

## Poultry Biotechnology as an Optional Tool to Improve Poultry Industry in Ethiopia

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**Abstract:** Agricultural led transformation is one of the way-through to achieve fast development and sustained food supply in Ethiopia. As the country economy largely depends on agriculture, traditional poultry production is practiced across the country and playing significant roles in the livelihoods of rural households. It is the sector whereby little technology intervention potentially come-up with big impacts and one of the fertile area of investment with huge demand for the introduction of improved poultry packages at large. Poultry Biotechnology encompasses assisted breeding and reproductive biotechnology like Artificial insemination to the advanced tools of cloning and genetic engineering used to alter the existing genetic compositions of chickens to improve their health as well as their productive performance. The high quality product from transgenic eggs and meat can also boost human health. Concomitantly, biotechnology tools reinforce the process to scale-up current small-scale farm in to the large intensive poultry farms. The lesson learned so far by the government and few private investments also indicated promising success. On-top of this, policies and regulations that uplift practical acceptance of biotechnology is indispensable. In this regard, the current review was written to provide compelling foundations to initiate biotechnology research and commercial investment on poultry sector in Ethiopia.

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### 1. Introduction

In sub Saharan developing country including Ethiopia, Agricultural led transformation is one of way through to achieve accelerated development and sustained food supply. In traditional agricultural context in Ethiopia, poultry production is mainly practiced across the country and the economic, nutritional and socio cultural roles in the livelihoods of rural house holds remain beyond anticipation (Fantie et al., 2013; Shishay et al., 2014).

It is one of the livestock sectors whereby little technology intervention potentially come-up with big impacts. The conventional poultry production improvement packages previously introduced to the farmers have been promising. On top of this and following the trend of fast developing world, high level poultry production biotechnology can be considered as a key intervention to satisfy the increasing feed demand and to bust the nation economy at large. Biotechnology contextually defined as any technological application that uses biological systems, living organisms or their derivatives to make or modify poultry and their products (Bunders *et al.*, 1996; Ranjekar *et al.*, 2003).

The application of poultry biotechnology tools in the current world has proven to be effective in the difficult task underway to fulfilling a number of basic human needs like food, health, energy and to

safeguarding of the environment. More importantly biotechnology allows improving multiple traits at a time. It encompasses a broad range of techniques from simple artificial insemination, cross breeding for the genetic as well as peri-genetic improvement of poultry to the advanced level of seemingly controversial technologies of cloning and genetic engineering (Abraham and Pal, 2014). The two decade long standing approval of genetically modified organism (GMO) for human consumption in 1994 and the current trend of approval for the use of and genetically engineered chicken eggs (FDA, 2015) boosted the momentum and open-up the floodgates for poultry biotechnology in foreseeable future. The production of transgenic chickens has increasing applications in poultry biotechnology (Vergara and Cantosoler, 2012) and bioreactors for pharmaceutical protein; perhaps the application with the greatest global impact expected to increase. The increasing demand of chicken meat and egg production forge application of advanced biotechnology tools that improves production traits as well as other complimentary traits at a time (Ivarie, 2006).

A trait of major interest in the poultry industry includes breed improvement, product quality and quantity impotent, disease resistance and biopharming. Research using transgenic technology to develop avian influenza-resistant chickens is already

gaining momentum and may expand as a novel control strategy to protect against other industry threatening diseases such as Marek's disease and Newcastle disease (Lyall, 2011). Of equal importance is the protection of humans from potentially devastating zoonotic diseases (Morris and Illinois, 2001).

The development of transgenic chicken technology has lagged far behind that of mammalian species. Two reasons for this are that, only a one-cell-stage oocyte can be obtained from a sacrificed hen and that the yolk prevents high-magnification microscopic observation of oocyte. Transgenes can be integrated into the host genome efficiently using retroviral vectors and the integrated genes are expressed stably (Kenichi, and Shinji, 2013).

In Ethiopia regardless of currently blooming economy and increasing demand of improved biotechnology intervention, there are few research and information that have been done in poultry biotechnology. Moreover, the amount of work that involves advanced biotechnology tools and techniques in poultry production is quite limited indicating the sector as a fertile area of investment that have been reflected by the fascinating success of few commercial poultry producers in peri-urban area of the country. Hence this review is to provide ground information for the potential role of Biotechnology tools to improve Poultry sector in Ethiopia.

