meats obtained from the different genotypes.

3.1 THE SURVEY WORK

3.1.1 Description of the Survey Area

Kumasi, the capital town of the Ashanti Region of Ghana was where the survey was carried out. The Ashanti Region lies between longitudes 0.15W and 2.25W and latitudes 5.50N and 7.46N. The region is a key player in the poultry industry and was ranked first with an egg production level of 1,032.2 million eggs produced per annum as against 323.2 million from the Greater Accra Region of Ghana (MOFA, 2005).

Kumasi and its surrounding towns form the hub of commercial activities in the region. It has an approximate land area of 254 square kilometers and it is located between longitudes 1º 37‟

18W and latitudes 6º 41‟ 37N. It shares borders with the Kwabre District to the North, EjisuJuaben Municipal to the East, Bosomtwe District to the South and Atwima Kwanwoma and

Atwima Nwabiagya District to the West. The current population is estimated at about 1,517,000, with a growth rate of 2.5% per year (MOFA-KMA, 2009). The Kumasi Metropolis is characterized by temperatures ranging from 21.5ºC to 30.7ºC and falls within the sub-equatorial type of climate. The annual rainfall has its peak of 214.3mm and 16.2mm in June and September respectively. The rainfall pattern is normally good and uniformly distributed. The average humidity is about 84.16% at 9.00 GMT and 60% at 15.00 GMT

(MOFA-KMA, 2009).

3.1.2 Data Collection and Sampling Technique used in the Survey

Data were collected by both administration of questionnaires and interview **(see Appendix 1)**. Six (6) markets were randomly selected for the survey namely: Kumasi Central Market, Sofoline Market (opposite Prempeh College), Tanoso Market, Abuakwa Market, Santasi Roundabout Market and Tafo Market. Ten (10) market women were selected at random from each market, making a total of sixty (60) people for the survey. The questionnaires were effectively administered and collected as the researcher personally took them to the market women and administered them one-on-one, translating the content of the questions to people who could not read or understand them.

The randomly selected market women were also given birds to sell in order to determine how the birds sold in those markets. Ten (10) cockerels each of normal, naked-neck and frizzlednaked neck were given to one of the Ten (10) market women selected at each market for sale. In all, a total of hundred and eighty (180) birds were supplied. The birds were kept in

sizeable cages and well fed and watered to avoid any incidence that might reduce market value. The birds were sold concurrently at all the markets before and during the Christmas season at same prices. The market women were asked to begin sale of birds at 9.00 am and end at 5.00pm each day throughout the survey period. Data on the number of birds sold and the number of days it took to sell the birds from each genotype were recorded from the market women.

3.1.3 Data Analysis of Survey Work

The collected data were analyzed using Statistical Package for Social Sciences (SPSS) version 16 (2007).

3.2 THE EXPERIMENTAL WORK

The experimental phase consisted of two sections, (1) the raising of the birds till maturity to determine haematological and serum biochemical parameters, as well as carcass characteristics of the different genotypes and (2) the processing of the meat of birds after slaughtering to determine sensory profile of burger produced from the meats of the different genotypes of chickens.

3.2.1 Experimental Site and Duration

The experimental work was done at the Department of Animal Science, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The area has a prevailing tropical climate and the minimum and maximum monthly mean ambient temperatures of the area for the duration of the experimental period were 32.7^{0}C and 22.2^{0}C respectively with a mean relative humidity of 65.8% (MOFA-KMA, 2009). The area lies between longitude 010 033‟W and latitude 060 41‟ N in a hot humid environment. High

temperatures occur during the months of November-April with average maximum temperatures occurring in February and March while the lowest are experienced in July.

Rainfall in the area is bimodal with an annual mean of 1500 mm. The rainy seasons cover April-July and September-November. A short dry season separates the two periods in August. The main dry season lasts from November to February (MOFA-KMA, 2009).

3.2.2 Experimental Birds

Three hundred (300), eleven (11) weeks old crossbred cockerels made up of one hundred (100) heterozygous naked neck (*Nanaff*), one hundred (100) double heterozygous frizzled naked neck (*NanaFf*) and one hundred (100) normal feathered birds (*nanaff*) were housed in fifteen (15) open-sided deep litter pens with twenty (20) cockerels in each pen from October to December, 2009. The birds used were the offspring of crosses between local heterozygous naked neck (*Nana*) and heterozygous frizzled (*Ff*) males and hybrid commercial Lohmann females. The heterozygous naked neck (*Nana*) and heterozygous frizzleds (*Ff*) were crossed with normal feathered (*nanaff*) Lohmann Brown Classic layers in two separate matings producing offspring that were heterozygous for the naked neck gene (*Nanaff*), heterozygous for the frizzled gene (*nanaFf*) and those that had normal Feathers (*nanaff*) in the first filial (F1) generation. The F1 heterozygous naked neck males were then mated to the F1 heterozygous frizzled females in a reciprocal cross to produce *NanaFf, nanaFf, Nanaff* and *nanaff* in the F2 generation in both matings.

