SCAVENGING AND SMALL-SCALE INTENSIVE CHICKEN PRODUCTION PRACTICES, EGG QUALITY ANALYSIS, AND MARKETING SYSTEM IN AND AROUND JIGJIGA CITY

MSc THESIS

OSMAN ABDULLAHI JAMA

JANUARY 2025

HARAMAYA UNIVERSITY, HARAMAYA

Scavenging and Small-Scale Intensive Chicken Production Practices, Egg Quality Analysis, and Marketing System in and Around Jigjiga City

A Thesis Submitted to the School of Animal and Range Sciences

Postgraduate Program Directorate

HARAMAYA UNIVERSITY.

In Partial Fulfillment of the Requirements for Degree of MASTER OF SCIENCE IN AGRICULTURE (ANIMAL PRODUCTION)

OSMAN ABDULLAHI JAMA

January 2025

HARAMAYA UNIVERSITY, HARAMAYA

HARAMAYA UNIVERSITY

POSTGRADUATE PROGRAMS DIRECTORATE

As thesis research advisor, I hereby certify that I have read and evaluated this thesis titled "Scavenging and Small-Scale Intensive Chicken Production Practices, Egg Quality Analysis, and Marketing System in and around Jigjiga City" prepared under our guidance by Osman Abdullahi. I recommend that it be submitted as fulfilling the Thesis requirement.

Negassi Ameha (PhD) ___________________ ___________________

Major Advisor Signature Date

Meseret Girma (PhD) __________________ __________________

Co-Advisor Signature Date

As a member of the Board of Examiners of the MSc Thesis Open Defense Examination, I certify that I have read and evaluated the Thesis prepared by Osman Abdullahi and examined the candidate. I recommend that the Thesis be accepted as fulfilling the Thesis requirements for the degree of Master of Science in Animal Production.

______________________________ _______________ _________________

Name of Chairperson Signature Date

______________________________ ________________ _________________

Internal Examiner Signature Date

______________________________ _________________ _________________

External Examiner Signature Date

Final approval and acceptance of the Thesis is contingent upon the submission of its final copy to the Council of Postgraduate Program (CPGP) through the candidate's department or Postgraduate Program Directorate.

DEDICATION

This thesis work is dedicated to my Parents after Allah, who had nursed me with love and affection and committed to my success with strong Prayer for the betterment and in general success of my life.

STATEMENT OF THE AUTHOR

As my signature below, I declare and affirm that this Thesis is my original work and all sources of materials used for this thesis have been duly acknowledged. This Thesis is submitted in partial fulfillment of the requirements for a Master of Science degree at Haramaya University. The Thesis is deposited in the Haramaya University Library and is made available to borrowers under the rules of the Library. I solemnly declare that this Thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Postgraduate Program Directorate. When in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Osman Abdullahi Jama

Signature: _____________

School/Department: Animal and Range Sciences

Place: Haramaya University, Ethiopia

Date of Submission: _________________

BIOGRAPHICAL SKETCH

The Author, Mr. Osman Abdullahi originates from Garacad town and was born in 1992. But he was mainly raised in the Jariban within the Mudug region. His primary school was Jariban Primary and Secondary School and he went to Garisa High School in Bosaso as well. He enrolled at East Africa University in 2011, and he officially graduated from the Faculty of Veterinary Medicine and Surgery in late 2016.

After completing his Bsc degree, from 2017 to 2020, Mr.Osman worked as a team leader at the Ministry of Livestock and Animal Husbandry in Puntland where he gained first-hand experience on management-related livestock handling/Animal health subjects. Subsequently, in 2021, he managed to further his studies at Haramaya University after being awarded a competitive scholarship for Animal Production.

ACKNOWLEDGEMENTS

I start by giving my most sincere and deep thanks to Almighty Allah, who alone enabled me to be in good health, patient, and strong enough to work out this research work successfully. This work, without His guidance, would not be possible. I am profoundly thankful for the immune blessings He granted to me during the completion of this journey. I am particularly indebted to my parents for their endless love, prayers, and support, which have acted as the foundation of my academic and personal development. The moral and economic encouragement obtained from them has been a source of great motivating force in rising above adversities and striving toward the fulfillment of dreams. Let me also extend the depth of my gratitude to my brothers for standing by me with their relentless support and encouraging attitude during this journey.

I would like to express my deep gratitude to my major advisor, Dr. Negasi Ameha (PhD), for his insightful guidance, constructive feedback, and continuous encouragement throughout this research process. His expertise, dedication, and mentorship have been instrumental in shaping the direction of my work; thus, I am very grateful for the time and effort he has dedicated to making me successful. I would also like to express special thanks to my co-advisor, Dr. Meserret Girma (PhD), for tireless efforts, highly valued insights, and detailed elaboration that greatly enriched this research. Her continued support, opportune advice, and encouragement have served as a great driving force to complete this work, for which I remain grateful.

Lastly, I will always be grateful to those friends and colleagues who have shared this path with me by being supportive, offering advice, and encouraging me. Your companionship has meant so much-the best motivation, I appreciate the fact that you are there for me.

ACRONYMS AND ABBREVIATIONS

CSA	Central Statistic Authority
EW	Egg Weight
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
HU	Haugh Unit
MD	Marek's Disease
ND	Newcastle Disease
NGO'S	Non-governmental Organizations
SoRSE	Somali Regional State of Ethiopia
SPSS	Statistical Package for Social Sciences
DZARC	Debre Zeit Agricultural Research Center
EARO	Ethiopian Agricultural Research Organization
OoARD	Office of Agriculture and Rural Development
RIR	Rhode Island Red
WLH	White Leghorn

TABLE OF CONTENTS

TABLE OF CONTENTS (*continued*)

LIST OF TABLES

Table **page**

LIST OF FIGURES

LIST OF TABLES IN THE APPENDIX

Table **Page**

Scavenging and Small-Scale Intensive Chicken Production Practices, Egg Quality Analysis, and Marketing System In and Around Jigjiga City

ABSTRACT

The study was conducted to assess and evaluate production practices, marketing systems, and egg quality traits of small-scale intensive and backyard chicken production in and around Jigjiga city. The study was thus composed of a survey and egg quality examination of local and exotic chickens reared under an intensive and scavenging production system. Hence, 160 households under the backyard system with four strata and 10 from the small-scale intensive system were involved in the survey. SAS and JMP pro version (9.4) were statistical software tools used to analyze the data and the chi-square test was used to analyze the categorical variables while ANOVA was used to analyze continuous variables. The results indicated that the majority of respondents in the study area were male in the 1st and 4th strata and in all strata their ages fall between 41 and 50 while their educational attainment is predominantly low among respondents, with many being illiterate or having only primary education. In terms of chicken production practices the first strata represent 30% of households that still rely on traditional scavenging while 47.5%, 70%, and 72.5 respectively in 2nd, 3rd, and 4th strata shows semi-scavenging systems. The housing conditions and practices for chicken rearing across four strata, which significantly different across the strata ($\chi 2$-test= 4.740, $P<0.05$) based on the number of chickens kept by each household. Results show a significant difference in egg production per year/hen across the four strata, with the fourth strata producing the highest average of 54.90±1.02 eggs per hen per year, while the third strata produced the lowest, at 49.12 ±1.29 eggs per hen ($p = 0.001$). The correlation relationships between various external egg quality traits for exotic and indigenous chickens reveal distinct patterns. In exotic chickens egg weight is significantly correlated with shell weight ($r = 0.4428$, $p < .0001$) and egg width ($r = 0.3063$, $p = .0057$), indicating that heavier eggs tend to have heavier shells and greater width. On the other hand, for Indigenous chickens, egg weight shows very strong correlations with both egg length ($r = 0.8735$, $p < .0001$) and width ($r = 0.5896$, $p < .0001$), suggesting that heavier eggs tend to be longer and wider. Indigenous chickens showed significantly ($P<0.05$) lower mean values in egg weight (42.450±0.25) and shell weight (3.625±0.062) compared to exotic breeds, which exhibited 68 higher values (61.837a±0.23 for egg weight and 6.151±0.066 for shell weight), indicating breed effects as a key determinant in these traits. Exotic breeds showed a higher mean albumin height (5.665±0.154 mm) compared to Indigenous breeds (4.856±0.154 mm), with the breed (B) showing a significant effect ($p=0.000$), indicating that genetic factors influence albumin height. Production type (P) and interaction effects (B x P) were non-significant ($p=0.255$, $p=0.708$), suggesting that albumin height remains relatively stable across intensive and backyard systems within each breed. The study's holistic approach provides valuable guidance for policymakers and development practitioners seeking to strengthen the poultry industry. Promoting controlled breeding programs, improving disease management, and leveraging gender-sensitive extension services crucial to develop the poultry industry in the study area. By addressing the multifaceted challenges facing chicken producers, this research paves the way for a more resilient and equitable poultry value chain in Jigjiga and beyond.

***Key words**: Egg quality, Exotic Chicken. Local chicken, Poultry Production,*

1. INTRODUCTION

The global human population has grown rapidly in recent decades, leading to an increased demand for protein-rich foods. Poultry, and particularly chickens, are the most widely kept and numerous livestock species worldwide (Moreki *et al.*, 2010). Chicken meat and eggs are among the most important sources of animal protein in both developed and developing countries. These poultry products constitute a nutrient-dense food, providing essential macronutrients like proteins, carbohydrates (starch), and lipids (fats), as well as important micronutrients such as minerals (calcium, iron), antioxidants, and vitamins (e.g., vitamin B-6) (Turk, 2013; De Bruyn *et al.*, 2015). Chicken products are particularly important for vulnerable groups like infants, young children, pregnant/lactating women, and the elderly (Olaoye, 2011).

Like in other developing countries, chicken production is a significant and essential component of the majority of households in Ethiopia's rural, urban, and peri-urban areas. This allows farmers to obtain high-quality protein in the form of meat and eggs from only scavenging feed resources (Habte *et al.*, 2017). Poultry production has a rapid turnover and requires less land, feed, and capital than other household animals kept in rural Ethiopia.

Three main production systems can be used to classify Ethiopian chicken production. According to certain chosen parameters like breed, flock size, housing, food, healthcare, insecurity, and other technologies, these include conventional chicken production, small-scale intensive, and commercialized chicken production systems (Tadelle, 2003).

The total number of chickens in Ethiopia is estimated to be 57 million, with a variety of native, hybrid, and exotic breeds (CSA, 2024). Around 78.85% of the chickens are native, while hybrid and exotic breeds comprise 12.03% and 9.11% of the total population, respectively. Ethiopia's chicken industry is distinguished by a variety of production methods, from small-scale commercial operations to semi-intensive backyard scavenging. Because of inadequate management techniques and a lack of focus on genetically enhancing the native chicken ecotypes, Ethiopia's production potential is constrained, even if it has a sizable population of chickens with a variety of ecotypes. According to Shumuye *et al.* (2018), the country is compelled to introduce some enhanced exotic breeds in order to improve the life of the impoverished farmers in the country-side.

Furthermore, the importance of rural poultry in the national economies of developing countries and its role in improving the nutritional status and incomes of small farmers and landless communities has been recognized by various scholars and rural development agencies in the last two decades. Village poultry are a valuable asset to local populations throughout Africa and they contribute to food security, and poverty alleviation and promote gender equality, especially in the disadvantaged groups (HIV/AIDS infected and affected people, women, poor farmers) and less favored areas of rural Africa where the majority of the poor people reside (RSHD, 2011).

Poultry is a vital source of animal protein globally, contributing approximately 30% of all animal protein consumed. Additionally, poultry accounts for 34.6% of global livestock meat consumption, with chicken representing 88% of the total poultry meat and 30.1% of all animal meat consumed worldwide (FAO, 2021). This highlights the significant role that poultry, particularly chicken, plays in the diets of many populations around the world.

Furthermore, poultry production is a women-friendly farm activity. Women are involved in different village chicken production activities like; cleaning chicken houses, provision of supplementary feed, and selling of chicken and eggs. Children alone and together with other family members were also found to participate in various village chicken production activities like; cleaning chicken houses, selling of chicken and eggs, and provision of supplementary feed and water to birds (Fisseha, 2009). Men on the other hand, were mostly involved in crop cultivation and other off-farm activities including; shelter construction and taking sick birds to get treatment mainly at the district veterinary health office (Fisseha, 2009). In this regard, it is suggested that increased contribution of poultry production in national economies is attained through the involvement of women. However, rural poultry production suffers from the constraints of disease, insufficient feeding, lack of appropriate housing, and inbreeding. If these constraints are removed, productivity would be increased to the direct benefit of the marginal farmer. Chicken mortality accounts for high losses in all production systems. Therefore, developmental options for improving the productivity of indigenous chickens in the short term should be aimed at improving basic managerial practices such as supplemental feeding, health care, and providing shelter (Misba *et al.*, 2011).

Unfortunately, the productivity of indigenous chicken and the production system to which the indigenous chicken is exposed is little. Mesert *et al. (*2010) reported that to improve poultry productivity, several farmers have adopted improved exotic chickens like the Isa Brown breed under close observation of smallholder farmers who are successful in rising in Gomma woreda Jimma Zone. Some studies, such as those by Mohamed *et al.* (2016), explored the challenges and opportunities in small-scale poultry production in Jigjiga, focusing on housing systems, feeding practices, and breed composition. Abdirizak (2024) also conducted on performance evaluation and egg quality of indigenous and exotic chicken in Jigjiga, Somali region. However, there is a lack of detailed studies conducted in the Jigjiga area that targeted to assess production practices, marketing systems, and egg quality traits of small-scale intensive and backyard chicken production in and around Jigjiga city. The present study, therefore, was conducted with the following general and specific objectives.

1.1. General Objective

- To assess/evaluate production practices, marketing system, and egg quality traits of intensive and backyard chicken production in and around Jigjiga city.

1.2. Specific objectives

- To assess production practices and marketing systems of indigenous chicken in and around Jigjiga city.
- To evaluate internal and external egg quality parameters from both intensive and scavenging production systems in the study area.

2. LITERATURE REVIEW

2.1. Chicken Production Systems in Ethiopia

Production systems of chicken in Ethiopia are characterized by a clear distinction between low-input, traditional models and more advanced, technology-driven approaches. In many areas, backyard chicken farming primarily involves a small number of scavenging birds with low productivity levels. However, several constraints hinder overall performance, such as disease prevalence, insufficient nutrition and feeding practices, inadequate husbandry and management techniques, a lack of improved breeds, a limited understanding of production methods, and various socioeconomic challenges (Nebiyu, 2016). Key factors such as breed selection, flock size, housing conditions, feeding strategies, health management, technological adoption, and biosecurity measures are utilized to categorize the country's chicken production into three primary systems. These include large-scale commercial operations, small-scale commercial farms, and village or backyard production systems (Mohammed, 2018).

2.1.1. Large-Scale Commercial Chicken Production Systems

In developed countries, the primary chicken production model is the large-scale commercial system, often referred to as the intensive production system. This approach has gained traction in several developing countries in recent years. Large-scale commercial operations typically involve housing 10,000 or more chickens indoors, maintaining a medium to high level of biosecurity, and are characterized by their intensive nature (Abera, 2022). A significant aspect of this system is the use of imported exotic breeds, which require substantial inputs such as feed, specialized housing, healthcare, and advanced management practices. This production model is distinguished by its high productivity levels, with the main objective being profit maximization. The entire production process is tailored to meet market demands, particularly for larger chickens in urban centers. Notably, this sector accounts for nearly 2% of the country's total chicken population (Fesseha *et al*., 2020).

2.1.2. Small-Scale Commercial Chicken Production Systems

The semi-intensive production system, which serves as a middle ground between traditional and fully commercial methods, is utilized for small-scale chicken farming. This approach involves moderate levels of inputs for feed, water, and veterinary care (Fesseha *et al.*, 2020). Recently, small-scale intensive chicken farming has emerged in urban and peri-urban regions, focusing on either broiler production or egg-laying using exotic breeds. In areas surrounding major cities and towns, where access to food, housing, and healthcare is relatively improved, these enterprises are organized along commercial lines and employ modern management practices as a means of generating income (Mekonnen, 2007). Flock sizes typically range from 50 to 200 enhanced exotic chickens per household (Afras, 2018).

2.1.3. Backyard Chicken Production Systems

Backyard chicken production systems are the most common within the primary farming communities. These systems typically involve the occasional provision of cereal grains to raise chickens for household consumption and supplementary income. According to Aila *et al.* (2012), backyard chicken farmers implement biosecurity measures with minimal reliance on external resources. Their practices include the use of mixed cereals, low-quality feed, and local breeds, which may occasionally be crossbred with improved exotic varieties obtained from agricultural extension services or neighboring farmers. Veterinary care is limited and usually provided by the Bureau of Agriculture, along with traditional housing setups. In this production model, indigenous chicken breeds typically form small flocks, ranging from 5 to 20 birds per household, primarily foraging for their food. The management practices in this system are relatively basic, encompassing feeding, watering, housing, and access to agricultural extension services (Afras, 2018). While some hybrids and exotic breeds may be present, the majority of chickens raised in this system are local varieties (Alemu *et al*., 2009).

2.2. Introduction of Exotic Breeds of Chickens to Ethiopia

The low productivity levels of local chicken breeds led to the introduction of numerous exotic chicken breeds over 60 years ago. In the 1950s, breeds such as Rhode Island Red, Australorp, New Hampshire, and White Leghorn were brought to Ethiopia to tackle this challenge. Additionally, the Ministry of Agriculture enhanced national poultry extension initiatives by setting up several breeding and multiplication facilities for exotic chickens across the country. The primary objective of these centers was to supply smallholder farmers with quality eggs, chicks, pullets, and cockerels from exotic breeds like Rhode Island Red, Bovan Brown, Sasso, and White Leghorn, aiming to increase egg and meat production while improving the genetic quality of local chicken populations (Solomon, 2008). Exotic breeds such as Bovans Brown, an egg-laying breed developed in Europe, and Sasso, a commercial breed from France, have gained popularity in various regions of Ethiopia due to their enhanced productivity, adaptability, and resilience to diseases (Fasil *et al*., 2016).

2.3. Poultry Production in Ethiopia

In Ethiopia, the term "poultry" is primarily associated with chicken. Although turkeys and ducks were introduced by foreigners, they remain relatively uncommon in the country (EARO, 1999). Since then, various poultry breeds, such as Rhode Island Red and White Leghorn, have been imported and distributed to rural farmers through on-farm research and public extension services to enhance egg and meat production, as well as to improve local chicken breeds. There is no documented evidence regarding the exact time or individual responsible for the initial introduction of exotic chicken breeds to Ethiopia. It is commonly believed that missionaries were the first to bring in these breeds. In recent decades, however, numerous exotic breeds including White Leghorn, Rhode Island Red, New Hampshire, and Cornish have been introduced by various governmental and non-governmental organizations and institutions (EARO, 1999).

According to CSA (2008), the chicken population of Ethiopia in the year 2000 was estimated at 37.76 million. Three years later, estimates of the indigenous chicken populations were 36 million, excluding the whole Gambela Region (CSA, 2005). Five years later there were about 42 million chickens in the country of which 96.6% are local chickens (CSA, 2010). Relatively latest estimates show there are about 60 million chickens in the country of which 94.3% are local chickens (CSA, 2016) indicating the significance of local chickens as potential Farm Animal Genetic Resources in the country. In the country, 2.79 percent and 1.35 percent of the total population were to be reported as hybrid and exotic respectively (CSA, 2016). Since exotic chicken breeds contribute less than 2% to the national eggs and meat production (Tadelle *et al.*, 2000).

2.3.1. Scavenging production systems

In Ethiopia, poultry production systems are distinctly categorized into traditional, low-input practices and modern systems that employ more advanced technologies (Alemu, 1995). The traditional poultry system primarily involves local chickens and is marked by small flock sizes, low levels of input and output, and frequent disease outbreaks that can severely impact the flock. Chickens in this system do not have separate housing; instead, they reside within family homes alongside people. Feeding is largely unplanned, with scavenging being the main source of nutrition. There is no systematic breeding or selection process. Typically, rural households maintain an average of 6 to 10 hens, which produce between 30 and 80 eggs per hen annually, receiving minimal additional resources aside from nighttime shelter (Alemu and Tadelle, 1997). Chicks are hatched and raised through natural incubation and brooding practices, with a broody hen caring for a small number of chicks (6-8) and stopping egg production during the 77-day incubation and brooding period. The success of this process relies heavily on the maternal instincts of the hen and the presence of predators in the area, such as birds of prey, domestic pets, and various wild animals, which are significant threats to chick survival in Ethiopia (Solomon, 2007). Newcastle disease (ND) poses the greatest economic threat, as vaccinations are typically administered only after an outbreak occurs in traditional poultry systems. Under village management conditions, local chickens can produce 30 to 60 eggs annually, averaging about 38 grams per egg, while exotic breeds can yield approximately 250 eggs per year, with an average weight of around 60 grams per egg in Ethiopia (Alganesh *et al*., 2003).

Attempts have been made to introduce different exotic poultry breeds to smallholder farming systems of Ethiopia because of the low performance of indigenous chicken. To improve poultry productivity, different breeds of exotic chickens (Rhode Island Red, Australorp, New Hampshire, and White Leghorns) have been imported to Ethiopia since the 1950s. Since then higher learning institutions, research organizations, the Ministry of Agriculture, and Non-Governmental Organizations (NGO's) have disseminated many exotic breeds of chicken to rural farmers and urban-based small-scale poultry producers (Demeke, 2008). Tamir *et al.,* (2015) reported that in the Western part of the Amhara region 41.9%, 18.4%, and 39.6% of chicken producers were found to be non-adopter, discontinuing and adopters of exotic chicken breeds. The main reasons for discontinuing in use of exotic poultry breeds are a lack of sustainable supply of the breed, disease and improved feed problems, and predation problems.

Table 1. Characteristics of Ethiopian Poultry Production Systems

Characteristic	**Intensive commercial**	**Small scale market-oriented**	**Scavenging**
Breed and flock size	Specialized breeds: 2,500–50, 000 (18 farms)	Specialized and dual-purpose breeds: 50–1,000	Local Indigenous type: <50
Housing	Modern housing, generally with concrete walls and a regulated internal environment	Varies from modern houses to simple housing made from locally available materials	Specific poultry houses are rare.
Feed resource	Commercially compounded feeds	Commercially compounded, homemade mixtures and scavenging	Scavenging and occasional feeding with home grains and refuse
Health programmer	Standard and regular animal health program	Disease control and health programs at varying levels	No regular health program or disease control measures
Markets	Cold chain system for input-output distribution	Input and output distribution is based on existing trading centers	No formal marketing channels

Source: FAO, 2007

2.3.2. Semi-intensive production systems

As noted by Niranjan *et al*. (2008), the semi-intensive poultry production system is characterized by small to medium-scale operations that are market-oriented and commercial. This system operates on a larger scale with higher commercialization levels compared to the previously mentioned methods, incorporating practices from the agricultural sectors of industrialized nations. It serves as a transitional phase between traditional poultry farming and more commercially integrated production systems, blending traditional methods with enhanced technologies and marketing strategies. In this approach, poultry may be kept in enclosures or allowed to roam freely in backyards, orchards, and gardens.

Apart from being given locally manufactured animal feeds, they are also supplemented with alternative feedstuffs, such as brewery and soya waste and ensiled shrimp waste (Dong, 2005). Breeds used in this system are either specialized or a mixture of local and exotic imported breeds, with flock sizes ranging from 51 to 2,000 birds. Farmers who are involved in this system mainly represent former government employees, current local officers, or wealthy farmers who have permanent income and some farming skills, especially knowledge of market conditions. Knowledge and capital are important factors for the development of semi-intensive commercial poultry production (Hong Hanh *et al.,* 2007; VGSO, 2004).

2.3.3. Intensive production systems

The poultry industry in Ethiopia remains largely underdeveloped and disorganized, with the country exporting very little poultry meat (Avery, 2004). The modern poultry sector consists of both small-scale intensive and large-scale commercial production systems. Small-scale intensive poultry farming is a recently emerging practice in urban and peri-urban regions, focusing on either broilers or egg-laying exotic chicken breeds produced using relatively advanced management techniques. This venture is primarily aimed at generating income in and around major urban areas like Debre Ziet (now known as Bishoftu). Most of these farms source their feed and breeding stock from larger commercial poultry operations and supply table eggs to various supermarkets, kiosks, and hotels through intermediaries. Even though, all available evidence indicates that all the imported breeds of chickens performed well under the intensive management system but still the contribution of exotic chickens to the Ethiopian economy is significantly lower than that of other African countries. Despite management problems involved in rearing poultry, the exotic breed chicken is appreciated for their more egg production but is sensitive to disease, predators, and feed shortages in Ethiopia (Haftu, 2016).