## 2. General Characteristics of Biotechnology in View of Ethiopian Poultry Sector

Conventional biotechnology research involves animal and plant breeding and selection, artificial insemination, super ovulation and in-vitro fertilization, embryo-transfer, vegetative and micro propagation, and tissue culture techniques, as well as biochemical, genetic, immunological and molecular studies of biopharming and GMO's. It utilizes basic biotechnology techniques available at low cost as well as high throughput sequencing technologies. It is often carried out in the various research institutions, universities and colleges. Nevertheless, advanced biotechnology researches using recombinant deoxyribonucleic acid (DNA) cell fusion, cloning, transgenesis, gene therapy and other similar technologies are now a day becoming fascinated area for research and commercial investments. Such intervention ought to impact the future development and life of an individuals, yet not well inaugurated in poultry sector of the country (Mola *et al.*, 2006).

Diverse Ethiopian communities have been employing traditional biotechnologies to produce alcohols, beverages and foods such as Araqi, Bordie, Enjera, Katikala, Korefie, Qotcho, Senafitch, Taj and Tella, both at household and small-scale commercial

levels (Desta, 2010). In fact, the use of small-scale traditional biotechnologies specialized in the production of alcohols and beverages continued, and have become major economic engines for the fast technology transfer and adoption in the country. Similarly in poultry sector, the promising current agricultural development and transformation policy showed poultry as one of micro-enterprise to create job and livelihood thereby played a vital role the urbanization of many settlements during the last few years (ESTA, 2006).

Evidently, several developed nations in the Western hemisphere and the Asia-Pacific region are already benefiting significantly from modern biotechnology. It is now amicable to expand the conventional biotechnologies, particularly animal-breeding and selection techniques, large scale improved breed supply to small scale farmers and associated package level extension of improved biotechnology tools at large remain an area demanding high agricultural investment (EARO, 2015).

Unfortunately, majority of developing countries including Ethiopia have very little, access to this emerging sector. Ethiopia is not exceptional, but there are focal national poultry researches and extension buffer at federal and regional level, presence of improved commercial poultry farms around peri-urban and availability of National Veterinary Institutes (NVI) can be mentioned as a good bilateral asset for future development of poultry biotechnology. Learnt from experience from the dairy biotechnology research inaugurated at Holeta Agricultural Research Center and the university level academic professional availability makes the country to focus on modern biotechnology although in both cases, biotechnology as an academic discipline and economic sector was not given strong emphasis. The Ethiopian agricultural Research Organization (EARO) can be regarded as the leading Research & Development institute initiating

tangible activities in biotechnology. The draft National Biotechnology Forum includes policy, and legal, administrative and technical instruments that ensure adequate level of safety in transfer, development, handling and use of GMOs and their products also open-up the floor for future development of modern biotechnology (FEPA, 2007).

On the top of these, Ethiopia's commercially important crops namely, barley, beans, coffee, various fruits and vegetables (banana, garlic, grape, lemon, mango) and spices are equally diverse. Hence, multidimensional plasticity of biotechnology can best fit in to and has the potential to increase the quantity and the quality of such inter-linked agricultural entities. With smart move to such components of

agricultural biotechnology, it is crystal-clear that poultry biotechnology is capable of serving as a transformation bridge for countries future agricultural led industrialization (Desta, 2010).

### 3. Ideal Biotechnology Tools in Poultry Sector

Transgenic animal bioreactors have held great promise for revolutionizing the manufacture of human biopharmaceuticals. Furthermore, successful drug approval for commercialization has recently been achieved (Houdebine *et al.*, 2009). Transgenic chickens may offer several advantages as bioreactors over mammals, such as high protein productivity in eggs, straightforward scalability and similar protein glycosylation to that of humans (Raju *et al.* 2000).

Genetically modified organism (GMO) is a living organism, e.g. bacteria, plant, animal, whose genetic composition has been altered by means of gene technology. The genetic modification usually involves: insertion of a piece of DNA and/or synthetic combination of several smaller pieces of DNA, into the genome of the organism to be modified. This process is called transformation. These DNA pieces are usually taken from other organisms such as bacteria or virus and main methods used for genetic modification are microinjection (also called pronuclear injection), viral transfection, and manipulation of chicken embryo stem cells, artificial insemination, cloning and transgenes in egg, chicken and meat (Holst, 2001). GMO can also be used as effective micro-organisms, a prebiotic and probiotic food supplements for both poultry and human beings.