The naked neck (*Nanaff*), frizzled (*nanaFf*), normal Feathered (*nanaff*) and double heterozygous frizzled-naked neck birds *(NanaFf*) of the second filial generation (F2) were selected and mated producing homozygous naked neck (*NaNaff*), heterozygous naked neck (*Nanaff*), homozygous frizzleds (*nanaFF*), heterozygous frizzled (*nanaFf*), normal Feathered (*nanaff*) and frizzled naked neck birds (*NaNaFf, NanaFF, NanaFf and NaNaFF*) as the third

filial (F3) generation. Heterozygous naked neck *(Nanaff*), double heterozygous frizzled naked neck (*NanaFf*) and normal Feathered (*nanaff*) birds of the F4 generation were selected for this research work.

3.2.3 Experimental Design

The three genotypes constituted the treatments and each treatment was replicated five times in a Completely Randomized Design with 20 birds in each replicate.

3.2.4 Management of the Birds

3.2.4.1 Housing and Feeding

The birds were kept in an open-sided partitioned deep litter house with stock density of 0.15m^2/bird for 9 weeks. There were 15 pens in all with each pen housing 20 cockerels. Feed (commercial grower diet) and water were supplied *ad libitum* in 2.5kg capacity hanging feeders and 10L capacity plastic fountain drinkers respectively. The feed and nutrient compositions are shown in **Table 3.1** and **Table 3.2** respectively.

Table3.1: Feed composition of diet fed to birds

Feed ingredient	Quantity (%)
Maize	68
Wheat bran	9
Concentrate	6
Cottonseed cake	7
Fishmeal	8
Oyster shell	2
Total	**100**

Source: Akate Farm and Trading Co. Ltd.

Table 3.2 Nutrient composition of the diet fed to birds

Nutrients	(%)
Metabolizable Energy **(MJ/kg)**	11.5
Crude Protein	16
Crude fat	4
Lysine	0.75
Methionine	0.35
Calcium	1.0
Cystine	0.3
Phosphorous	0.45

Source: Akate Farm and Trading Co. Ltd.

3.2.4.2 Medication and Vaccination

The schedule used for medication and vaccination is shown in **Table 3.3.**

Table 3.3 Vaccination schedule and medication

Week/period	Vaccine	Method of administration
1	HB1	Drinking Water
2	Gumboro and Doxin 200	Drinking Water
4	Lasota	Drinking Water

Source: Akate Farm and Trading Co. Ltd.

3.2.5 Preparation of Chicken Burgers

3.2.5.1 Preparation of Chicken Burgers

Breast muscle was deboned from the different treatments, labeled and chilled. The chilled chicken meats were minced using a meat mincer (Mado Super Wolf, Germany) through a 5mm

diameter plate. The minced meat was mixed with a spice mix (**Table 3.4**) to obtain a uniform mixture.

Table 3.4 Composition of spice mix used for making burgers

Ingredient	Quantity (g/kg)
Water	50.0
Salt	16.0
Garlic	2.0
Black pepper	1.0
Hot pepper	1.0

The meat-spice mixtures were then formed into burgers using a hand press burger machine. Each burger weighed approximately 100g. The burgers were appropriately labeled, bagged and frozen for 24 hours and grilled to a core temperature of 65^{o}C. A meat piercing thermometer was used to monitor the grilled core temperature. The grilling was done separately using a separate kitchen foil on the grill for each treatment.

3.2.6 Parameters Measured

3.2.6.1 Haematological Parameters

At week 18 blood samples from 9 birds (three birds per genotypic group) randomly selected from each treatment were taken. After two weeks another sample was also taken from randomly selected birds from each treatment. The birds were given neither food nor water for a period of 24 hours before blood samples were taken. At each sampling period, blood from the wing vein of each chicken was taken with the use of a 23-guage needle fixed to a 3ml syringe (Campbell, 1995). After removal of feathers around the wing vein, a sterile cotton swab soaked in 70%

ethanol was used to dilate the vein slightly before bleeding. Blood samples were obtained by puncturing the bronchial veins on the underside of the web of the wing. Blood samples taken were quickly transferred into appropriate blood tubes pretreated with EDTA (Ethylene-diamine-tetra acetic acid) and thoroughly shaken to mix both blood sample and EDTA (Jain, 1993). The sample glass tubes were submerged in an ice box filled with ice cubes to prevent deterioration of the samples (Ritchie *et al*., 1994). An assay of the blood samples was carried out at the KNUST Hospital Laboratory. A preparation for a single blood cell for each type of blood cell was done with the use of blood films. They were fixed and stained with the use of Wright-Giemsa‟s staining method. Manual counts on total red and white blood cells were carried out using hemocytometer (Campbell, 1995). Packed Cell Volume (PCV) was measured with a standard technique using microhematocrit capillary tubes. The samples were centrifuged at 500 rpm (revolutions per minute) for three minutes in a macro centrifuge to generate serum for biochemical analysis. Hemoglobin concentration

(Hb) was also determined with the use of Cyanmethemoglobin method. Erythrocyte indices, i.e., mean value of corpuscular volume (MCV), mean value of corpuscular hemoglobin (MCH) and mean value of corpuscular hemoglobin concentration (MCHC) were also determined. The results obtained were computed for total Red Blood Concentration (RBC),

Packed Cell Volume (PCV) and hemoglobin concentration (Hb), respectively (Ritchie *et al.*, 1994).