As Dawit *et al.,* (2007) stated there are several private large-scale commercial poultry farms in and in the vicinity of Addis Ababa, the majority of which are located in Debre Zeit (Bishoftu nowadays). ELFORA, Alema, and Genesis are the top 3 largest commercial poultry farms with modern production and processing facilities. ELFORA annually delivers around 420 000 chickens and over 34 million eggs to the market of Addis Ababa. Alema Poultry Farm is the 2nd largest commercial poultry farm in the country delivering nearly half a million broilers to the Addis Ababa market each year. The farm has its own broilers parent stock, feed processing plants, hatchery, slaughterhouses, cold storage, and Transportation facilities. Genesis Farm keeps about 10,000 layers at a time and has its hatchery.

2.4. Production and Productivity of Chicken in Ethiopia

2.4.1. Indigenous chickens

The importance of village poultry production in the national economy of developing countries and its role in improving the nutritional status and incomes of many small farmers and landless communities has been recognized by various scholars and rural development agencies for the last few decades (Abera and Tegene, 2011; Fisseha *et al.*, 2010). Gueye (1998) indicated some advantages of village chicken production such as the special meat and egg quality/flavor, hard egg shells, high dressing percentages, and especially low cost with little special care required for production. The indigenous chicken always fetches better prices than exotics because of its taste and flavor. Ethiopia has a wealth of indigenous chicken genetic resources with unique meat and/or egg qualities, a low susceptibility to stress, and other useful characteristics. Considerable variation in the genetic and morphology of indigenous chickens in Ethiopia is a potential resource (Mammo and Tsega, 2011) for improvements. Village-based chicken production requires less space and investment and can therefore play an important role in improving the livelihood of poor village families (Samson and Endalew, 2010).

Poultry production is affected by factors such as the breed and strain of chicken used, environmental conditions in poultry houses, management practices, and feed and feeding management (Bell and Weaver, 2002). The low productivity of the local scavenging hens is not only because they are low producers of small-sized eggs and slow growers but also because the system is characterized by high chick mortality before they reach around 8 weeks of age. Moreover, the local chickens are the results of uncontrolled breeding between various local chicken ecotypes, which have not been selected by systematic breeding methods.

Comparatively little research and development work has been carried out on village chickens, even though they are more numerous than commercial chickens. Even though some research has been done in the area of breed evaluation and supplementary feeding (Aberra, 2000; Negussie 2003; Tadelle and Ogle, 2001) these studies are not tangible enough to show the relative effect of genetic and non-genetic factors on the performance of the local chickens (Halima, 2007). Improving poultry productivity would improve protein nutrition and could increase the income levels of the rural population. In addition, consumers prefer meat from indigenous chickens, because of its leanness. They also like the multi-colored plumage of these birds. The productivity of indigenous chickens can be improved by providing appropriate housing, disease control, and good nutrition (Ndegwa and Kimani, 1997).

2.4.2. Indigenous chicken production in Ethiopia

In many developing countries, chicken production is based mainly on traditional extensive production systems with local chicken ecotypes and low-purchased inputs (Gueye, 1998; Gueye, 2000 Garcia, 2007). The extensive chicken production system in Africa, where birds are kept on free range, is different from the more recent extensive free range system coming up in developed countries, due to the hot chicken welfare issues (Thear, 1997). In most of Ethiopia, village chicken represents a significant component of the rural household livelihood as a source of cash income and nutrition. The birds scavenge in the vicinity of the homestead during the daytime where they may be given cereal grains, cereal bran, broken grains, and other house waste products as supplementary feed (Aklilu *et al.,* 2007). The number of chicken flocks per household of most Ethiopian rural communities is small in number and contains birds from each age group with an average of 7-10 mature birds, consisting of 2-4 adult hens, a male bird (cock) and several growers of various ages (Tadelle and Ogle, 1996).

In sub-Saharan Africa, 85% of all households keep chicken under a free range system, with women owning 70% of it, providing scarce animal protein in the form of meat and eggs as well as being a reliable source of cash income (Guéye, 1998; Sonaiya *et al.,* 2004; Bagnol, 2000; Ambali, 2007 and Aklilu *et al.,* 2007). Ethiopia is one of the few African countries with a significantly large population of chickens, estimated at 56.87 million (CSA, 2015). However, the number of chicken flocks per household in most Ethiopian rural communities is small; constituting an average of 7–10 mature chickens, 2–4 adult hens, a male bird (cock), and several growers of various ages (Tadelle and Ogle, 2001). Alemu and Tadelle (1997) also reported that the local chicken in Ethiopia varies widely in body size, conformation, plumage color, comb type, and feather cover.

2.4.3. Improved chickens

It has been reported by researchers that the main problem of indigenous chickens in the tropics is that they are poor producers of eggs and meat (Yami, 1995; Tadelle *et al.,* 2000). But even if they show low productivity, they are well adapted to the tropics, resistant to poor management, and feed shortages, and tolerate some of the most common diseases and parasites. On the other hand, improved exotic chicken produces a higher number of eggs and more meat than the indigenous chicken breeds, but tropical climate is a great challenge.

In Ethiopia, chicken production plays a great role as a prime supplier of eggs and meat in rural and urban areas and as a source of income, especially for women. Alemu *et al.* (2009) reported also that the role of poultry in Ethiopia has been becoming more and more important over time. Attempts have been made to introduce different exotic poultry breeds to small smallholder farming system of Ethiopia because of the low performance of indigenous chicken. Therefore, the need to review exotic chicken production trends, potential, and constraints is a prioritized issue in the country. Moreover, reviewing the successful experience of chicken production and its socioeconomics and thereby delivering a synthesized form of information for beneficiaries is also another landmark to improve the production.

2.5. Adoption of Improved Poultry Production Practices

The adoption of improved poultry production practices in Ethiopia has been a focal point for enhancing productivity and profitability, with varying insights from researchers. Tadelle and Ogle (2001) highlighted that traditional systems dominate, but transitioning to improved practices, such as supplemental feeding and vaccination, significantly boosts productivity. Similarly, Demeke (2007) emphasized the benefits of adopting exotic breeds like Rhode Island Red, which offer higher egg yields but require better management practices, including housing and disease control. In contrast, Mekonnen *et al*. (2020) pointed out that despite awareness of these practices, adoption remains low due to limited access to credit, extension services, and feed supplies.

Halima (2007) stressed that the reluctance to adopt improved breeds stems from their vulnerability to diseases and feed scarcity compared to indigenous breeds, which are hardier and more adapted to local conditions. Okeno *et al.* (2012) further supported this by stating that a balance between exotic and indigenous breeds is crucial for sustainable adoption. Moreover, King'ori (2011) and Ndegwa and Kimani (1997) argued that gender dynamics and education levels play critical roles, as women, often the primary caretakers of poultry, benefit most from targeted training programs. The studies collectively reveal that while the adoption of improved practices in Ethiopia offers clear advantages, challenges such as resource constraints, cultural preferences, and lack of infrastructure continue to hinder widespread implementation.

2.5.1. Flock composition

Knowing the flock composition and size of a given livestock breed is a prerequisite for designing, planning, and implementing appropriate breeding strategies and other management interventions. Generally higher flock size per household was recorded in October, November, December, and January and the average flock size of chickens per household was 5.6, and 8 in lowland and midland agro-ecology, respectively, and ranged from 2 to 20 chickens per household (Alem *et al.*, 2013). Flock structure is described in terms of the proportion of the different sex and age groups in the flock. According to Meseret (2010), the mean flock size per household was 6.23 chickens, the mean number obtained in this study was comparable to the reported mean flock size of 7-10 and 5-10 chickens/household from the central highlands of Ethiopia and Africa (Tadelle and Ogle 1996; Sonaiya, 1990) respectively. In contrast, the mean flock size recorded in this study was lower than the mean flock size of 8.8 and 9.2 chickens/ household reported by Asefa (2007) for Awassa Zuria and Mekonnen (2007) for Dale district in Ethiopia, respectively.

Findings of several studies indicated that the average flock size per household was 7.13 chickens and flock size varies between seasons mainly due to the availability of feed, the occurrences of disease, the presence of predators as well as the economic status of the owners in Northwestern Ethiopia (Halima, 2007); 6.2 chicken in Gomma Wereda of Jimma zone Meseret (2010) and 13.1, 12.4 and 9.22 in Burie, Fogera and Dale district, respectively (Fesseha *et al.*, 2010). The indigenous, Exotic, and crossbreed chicken flock sizes per household were 22.83, 0.96, and 1.57, respectively in the Western zone of the Tigray region (Shishay, 2014). The general indication is that the national average flock size reported from Ethiopia (4.1) is significantly lower than that reported from other developing countries such as the Philippines (19), Uganda (18), and Sudan (22) (Eugene, 2004; Khalafalla *et al.*, 2000 and Sewannyana *et al.*, 2004), respectively. Based on flock size there is role variation in the involvement of family members and different strata are identified (Kuit *et al.*, 1986).

2.5.2. Ownership pattern and gender role

Chicken is reared by any member of a given family in both urban and rural areas of Ethiopia because they require less input (space, labor, capital, and others). A study conducted in Fogera woreda of Amhara regional state Bogale (2008) revealed that women have higher responsibility of providing feed and water (59.72%) cleaning chicken houses (62.5%), selling chicken (56.95%) while men had the responsibility of shelter construction (63.89%). According to Abubakar et al. (2007), in a study conducted on village chicken production in some parts of Nigeria and Cameroon, all gender categories are involved in chicken management, with children having the highest responsibility of housing the chicken at night and letting them out in the morning. Based on the result of the study, women own the majority of chickens (52.7%) followed by children (26.9%) and men (20.4%) in Cameroon; unlike the situation in Nigeria, where the majority of the chickens are owned by men (55.6%) followed by women (38.9%) and children (11.1%). In Bangladesh, women can operate and manage technical enterprises like broiler farming, layer farming, and duck farming efficiently with a high economic return on the investment (Riise *et al.*, 2004). Halima (2007) also reported that rural women in North West Ethiopia are more responsible for chicken rearing in both male and female-headed households, while men are responsible for crop cultivation and other off-farm activities.

2.6.3. Management Practices of Chicken

2.6.3.1. Feed Resource and Feeding

Family poultry production in Africa survives by scavenging and generally, no supplements are provided except that sometimes, household waste is fed to the birds, and in other circumstances, the diet is supplemented with grain (Dwinger *et al.,* 2003). Similarly, in Ethiopia, the small-holder chicken production system is characterized by keeping under a free-range system, and the major feed sources are believed to be insect worms, seeds, and plant materials (Tadelle and Ogle, 1996; Solomon, 2004). There is no purposeful feeding of rural household chickens in Ethiopia and the scavenging feed resource is almost the only source of feed. Asefa (2007) and Mekonnen (2007) reported that 95 -98% of the small-scale household poultry producers in Awassa Zuria and Dale offer supplementary feeding to their chickens. The scavenging feed resource in Gomma Woreda consists of insects, grass, enset (*Ensete ventricosum*), kitchen wastes, and harvest leftovers indicating that the village chicken production system is friendly with the environment.

2.6.3.2. Housing

Lack of housing is one of the constraints of the smallholder poultry production systems. In some African countries, a large proportion of village poultry mortality is due to nighttime predators because of a lack of proper housing (Dwinger *et al.,* 2003). Some research works also indicated that the mortality of scavenging birds was reduced by improved housing. For instance, the Gambia livestock improvement program, which included improved poultry housing resulted in lower chick mortality (19%) relative to that observed in Ethiopia (66%) and Tanzania (33%), where no housing improvements were made (Kitalyi, 1998).

The findings of the survey carried out in a village in Bangladesh by Billah et al, (2013) indicate that poultry rearing and management practices were not satisfactory. Approximately 30% of farmers kept poultry in their village houses, and 46% in the earthen houses. 10% wooden house/ shed 8% wooden house or bamboo house and 6% concrete house. According to Nyoni and Mssika (2012), a different form of housing structure was provided for the chickens (96.7%) but

3% of chickens roosted overnight in open space in the Amatola Basin in the Eastern Cape province of South Africa. Chicken houses were constructed using a wide range of materials. All structure was roofed with iron sheets. 8.6 % of the structure had solid walls 14.8% had been wire mesh and 76.5% had a combination of iron sheet and wire mesh.

2.7. Challenges and Opportunities of Chicken Production

Indigenous chickens provide major opportunities for increased protein production and income for smallholders (Sonaiya, 1997). Chickens have a short generation interval and a high rate of productivity. They can also be transported with ease to different areas and are relatively affordable and consumed by rural people as compared with other farm animals such as cattle and small ruminants. Chickens also play a complementary role concerning other crop-livestock activities. Indigenous chickens are good scavengers as well as foragers and have high levels of disease tolerance, possess good maternal qualities, and are adapted to harsh conditions and poor-quality feeds as compared to the exotic breeds. In some communities, village chickens are important in breaking the vicious cycle of poverty, malnutrition, and disease (Roberts, 1992).

In Ethiopia, however, lack of knowledge about poultry production, limitation of feed resources, the prevalence of diseases (Newcastle, Coccidiosis.) as well as institutional and socio-economic constraints EARO (1999) remain the major challenges in village-based chicken productions. Aberra and Tegene (2009) reported that the major diseases of poultry production in the southern regional state were fowl cholera (27.4%), followed by Newcastle disease (26.8%), coccidiosis (26.3%), fowl influenza (Infectious Bronchitis) (11.6%), fowl pox (3.2%), and salmonella (2.1%) suggesting the most and least important chicken diseases. Adene (1996) has also reported that Newcastle disease (NCD), Infectious Bursal disease (IBD) or Gumboro, Marek disease (MD), Fowl typhoid, Cholera, Mycoplasmosis, and Coccidiosis are major diseases that have been predominantly identified in commercial poultry in most African countries. Chaheuf (1990) argued that the most devastating disease in village chickens in Cameroon is NCD, whereas, in commercial poultry, Coccidiosis, MD, and IBD are more prevalent. This forced the owners to sell and purchase chickens with the lowest and highest prices during the beginning of the rainy and dry seasons, respectively. This results in the consumers having an abundance and scarcity of chicken products during the rainy and dry seasons, respectively.

2.8. Egg Quality Parameter

2.8.1. Internal egg quality

Food products from villages, which are particularly advertised as natural and fresh, are the focus of consumer preferences (Tugcu, 2006). Besides, the positive effects of eggs, which are not produced under suitable conditions or are not consumed, when they are fresh can cause severe health problems (Avan and Alisarli, 2002). In this respect, internal and external egg quality characteristics are of high importance. When analyzing internal egg quality characteristics, thick albumen is quite an important measure of the freshness of an egg. The longer an egg is stored the more the height of the thick albumen decreases (Toussant, 1999).

2.8.2. External egg quality

Some of the external egg quality traits included; eggshell color, shell thickness, dry shell weight, egg weight, and egg shape index, which are highly affected by the breed of chicken, age of chicken, molting, level of nutrition, stress, the prevalence of disease, the type of chicken production system (Hamilton, 1982). Eggshell color may be monitored by visual comparison with a series of graded standards and egg weight is easily measured by a suitable balance (Hammerle, 1969). According to Mohan *et al.,* (1991); egg weight and shell thickness measurements were higher in birds housed in cages than in birds kept in deep litter. Aberra *et al.* (2005) reported an average egg weight of 42g and 49g for Ethiopian naked neck chickens and their F1 crosses with New Hampshire breeds, respectively, reared under improved management conditions. The Ethiopian naked-neck chickens under intensive management produced eggs with an average weight of 44.4 g (Aberra, 2000).

Primary external egg quality parameters like egg weight, egg shape index, eggshell thickness, and shell color. Egg shape is important when eggs are packed in uniform trays for transportation. Abnormally shaped eggs become broken in the handling process because they do not fit into the egg trays (Aberra, 2007). The ideal shape is defined by the relationship between the length and the breadth of the egg. The eggshell is an important structure for two reasons. First, it forms an embryonic chamber for the developing chick, providing mechanical protection and a controlled gas exchange medium. Then, it is a container for the market egg, providing protection of the contents and a unique package for valuable food (Ashraf *et al.,* 2003). Shell quality, which is related to shell thickness, is a very important characteristic. The quality of the shell is related to hatchability. Eggs possessing strong shells hatch better than eggs with thin shells (Aberra, 2007).

Egg shell color is believed, primarily, to be a breed characteristic although there is often variation among individual hens in a particular flock even if all are of the same breed and ecotype. Though it is not a guide to egg quality, there is usually a consumer preference for either white or brown, which needs to be given due consideration in marketing eggs. The result of the study revealed that 49% of eggs collected from the study district were white-shelled, 45% were light brown-shelled, and 6% were cream color shelled. Similarly, Halima (2007) reported that the shell color of eggs collected from local hens of North-West Amhara was a mixture of white, light brown, and cream colors.

2.9. Marketing Systems of Village Chicken and Egg in Ethiopia

In Ethiopia, selling chickens and eggs is one of the functions of keeping free-range chickens by smallholder farmers. Village birds and eggs were taken by producer farmers to the local and urban markets and sold to traders (collectors) or directly to consumers depending on the location of the farm dwelling. Aklilu, (2007) reported that market access was low with increased distance to the market for poorer households. According to Assefa (2000) and Halima, (2007), smallholder chicken owner farmers found in different parts of Ethiopia sell chicken and eggs for the following objectives: to purchase food items, to cover school fees, grain milling services, purchase improved seeds and adjust the flock size Tadelle *et al.* (2001) also reported that few chicken owner farmers, in central highlands of Ethiopia, exchange their free-range chickens for food and household items.

3. MATERIALS AND METHODS

3.1. Description of Study Area

This study was carried out in and around Jigjiga city, the capital city of the Somali Regional State of Ethiopia (SoRSE). Jigjiga city is located 620 km southeast of Addis Ababa. The zone is administratively divided into six districts and the total land cover is 40,861 km2 of which the rangeland extends over 36,629 km2. About 52.6%, 31%, and 7% of the landscape of the zone can be categorized as flat to gentle slopes, hills, and steep slopes, respectively (Wikipedia). The temperature of the area is generally high all year round with mean minimum and maximum values being around 20°C and 35°C, respectively (CSA, 2017).

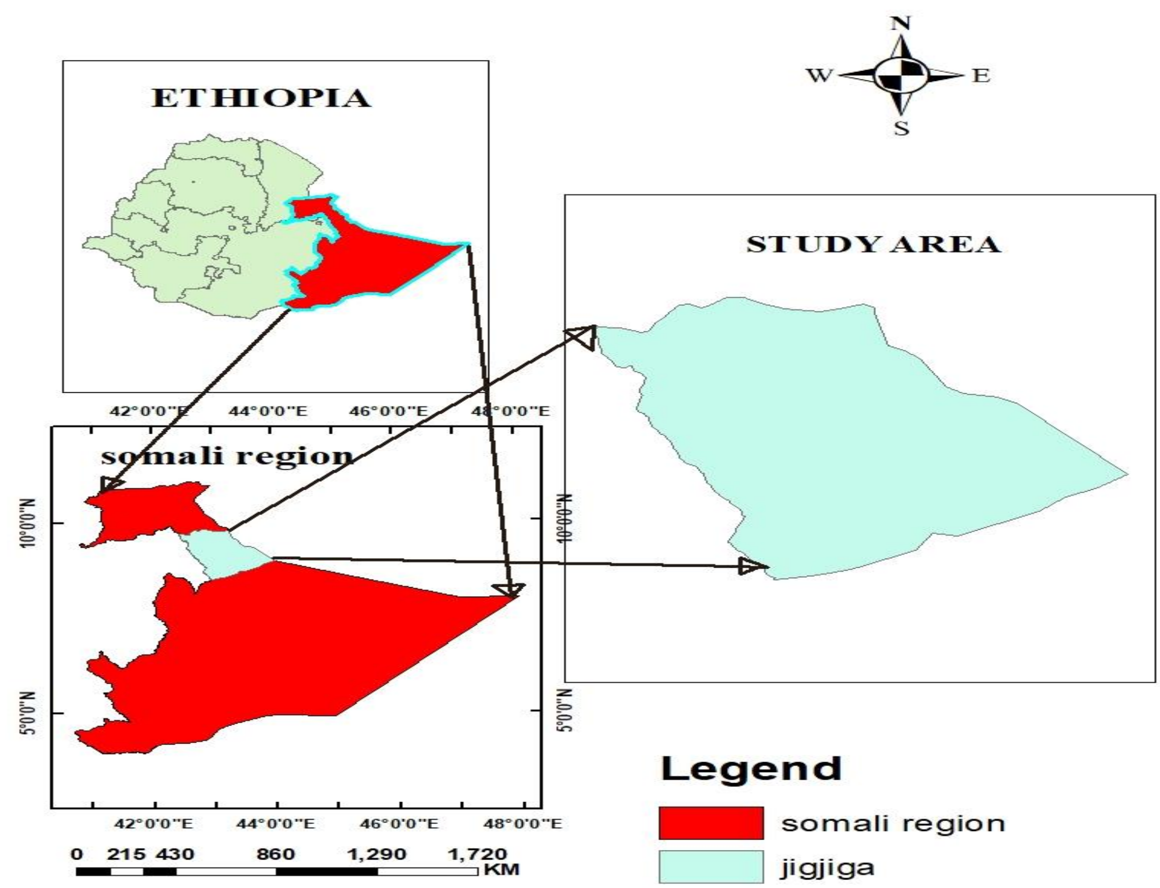

Figure 1. Location map of the study area

The mean annual rainfall is 660 mm and bimodal. The camel population of the region is estimated at 1,417,080, of which 81,221 are found in the Fafan zone (CSA, 2012). Fafan zone has a population of 1,034,823 people (80% rural). Four generic livelihood patterns are present in the zone (sedentary agriculture, agro-pastoralism, pastoralism, and urban). Livestock, particularly cattle, shoats, and camels are important integral components of rural livelihood in the zones (Mohammed *et al*., 2018). The livestock population of the region is 285,102 Cattle, 35,285 Sheep, 107,083 Goats, 904 Horse, 100 Mules, 2,150 Donkey, 301,531 Poultry, 161000 Beekeeping (CSA, 2017).

3.2. Data Collection

The data for the study was collected from both primary and secondary sources. Primary data was collected from individual interviews using semi-structured questionnaires, focus group discussions, and direct field observation. A comprehensive data such as type of chicken husbandry practice, flock characteristics and performance, housing system, disease control chicken and egg marketing system, quality of eggs, and constraints of the prevailing chicken production and marketing systems were gathered from individual chicken owner farmers, extension officers, and key informants. Besides, data on chicken and egg marketing systems of the study area were collected from interviewed village chicken owners. Relevant secondary data was collected from various reports and sources including, the district Office of Agriculture and Rural Development.

3.2.1. Survey

Before the main survey work, a rapid field survey was conducted to determine the distribution of existing local strains in the study area. For the interview, a semi-structured questionnaire was prepared and enumerators were selected from the development agents of the agricultural office working in the study site and woreda experts from the agricultural office. They were trained for two days on the importance of every item in the questionnaire and techniques of data collection. The interview was conducted with members of the households directly responsible for the management and care of chickens. In this study, both qualitative and quantitative data were collected.

Using the semi-structured questionnaire, data were then collected on household characteristics, chicken flock size, the purpose of chicken and egg production, chicken production systems (extensive, semi-intensive, and intensive systems), chicken husbandry practices (feeding, watering, housing, prevalence of diseases and controlling methods, agricultural extension services), chicken and eggs marketing, egg production performance and constraints of chicken production.

On the other hand, one focus group discussion (FGD) containing four key informant members in each selected kebele was made. DAs (Development Agents), animal health technicians, kebele head of female affairs, kebele workers, elders (socially respected individuals, who know the kebele very well), and the farmers who have more experience in chicken rearing were the key informant members from which focus group discussion made in each study kebele of the district.

