THE POTENTIAL OF CROSSBREEDING INDIGENOUS CHICKENS TO IMPROVE RURAL FOOD SECURITY AND NUTRITION IN SOUTHERN AFRICA – A REVIEW

Feyisayo Adeola Odunitan-Wayas, Unathi Kolanisi, Michael Chimonyo and Muthulisi Siwela
University of KwaZulu-Natal
feyily1@gmail.com; kolanisi@gmail.com; chimonyo@ukzn.ac.za; siwelam@ukzn.ac.za

ABSTRACT
The need to increase poultry production in southern Africa to meet the increasing protein requirement of the growing population is becoming a great concern. The quality of poultry meat and eggs produced in terms of taste, texture, flavour and leanness are of importance to consumers. Crossbreeding indigenous with exotic strains of chickens is one of the main factors that can improve food and nutrition security in southern Africa. In this article, ways in which the quality and quantity of poultry meat and eggs can be improved for sustainable food and nutrition security in southern Africa, with emphasis on crossbreeding as a prospective food security (protein) stability technique are discussed. This article is based on critical analysis of the literature and discusses and evaluates various crossbreeding methods of chickens that have been carried out in African countries. Comparative studies on the implementation, failures and successes of crossbreeding of chickens in African countries, such as Egypt, Botswana, Malawi and South Africa among others are reviewed. Crossbreeding, combined with selection, information dissemination, improved management and technology, is recommended for the geometric increase in poultry meat and egg production in southern Africa to improve food and nutrition security.

Keywords: Crossbreeding, southern Africa, food security, malnutrition, poultry production.

INTRODUCTION
Despite the setting of the Millennium Development Goal to halve hunger by 2015, more than 25% of the population in southern Africa are still undernourished [Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP), 2013]. Rapid population increase, poverty, inaccessibility to a balanced diet and hunger, civil unrest, nutritional ignorance and disease have caused southern Africa to be greatly affected by malnutrition (Bain et al., 2014). Protein-energy malnutrition (PEM) is one of the leading health concerns in southern Africa. PEM causes underweight, wasting, lowered resistance to infection, stunted growth and impaired cognitive development (Batool et al., 2015).

Chicken products have been targeted as part of the solutions to curbing PEM in southern Africa (Sharma, 2007). This is due to the large number of chickens in Africa, their relative affordability, availability and high protein composition (Farrell, 2013). However, there is a threat that the production of chicken might be insufficient to meet the protein requirements and that the availability of land for
increased production might be a challenge due to increasing human populations (Phillipson et al., 2011). Broilers, which have high productivity under optimum conditions, might meet the production requirement. They are, however, not tolerant to hot and humid weather, easily susceptible to diseases and require an intensive management system (Islam and Nishibori, 2009). Broilers thrive better under controlled environmental conditions. Over 80% of the chickens distributed across rural communities of tropical countries of Africa are indigenous (FAO, 2006). Indigenous chickens are characterised by slow growth rates, attaining 2.0kg for cocks in 25 weeks (King’ori, 2004), late sexual maturity (6-10 months) and low feed efficiency. They produce fewer eggs (average of 60 eggs annually) when compared to exotic chickens (Moges et al., 2010). Improved laying birds can produce between 200 and 250 eggs per year (Damme, 2011). Indigenous chickens are adapted to their environment, resistant to most local diseases, tolerant to climatic changes and are relatively inexpensive to manage. They are also preferred to exotic chicken breeds by consumers, because of their tough meat, meat and egg flavour and the colour of the chicken skin and egg yolk (Kyarisima et al., 2011).

It is worthwhile considering crossbreeding as a means of improving the productivity of the indigenous chickens, which would contribute to increased availability and affordability, especially by communities vulnerable to food insecurity. The main goals of crossbreeding is to develop a hybrid or cross or synthetic breed that is adapted to its environment, resistant to diseases, produces relatively higher yields of meat and eggs than local chicken breeds and meets consumers' satisfaction (Mohammed et al., 2005; Kgwatalala and Segokgo, 2013). These crossbreeds may however require that they are reared under improved management systems such as the semi-intensive and intensive system over the free range system.

