Genetic and nutrition development of indigenous chicken in Africa

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Abstract

This review gives insights into genetic and feeding regime development for indigenous chicken genetic resources. We highlight and combine confirming evidence of genetic diversity and variability using morphological and molecular techniques. We further discuss previous past and current genetic attempts to improve on reproduction and production traits in these genetic resources. We detail evidence of their importance on disease tolerance as well. Their utilization for improved productivity for directional selection, gene introgression and cross breeding scheme are discussed. We decipher nutrients requirement for indigenous chicken and report nutritive contents of various local feedstuffs under various production systems. Various conservation strategies for sustainable utilization are hereby reviewed.

Keywords: *conservation, genetic resources, nutrition regime, production systems*

Indigenous chicken genetic resources variability

Poultry are domesticated avian species that are raised for eggs, meat and feathers. The term "poultry" includes chickens, turkeys, guinea fowls, ducks, geese and other species such as quails and pigeons, or birds considered to be game, like pheasants. About 90 percent of the poultry population are chicken and are the most important poultry species in all parts of the world (FAO 2014). The term "poultry" is therefore often used synonymously for chickens. In developing countries many people keep small numbers of chicken for home consumption, to sell and for various socio-cultural uses. This practice was originally concentrated in villages and thus termed "village poultry" production. However, increasing urbanization and demand for poultry products has resulted in the growth of village type poultry in urban and peri-urban areas. The term "family poultry" was created to describe the full variety of all small-scale poultry production systems found in rural, urban and peri-urban areas of developing countries. It is used to describe poultry production practiced by individual families as a means of obtaining food security, income and gainful employment (Besbes et al 2012). The vast majority of these poultry are chicken, and particularly indigenous or local chicken.

There exists biodiversity that encompasses the genetic variants within and among the local genotypes of chickens distributed around the world. These genetic variants have evolved as the result of domestication, selection and breeding (Khobondo et al 2014). Chicken populations can be categorized into; wild populations, indigenous and local breeds that are unselected but domesticated, selected breeds for morphological traits mostly by fanciers, selected lines for quantitative traits such as industrial layers and broilers, and experimental research lines (Weigend and Romanov 2001). The modern world breeds of chickens can be grouped into four evolutionary lineages, egg-type chickens of Mediterranean origin, game chickens of Asiatic origin, meat-type chickens of Asiatic origin and true Bantams of various descents (Moiseyeva et al 2003).

Local or indigenous chicken, among chicken species, probably show the highest rate of variation of population types. For the local chicken characterized so far in Nigeria, Botswana, Kenya, Malawi, Sudan, Ethiopia etc a great variation is observed in morphological characteristics and production parameters (Kingori et al 2007). With respect to body weight three variants have been distinguished i.e. dwarf, normal and heavy body weights. Plumage pigmentation is varied but mainly tends towards blackish and brownish colors showing extended and pied colourations. Plumage distribution is mainly normal while special forms such as naked neck, frizzle and silkiness appear sporadically. The comb is mostly single but rose, pea, walnut, duplex and crest are also present. The shank and skin are also frequently pigmented showing green, grey and blue variants. In addition, melanin deposition in skin, meat, internal organs and bones are also encountered in some genotypes (FAO 2010). Some of these variants are due to the presence of major morphological marker genes which increases the adaptability of these breeds to tropical climatic environments. For example, the comb type indicates that the bird have been favoured by hot climatic conditions whereby large comb, such as single comb allows for efficient heat regulation (Apuno et al 2011). Scientists have conducted a series of experiments utilizing the indigenous chicken of many countries and several major genes were identified. These genes can be split into three categories; feather reducing genes, genes that reduce body size and genes that control plumage colour (FAO 2010).The genes were associated with ecological areas. The feathered chickens/genotypes are predominant in cold climates, their body is well covered with feathers to help in insulation and protection against losing body heat. The warm and hot climate is dominated by naked necks and frizzle feathers expression caused by incomplete dominant genes Na and F respectively, a feature that allows better heat dissipation. The naked-neck genotype is characterized by featherless skin on the neck, on the breast and on ventral part of the thigh (Khobondo et al 2014).

Recent advances in molecular genetics and genomics has given more insight to these indigenous chickens. Major histocompatibility complex (MHC)-linked markers, LEI 0258 and MCW0371 found 46 alleles (194-550 bp) and 10 alleles (198-207 bp) respectively for Kenyan indigenous chicken (Ngeno et al 2014). This is greater than 42 (Hako-Touko et al 2015; for Cameroon chicken), 24 alleles reported by Lwelamira et al. (2008; for Tanzanian chickens) and 29 alleles by Fulton et al (2006) but smaller than 52 alleles reported on 80 different populations or lines of