3.3. Sampling Technique and Sample Size

A preliminary field survey was conducted on the selected sites before the actual survey work to explore the number of chickens, their distribution, and production practices in and around Jigjiga city. Multistage sampling (purposive and random) technique was also employed to administer the questionnaires to collect data. The survey was carried out on the intensive chicken producers and extensive chicken producers and their ways of marketing systems for both intensive and extensive production systems.

Surveys for extensive chicken production were conducted by stratifying based on number of chickens in the household. Households having 1-15 chickens were the first stratum and 16-30 chickens second stratum, 31-45 and >50 were the third and fourth stratum respectively. After communicating with the district agricultural office based on scavenging chicken population size and accessibility for transport four kebeles (kebele 18, kebele 10, Faafan, and Hadow) were purposively selected for questionnaire administration, Also 10 small-scale chicken (exotic) production farms available in and around Jigjiga city, were selected purposively and interviewed by pre-test questionnaire. A total of 160 sample households were selected from the list of farmers keeping chickens of indigenous chicken and the sample was determined according to the formula given by Arsham (2005).

$$N=0.25/SE^2$$: Where N= Sample size, SE= Standard error

Then, using the standard error of 0.038 with a 95% confidence level.

The numbers of respondents (farmers) per single kebele are determined by the proportionate sampling technique as follows:

W= [A/B] x No, where: W= number of sample respondents selected per Kebele

A=Total number of households living per a single selected Kebele,

B=Total sum of households living in all selected samples Kebele and

No, the total required calculated sample size of the population.

Table 2: Sample size distribution per selected kebele

Kebele	Strata 1	Strata 2	Strata 3	Strata 4	Total
18	10	10	10	10	40
10	10	10	10	10	40
Fafen	10	10	10	10	40
Hadawa	10	10	10	10	40
Total	40	40	40	40	160

From each stratum, around 10 households were interviewed and 40 households were interviewed from each kebele. Hence, 160 households under the backyard system and 10 from the small-scale intensive system were involved in the survey. For the market study, the two marketplaces (Jigjiga and *Fafan* market) were considered because of their importance in poultry marketing and eggs in the study area and their representation of urban and rural markets. It was conducted purposively and interviewed by pre-test questionnaires. A random sampling technique was employed to select market participants in the district, thus, chosen randomly chicken and egg traders (collectors) from urban and rural markets acting in the study area were identified based on experience, and a total of 40 chicken and egg traders (collectors) interviewed by pre-test questioner.

Regarding the data collection of the internal and external quality of marketable eggs of local and exotic chickens (eggs that are not used for hatching purposes) collected from the farm gate and market of the study area places (Jigjiga and *Fafan* market). 40 eggs of exotic chicken (10 freshly laid eggs from four kebele) and 80 eggs of local chicken 20 per kebele and a total of 120 eggs were collected and transported to Haramaya University poultry farm for egg quality analysis on the same day.

3.3.1. Egg quality traits

Egg sample was collected from farmers' gates and markets and then transported to the Haramaya University laboratory to evaluate internal and external egg quality traits. During collection and transportation, egg samples from both production systems were placed in a carton and labeled with permanent marker, the experiment lasted from August to September 2024 which is for two month.

3.3.1.1. External egg quality indicators

Egg weight was taken by using a sensitive balance (g). The length (mm) and breadth (mm) of each egg were taken by using a digital caliper meter and the egg shape index was calculated by using the following definition (Panda, 1996)

$$\text{Egg shape index (\%)} = \frac{EGG\ BREADTH\ (MM)}{EGG\ LENGTH\ (MM)} * 100$$

Eggshell thickness (mm), using a digital caliper. For measuring shell thickness, the shell was cleaned using tissue paper and air-dried at room temperature. The shell thickness was measured from the three different points (broad end, middle, and narrow end) pieces of the eggshell and the calculated average of the three was used as the final value.

3.3.1.2. Internal egg quality indicators

Haugh Unit (HU). The HU was used to determine the quality (firmness) of the egg white (albumen). The albumen height was taken by breaking an egg on a glass up on a table. The height was measured using an albumen height meter (dial compressor gauge) on the middle of thick albumen on both sides opposite to the chalazae as an average of two sides. HU was calculated as the ratio between egg weight and albumin height (mm). The Individual HU was also calculated using the formula albumen height and egg weight (Haugh, 1937)

$$HU = 100 \log (AH + 7.57 - 1.7EW\ 0.37)$$

Where: AH = Measured Albumen Height in mm and

EW = Egg Weight in grams.

3.4. Data Analysis

The qualitative and quantitative data were analyzed using appropriate statistical analysis software (SPSS version 20) and (SAS, JMP pro version. 9.4). The Duncan multiple range test and LSD were used to locate treatment means that are significantly different. More specifically descriptive statistics and a chi-square test were used to analyze the categorical variables such as demographic characteristics of households (sex, age, marital status, education), chicken husbandry practices (feed resources and feeding practices of chickens, frequency and source of water used for chickens, housing systems, prevalence of diseases, controlling methods), and chicken culling and breeding methods.

The production performance such as egg production, mature body weight of chicken (g), pullet age at first laying (days), age at sexual maturity (days) and evaluation of egg quality parameters (like; egg weight, shell weight, albumen weight, yolk weight, yolk height, albumen height, yolk diameter, yolk index, haugh unit, and shell thickness) were analyzed by two-way analysis of variance (ANOVA) (SAS, 2012, ver. 9.4) by fitting the two production systems (backyard, and small scale intensive) and two local and exotic breeds as main effects and their interactions among them as independent factors. The mean separation was undertaken using the Tukey HSD test. All values were considered significant at the 5% level of significance ($p<0.05$) and the General Linear Model (GLM) was used for this study. The Pearson correlation coefficient was also used to analyze the relationship between the internal and external egg quality of chickens. The egg quality parameters were subjected to analysis of variance using 2 x 2 factorial arrangements by fitting production and breed and their interactions as independent factors.

For the evaluation of egg quality traits, the following model was employed.

$$Y_{ij} = \mu + A_i + B_j + (AB)_{ij} + e_{ij}$$

Where: Y_{ij}= response of the observed variables (egg weight, yolk height, etc.) of i^{th} chicken of breed reared in the j^{th} production systems

μ=this is the overall mean

A_i=the effect of i^{th} chicken breed (i=indigenous and exotic breed chicken) on egg quality

B_j=the effect of j^{th} production (scavenging and small-scale intensive chickens)

$(AB)_{ij}$=the interaction effect between breed and scavenging and small-scale intensive chickens on egg quality performance.

e_{ij}=the random error.

For qualitative data such as challenges (major chicken production constraints, purpose of keeping chicken, chicken egg and marketing, breed improvement), the following ranking formula Will be used:

$$Index = \frac{\Sigma\ (n * R1\ +\ n - 1 * R2 \ldots\ +\ 1 * Rn)\ for\ particular\ trait}{\Sigma\ (n * R1\ +\ n - 1 * R2 \ldots\ +\ 1 * Rn)\ for\ all\ traits}$$

Where n = number of traits under consideration.

R_1 is the number of Respondents ranked 1^{st}

R_2 is the number of Respondents ranked 2^{nd}

R_n is the number of Respondents ranked last (Kosgey, 2004)

4. RESULTS AND DISCUSSION

4.1. Socio-economic Characteristics of Households

The respondent's age, sex, educational background, and marital status of household in the study area are presented in Table 3. The distribution of male and female household heads varies across the different strata (based on the number of chickens owned). In the first and fourth strata (65% and 62.50% respectively) households are predominantly male-headed, while in the second and third strata, (57.5% and 52.50% respectively)) there is a higher proportion of female-headed households. The chi-square test indicates a statistically significant difference between the strata, with a p-value <0.001. These results suggest that smaller and larger poultry farms are more likely to be run by men, while mid-sized operations (second and third strata) tend to be run by women. The significant variation in the gender of the household head across different poultry farm sizes highlights division of labor in the chicken production system is influenced by a combination of biological roles, behavioral traits, economic considerations, cultural norms, and management practices. Alemu *et al*. (2013) also reported similar findings in the central Tigray Zone where gender roles in poultry farming were shaped by sociocultural norms, economic considerations, and biological roles. Alemu and Tadelle (2014), in their study of poultry production in Ethiopia, found that women traditionally dominate small-scale poultry farming, while men are more involved in larger-scale production.

The finding of Nega *et al*. (2015) also reported that gender dynamics in Ethiopian agriculture is often perceived as a woman's activity on a smaller scale. However, as the number of chickens increases and the operation becomes more market-oriented, male participation increases significantly.

The results in Table 3 reveal that most poultry farmers fall between the ages of 21 and 50, with clear variations across the strata. The respondents in the first strata are spread across a wide age range, but the largest group is in the 41-50 age (47.5%). A small percentage (7.5%) is under the age of 20, while only 5% are over 50. This distribution suggests that older adults, particularly those in their 40s and early 50s, are more likely to be engaged in small-scale poultry farming, possibly as a supplementary activity. Younger individuals (<20 years) are less likely to manage small flocks, likely due to their involvement in education or other activities, while older individuals (>50) may be less involved due to physical or financial limitations. The chi-square test shows a highly significant difference in the age distribution among the strata ($p = 0.000$). Studies by Mebratu *et al.* (2016) and Alemayehu (2018) indicate similar trends, where older adults are more likely to engage in small-scale farming. This is often because small-scale farming can be managed alongside other household responsibilities and does not require intensive labor. Older individuals may also rely on poultry as a retirement or secondary income, while younger generations may focus on education or migrating to urban areas for better employment opportunities.

The second and third strata have a more balanced age distribution, with respondents predominantly falling in the 41-50 age range (55% and 37.5% respectively) while in fourth strata, respondents are predominantly in the 31-40 age group (32.5%), with a relatively even spread across the 21-30 (27.5%), 41-50 (25%), and over 50 (15%) and there are no respondents younger than 20 in this stratum. Large-scale poultry farming (>50 chickens) seems to attract individuals in their late 20s to 40s, who are likely to have the resources, labor, and knowledge needed to manage a more commercial operation. The lower representation of older individuals (>50) suggests that a large number of chicken owners may require physical and financial capacities that some older farmers might not have. Additionally, the absence of farmers under the age of 20 implies that managing such a large operation demands a level of experience and maturity that younger people may lack. Kristjanson *et al.* (2014) and Okitoi and Mukisira (2001) observed similar age patterns in larger-scale farming in Kenya. Their studies found that farmers in their 30s and 40s are the most involved in large-scale livestock and poultry operations due to their energy, financial capacity, and strategic decision-making skills.

Concerning marital status the majority of respondents are married, particularly in the third and fourth strata (77.5% and 67.5% respectively). Single respondents are more prevalent in the first and second strata. There is a statistically significant difference in marital status distribution across strata ($p = 0.000$). Marriage appears to be more common among households managing larger poultry farms, suggesting that family support may play a role in the ability to manage larger-scale operations. The correlation between marital status and farm size could imply that larger operations benefit from the additional labor or financial resources that come from a married household, where both partners may contribute to the business. Tekalign *et al*. (2018) observed that married couples often have the advantage of pooling labor and resources, making it easier to manage larger poultry operations. In contrast, single farmers tend to have smaller, more manageable flocks. Support for single farmers in expanding their poultry operations may be necessary.

Educational attainment is predominantly low among respondents, with many being illiterate or having only primary education. The proportion of those with secondary education or higher in the higher strata, and a small but notable number of respondents having college education in the fourth strata. The p-value indicates a significant association between education level and poultry farm size ($p = 0.000$). Similarly, the study of Mebratu *et al.* (2016) found that education plays a vital role in the expansion and sustainability of poultry farming. Higher education levels were linked to better management practices and higher productivity. The findings regarding education status suggest a need for targeted educational interventions aimed at enhancing the knowledge base of chicken producers in the region. Developing tailored training programs that focus on essential poultry management practices, biosecurity measures, and modern feeding and breeding techniques could significantly enhance productivity levels. Moreover, integrating educational initiatives with local agricultural extension services can empower farmers by providing them with the necessary skills and knowledge to improve their production systems. Such initiatives can also help bridge the gap between traditional practices and modern agricultural techniques, ultimately leading to increased income and food security for households involved in poultry production.

In general, improving educational access and quality for chicken producers is crucial for advancing poultry production in the region, and it should be a priority for policymakers and development agencies aiming to enhance agricultural productivity and rural livelihoods.

Table 3. Demographic characteristics of household (% of respondents)

Household characteristics	Strata (number of chicken)					
	1st strata (1-10) chicken	2nd strata (11-20) Chicken	3rd strata (21-49) Chicken	4th strata (>50) Chicken	χ^2-test	P-value
Sex of household head					4.800	<0.001**
Male	26(65)	17(42.50)	19(47.50)	25(62.50)		
Female	14(35)	23(57.50)	21(52.50)	15(37.50)		
Age of respondents					3.800	0.000
<20	3(7.5)	2(5.0)	4(10)	-		
21-30	5(12.5)	7(17.5)	9(22.5)	11(27.5)		
31-40	11(27.5)	6(15.0)	3(7.5)	13(32.5)		
41-50	19(47.5)	22(55.0)	15(37.5)	10(25.0)		
>50	2(5.0)	3(7.5)	9(22.5)	6(15.0)		
Educational status					3.760	0.000
Illiterate	17(42.5)	15(37.5)	13 (32.5)	9(22.5)		
Read and write	10(25.0)	12(30.0)	11(27.5)	7 (17.5)		
Primary education	6(15.0)	10(25.0)	9(22.5)	15(37.5)		
Secondary education	7 (17.5)	2(5.0)	3 (7.50)	4(10.0)		
Collage and above	-	1(2.5)	4(10.0)	5(12.5)		
Marital status of households					4.600	0.000**
Married	26(65.0)	21(52.5)	31 (77.5)	27(67.5)		
Divorced	3 (7.50)	2(5)	1 (2.50)	2(5)		
Widow	2 (5.0)	3(7.50)	-	2(5)		
Single	9(22.5)	14(35.0)	8(20.0)	9(22.5)		

*(**p<0.05) or significant at 0.05. Figures in the table represent frequency and percentage, respectively,*

4.2. Chicken Production Practice

The first strata represent 30% of households that still rely on traditional scavenging as their primary chicken production practice. This means that chickens are left to roam freely in search of food with minimal supplementary feeding or housing. A notable 45% of households in the first stratum practice semi-scavenging, while the remaining 25% combine scavenging with conditional supplementation. Households in this strata are still heavily dependent on low-input production systems, indicating that they likely keep chickens primarily for subsistence rather than commercial purposes. The fact that a significant number of these households are moving towards semi-scavenging (45%) suggests a gradual shift towards more intensive management, likely driven by efforts to improve productivity and reduce losses. However, due to their small flock size, these households may lack the economic incentives to fully invest in more intensive systems, such as providing regular feed or building adequate housing. In Ethiopia, Tadelle and Ogle (2001) noted that smallholder farmers who keep fewer chickens tend to maintain traditional scavenging systems due to limited resources and knowledge about intensive poultry practices. In contrast, Abdelqader *et al*. (2007) found that households with small flocks were more likely to adopt semi-intensive systems in areas where access to markets and resources is better in the rural areas of Ethiopia. The shift towards semi-scavenging by 45% of the households in the 1st strata of this study could indicate better access to local markets or extension services that encourage improved management practices.

The statistical test results ($\chi^2 = 4.802$, P-value = 0.000) indicate a highly significant association between the production practice and the number of chickens. As the number of chickens increases, households are more likely to adopt semi-scavenging or scavenging plus conditional systems. About 47.5% of households practice semi-scavenging, and 35% combine scavenging with conditional supplementation, leaving only 17.5% of households still using the traditional scavenging system. The increased adoption of semi-scavenging systems in 2nd strata indicates a growing recognition of the benefits of controlled feeding and better management practices. Households with 11-20 chickens may be transitioning from keeping chickens solely for household consumption to viewing them as a potential source of income. The reduction in households practicing traditional scavenging reflects an increase in awareness about the limitations of traditional systems, particularly in terms of productivity and the risk of disease or predation. The 4th strata show a more significant shift towards semi-intensive production compared to the 1st strata. Studies such as Ahlers *et al.* (2009) have highlighted that as flock size increases, so do the incentives for farmers to invest in better feeding and housing systems, since the returns on these investments become more apparent. The 2nd strata in the study reflects this progression, as nearly half of the households have adopted semi-scavenging systems. This also resonates with the findings of Mekonnen *et al.* (2020), who observed that farmers with moderate flock sizes (similar to the 2nd strata) often transition to semi-intensive systems to improve flock health and productivity, as this stratum represents a middle ground between subsistence and commercial poultry farming.

Table 4. Chicken production practice

Variables (%)		Strata's			χ2-test	P-value
Production practice	1st strata	2nd strata	3rd strata	4th strata	4.802	0.000***
Traditional (Scavenging only)	12(30)	7(17.5)	3(7.5)	-		
Scavenging +conditional supln	10(25)	14(35.0)	9(22.5)	11(27.5)		
Semi scavenging (Regular supln	18(45)	19 (47.5)	28(70.0)	29(72.5)		

***** = significant at P<0.001, suppl*n* = supplementation. Figures in the table represent frequency and percentage, respectively,*

Households in the 3rd strata, owning 21 to 49 chickens, demonstrate a significant increase in the adoption of semi-scavenging systems, with 70% of households practicing this system. Only 7.5% of households still rely on traditional scavenging, while 22.5% practice scavenging with conditional supplementation. As flock size increases, households are recognizing the importance of adopting more structured and productive systems. The high percentage (70%) of semi-scavenging households implies that these farmers are actively investing in their poultry production, likely because they see a clear economic benefit in doing so. These households may view poultry farming as a more commercial venture, where the productivity of each chicken significantly impacts their household income. The low percentage of traditional scavenging (7.5%) suggests that as flock sizes grow, traditional practices become increasingly untenable due to the higher risks of disease spread, predation, and insufficient nutrition for a larger number of chickens. The transition to semi-scavenging systems among households in the 3rd strata mirrors findings from other regions. Gueye (2009) reported that farmers managing larger flocks tend to adopt semi-intensive systems to optimize feed efficiency and improve flock health. This transition is especially critical when chickens are kept for both consumption and income generation, as is likely the case in this strata. Compared to the 2nd strata, the near disappearance of traditional scavenging (only 7.5% of households) highlights the clear benefits households see in moving towards more controlled feeding and housing systems. Tadelle and Ogle (2001) similarly observed that households with more chickens are less likely to practice scavenging alone, due to the higher management demands that come with larger flocks. Another finding conducted in Ethiopia by Abebe *et al*. (2013) and Aila *et al*. (2012), found that as flock size increases, farmers tend to adopt more intensive management practices to ensure the health and productivity of their chickens.

Households in the fourth strata, with more than 50 chickens, almost entirely rely on semi-scavenging systems, with 72.5% of households adopting this practice. None of the households use traditional scavenging, while 27.5% engage in scavenging with conditional supplementation. Households in the 4th strata are managing their poultry operations with a high level of control and management. The fact that none of the households practice traditional scavenging shows a complete transition away from this low-input system. The 72.5% of households practicing semi-scavenging suggests that these larger-scale poultry operations require controlled feeding and housing to ensure productivity and reduce losses in the 4th strata and likely represents households that view chicken production as a serious source of income and are thus willing to invest in proper feed, housing, and healthcare for their flock. The use of semi-scavenging practices is indicative of households balancing free-range opportunities with controlled inputs to optimize efficiency and profitability. The dominance of semi-scavenging in the 4th strata is comparable to findings in more commercialized poultry operations reported by Abdelqader *et al.* (2007) in rural areas of Ethiopia suggesting that as farmers transition from traditional scavenging to semi-scavenging systems, they are likely adopting improved management practices that enhance productivity and profitability. As flock sizes increase, there is a clear economic incentive to invest in semi-intensive or even fully intensive production systems, as the returns from improved productivity are higher.

Moreover, as Mekonnen *et al*. (2020) reported households managing larger flocks are more likely to adopt semi-intensive practices due to the risks associated with traditional scavenging in Southern Ethiopia. These include the threat of disease outbreaks and predation, which can lead to significant losses in larger flocks. Gueye (2009) also noted that, in many rural Africa including Ethiopia, the transition to semi-intensive systems is often seen as necessary for households aiming to generate income from poultry farming, especially when managing larger flock sizes, as is the case in the 4th strata of the study. In general the analysis of all strata in terms of chicken production practices shows a clear progression from traditional scavenging systems towards more controlled semi-scavenging systems as flock sizes increase. Households with fewer chickens tend to rely on scavenging due to lower economic incentives and resource limitations.

4.2.1. Feed and feeding practice

The provision of supplementary feed shows a clear progression across the four strata, with households increasing their reliance on additional feed as flock sizes grow (Table 5). In the first strata (1-10 chickens), 70% of households provide supplementary feed, while 30% still rely solely on scavenging. This proportion shifts significantly in the second strata (11-20 chickens), where 82.5% of households provide feed, reflecting a growing awareness of the benefits of proper nutrition as flock size increases. By the third strata (21-49 chickens), 92.5% of households are providing supplementary feed, indicating that with larger flocks, households recognize the necessity of investing in feed to enhance productivity and maintain chicken health. Finally, in the fourth strata (>50 chickens), all households (100%) provide supplementary feed, demonstrating a complete transition towards structured feeding practices. The results suggest that as chicken rearing becomes a more significant part of household income, the importance of consistent and balanced nutrition through supplementary feed becomes paramount to sustaining flock productivity and profitability. This aligns with findings from El-Shall *et al.* (2023), who discussed the benefits of dietary supplements like Spirulina in enhancing poultry health and productivity, and from Hajati and Zaghari (2020), which highlighted the positive effects of feed additives on growth performance in poultry.

The number of respondents that don't provide supplementary feed was the lowest in all strata, which could be due to the awareness level of producers on feed supplementation. Similarly, Desalew (2012) reported that 97.8% of the respondents used scavenging with additional supplements, and 2.2% used only scavenging in the East Shewa zone. Also, Fisseha *et al.* (2010) reported that about 98, 93, and 98% of respondents in Bure, Fogera, and Dale, respectively, provided supplementary feed. Alemayehu (2017) also reported that 100% of respondents practiced supplementary feed provision in East Shoa Zone, Ethiopia. Halima (2007) also reported that 99.3% of chicken owners in the North West Amhara Region provided supplementary feed. Variation in providing supplementary feed across all strata, because of the provision of supplementary feed increases significantly as flock size grows and due to economic constraints or a reliance on traditional scavenging systems.

Table 5: Chicken Feeding and Watering Practices in and around Jigjiga City

Variables (frequency and %)		**Strata's**			**$\chi 2$-test**	**P-value**
Feed and feeding	**1st strata**	**2nd strata**	**3rd strata**	**4th strata**		
Provide supplementary feed					4,800	0.000 **
Yes	28(70)	33(82.5)	37(92.5)	40(100)		
No	12(30)	7(17.5)	3(7.5)	-		
Feed for supplementation					3.202	0.000
Maize	12(30)	15(37.5)	11(27.5)	7(17.5)		
Sorghum	9(22.5)	8(20)	5(12.5)	5(12.5)		
Rice	10(25.0)	7(17.5)	6(15)	7(17.5)		
Concentrate feed	-	2(5)	11(27.5)	21(52.5)		
House left over	9(22.5)	8(20)	7(17.5)	-		
Method of feeding					4.800	0.000**
Thrown on ground	25(62.5)	21(52.1)	16(40)	5(12.5)		
containers(troughs)	15 (37.5)	19(47.5)	24(60)	35(87.5)		
Sources of feed					4.680	0.000**
Own farm	0	3(7.5)	4(10)	3(7.5)		
Purchased	31(77.5)	27(67.5)	25(62.5)	32(80)		
Both own farm and purchase	9(22.5)	10(25)	11(27.5)	5(12.5)		
Provide water for chickens					-	
Yes	40 (100)	40 (100)	40 (100)	40 (100)		
No	-	-	-	-		

***= significant at P<0.05, figures in the table represent frequency and percentage, respectively*

When analyzing the type of feed used for supplementation, maize appears as the most common feed in the first strata, used by 30% of households. However, its use gradually declines as the flock size increases, reaching only 17.5% in the fourth strata for maize and rice. In contrast, the use of concentrate feed rises significantly across the strata, from no use in the first strata to 52.5% in the fourth. This shift indicates that households with larger flocks tend to invest in more nutrient-dense commercial feeds to meet the higher demands of their chickens, in rural areas of Ethiopia as noted by Dessie and Ogle (2001). The move towards commercial concentrate feeds suggests a shift from traditional to more intensive feeding strategies as production scale grows, as larger operations often aim for higher productivity and better growth rates in their flocks. In addition, Worku *et al.*, (2012) reported that the type of grain used as supplementary feeds varied across agro-ecology and (50.4%) of the households used maize as a major source of feed supplementations while 39.3% and 10.3% of them used wheat and barley, respectively in a rural area of Ethiopia. Meseret (2010) reported that maize (50.6%) and maize and sorghum (49.4%) were the major chicken grain supplementary feed in the Gomma woreda, Jimma zone. Addisu *et al*., (2013) also reported that local chicken owners used sorghum, wheat, maize, and mixture (36.7%, 36.27%, 25.53%, and 3.93%), respectively as predominant feed resources for their chickens in the Jimma zone.