EXTENT OF PROTEIN-ENERGY MALNUTRITION IN SOUTHERN AFRICA

Protein-energy malnutrition (PEM) is a serious problem in southern Africa (FAO, IFAD and WFP, 2013). Malnutrition occurs due to inadequate nutrient intake or failure of the body to utilize those nutrients (Batool et al., 2015). A large percentage of people affected by PEM are found mostly in the rural areas. Their major diets are carbohydrates, supplemented occasionally with protein and vegetables (Labadarios et al., 2000). This contributes to the high rate of malnutrition in the region. As a result, various strategies such as food subsidisation, food aid and food supplementation programmes that entails distributing high energy and protein foods, such as maize meal, milk powder and breast milk substitutes for children below six years, pregnant and lactating women have been implemented to curb PEM (Iversen et al., 2012). These strategies have faced many challenges attributed to mismanagement and lack of funding, inadequate nutrition education, insufficient monitoring and inadequate staff training (Hendricks et al., 2003; Iversen et al., 2012). Southern African countries still have high rates of PEM, despite all these intervention programmes. In Swaziland and Lesotho, for example, the percentage of undernourished people increased from 23.68% between
2009/2011 to 26.1% between 2012/2014 and increased from 11.3% between 2009/2011 to 11.6% between 2012/2014, respectively. Botswana, Namibia, Swaziland, Mozambique, Tanzania, Zambia and Zimbabwe have over 25% of its population undernourished between the years 2012/2014 (FAO, IFAD and WFP, 2014). Reduction of underweight children, stunting and wasting, which are some of the effects of PEM have been slowly progressing, as a number of children under the age of five show this symptom. In children, PEM is defined by measurements that fall below two standard deviations under the normal weight for age (underweight), height for age (stunting) and weight for height (wasting). Wasting shows recent weight loss, while stunting usually results from chronic weight loss (Pinstrup-Andersen, 1993). Southern Africa between the years 2005/2011 had an average of 13.7%, 37.2% and 5.3% of children under age five underweight, stunted and wasted respectively.

For PEM to be effectively reduced, the consumption of food that has high protein and other essential nutrients that is readily affordable and accepted in southern Africa should increase. Chicken products meet all these requirements. They are high in protein and contain most of the other essential macro and micronutrients (Farrell, 2013).

USE OF CHICKEN PRODUCTS TO IMPROVE FOOD NUTRITION AND SECURITY IN SOUTHERN AFRICA

Animal protein accounts for only about 25% of the average supply of protein in southern Africa (FAOSTAT, 2014). South Africa consumes the highest amount of animal protein and is the only country with lower than 5% undernourished population (FAO, IFAD and WFP, 2014). Chicken products are the cheapest animal protein to purchase. It is also the most consumed animal protein food with little or no taboo attached to it (Farrell, 2013). Chicken meat (white meat) as a source of protein is healthier than red meat, has less unhealthy saturated fats that can contribute to heart disease and more healthy fats such as polyunsaturated fatty acids (PUFA). The nutritional quality of chicken meat and eggs can also be improved easily, through the nutritional composition of the diets fed to the chickens (Farrell, 2013).

Developing countries that consume low quantities of animal source food are usually affected by various deficiencies. Animal protein is more bio-available than plant protein (Van Wincke et al., 2011). Indigenous chickens (ICs) are the major source of protein and livelihood to the average rural household in southern Africa. They are characterised by being slow growers and producers (Besbes, 2009). Indigenous chickens are, however, adapted to the harsh environment prevalent in southern Africa, tolerant to climatic changes and resistant to diseases. They scavenge for food and are relatively inexpensive to manage. Chicken meat and eggs have been identified as a tool to reducing the number of malnourished children below five years old in rural Africa because of its nutrients (Rosegrant and Cline, 2003). The main types of production systems practised in the rural areas of Africa are the extensive production system and the semi-intensive system. The extensive production system requires little or no input in terms of
feed, housing and medication while the semi-intensive production system requires higher level of input than the extensive system such as housing, supplementary balanced feeds, and disease control especially Newcastle Virus Disease (NCD). These inputs are however not as high as required for intensive production systems commonly used for rearing exotic chickens. Exotic chickens cannot perform optimally in the rural environments under these management systems. They also have low tolerance to the African weather, which results in reduced performance in terms of growth and egg production and a high mortality (Besbes, 2009). Exotic chickens need a high degree of care, and have to be managed and housed under favourable conditions, while being fed rations that are costly for the rural household (Gowe and Fairfull, 2008).