Africa, Asia and Europe by Chazara (2013). These allele sizes of 181–552 bp (Fulton et al 2006) and 182–539 bp have been reported and proved to be varied. Molecular characterization of indigenous chicken in Ethiopia, Uganda, Sudan and Kenya using 30 microsatellite markers, found that the sampled indigenous chicken can be grouped into six genetic clades thus minimizing the morphological variants (Mwacharo et al 2007). However, another study by the same author using 30 autosomal microsatellite markers on genomic DNA revealed three major gene pools/groups (Mwacharo et al 2013). That study also revealed population admixture between the three gene pools with east to west genetic cline of gene pool two. Clustering analysis by the Ngeno et al (2014), indicated a clear ecotype subdivision into two to three genetically distinct groups for MHC linked microsatellites and two groups for non MHC markers. This finding confirms that these indigenous chicken (IC) ecotypes host many and highly diverse MHC and non MHC markers showing genetic variability. Cameroon native chicken population were clustered in three distinct groups according to agro-ecological zones (ecotypes) and their genetic make-up for LEI0258 and MCW0371 loci. Their findings concluded that the genetic diversity of the Cameroon native chicken MHC-B is very rich and potential resource for the development of new serological reagent adapted to chicken outbred populations (Hako-Touko et al 2015). The sequencing of the different animal genome made large amounts of genetic markers available in the form of single nucleotide polymorphisms (SNPs). This massive increase in marker numbers as a result of high-throughput genotyping technologies, allowed diversity studies and routine genome-wide association studies (GWAS) to be performed in many animal populations (Meuwissen et al 2001). For instance, Horro and Jarso Ethiopians indigenous chickens were genotyped with a 620K SNP array. A multidimensional scaling analysis showed that the two populations were genetically distinct (Psifidi et al 2014) thus confirming diversity.

Contributions of indigenous chicken to households

Indigenous chicken make substantial contributions to household food security throughout the developing world. Indigenous chicken serve as an investment and source of security for households. They are used as sources of meat and eggs for consumption. They are a source of income (Muchadeyi et al 2007) and thus represents a major contribution towards achieving Millennium Development Goal 1 (halve the number of poor people in the world by 2015). Their demand is ever increasing and marketing is easy thus providing source of income to families (Bett et al 2012). Indigenous chicken are alternative source of animal protein due to the fact that they can be slaughtered and consumed as a single meal hence do not require storage facilities. Indigenous chicken are also a means of investment to the welfare of women and children in traditional, low-input farming systems in the tropics (Dana et al 2010; Okeno et al 2012). Besides rural households, these low-input, low-output poultry-husbandry systems are an integral component of the livelihoods of most of peri-urban, and some urban, households in most parts of the developing world (Magothe et al 2012). A review by Gueye (2000) indicated that an average family flock of five adult chickens (two cocks and three hens) enables women in Central Tanzania to have an additional income equivalent to 10% of the average annual income. In the Niger Delta, family poultry husbandry contributes 35% of the income of household women, which represents about 25% of Nigerian minimum wage and 50% of the per capita income. In Cameroon, they contribute significantly to poverty alleviation and food security of more than 60 per cent of families living in rural areas (HakoTouko et al 2013). Experiences in many other developing countries have shown that village poultry can be used as an effective means of empowering women and as a tool for poverty alleviation (Kitalyi 1998). Besides economic considerations, the chickens are useful in a number of social, cultural and spiritual activities such as entertainments, gifts, funeral rights and spiritual cleansing (Njenga 2005). In some parts of Kenya, cock fighting is an exciting and popular entertainment for rural folk (Maina 2000). Other uses include disposal of kitchen leftovers, manure production and being biological clocks for telling time of the day especially in rural areas (Njenga 2005). Chicken are also used as animal model in biomedical research.

Production systems

Indigenous chicken production systems are dependent on objectives; commercial or subsistence (Kitalyi 1998), husbandry practices and levels of inputs and outputs. Menge et al (2005) identified and categorized indigenous chicken production systems in Kenya into; free range systems, semi-intensive systems and intensive systems (Table 1).

Table 1. Characteristics of different production systems of indigenous chicken.

Variable	Production system		
	Intensive	**Semi intensive**	**Extensive**
Biosecurity	High	Mod-low	Low
Location	Near town/cities	Smaller towns and rural areas	Everywhere. Dominates in remote areas
Birds kept	indoors	Part time indoors/out most of the day	Out most of the day
Housing type	Permanent chicken house	Chicken house	Coops,kitchen, habitat house
Veterinary service	Pays for veterinary service	Pays / depends on government vet service	Depends on veterinary service
Source of veterinary medicine	Market	Market/ Government	Market / Government
Input	High	Medium to low	Low
Feeding regime	Full ration	Supplementation	Free range
Source of technical information	Consultancy, sellers of input	Government extension service	Government extension service
Profitability/year (Ksh)	-4667.07	127.14	647.52
Market output	High	Medium-low	Low
No. of birds	5 to 500	5 to 50	Less than 30

Free range system/Extensive system

Chickens are reared extensively for meat and egg provision for household consumption, occasional source of income and various socio-cultural obligations (Njenga 2005). The system is prevalent in low human population density rural areas and is based entirely on low input-low output management. Flocks are hardly more than 30 adult birds per household, there is minimal care and no supplementation (Nzioka 2000). The birds leave their night shelters in the morning and are left to source any available feed resources around the homestead and take care of themselves. Free-range feed resources utilized include grass, insects, earthworms and various seeds (Birech 2002). During cropping seasons, birds are sometimes confined and supplemented with maize, kitchen leftovers and any other available feed resource. Night shelters include rudimentary coops, kitchens, stores and human habitats. Due to low inputs, production is also low but the cost per unit of egg or meat is nearly negligible (Birech et al 2002).