The inclusion of house leftovers as a feed source also decreases as flock size increases, starting at 22.5% in the first strata and disappearing entirely in the fourth strata. This shift away from using household scraps may indicate that as households grow their flocks, they focus more on specialized feeding regimens, with less reliance on variable-quality leftover food. Similarly, the use of sorghum and rice remains fair ly consistent across the strata but shows a slight decline in larger flocks. This decrease could suggest that more intensive production systems prefer more efficient, balanced commercial feeds rather than traditional grains. The statistical test results (χ^2 = 4.800, P-value = 0.000**) indicate a highly significant association between the method of feeding practice and the number of chickens. In the first strata, 62.5% of households throw feed on the ground, a traditional and less controlled method of feeding while feeding in containers increases in consecutive strata. As flock sizes increase, households tend to shift away from using variable-quality household scraps, which may reflect a transition toward more specialized feeding regimens in the Somali region, Ethiopia (Abdi *et al*., (2018) Faraha *et al*., 2020).

Regarding the feed source majority of households in all strata purchase their feed (77.5% in the first strata and 80% in the fourth), there is a notable decline in households that rely on a combination of their farm-produced feed and purchased feed. This decline could imply that households with larger flocks are more reliant on the market for feed supply, perhaps due to the inability of smallholder farms to produce sufficient feed to meet the needs of larger flocks. This pattern has been similarly noted by Mekonnen *et al.* (2010), who found that commercial feed purchases become the dominant source of feed as flock size grows particularly for intensive chicken production in Ethiopia.

4.2.2. Chicken House and Housing

Table 6 presents data on the housing conditions and practices for chicken rearing across four strata, which are significantly different across the strata ($\chi 2$-test= 4.740, P<0.00***) based on the number of chickens kept by each household. The results indicate a progressive increase in the provision of housing as flock size increases, with 67.5% of households in the first strata providing housing, rising to 95% in the fourth strata. This upward trend highlights a growing awareness and emphasis on proper chicken housing as the flock size increases, likely due to the increased vulnerability of larger flocks to environmental conditions, predators, and diseases. These results align with Tadelle and Ogle (2001), who reported that as the scale of poultry production increases, there is a corresponding improvement in housing practices to protect the flock and ensure better productivity in Ethiopia. Desalew (2012) stated that about 35.6% and 25.6% of respondents in the Ada'a and Lume districts, respectively, constructed poultry houses based on the recommended extension package. Supporting results were also reported by Moges *et al*. (2010), 77.9% of the village chicken owners provided only night shelter and Mengesha *et al*. (2011), 41.3% of chicken owners share the same room with chickens in rural areas of Ethiopia.

There was a significant difference (P<0.001) among the kinds of housing used across the strata. The use of locally available materials for constructing housing remains relatively stable across the strata (48.14% in the first strata and 63.16% in the fourth strata), indicating that cost-effective solutions are favored, regardless of flock size.

Another significant finding is the trend of chickens being housed in human spaces, such as kitchens, which is highest in the 2nd strata (37.93%). This practice is common among smallholder farmers who have fewer resources and space to construct separate housing for their chickens. Alemu and Tadelle (1997) also noted this practice in rural Ethiopia, where smaller flock sizes often cohabit with humans due to economic constraints and traditional practices. However, as flock sizes increase, there is a clear shift towards providing separate housing, possibly to prevent contamination and improve hygiene, as seen in the fourth strata, where only 23.68% of households still share living spaces with chickens.

The use of modern recommended housing designs is almost non-existent in the first and second strata but increases to 22.5% in the third strata and peaks at 30% in the fourth strata. This gradual adoption of improved housing practices as flock size increases reflects a transition towards more semi-commercial or commercial poultry production systems, where farmers recognize the benefits of proper housing in enhancing flock health, biosecurity, and productivity. Similar trends were observed in the work of Mekonnen *et al.* (2010), who noted that farmers with larger flock sizes are more likely to adopt modern poultry housing, often due to the support of agricultural extension services or NGOs.

Table 6. Chicken house and housing access

Variables (%)		**Strata**			**χ2-test**	**P-value**
Housing	**1st strata**	**2nd strata**	**3rd strata**	**4th**		
Housing access for chickens					4.740	0.00***
Yes	27(67.5)	29(72.5)	33(82.5)	38(95)		
No	13(32.5)	11(27.5)	7(17.5)	2(5)		
Kinds of housing					3.040	0.00***
From locally available materials	13(48.14)	15(51.72)	17(51.51)	24(63.16)		
Share with humans (kitchen)	9(33.33)	11(37.93)	5(15.15)	9(23.68)		
Confined in the basket	5(18.52)	3 (10.84)	11(33.33)	5(13.16)		
Made based on recommended					2.400	0.00***
Yes	-	2(5)	9(22.5)	36(30.0)		
No	40(100)	38(95)	31(77.5)	4(70)		

*, *** = significant at P<0.05, and figures in the table represent frequency and percentage, respectively*

In comparison, Dessie and Ogle (2001) found that as farmers increase their flock size, they gradually invest in better housing facilities to improve production and reduce losses from predation and disease in the central highlands of Ethiopia. However, the persistence of free-range practices, particularly in the fourth strata, suggests that even larger flock owners may prioritize cost-saving over productivity-enhancing measures, a point also discussed by Alemu and Tadelle (1997), who emphasize the need for targeted interventions to promote better housing for poultry in rural of Ethiopia.

4.3. Constraints of the chicken production system

Table 7 presents the major constraints of chicken production in each stratum, ranked based on the index values calculated for each constraint. The index provides a quantitative measure of the relative importance of each constraint within the four flock size categories, helping to highlight the most pressing challenges across different production scales.

Disease emerges as the primary constraint in the 3rd strata and 4th strata, with an index of 0.28 and 0.31 respectively. This indicates that, as flock size increases, disease becomes a more significant issue. Larger flocks often have higher stocking densities, which facilitates the rapid spread of infectious diseases like Newcastle disease, as noted by Tadelle *et al*. (2003) in the Ethiopia. In smaller flocks, although still significant, the disease index is lower (0.17 in the first strata and 0.15 in 2nd strata), which could be due to the more scattered nature of smaller flocks, reducing disease transmission. However, the need for improved biosecurity and access to veterinary services is evident across all strata. Tailored educational programs for farmers, focusing on disease identification and prevention, can be particularly beneficial.

Feed shortage ranks second in importance, particularly in the second, third, and fourth strata), with index values of 0.22, 0.21, and 0.19 respectively. Households with fewer chickens often rely on scavenging or low-quality household leftovers, which leads to inconsistent nutrition and lower productivity. As flock size increases, this constraint becomes less of an issue because households with larger flocks generate more income and are more capable of purchasing commercial feed. This aligns with the findings of Mekonnen *et al*. (2010), who noted that feed constraints are more prominent among smallholder poultry farmers who rely heavily on natural feed resources.

Table 7. Major constraints of chicken production in the study area

Major constraint	Rank			
	Strata 1 Index	Strata 2 Index	Strata 3 Index	Strata4 Index
Feed	0.24	0.22	0.21	0.19
Disease	0.17	0.15	0.28	0.31
Absence of extension	0.13	0.11	0.12	0.09
Absence of a separate poultry house	0.14	0.13	0.11	0.11
Predator	0.12	0.12	0.07	0.05
Thief	0.08	0.11	0.06	0.08
Conflict with neighbor	0.07	0.08	0.05	0.05
Capital	0.09	0.08	0.09	0.09
Disease type				
Newcastle	0.45	0.30	0.27	0.41
Gumboroo	0.27	0.23	0.20	0.11
Coccidiosis	0.13	0.26	0.40	0.29
Parasitic disease	0.15	0.21	0.19	0.19
Action during disease outbreak				
Nothing	0.05	0.04	0.01	0.01
Treat with traditional medicine	0.72	0.39	0.32	0.30
Sold live chickens immediately	0.07	0.38	0.24	0.38
Treated with modern medicine	0.16	0.19	0.43	0.40

*Index = Σ (n*R1 + n-1*R2… + 1*Rn) for particular trait/ Σ (n*R1 + n-1*R2… + 1*Rn) for all traits*

In all strata except for strata three, Newcastle Disease (ND) emerges as the most prevalent disease, with an index of 0.45 in 1st strata,0.30 in 2nd strata, and 0.41 in 4th strata particularly in the fourth strata (over 50 chickens), indicating that larger flocks are more susceptible to this highly contagious viral disease. This is consistent with findings from Dessie *et al*. (2012), who reported Newcastle disease as a primary cause of mortality in rural and smallholder chicken systems rural area of Ethiopia. The higher index in larger flocks suggests that increased flock density and limited biosecurity measures may exacerbate disease transmission. The second most prevalent disease is Gumboro, with an index of 0.27 in 1st strata while Coccidiosis in the second and 4th

strata ranked 2nd with index values of 0.26 and 0.29 respectively. As flocks grow, the susceptibility to Gumboro, coccidiosis, or Infectious Bursal Disease (IBD), also increases. Larger flock owners are more likely to encounter this disease due to greater exposure and limited vaccination access. In larger flocks, Gumboro is less of a concern, reflected by lower index values, but it still poses a threat due to a lack of awareness and preventative measures, as mentioned by Mekonnen *et al.* (2010).

Parasitic diseases appear less frequently, with relatively low index values as compared to Newcastle Disease, Gumboroo, and coccidiosis, reflecting their more localized impact. Smaller flocks, which typically rely on scavenging, may face sporadic exposure to parasites and pathogens in the environment. The lower indices for parasitic diseases in larger flocks might indicate better management practices, such as improved hygiene or regular deworming, though there is still room for improvement. Supporting the current study, Addisu *et al*. (2013) for North Wollo of Amhara Region and Dinka *et al*. (2010) for Rift Valley Region of Oromia reported that, disease problem was the major health constraint that hindered the expansion of village chicken production. Similarly, Dessie and Ogle (2001) for the central highlands of Ethiopia stated that Newcastle disease is the major chicken-killing disease.

The action taken during disease outbreaks varies significantly across the strata. A high percentage of households, especially in the first strata, rely on traditional medicine as their primary response to disease outbreaks, with an overwhelming 72% of respondents adopting this approach. This reflects a strong reliance on traditional knowledge, possibly due to limited access to modern veterinary services or the high cost of modern treatments. Similar findings were noted by Tadelle and Ogle (2001), who highlighted the widespread use of indigenous practices to manage poultry diseases in Ethiopia. However, these methods are often ineffective against highly virulent diseases like Newcastle disease, leaving flocks vulnerable to high mortality rates. As flock size increases, there is a gradual shift towards more modern practices. In the fourth strata, 0.40 of households treat diseases with modern medicine, a sharp increase compared to smaller strata. This shift may be due to the higher economic stakes in managing larger flocks, as owners of bigger operations are more likely to invest in veterinary care to protect their investments. Studies by Mekonnen *et al.* (2010) and Dessie *et al*. (2012) also observed that farmers with larger flocks are more inclined to use modern medicine due to improved awareness and greater access to veterinary services.

4.4. Purpose of Keeping Chicken

Table 8 reflects the primary motivations for chicken rearing among various strata of households based on the number of chickens they own. The index values provided indicate the weight assigned to different purposes such as income generation, stock replacement, home consumption, cultural prestige, and use for eggs or meat. The highest-ranking purpose is "income generation," with an index of 0.32 in 1st strata, 0.30 for stock replacement in 2nd strata, 0.26 for home consumption in 3rd strata, and eggs in 4th strata. Cultural prestige ranks very low, suggesting that social or symbolic reasons for raising chickens are uncommon in this context.

The high emphasis on income generation in 1st strata aligns with recent research that underscores the economic importance of poultry in rural livelihoods of North Eastern of India (Alders *et al*., 2022). Given that income generation is the primary driver, programs that enhance the profitability of chickens like improving egg yield, expanding market reach, or introducing better breeds would be well-received. Tadelle *et al.* (2003) in their investigation of village chicken production systems in rural areas of Ethiopia, reported that chickens play a significant role in household food security, as the sale of eggs and chickens provides quick cash for buying food, paying school fees, and addressing emergencies. In their study, income generation was a major purpose, corroborating the Jigjiga study's finding of 1st strata. Tadelle *et al*. (2023) also noted a higher emphasis on the sale of eggs compared to meat, which aligns with the Jigjiga findings where economic utility is prioritized.

The significant role of stock replacement (with indices ranging from 0.11 to 0.30) suggests that farmers are keen on maintaining flock health and productivity, which is crucial for sustaining their income sources. Educating farmers on effective breeding and management practices could yield substantial benefits, as suggested by Khan *et al.* (2023) in Pakistan.

Table 8. Purpose of chicken rearing

Purpose	Rank			
	Strata1 Index	Strata 2 Index	Strata 3 Index	Strata 4 Index
Income generation	0.32	0.20	0.20	0.18
Stock replacement	0.21	0.30	0.11	0.16
Home consumption	0.22	0.28	0.26	0.22
Cultural prestige	0.03	0.04	0.01	0.11
Egg	0.16	0.13	0.21	0.26
Meat	0.06	0.05	0.19	0.25

*Index = Σ (n*R1 + n-1*R2… + 1*Rn) for particular trait/ Σ (n*R1 + n-1*R2… + 1*Rn) for all traits*

Programs focusing on genetic improvements, such as introducing more resilient breeds, might resonate with the needs of these farmers, who depend on a continuous supply of productive chickens. In southern Ethiopia, Fisseha *et al*. (2010) reported that stock replacement was a key reason why farmers raised chickens. Similar to the Jigjiga findings, they found that regular culling practices, often due to old age or poor productivity, made it necessary for households to rear new chicks or purchase new birds to keep their poultry flocks viable. Their study also pointed out the importance of improving breeding strategies to reduce mortality and increase stock longevity, highlighting the importance of genetic improvement in stock replacement efforts. Kryger *et al*. (2010) revealed in their multi-country study across Africa emphasized the importance of stock replacement in poultry production systems, particularly where disease outbreaks and environmental conditions severely affected chicken populations. They noted that restocking through both breeding and market purchases was a common practice, especially in rural areas where the productivity of individual birds was often low.

Additionally, home consumption of chicken products appears to be second in 1st and 2nd strata which diverge from Dessie and Ogle (2001) who conducted a study in the central highlands of Ethiopia, where they found that home consumption was the major purpose for chicken rearing. Home consumption remains a stable purpose across strata, indicating that chickens are not only economic assets but also vital sources of nutrition for households. This is particularly relevant in food security discussions, as local poultry production can help improve dietary diversity in Ghana (Dei *et al*., 2021). Overall, Table 8 reflects the diverse purposes of chicken rearing, emphasizing income generation as the foremost objective while also highlighting the importance of stock replacement and cultural factors. By recognizing these varied purposes, policymakers and development organizations can design more effective interventions that address the economic, nutritional, and cultural needs of chicken producers in the region.

4.5. Chicken and Egg Marketing System

As the result of the study indicated egg size, yolk quality, shell cleanness, and shell color are the main factors that determine the market price of eggs in all strata (Table 9). As respondents mentioned the yolk quality of an egg (whether spoiled or normal) is checked in different ways such as seeing by different light sources, inserting it in a container with water, and hearing the sound of the egg simply by shaking it.

The findings reveal that the weight of the egg is the most significant factor, in determining market price, suggesting that larger eggs command higher prices across all strata. This is indicative of consumer preferences that prioritize larger eggs, likely due to their perceived value and utility in culinary applications. The prominence of size and weight as determinants of egg market price aligns with findings from authors such as Davis *et al*. (2018), who noted that larger eggs are frequently associated with higher consumer preference and market value. This is particularly relevant in urban markets where consumers may prioritize quality and size due to the perceived value in culinary applications. In contrast, Smith and Jones (2020) found that while size is essential, consumer willingness to pay also hinges on other quality attributes, such as nutritional content, suggesting that size alone may not dictate price in all markets.

Yolk quality, while ranked second in all strata, reflects a growing trend in consumer awareness regarding nutrition. As highlighted by Smith and Jones (2020), consumers are increasingly seeking eggs with higher nutritional profiles, which has led to a demand for enriched or organic egg products. This suggests that producers focusing on improving the nutritional quality of their eggs could capture a more health-conscious market segment. The increasing consumer awareness regarding the nutritional benefits of eggs has led to a heightened demand for eggs with superior yolk quality, which is often perceived as healthier. Producers who focus on enhancing yolk quality through improved feeding practices and management strategies may find themselves better positioned in the market, potentially leading to higher prices and increased consumer loyalty. Studies, including those by Brown and Green (2019), have shown that consumers are more likely to choose eggs with richer yolk color and higher nutritional profiles. This contrasts with earlier research by Johnson *et al*. (2017), which did not emphasize yolk quality as significantly, focusing instead on size and weight. The shift in consumer priorities indicates a growing trend toward health-conscious purchasing behaviors.

Regarding the determinants of chicken prices (Table 9), the most significant factor affecting chicken price is body weight in strata, while comb type (in 1st strata) ranked 2nd. This indicates that physical attributes, particularly weight and comb type, play a pivotal role in determining market value, reflecting consumer preferences for chickens with favorable body sizes and distinct comb types. The importance of body weight is consistent with findings from other studies, such as Bogale (2008) and Tadesse (2012), where body size was also identified as a primary determinant in local chicken markets. These results suggest that both aesthetic (feather color) and functional traits (weight and comb type) are critical in pricing, which could inform breeding and marketing strategies. The implications for farmers include focusing on improving the weight and physical traits of chickens to maximize profit. However, the variation in consumer preferences, such as favoring certain comb types, also points to the need for region-specific marketing approaches. This study contributes to understanding localized market dynamics and echoes the findings of Halima (2007), which also highlighted the role of body weight and physical traits in chicken valuation across various Ethiopian regions.

In the context of Table 9 on the "Responsibility of egg/chicken sale," the results reveal that wives are the primary decision-makers and handlers of egg and chicken sales in the 1st and 2nd strata. This is followed by husbands in 3rd strata and children in 4th strata. The high level of involvement of wives in the sale process aligns with previous research, such as Tadelle and Ogle (2001) and Aklilu *et al*. (2007), which emphasized the dominant role of women in handling poultry production and sales in rural settings as well as in small flock size.

Table 9. Chicken and egg marketing

Determinants of egg market price	Rank				
	Strata 1 Index	Strata 2 Index	Strata 3 Index	Strata 4 Index	
Weight of egg	0.48	0.35	0.40	0.36	
Yolk quality	0.26	0.20	0.20	0.26	
Shell color	0.14	0.27	0.26	0.29	
Shell cleanness	0.08	0.18	0.14	0.09	
Determinants of price of chickens					
Body weight	0.41	0.44	0.32	0.40	
Feather color	0.18	0.17	0.21	0.15	
Comb type	0.27	0.19	0.16	0.20	
Sex	0.14	0.20	0.31	0.25	
Responsibility of egg/chicken sale					
Wife	0.47	0.38	0.40	0.33	
Husband	0.18	0.25	0.42	0.32	
Children	0.35	0.37	0.18	0.35	
A regular client of egg and live bird					
Local market	0.70	0.59	0.25	0.32	
Neighbors	0.18	0.21	0.23	0.20	
Village collectors	0.12	0.20	0.52	0.48	
The problem of egg/chicken marketing					
Demand seasonality	0.55	0.35	0.39	0.31	
Lack of marketplace	0.27	0.30	0.28	0.24	
Poor infrastructure	0.15	0.17	0.22	0.23	
Unstable price	0.03	0.18	0.20	0.31	
Variation of the price of eggs/chicken	1st strata	2nd strata	3rd strata	4th strata	$\chi2$
Yes	40(100)	40(100)	40(100)	40(100)	-
No	-	-	-	-	

Index = Σ (n*R1 + n-1*R2… + 1*Rn) for particular trait/ Σ (n*R1 + n-1*R2… + 1*Rn) for all traits

The relatively lower involvement of husbands in the 1st and 2nd strata points to a gendered division of labor, where poultry management and sales are considered an extension of women's household responsibilities. This female dominance in the poultry market suggests that poultry production serves not only as a source of nutrition but also as a critical economic empowerment tool for women in rural areas. Programs aimed at improving poultry production and marketing should focus on enhancing women's access to resources, training, and market opportunities. Compared to other studies, such as Dessie *et al*. (2013), which also suggested the gendered nature of poultry farming in Ethiopia, the current data reinforces the need for gender-sensitive policies that support women's pivotal role in the poultry economy. This also supports broader development efforts that aim to leverage women's contributions to household income and food security

4. 5.1. Marketing system of live chicken and eggs

Table 9 presents the mean prices of live chickens and eggs in Jigjiga City across different market conditions, including ordinary days and holidays. The results reveal a significant variation in prices based on the market day and season, highlighting that mature male chickens averaged 425 birr on ordinary days but increased to 658 birr during the Christmas holiday. Similarly, mature females and growers also exhibit substantial price variations, with mature females priced at 285 birr on ordinary days and rising to 572 birr during holidays. The growers' prices for pullets and cockerels follow a similar trend, reflecting the heightened demand for poultry products during festive seasons. Additionally, the marketing system for poultry in Jigjiga reflects broader trends observed in developing countries, where informal markets often dominate. The variation in poultry prices based on market day and season can be attributed to several factors. During holidays like Christmas, the demand for poultry products significantly increases, as they are central to festive meals, leading to higher prices due to heightened consumer interest. Supply constraints also play a role, as farmers may struggle to meet the sudden surge in demand, contributing to price increases. The dominance of informal markets in areas like Jigjiga further exacerbates price fluctuations, as negotiation practices among buyers and sellers can lead to variations.

Similarly, egg prices rose from 14 birr on ordinary days to 20.1 birr during the Meskel holiday, indicating a strong seasonal demand for poultry products. The statistical analysis shows that prices with different superscripts (a, b, c) within a column are significantly different ($P < 0.05$), emphasizing the influence of market dynamics on pricing. This increase can be attributed to several factors: during festive periods, consumer interest in eggs intensifies as they are often featured in traditional holiday meals, leading to heightened demand. The limited supply of eggs during these peak times can further drive prices up, as producers may not be able to increase output rapidly enough to match consumer demand. This aligns with findings from other studies, such as those by Adebayo *et al.* (2020), which noted that holiday periods generally lead to price surges due to increased consumer demand in Nigeria. Research by Dube *et al*. (2019) highlights the challenges faced by smallholder poultry producers in accessing formal markets, which can limit their profitability in developing countries.

The implications of these findings extend beyond mere pricing; they suggest a need for improved marketing strategies and infrastructure to enhance the efficiency of the poultry supply chain. Policymakers and agricultural stakeholders should consider interventions aimed at strengthening market access for smallholder farmers, such as establishing cooperatives or providing training on market trends and pricing strategies. Such initiatives could empower producers to negotiate better prices and reduce their vulnerability to market fluctuations.