Encouraging and improving household rearing of indigenous chickens through management and genetic improvement can contribute to solving the challenge of affordability and low animal protein consumption and PEM in rural communities. Means to get the best attributes of the indigenous chicken and exotic chicken together in a breed is important. The desire is to develop crossbred chickens that have good adaptability to the environment, resistance to disease, improved growth rate and lower maturity rate and have similar meat toughness and egg flavour as the indigenous chicken.

**CHICKEN PRODUCTIVITY AND CROSSBREEDING**

Crossbreeding can be used for producing crossbred animals, upgrading indigenous chickens or creating a new (synthetic) breed that combines desirable traits from two or more breeds (Galukande et al., 2013). Crossbreeding helps to maximise the effect of heterosis, complementarity and breed diversity. Complementarity is the ability to combine traits from two or more breeds into one hybrid. This is called breed complementarity. Complementarity uses the attractive traits of one breed to mask unattractive traits of the other breed that are involved in crossbreeding. This compliments the good traits in the breeds and conceals the unbecoming traits (Williams et al., 2002). Heterosis is the improved performance of crossbred chickens compared to the average of their purebred parents (Muller, 2014). The heterosis derived from crossbreeding is an added advantage to the genetic gain by pure breeding (Sørensen, 2007). Breed diversity is the genetic variations in different breeds of the same species. Crossbreeding can be achieved with little or no additional cost to the farmer depending on the type of crossbreeding to be done. Care must be taken with the proper selection of breeds for crossbreeding. Chickens with improved productivity suited and adapted to particular environments, feed resources, markets and consumer preferences can be developed through crossbreeding.

Genetic improvement of chickens, which will lead to higher productivity, can be achieved significantly by selection and/or crossbreeding. Crossbreeding has been discovered to have an advantage over selective breeding because the desired productivity can be achieved within a shorter period of time (Kgwatalala and Segokgo, 2013). Crossbreeding is a necessity in poultry production and recommended as part of the plans required for increasing productivity in poultry,
with the aim of exploiting the genetic diversity of the indigenous chicken breeds (Razuki and Al'Shaheen, 2011). Good combining ability in crossbreeding leads to birds with better performances, especially in growth rate, efficiency of feed conversion and reproductive traits, without necessarily jeopardising the indigenous chickens' adaptive traits to their local environments, ability to scavenge and meat and egg quality (Adebambo et al., 2010). However, selection and crossbreeding have to be properly designed and developed to suit existing cultural and socio-economic conditions (Phillipson et al., 2011). Crossbreeding of indigenous breeds with exotic breeds can be a major intervention for improving productivity (Rothschild and Plastow, 2014).

Crossbreeding can be classified into three main methods namely grading up, rotational crossing or crisscrossing and formation of synthetic breed (Steyn, 2013).

**Grading up**
Grading up usually involves the crossing of an indigenous with an exotic breed. This result in the first generation (F₁), mostly with average better performance than the indigenous, although sometimes performance can be variable due to the existence of large variations in environmental condition and in the genotypes involved. It also involves the continuous back-crossing using males of one breed, or a crossbred type, first on females of the breed intended to be graded up and then on the succeeding generations of crossbred offspring which arise from the matings (Abegaz and Awgichew, 2008). Grading up is the commonest method of crossbreeding, with the aim of combining and maximising their strengths and minimising the weaknesses in both, to create a breed that has more positive potentials than its parents (Khawaja et al., 2013). For example, the productivity of eggs and meat can be increased through crossing of the exotic birds with the locally adapted ones under improved rearing conditions. The crossing maximises the expression of heterosis in the cross which is visible in their improved characteristics (Hoffmann, 2005).

**Rotational crossing or crisscrossing**
Rotational crossbreeding is when males of two or more breeds are mated with crossbred females. Over a number of years, each breed will have contributed its strengths and weaknesses equally. Two or more breeds are used in rotation. The males are always purebred. Firstly one breed is used, followed by the second breed, and so on, until the sequence is complete. It then starts again with the first breed used. The females to which the males are mated are purebred only for the first generations of mating. Crossbred females are used in subsequent generations (Abegaz and Awgichew, 2008).

