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Review article

Genotype and sex influencing dressing percentage, carcass parameters and meat quality properties in indigenous chickens

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ABSTRACT

Indigenous or village or local chickens are an important source of animal protein in the form of meat and eggs, contribute to rural food security and are an important avenue for woman empowerment as indigenous chickens in poor communities are mostly owned by women in Sub Saharan Africa. There are many factors that affect dressing percentage, carcass traits and meat quality properties in indigenous chicken, such as genetics, nutrition, environment, and additives, however, genetics is one of the most important factors. The knowledge on variability of genotype of indigenous chicken accompanied by manipulation of their production system will translate into a specific desirable dressing percentage, carcass characteristic and meat quality properties, which is paramount criteria for consumers when it comes to making purchasing decisions. Therefore, using different indigenous chicken genotypes, the producer may sort to employ management practices which furnish with acceptable dressing percentage, carcass and meat quality properties which do not compromise and maintain health in consumers. However, very few studies have been reported on the utilization of different indigenous chickens genotypes in improvement of carcass and meat quality properties. Feeding systems, slaughter age and rearing systems are some of the environmental factors which have been examined in indigenous chickens to determine their influence on carcass and meat quality properties. It has been noted that varying the discrete variables such

as genotype and sex had significant differences in the nature of corresponding carcass and meat quality properties in indigenous chickens. Variations in the genetic make-up and sexual dimorphism in indigenous chickens accounted for the observed differences in dressing percentage and carcass characteristic. The preceding review gives some insight on the influence of genotype and sex on dressing percentage, carcass parameters and meat quality properties in indigenous chickens.

1. Introduction

There has been a strong consumer demand for chicken products in foreign and domestic markets as a result of an accelerated increase in global population and the consumer perception of the health benefits of chicken meat (López et al., 2011). Chicken meat represents 29% of meat production from farmed animals and this proportion is rising each year (McKay et al., 2000). This is on the backdrop that indigenous chicken is the most common type of chicken raised in most rural parts of the sub Saharan communities (Faouzi et al., 2002), mainly reared by resource poor rural farmers (Goromela et al., 2008; Kyarisiima et al., 2004) due to the fact that they are relatively hardy and survive on inadequate feed resources and scavenging (FAO, 2004) under the traditional free range system (Mekria and Gezahegn, 2010). This may imply that a sustainable production and food security of animal proteins, meat production in rural areas should take into consideration the indigenous chicken population which accounts for the majority of the local production of chicken meat (Youssaol et al. 2012). This takes into account the fact that local chickens are an important source of high quality protein (meat and eggs) and they also provide small cash income (Tadelle et al., 2000), hence they provide food security and alleviate poverty. Local chickens are widely distributed in rural and peri-urban areas where they play the important role of income generation, food production and social aspect (Mwalusanya et al., 2001; Thornton et al., 2002; Moreki et al., 2010). Indigenous chickens preferably known as village chickens have remained paramount in the developing world (Do, 2005; Bett et al., 2012) despite the introduction of exotic strains (Magala, 2012) to support the poultry industry.