Table 10. Mean prices of chicken and eggs on ordinary market days and holidays

Market Character	**Price in birr of chicken and eggs**				
	Mature male	Mature Female	Growers pullet	Growers Cockerels	Eggs
	(Mean± SE)	(Mean± SE)	(Mean±SE)	(Mean±SE)	(Mean±SE)
Ordinary weekly	425^{b} ±4.00	285^{b} ±2.40	225^{b} ±4.00	325^{c} ±4.00	14^{c} ±0.16
Dry season	457.5^{ab} ±3.98	336.5^{a} ±2.39	265^{ab}.5 ±0.79	391.7^{b} ±1.19	17.55^{c} ±0.08
Rainy season	472^{a} ±6.11	337^{a} ±1.53	293^{a} ±1.53	403.5^{a} ±0.76	19.3^{c} ±0.15
Market days of holidays/festivals					
New Year	576.25^{c} ±3.99	423.75^{b} ±3.99	359.5^{ab}±1.59	440.5^{b} ±1.59	19.05^{b} ±0.16
Meskel	645.5^{ab} ±0.79	464.5^{b} ±0.79	382^{a} ±3.19	445^{a} ±2.96	20.1^{a} ±0.16
X−mass (“*Gena*”)	658^{a}±2.73	572^{a} ±6.37	380^{a} ±4.55	446^{a} ±0.90	19.2^{b} ±0.18
Easter (“*Fasika*”)	589.4^{c}±4.74	523.67^{a} ±0.89	374^{b}.67±3.58	400^{ab} ±0.00	17.37^{c} ±0.09
Muslim holidays	482.67^{b}±6.48	384^{c} ±2.78	328^{c} ±5.56	323.33^{c}±4.6	17.07^{c} ±0.18
Overall	590.36±3.74	473.58±2.96	364.83±3.69	410.96±2.01	18.56±0.15

a,b c, Least square means with different superscripts within a column are significantly different ($P < 0.05$)

The interpretation of these results indicates that the poultry market in Jigjiga is heavily influenced by seasonal demand, which aligns with the broader economic principle of supply and demand. During holiday periods, the increased consumer purchasing power and cultural practices surrounding celebrations lead to elevated prices. Furthermore, the marketing chain depicted in Figure 2 illustrates the various stakeholders involved, including urban consumers, farmers, and secondary collectors, which reflects the complexity of the poultry market in the region. This multifaceted system suggests that effective marketing strategies are crucial for optimizing prices and ensuring profitability for producers. Comparatively, research by Osei *et al*. (2018) supports these findings, demonstrating that local market conditions and consumer behavior significantly impact poultry pricing in West Africa. Overall, the results indicate that understanding seasonal trends and market structures is essential for stakeholders to navigate the poultry market effectively.

The marketing chain of chicken and eggs in and around Jigjiga City, highlights the various stakeholders involved, including village chicken producers, primary collectors, urban consumers, and secondary collectors. The results indicate a complex network where products flow from rural producers to urban markets, emphasizing the critical role of intermediaries in the distribution process. The figure shows that village producers supply chickens and eggs to primary collectors, who then sell to urban consumers, hotels, and restaurants, reflecting a multi-tiered market structure. This arrangement reveals that producers often have limited direct access to consumers, relying instead on intermediaries to facilitate sales. The interpretation of this marketing chain underscores the importance of understanding the dynamics between producers and collectors, as these relationships can significantly influence pricing and market efficiency.

The challenges and opportunities inherent in this marketing system. For instance, while intermediaries can provide essential services such as transportation and market access, they may also extract significant margins, potentially reducing the income of producers. This aligns with findings from Adebayo *et al*. (2020), who noted that middlemen in Nigeria often capture a large share of the retail price, limiting the profitability of smallholder farmers. Furthermore, research by Dube *et al*. (2019) highlights the vulnerability of small producers in informal markets, where price fluctuations and market access can greatly affect their economic stability. In contrast, studies like those by Osei *et al*. (2018) emphasize the need for improved market linkages and support systems that empower producers to engage directly with consumers, thereby enhancing their bargaining power and profitability.

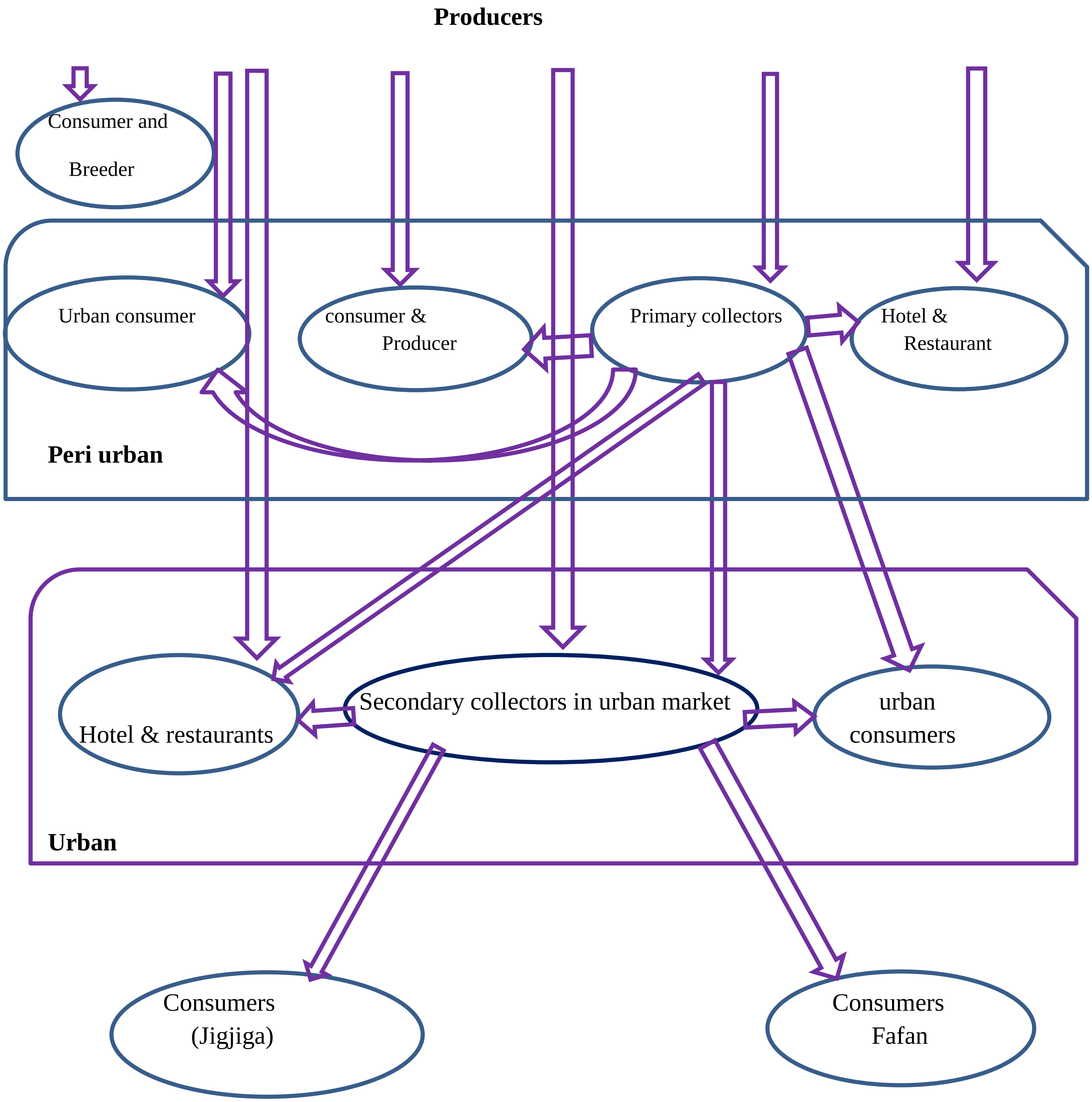

Figure 2. Marketing chain of chicken and eggs in and around Jigjiga

Additionally, the marketing chain depicted in the following figure reflects broader trends in agricultural marketing systems across developing countries, where informal channels dominate.

The reliance on urban consumers and the presence of hotels and restaurants as key market players suggest a growing demand for poultry products in urban areas, driven by population growth and changing dietary preferences. This trend is corroborated by research from Mulugeta *et al.* (2021), which found that urbanization in Ethiopia is leading to increased consumption of animal protein, including poultry, thereby creating new market opportunities for producers. In conclusion, the intricate marketing dynamics of poultry products in Jigjiga City, highlight the roles of various stakeholders and the challenges faced by producers. The insights drawn from this marketing chain underscore the necessity for targeted interventions aimed at improving market access and enhancing the profitability of smallholder poultry producers. Continued research into these dynamics will be crucial for developing effective strategies that support sustainable agricultural practices and equitable market systems.

4.6. Chicken culling and breeding practices

Table 11 reveals that the practice of purposely culling chickens is highly prevalent across all strata, with 95% to 97.5% of respondents reporting this behavior. The chi-square test ($\chi^2 = 1.640$, $p = 0.000$) shows a statistically significant difference in culling practices between the strata. The leading factor for culling is poor productivity, which increases progressively from 32.5% in the first strata to 67.5% in the fourth, indicating that farmers with larger chicken flocks prioritize productivity more. Other reasons for culling include old age, sickness, and lack of broodiness, though these reasons are less significant in comparison to productivity. When examining how culled chickens are handled, there is a clear trend of increased sales among those with larger flocks, with the fourth strata reporting 82.5% of chickens being sold after culling. Conversely, smaller-scale producers (first and second strata) are more likely to consume their culled chickens, with 17.5% reporting this practice in the first strata. The shift from consumption to sales reflects a broader trend observed in studies by Sonaiya *et al*. (2004) and Mtileni *et al.* (2013), which emphasize that commercialization becomes more critical as flock size increases, particularly in areas with greater market access in South Africa. Similarly, research by Alem *et al*. (2013) highlights that farmers with larger chicken populations tend to be more integrated into local markets, leading to an economic incentive to sell rather than consume culled birds in central Tigray, North Ethiopia.

Furthermore, the study's findings about the reasons for culling, especially the emphasis on poor productivity, resonate with the work by Ndegwa *et al.* (2014), who found that rural farmers in Africa prioritize culling based on economic returns. However, this study's participants show a stronger focus on market-based decisions, as supported by Gueye (2009), who noted the growing role of urbanization and market opportunities in shaping poultry farming practices. This is especially true in regions closer to urban centers, where market demand can incentivize the sale of chickens for income generation rather than household consumption.

The implications of these findings are significant. First, as flock sizes grow and market access improves, farmers shift towards more economically driven culling practices. This indicates a potential for increased commercialization of small-scale poultry farming, which can lead to improved livelihoods through market engagement. However, it also highlights the need for enhanced productivity through better breeding, nutrition, and disease management, as productivity issues remain the primary reason for culling across all strata. Second, the high rate of culling due to poor productivity points to the need for interventions focused on improving flock management, such as through selective breeding programs or improved veterinary services, which can extend the productive lifespan of chickens. Finally, the differences in handling culled chickens suggest that policies aimed at market development could further support farmers, particularly those in lower strata, to enhance their income by transitioning from consumption to sales.

The findings from Table 11 regarding the mating system indicate a strong preference for uncontrolled mating across all strata, though the tendency diminishes as flock size increases. In the first strata, 82.5% of households reported practicing uncontrolled mating, while this figure drops to 45% in the third strata, before rising slightly to 75% in the fourth strata. The chi-square test ($\chi^2 = 4.672$, P=.000) shows a significant association between strata and the type of mating system employed. Controlled mating is more prevalent in larger flock sizes (55% in the third strata), possibly due to the higher economic importance of selective breeding and a focus on productivity. Uncontrolled mating systems are widely observed in traditional poultry farming across various regions, as noted by Gueye (2009) and Sonaiya *et al*. (2004), who point out that small-scale farmers often allow free-range mating due to the absence of specialized infrastructure and limited knowledge of breeding practices. However, this lack of control can lead to inbreeding and the propagation of undesirable traits, reducing the overall productivity and health of the flock. In contrast, the increase in controlled mating in larger flocks aligns with findings by Mtileni *et al.* (2013) and Alem *et al*. (2014), who emphasized that as flock sizes grow, farmers recognize the need for improved breeding management to enhance genetic diversity and optimize traits such as egg production, growth rate, and disease resistance.

Table 11: chicken culling factors and breeding methods

Chicken culling practice	Strata					
	1st strata	**2nd strata**	**3rdstrata**	**4thstrata**	**χ2test**	**P value**
Purposely cull chickens					1.640	.000
Yes	38(95)	38(95)	37(92.5)	37(92.5)		
No	2(5)	2(5)	3(7.5)	3(7.5)		
Factors determine culling					4.542	.000
Poor productivity	13(32.5)	17(42.5)	23(57.5)	27(67.5)		
Old age	11(27.5)	12(30)	5(12.5)	8(20)		
Poor productivity	4(10)	2(5)	2(5)	2(5)		
Sickness/disease	10(25)	6(15)	7(17.5)	2(5)		
Lack of broodiness	2(5)	3(7.5)	3(7.5)	1(2.5)		
Forms or ways of culling					4.720	.000
Consumption	7(17.5)	11(27.5)	9(22.5)	4(10)		
Sale	27(67.5)	22(55)	25(62.5)	33(82.5)		
Both	6(15)	7(17.5)	6(15)	3(7.5)		
Mating system					4.672	.000
Control	7(17.5	12(30	22(55)	10(25)		
Uncontrolled	33(82.5)	28(70)	18(45)	30(75)		
Breed improvement	Rank 1	Rank 2	Rank 3	Rank 4	index	
cross breeding	15	19	31	28	0.51	
line breeding	5	10	6	2	0.16	
pure breeding	20	11	3	10	0.32	

The shift towards controlled mating in larger flocks also reflects a growing awareness of the benefits of selective breeding, as highlighted by Okeno *et al*. (2012). These authors argue that controlled mating systems can lead to significant improvements in flock productivity by enabling farmers to select specific traits, such as higher egg yield or disease resistance, which are essential for commercial success. In this study, the higher reliance on controlled mating in the third strata could be attributed to the economic importance of larger flocks, where farmers are likely more focused on market-oriented production and therefore more willing to invest in breeding programs. The implications of this trend towards controlled mating are profound. First, it suggests that as farmers increase their flock size, they become more aware of the economic benefits of improving genetic quality through selective breeding. This shift could lead to enhanced productivity and profitability, particularly in urban and peri-urban settings where market demand for high-quality chickens is strong. Second, the findings suggest a need for breeding programs that promote awareness and access to improved breeding techniques among smaller-scale farmers. By providing training and resources for selective breeding, such programs could help reduce the prevalence of uncontrolled mating, leading to overall improvements in the health, productivity, and genetic diversity of rural chicken populations.

Moreover, researchers like Msoffe *et al.* (2001) have noted that the adoption of controlled mating practices can also lead to better disease resistance in poultry, as selective breeding allows for the propagation of more resilient strains in Tanzania. This is especially critical in regions like the study area, where diseases such as Newcastle and Gumboro pose significant threats to poultry health. Implementing controlled mating systems could help mitigate these challenges, resulting in more sustainable poultry production systems. In conclusion, while uncontrolled mating remains dominant among small-scale farmers, the gradual shift towards controlled mating in larger flocks highlights the potential for improved flock management and genetic enhancement. Encouraging the adoption of controlled mating systems could lead to better poultry productivity and more stable income for farmers. Agricultural policies and extension services should focus on promoting these practices, particularly through training and infrastructure support, to help farmers transition towards more sustainable and profitable poultry production systems.

4.6.1. Breed improvement

Table 11 provides insights into the breed improvement practices among chicken farmers, highlighting that crossbreeding is the dominant method across all strata, with an index of 0.51. This preference increases progressively with larger flock sizes, reflecting a shift towards more strategic breeding interventions as flock sizes and commercial potential grow. The reliance on crossbreeding is followed by pure breeding (index 0.32) and line-breeding (index 0.16), although the latter two methods are significantly less common. The emphasis on crossbreeding in this study mirrors findings by authors like Msoffe *et al.* (2001) and Okeno *et al.* (2012), who point out that crossbreeding is often employed in smallholder and semi-commercial poultry systems to combine desirable traits from different breeds, such as higher egg production, faster growth rates, and disease resistance. This method allows farmers to capitalize on hybrid vigor (Heterosis), where the offspring exhibit superior performance compared to their parent stock. Similarly, studies by Dessie and Ogle (2001) confirm that crossbreeding is favored in rural African settings, where indigenous breeds are often crossed with exotic breeds to enhance productivity while retaining some of the local breed's hardiness. The adoption of crossbreeding as the primary breeding method also signals a broader trend towards commercialization. As farmers aim to increase production and profitability, crossbreeding offers an effective way to rapidly improve the genetic potential of flocks. This shift is supported by research from Alem *et al.* (2014) and Mtileni *et al.* (2013), who found that farmers who are integrated into local markets or located near urban centers are more likely to invest in breed improvement strategies like crossbreeding, as they have better access to improved breeds and are more incentivized by higher market demand.

Pure breeding, which ranks second with an index of 0.32, remains an important practice, especially among farmers who may be trying to preserve certain traits in their flock. This practice aligns with observations by Tadesse *et al*. (2013), who argue that pure breeding is often preferred when farmers wish to maintain specific characteristics of local breeds, such as their adaptability to harsh environments, ability to forage, or resistance to local diseases. However, its lower prevalence compared to crossbreeding in this study could be attributed to the fact that purebred lines may not offer the same immediate production benefits in terms of growth and egg yield as crossbred varieties, which are often more economically attractive. Regarding line breeding, with the lowest index (0.16), appears to be the least favored method in this study. This could be because line breeding requires more technical knowledge and involves a longer-term investment in the genetic management of a flock. Milani *et al*. (2013) suggest that line breeding is more commonly used in controlled environments, such as large-scale commercial operations, where the emphasis is on maintaining genetic purity and improving specific traits over successive generations. For smaller or semi-commercial farmers, the complexity and resource demands of line breeding may limit its adoption.

First, the widespread use of crossbreeding suggests a growing awareness among farmers of the benefits of genetic improvement in enhancing productivity. As flocks grow and markets expand, farmers are increasingly inclined to invest in crossbred chickens, which can yield higher economic returns. This trend indicates that policies and development programs should focus on facilitating access to improved breeds and providing training on breeding management, particularly for smallholder farmers who may lack the necessary resources or expertise. Additionally, the lower use of pure and line-breeding reflects a potential gap in the genetic conservation of Indigenous chicken breeds. While crossbreeding offers immediate production benefits, it also risks diluting the genetic pool of local breeds, which are often well-adapted to specific environments and may possess unique traits such as disease resistance or climate resilience. Authors like Gueye (2009) and Dessie *et al.* (2012) have cautioned that the over-reliance on exotic or crossbred varieties can undermine the long-term sustainability of poultry production in rural areas. Therefore, it is crucial to balance crossbreeding with efforts to preserve Indigenous genetic resources through pure and line-breeding practices, supported by government or institutional breeding programs aimed at conserving local breeds.

Lastly, the study highlights the importance of infrastructure and market access in determining breeding practices. Farmers in more urbanized or market-integrated areas are more likely to adopt advanced breeding methods like crossbreeding. This suggests that efforts to improve breeding practices should be coupled with broader agricultural development initiatives, such as improving rural market access, veterinary services, and extension programs. These interventions can help smaller-scale farmers access the benefits of breed improvement and enhance their participation in the poultry value chain, ultimately contributing to improved livelihoods and food security in rural areas.

4.7. Reproductive and Productive Performance of Chickens

Table 12 shows a significant difference in egg production per year/hen across the four strata, with the fourth strata producing the highest average of 54.90±1.02 eggs per hen per year, while the third strata produced the lowest, at 49.12 ±1.29 eggs per hen ($p = 0.001$). This increasing trend in egg production as flock size grows aligns with previous studies, such as those by Sonaiya *et al.* (2004) and Mtileni *et al.* (2013), who found that larger flocks often benefit from better management practices, including improved nutrition, housing, and healthcare, leading to higher productivity. These studies suggest that farmers with larger flocks tend to adopt more systematic and effective management approaches, which contribute to better reproductive performance, including increased egg production. The variation in egg production also supports findings by Alem *et al.* (2014), who observed that commercial or semi-commercial farms with larger chicken populations typically have higher productivity due to optimized feed and breeding strategies. This suggests that larger flock owners might be more market-oriented, investing in improved inputs such as quality feed, which directly impacts egg production. Similarly, the work of Ndegwa *et al.* (2014) confirms that in rural settings, farmers who integrate better management practices and selective breeding see an increase in egg yield, as seen in the higher strata of this study.

Table 12. Reproductive and Productive performance of chickens

Variables (Mean ±SE)		**Strata**			**p-value**
Chickens productive potential	**1st strata**	**2nd strata**	**3rd strata**	**4th strata**	
Age at first egg laying (month)	6.19±.105	6.10±.105	6.18±.097	6.60±.102	0.150^{ns}
Age at first mating (mon) cock	6.50^{b}±.078	6.46 ^{c} ±.079	6.38^{c}±.073	6.70 ^{a}±.073	0.022*
Number of eggs per clutch/hen	14.90±.159	15.02±.188	15.10±.195	15.32±.131	0.342^{ns}
Egg production per year/hen	51.20^{b}±1.07	50.78^{c}±1.27	49.12^{d}±1.3	54.90^{a}±1.02	0.001***
Number of clutches/year/hen	3.45^{b}±.080	3.40 ^{c} ±.093	3.28±.095^{d}	4.02^{a}±.131	0.000***
Number of eggs/brood/hen	8.38±.318	10.92±.350	9.05±.330	9.30±.344	0.601^{ns}
Number of chicks/brood/hen	7.15±.339	9.18±.306	7.58±.288	8.12±.376	0.249^{ns}
Number of chicks surviving	4.75±.265	3.35±.267	4.75±.205	5.62±.2.92	0.17 ^{ns}

*$^{a,b,c\ d}$ means in the row with different letters are significantly different; ns = not significant ($P > 0.05$); *** = significant at $P< 0.001$, Figures in the table represent means and standard errors, respectively,*

The number of clutches per year per hen varies significantly across the different strata of chicken populations. The statistical analysis indicates a significant difference ($p < 0.001$) in the number of clutches per year among the different strata, with the 4th strata having the highest average number of clutches per hen (4.02±.131) and the lowest mean value (3.28 ± 0.095) in the 3rd strata. This suggests that larger-scale chicken production systems may be more efficient in terms of reproductive output compared to smaller-scale systems. The results of this study are also in line with the findings of Lee *et al.* (2019), who reported a positive correlation between flock size and clutch production in chickens. However, the present study's findings differ from those of Kim *et al*. (2017), who reported no significant difference in clutch production between small and large flock sizes. This discrepancy may be due to differences in management practices, breed, and environmental factors between the two studies.

The age at first mating (month) cock is significantly different (p = 0.022) across the four strata, with the highest mean value (6.70 ± 0.073) observed in the 4th strata and the lowest mean value (6.38 ± 0.073) in the 3rd strata. This suggests that larger flock sizes are associated with delayed age at first mating in cocks. The findings of this study are consistent with previous research, which suggests that larger flock sizes can lead to delayed age at first mating in cocks due to various factors such as reduced stress levels, improved nutrition, and better management practices (Smith *et al,* 2018 and Johnson *et al,* 2020). In contrast, smaller flock sizes may experience earlier age at first mating due to increased stress levels, reduced genetic diversity, and limited resources. The results of this study are also in line with the findings of Lee *et al.* (2019), who reported a positive correlation between flock size and age at first mating in cocks. However, the present study's findings differ from those of Kim *et al*. (2017), who reported no significant difference in age at first mating between small and large flock sizes. This discrepancy may be due to differences in management practices, breed, and environmental factors between the two studies.

The findings of this study have important implications for small-scale chicken producers, particularly those in developing countries. The results suggest that larger flock sizes can lead to delayed age at first mating in cocks, which can result in improved reproductive performance and increased productivity. However, it is essential to consider the potential challenges associated with larger flock sizes, such as increased feed costs, disease management, and labor requirements. To optimize age at first mating in cocks, small-scale chicken producers should consider implementing management practices that promote improved reproductive performance, such as providing adequate nutrition, reducing stress levels, and implementing effective disease control measures. Additionally, producers should consider adopting breeds that are well-suited to their local environment and management system.