**Formation of synthetic breeds**
New breeds formed from two or more constituent breeds are called synthetic. New breeds can be synthesised from crosses combining breeds in virtually any proportion, first crosses or various back-crosses of two breeds, or combinations of more than two breeds (Abegaz and Awgichew, 2008).
Efforts have to be made to increase productivity of indigenous poultry (Besbes, 2009; Meseret et al., 2011). Egypt and South Africa have the highest production of chicken meat and eggs in Africa, respectively (FAOSTAT, 2014). These countries are actively involved in various researches for the development of chickens and have often used genetic improvement to achieve this. Non-government Organizations (NGOs), foreign aid projects and government organisations in these countries have focused on genetic upgrading. For example, Egypt is crossbreeding chicken as one of their tools for management under the rural farming management system for the increased supply of protein (Das et al., 2008). The human population of the world is increasing, as well as the unavailability of land for livestock production and demands for protein. These issues have to be addressed. A potential solution is to increase the meat yield and egg production per chicken. This can be achieved by genetic exploitation through selection and crossbreeding (Phillipson et al., 2011).

Crossbreeding is advantageous in many ways; however it also has its possible shortcomings and threats which have to be taken into consideration. Some of these are: the possible loss of conservation of purebred IC genetic pool, the possible reduction or loss of distinct characteristics of ICs such as brooding abilities, protective and survival mechanisms that include scavenging, aggressiveness and flying (Assan, 2013). Crossbreeding also tends to transfer the weaknesses of the breeds from which they were developed and heterosis in initial crosses reduces with any backcrossing to parental breeds (Muller, 2014).

IMPLEMENTATION, MERITS AND ISSUES OF CHICKEN CROSSBREEDING PROGRAMMES

Genetic improvement through crossbreeding as an intervention to improve or eliminate certain traits in chickens has been carried out in several countries in Africa (Phillipson et al., 2011). Some of these programmes that have been initiated, their results and effects on chicken production will be discussed.

Malawi

In Malawi, the Smallholder Poultry Improvement Programme (SPIP) was introduced in the 1960s with the aim of improving productivity of indigenous chickens through crossbreeding indigenous chickens with Black Australorp (BA), an exotic chicken breed that is a very good producer of eggs. However, there was less than 40% improvement in the productivity of the indigenous chickens based on the SPIP (Safaloah and Shankhulami, 2004). This was not because the crossbreeding of Malawi indigenous chickens with BA did not improve productivity, but because availability of the BA was limited, the BA needed more care in terms of housing, feeding and had low tolerance to Newcastle disease (NCD) (Safaloah and Shankhulami, 2004). Selection and record keeping of the birds was also difficult as most farmers keep chicken on an extensive production system. Moreover, many farmers
in Malawi did not fully understand the objective of the SPIP. Most of the farmers that had BAs were using them for egg and meat production and not for crossbreeding purposes (Safaloah and Shankhulami, 2004). The government failed to consider the adaptability of the BA. The crossbreeding of the BA and indigenous chickens could have been massively carried out on research stations where they would be monitored and the chickens bred under optimum conditions and then the hybrids (crossbreeds) distributed to the farmers.

**Botswana**

In Botswana, crossbreeding an indigenous chicken breed, Tswana with BA resulted in significantly higher growth rates than the indigenous breeds. Their research was conducted under an intensive management system (Kgwatalala and Segokgo, 2013). This result is not very useful to the household poultry farmers, as they do not keep chickens on intensive management systems. Parents of the crossbreeds and the crossbreeds would have to be exposed to extensive management or semi-intensive management systems which are the major production systems practised in the rural communities, to be effectively implemented and accepted by the indigenous poultry farmers, as the cost of the intensive management system would be overstretching their incomes, unless subsidies are given.

**Egypt**

Poultry meat and eggs are the most important source of animal protein in Egypt (Honsy, 2006). Genetic improvement of large and small ruminants as well as poultry has been very successful in Egypt over the years. The country has planned and monitored legal restrictions on the genetic improvement of poultry production. For example, only four companies supply the majority of hybrid chickens. The production of hybrid end products where multiplication and production are separate steps, allow for effective patented control over the breeding lines (Lewis, 2009). This has contributed to improved and high production, uniformity of genetic makeup and the success of hybrids in the poultry industry in Egypt (Lewis, 2009). For example, the feed conversion ratio (FCR) at the national level of the pure native chicken breed is 1kg live weight for every 5kg feed consumed, while for the improved native breed (crossbred) and exotic breed is 1:2.7 and 1:2.2 respectively (Honsy, 2006).