Semi-intensive system

In this system, chickens are kept in small flocks of between five and 50 birds mainly for consumption and sale. Levels of inputs range from low to medium depending on the commercial value attached to the flock. The birds are left to free range around the homestead or in fenced runs feeding on grass, insects, kitchen wastes, and any other available feed resource (King'ori et al 2010). They are provided with some form of housing ranging from simple shelters to proper chicken houses. Healthcare depends on the commercial value attached to the enterprise. However, water and supplementary feeds are provided. Because input levels are low, production is lower than in intensive system. The system is common in high human population density rural and peri-urban areas.

Intensive system

The size of the flock ranges from 5 to 500 adult birds, depending on the objectives. The birds are fully confined in constructed shelters or runs and provided with commercial or home-made feed rations, may occasionally get greens (kales, cabbage, spinach, young grass and some weeds) (Kingori et al 2010) and get health care. Deep litter and slatted floors are the most common housing systems used. Usually the birds are reared for household consumption, but are mostly for sale. The system is characterized by more eggs production, high growth rates with lower mortalities (Okeno et al 2012). The system is rare in rural due to high costs of inputs and high levels of management required but common in urban and peri-urban areas where households own very limited or no land but are able to provide the required inputs (Menge et al 2005). Table 1 defines the variable used to characterize indigenous chicken production system.

Genetic improvement on immunity, reproductive and production traits of indigenous chicken

Past and current attempts to genetically improve production and reproductive indigenous chickens

In the past, genetic improvement programs for increasing chicken productivity in developing countries was mainly focused on the use of imported temperate breeds (Dana et al 2011). Many exotic breeds of chicken (White and brown Leghorns, Rhode Island Red, New Hampshire, Cornish, Australorp, Light Sussex etc.) were introduced over the years. The other approach to improve productivity of the indigenous chicken production has been use of crossbreeding to exploit heterosis. This approach involved crossing of unselected indigenous chicken to different levels of exotic breed. In Ethiopia, evaluations of crossbred chicken at the DebreZeit Agricultural Research Centre indicated that 62.5% white leghorn crosses showed superior egg production to the locals and pure white leghorns (DZARC 1991; DZARC 2007) under intensive system. In a cross breeding program at Assela, Brannang, Persson (1990) also compared different York x local crosses, and their results indicated that egg production declined with increasing level of exotic inheritance (above 50%). Increasing the level of exotic blood also resulted in loss of broody behaviour, a trait of considerable economic value under village systems. Although the cross breeding programs produced successful results under experiment stations almost all of them were discontinued decades ago for various reasons (Dana 2011).

In the 1970s and 1980s the Ministry of Agriculture in Kenya and Ethiopia initiated a cockerel distribution and exchange scheme. This involved importation and distribution of cockerels to be used as breeding males in villages. In Ethiopia, the scheme failed because of lack appropriate design of crossbreeding scheme, it is logical to crossbreed after pureline selection of indigenous chicken which was not a case in this scheme. Secondly, farmers were unwilling to remove their local cocks and the exotic cocks failed to adapt in the village environments (Dana et al 2011).

In Kenya, the genetic improvement was started through a cross breeding scheme by the National Poultry Development Program (NPDP).Unlike Ethiopia, the program utilized crossing between cockerels and pullets of exotic breeds with the local indigenous chicken. The program witnessed improved performance in the crossbreds but declined with subsequent generations (Okeno et al 2012). Failure of the program to meet stakeholders' expectation led to its termination in 1993. The factors attributed to its failure included poor planning and understanding of the indigenous chicken subsector with respect to production environment, needs of actors in the indigenous chicken value chain, lack of clear breeding objectives and lack of sustainable breeding program to supply constant pureline breeding stock (Magothe et al 2012).

In Malawi, crossbreeding has been adopted to improve indigenous chickens, where Black Australorp (BA) was introduced since 1960 (Safalah 2001). The Government supported and implemented three hatcheries, one in each region (Mzimba, Lilongwe and Karonga), to facilitate hatching and distribution of six weeks old BA to households in villages. The theory of crossing was viable, to improve meat and egg from BA and adaptation to scavenging from indigenous chicken through combined effects in a crossbred. However, no tangible results and impact has been noted. Notable problem has been lack of capacity to implement systematic mating at village level. Several crossings take place beyond first generation, leading to mating among related birds and subsequent inbreeding, hence reversing effects of crossing.