3.2.6.2 Serum Biochemical Parameters

For biochemical analysis, the sera obtained as described above were frozen and the frozen plasma was allowed to thaw and pipetted into a dry clean bottle and stored at -20^{o}C. Using a spectrophotometer at a wavelength of 500nm, total protein, albumin and total cholesterol were

analyzed. The level of globulin was calculated as the difference between total plasma protein and albumin (Campbell, 1995).

3.2.6.3 Live Weight and Carcass Indices

At the end of the 19th week, three cockerels per replicate (45 cockerels in all) were randomly selected and slaughtered by cutting the jugular vein to allow for proper bleeding. Prior to slaughter, the cockerels were starved (but given water) for 10 hours to facilitate easy evisceration (Hagan *et al.*, 2011*).* After scalding in hot water (90^{o}C) for about a minute, the feathers were manually plucked and the carcasses were washed in clean water. Each carcass was cut into parts after evisceration for carcass evaluation. The internal organs, such as heart, kidney and gizzard were all weighed separately and recorded.

The parameters determined were:

i. Live weight (LW) ii. Bled weight (BW) iii. Defeathered weight (DFW) iv. Dressed weight and dressing percentage (DW)
v. Chilled weight (CW) vi. Neck weight (NW) vii. Drumstick weight (DrW)
viii. Thigh weight (TW) ix. Wing weight (WW)
x. Gizzard weight (GW) xi. Heart weight (HW) xii. Spleen weight (SW) xiii. Breast weight (BsW) xiv. Breast muscle weight (BMW)

3.2.6.4 Water Holding Capacity (WHC) of Burger

Water holding capacity was determined using the method described by Honikel and Hamm (1987). Five samples of burgers from each genotype were ground. 5.0g of each ground meat sample was put into centrifuge tubes and the tubes were placed in water bath at 95^{o}C for 30 minutes, after which the tubes were removed and centrifuged at 2000 rpm for 15 minutes. The samples were removed and re-weighed to determine the native water retained in the sample. Water holding capacity was calculated as the fraction of the native water retained in the sample after heating and at the beginning of the holding time (Hamn, 1986; Warris, 2000). Each treatment determination was repeated thrice.

3.2.6.5 Preparation of Burgers for Sensory Profile Analysis

After grilling, the burgers were allowed to cool for 3 minutes and cut into 25g pieces each. A 3 – digit random numbers was used to identify each treatment. The cut burgers were placed three pieces (one from each treatment) on a disposable plate and served to a panel of 80 consumers who were selected randomly to evaluate the sensory profiles of grilled burgers.

They included students and workers from the Kwame Nkrumah University of Science and Technology and clients of the Meat Science Unit, they were tasked to evaluate the sensory profile of burgers. The panelists were taken through a trial session on how to carefully judge the grilled burger for such qualities as appearance, taste, flavor, tenderness, colour and overall acceptability for 30 minutes. The panelists used a 9-point hedonic scale (**Appendix 2)** where 9 = „Like extremely“ and 1 = “Dislike extremely“ and the panelists were served with drinking water to rinse their mouth between tasting the different treatments.

3.2.7 Statistical Analysis of Experimental Data

The data were analyzed using the linear model below;
Carcass Parameters:

Yijk = μ + Gk + E ijk

Where Yijk = Observation for a given variable μ =

Overall general mean common to all observations *Gk*

= Genetic effect due to jth genotype (k=1, 2, 3)

E*ijk* = random error effects peculiar to each observation

Analysis of variance (ANOVA) was performed by using GenStat (2009) statistical package (GenStat Release 12th Edition) and means were separated using LSD test at 5% significance level.

CHPATER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Survey Work

Results obtained at the different sales points during the survey are shown in **Table 4.1.**

In all the six (6) selected chicken sales points, it was only at the Kumasi Central Market where naked neck birds could be found among the type of birds sold (**Table 4.1)**. In all the markets, spent layers were the most marketable. The reason was that the meat of layer birds is tough and can be used for both stew and soup whiles the broiler meat is too tender and is only good for stew.

Table 4.1 Markets / Sales point, Type of birds sold and their sources

Market/ Sales point	Type/ Breeds of Birds sold	Average no. of birds sold per week	Source of birds	Most marketable breed
Sofoline	Layers	45 – 50	Middlemen Mfum Farms Darko Farms Akate Farms Afariwaa Farms Dalugya Farms Topman Farms	Layers
	Broilers	30 – 40		
Kumasi Central Market	Layers	50 – 60	Same as above	Layers
	Broilers	40 – 50		
	Naked neck Birds	20 – 30		
Tanoso	Layers	30 – 50	Same as above	Layers
	Broilers	30 – 40		
Santasi Roundabout	Layers	30 – 50	Same as above	Layers
	Broilers	30 – 40		
Abuakwa	Layers	25 – 40	Same as above	Layers
	Broilers	20 – 40		
Tafo	Layers	40 – 50	Same as above	Layers
	Broilers	30 – 40		

The response of ten (10) market women each interviewed at six (6) different markets are reported in **Table 4.2**. All the sixty (60) women interviewed admitted having seen a naked neck bird before, however, a few (8.3%) of them responded that currently they will not readily accept to sell the naked neck bird because of the difficulties they go through in obtaining the birds (**Table 4.2)**. Majority (91.7%) of the respondents admitted that they will readily accept to sell the naked neck birds.