#### 3.1 Artificial Insemination

Artificial insemination (AI) in poultry is as simple as the manual collection and transfer of semen into the female's vagina. Basically it is a two-step procedure: first, collecting semen from the male and second, inseminating the semen into the female. Depending on the objectives and goals of the farm or laboratory, there may be intervening steps such as semen dilution, storage, and evaluation (Spasojevic, 2010). The goal of AI is to produce a succession of fertilized eggs between successive inseminations, controlled breeding and genetic manipulation, safeguard disease transmission and also reduce cost of raising multiple cockerel and to manage farm record and genetic (Johnson and Woods, 2007).

#### 3.2. Cloning

The first successful attempt of mammalian somatic cell Nuclear Transfer (NT) came with the birth of two cloned lambs derived from cultured embryonic cells. Later, it was shown that a differentiated somatic nucleus derived from an adult animal could be used to produce a clone when fused to an enucleated oocyte, e.g. "Dolly"(Wilmut, 1997). Following this pioneering work, the technology has

been applied successfully in a number of species. In this technology, the early embryo is reconstructed employing a somatic cell nucleus (nuclear donor) injected into an enucleated egg (recipient cytoplasm, also described as cytoplasm donor). To achieve normal development, the mitotic donor nucleus must be reprogrammed by elements in the recipient cytoplasm and resume cell division. Scientists who created Dolly are planning to create a cloned hen that lay a golden egg which is rich in proteins fighting against human cancer, many human and animal infectious diseases (USNLMIH, 2000).

To date, avian NT has not been possible due the technical difficulties associated with accessing, visualizing and manipulating the early avian oocyte. Birds with the very best naturally occurring combination of agronomic traits can be cloned and subsequently breed to produce flocks of 'elite' birds. Transgenic poultry provides a cost effective and more rapid method than traditional mammalian systems. Nuclear transfer technology in avian species have four separate steps: visualization of nuclear structures within the early egg, laser-mediated ablation of these structures, isolation and microinjection of a somatic cell nucleus into an enucleated cytoplasm and hatching of the reconstructed zygote (Campbell, 1996 and Wilmut, 1997).

### 3.3 Potential Outcomes of Biotechnology Tools in Poultry Sector

#### 3.3.1 Transgenic Egg

Transgenic egg is an egg which is genetically modified either using lent viruses by egg manipulation or from genetically engineered chicken. The procedures with chickens are carried out under animal experiment license. Transgenic cockerels are used for artificial insemination of 6 hens per cockerel twice weekly. Fresh-laid fertile eggs are collected daily and stored at 14°C until required, and are stored for no longer than 7 days and genetically manipulated (Helen, 2006).

#### 3.3.2 Transgenic Chicken

Transgenic Chicken are Genetically Modified Chicken (Recombinant DNA Technology). The technique of removing, modifying, or adding genes to a DNA molecule. Altering the genes in living organisms (chicken) to produce GMOs (chicken). The production of transgenic chickens is technically challenging because embryonic development occurs on the surface of the egg yolk and development to hatch requires incubation in a shelled egg. Professor Helen Sang and colleagues at the University of Edinburgh's Roslin Institute developed a host egg culture system that enabled hatching of embryos after genetic manipulation and constructed lent viral vectors capable of delivering transgenic to early chick embryos, which were subsequently hatched as healthy

chicks (Helen, 2006). Beside its commercial use, transgenic chicken can also be used in the experimental research like animal disease model, for drug discovery and for transgene phenotype evaluation.

### 3.3.3 Transgenic Meat

Transgenic poultry meat is a meat obtained from genetically altered poultry. Because of the relatively high price of breast meat in developed countries, considerable efforts have been directed towards improving this trait. Approaches include sib selection based on conformation and, more recently, indirect measurement technologies involving real-time ultrasound, magnetic resonance imaging, computer-assisted tomography and ichnography. (McKay, 2008)

## 4. Economic and Health Benefit of poultry Biotechnology

Considering the fact that diverse Ethiopian communities have been employing traditional biotechnologies to produce alcohols, beverages and foods at household, small-scale and commercial levels (EARO, 2000), introduction modern poultry biotechnology might not surprise the people rather provide diverse commercial and economically platform. Genetic modification in the chicken has potential to improve productivity of domestic poultry. In the context of social economics, poultry value chain also encompasses multiple stack holders and gives privilege for plasticity for investment. As the human population and income of the nation increase, the demand for food of animal origin increases.