The realization of indigenous chicken potential has prompted current genetic improvement programs. A viable option is to develop a protocol that will ensure improved meat and egg performance (Okeno et al 2013), sustained adaptation on slightly modified scavenging environments and ensuring conservation of indigenous chicken ecotypes. For instance, since 2006 another collaborative programme called the smallholder indigenous chicken improvement programme (INCIP) was initiated in Kenya and Malawi. To get founding population, indigenous chicken eggs and live chicken were collected from various Agro-ecological regions or ecotypes namely; Kakamega, Bondo, Narok, West Pokot, Bomet, Taita-Taveta, Lamu, Egerton and Mwingi in Kenya. In Malawi, eggs and live birds were sourced from Mzimba and Lilongwe Districts, Northern and Central Regions of Malawi respectively. These ecotypes are currently on station at Egerton University poultry research and breeding facility and University of Lilongwe in Kenya and Malawi respectively for multiplication, performance recording and selection. This is the first attempt to improve indigenous chicken in both countries. Studies on characterization of kenyan indigenous chicken had been done in Kenya (Okeno et al 2013; Ngeno et al 2014) and establishment of their potential is ongoing. It is upon the performance records that selection and mating are based. In line with the project objectives several studies have been conducted and findings disseminated. Ngeno (2011) reported variations on body weights among the ecotypes, and estimated heritabilities and genetic correlations for growth at various stages. Magothe et al (2010) found that genotypes (the naked-neck, frizzle and crested-head) do influence body weights and growth patterns. The authors noted that the crested-head genotype had a slower growth rate and were lighter compared to the normal-feather genotype when subjected to the same level of management.

In determining forward/directional selection, a study by Okeno et al (2011) determined the selection criteria by farmers and traits of economic importance along the indigenous chicken value chain. They reported selection based on growth rate, large body size, high egg production, hatchability and good mothering ability. In this study the author's reported normal feathered, crest-head, necked–neck and giant genotypes as the most predominant genotypes. To define breeding objectives among farmers, marketers and consumers, the study identified egg number, growth rate, body size, fertility, disease resistance, meat quality, egg size, egg shell color, broodiness and mothering ability to be traits of economic importance that should be included in future breeding program (Okeno et al 2011). Okeno (2013) evaluated the breeding objectives for purebred and crossbred selection schemes for adoption in indigenous chicken breeding programmes and reported a possibility for improving indigenous chicken dual purpose breeds or specialized lines for eggs and meat production. Broiler line and dual purpose breeding schemes are first and second most profitably respectively (Okeno 2013).

Realization of these findings, requires establishment of a breeding protocol which should entails; choice of breeding goal, choice of selection criteria, design of the breeding scheme, recording of the birds, genetic evaluation of the chicken, selection and breeding, progress monitoring, genetic response and dissemination of genetic improvement. This therefore calls for development of pure phenotypes through elaborate data recording, mating of same phenotypes and selecting off-shoots out. Development of crosses can be achieved through mating of different phenotypes within and between pureline types and existing exotic strains of Broiler and Layer strains. Characterizing the crossbred growth, egg and adaptation traits for heterosis estimation should follow. Alternatively, indigenous chicken composite can be developed through crossing and selection practices. Upon genetic improvement, the improved indigenous chicken will be distributed to farmers through eggs, day old chicks, chicks after brooding age.

Genetic improvement on resistance to infection and diseases

Amongst traits of economic importance for IC in developing countries, genetic resistance to infection was ranked of preference (Okeno et al 2012). Genetic resistance can be either resistance to infection, which will prevent the pathogen from becoming established in the animal, or resistance to disease, which prevents or reduces the development of pathological symptoms in animals infected with the pathogen. Genetic resistance is generally assumed to be considerable varied among breeds with respect to their ability to withstand and survive pathogenic infections (Sørensen 2010). The best scenario is manifested upon outbreaks of Newcastle disease (NCD) in the tropics where most birds die but some resist the disease and survive. In large-scale commercial poultry production it is common to vaccinate against pathogens that may harm the birds. Smallholder farmers regularly face financial constraints that make vaccination difficult to implement (Sørensen 2010). It is very important that birds kept under free range systems have sufficient heritable robustness to withstand the high levels of disease challenge to which they are exposed.

Reports on the performance of indigenous chickens in developing countries suggest that they are more disease resistant than exotic birds, abeit with reservations. This is because most of the reports are based on questionnaire type of study that are rarely experimental and may not show true picture of immunity. For example, Hassan et al (2004) reported that the Mandarah ecotype in Egypt can withstand infectious bursal disease virus. Mdegela et al (2000) found that the Kuchi ecotype were resilient to fowl typhoid. Adene (1989) reported the Fayoumi breed were less vulnerable to avian leucosis complex. Kaingu et al 2011 reported high prevalence of parasites despite satisfactory perfomance. Rahman et al (1997) reported a field study in Bangladesh in which the mortality rate excluding predation varied from 16 percent to 35 per cent among different strains/breeds over a laying period of 9.5 months. Moreover, the frizzling and naked neck genes were considered for disease tolerance besides increased feed efficiency, growth rate and egg production (Ajayi 2010; Egahi, Dim and Momoh 2013). Mahrous et al (2008) reported higher total antibody titre from naked neck and frizzled feathers compared to their normal-feather counterparts. Hamal et al (2006) demonstrated more efficient phagocytic ability of naked-neck and frizzled birds than normal feathered genotype.

Allele 205 has been positively associated with higher primary antibody responses against Newcastle disease (NCD). Allele 307 was negatively correlated with elevated primary antibody responses against NCD but positively correlated with bodyweight (Lwelamira et al 2008). A total of 45 LEI0258 marker alleles have been reported in Kenyan indigenous chicken, with allele 194 and 349 found to be predominant. These alleles host the MHC haplotype B11, which is known to confer resistance to Marek's disease virus (Wakenell et al 1996). There are advances in use of SNPs for genome wide disease association studies, for example Horro and Jarso Ethiopian indigenous chickens were genotyped with a 620K SNP array. In Horro chickens, genome-wide scans revealed nine SNP with chromosome-wide significant association with Salmonella resistance and seven SNP with genome wide significant association with IBDV resistance. In Jarso chickens, these scans revealed one SNP with genome-wide and two SNP with chromosome-wide significant association with Salmonella resistance, and one SNP with genome wide and three SNP with chromosome-wide significant association with IBDV resistance. All significant SNP for each region for either disease were located on different chromosomes (Psifidi et al 2014).

