Hatchery and broody technologies and least cost ration practice for poultry production improvement in Ethiopia: Review

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Abstract: The objectives of this review were to show how the day-old chicks produced in rural area by easily managed incubator. For this review, narrative review system was administered by collecting more than 60 recent articles that are related to the topic. In Ethiopia, from 51.35 million chicken population 96.83% is indigenous and the remaining 2.37 and 0.8% are exotic and hybrid breeds, respectively. These Indigenous chickens are characterized as low production 30–60 eggs/year and low average weight 38 gm as compared to 250 eggs/year and 60 gm egg weight of exotic breeds. Introduction of exotic breeds was started before 50 years back yet the expansion is very low due to different constraints. The egg per capita consumption in developing countries is 42 eggs per year, which is very low as compared to 153 eggs per year in developed countries. Investigating suitable and full package technologies intervention is imperative strategy to improve poultry production in rural, pre-urban and urban communities of Ethiopia. Therefore, evaluating and designing of mini-hatchery and broody technologies and least cost poultry ration have significant effect to boost poultry production sustainably and efficiently in Ethiopia.

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PUBLIC INTEREST STATEMENT

Chicken production in Ethiopia is the primary commodity to assure food self-sufficiency, increasing economic growth, youth job opportunity, and empowering of females. In this review, a comprehensive and current overview of numerous chicken production and productivity improvement studies have been organized and discussed in a holistic manner, but do not contribute to as such for the societies due to different constraints. As conclusion, the authors provided different measures that can be adapted to enhance the contribution of chicken to the rural community that easily accessible, and manageable and sustainable technologies implementation is very important to improve the challenges of the sector. Mini-hatchery, hay box brooder and homemade least cost ration are the most important alternatives technologies in developing counties.
Subjects: Agriculture & Environmental Sciences; Agriculture; Environmental Sciences; Agriculture and Food; Plant & Animal Ecology

Keywords: hay box; least cost; mini-hatchery; poultry; poverty; ration

1. Introduction
The global meat production is increased almost quadrupled for the last 50 years from 78 million tons in 1963 to 308 million tons in 2015. The poultry meat also grew 207% from 54 million tons to 112 million tons for the last two decades (Bolelie, I.C., et al., 2016). Poultry production is the most important commodity for developing countries to increase the GDP, food self-sufficiency, poverty reduction, livelihood improvement, and economic growth (Tafesse, 2005; Dessie et al., 2013). But the per capita consumption of egg in developing countries is 42 per year, which is very low as compared to 153 eggs per year in developed countries (FAO, 2013).

In Ethiopia, poultry production and productivity are very low due to lack of suitable artificial incubation and brooding facilities. The rural area of the country is depending on natural incubation and brooding by using broody hen to hatch chicks. Nevertheless, its rearing and protecting little number of chicks (6-8) stop egg laying during the complete incubation and brooding periods of 81 days. These types of brooding practice is exposed to predators such as prey, pets and some wild animals listed as the main causes of premature death of chicks (Demeke, 2007; Gueye, 1998). The other major challenge of chicken production in Ethiopia is inconsistent supply of exotic day-old chicks and inadequate feeding and nutrition (Disha et al., 2015; Solomon, 2004).

In Ethiopia, indigenous chickens are largely dominated flock size (Tadelle & Alemu, 1997). About 95.86% of chicken product is produced from indigenous chicken (Solomeno, 2008). Most of the feed processing mill is concentrated around the capital city of the country and have high transportation cost to transport in to the side of the area (Yami & Dessie, 1997). This review covers different mechanisms to improve exotic breed expanding and preparing least cost ration from locally available ingredients that affordable by rural communities in terms of cost and accessibility. Use of sand mini-hatchery and hay box brooder are other technologies to hatch and brood huge number of day-old chicks (DOCs), respectively (Demeke, 2001; Rota et al., 2010). Sand mini-hatchery can be made by locally available materials, and has efficient hatchability performance equivalent to modern hatcheries that effective in Asian countries for the last decayed (IFAD, 2011). This review shows the importance of these full package technologies intervention for poultry production improvement under rural people and small-scale production.

2. The objectives of this review
   - To show day-old chicks producing mechanism in rural area by easily managed incubator.
   - To illustrate how to prepare least cost chicken ration formulation from locally available ingredients.
   - To identify the technologies gap for poultry production improvement in rural community.