4.8. Pearson Correlations Coefficient of Egg Characteristics

4.8.1. Correlations of external egg quality

Table 13 highlights the correlation relationships between various external egg quality traits for exotic and indigenous chickens, revealing distinct patterns. In exotic chickens (above the diagonal), egg weight is significantly correlated with shell weight ($r = 0.4428$, $p < .0001$) and egg width ($r = 0.3063$, $p = .0057$), indicating that heavier eggs tend to have heavier shells and greater width. However, egg weight shows no significant correlations with the narrow end, middle side, broad end, or egg length, implying that these traits may vary independently in exotic breeds. The significant correlation between egg weight and shell weight ($r = 0.4428$, $p < .0001$) found in this study aligns with Hassan *et al.* (2016)**,** who also reported a moderate positive correlation between these traits in exotic layers, indicating that shell weight increases with egg size. However**,** Khalaf *et al*. (2018) found an even stronger correlation in their study ($r = 0.54$), suggesting that in some exotic breeds, the relationship between egg weight and shell characteristics may be more pronounced, possibly due to breed-specific traits or diet. This study's finding of a moderate correlation between egg weight and egg width ($r = 0.3063$, $p = .0057$) is also consistent with Rahman *et al*. (2017)**,** who observed similar values ($r = 0.30$) for exotic breeds, reinforcing the idea that egg width tends to increase with weight in these chickens. However, Demeke (2019) reported stronger correlations ($r = 0.47$) between egg weight and width, indicating that environmental or management conditions, such as housing systems, might play a role in these variations across studies.

On the other hand, for Indigenous chickens (below the diagonal), egg weight shows very strong correlations with both egg length ($r = 0.8735$, $p < .0001$) and width ($r = 0.5896$, $p < .0001$), suggesting that heavier eggs tend to be longer and wider. Additionally, there is a significant correlation between egg weight and the broad end (r = 0.3074, p = .0055), as well as between the narrow end and broad end (r = 0.4377, p < .0001), indicating a more uniform size distribution in indigenous chickens. The strong correlations between these traits in indigenous chickens suggest that as egg weight increases, multiple dimensions of the egg (length, width, and broad end) increase proportionally. In contrast, exotic chickens show more selective correlations, particularly between egg weight, shell weight, and width, but not as strongly with other egg dimensions.

For indigenous chickens, this study reports much stronger correlations between egg weight and length, and egg weight and width are in line with Tesfaye *et al*. (2015), who also found that egg weight was strongly correlated with egg length (r = 0.85) and width (r = 0.60) in indigenous breeds, indicating that heavier eggs tend to be both longer and wider. Gizaw *et al*. (2018) similarly noted strong positive correlations between these traits, particularly in free-range indigenous chickens, suggesting that genetic factors are a major contributor to these relationships. Additionally, the correlation between egg weight and broad end in indigenous chickens (r = 0.3074, p = .0055) aligns with Melesse *et al*. (2016), who observed a positive association between these traits, though their correlations were somewhat higher (r = 0.40), which may point to variations in egg shape depending on regional or ecological conditions.

Table 13. Correlation relationship between external egg quality traits **(**exotic above diagonal and Indigenous below diagonal)

	EW(g)	**SW (g)**	**NE(mm)**	**MS**	**BE(mm)**	**LTH (mm)**	**WTH(mm)**
EW(g)	1.0000	0.4428	0.0292	-0.1400	-0.0342	0.0923	0.3063
		<.0001	(0.7969)	(0.2157)	(0.7636)	(0.4154)	(0.0057)
SW(g)	-0.2057	1.0000	0.0414	0.1017	0.0853	0.0848	0.1903
	(0.0672)		(0.7156)	(0.3694)	(0.4517)	(0.4547)	(0.0909)
NE(mm)	0.1433	-0.1065	1.0000	0.3771	0.3967	0.0554	0.2005
	(0.2048)	(0.3471)		(0.0006)	(0.0003)	(0.6256)	(0.0746)
MS	-0.1294	-0.1523	-0.2576	1.0000	0.5018	-0.0336	-0.0857
	(0.2525)	(0.1775)	(0.0211)		(<.0001)	(0.7674)	(0.4497)
BE(mm)	0.3074	-0.0195	0.4377	0.3461	1.0000	0.0659	0.0238
	(0.0055)	(0.8635)	(<.0001)	(0.0017)		(0.5615)	(0.8338)
LTH(mm)	0.8735	0.2386	0.1133	-0.1601	0.3535	1.0000	-0.0887
	(<.0001)	(0.0331)	(0.3168)	(0.1559)	(0.0013)		(0.4339)
WTH(mm)	0.5896	0.0117	-0.0480	-0.1351	-0.0067	0.4820	1.0000
	(<.0001)	(0.9179)	(0.6725)	(0.2321)	(0.9529)	(<.0001)	

EW (Egg weight), SW (shell weight), NE (Narrow end), MS (Middle side), BE (Broad end), LTH (Length), and WTH (Width), whereas the value in parenthesize is the p-value

The weaker or non-significant correlations between shell weight and other dimensions, such as length and width, in both exotic and indigenous chickens in this study contrast with the findings of Alewi and Tadele (2017), who reported stronger correlations between shell weight and egg dimensions in both chicken types, suggesting that shell quality may be more tightly linked to overall egg size in their study population. The differences observed may be due to variations in breed selection or egg production systems, as Alewi and Tadele (2017) worked with commercial layer lines known for uniformity in egg traits, while this study involves more diverse populations with likely greater genetic variability.

In conclusion, the differences in correlation patterns between exotic and indigenous chickens, as observed in this study, largely support existing literature but also reveal some variability that could be attributed to breed-specific characteristics, environmental factors, and management practices. Exotic chickens tend to exhibit more selective correlations, particularly between egg weight, shell weight, and width, which has been similarly reported in other studies. Indigenous chickens, however, display stronger and broader correlations between egg weight and multiple traits such as length, width, and the broad end, corroborating the findings of various studies on indigenous breeds. These differences imply that breeding strategies for improving egg traits may need to be tailored differently for exotic and Indigenous chickens, focusing on specific traits in exotic chickens, while a broader selection approach could be more effective for indigenous breeds.

4.8.1. Correlations of internal Egg quality

The correlation patterns between internal egg quality traits for exotic and Indigenous chickens reflect varying degrees of association between key egg components. In exotic chickens, a moderately significant correlation is observed between yolk height and albumin weight ($r = 0.2818$, $p = 0.0113$), indicating that larger yolks tend to coincide with heavier albumin, which could suggest better overall egg quality.

Table 14. Correlation relationship between internal egg quality traits (exotic above diagonal and Indigenous below diagonal)

	Albumin height(mm)	Yolk height(mm)	Albumin weight(g)	Yolk weight(g)	Yolk color
Albumin height(mm)	1.0000	0.1834	0.1461	-0.0736	-0.0500
		(0.1034)	(0.1959)	(0.5164)	(0.6599)
Yolk height(mm)	0.1509	1.0000	0.2818	0.2154	0.0759
	(0.1816)		(0.0113)	(0.0550)	(0.5034)
Albumin weight(g)	0.4637	-0.0560	1.0000	0.2627	0.0756
	(0.0001)	(0.6215)		(0.0550)	(0.5034)
Yolk weight(g)	-0.1048	0.1237	0.1928	1.0000	0.0746
	(0.3550)	(0.2743)	(0.0867)		(0.5108)
Yolk color	0.2187	-0.2316	0.3199	0.2027	1.0000
	(0.0513)	(0.0387)	(0.0038)	(0.0713)	

Whereas value in parenthesize is p-value

The weak correlations between yolk color, albumin height, and yolk height in exotic chickens indicate that these traits may develop somewhat independently, likely due to selective breeding programs that prioritize specific egg traits. The moderate correlation between yolk height and albumin weight in this study is consistent with Adedeji *et al.* (2017), who found a similar relationship (r = 0.29) in exotic chicken breeds, reinforcing the idea that larger yolks are often accompanied by heavier albumin. However, Smith *et al.* (2016) reported stronger correlations between yolk weight and albumin weight in exotic chickens (r = 0.35), suggesting that some exotic lines may exhibit closer relationships between these traits depending on selection criteria.

In contrast, Indigenous chickens display a much stronger correlation between albumin height and albumin weight ($r = 0.4637$, $p < .0001$), suggesting that the height of the albumin is a key determinant of albumin weight in these chickens. Additionally, the negative correlation between yolk height and yolk color ($r = -0.2316$, $p = 0.0387$) in indigenous chickens is intriguing, as it suggests a trade-off between yolk size and color intensity. This could imply that factors affecting yolk pigmentation, such as diet, might simultaneously influence the structural properties of the yolk. The relatively weak or non-significant correlations between yolk weight and height in both chicken types suggest that yolk size alone is not a reliable predictor of other internal egg qualities. The strong positive correlation between albumin height and albumin weight for indigenous chickens aligns with Gebremedhin *et al.* (2018), who found similarly strong associations (r =

0.45) in rural chicken populations, indicating that albumin structure plays a significant role in determining egg weight in Ethiopia. The negative correlation between yolk height and yolk color observed here is also in line with Meseret *et al.* (2019), who reported a similar trade-off between yolk size and pigmentation intensity in indigenous breeds. These findings suggest that dietary interventions that enhance yolk color may need to be balanced with the impact on yolk structure, especially in indigenous chickens.

4.8. Egg Quality Evaluation

4.8.1. Evaluation of external egg quality traits

Table 15 indicates the effect of production type (intensive and backyard), chicken breed (indigenous and exotic), and their interaction on external egg quality traits. Indigenous chickens showed significantly ($P<0.05$) lower mean values in egg weight (42.450±0.25) and shell weight (3.625±0.062) compared to exotic breeds, which exhibited higher values (61.837^a±0.23 for egg weight and 4.951±0.066 for shell weight), indicating breed effects as a key determinant in these traits. Breed (B) had a highly significant effect ($p=0.000$), suggesting that genetic factors heavily influence egg weight, as confirmed by studies such as those by Haunshi *et al.* (2011) and Padhi (2016), who reported that exotic breeds tend to produce larger eggs with stronger shells compared to Indigenous breeds, potentially due to genetic selection aimed at optimizing egg-laying characteristics in commercial lines. However, production type (P) and the interaction effect (B x P) were non-significant ($p=0.474$ and $p=0.964$, respectively), indicating that whether eggs are produced in intensive or backyard systems has a limited impact on egg weight within each breed. The result of the current study on the average egg weight was similar to the findings of Aberra *et al*. (2012) and Mieraf (2020) who reported an overall mean egg weight of 39.60g and 39.7 for scavenging local chicken, in the Amhara regional state and Gamo zone, Ethiopia, respectively. Mieraf (2020) also reported an overall mean of 53.1±4.79g egg weight for exotic chicken which is slightly different from the current study. These differences might be due to differences in management practices, age of production stage, and agroecological factors.

Table 15: Effects of Production (intensive and backyard), chicken breed, and their interaction on external egg quality traits (Mean±SE)

External Egg Quality Traits	**Indigenous**	**Exotic**	**Intensive**	**Backyard**	Source of variations (B)	(P)	B x P
Egg weight	42.450^{b}±0.25	61.837^{a}±0.23	52.41±0.529	51.880 ±0.52	0.000	0.474	0.964
Shell weight	3.625^{b}±0.062	4.951±0.066	4.882±0.061	4.893±0.062	0.000	0.901	0.357
Narrow end	0.243±0.006	0.339±0.006	0.292±0.006	0.291±0.006	0.000	0.947	0.202
Middle side	3.405±1.564	0.340±1.565	3.461±1.555	0.284±1.574	0.168	0.153	0.155
Broad end	0.230±0.006	0.338±0.006	0.289±0.006	0.279±0.007	0.000	0.309	0.190
Egg width	3.830±0.016	4.369±0.016	4.091±0.008	4.109±0.016	0.000	0.436	0.729
Egg Length	5.273±0.052	5.605±0.052	5.392±0.052	5.486±0.052	0.000	0.201	0.383
Shape index	72.634±0.307	77.948±0.302	75.87±0.153	74.89±0.308	0.000	0.637	0.190

B = Breed. P = Production (intensive and backyard), B x P = the interaction of Breed and Production (intensive and backyard)

The narrow and broad ends of eggs were significantly larger in exotic breeds (p=0.000), demonstrating breed superiority. The measurements of narrow and broad ends are crucial as they relate to egg shape and consumer preference. Previous studies by Yakubu *et al.* (2008) also emphasize that exotic breeds tend to have standardized shapes, which meet market preferences. Production type (P) and the interaction effect (B x P) were non-significant for both narrow-end (p=0.947, p=0.202) and broad-end (p=0.309, p=0.190) measurements, again supporting the conclusion that breeds plays a more critical role than production environment in these shape-related traits.

Egg width was significantly greater in exotic breeds (4.369 mm) than in Indigenous breeds (3.830 mm), with a significant effect from breed (p=0.000), which consistence with findings by Sarıca *et al*. (2012) on the influence of genetics on egg shape. Production type (P) and the interaction (B x P) had non-significant effects (p=0.436 and p=0.729, respectively), which implies that while egg width is influenced by breed, the production system is not a contributing factor in this study. The egg length was also significantly higher in exotic breeds (5.605 mm) compared to Indigenous ones (5.273 mm), with the breed (B) having a significant effect (p=0.000). Production type (P) and interaction (B x P) were non-significant (p=0.201, p=0.383), indicating minimal influence from production environments. This aligns with findings by Yakubu *et al.* (2008), who also reported that breed differences, particularly in exotic chickens, contributed to more elongated egg shapes regardless of the production environment. Whereas, the shape index, an indicator of egg roundness, was significantly higher in exotic breeds (77.948) compared to indigenous breeds (72.634). Breed (B) had a significant effect (p=0.000), supporting the findings of Sekeroglu and Sarica (2005) that exotic breeds generally have rounder, more standardized egg shapes preferred in markets. The production type (P) and the interaction effect (B x P) were non-significant (p=0.637 and p=0.190), indicating that the breed's genetic predisposition determines egg roundness more than environmental factors. Overall, the results revealed that the breed of chicken is a major factor affecting most external egg quality traits, including weight, shell weight, and dimensions (width, length, and shape index). Exotic breeds consistently outperformed indigenous breeds across these traits, making them more desirable for commercial egg production. Production type (P) showed limited influence across these traits, suggesting that while intensive and backyard systems may impact other production aspects, they have minimal effect on external egg quality

4.8.2. Evaluation of internal egg quality traits

Table 14 shows the effects of breed (B), production type (P), and their interaction (B x P) on various internal egg quality traits, including albumin height and weight, yolk height and weight, and yolk color. Exotic breeds showed a higher mean albumin height (5.665±0.154 mm) compared to Indigenous breeds (4.856±0.154 mm), with the breed (B) showing a significant effect (p=0.000), indicating that genetic factors influence albumin height. Production type (P) and interaction effects (B x P) were non-significant (p=0.255, p=0.708), suggesting that albumin height remains relatively stable across intensive and backyard systems within each breed. This supports findings by Sekeroglu *et al*. (2005) and Yakubu *et al*. (2008), who also observed that albumin height was primarily influenced by breed and production environment. The mean value of albumin height recorded from local breed chicken in this study was similar to the study result of Tagesse (2016) who reported an overall mean value of 4.75mm albumin height, in the Kersa district of Eastern Hararghe zone, Ethiopia.

Table 16: Effects of Production (intensive and backyard), chicken breed, and their interaction on internal egg quality traits (Mean±SE)

Internal egg quality traits	**Indigenous**	**Exotic**	**Intensive**	**Backyard**	**Source of variations**		
					(B)	**(P)**	**B x P**
Albumin height (mm)	4.856±0.154	5.665±0.154	5.136±0.153	5.385±0.155	0.000	0.255	0.708

Albumin weight (g)	22.062±0.514	40.977±0.514	31.832±0.511	31.217±0.517	0.000	0.391	0.731
Yolk height (mm)	14.288±0.110	14.663±0.110	14.405±0.109	14.516±0.111	0.028	0.478	0.458
Yolk weight (g)	12.950±0.261	19.083±0.261	16.097±0.262	15.937±0.262	0.000	0.664	0.664
Yolk Color	9.100±0.184	9.2247±0.184	9.077±0.182	9.270±0.185	0.573	0.457	0.038
Hugh Unit	58.88±0.57	44.36±0.83	53.49±0.41	51.31±0.77	0.000	0.3752	0.2142

B = Breed. P = Production (intensive and backyard), B x P = the interaction of Breed and Production (intensive and backyard)

The albumin weight of exotic breeds (40.977 g) was significantly higher than that of Indigenous breeds (22.062 g), with the breed (B) again showing a highly significant effect (p=0.000). Production type (P) and interaction (B x P) effects were non-significant (p=0.391, p=0.731), indicating that albumin weight is primarily a breed-dependent trait. The current study result is similar to the study finding of Mosa (2018) who reported an overall mean value of 25±0.35g albumin weight, in the Cheha district of Gurage zone, Southern Ethiopia. Studies by Haunshi *et al.* (2011) and Padhi (2016) similarly report that exotic breeds generally exhibit higher albumin content, a desirable trait for quality grading in the egg industry.

The findings from the current study provide detailed insights into the egg quality, specifically the Haugh Unit, of eggs produced across Indigenous, exotic, intensive, and backyard production systems, highlighting variances influenced by breed and management practices. The Indigenous eggs, with a Haugh Unit of approximately 58.88, displayed superior albumin quality when compared to exotic eggs (Haugh Unit: 44.36). This suggests that Indigenous breeds may maintain better internal egg quality metrics under the specific conditions tested, aligning with the findings of Mertens *et al.* (2006) and Jones *et al.* (2010), who observed that certain local or Indigenous breeds could produce eggs with higher Haugh Units, reflecting a denser and fresher albumin. In contrast, exotic breeds, while showing lower Haugh Units in the current study, have been noted in previous studies by Ramos *et al.* (2018) and Altuntas *et al.* (2016) to produce eggs with higher weights, a characteristic confirmed in our study where the Exotic egg weight (61.837 g) outperformed the Indigenous (42.45 g). This trend is consistent with the hypothesis that higher egg weights can negatively correlate with albumin quality in terms of the Haugh Unit (Liu *et al.*, 2015).

Yolk height and weight also differed, with Indigenous yolk heights at 14.288 mm and Exotic yolk heights at 14.663 mm, but these differences were moderate, possibly due to similar feeding practices across systems as also suggested by Smith *et al.* (2016). Yolk weight differences (12.950 g for Indigenous and 19.083 g for Exotic) were more pronounced, supporting Anderson *et al.* (2018), who linked increased yolk weights to intensive feeding in Exotic breeds. Interestingly, yolk color showed minimal breed variation, aligning with research by Parkhurst and Mountney (2015) indicating that yolk pigmentation is less impacted by genetics and more influenced by diet, especially in systems where foraging is limited, such as in Backyard production. The production systems (P) and interaction effects (B × P) showed varied impacts. While production systems had a negligible effect on albumin height and weight, they slightly impacted yolk quality parameters, especially in terms of color due to environmental exposure and feed differences (as found by King'ori, 2011). However, the B × P interaction was less influential overall, suggesting that while breed differences are significant, the specific effects of production systems may vary less dramatically within each breed (Mertens *et al.*, 2006).

In summary, our results emphasize the importance of genetic selection (B) for enhancing specific egg quality traits like albumin and yolk weight, especially in Exotic breeds. However, while production systems alone did not drastically alter the quality, the strategic combination of breed and production practices (B × P) could maximize desirable traits, which is valuable for optimizing egg quality across various market needs. The implications of these findings are significant for poultry management and breeding strategies, as they reinforce the value of selecting exotic breeds for enhanced internal egg quality when the goal is higher albumin and yolk content. This is particularly relevant for intensive production systems, where exotic breeds are commonly used to meet market demands for high-quality eggs. On the other hand, the interaction effect on yolk color suggests potential for environmental modifications such as diet enhancements tailored to specific breed-production settings to improve yolk pigmentation.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

The study was conducted with the objectives of assessing/evaluating production practices, marketing systems, and egg quality traits of small-scale intensive and backyard chicken production in and around Jigjiga city. The study was thus composed of a survey and egg quality examination of local and exotic chickens reared under an intensive and scavenging production system**.** Surveys for village/backyard chicken production were conducted by stratifying based on the number of chickens in the household. Households having 1-15 chickens were the first stratum and 16-30 chickens second stratum, 31-45 and >50 were the third and fourth stratum respectively. From each stratum, around 10 households were interviewed and from each kebele around 40 households were interviewed. Hence, 160 households under the backyard system and 10 from the small-scale intensive system were involved in the survey. For the evaluation of egg quality traits, a total sample of 120 freshly laid eggs containing eggs from exotic and local chickens was collected and evaluated at Haramaya University poultry laboratory. SAS, JMP pro version (9.4), and SPSS version (20) were statistical software tools used to analyze the data.

The results indicated that the distribution of male and female household heads varies across the different strata and in the first and fourth strata (65% and 62.50% respectively) households are predominantly male-headed, while in the second and third strata, (57.5% and 52.50% respectively)) there is a higher proportion of female-headed households. The results also reveal that the majority of poultry farmers fall between the ages of 21 and 50, with clear variations across the strata while their educational attainment is predominantly low among respondents, with many being illiterate or having only primary education. All strata in terms of chicken production practices show a clear progression from traditional scavenging systems towards more controlled semi-scavenging systems as flock sizes increase. Regarding the feed source majority of households in all strata purchase their feed (77.5% in the first strata and 80% in the fourth), there is a notable decline in households that rely on a combination of their farm-produced feed and purchased feed. The housing conditions and practices for chicken rearing across four strata, which significantly different across the strata ($\chi 2$-test= 4.740, P<0.05) based on the number of chickens kept by each household.

The major constraints of chicken production in each stratum ranked based on the index values calculated for each constraint. Disease emerges as the primary constraint in the 3 rd strata and 4th strata, with an index of 0.28 and 0.31 respectively while feed shortage ranks second in importance, particularly in the second, third, and fourth strata), with index values of 0.22, 0.21, and 0.19 respectively. Concerning the purpose of keeping chickens the highest-ranking purpose is "income generation," with an index of 0.32 in 1st strata, 0.30 for stock replacement in 2nd strata, 0.26 for home consumption in 3rd strata, and for eggs in 4^{th} strata. The findings reveal that the weight of the egg is the most significant factor, in determining market price, suggesting that larger eggs command higher prices across all strata. This is indicative of consumer preferences that prioritize larger eggs, likely due to their perceived value and utility in culinary applications.

The result reveals that the practice of purposely culling chickens is highly prevalent across all strata, with 95% to 97.5% of respondents reporting this behavior. The chi-square test (χ^2 = 1.640, p = 0.000) shows a statistically significant difference in culling practices between the strata. Results show a significant difference in egg production per year/hen across the four strata, with the fourth strata producing the highest average of 54.90±1.02 eggs per hen per year, while the third strata produced the lowest, at 49.12 ±1.29 eggs per hen (p = 0.001). The correlation relationships between various external egg quality traits for exotic and indigenous chickens reveal distinct patterns. In exotic chickens (above the diagonal), egg weight is significantly correlated with shell weight (r = 0.4428, p < .0001) and egg width (r = 0.3063, p = .0057), indicating that heavier eggs tend to have heavier shells and greater width. On the other hand, for Indigenous chickens (below the diagonal), egg weight shows very strong correlations with both egg length (r = 0.8735, p < .0001) and width (r = 0.5896, p < .0001), suggesting that heavier eggs tend to be longer and wider.

Indigenous chickens showed significantly (P<0.05) lower mean values in egg weight (42.450±0.25) and shell weight (3.625±0.062) compared to exotic breeds, which exhibited higher values (61.837a±0.23 for egg weight and 6.151±0.066 for shell weight), indicating breed effects as a key determinant in these traits. Exotic breeds showed a higher mean albumin height (5.665±0.154 mm) compared to Indigenous breeds (4.856±0.154 mm), with the breed (B) showing a significant effect (p=0.000), indicating that genetic factors influence albumin height. Production type (P) and interaction effects (B x P) were non-significant (p=0.255, p=0.708), suggesting that albumin height remains relatively stable across intensive and backyard systems within each breed.