Utilization of indigenous chicken genetic resources

The economic strength of indigenous chicken lies in their low input low output production that best suits rural poor farmers. The prevailing circumstances has necessitated development of indigenous chicken in Egypt (Kosba et al 2006), Iran (Kamali et al 2007) and high yielding exotic hybrids (Siegel et al 2006). Current development involves selection for egg and meat purelines for convectional breeding scheme. The study of effects of peculiar genes on economic traits indicated that some of these are related to tropical adaptability. A list of such genes with direct and indirect effects has been presented by Horst (1988). He indicated that the native genotypes are ‘gold mines’ of genomes and major genes for improvement of high yielding exotic germplasm for tropical adaptability and disease resistance. Genotypes possessing the naked-neck and frizzle genes, either singly or in combination are associated with increased growth rates, superior body weights, better feed conversion, higher egg production and disease tolerance in tropical environments (Islam and Nishibori 2009; Magothe et al 2010). These genotypes and Kuchi genotype, found in the coastal region of Kenya and Tanzania (Msoffe et al 2002) would be ideal for meat production in warm and humid areas. The Kuchi genotype has game chicken characteristics and would thus be better able to evade or fight off predators (Magothe et al 2012). The dwarf genotype has better feed efficiency and mass egg production. They have a lower feed intake due to reduced body size and produce more eggs and could thus be utilized for cross-breeding purposes thus employing mating as a breeding tool.

In practice, introgression of Naked neck and Frizzling genes in the high producing layer and broiler populations for improvement of tropical adaptability have been done at the Central Avian Research Institute, Izatnagar, India. BL-β II gene for disease resistance from Aseel breed on Indian chicken has been cloned as well (Singh and Singh 2004). Cahaner and co-workers have utilized the Naked neck gene for improvement of tropical adaptability of broiler in Israel. In Eqypt, the Fayoumi breed has been selected and shows resistance to Marek's disease (Tixier-Boichard et al 1998) and coccidiosis (Pinard-van der Laan et al 1998). This breed was realized after 20 years of selection and has shown better resistance to disease when vaccinated and fed anti-coccidial additives (Tixier-Boichard et al 2009). In addition to these examples, where local genetic resources are utilized for breed development of commercial breeds, they are also needed for conservation.

Feeding regime development on indigenous chicken

Feeding of Indigenous chickens

The predominant production system for indigenous chicken is extensive or free range characterized by scavenging for feed the whole day and confinement at night. Indigenous chickens are excellent foragers (Barua and Yoshimura 1997). Scavenged feed comprises of insects, food waste, green grass, leafy vegetables, grains (Kingori 2004; Nyaga 2007). The scavenged feed material can be defined as all the materials that are always or seasonally available in the environment and which the scavenging birds can use as feed (Sonaiya et al 2002) and also kitchen wastes. Analysis of scavenged feed has been determined. The percentage mean crude protein (CP) level in scavenged diets is 11.2 (Birech 2002). The nutrient intake of indigenous chicken under free-range system is enough to meet maintenance requirement and support minimum growth rate and egg production (Kingori 20014). There exists a natural balance between the free-range fee resource base and the biomass of a chicken flock in any given environment (Roberts 1997). A definite biomass of a chicken flock can be supported by the free-range feed resource base, beyond which weaker birds in the flock begin to die. In Togo and Burkina Faso, techniques for production of termites and maggots have been developed to increase the free-range feed resource base and chicken biomass produced (Kitalyi 1999). Free-range feed resource base alone is not adequate for scavenging chickens (Mwalusanya 1998). For instance, deficits in protein and energy intakes in free-ranging chicken in Kenya were reported by Birech (2002).

Chicken have a genetically predetermined requirement for nutrients and hence will eat to meet these requirements for first limiting nutrients (Emmans 1987). Chicken like other animals regulate feed intake on voluntary basis when allowed ad libitum access to feed. The diet scavenged has a wide variation in its ingredient and nutrient levels, therefore, these chicken may rightly be perceived as compounding their own diet from free-range feed resource (Birech 2002) and in most cases they do not meet their requirement for limiting nutrients except for crude fibre. Kingori (2007) indicates that the dry matter (DM) content of the feed material is low during the rainy season restricting dry matter intake and productivity of hens. Metabolizable energy of indigenous chicken from scavenged feed is sufficient to meet requirements for only low levels of egg production necessitating the need to add energy in rations of indigenous chicken. Protein supply may be particularly limiting resulting in the generally observed poor growth (Mwalusanya et al

2002). Protein supply may be critical especially, during drier months, whereas energy is critical at all times and particularly during rainy season. Formulation of nutrient supplementation for scavenging chickens may even be more critical during certain seasons of the year, where feed to be scavenged is limited. In most cases, concentration of crude protein and Calcium are below recommended requirements for egg production, and the intake from scavenging are even more unbalanced if energy to protein and calcium to phosphorous ratio are taken into account (Kingori 2007).