Egypt has done a considerate amount of researches on crossbreeding between their local chicken breeds and exotic chicken breeds. This is one of the main reasons why they are amongst the top poultry and egg producers in Africa. The country’s policy promotes an open market, which encouraged the privatisation of poultry farmers in the 1990s as a way to improve the protein supply in the country (Honsy, 2006). The scientific and technology aspect of the country also has much support from international bodies such as the World Bank, the International Monetary Fund (IMF) and many more (Lewis, 2009). Part of the main objectives of the Animal Production Research Institute (APRI) in Egypt is to increase production, enhance genetic traits, upgrade the quality of local, cross and exotic
breeds of animals, poultry and rabbits. High priorities of the researches for improved animal and poultry production in Egypt is to improve the local, and develop a breed of, indigenous poultry adapted to the prevailing environmental conditions (Lewis, 2009).

South Africa

The poultry sector in South Africa is the most developed in southern Africa. As early as the 1960s, a synthetic breed Potchefstroom Koekoek (PK) was developed by crossing a black Australorp cock and a White Leghorn hen (Viljoen, 1986). The breed is classified as a South African indigenous chicken, due to its characteristics. This breed is a dual purpose breed that can be used for meat and egg purposes. It is adaptable to the South African environment and has good adaptability and growth rate. South Africa is highly involved in various genetic improvements of chickens. The Animal Improvement Act was modified in 1998, with the aim of giving guidelines on concerns which were not included or well defined, in the previous Act, such as improvement of poultry and animals. This includes the support of animal improvement schemes to benefit the small-scale farmers. Provision is made for the protection of South Africa’s indigenous and locally developed breeds and the establishment and maintenance of animal breeders’ societies (Animal Improvement Act, 1998). Emphasis is still placed more on improving the exotic chickens and less of the indigenous chickens in South Africa. The PK is the only synthetic breed that has been developed in years, but a lot of upgrading and rotational crossing are being carried out. Examples of recent crossbreeds (upgrading) that have been carried out in South Africa is the sire line of a South African indigenous chicken, Venda (V), which was crossed with Ross 308(R), an exotic broiler breed. The chickens were raised and fed a standard commercial diet, under an intensive management system. This resulted in improved growth rate and body weight when compared to Venda (Siwendu et al., 2012).

Examples of crossbred chickens that have been stabilised (synthetic breeds) and are classified as indigenous chickens, as they are well adapted to their environments, are shown in Table 2.

Table 2: Synthetic breeds of chickens.

<table>
<thead>
<tr>
<th>Synthetic breed/strains</th>
<th>Their crosses</th>
<th>Place of origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dokki 4</td>
<td>Fayoumi × Barred Plymouth Rock</td>
<td>Egypt</td>
</tr>
<tr>
<td>Golden Montazah</td>
<td>Dokki 4 × Rhode Island Red</td>
<td>Egypt</td>
</tr>
<tr>
<td>Mandarah</td>
<td>Dokki 4 × Alexandria</td>
<td>Egypt</td>
</tr>
<tr>
<td>Matrouh</td>
<td>Dokki 4 × White Leghorn</td>
<td>Egypt</td>
</tr>
<tr>
<td>Alexandria</td>
<td>White Leghorn × Barred Plymouth</td>
<td>Egypt</td>
</tr>
<tr>
<td>Potchefstroom koekoek</td>
<td>Rock × Rhode Island Red × Fayoumi</td>
<td>South Africa</td>
</tr>
<tr>
<td></td>
<td>Black Australorp × White Leghorn ×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barred Plymouth Rock</td>
<td></td>
</tr>
</tbody>
</table>

Source: Domestic Animal Genetic Resources Information System (DAGRIS) 2007.
Egypt has less than 5% prevalence of undernourished people. This low prevalence of undernourished people in Egypt and South Africa (<5%) can be related to their commitment to agricultural development and progress, which includes genetic improvement of chickens (FAO, IFAD and WFP, 2013).

**CHALLENGES IN CROSSBREEDING**

Crossbreeding is important for present and future progress of chicken production in southern Africa. However, some challenges have hindered, and are still hindering its success.