Table 4.2 Response of market women interviewed at six markets to the sales of naked neck birds.

Market / Sales Point	No. of people interviewed	Response of people	
		Yes	**No**
Sofoline	10	8 (80%)	2 (20%)
Kumasi Central Market	10	10 (100%)	0
Tanoso	10	10 (100%)	0
Santasi Roundabout	10	8 (80%)	2 (20%)
Abuakwa	10	10 (100%)	0
Tafo	10	9 (90%)	1 (10%)
Total	**60**	**55 (91.67%)**	**5 (8.33%)**

Tables 4.3 &4.4 represent the summary of the sales at all the six (6) selected fowl sales point including the number of days used to sell all the birds at the six selected fowl sales points. At Sofoline market the demand was so high that all the birds were sold within two days. It was followed by the Kumasi central market where the birds were sold out in three days. Next was Tanoso while Tafo was the last to complete its sales.

Table 4.3 Sales of the three genotypes (i.e nanaff, Nanaff, NanaFf) before Christmas

Genotypes	**Replicates**	**No. of Days Used**	**No. of Birds Left**
normal naked neck	30	13	0
frizzled naked neck	30	9	0
	30	14	0

Table 4.4 Sales of the three genotypes (i.e. nanaff, Nanaff, NanaFf) during Christmas

Genotypes	**Replicates**	**No. of Days Used**	**No. Of Birds Left**
normal naked neck	30	10 6	0
frizzled naked neck	30	12	0
	30		0

At almost all the sales point the naked neck was first to finish followed by the normal feathered with the double heterozygous frizzled naked neck being the last. On the whole, it took less than fourteen (14) days for all the birds to be sold. During the non-festive period (before Christmas) the price of birds was low as compared to the festive period (during Christmas). This agrees with a research by Sonaiya *et al.* (1999), who reported that, "in Nigeria the sale of birds and eggs take place in the villages" market. Prices fluctuate during the year being low after Christmas when the granaries are empty and the crops are still growing and everybody needs ready cash. At such times, traders come to buy and to resell in big cities, sometimes middle men are involved".

Several reasons accounted for the fast sales of the naked neck birds as explained by the people interviewed. Some saw the crossbred naked neck to be very beautiful and seem more appetizing to be consumed than the local breeds reared in the houses. This agrees with the findings of Eberhart and Washburn (1993), who commended the rearing of meat-type birds carrying the *Na* gene and stated that when they are grown in a warm environment (usually over 30^{o}C) they have larger body weight, better feed efficiency, a lower percentage of feathers, slightly more fleshing, higher viability and sometimes a lower rate of cannibalism (Cahaner and Deeb, 2001) compared with their normal feathered counterparts. Others see it to be a replacement of the local (native fowls), especially to those in the cities who do not have the opportunity to rear the local birds. Some said they have heard that it taste better than the normal feathered birds and will want to have a taste of it. This agrees with a report by Horst (1989) that local domestic chicken in developing countries still contribute much toward meat and egg supply, despite the distribution of high yielding stocks from developed regions. Horst (1989) continued that the

products from the local poultry stock are widely preferred because of their pigmentation, taste, leanness and their availability for special dishes.

Others also complained that the imported breeds of fowl has softer meat which was, less flavoured confirming the report of Kitalyi (1998), that the preference for meat from commercial poultry was low, because many traditional consumers complained that broiler meat had less flavour and was too tender. Others also purchased the naked neck specifically to be used for sacrifices especially during the non-festive period. This agrees with the findings of Sonaiya (2003) who reported that in many customs of indigenous people, poultry is used for ceremonies, sacrifices, gifts and as savings in the villages. Chickens are given or received to show or to accept good relationship or to say thanks for a favour or help. It is worth knowing that the demand for the naked neck birds was so high that the traders kept calling the researcher for a supply even several weeks after the work.

4.2 Experimental Work

4.2.1 Haematological and Serum Biochemical Indices of Crossbred Cockerels.

4.2.1.1 Haematological Parameters

The mean haematological and serum biochemical values of Nanaff (Heterozygous naked neck), nanaff (normally feathered birds) and NanaFf (double heterozygous frizzled naked neck) genotype cockerels are shown in **Table 4.5.** The haematological analysis on the chickens did not show any significant differences ($p>0.05$) in all of the parameters measured.

The results of the haematological characteristics of the three different genotypes at both 18 and 20 weeks of age showed no significant differences ($P>0.05$) in mean values of Haemoglobin (Hb), packed cell volume (PCV), red blood cell (RBC), white blood cell (WBC), the mean corpuscular haemoglobin (MCH), the mean corpuscular volume (MCV) and the mean

corpuscular haemoglobin concentration (MCHC). The results of the present study are in agreement with the haematological values reported by Oke *et al.* (2007) where no significant (P>0.05) genotypic effect was observed between the naked neck and normal feathered cockerels.