3. Importance of chicken production
Poultry population is estimated about 22 billion in the world and 75% of the populations live in developing countries (FAO, 2013; Salam, 2005). The demand of poultry products has been increased in both nutrition and poverty alleviation in village community but the supply is under its potential. Poultry has been contributed to socio-economic roles as food securities, generating additional cash incomes and religious/cultural ceremonies (Alemu et al., 2009; Gueye, 1998). It is the largest livestock species and the major protein sources for consumers in most of the countries around the world and it accounts 30% from all animal protein consumption (Al-Khalifa et al., 2007). In the world, chicken meat has been increased and 70% of the market is dominated by broiler meat (R.T Wilson, 2010). In addition to this, chicken meat and eggs are rich in essential amino acids like Lysine, Threonine, Methionine, Cysteine and...
Tryptophan that are limited in cereal crops (FAO, 2013). Chicken eggs and meat are more readily available products than many other animal products in terms of required small unit size to be stored, preserved and low fat content (FAO, 2013; FAS (Food Agricultural Service), 2017). It is also the most preferable commodity in Ethiopia to improve the livelihood of the community (Melkamu, 2013). But the average per capita chicken products consumption of Ethiopia is 0.5 kg which is lowest in the world and in Sub-Saharan Africa countries accounts 14.9 kg and 2.3 kg, respectively (Gueye, 1998).

3.1. Chicken production for livelihood improvement
Livestock has been contributing about 40% and 30% of agricultural gross domestic product (GDP) in global and developing countries, respectively (Al-Khalaifa et al., 2007). Particularly in developing countries, chicken production is the primary commodity to increase the GDP, poverty reduction, and food self-sufficiency (Melkamu, 2013; R.T Wilson, 2010). It also provides safety net as the form of liquid assets and a strategy of diversification for food production (FAS (Food Agricultural Service), 2017). This evidence explained that chicken have to play multiple roles in the livelihoods of poor people in developing communities. Therefore, gives more stress for the important role of livestock to sustainable agricultural development and livelihood improvement.

3.2. Chicken production as source of protein
The contribution of food from animal origin to the nutritional status of the world population is well documented (World Bank, 2009; David, 2010; Freeman et al., 2007). Livestock products account for almost 30% of human protein consumption and poultry meat share 36% from the total livestock meat production (Bwibo et al., 2003; FAO, 2013). Animal origin foods are rich in energy and excellent supply of protein, vitamins, minerals and essential fatty acids (Ndlovu, 2010; Randolph et al., 2007; Steinfield et al., 2006). Homestead and small-scale chicken production contributes to meeting the indispensable nutritional needs of families, especially for children, pregnant and lactating women. Chicken meat and eggs provide a readily available high-quality and cheap source of proteins, vitamins and minerals for vulnerable and rural community especially in developing countries (Neumann et al., 2002).

Animal protein consumption is increased due to the economic level increment of the world population which is expected to grow at 2 to 3% per year (Kay, 2016; Leroy & Frongillo, 2007). Chicken meat is the best source of quality protein for nutrition under sub-Saharan Africa (SSA) and South Asia countries for smallholder farmers (Dave H., 2007; David, 2010). Therefore, affordable alternative technologies for village community are required to improve chicken production in low skill and cost requirement.

3.3. Chicken production for poverty alleviation
In the world, more than 2 billion people are suffered in serious lack of micro nutrient and 200 million children are stunted or wasted (FAO, 2009). On the other hand, about 1.4 billion people are under malnutrition in high-, middle-, and low-income countries (Muchenje et al., 2001). In south east Africa countries, about 38 million people are facing severe food insecurity due to incident of droughts (Ruel et al., 2013). Ethiopian government was trying to combat this community challenges by intervene different stunting growth reduction strategies.

One of the intervention strategies is improving the livestock productivity by setting of five years master plan (LMP). According to the LMP, improved chicken breeds, egg and meat production is increasing by 346 and 351%, respectively (Ruel et al., 2013). Thus to achieve this ambition plan, implement low cost, easily manageable technologies and full package for all parts of the country (Melkamu, 2013).

4. Chicken production challenges
The major challenges of chicken production in Ethiopia are feed shortage, inadequate technologies, chicken mortality, inadequate feeding management, poor housing system, and low genetic performance of indigenous chicken (Ashenafi et al., 2004; Halima, 2007; Dessie et al., 2013; Barry Shapiro et al., 2015; Global Nutrition Report, 2017). Here, only focused on the first three challenges of the sector.
4.1. Feed shortage
In Ethiopia, chicken are depending on scavenging feed resource rather than supplementary feed resource (Assefa et al., 2015; CSA (Central Statistics Agency), 2009; Dessie, 1996; Maphosa et al., 2004). This scavenging feed resource is depending on season and backyard condition, which indicated that in most of the season chicken, are indiscriminately for feed scarcity (Leulseged Abera & Geta, 2014; Yoseph, 1998). However, some parts of the country have an experience to supply their chicken in addition to scavenging in the morning and evening but not based on the nutrient requirement of the chicken (Leulseged Yoseph, 1998). In Ethiopia, under both rural small holder and large-scale chicken production systems chicken feed and nutrition is one of the most critical constraints (Dessie et al., 2013; Mazengia et al., 2012; Molla, 2010; Solomon, 2004). In addition to this inadequate supplementation, feed availability, feed quality and feed cost are the other challenges of chicken productivity in Ethiopia. These are the reason, why Ethiopian chicken production and productivity are at infant stage.