Nutrient Requirements

The various categories of chickens require a balanced diet for optimum performance. The diets should be comprised of energy, protein, minerals and vitamins in the right proportions and offered in adequate quantities. Water should be offered ad libitum. Studies on the energy and protein intakes by indigenous chicken under different production systems are presented in Table 2. The energy and protein intakes/requirements for chicks from hatching to 5 weeks of age have not been determined. The Mineral and vitamin requirements for the indigenous chicken have also not been determined at all ages.

Table 2. Energy and protein intakes/requirements of Indigenous Chicken

Age (wks)	Nutrient Intake		Reference	Production system
5-8	17.79	365.02	Chemjor (1998)Kingori *et al* (2003)	Intensive
8-14	14.36	540.09		
14-21	13.85	832.21		Intensive
14-21	10.9	971		
14-21	8.5	910	Kingori *et al* 2007)	Scavenging only
Laying Hens (46-54 wks)	9.70	1100	Kingori *et al* 2010)	Intensive
Laying Hens (42-50 wks)	14.77	1185	Kingori *et al* 2014)	
Growers and Mature Chickens	8.5	910	Birech (2002)	Scavenging only
13-25	11.7	949.04	Kingori *et al* (2007)	Scavenging + Protein supplementation

Under extensive and semi intensive production system, the effect of supplementation has been determined. Growth rate doubled when protein supplementation was offered to growers to cover the deficit between the requirement and intake from scavenging (Birech 2002, Kingori et al 2003, 2007). Egg production tripled when the energy and protein deficit from scavenging was supplemented (MoALD&M 2000; Olwade et al 2009; Kingori et al 2010, 2014).

Nutrient requirements and performance of indigenous chickens

Chinrasri (2009) defined nutrient requirement as the amount of nutrients needed by animals to maintain their activities, maximize growth and feed utilization efficiency, improve laying capacity and hatchability and optimize fat accumulation. Nutrients like carbohydrates, lipids and protein that the chicken utilizes as sources of energy or as parts of its metabolic machinery are essential requirements for growth. Growth involves deposition of bones, muscle and fat, each exhibiting an individual pattern of development (Carlson, 1973). The most rapid growth or weight gain is made when the chick is young (Mignon-Grasteaus et al 2001). As the chick grows older, the weekly increments of weight become materially less although nutrient requirement increases (Mignon-Grasteaus et al 2001).

The actual shape of the growth curve can be affected by numerous factors such as nutrition, environment, health, sex and genotype. Amongst all these factors, nutrition plays a significant role. As suggested by Larry (1989) proper nutrition is a key factor in determining performance and productivity of chickens. There is need therefore to formulate rations that will fulfill all the nutrient requirements, including energy and protein for growth.

Under extensive production system, the Dry Matter Intake (DMI) and Crude Protein Intake (CPI) by scavenging chicken to meet growth can be estimated using the following equations (Birech 2002):

· DMI (g/d) = 22.4 + 2.25 x crop content

· MEI (Mj/d) =0.15 + 0.03 x crop content

Therefore for optimum production, energy and protein supplementation has to be provided since they are limiting under this system. Energy requirements in chicken are expressed in terms of metabolizable energy (ME) per day (Birech,2002) as shown in the formula. Chicken usually consume just enough food to meet their energy requirements since the control of feed intake is believed to be based primarily on the amount of energy in the diet (Nahashon et al 2006). Increasing the dietary energy concentration leads to a decrease in feed intake and vice versa (Veldkamp et al 2005), thus affecting growth.

The dietary requirements for protein are actually requirements for the amino acids contained in the protein. Amino acids obtained from dietary protein are used by the chicken to fulfill a diversity of functions such as growth, meat or egg production. Protein is a key nutrient and its deficiency in a feed reduces growth. Harper and Rogers (1965) reported that protein deficiency in a feed reduced growth in broiler chickens as a consequence of depressed appetite and, thus, intake of nutrients. Feeding animals below their energy or protein requirements thus reduces growth and efficiency of nutrient utilization.

Age is an important factor that contributes to a bird's response to nutrient composition of a diet. In fact, muscular protein deposition decreases as the bird advances to maturity (Samadi and Liebert 2006) but indigenous chicken are known to be slow growing with a low carcass weight (Missohou et al 2002, FAO 2004). Protein efficiency is better at the lower level of dietary protein on indigenous Chicken (18% CP (Magala et al. 2012). At 18% CP level, increasing dietary energy from 2800 to 3000 kcal/kg ME resulted into a 42g decrease in weight gain. Conversely, at 2800 kcal/kg ME an increase in dietary protein from 18% to 20% CP resulted into a 74g decrease in weight gain. At 3000 kcal/kg ME, there was only a slight increase in weight gain as a result of increasing dietary protein, indicating the importance of balancing the energy to protein ratio when formulating indigenous chicken diets.