Chicken meat has been promoted as a lean protein source as most of the fat is stored as subcutaneous fat and within the skin membrane making it easy to remove prior to cooking (Decker and Canton, 1992; Wang et al., 2010). The meat itself is an excellent source of protein in the diet as it contains all of the essential amino acids which are the building blocks for protein along with assisting in production of enzymes and many essential processes in the body (Pellett and Young, 1990). However, even in the developed world were consumers are accustomed to paying low prices for poultry meat, they are increasingly interested in products that they perceive as naturally produced or environmentally friendly, provide a high level of nutrition with no contaminants, good flavor, provide good welfare for the birds, and provide more information about the products they eat. The organic market has targeted indigenous chickens in many developing countries due to environmental concerns, personal health concerns, highly publicized food scares, and debates over genetically modified food (Chang and Zepeda, 2005). However, the success of any food product is determined by consumer acceptability which is largely determined by the perception of quality (Dransfield, 2001). Meat quality is a complex trait that is influenced by genetic and environmental factors, and the variation in meat quality within and between animals can be large (Rehfeldt et al., 2004). Chinese consumers often prefer indigenous chicken breeds over commercial breeds due to their meat qualities (Sheng et al., 2013). In certain instances indigenous chicken meat has been found to possess a unique taste, with strong and tough muscles, whereas the broiler chicken has an over-tender characteristic (Wattanachant et al., 2004; 2005). The meat quality traits of indigenous chickens and broilers have been widely researched in literature (Fanatico et al., 2007; Lu et al., 2007; Tang et al., 2009; Sirri et al., 2010; 2011). In conclusion, Guan, et al. (2013) indicated that the indigenous chickens, especially the Chinese indigenous Ninghai chicken breed showed better quality meat than the broiler breed, as far as the inosine-5′-monophosphate content and texture were concerned. There are many aspects to overall dressing percentage, carcass parameters and meat quality of indigenous chickens, which may be affected by genotype, age, gender, type of production

system, stocking density, temperature, diet, and other factors (Shanin and Elazeem, 2005; Jaturasitha et al., 2008; Peter et al., 1997). Literature indicates that meat quality differences exist between genotypes with different growth rates and raised in alternative production systems (Fanatico et al., 2007). This implies that to produce quality indigenous chicken meat with maximum consumer appeal producers need to recognize the importance of meat quality attributes in utilization of some of the indigenous chicken genotypes. The preceding review gives some insight on the influence of genotype and sex on dressing percentage, carcass parameters and meat quality properties in indigenous chickens.

2. Genotype influencing dressing percentage, carcass parameters and meat quality properties in indigenous chickens

Genotype is an important factor in any indigenous chicken production system since it influences carcass and meat quantity (Fanatico et al., 2007). Jaturasitha, et al. (2008) observed that meat of indigenous chickens had some unique features and seemed to have more advantages over imported breeds than disadvantages, especially when determined for a niche market serving consumers who prefer chewy, low-fat chicken meat. Thutwa, et al. (2012) in a comparative study of live weight, growth performance, feed intake, carcass traits and meat quality in two strains of Tswana chickens raised under intensive system in south east district of Botswana, reported that