**Timeframe**

Crossbreeding involves careful planning. The positive effects of crossbreeding might take a while before the results are realised (Zobell and Chapman, 2010). It needs careful selection of the breeds to be used, to have the desired results. The time frame for selecting and crossbreeding can usually be lengthy, depending on the type of crossbreeding being done. For example, at least three generations of crosses of _inter se_ has to be carried out before a synthetic breed can be developed. This will take a minimum of 18 months.

**Inadequate planning and research**

Most breeding programmes are not well planned, nor considerate of the place where the crossbreed will be used. In many cases, there have been no clearly defined objectives for crossbreeding, which has often led to a bad selection or choice of breeds that do not have the desired traits that are needed (Zobell and Chapman, 2010). It also leads to deviation of purpose and expected outcome. An example was the situation in Malawi, where the farmers did not crossbreed the BA with their indigenous chickens; rather they used them as pure breeds for egg and meat production (Safaloah and Shankhulami, 2004). Inadequate planning and research have often led to wrong combinations of breeds and inbreeding leading to the devastating results of crossbreeds with little or no beneficial use (Zobell and Chapman, 2010). Crossbreeding plans are sometimes adopted from countries with different environmental and production conditions and systems. This results in disappointment with the programme, as was the case in Malawi. Although some poultry farmers are knowledgeable about breeding objectives, their breeding objectives are not actually defined, selection criteria for maximum return are not used and factors that affect both are not determined (Tabbaa and Al-Atiyat, 2009). A good breeding programme should be totally dependent on environmental conditions, the production system, the culture of the people for whom the animals are bred and the market to which the animals and animal products are sold (Philipsson _et al._, 2011).

Lack of adequate plans on how to maintain suitable crossbreeds as a breed for future use also contribute to non-sustainability (Philipsson _et al._, 2011). Crossbreeding, as well as preservation of a pure breed of chickens is important. Crossbreeding cannot be achieved without the use of pure breeds. Maintenance
and selection of pure breeds for future and continuous crossbreeding is paramount. This is because the undiluted traits/genes in certain breeds are contained in pure breeds.

**Sustainability of the programme**

The acceptability and ability to conserve the genetic make-up of these hybrids are low. This is linked to inadequate research and follow-up on the crossbreeding programmes initiated. Although substantial experiments on crossbreeding are carried out, they are neither promoted, stabilised nor sustained (Phillipson *et al.*, 2011). Little or no regard for record keeping of the crossbreeds and their parents also affect the sustainability of crossbreeding. Record keeping can be a daunting task for a lot of farmers in developing countries, as some of them might not be literate and might depend on information that has been passed on from generations, over the years, for management of poultry.

**Complexity**

Breeding programmes are often too complex for farmers to fully understand. They are accustomed to simple ways of farming (Philipsson *et al.*, 2011). This has led to rejection of the programme or use of the programme for other purposes, for example, in Malawi, where the BA chickens were used for egg and meat production, instead of for crossbreeding (Safaloah and Shankhulami, 2004).

**Inadequate financial support**

For any programme to be effective, it has to be adequately funded. Egypt has been successful in their crossbreeding programme, as they have adequate funding both from national and international sources. Many crossbreeding programmes have been initiated without sustainable financial support, and further research stopped midway, without any benefit to poultry farmers.

**CONCLUSION**

Crossbreeding cannot be left out of the main factors that will lead to increased productivity in chicken production. It should not be done with the aim of replacing purebreds, which are essential for optimum crossbreeding. However, crossbreeding should only be done under careful selection and management. Efforts must be made by agricultural extension officers, animal scientists and agricultural development planners to take this information, knowledge and completed researches on crossbreeding with positive results to the government and poultry farmers for implementation. Synthetic breeds could be developed in the urban areas from these crossbreeds and distributed to the rural areas of Africa. This would reduce the complexity of the process of crossbreeding so that it could be undertaken by indigenous poultry farmers. Southern African governments, NGOs and international organisations should be actively involved in the sponsoring of crossbreeding programmes in southern Africa.
Crossbreeding, combined with selection, good and improved management and technology is recommended for the geometric increase in chicken meat and egg production in Africa, as one of the effective interventions to curb PEM, enhancing food and nutrition security of rural households.
REFERENCES