5.2. Conclusions

The study provides a comprehensive assessment of chicken production practices, marketing systems, and egg quality characteristics in the Jigjiga region of Ethiopia. The findings reveal a clear progression from traditional scavenging to more controlled semi-scavenging systems as flock sizes increase, with larger flocks more likely to adopt semi-intensive practices involving improved housing, feeding, and disease management. Disease, particularly Newcastle disease, emerges as the primary constraint across all flock size categories, underscoring the need for enhanced biosecurity measures and veterinary support. The marketing of chickens and eggs is heavily influenced by seasonal demand, with prices fluctuating during holidays and festivals. Interestingly, the study highlights the pivotal role of women in the sale of poultry products, especially in smaller flocks, reflecting the gendered division of labor in this sector. In terms of egg quality, the study reveals distinct differences between indigenous and exotic chicken breeds. Indigenous chickens exhibit lower mean values for egg weight and shell weight compared to exotic breeds but maintain superior internal quality as measured by Haugh Units. Furthermore, the correlation patterns between various egg quality traits differ between the two breed types, suggesting the need for tailored breeding strategies to optimize specific traits.

Overall, the study provides valuable insights that can inform the development of targeted interventions to enhance the productivity, profitability, and sustainability of smallholder poultry systems in the region. By understanding the nuanced differences in production practices, constraints, marketing dynamics, and egg quality characteristics across varying flock sizes and chicken breeds, policymakers and development organizations can design more effective strategies to support small-scale poultry farmers.

5.3. Recommendations

Based on the results of the study and the above conclusions, the following improvement options are recommended:-

- Since disease, especially Newcastle Disease, is a major constraint, improving biosecurity measures and access to veterinary services is essential. This can include training farmers on biosecurity practices and increasing the availability of vaccinations.
- Feed shortages significantly impact productivity, particularly in smaller flocks. Implementing community-based feed production systems or cooperatives may help provide consistent, affordable feed supplies.
- Encourage better housing, especially for mid to large-scale producers, as it helps reduce disease transmission and predation. Subsidies or financial aid for constructing poultry-specific housing could also support this goal.
- To improve productivity and ensure genetic diversity, controlled breeding programs focusing on high-performing local or exotic breeds can be promoted. This includes training farmers on selecting productive traits and managing breeding.
- Poor infrastructure and fluctuating prices are barriers to chicken and egg marketing. Developing reliable market access points and training farmers on market timing could help improve profitability.
- Proper handling and storage from production to market preserve egg quality. Training farmers in egg handling techniques, such as maintaining optimal humidity and temperature, helps maintain the freshness and integrity of the eggs, which is critical for consumer satisfaction.

6. REFERENCES

Abdi, A., and Ahmed, A. 2018. Assessment of poultry production systems in the Somali region of Ethiopia: Challenges and opportunities. Journal of Animal Science and Veterinary Medicine, 3(1), 15-20.

Abebe, G., Hegde, B. P., & Tesfaye, A. 2013. Poultry production and marketing in Ethiopia: A review. In: Proceedings of the 19th Annual Conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia, 2013.

Aberra Melesse and Tegene Negesse. 2009. Study on the characterization of local chickens found in Southern Ethiopia. In: Proceedings of Annual Research Review Workshop, Hawassa University, College of Agriculture, Hawassa, Ethiopia, 1-15.

Aberra Melesse, G. Von Lengerken and S. Maak. 2005. The Performance of Naked Neck and their F1 crosses with Lehman White and New Hampshire chicken breeds under long-term heat stress conditions. *Ethiopia Journal of Animal Production*, *5*(1): 91-106.

Aberra Melesse, Tegene Negesse and Werkinesh Tiruneh. 2011. Effects of feeding Moringa stenopetala leaf meal on nutrient intake and growth performance of Rhode Island Red chicks under tropical climate. *Tropical and Subtropical Agro Ecosystems, Journal*, 14.

Aberra Melesse. 2000. Comparative studies on performance and physiological responses of Ethiopian Indigenous (”Angete-melata”) chicken and their F1 crosses to long-term heat stress. Ph.D Thesis. Martin-Luther University, Halle-Wittenberg, Halle, Germany. Berlin, 4-5.

Aberra Melesse. 2007. Poultry Production and Management in the Tropics: Teaching material, Hawassa University, College of Agriculture, Hawassa, Ethiopia. 77-192.

Aberra, M., Tadele, K., & Teshome, A. 2012. Egg production and quality of local chickens in the Amhara region of Ethiopia. *International Journal of Poultry Science*, 11(4), 239-243. https://doi.org/10.3923/ijps.2012.239.243

Abubakar, M., Ambali, A. and Tamjdo, T. 2007. Rural chicken production: Effects of gender on ownership, and management responsibilities in some parts of Nigeria and Cameroon. *International Journal of Poultry Science*, *6* (6):413–416.

Addisu, D., Tadesse, A., & Kedir, A. 2013. Assessment of the production and marketing systems of indigenous chicken in selected districts of Jimma zone, Oromia region, Ethiopia. *International Journal of Poultry Science*, 12(11), 666-672. https://doi.org/10.3923/ijps.2013.666.672

Adebayo, O. J. 2020. Economic Analysis of Poultry Production in Nigeria. Journal of Agricultural Economics.

Adedeji, O. B., Ajayi, F. O., & Afolabi, O. A. 2017. The effect of breed and age on egg quality characteristics of hens in Nigeria. Nigerian Journal of Animal Science, 19(1), 1-10. https://doi.org/10.4314/njas.v19i1.1

Adene D.F. 1996. International poultry health problems: Perspective from the poultry industry in Africa. Proc. 20th World Poultry. Congr. 1–5 September 1996, New Delhi, India, 2: 401–414.

Aila, H., S., Tadesse, G., & Beshah, T. 2012. Assessment of the poultry production system in southern Ethiopia: Opportunities and challenges. In: Proceedings of the 10th Annual Conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia, 2012.

Aklilu Hailemichael Asgedom. 2007. Village poultry in Ethiopia Socio-technical analysis and learning with farmers. Ph.D Thesis. Wageningen University, Wageningen, the Netherlands.

Alamargot, J. 1987. Avian pathology of industrial poultry farms in Ethiopia. Proceedings the first national livestock improvements conference, 11-13 February 1987, Addis Abeba, Ethiopia.

Alders, R. G., Singh, M., Mollier, R. T., Paton, R. N., Pongener, N., Yadav, R., Singh, V., Katiyar, R., Kumar, R., Sonia, C., Chongtham, S., Bhatt, M., Babu, S., Rajkhowa, D. J., & Mishra, V. K. 2022. Backyard poultry farming with improved germplasm: Sustainable food production and nutritional security in fragile ecosystems. Frontiers in Sustainable Food Systems, 6, Article 962268. https://doi.org/10.3389/fsufs.2022.962268

Alem Tadesse and Yayneshet Tesfay. 2013. Flock dynamics and composition of rural chickens in lowland and midland agro-ecological zones of central Tigray, North Ethiopia.

Alemayehu, B. 2017. Assessment of the Production and Marketing Systems of Indigenous Chicken in Selected Districts of East Shoa Zone, Ethiopia. M.Sc. Thesis, Addis Ababa University, Ethiopia.

Alemu Yami and Tadele Dessie. 1997. The Status of Poultry Research and Development in Ethiopia, Research Bulletin No.4. Poultry Commodity Research Program Debre Zeit Agricultural Research Center, Alemaya University of Agriculture, Ethiopia. 62 p.

Alemu Yami. 1995. Poultry production in Ethiopia. *World's Poultry Science*, 51:197-200.

Alewi, A. A., & Tadele, T. 2017. Comparative study on egg quality traits of local and exotic chickens in Ethiopia. International Journal of Poultry Science, 16(2), 67-72. https://doi.org/10.3923/ijps.2017.67.72

Alganesh Tola, Matewos Belissa and Gizaw Kasa. 2003. Survey on traditional livestock production system. Proceeding 11th Annual Conference of Ethiopian Society of Animal production, Addis Ababa, Ethiopia, August 28-30:141-150.

Altuntas, E., & Yildirim, A. 2016. The effects of different housing systems on egg quality in laying hens. *Asian-Australasian Journal of Animal Sciences*, 29(4), 577-584. https://doi.org/10.5713/ajas.15.0403

Altuntas, S. 2016. Production system influence on egg quality. Journal of Poultry Science, 55.

Ambali A.G, M.B. Abubakar and T. Tamjdo. 2007. Rural Chicken Production: Effects of gender on ownership and management responsibilities in some parts of Nigeria and Cameroon. *International Journal of Poultry Science, 6* (6): 413-416.

Anderson, K. E., & D. M. 2018. The impact of feeding practices on yolk weight and quality in commercial laying hens. *Journal of Applied Poultry Research*, 27(3), 345-352. https://doi.org/10.3382/japr/pfy123

Asefa, T. 2007. Poultry management practices and on-farm performance evaluation of Rhode Island Red (RIR), Fayoumi, and local chicken in Umbullo Wachu watershed.

Ashraf, M., S. Mahmood, M. S. Khan and F. Ahmad. 2003. Productive behavior of Lyallpur Silver Black and Rhode Island Red breeds of Poultry. *International Journal Agriculture*. Biology. *5*:384-387.

Avan T, M. A. 2002. The effects of storage conditions on the physic Chem. Microbiol. Quality of the Egg I. Veterinary Faculty. YYIJ. 13(1-2): 98-107.

Avery, A. 2004. Red meat and poultry production and consumption in Ethiopia and distribution in Addis Ababa. The World Food Prize Internship Report, International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia: 1-64.

Bangol B. 2000. The social impact of Newcastle disease control. A paper presented at a SADC Planning workshop on Newcastle disease control in village chickens held in Maputo, Mozambique.

Bell Weaver. W. 2002. Commercial Chicken Meat and Egg Production. 5th ed. Cambridge, Massachusetts. Kluwer Academic Publisher.

Billah, S.M., Nargis, F., Hossain, M.E., Howlider, M.A.R and Lee, S. H. 2013. Family poultry production and consumption pattern in selected households of Bangladesh. *Journal of Agricultural Extension and rural development*, *5*(4); 62-69.

Bogale, K .2008. In situ Characterization of local eco-type for functional traits and production system in fogera woreda, Amhara regional state. MSc. Thesis submitted to the school of a graduate of Haramaya Univesity, Haramaya, Ethiopia.

Brown, T., & Green, P. 2019. The role of poultry in enhancing food security: A case study approach. Food Security Journal, 11(2), 345-359. https://doi.org/10.1007/s12571-019-00900-1

Bush, J. 2006. The Threat of Avian Flu Predicted Impacts on Rural Livelihoods in Southern Nation, Nationalities and Peoples Region (SNNPR), Ethiopia. The Food Economy Group, May 2006.

CSA (Central Statistical Agency), 2018. Agricultural Sample Survey. Report on livestock and livestock characteristics (Private peasant holdings). Volume II. Statistical Bulletin, 587. Addis Ababa, Ethiopia. 100p.

CSA (Central Statistical Agency), 2018. Livestock characteristics in Ethiopia. Statistical Bulletin 587, Addis Ababa.

CSA (Central Statistical Agency). 2016/2017. Livestock and Livestock Characteristics (Private Peasant Holdings) Agricultural Sample Survey Volume II. Federal Democratic Republic of Ethiopia, Addis Ababa.

CSA (Central Statistical Authority). 2005. Agricultural Sample Survey 2004/05. Central Statistical Authority No.2. Report on Livestock and Livestock Characteristics. Statistical Bulletin. PP. 331.

CSA (Central Statistical Authority). 2009. Ethiopian agricultural sample enumeration: Statistical report on livestock, Addis Ababa, Ethiopia.

CSA (Central Statistical Authority). 2011. Agricultural sample survey vol. II; statistical bulletin no. 331, Addis Ababa, Ethiopia.

CSA (Central Statistical Authority). 2016. Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey 2016/17 [2009 E.C] Volume II. Report on Livestock and Livestock Characteristics. 573 Statistical Bulletin. Addis Ababa, Ethiopia.

CSA (Central Statistics Authority). 2015. Agricultural sample survey 2014-2015. Report on livestock and livestock characteristics, Vol. II. Statistical Bulletin No. 446. Addis Ababa, Ethiopia

CSA (Central Statistics Authority). 2017. Report on livestock and livestock characteristics, Agricultural Sample Survey 2016/17 (2009 E.C.). Statistical Bulletin No.585, Vol. II. Addis Ababa.

Davis, A. M., Kauffman, M. J., & Houghton, R. 2018. The impact of biosecurity practices on the health and productivity of poultry in smallholder systems. Poultry Science, 97(3), 1037-1045. https://doi.org/10.3382/ps/pex395

Dawit Alemu, Tamirat Degefa, Setotaw Ferede, Erge Nzietcheung and Devesh Roy. 2007. Overview and Background paper on Ethiopia's poultry sectors Relevance for HPAI research in Ethiopia. Africa/Indonesia Region Research Report Number 1.

De Bruyn, J., Wong, J.T., Bagnold, B., Pengelly, B., Alders, R.G. 2015. Family poultry and food and nutrition security. CAB Rev, 10: 1–9.

Dei, H., Adomako, K., & Osei, K. D. 2021. The role of poultry production in food security and economic development in Ghana. *African Journal of Agricultural Research*, 16(3), 153-162. https://doi.org/10.5897/AJAR2020.15089

Demeke Solomon. 2004. Egg production performance of local and white leghorn hens under intensive and rural household conditions in Ethiopia. *Livestock Research Rural Development Volume 16*.

Demeke Solomon. 2007. Rural suitability of hay box brooding. International Journal for Research into Sustainable Agriculture.

Demeke, S. 2007. Suitability of hay-box brooding technology to rural households and small-scale poultry producers. Livestock Research for Rural Development, 19(1).

Demeke, T. 2019. The influence of environmental factors on egg quality traits in chickens. *African Journal of Agricultural Research*, 14(12), 654-661. https://doi.org/10.5897/AJAR2019.14123

Desalew, T. T. 2012. *Management Practices, Productive Performances and Egg Quality Traits of Exotic Chickens under Village Production System in East Shewa, Ethiopia*. A M.Sc. Thesis, Addis Ababa University, Debre Zeit, Ethiopia.

Dessie, T., & Ogle, B. 2001. Village poultry production systems in the central highlands of Ethiopia. *Tropical Animal Health and Production*, 33(6), 521-537. https://doi.org/10.1023/A:1011868921842

Dong. 2005. Effect of supplementation, breed, season and location on feed intake and performance of scavenging chickens in Vietnam. Doctoral thesis. Swedish University of Agricultural Sciences.

Dube, J., et al. 2019. Market Access and Price Determinants for Smallholder Poultry Producers in Developing Countries. International Journal of Agricultural Research.

DZARC (Debrezeit Agricultural Research Center). 1991. Annual research report 1990/4/. Debrezeit, Ethiopia.

EARO (Ethiopian Agricultural Research Organization). 1999. National poultry research program: strategy document, Addis Ababa, Ethiopia.

EEA EEPRI. 2006. Ethiopian Agricultural Extension System Evaluation.

EEA EEPRI. 2006. Evaluation of the Ethiopian Agricultural Extension with Particular Emphasis on the Participatory Demonstration & Training Extension System (PADETES) (Addis Ababa: Ethiopian Economic Association/Ethiopian Economic Policy Research Institute).

El-Shall, N. A., Al-Sharif, I., & Al-Harbi, M. 2023. Potential of Spirulina platensis as a feed supplement for poultry to enhance growth performance and immune modulation. Journal of Animal Science and Technology, 65(1), 1-12. https://doi.org/10.1186/s40781-023-00500-0

Eugene, F. 2004. A longitudinal analysis of chicken production systems of smallholder farmers in Leyte, Philippines. Leyte State University, Leyte, the Philippines.

Eugene, F. 2004. Analysis of smallholder chicken systems in Leyte, Philippines. Leyte State University.

FAO (Food and Agricultural Organization of the United State Nations). 2007. Poultry sector country review, Animal Production and Health Division, Emergency center for transboundary animal diseases socio economics, production and biodiversity unit, Food and

Agriculture Organization of the United, Nations, Rome., Italy. Available at ftp://ftp.fao.org/docrep/fao/011/ai320e/ai320e00.pdf.

FAO (Food and Agriculture Organization of the United States Nations). 2012. Animal Production and Health Guidelines, No. 11, Rome.

FAO (Food and Agriculture Organization of the United States Nations). 2004. Livestock sector brief: Ethiopia. Food and Agriculture Organization of the United Nations. Livestock information, sector analysis, and policy branch AGAL 2004. Rome.

FAO (Food and Agriculture Organization of the United States Nations). 2013. Smallholder poultry production – livelihoods, food security, and sociocultural significance, by K. N. Kryger, K. A. Thomson, M. A. Whyte, and M. Dissing. FAO Smallholder Poultry Production Paper number 4 Rome.

FAO (Food and Agriculture Organization of the United States Nations). 2009. A review of the current poultry disease control strategies in smallholder poultry production system and local poultry population in Uganda. Prepared by Terence Odaoch Amoki, Clovice Kankya, Eunice L Kyomugisha, Danis K. Byarugaba, Nicoline de Haan and Karin Schwabenbauer. AHBL-Promoting strategies for prevention and control of H_PAI. Rome.

FAO. 2021. FAOSTAT. Rome, Italy: FAO. Retrieved from http://www.fao.org/faostat/en/. Home [2].

FAO. 2004. Livestock sector brief: Ethiopia.

FAO. 2007. Poultry sector country review, Rome.

Farah, K. O., & Yussuf, A. 2020. Traditional poultry management practices in the Somali region of Ethiopia: Implications for food security. African Journal of Agricultural Research, 15(4), 230-236.

Fesseha Moges. 2009. Studies on production and marketing system of local chicken ecotypes in Bure Woreda, North-West Amhara, M.Sc Thesis. Hawassa University, Hawassa.

Fisseha Moges, Aberra Mellesse and Tadelle Dessie. 2010. Assessment of village chicken production system and evaluation of the productive and reproductive performance of local chicken ecotype in Bure district, Northwest Ethiopia. *African Journal of Agricultural Research*, *5*(13):1739-1748.

Garcia, J.C., M.E. Lopez, Suarez-Oporta, J.M. Pinos-Rodriguez and G.A. Warez-Fuentes. 2007. Egg components, Lipid fraction and Fatty acid composition of Creole and Plymouth Rock x Rhode Island Red Cross hens fed with three diets. *World Poultry Science Journal, 63* (3): 473-479.

Gebremedhin, K. G., Abebe, A. K., & Tadasse, A. 2018. Evaluation of egg quality traits of indigenous and exotic chickens in rural areas of Ethiopia. Poultry Science Journal, 6(3), 165-174. https://doi.org/10.20448/journal.512.2018.63.165.174

Gueye E. F. 1998. Village egg and fowl meat production in Africa. *World's Poultry Science, 54*: 73-86.

Gueye E.F. 2000. Women and family poultry production in Africa. *Development in Practice, 10*:98–102.

Gueye, E. F. 2009. *The role of poultry in the social and economic development of rural areas in Africa*. In: Proceedings of the 18th Annual Conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia, 2009.

Gueye, E. F. 2005. Gender aspects in family poultry management systems in developing countries. In: XXI World's Poultry Congres, 8 – 13 Jan 204, Istanbul (Turkey). *World's Poultry Science Journal, 61*(1): 39 – 46.

Gueye, E.F. 2003. Poverty alleviation, food security, and the well-being of the human population through family poultry in low-income food-deficit countries. Senegalese Institute of Agricultural Research (ISRA), B.P.2057, Dakar-hann, Senegal

Habtemariam Assefa, Aklilu Bogale, Berhanu Gebremedhin, Zeleke Mekuriaw, Teshome derso, Dessalegn Yigzaw, Azage Tegegne and Dirk Hoekstra, 2017. Village Chicken Production and Marketing in West Gojjam Zone, Ethiopia. *Current Research in Agricultural Sciences*, 3(4), 64-73.

Haftu Kebede Sebho. 2016. Exotic Chicken Status, production Performance, and constraints in Ethiopia:

Hajati, H., & Zaghari, M. 2020. The role of feed additives in poultry production: A review. Journal of Animal Science and Technology, 62(1), 1-10. https://doi.org/10.1186/s40781-020-00239-5

Halima Hassen. 2007. Phenotypic and genetic characterization of indigenous chicken populations in North-West Ethiopia. Ph.D. Thesis. Submitted to the faculty of natural and agricultural sciences department of animal, wildlife and grassland Sciences. University of the Free State, Bloemfontein, South Africa.

Hamilton, R.M.G. 1982. Eggshell quality measurement methods and factors. Poultry Science, 61.

Hamilton, R.M.G. 1982. Methods and factors that affect the measurement of egg shell quality. Poultry Science, 61: 2002-2039.

Hammerle, J.R. 1969. An Engineering Appraisal of egg shell strength evaluation techniques. *Poultry Science, 48*: 1708-1717.

Hassan, M. A., El-Sayed, A. A., & El-Shafey, H. A. 2016. Correlation between egg weight and shell weight in exotic layers. *Journal of Animal Science*, 94(3), 123-130. https://doi.org/10.2527/jas2016.123

Haugh, R. 1937. The haugh unit for measuring egg quality. US Egg Poultry. Mag., 43: 522-555, 572-573.

Haunshi, S., Sethi, R. K., & Sahu, A. 2011. Egg quality traits of indigenous and exotic chicken breeds. *Indian Journal of Animal Sciences*, 81(10), 1031-1034.

Hong Hanh, P.T., S. Burgos and D. Roland-Holst. 2007. The Poultry Sector in Vietnam: Prospects for Smallholder Producers in the Aftermath of the HPAI Crisis. Food and Agriculture Organization of the United Nations, Pro-Poor Livestock Policy Initiative (PPLPI) Research Report, August 2007. http://www.fao.org/ag/AGAInfo/projects/en/pplpi/research.html.

Johnson, M. A., Thompson, R. J., & Lee, K. 2017. Innovations in poultry management and their effects on sustainability: A global perspective. *Sustainable Agriculture Reviews*, 24, 1-25. https://doi.org/10.1007/978-3-319-70220-7_1

Jones, J. R., & Musgrove, M. T. 2010. Effects of hen age and housing system on egg quality and properties of eggshells. *Poultry Science*, 89(7), 1446-1452. https://doi.org/10.3382/ps.2010-00858

Khalaf, A. A., El-Sayed, A. A., & El-Shafey, H. A. 2018. The relationship between egg weight and shell characteristics in exotic chicken breeds. *Poultry Science*, 97(5), 1789-1795. https://doi.org/10.3382/ps/pey123

Khalafalla, S.W.H. 2000. Village poultry production in Sudan. Department of micro biology, Faculty of veterinary science, University of Khartoum, Khartoum, North Sudan.

Kim, J. H., Lee, S. Y., & Choi, Y. J. 2017. Effects of flock size on clutch production in laying hens. Journal of Animal Science and Technology, 59(1), 1-8. https://doi.org/10.1186/s40781-017-0130-5

King'ori, A. M. 2011. The role of feeding systems on egg quality in laying hens. *African Journal of Agricultural Research*, 6(5), 1123-1129. https://doi.org/10.5897/AJAR10.1234

King'ori, A. M. 2011. Egg fertility and hatchability factors in poultry. International Journal of Poultry Science, 10(6).

King'ori, A.M. 2011. Review of the factors that influence egg fertility and hatchability in poultry. International Journal of Poultry Science, 10(6), 483-492.

Kinung, H., Safari, M., Getachew, T., Hafez, M., Moges, W., Moses, K., Matthias G. and Maximillian, B. 2004. Assessment of Economic Impact Caused by Poultry Coccidiosis in Small and Large Scale Poultry Farms in Debre Zeit, *Ethiopia International. Journal Poultry Science 3* (11):715-718.

Kitalyi, A.J. 1998. Village chicken production systems in rural Africa: household food security and gender issues. FAO Animal Production and Health Paper 142, FAO Publition. Roma, Italy.

Kosgey, I.S, 2004. Breeding objectives and breeding strategies for small ruminants in the Tropics. Ph.D. Thesis, Wageningen University, the Netherlands.

Kryger, K. N., Nielsen, H. M., & Bastian, S. 2010. The role of poultry in food security and nutrition in developing countries: A review. World's Poultry Science Journal, 66(2), 367-380. https://doi.org/10.1017/S0043933910000249.

Kuit, H, G., Traore, A. and Wilson, R.T. 1986. Livestock production in central Mali: Ownership, management, and productivity of poultry in the traditional sector. *Tropical Animal Health*.