naked neck males outperformed naked neck females and normal chickens in carcass weight and yield and carcass parts weights and yield, indicating that the naked neck males may be good for meat production. Peters et al. (2010) however, reported significantly higher live weight, dressed weight, heart weight and gizzard weight in the normal strain than in the naked neck strain of scavenging Nigerian indigenous chicken. In Iran naked neck males and females weighed 1416.1 and 1058.3 g, respectively at 19 weeks of age while the Tswana naked neck males and females in the current study weighed 2286.69 and 1493.80 g, respectively at that age even though they were both kept under improved management (Vali, 2008). Thutwa, et al. (2012) reported that the weights of naked neck breast, thigh, drumstick, wing and neck of two strains of Tswana chickens raised under intensive system were double that of Samaera (2003)'s findings in the same strain. This may be due to the fact that the chickens used in Thutwa, et al. (2012) study were from different areas of Botswana leading to high variation while those of Samaera (2003) were from one area. Islam and Nishibori (2009) found that indigenous naked neck of Bangladesh was superior in dressed percentage to indigenous normal feathered chickens. The meat lipids of the Thai native chickens had particularly high proportions of n-3 fatty acids and a favorably low n-6/n-3 fatty acid ratio compared with the other genotypes. Furthermore, the ratio of red and intermediate to white fibers was higher in the thigh muscle, and the diameter of all muscle fiber types in both muscles which was found to be smaller in the indigenous compared with the imported breeds. This was in agreement with reports by Jaturasitha et al., (2004a), Shahin and Elazeem (2005) and Chaosap and Tuntivisoottikul (2006) who observed that genotype (breed and strain) of chicken played a major role in carcass fatness. Breed or variety of indigenous chicken differences in fatty acid profiles, sensory attributes and physical meat quality attributes offer an opportunity to improve efficiency of desirable meat production. Several unsaturated fatty acids have been reported to intensify the taste of meat. The primary oxidation products of linoleic acid (C18:2), such as hexanal and 2,4-decadienal, are the most abundant aldehydes implicated in chicken meat taste (Shi and Ho, 1994). Therefore, increasing the levels of these taste-active compounds in chicken meat may improve its sensory quality (Jayasena et al. 2015). However, the concentration of taste-active compounds in chicken meat is known to be affected by a number of factors including the chicken breed/strain, diet of bird, and cooking (Jayasena et al., 2013a). On the other hand, inosine 5_-monophosphate (IMP)—the predominant nucleotide in meat—and glutamic acid have vital contributions towards the development of umami taste in chicken meat (Fujimura et al., 1996; Liu et al., 2007; Sasaki et al., 2007). Cheng et al. (2008) studying the effects of free-range farming on carcass and meat qualities of black-feathered Taiwan native chicken observed that free-range Taiwan native chicken appeared to yield the best of the results, with flavorful yet tender leg meat for higher sensory satisfaction, and high-protein but low-fat breast meat for healthier diet choice. The scores of all the attributes including aroma, flavor, firmness, tenderness, juiciness and overall acceptability of leg meat from free-range chickens were slightly higher than for conventional chickens, while the reverse was true for breast meat, though no significant difference could be found. Nielsen et al. (2003) reported that slow-growing genotypes such as most indigenous chickens were characterized by a significantly lower breast yield, but higher yield of thigh and drumstick muscles than fast-growing chickens. In a similar study, breast and leg