Table 4.5 Mean Haematological Values of the three genotypes (i.e. nanaff, Nanaff, NanaFf) at 18 and 20 weeks of age

Age (weeks)	**Genotype**	**Parameter**							
		Hb (g/dl)	WBC ($x10^3/\mu l$)	RBC ($x10^6/\mu l$)	PCV (%)	MCV (fl)	MCH (pg)	MCHC (g/dl)	PLT ($x10^3/\mu l$)
Eighteen (18)	nanaff	13.53	13.37	2.92	36.73	126.13	46.39	36.55	9.33
	Nanaff	13.93	14.02	3.02	37.77	125.20	46.23	37.18	10.67
	NanaFf	12.60	13.42	2.72	35.83	132.03	46.86	35.45	10.00
	L.s.d.	1.61	1.39	0.44	7.25	10.49	4.48	6.08	1.49
	S.e.d.	0.66	0.57	0.18	3.00	4.30	1.83	2.49	0.61
	p- value	*0.196*	*0.488*	*0.306*	*0.814*	*0.298*	*0.939*	*0.788*	*0.171*
Twenty (20)	nanaff	12.23	13.42	2.62	32.17	123.17	46.73	38.03	10.00
	Nanaff	14.03	14.14	3.02	36.43	121.07	46.50	38.47	11.33
	NanaFf	12.60	13.36	2.71	32.73	120.77	46.27	38.30	9.00
	L.s.d.	2.89	1.30	0.58	7.04	8.45	4.68	1.89	2.40
	S.e.d.	1.18	0.53	0.24	2.88	3.45	1.91	0.77	0.98
	p-value	*0.339*	*0.326*	*0.282*	*0.340*	*0.760*	*0.971*	*0.855*	*0.135*

#
Treatment means were compared at 5% level of significance (P<0.05); a, b, c means within column bearing different superscripts are significantly different. L.s.d: least significant difference; P: Probability-value

The observed haematological values of blood cells of the three different genotypes of the tested chickens in this study revealed that all the mean values of blood cells fell within expected blood values for the normal growth of chickens and they were within the range of values reported by

Pollock *et al.* (2001). This is an indication that the health conditions of the three chicken genotypes investigated could be classified as conditions for normal growth of chickens. Thus, the naked neck and frizzling genes have no effect on the haematological parameters which determine chicken health.

An increase in haemoglobin concentration could be related to an increase in metabolic activity necessary to satisfy the energy demands for maintenance under stress conditions. According to Pollock *et al.* (2001), a haemoglobin concentration below 7g/dl is an evidence of sign of anaemia in chickens. It could therefore be inferred that none of the various genotypes proved to be anaemic since they all had haemoglobin concentrations above 7g/dl **(Table 4.5)**.

4.2.1.2 Serum Biochemical Components.

At the 18th week, the mean values of total protein, albumin, cholesterol and globulin of the genetic groups were not significantly influenced (P>0.05) by the different genotypes (**Table 4.6)**. These findings are in consonance with the reports of earlier works by Ladokum *et al.* (2008) in a study of haemotological and serum biochemical indices of indigenous naked neck and normal feathered chickens.

Also, when the birds were 20 weeks old, the mean values of total protein, albumin and globulin of the different genetic groups were not significantly affected (P>0.05). However, the normal feathered genotype had a significantly higher (P<0.05) cholesterol content (4.067mmol/l) than the heterozygous naked neck (3.467mmol/l) and the double heterozygous frizzled naked neck (3.533mmol/l), but the heterozygous naked neck and the double heterozygous frizzled naked neck showed no significant differences (P>0.05). This suggests that the presence of Na gene in

a single state significantly decreased total cholesterol level in *Nana* compared to the *nana* genotype **(Table 4.6)**.

Table 4.6 Mean Serum Biochemical Values of the three genotypes (i.e nanaff, Nanaff, NanaFf) at 18 and 20 weeks of age.

Age (week)	Genotype	Parameter			
		Total Protein	Albumen	Globulin	Cholesterol
		(g/l)	(g/l)	(g/l)	mmol/l 4.20
Eighteen	nanaff	46.07	29.03	17.03	3.90
(18)	Nanaff	50.93	33.40	17.53	
	NanaFf	42.47	25.80	16.67	4.00
	L.s.d.	16.18	13.02	5.46	1.34
	S.e.d.	6.61	5.32	2.23	0.55
	p-value	*0.478*	*0.413*	*0.923*	*0.86*
	nanaff	49.03	28.90	20.43	4.07^{a}
	Nanaff	61.76	38.47	21.97	3.47^{b}
Twenty (20)	NanaFf	54.27	27.07	19.80	3.53^{b}
	L.s.d.	13.50	11.95	2.62	0.43
	S.e.d.	5.70	4.89	1.07	0.18
	p-value	*0.089*	*0.117*	*0.195*	*0.027*

#
Treatment means were compared at 5% level of significance (P<0.05); a, b, c means within column bearing different superscripts are significantly different. L.s.d: least significant difference; P: Probability-value

The results show that all the mean values of the serum biochemical components considered fitted within the range of values reported by Pollock *et al.* (2001) with the exception of total protein and albumen values for the naked neck birds. Galat *et al.* (2007) recorded a

nonsignificantly (P>0.05) higher total plasma protein in normal-size heterozygous naked neck birds compared to normal feathered ones. They explained that the higher value was due to the acute phase of an immune response (hyper active of immunity system), where the liver cells produced and secreted acute phase protein (APP), which gives protection to birds against infection or any invasion. The high total plasma protein shows the important role of globulin in terms of immunity. A higher globulin level may indicate a higher level of immunity and may help to reduce the negative effects associated with malnutrition (Ladokun *et al.*, 2008).