Protein requirement

If dietary protein is inadequate, there is a reduction or cessation of growth or productivity and a withdrawal of protein from less vital body tissues to maintain the functions of more vital tissues

(NRC, 1994). As such, protein requirements vary considerably according to the physiological state of the indigenous chicken, that is, the rate of growth or egg production. Other factors contributing to variations in protein requirements of the chickens include age, body size, sex and breed. Matching the feed protein levels with animal protein requirements is crucial for maximizing animal performance.

Chemjor (1998) reported that a dietary protein level of 13 % was adequate for indigenous chickens aged between 14 and 21 weeks. King'ori et al. (2003) observed that indigenous chickens require a protein level of 16 % to optimize feed intake and growth between 14 and 21 weeks of age. Furthermore, Ndegwa et al. (2001) reported that indigenous chickens fed diets containing 17 to 23 % CP had similar growth rates and feed intakes, suggesting that a 17 % CP diet was sufficient for these chickens. This noticed increase in protein requirement could be due to difference in production system and production improvement with time.

King'ori et al. (2003) compared the effect of varying crude protein levels of 100, 120, 140, 160 and 180 g/kg DM on the feed intake, feed conversion ratio and live weight of growing indigenous chickens raised intensively between 14 and 21 weeks of age. Results from this study indicate that feed intake per bird increased with increasing dietary protein levels. Similarly, live weight gain increased with increasing protein levels while feed conversion ratio decreased with increasing dietary protein levels. However, feed intakes, feed conversion ratio and live weight gain for birds offered diets containing 160 and 180g CP/kg DM did not differ significantly.

Feeding regime development

Development of the feeding regime is guided by age of the chickens, physiological status whether growing, laying, incubating/broody or active cocks. The system of production that influence the nutrient intakes and level of activity. The climatic factors which include environmental temperature, humidity, rainfall, season whether wet or dry also affect feed formulation. Feed composition and availability depends on season, locality (geographical and scavenging area) and production system. Different locally available feedstuff provide nutrients required by the birds, and maximum and minimum limits have been determined (Kingori et al 2014).

Proteins should comprise up to 20% of the diet and it is always adviced to have a ratio of 1:1 of animal to plant protein sources for optimum amino acid profile (Mustafa et al 2012). Protein is the most expensive of all the ingredients in poultry diets. Protein rich feedstuffs include blood meal, fish meal, meat and bone meal, oil seed meals (cotton seed meal, soya bean meal, sunflower meal, ground nut meal), maize germ, corn gluten meal, prosopis pods (*Prosopis julliflora*), beans, peas, insects and earth worms. There exists great potential in utilizing insects as feed for the free-range poultry production systems (Maciorowski et al 2007). Insects are alternative protein sources that meet dietary requirements and reduce feed costs. They have high protein, fats, minerals and vitamins (Bukkens 2005). Insects can be reared and fed on a variety of organic waste materials that are available in adequate amounts in different regions. Advances in provision of alternative protein sources are on going, maggots and termites can now be raised in bulk and supplimented to free range production system of chickens. Energy may constitutes more than 75% of the diet. Energy rich feedstuffs are maize, millet, sorghum, bran (maize and wheat), pollard, roots and tubers. Minerals and Vitamins may make up to 5% of diet. Vitamin rich feedstuffs are greens-young grass, weeds, vegetables (kale, spinach, and cabbage), fresh cow dung and vitamin supplements while Mineral rich feedstuffs include bone meal, egg shells and mineral supplements (Kingori et al 2014).

From the information on the nutrient requirements for each category of chickens in the different systems of production, and the available feed resources, diets can be formulated. However, expert knowledge is required to formulate. Knowledge on the nutritive value of the locally available feed ingredients (Table 3) is a must for good diet formulation. Where commercial poultry diets are available, quantities to be offered can be computed to meet the requirements for the chicken categories being kept. The research finding on improved indigenous chicken should be incorporated in nutrition Tests to establish nutrient requirements of developed breeds and thus develop different rations and regimes for indigenous chicken and their crosses.

Table 3 . Energy and protein content of locally available feedstuffs

Feed ingredient	Energy (ME-Mj/kg)	Protein (DCP-g/kg)	Reference
Sorghum grain	15	97	McDonald et al (1989)
Wheat	13.7	99	
Maize	15.0	76	
Potato	13.3	69	
Cassava meal	14.9	19	
Sunflower meal	9.6	270	
Corn gluten meal	10.9	249	
Cottonseed meal	12.1	311	
Soya bean meal	12.3	490	
Groundnut meal	14.5	447	
Bean meal	12	244	
Pea meal	12.7	237	
Coconut meal	7.78	123	
Fish meal	12.6	500	
Blood meal (ring dried)	15.0	829	
Blood meal (Fermented dried)		632	Kingori (1996)
Blood meal (Boiled dried)		866	Kingori (1996)
Prosopis pods (mature)	15.3	162	Choge *et al* (2007)

Conservation strategies for indigenous chicken

Documentation of existing genetic resources is a very crucial component of breed conservation. It should include the description of the population sizes and phenotypic characteristics of breeds, their economic performance, any special traits they may have, and their cultural/historical importance. Decisions on selecting breeds for conservation entail several criteria to use including the adaptation to a specific environment, possession of traits of current or future economic importance or scientific interest, and the cultural or historical value of the breed and degree of endangerment (Ruane 1999). The degree of endangerment is probably the most important factor in conservation decisions.