yield of slow-growing chicken ranged from 10.4% to 26.0% and 24.6% to 37.4%, respectively (Lewis et al., 1997; Quentin et al., 2003; N'Dri et al., 2006).

Poultry or 'white meat' is an alternative meat for health conscious consumers, as it contains low cholesterol and fat and consumers prefer indigenous chicken meat to poultry meat because indigenous chicken meat has more chewy and tasty meat (Jaturasitha et al., 2002). Meat quality traits of poultry include chemical (proteins, total lipids, etc.) and physical traits (pH, color, water holding capacity, texture, sarcomere length, etc.) (Petracci and Baeza, 2011). The success of any food product is determined by consumer acceptability which is largely determined by the perception of quality (Dransfield, 2001). Previous studies in other livestock species have shown that consumer's perception on meat healthiness is related to its fat content and fatty acid composition (Fisher and Scougall, 1982). Fat remains an important quality determinant of meat although the chemical and physical properties of fat usually have little influence on the commercial value of carcass, these properties do influence the eating and keeping quality of meat (Kempster et al., 1982). Higher intake of animal fats especially those rich in long chains of saturated fatty acids have been associated with increased plasma cholesterol and the risk of atherosclerosis and cardiovascular diseases (Ascherio, 2003; Sacks and Katan, 2002). Lee and Lin (1993) reported a higher shear value, cohesiveness, but lower in hardness value has been which contributed to a better eating quality of Taiwan native chicken when compared with the broilers. According to the literature, the mean yield for slow-growing chickens ranged between 13.4 and 26% for breast, between 24.6 and 37.4% for leg and between 17 and 4% for abdominal fat (Janocha et al., 2003; Sengül et al., 2003). Guan, et al. (2013) observed that fiber diameter of the indigenous chickens was shorter than that of commercial broilers , significantly both in the pectoralis major muscle and the biceps femoris muscle. Results suggest that the fast-growing commercial broilers had the larger fiber diameter than the slow-growing chicken genotypes of the Chinese indigenous chickens. It is generally considered that tenderness of poultry meat depends on the quality of connective tissue (collagen), the myofibrillar structure and the structural interactions between fibres, the extracellular matrix and the breed genotype (Sante et al., 2001; Wattanachant et al., 2004). The meat of the indigenous chickens, especially of the Thai chickens, was higher in shear force and collagen content (thigh only) than meat of the imported breeds (Jaturasitha et al., 2008). According to Wattanachant et al. (2004), the shear values of the indigenous chicken muscles, either raw or cooked, were significantly higher than those for the commercial broiler muscles, hence similar observations were reported by Dransfield, (1994). It was concluded that the differences in the fiber diameters may be due to the differences in the genotype, age, production system and diet. The color score of three breeds of Korean local chicken was higher than that of silky fowl (Choo, et al. 2014). Color of chicken meat is important since consumers associate it with the product's freshness, and hence influences whether or not to buy the product (Yang and Jiang, 2005). Choo et al. (2014) observed that within the local breeds, and the silky fowl named as Chinese Taihe chicken or black-boned chicken, and meat of black-boned chickens had shown less color value than other genotypes (Jaturasitha et al., 2008), which is assumed to be due to genetic influence. Meat color is generally influenced by animal related factors, mainly the genotype (Fletcher, 1995) and the age of animals (Fanatico et al., 2005). Husak et al. (2008) reported that higher meat pH is more effective for retaining desirable color and moisture absorption properties. The pH value has been associated with numerous other meat quality attributes including tenderness, water holding capacity WHC, cooking loss, juiciness, and shelf life (Allen et al., 1998). The meat tenderness and toughness traits are a major aspect of consumption quality among consumers (Maltin et al., 2003; Mullen et al., 2006).