All the results from the study (**Table 4.6)** suggest that the *Na* gene in a single state and the *F* gene had a positive numerical effect on the total protein, albumen and globulin and a significant effect on the total cholesterol level in the birds. In addition, the study revealed that none of the various genotypes was suffering from a liver disease, exudation due to severe skin lesions (burns) and excess fluid therapy because from **Table 4.6** all the parameters fitted within the normal range as reported by Margaret (2001).

4.2.2 Live Weight and Carcass Parameters of Crossbred Cockerels.

4.2.2.1 Live Weights, Bled, Defeathered, Dressed and Chilled Weights

Results of live weight, bled weight, defeathered weight, dressed and chilled weights of cockerels as affected by type of gene are presented in **Table 4.7**.

There were no significant differences (p>0.05) between the means of the live, bled, defeathered, dressed and chilled weights of the cockerels with the three genotypes. The absence of significant difference between the Nanaff, nanaff and NanaFf gene birds in this study disagrees with the findings of Adedeji *et al.* (2006) who recorded a significantly (P<0.05) higher body weight among naked neck birds at fifteen weeks of age compared to normal feathered ones.

4.2.2.2 Gizzard Weight, Spleen and Heart Weight

The *Nanaff* genotype was not significantly ($p>0.05$) higher in gizzard weight (47.7g) compared to the *nanaff* (42.1g) and *NanaFf* (45.7g) genotype **(Table 4.7)**. This is in agreement with the findings of Galal *et al*. (2007) who recorded no significant difference between the heterozygous naked neck and normal feathered birds. The heart weight of *NanaFf* cockerels recorded was not significantly ($p>0.05$) heavier than those of both the *Nanaff* and *nanaff* cockerels. There was no significant ($p>0.05$) difference between the spleen weight of the frizzled-naked neck and the normally feathered cockerels but both had significantly ($p<0.05$) lower spleen weights than those of the naked neck cockerels. This is in agreement with the findings of Galal *et al*. (2007) who reported that the heterozygous naked neck genotype had significantly higher relative thymus and spleen weights compared to normal type. They suggested that the presence of the naked neck gene in a single state increased the relative weights of the lymphoid organs in the chicken. Ubosi *et al*. (1985) also stated that the size of the spleen of avian species may be influenced by genotype.

4.2.2.3 Drumstick, Thigh, Wing, Neck, Breast and Breast Muscle Weight.

Frizzled-naked neck cockerels had drumstick weight (400.9g) that was not significantly different ($p>0.05$) from the weights recorded by the other genotypes. Thigh weights of naked neck (194.7) and frizzled-naked neck cockerels (192.9g) were also not significantly higher than those of normal feathered cockerels (192.1g). However, wing weights of naked neck (152.0g) and frizzled-naked neck cockerels (153.7g) seemed to be slightly higher than those of normal feathered cockerels (151.4g), but the observed differences in wing weights among the three genotypes were not statistically different ($p>0.05$). The breast weights for the three genotypes were 248.0g, 246.5g and 245.5g respectively for normal feathered, naked neck and frizzled-

naked neck cockerels and there were no significant differences ($p>0.05$) among the three genotypes. The lack of significant differences among these chicken cuts (parts) was earlier reported by Patra *et al*. (2002).

Neck weight for naked neck cockerels (95.5g) was significantly higher ($p<0.05$) compared to the neck weights of normal feathered (81.1g) and frizzled-naked neck cockerels (83.4g). The normal feathered and frizzled-naked neck had similar ($p>0.05$) neck weights. This observation agrees with the findings of Kgwatalala *et al.* (2013) who recorded a significantly higher neck weights for naked neck compared to the normal feathered birds. The main effect of the naked neck gene is the reduction of the whole feather coverage especially in the neck and breast areas by about 30-40% as compared with the normal chickens (Horst and Rauen, 1986 and Mérat, 1986). The heavier neck weight associated with the Na gene 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), Adedeji *et al.* (2006) and Galal *et al*. (2007). Cahaner *et al*. (1993) stated that 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 and such protein that would have been used to form feather would now be used for meat tissue development (Cahaner *et al*., 1993). The breast weight and the breast muscle weight recorded in this study were not-significantly higher than that of the normal feathered cockerels.

Table 4.7 Mean Live weight and weights of Carcass Parameters of the three genotypes (i.e nanaff, Nanaff, NanaFf)

Genotype	Parameter(g)													
	LW	BW	DFW	DW	CW	NW	BsW	BMW	DrW	TW	WW	GW	HW	SW
nanaff	1730	1671	1497	1317	1053	81.1[b]	248.0	167.3	386.5	192.1	151.4	42.1	6.87	3.67[b]
Nanaff	1767	1697	1573	1373	1060	95.5[a]	246.5	169.9	385.0	194.7	152.0	47.7	6.87	4.07[a]
NanaFf	1687	1610	1510	1300	1053	83.4[b]	245.5	174.0	400.9	192.9	153.7	45.7	7.47	2.67[b]
L.s.d.	146.90	145.60	137.8	122.7	119.4	9.87	29.40	23.56	45.05	23.84	13.81	5.59	1.050	0.751
S.e.d.	72.80	72.10	68.30	60.80	59.20	4.89	14.57	11.67	22.32	11.81	6.85	2.77	0.52	0.37
p-value	0.551	0.468	0.493	0.882	0.991	0.011	0.986	0.845	0.737	0.975	0.943	0.135	0.419	0.002