As a result the sector remain to be fertile area of research, technology intervention in foreseeable future, With respect to health, poultry biotechnology is a promising tool to tackle both endemic and pandemic diseases. If we take Avian Influenza because of diversified viral strains and their potential for evolutionary shift and drift, viruses are not adequately controlled by vaccination consequently; they pose a global threat to both poultry production and human health. The potential way to control diseases such disease and others like Newcastle Disease and Marek's disease in commercial poultry is possible by introducing novel genes that confer resistance to infection or develop chickens that are genetically resistant (Chen *et al.*, 2008).

Transgenic chickens that do not transmit avian influenza when infected with H<sub>5</sub>N<sub>1</sub> virus were genetically modified to produce a synthetic decoy Ribonucleic acid (RNA) derived from a sequence present in all strains of avian influenza, and which interferes with virus replication (Sang and Laurence, 2013). Such technology counterbalance the suspect of flue epidemics associated risks that severely affect individual's farm as well as countries economy.

The increase in antibiotic-resistant bacteria and the desire to treat pathogens that do not respond to antibiotics such as viral pathogens, along with immune-compromised individuals has initiated the administration of specific antibodies as an alternative to antimicrobial chemotherapy to treat infections. As a result it reduces treatment and professional cost (Stefan A, 2007). For this reason, most of the IgY research carried out has been with regard to immunotherapy. Transgenic chicken (genetically modified or engineered poultry have high economic (agronomic traits) output i.e. egg and meat for commercial and small scale poultry industry (Carlander *et al.*, 2000).

Oral administration of IgY has been tried and found useful in treatment of human and animals against microbes. Its potential applications for prevention and treatment of infections caused by pathogenic bacteria and viruses have a great role in poultry industry (Michael *et al.*, 2010). More recently, the eggs of the genetically engineered chicken found to contain an enzyme that can treat a rare disease and get approval for Transgenic Chicken Use can be considered a break-through for future poultry biotechnology (FDA, 2015).

## 5. Constraints and Future Solutions

Controversial ideas like cultural beliefs, customs and religious taboos such as altering the natural genetic composition of any living creature considering it a sinful act, some strange rules and regulations which crowd down biotechnology, at national and international level are to name few of constraints (Paarlberg, 2008). However the fascinating scientific advancement was pretty enough to unveil and curb such taboos and made common understanding among the scientific community on the safety and use of biotechnology tools, principles and products at large.

Ethiopia hosts few research and teaching institutes that carry out research in biotechnology and related fields. Moreover, some universities (Addis Ababa, Gondar and Jimma) have launched biotechnology education programmes, while others like Mekelle Institute of Technology and Wolkite University are preparing to open soon. Among the factors that affect advancement and application biotechnology tools includes lack of experts in the area and facilities, equipment's, tools and supplies (EARO, 2000). The simplistic rationale is much effort is needed on the background assets maintained so far and keep the momentum to satisfy the demand of growing population. In this regard, persistent development policy implementation for poultry technology development, adoption and extension, and involvement of micro-entrepreneurs, large scale commercial farms and private investors by far

important.

### 6. Concluding Remarks

Application of Biotechnology tools in poultry sector can be considered as one of the driving pivot for agricultural transformation in developing country. In Ethiopia poultry biotechnology plays central role in busting the nation economy, maintaining public health and sustained livelihood for rural farmers. Moreover, improving poultry production can be started with low input level of improved breed extension, AI, improved management, vaccination and to higher level of transgenesis can be made at different level. However; it encounters prevailing challenges that can be solved at different levels. Systematic approach and policies to re-inforce the efficient utilization of available limiting resource and man-power to improve agronomic traits and resistance of multi species against different pathogenic invasion is by far critical. The traditional attitude and beliefs of society have to be changed for the successful application of biotechnology tools in poultry so as to encourage adoption of modern poultry farming.

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### Conflicts of Interest

The authors have no conflict of interest to declare.

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5/4/2019