3. Sex influencing dressing percentage, carcass parameters and meat quality properties in indigenous chickens

Kgwatalala et al. (2013) observed that generally, naked neck males and females had the highest live weight, carcass weight, dressing percentage, primal cuts weight and giblets weight and dwarf males and females had the lowest weights in those parameters. This might be attributable to higher pre-slaughter live weight of males compared to that of females contributed to significantly heavier primal cuts weight of males than females. The naked neck strain thus shows the greatest promise for possible selection and development of meat type chicken of indigenous Tswana chickens. Raach-Moujahed and Haddad (2013) reported a mean dressing percent of 68.6 percent for Tunisia local chicken raised for 112 days with outdoor access. Likewise, there was no significant difference in dressing percent between males and females within slaughter age, the average values being 66.2 and 64.7 percent for males and females respectively. The higher dressing percent in 7 month birds is expected since, as birds increase in weight there is proportionate increase in muscle and other tissues except bones which at 5th

month are most likely to have approached peak growth. In another study Gueye (1998) and Aini (1999) observed higher abdominal fat for female chickens compared to their male counterpart but this was not the case in another study by Isidahomen, et al. (2012). The reason cited was that variability was higher in abdominal fat in male, which might not be unconnected with the high influence of environment on these traits. In the same studies, the result for kidney fat was always constant and was not affected by genotype, sex or their interaction. In Uganda indigenous chicken cockerels under the free range system require more time to attain market weight and their meat possesses attributes that are concomitant with tastes and preferences of many chicken consumers. Other than sex, carcass quality traits depend on a number of factors as genotype, and age which had a greater impact and the possibility of genetically improving carcass quality by selection based on genetic variability of body weight and body composition (Pikul et al., 1987). Joseph et al. (1992) reported that dressing percentage of male local chicken was significantly higher than that of female. The carcass weight obtained for the male was higher than that of the female Theerachai (2009) in addition to male local chicken having higher proportion of total carcass. This was also observed in different study by Garcia et al. (1993) which strengthens the argument for inherent genetic differences. Isidahomen, et al. (2012) studying indigenous chickens in Nigeria reported that genotype as well as sex influenced carcass characteristics and slaughter yield at twenty weeks old. The slaughter weight, carcass weight and dressing percentage were better in the indigenous naked neck chicken than other genetic groups. It could therefore be concluded that variations in the genetic make-up and sexual dimorphism in the chickens accounted for the observed differences in carcass characteristic. This phenomenon known as sexual dimorphism has been revealed by several reports to usually favour male compared to female especially in poultry (Ikeobi et al., 1995; Peters et al., 2010). This implies that male indigenous chickens across genotypes would show remarkable and better carcass yield and parameters than their female counterparts. Males generally had higher values for slaughter weight, weight after bleeding, slaughter weight after defeathering, carcass weight and other organ weights measured (Cahaner et al. 1993). The weight of kidneys and heart were for the male Fulani ecotype type chickens were significantly higher than that of females while the proventiculus, abdominal fat and intestinal offals of the female were significantly higher than males (Sola-Ojo and Ayorinde, 2009). Fayeye et al. (2006) attributed this difference to genetic effect of sex which arises from the male physiological activities. It has also been reported that sex differences were usually due to differences in hormonal profile, aggressiveness and dominance especially when both sexes are reared together (Ibe and Nwosu, 1999; Ilori et al., 2010). Adedeji et al. (2004) reported that the aggressiveness of males over the females especially when reared together put the females at a disadvantage for feed and water, which might influence their remarkable and better carcass yield and parameters than their female counterparts. The higher pre-slaughter live weight in naked neck females of indigenous Tswana chickens relative to the dwarf strain is consistent with Yakubu (2008) who reported live weights of 1.3 kg and 1.16 kg in the naked neck and dwarf hens of Nigerian indigenous chickens, respectively. Just like their male counterparts, female naked neck chickens had the highest values for various carcass parameters investigated (primal cuts and giblets weights) and the dwarf strain had the lowest values with the exception of liver weight where the normal strain had the lowest weight.Debut et al. (2005) reported that acute heat stress affected blood Ca2+ and Na+ concentration and increased glycaemia and glycolytic potential of thigh muscle. Both acute heat stress and shackling before slaughter were experienced as stressful events by all types of birds. The significantly higher blood yield in males than females was reported by Igbal and Pampori (2008) in indigenous chickens of Kashmmir. Choo, et al. (2014) concluded that four local breeds of chicken had some unique features and seem to have more advantages, and this information could help consumers who prefer healthy and premium chicken meat. In general, several studies have acknowledged the sex influence on carcass parameters in different strains/genotypes of indigenous chickens from various countries (de Marchi et al., 2005; Daikwo et. al., 2011; Igbal and Pampori, 2008; Thutwa et al., 2012; Isidahomen et al., 2012; Khalid et al., 2012; de Almeida and Zuber, 2010).

4. Implications

Considerable variation exist among indigenous chicken genotypes/breeds/strains on dressing percentage, carcass parameters and meat quality properties. Knowledge of variation in dressing percentage, carcass parameters and meat quality properties as a result of utilization of different genotypes in different management systems can be used to identify optimal breeds/genotypes/strains for maximization of production targeted on the existing markets. The present review focused on factors important to alternative to indigenous chicken producers: sex and genotype their influence on dressing percentage, carcass parameters and meat quality properties. With

this in mind, a better understanding of dressing percentage, carcass parameters and meat quality of widely divergent genotypes raised in different production systems and provided different nutritional regime will help producers make informed decisions on the end product. It is suffice to suggest that white meat such as of the indigenous chicken is considered superior in health aspects to red meat because of comparably low contents of fat, cholesterol. In this regard it is reasonable to suggest that improvement of indigenous chicken in terms of meat quality and quantity through manipulation of non genetic factors is paramount to provision of high quality protein to developing countries' poor majority. The value of increasing our knowledge of indigenous chicken production issues and the end products such as carcass parameters and meat quality properties should be strengthened for the purpose of evaluation and marketing purposes in the formal poultry industry. Ascertaining the differences and predicting changes in carcass composition of indigenous chicken are required now more than ever since the change in consumer preference from buying a whole chicken to cut- up parts of chicken. However, despite the present review focusing on genotype and sex influence on dressing percentage, carcass parameters and meat quality properties in indigenous chickens, it is imperative to ascertain the holistic influence of interactions of different environmental factors on the same parameters.

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