There is existence and witnessing of a fast decline in the population of many native breeds and varieties of chicken, some of which are in danger of extinction. Thus calling for decision to conserve. The seen decrease in indigenous chicken population, is so despite their favour by local people, especially in the tribal and rural sectors, mainly due to its' believed special capabilities such as adaptability to unfavourable environments (Dana et al 2011) and better immunocompetence (Lwelamira et al 2008). Late sexual maturity, poor egg production, slow growth rate, broodiness, smaller egg, small body size and lack of elaborate conservation efforts are some of the reason for decline in number. To mitigate some of these shortfalls, breeders have taken recourse to intense selection (Khobondo et al 2014) and introduction of high yielding exotic germplasm (Besbes et al 2007) thus diluting or replacing indigenous chicken. According to Weigend and Romanov, (2002), nearly half of the 938 avian breeds of the five species (chicken, duck, goose, turkey and muscovy duck) have been classified as being at risk of loss. Two major players have fueled this extinction, industrial companies do not publicize the size and nature of their operation and resources, and fancy breeders do not always apply a universal system for individual identification to keep private registers (Tixier-Boichard et al 2009). Secondly, there are non inclusive board room management decisions at the academic, industrial and local levels. These expose most genetic stocks to be at risk of being lost. There is a need to conserve the genetic variation of existing populations in order for them to be able to evolve in response to future environmental changes and to maintain population fitness against inbreeding depression (Reed and Frankham 2003). The danger of extinction started happening before characterization of most of these indigenous chicken. Neither were monitoring tools were in place. Thanks to current deliberate effort to characterize these genetic resources.

There are different genetic principles that can be used in long-term conservation and management of genetic resources, heterozygosity of the population being the most important one. By integrating population genetics and molecular genetics, conservation genetics can assess variation within and among populations. It is important to maintain allelic diversity across the species (Notter 1999). A combination of information based on phenotypic data, historical record and molecular genetic variation should be used in decision-making (Delany 2003). Conservation approaches should be applied to all individuals, breed organizations, local communities and industrial hatcheries. Conservation has four main steps including inventory, evaluation, choice and preservation. Studies using microsatellite markers were used to assess the diversity in Ethiopian, Kenya, Uganda, South Africa, Sudan chickens, the results indicating that most (97%) of the genetic variation in the populations was ascribed to the within breed/population diversity which has been shaped by subtle combinations of human and natural selection (Mwacharo et al 2013). Molecular genetics has given more insight to these genotypes and reduced the polymorphs into three major genetic pools (Ngeno et al 2014). Single nucleotide polymorphism is a new molecular marker system which offers opportunities to assess the genetic diversity in farm animal species. They could be the marker of choice for diversity studies in the future because they can be used in assessing either neutral or functional variation (FAO 2007). SNPs are currently being employed to study genetic diversity in Kenyan local chickens. Characterization by any means is important in understanding the genetic resources at disposal.

Several method of conservation are available, the ideal method of conservation could be in situ or on-farm conservation by the farmers. However, this cannot be sustained unless it brings adequate economic benefits to the livelihoods of the farming communities. In Kenya for example, InCIP propose to train farmers to optimally utilize the indigenous chicken that match with their environment and production system. For instance, in hot and humid ecological zones/regions, InCIP advocate for rearing of adaptive genotypes (naked neck and frizzled feathers) that best suits the environment. These genes are known to reduce feather coverage and affect their structure to help heat loss by convection. Naked neck and frizzle feather genotypes have increased growth rates, body weights, feed conversion, egg production and disease tolerance in tropical temperatures above 25°C (Mahrous et al 2008). In cold and around mountains, the bearded and feathered-shank types are adapted (Bartels 2003) and have been shown to have increased body weight and egg mass

(Fayeye et al 2006) for better egg and meat productivity in very cold environments. Where management is enhanced, with high input availability, high producing meat and egg pure lines is encouraged. This may be complimented with cross-breeding with exotic breeds. Hiemstra et al. (2006) summarized the needs for integrating different approaches to support conservation of animal genetic resources. Given the constant evolution of agricultural production and marketing, in situ or on-farm management of genetic resources should include the genetic improvement of the animal genetic resource so as to ensure its competitiveness as a future livelihood option. It is prudent to give serious consideration to other options of conservation (ex situ in vivo or in vitro) as complementary approaches, this is due to risks and uncertainties in in situ conservation. For example, Cryoconservation of avian sperms, ova and embryo has been successful in France (Blesbois 2007; Blesbois et al 2008) and could be applied to local chicken as well. Cryoconservation could be explored to bring back randomness. Since, the ultimate goal is to develop a genetic improvement scheme using a locally adapted population of chickens. This will increase competitiveness of local breeds in the rural settings and at the same time will serve as an ex situ in vivo conservation scheme complementing other conservation strategies. It is noted that conservation is a nonprofit venture, therefore institutions and government agencies should be in forefront in its implemention.

Conclusion

- Indigenous chicken are highly varied and diversied. This variation have been exploited for gene introgression through backcrossing and transgenesis technique with exotic breeds. Matching the different genotypes to appropriate environment is a sustainable way of conservation and better utilization of feed resources available in those ecotypes under different production system.

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