[#]Treatment means were compared at 5% level of significance (P<0.05); a, b, c means within column bearing different superscripts are significantly different.
L.s.d: least significant difference; P: Probability-value

LW=LIVE WEIGHT; BW=BLED WEIGHT; DFW=DEFEATHERED WEIGHT; DW=DRESSED WEIGHT; CW=CHILLED WEIGHT; NW=NECK WEIGHT; BsW=BREAST WEIGHT; BMW=BREAST MUSCLE WEIGHT; DrW=DRUMSTICK WEIGHT; TW=THIGH WEIGHT; WW=WING WEIGHT; GW=GIZZARD WEIGHT; HW=HEART WEIGHT; SW=SPLEEN WEIGHT

4.2.3 Water Holding Capacity (WHC) of Burgers

The water holding capacity (WHC) of the burgers were not significantly different ($p>0.05$) for *Nanaff* (heterozygous naked neck) and *NanaFf* (double heterozygous frizzled naked neck). However, the *Nanaff* and *NanaFf* had significantly ($p<0.05$) higher values for *nanaff* **(Table 4.8)**.

Table 4.8 Percentage Water Holding Capacity of Burger of the three genotypes (i.e nanaff, Nanaff, NanaFf)

Genotype	WHC (%)
nanaff	89.880[b]
Nanaff	98.880[a]
NanaFf	98.720[a]
L.s.d.	2.1043
S.e.d.	0.970
p-value	<.001

[#]Treatment means were compared at 5% level of significance ($P<0.05$); a, b, c means within column bearing different superscripts are significantly different. L.s.d: least significant difference; P: Probability-value

This suggests that the presence of the Na gene in a single state significantly increased the WHC as compared to the nana genotype. According to Huff-Lonergan and Lonergan (2005), much of the potential for water-holding capacity or drip loss is truly established very early in the life of a product and in some instances, the genetics and the handling of the live animal can play a major role in influencing the potential water-holding capacity of that product. Water holding capacity according to Honikel (1998) is the ability of muscle to retain naturally occurring moisture and this retained moisture according to Huff-Lonergan and Lonergan (2005) influences the yield,

palatability and quality (appearance, juiciness, tenderness and flavour) of meat. It also affects the processing of meat. Therefore the superiority of the naked-neck over the normal feathered genotypes in terms of water holding capacity makes it better than the normal feathered genotype with respect to meat yield, processing ability and general appearance of the meat, Van Laack *et al*. (2000) stated that concomitant reduction in WHC affects yield, processing ability and general appearance of meat.

4.2.4 Sensory Profile

4.2.4.1 Age Distribution

The panel consisted more of the younger students between the ages of 15-25 (54.1%) and 26-35 (31.6%) with a small proportion of elderly persons aged above 35 years **(Fig 4.1)**.

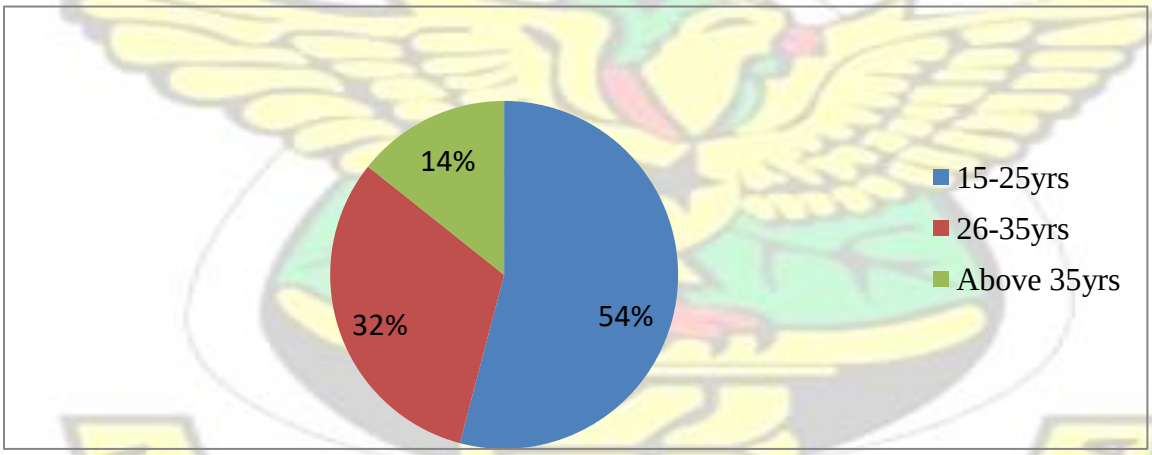

Figure 4. 2. Age Distribution of Panelists for Sensory Evaluation

The distribution of ages of panel members is very important because according to the 2010 population census of Ghana, the younger age group (15-34 years) are in the majority, occupying about 53.4% of the entire population and the elderly (above 64 years) are the minority with 5.3% of the population while those below 15years of age are about 41.3% (GSS,2010), therefore, If the

outcome of the sensory evaluation is positive, then there is no doubt that there will be ready market for the sale of the superior genotype with respect to the age distribution in discussion.