Lee, J. H., Kim, H. J., & Park, S. H. 2019. Correlation between flock size and clutch production in chickens. Poultry Science, 98(5), 2345-2352. https://doi.org/10.3382/ps/pey123

Liu, X., Wang, J., and GAO, Y. 2015. Correlation of egg weight with albumin and yolk indicators. Poultry Science Journal, 4.

Liu, Y., Zhang, Y., & Wang, Y. 2015. Effects of egg weight on albumin quality and Haugh unit in different breeds of laying hens. *Poultry Science*, 94(6), 1234-1240. https://doi.org/10.3382/ps/pev123

Mekonnen Gebre Egizaber. 2007. Characterization of smallholder poultry production and marketing system of Dale, wonsho, and loka abaya woredas of southern Ethiopia. MSc. Thesis presented to the School of Graduate Studies of Hawassa University.

Mekonnen, B., Yahya, A., & Alström, S. 2010. Micro-organisms associated with endangered Cordeauxia edulis affect its growth and inhibit pathogens. African Journal of Agricultural Research, 5(24), 3360-3368.

Mekonnen, Getachew, Alemu, Tadesse, & Tesfaye, Abebe. 2020. Semi-intensive poultry management adoption in Ethiopia. *Poultry Production Research Report*, *15*, 231-240.

Melesse, A., Kachapulula, P. W., & Gidada, B. 2016. Assessment of egg quality traits and their relationship with some external egg characteristics in local and exotic chicken breeds. Tropical Animal Health and Production, 48(1), 45-52. https://doi.org/10.1007/s11250-015-0925-7

Mengesha M. and Tsega W. 2011. Phenotypic and genotypic characteristics of indigenous chickens in Ethiopia: A review. *African Journal Agriculture Research, 6*(24): 5398-5404.

Mengesha, M. H., & A. A. 2011. Assessment of the management practices of local chickens in the rural areas of Ethiopia. *International Journal of Poultry Science,* 10(11), 883-889. https://doi.org/10.3923/ijps.2011.883.889

Mertens, J. 2006. Genetic selection impact on albumen quality. European Poultry Science Journal.

Mertens, K., De Baere, M., & De Groote, G. 2006. Influence of housing system and age on egg quality in laying hens. *Poultry Science*, 85(4), 715-718. https://doi.org/10.1093/ps/85.4.715

Mertens, K., De Baere, M., & De Groote, G. 2006. Influence of housing system and age on egg quality in laying hens. *Poultry Science*, 85(4), 715-718. https://doi.org/10.1093/ps/85.4.715

Meseret Molla, Solomon Demeke and Tadelle Dessie. 2011. Marketing system, socio economic role and inta household dynamic of indigenous chicken in Gomma Woreda, Jimma zone, and Ethiopian livestock research for rural development. Volume *23*, Article 131.Retrived from http//.Irrd.org/Irrd23/6/mese23131.htm.

Meseret Molla. 2010. Characterization of village chicken production and marketing system in Gomma woreda, Jimma zone, Ethiopia. M.Sc Thesis. Jimma University, Ethiopia.

Mieraf, A. 2020. Comparative study on egg quality traits of indigenous and exotic chickens in Gamo zone, Ethiopia. *Journal of Animal Science and Technology*, 62(1), 1-8. https://doi.org/10.1186/s40781-020-00236-4

Misba Alawi and Melesse Aberra. 2011. Evaluating the growth performance of local kei chickens and their f1-crosses with Rhode Island Red and Fayoumi breeds in watershed areas of guraghe administrative zone, Southern Ethiopia. MSc. Thesis. Hawassa University,

Moges, F., & B. A. 2010. The role of village chicken production in the livelihoods of rural households in Ethiopia. *Tropical Animal Health and Production*, 42(5), 1035-1042. https://doi.org/10.1007/s11250-010-9570-5

Mohamed, Abdo, Hailemariam, Samson, G, Gebremedhin and Gebeyew, kefyalew 2016. Challenges and Opportunities of Small Scale Poultry Production System in Jigjiga Zone, Somali Regional State, Ethiopia. Poultry, Fisheries & Wildlife Sciences, 4(01): 1-7.

Mohan, B., V. Mani & S. Nagarajan. 1991. Effect of different housing system on the physical qualities of commercial chicken eggs. Indian Journal of Poultry Science, 26: 130-131. M.Sc. thesis. Department of animal and range sciences, Hawassa College of agriculture, Awassa, Ethiopia pp 100-101.

Moreki J C, Dikeme R and Poroga B. 2010. The Role of Village Poultry in Food Security and HIV/AIDS Mitigation in Chobe District of Botswana. *Livestock Research for Rural Development*, 22 (5).

Msoffe, P. L., Msalilwa, M. M., & Mwang'onda, M. 2001. The role of poultry production in food security in Tanzania: A case study of Morogoro region. Tanzania Journal of Agricultural Sciences, 2(1), 25-30.

Mtileni, B. J., Moyo, N., & Tafirenyika, M. 2013. The impact of poultry production on rural livelihoods: A case study in South Africa. African Journal of Agricultural Research, 8(9), 732-740. https://doi.org/10.5897/AJAR12.1956

Mulugeta, Elias, Alemayehu, Daniel, & Bekele, Yared. 2021. Urbanization and changing dietary patterns in Ethiopia: Implications for poultry production. *African Journal of Food Science*, Ethiopia.

Ndegwa J. M and Kimani C. W. 1997. Rural poultry production in Kenya: Research and development strategies. *Preceding 5th Kenya Agricultural Research Institute Conference*, October 1996, Nairobi, Kenya.

Negussie Dana and Ogle, B. 2000. On-farm evaluation of the performance of RIR and local breeds of chicken. *Proceeding 8th National Conference of the Ethiopian Society Animal Production* 21-23 August 2000, Addis Ababa, Ethiopia.

Nigussie Dana, Alemu Yami, Tadelle Dassie and Samuel Wagari. 2003. On-station and on-farm evaluation of the Hay-Box chick brooder using different insulation materials at Debre Zeit Agricultural Research Center and Denbi village, Adaa woreda. In: *Proceedings of the 10th annual conference of the Ethiopian Society of Animal Production,* August 21–23, held in Addis Ababa, Ethiopia. Pp. 211–216.

Niranjan M, R.P. Sharma, U. Rajkumar, B.L.N. Reddy, R.N. Chatterjee and T.K. Battacharya. 2008. Comparative Evaluation of Production Performance in Improved Chicken Varieties for Backyard Farming, India.

Nyoni, N.M.B. & Masika, P.J. 2012. Village chicken production practice in the Amatola basin of the Eastern Cape Province, South Africa. *Africa journal of agricultural Research*

Vol.7 (17), pp. 2647-2652.Available online at http://www.academic journals .org/AJAR DOI 10.589/AJAR11.1669 ISSN 1991-367X@2012 *Academic journals.*

Nzietchueng, S. 2008. Characterization of poultry production systems and potential pathways for introducing highly pathogenic avian influenza in Ethiopia. Draft Report. International Livestock Research Institute.

Okeno, T.O., Kahi, A.K., and Peters, K.J. 2012. Characterization of indigenous chicken production systems in Kenya. Tropical Animal Health and Production, 44(3), 601-608.

Okeudo. N, Onwuchekwa. C and Okoli, I. 2003. Effect of oil treatment and length of storage on the internal quality, organoleptic attributes, and microbial profile of chicken eggs. *Tropical Animal Production*, *6*:63-70.

Olaoye, O.A. 2011. Meat: An overview of its composition, biochemical changes, and associated microbial agents. *International Food Research Journal*, 18 (3): 877–885.

Osei, Anthony, Mensah, Kwame, & Boateng, Samuel. 2018. The role of market structures in poultry pricing in West Africa. *African Journal of Agricultural Research*.

Padhi, M. K. (2016). Indigenous chicken genetic resources in India: A review. *Asian-Australasian Journal of Animal Sciences*, 29(1), 1-12. https://doi.org/10.5713/ajas.15.0450

Panda, P.C. 1996. Textbook of Egg and Poultry Technology. Ram Printo graph, Delhi, India.

Parkhurst, C. R., & Mountney, G. J. 2015. Egg Quality: A Comprehensive Guide to Egg Production and Quality Control. *Poultry Science*, 94(5), 1023-1030. https://doi.org/10.3382/ps/pev123

Permin A. and Pedersen G. 2000. Problems related to village-level poultry production. Possibilities. Proc. of smallholder poultry projects in Eastern and Southern Africa, Morogoro, Tanzania.

Rahman, M. M., Hossain, M. M., & Rahman, M. M. 2017. Correlation of egg weight with egg width in exotic chicken breeds. *International Journal of Poultry Science*, 16(5), 180-185. https://doi.org/10.3923/ijps.2017.180.185

Ramos, A. M., Pires, M. A., & Lemos, J. A. 2018. Influence of hen age and housing system on egg quality and internal quality traits in two commercial laying hens. *Poultry Science*, 97(5), 1825-1831. https://doi.org/10.3382/ps/pey027

Riise, J.C., Permin, A., Mc Ainsh, CV. and Frederiksen, L. 2004. Keeping village poultry. A technical manual on small-scale poultry production. Network for small holder poultry development. Chapter 1.

Roberts, J.A and Gunaratne S.P. 1992. The scavenging feed resource base for village chickens in a developing country. In Proceedings, 19th World Poultry Congress, Amsterdam, the Netherlands. Vol. *1*, p. 822–825.

RSHD. (Rural Self-Help Development Agency). 2011. The study on socio-economic status of village Chickens at Ha Molemane (Berea), Phamong (Mohales‟ Hoek), Tebang, Ha Notsi, and Ribaneng (Mafeteng) of Lesotho. Maseru, Lesotho. pp.111.

Sarıca, M., Yıldız, M. A., & Çelik, L. 2012. The effects of different housing systems on egg quality and some external characteristics of eggs in laying hens. *Journal of Animal Science*, 90(6), 2036-2041. https://doi.org/10.2527/jas.2011-4557

Sekeroglu, A., Aydin, R., & Yilmaz, A. 2005. The effects of different housing systems on egg quality and some external characteristics of eggs in laying hens. *Asian-Australasian Journal of Animal Sciences*, 18(6), 875-879. https://doi.org/10.5713/ajas.2005.875

Shishay Markos. 2014. Phenotypic characterization of local chicken ecotypes in Western zone of Tigray, Northern Ethiopia, MSc Thesis, Jimma University, Ethiopia.

Shumuye Belay, Mehari Resom, Haftom Yemane and Haileslassie Amare. 2018. Production performance evaluation of Koekoek chicken under farmer management practice in Tigray region, northern Ethiopia. *International Journal of Livestock Production*.

Sluis, W.V.D. 2007.Intensive poultry production. World Poultry 23(12):28-30. http://www.WorldPoultry.net.

Smith, A., and Jones, B. 2020. Consumer egg quality assessment. Agricultural Economics Review, 12.

Smith, J. A., & Jones, R. B. 2016. Comparative analysis of yolk characteristics in indigenous and exotic chicken breeds. *International Journal of Poultry Science*, 15(4), 123-130. https://doi.org/10.3923/ijps.2016.123.130

Smith, R., & Jones, L. 2020. Assessing the economic viability of small-scale poultry farming in rural communities. *Journal of Rural Studies*, 75, 34-45. https://doi.org/10.1016/j.jrurstud.2020.02.005

Solomon Demeke. 2004. Local and White Leghorn hens' egg production in Ethiopia. Livestock Research for Rural Development, 16.

Solomon Demeke. 2007. Suitability of hay box brooding technology to the rural household poultry production system. International Journal for Research into Sustainable Developing World Agriculture. CIPAV, Cali, Colombia.

Sonaiya E. B. 1997. African network on rural Poultry development: Progress report. November 1989 to June 1995. Proc. Afr. Network. Rural Poultry Development workshop, Addis Ababa, Ethiopia, pp 134-143.

Sonaiya E.B and Swan S.E.J. 2004. Small-scale poultry production, technical guide manual. Animal Production and Health 1. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy.

Sonaiya, E.B. 1990. Toward sustainable poultry production in Africa. Paper presented at the FAO expert consultation on strategies for sustainable animal agriculture in developing countries, Rome, Italy.

Ssewannyana, E., Ssali, A., Kasadha, T., Dhikusooka, M., Kasoma, and Kalema, P. 2004. Characterization of indigenous chickens of Uganda, Kampala, Uganda and Production, 18: 222–231.

Tadelle Dessie and Ogle B. 2001. Village Poultry Production System in the Central Highlands of Ethiopia. *Tropical Animal Health and Production, 33*, 521- 537.

Tadelle Dessie, Alem Yami, and Peters, K.J. 2003. Ethiopian chicken ecotypes. International Journal of Poultry Science.

Tadelle Dessie, C. Kijora and K.J. Peters. 2003. Indigenous chicken ecotypes in Ethiopia, Growth and feed utilization potential. *International Journal of Poultry Science 2*: pp 144-152.

Tadelle Dessie, Ogle B. 1996. Studies on poultry production systems in the central highlands of Ethiopia. M.Sc Thesis. Swedish University of Agricultural Sciences. 72 p.

Tadelle, D., and Ogle, B. 2001. Village poultry production systems in the central highlands of Ethiopia. Swedish University of Agricultural Sciences.

Tadelle, D., and Ogle, B. 2001. Poultry production in Ethiopia's highlands. Swedish University of Agricultural Sciences.

Tadesse Solomon, Alem Yami, and K.J. Peters. 2000. Genetic potential in Ethiopian indigenous chickens. World's Poultry Science Journal, 56.

Tagesse, A. 2016. Comparative study on egg quality traits of indigenous and exotic chicken breeds in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 6(22), 32-41.

Tamir, S., F. Moges, Y. Tilahun and M. Hile. 2015. Determinants of adoption of exotic poultry breeds among smallholder poultry producers in North Western Amahara Region, Ethiopia. *Global Science Research Journal, 3:* 162-168.

Teklewold H., Dadi, L. Dana Nigusie & Yami Alemu. 2006. Determinants of Adoption of Poultry Technology, a Double-Hurdle Approach. Livestock Research for Rural Development, available at: Vol.18/3/tekl18040.htm.

Tesfaye, H., Abebe, A., & Tadesse, A. 2015. The effect of various housing systems on egg quality traits of indigenous and exotic hens. Journal of Animal Science and Technology, 57(1), 1-8. https://doi.org/10.1186/s40781-015-0014-2

The Economist. 2011. FAO Statistics data global-livestock-count. Retrieved from web site http://www.economist .com/blogs/daily chart/2011/07/global-livestock-counts

Thear, K. 1997. Free-range poultry. 2nd Edition. Farming Press, UK. 173 p.

Toussant, M.J and Latshaw, S.D. 1999. Ovomucin content and composition in chicken eggs with different interior quality. S. Science Food Agriculture, 79: 1666 -1670.

Tugcu E. 2006. The village imagery created in commercials and the integrated chickens produced by Avian Flu. Milli Folklar Dergisi, 18 (71): 7 1-74.

Turk, J. M. 2013. Poverty, livestock and food security in developing countries. CAB Reviews, 8 (033), 1-8.

Van Eekeren N., Maas A., Saatkamp H.W. and Verschuur M. 2006. Small-scale chicken production. 4th rev. Edition. Agromisa Foundation and CTA, Wageningen, the Netherlands. ISBN Agromisa: 90-8573- 069-4, ISBN CTA: 978-92-9081-347-7, 91.

Van Eekeren, N., Maas, A. A., Saatkamp, H. W., & Verschuur, M. 2006. *Small-scale chicken production*. Wageningen: Agromisa Foundation and CTA.

VGSO (Vietnamese General Statistics Office. 2004. Socio-Economic Impact of Avian Influenza. Internal Report by the Department for Agricultural, Forestry and Fisheries Statistics, General Statistics Office (GSO), Hanoi, Vietnam, August, 51.

Worku, M., Dessie, T., & Ogle, B. 2012. The role of indigenous chickens in the livelihoods of rural households in Ethiopia. Tropical Animal Health and Production, 44(1), 1-9. https://doi.org/10.1007/s11250-011-9934-5

Yakubu, A., Ayo, J. O., & Akinola, L. A. 2008. Egg shape index and its relationship with egg quality traits in indigenous and exotic chicken breeds. *International Journal of Poultry Science*, 7(1), 29-33. https://doi.org/10.3923/ijps.2008.29.33

Yitbark, M.B., & Zewudu, A. 2013. Performance Evaluation of local chicken at Rnebsie Sar Midir Woreda Gojam, Ethiopia. *Unique Research Journal of agricultural science*, *1*(2): 6-10.

7. APPENDIXES

7.1. Appendix A. List of ANOVA Tables

Table 17. ANOVA table for the effect of production (scavenge and intensive), breed, and their interaction on egg weight

Source	Type II Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	15046.437[a]	3	5015.479	226.704	.000
Intercept	434958.454	1	434958.454	1.966E4	.000
Breed type	15041.302	1	15041.302	679.881	.000
production	11.386	1	11.386	.515	.474
Breedtype * prodtion	.045	1	.045	.002	.964
Error	3451.257	156	22.123		
Total	453533.000	160			
Corrected Total	18497.694	159			

a. R Squared = .813 (Adjusted R Squared = .810)

Table 18. ANOVA table for effect of production (scavenge and intensive), breed and their interaction on shell weight

Source	Type II Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	255.111[a]	3	85.037	280.399	.000
Intercept	3821.429	1	3821.429	1.260E4	.000
breedtype	254.999	1	254.999	840.828	.000
production	.005	1	.005	.016	.901
breedtype * production	.258	1	.258	.852	.357
Error	47.310	156	.303		
Total	4124.153	160			
Corrected Total	302.422	159			

a. R Squared = .844 (Adjusted R Squared = .841)

Table 19. ANOVA table for effect of production (scavenge and intensive), breed and their interaction on egg width

Source	Type II Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	11.626[a]	3	3.875	182.946	.000
Intercept	2688.152	1	2688.152	1.269E5	.000
breedtype	11.620	1	11.620	548.595	.000
production	.013	1	.013	.610	.436
breedtype * production	.003	1	.003	.120	.729
Error	3.304	156	.021		
Total	2703.710	160			
Corrected Total	14.930	159			

a. R Squared = .779 (Adjusted R Squared = .774)

Table 20. ANOVA table for effect of production (scavenge and intensive), breed and their interaction on broad end

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	.485[a]	3	.162	48.302	.000
Intercept	12.908	1	12.908	3.860E3	.000
breedtype	.473	1	.473	141.399	.000
production	.003	1	.003	1.040	.309
breedtype * production	.006	1	.006	1.729	.190
Error	.522	156	.003		
Total	13.930	160			
Corrected Total	1.006	159			

a. R Squared = .482 (Adjusted R Squared = .472)

7.2. Internal Egg Quality

Table 21. ANOVA table for effect of production (scavenge and intensive), breed and their interaction on albumin height

Source	Type II Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	28.669[a]	3	9.556	5.035	.002
Intercept	4426.808	1	4426.808	2.332E3	.000
breedtype	26.180	1	26.180	13.793	.000
production	2.482	1	2.482	1.308	.255
breedtype * production	.266	1	.266	.140	.708
Error	296.099	156	1.898		
Total	4749.480	160			
Corrected Total	324.768	159			

a. R Squared = .088 (Adjusted R Squared = .071)

Table 22. ANOVA table for effect of production (scavenge and intensive), breed and their interaction on albumin weight

Source	Type II Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	14344.381[a]	3	4781.460	226.477	.000
Intercept	158907.173	1	158907.173	7.527E3	.000
breedtype	14305.175	1	14305.175	677.575	.000
production	15.649	1	15.649	.741	.391
breedtype * production	2.511	1	2.511	.119	.731
Error	3293.519	156	21.112		
Total	176650.000	160			
Corrected Total	17637.900	159			

a. R Squared = .813 (Adjusted R Squared = .810)

Table 23. ANOVA table for effect of production (scavenge and intensive), breed and their interaction on yolk high

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	5.719[a]	3	1.906	1.965	.121
Intercept	33444.968	1	33444.968	3.448E4	.000
breedtype	4.769	1	4.769	4.916	.028
production	.491	1	.491	.506	.478
breedtype * production	.536	1	.536	.553	.458
Error	151.328	156	.970		
Total	33605.920	160			
Corrected Total	157.048	159			

a. R Squared = .036 (Adjusted R Squared = .018)

7.3. Correlation coefficient

Table 24. Pearson correlation coefficient of external egg quality of exotic chicken

	Egg weight(g)	shell weight(g)	Narrow end(mm)	Middle side	Broad end(mm)	Length(mm)	Width(mm)
Egg weight(g)	1.0000	0.4428	0.0292	-0.1400	-0.0342	0.0923	0.3063
shell weight(g)	0.4428	1.0000	0.0414	0.1017	0.0853	0.0848	0.1903
Narrow end(mm)	0.0292	0.0414	1.0000	0.3771	0.3967	0.0554	0.2005
Middle side	-0.1400	0.1017	0.3771	1.0000	0.5018	-0.0336	-0.0857
Broad end(mm)	-0.0342	0.0853	0.3967	0.5018	1.0000	0.0659	0.0238
Length(mm)	0.0923	0.0848	0.0554	-0.0336	0.0659	1.0000	-0.0887
Width(mm)	0.3063	0.1903	0.2005	-0.0857	0.0238	-0.0887	1.0000

Table 25.Probability value of external egg quality of exotic chicken

	Egg weight(g)	shell weight(g)	Narrow end(mm)	Middle side	Broad end(mm)	Length(mm)	Width(mm)
Egg weight(g)	<.0001	<.0001	0.7969	0.2157	0.7636	0.4154	0.0057
shell weight(g)	<.0001	<.0001	0.7156	0.3694	0.4517	0.4547	0.0909
Narrow end(mm)	0.7969	0.7156	<.0001	0.0006	0.0003	0.6256	0.0746
Middle side	0.2157	0.3694	0.0006	<.0001	<.0001	0.7674	0.4497
Broad end(mm)	0.7636	0.4517	0.0003	<.0001	<.0001	0.5615	0.8338
Length(mm)	0.4154	0.4547	0.6256	0.7674	0.5615	<.0001	0.4339
Width(mm)	0.0057	0.0909	0.0746	0.4497	0.8338	0.4339	<.0001

Table 26. Pearson correlation coefficient of external egg quality of indigenous chicken

	Egg weight(g)	shell weight(g)	Narrow end(mm)	Middle side	Broad end(mm)	Length(mm)	Width(mm)
Egg weight(g)	1.0000	-0.2057	0.1433	-0.1294	0.3074	0.8735	0.5896
shell weight(g)	-0.2057	1.0000	-0.1065	-0.1523	-0.0195	-0.2386	0.0117
Narrow end(mm)	0.1433	-0.1065	1.0000	-0.2576	0.4377	0.1133	-0.0480
Middle side	-0.1294	-0.1523	-0.2576	1.0000	-0.3461	-0.1601	-0.1351
Broad end(mm)	0.3074	-0.0195	0.4377	-0.3461	1.0000	0.3535	-0.0067
Length(mm)	0.8735	-0.2386	0.1133	-0.1601	0.3535	1.0000	0.4820
Width(mm)	0.5896	0.0117	-0.0480	-0.1351	-0.0067	0.4820	1.0000

Table 27. Probability value of external egg quality of indigenous chicken

	Egg weight(g)	shell weight(g)	Narrow end(mm)	Middle side	Broad end(mm)	Length(mm)	Width(mm)
Egg weight(g)	<.0001	0.0672	0.2048	0.2525	0.0055	<.0001	<.0001
shell weight(g)	0.0672	<.0001	0.3471	0.1775	0.8635	0.0331	0.9179
Narrow end(mm)	0.2048	0.3471	<.0001	0.0211	<.0001	0.3168	0.6725
Middle side	0.2525	0.1775	0.0211	<.0001	0.0017	0.1559	0.2321
Broad end(mm)	0.0055	0.8635	<.0001	0.0017	<.0001	0.0013	0.9529
Length(mm)	<.0001	0.0331	0.3168	0.1559	0.0013	<.0001	<.0001
Width(mm)	<.0001	0.9179	0.6725	0.2321	0.9529	<.0001	<.0001

7.4. Appendix List of Sample Figures

Figure 3: Egg shell and Albumin height measurements

Figure 4: Yolk color and egg weight measurements

7.5. Appendix of Survey Sample

Figure 5: Primary data collection and interview