The availability of high-quality feed ingredients and processed feed are essential for efficient chicken production but not accessible by small holder farmers (Dessie et al., 2002). In addition to this, the cost of processed feed is very expensive that not affordable by most rural communities (Dessie et al., 2002, 2013; Solomon, 2004). Therefore, least cost ration formulation for chicken from locally available ingredient is the most important option to undertake such challenges of chicken production system in Ethiopia.

4.2. Technology limitation
In Ethiopia, chicken production has significant contribution role for livelihood improvement and gross domestic product (GDP) growth but due to limited technologies implementation, the productivity of the chicken is under its potentials (FAO, 2013; Tadelle & Alemu, 1997). Inconsistent promotions of technology, low extension services and applicable technological innovation and adoption are the other challenges of the sectors.

4.3. Chicken mortality
Diseases prevalence like new castle disease (NCD), and coccidosis and predators like wild birds, prey and wild animals are the major cause for chicken mortality in Ethiopia (Melkamu, 2013). In central highland of Ethiopia, NCD is the primary causes to loss the village chicken (Serkalem, 2005). In some area of the country, predators are a reason for huge number of chicken was loss (Halima, 2007; Hunduma et al., 2010; Selam & Kelay, 2013; A. Alemayehu et al., 2015). Therefore, hay box brooder was a good alternative mechanism to reduce chicken mortality by predators in different districts of Oromia regional state, Ethiopia.

5. Chicken production improvement in ethiopia
Introducing of exotic breed in Ethiopia was started before 50 years back to improve chicken production from Kenya, Denmark and United States of America (Tadelle & Alemu, 1997). The most common exotic breeds were rode island red (RIR), Australorp, New Hampshire and white leghorn in different agriculture experiment station like Jimma, Alemaya, Debre Zeit and Shashemene. On the other hand, Ethiopian agricultural research organization (EARO) in 1997 was established and focused on poultry production improvement (Yami & Dessie, 1997). Given that, the research organizations, ministry of agriculture and non-governmental organizations (NGOs) have been distributed numerous exotic breeds to rural farmers and urban-based small-scale poultry producers (Tadelle & Alemu, 1997). But in Ethiopia 96.83% of the population are indigenous breed, while the remaining are exotic and hybrid breeds due to focused only on a single technology (CSA (Central Statistics Agency), 2009; Fisseha et al., 2010; Halima, 2007; Tadelle, 2003). Therefore, sand mini-hatchery, hay box brooder and least cost ration used as full package technologies to improve chicken production for the rural area of the country.
5.1. Sand min-hatchery importance
Day-old chicks (DOCs) production is the process for sustainable chicken production in rural area of Ethiopia but it is very low due to depending on the natural incubation system that has low performance. Rural community of the country could not have an access the automatic incubator due to its high cost and inaccessibility of light. Therefore, using of sand mini-hatchery is the most important alternative incubators in rural area of Ethiopia. This manual incubator is used to producing of DOCs in remote location far from the commercial hatchery centers and very crucial to reduce the mortality of chicks due to transportation from commercial hatcheries to isolated areas (Rota et al., 2010; N.H. Desha et al., 2015). As indicated in Table A1 the sand mini hatchery technology was successful in Asian countries, which has 80–85% hatchability performance and economically feasible for poor rural women (IFAD, 2011; Rota et al., 2010). Therefore, to evaluate, design and promote such types of technology in Ethiopia is very essential for chicken production enhancement particularly in village and small-scale chicken production system.

5.2. Hay box brooder importance
In rural areas of Ethiopia, 60% of chicken are dead due to diseases prevalence and predators (Tadelle & Alemu, 1997). Under backyard production system, the reproductive cycle of indigenous chicken consists of 20, 21 and 56 days for laying phase, incubation phase and brooding phase, respectively (Dessie & Ogle, 2001; Halima, 2007; Moredaa & Mesekel, 2016; Yami & Dessie, 1997). This implies that, indigenous hen would have to stay about 168 days out of production in every year. Hence, using of artificial hatchery and broody technologies is very important mechanism to avoid these problems in rural and small-scale chicken production system (Tadelle & Alemu, 1997).