4.2.4.2 Overall Acceptability, Flavour, Taste, Tenderness, Appearance and Colour of Burgers Produced from the three Genotypes

Table 4.9 Sensory Profile of Burgers of Crossbred Cockerel Genotypes

Attribute	**Type of Genotype used in Burger of chicken**					
	normal	naked neck	frizzled	L.s.d.	S.e.d.	*p-value*
Overall acceptability	6.42[b]	8.17[a]	6.25[b]	1.20	0.59	*0.004*
Flavour	5.92	7.83	6.83	2.026	1.00	*0.173*
Tenderness	6.42	7.50	6.58	1.563	0.77	*0.328*
Appearance	7.08	7.25	6.67	1.415	0.70	*0.692*
Taste	6.00	7.83	6.33	1.842	0.91	*0.113*
Colour	6.33	7.33	6.42	1.586	0.78	*0.374*

Treatment means were compared at 5% level of significance (P<0.05); a, b, c means within rows bearing different superscripts are significantly different. L.s.d: least significant difference; P: Probability-value

The overall acceptance of burger produced from normal feathered chickens was similar (p>0.05) to that of the frizzled naked necks both of which were significantly lower (p<0.05) than that from the naked neck. The rest of the sensory attributes showed no significant (p<0.05) differences, however, the numerical values showed that the naked neck seems to have higher values than both the frizzled naked neck and normal feathered cockerels. The normal feathered genotype had the

least numerical value in all the sensory attributes except the overall acceptability where it was second to the naked neck. It has been reported that indigenous birds, naked neck and frizzled, have higher levels of pigmentation, leanness (high protein and low fat content), taste, firmness and suitability for special dishes and because of these they fetch premium prices which are almost double of those of exotic chickens (Horst, 1991; Mafeni, 1995; Islam and Nishibori, 2009). Islam and Nishibori (2009) further stated that consumers prefer the meat and eggs of Indigenous naked neck chickens for reasons of pigmentation, leanness, taste, firmness, and they are also used in special dishes. It has also been reported that there is a shift in consumer preference and this shift has increased the demand of local unimproved chickens because of their superior meat flavour and texture, perceived health benefits and relatively low water footprint compared to exotic chickens (Dyubele *et al*., 2010; Hoekstra, 2012). In this respect the naked neck which was the most liked in terms of appearance/ colour will stand a good chance in terms of marketability or acceptance in the market as compared to their normal and frizzled-naked neck counterparts.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The results of the study showed that:

- the *Na* and *F* gene had no significant effect on the haematological parameters measured
- the *Na* gene significantly reduced the cholesterol level of cockerels but had no effect on the other serum biochemical indices evaluated.
- the *Na* gene significantly increased the weight of the neck and heart but had no effect on the other carcass traits measured.
- the *Na* gene significantly influenced the acceptability level of consumers.

In conclusion, among the three genotypes studied, the naked neck was preferable to the other genotypes due to its high meat proportion, meeting the preference of those consumers looking for chicken in this niche market. From a health point of view, the indigenous naked neck genotype, seem superior because its fat and cholesterol contents were low.

5.2. Recommendation

The preference for meat from commercial poultry is low. Many traditional consumers complain that commercial broiler meat has less flavour and the muscle is too tender, although higher prices were paid for village produced poultry meat and eggs. Thus for any meaningful and sustainable breeding strategy, there is the need to maintain and improve local birds to meet this demand and also the strategy should focus on the genetic potential of the indigenous breeds. Thus it is strongly recommended that there should be a conscious effort to develop and commercialize the naked-neck and frizzled birds in Ghana.

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APPENDICES

Appendix 1: Data collection and Sampling technique used in the survey

QUESTIONAIRES

PROJECT ON EFFECTS OF THE NAKED NECK (Na) GENE ON CARCASS TRAITS, HEAMATOLOGICAL AND SERUM BIOCHEMICAL PARAMETERS AND MARKETABILITY OF COCKERELS

INSTRUCTION

The information you provide on this form is for academic/professional purpose and will be kept strictly confidential. By honestly and kindly completing this form, you will be providing the researcher with valuable information on research work.

District **Town** **Sex** **Age**

……. …….. …….. ……..

QUESTIONS

1. How many years have you been selling birds? .....
2. What type (breed) of bird do you normally sell? ……..
3. What is the source of your birds? ……
4. How much do you buy a bird from the source?.....
5. How much do you sell a bird?.....
6. What is the average number of birds sold per week?.....
7. Which breed do you consider to be the most marketable? …….……
8. Can you account for the reason to the preference of the most marketable breed by consumers?
9. Do consumers ask of any other breed apart from what you have? Yes/No
10. If yes, what is the name of that bird?.....
11. Have you seen a naked neck bird before? Yes/No
12. Have you sold some before? Yes/No
13. If yes, why did you stop?
14. Would you readily accept to sell the naked neck birds? Yes/No
15. What do consumers say about the naked neck birds?
16. Can you suggest any reason to the preference of naked neck by consumers?

Appendix 2. Hedonic scale used for sensory evaluation of burgers

Like extremely	Like moderately	Like slightly	Like	Neither like nor dislike	Dislike	Dislike slightly	Dislike moderately	Dislike extremely
9	8	7	6	5	4	3	2	1