Chick’s brooding is relevant to the early age (0–8 weeks) of young chicks, that are unable to maintain their normal body temperature without the aid of supplementary heat either by natural broody hen or artificially like charcoal, wood, gas and electricity (Demeke, 2001). Because of sophisticated operation and unavailability of electric light electric brooder is difficult to implement in rural areas, while charcoal and gas methods are not maintained constant brooding temperature (Demeke, 2007, 2012). Thus, using hay-box brooder technology to grow baby chicks is a promising aid to fill these gaps (Dana et al., 2003). This technology has undertaken in layer types of chicken but not investigated on broiler and indigenous types of chicken.

5.3. Chicken ration formulation
Feed formulation is the process of finding the optimal combination of feed ingredients that meets the specific nutritional requirements for specific types of animals (Abdullah, 2016). In intensive chicken production about 60–70% cost incurred for feed and feed-related costs (Yenesew et al., 2015). Most of rural chicken are depending on scavenging feeding system and supplemented some grain at morning and evening time for laying and baby chicks (Dessie, 1996; FAS (Food Agricultural Service), 2017; Fisseha et al., 2010). The major feed sources for village chicken production systems are insect, worms, seed, and plant materials (Solomon, 2004). On the other hand, lack of vitamins and minerals are the serious problems in rural chicken production system (Dessie et al., 2002, 2013; Mazenga et al., 2012; Solomon, 2004; Yami & Dessie, 1997). In Ethiopia, the most constraint of commercial animal feed industry is low quality and quantity, high price of raw materials, lack of skilled man power and modern technologies (Bediye et al., 2018). However, some commercial feed processing plants and feed enterprises are founded in the corridor of Addis Ababa not accessible for rural communities (Yami & Woldesemayat, 2012).

Generally, in Ethiopia, there was no regular animal feed quality control mechanism, feed quality legislation and laboratory facilities for chemical analysis until the Ethiopian Quality and Standards Authority is working with the Ethiopian Society of Animal Production (Dessie et al., 2002, 2013). Therefore, for rural farmers and small-scale chicken eggs and meat producers least cost ration formulation from locally available ingredients is the best alternative mechanisms to improve the productivity of chicken without compromised the quality of complete ration.
6. Conclusion and recommendation
Poultry has significant role to alleviate the poverty and malnutrition problems of the community, particularly for developing countries due to its important production characteristics like easily managed, need low investment place and capital and short production return. The promotion of smallholder poultry production has created demand for day-old chicks in both rural, pre-urban and urban areas of Ethiopia. Day-old chicks are produced by different ways in the world, which are broody hens and electric incubator but both are not appropriate mechanism due to low supply and unsustainable supply of day-old chicks for those smallholder chicken producer and rural area of the country, respectively. To combat those problems sand mini-hatchery and hay box brooder are an appropriate technology used to hatch and brood huge number of DOCs in rural area in absence of electricity and easily managed by unskilled youth and women. For the rural chicken production improvement, easily accessible, and manageable and sustainable technologies implementation is very important. Therefore, evaluation, customize, and promotion of full package technologies is very important for poultry production improvement to rural community of Ethiopia.

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Competing interests
The authors declare that they have no conflict of interest.

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# Appendix

## Table A1. Advantages and disadvantages comparison of automatic and different types of manual incubators

| Parameter                  | Electric incubator | Sand method          | Rice husk method | Rice husk and quilt method |
|----------------------------|--------------------|----------------------|------------------|----------------------------|
| Electricity                | Required           | Not required         | Not required     | Not required               |
| Equipment                  | Sophisticated equipment | Local/traditional  | Local/traditional materials | Local/traditional materials |
| Installation in remote areas | Cannot installed in areas without electricity | Can installed in remote areas where electricity is not available | Can installed in remote areas unavailable of electricity | Can installed in remote areas where electricity is not available |
| Installation cost          | Highest            | Lowest               | Higher than sand but much lower than electric incubator | Higher than sand and rice husk but much lower than electric incubator |
| Maintenance cost           | Highest            | Lowest               | Higher than sand method | Higher than sand and rice husk but lower than electric |
| Temperature regulation     | Automatic          | Easier than rice husk and quilt method | More difficult than sand and rice husk and quilt | Easier than rice husk method |
| Humidity regulation        | Automatic          | Manual               | Manual           | Manual                     |
| Hatching % (chicken eggs)  | 80–85%             | 80–85%               | 70–75%           | 75–80%                     |
| Fuel cost                  | Highest            | Lowest               | Higher than sand method | Higher than sand and rice husk method |
| Users                      | Only wealthy people can afford this system | All, including landless and resource-poor households in marginal areas | All, including landless and resource-poor households in marginal areas | All, including landless and resource-poor households in marginal areas |

Source (IFAD, 2011)
