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Production system, and egg quality of village chicken reared under traditional management system in Angecha and Damboya districts of Kembata Tembaro Zone, Southern Ethiopia

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Abstract

The study was conducted in two selected districts of Kembata Tembaro Zone, Southern Ethiopia with objectives of to assess the production system, and egg quality of village chicken reared under traditional management system. Multi-stage sampling technique was used to select representative samples and one hundred eight six respondents (186) were interviewed with structured questionnaire. The data were organized and analyzed by using SPSS and SAS. The mean of Eggs per clutch per hen, Age at first lay, and number of clutches per hen/year were 15.82±0.54, 7.08±0.25, 5.26±0.25 and Age of sexual Maturity (Male=7.67±0.306 and female=8.13±0.301), respectively. The predominant breed is exotic (59.6%) with a village chicken production system. 50.55% of the respondents kept chicken in Perch at one corner of the common house, and 45.70% practiced isolation of sick birds from health to prevent disease transmission. The mean of eggs incubated, hatched, and hatchability percentages were (14.5±0.55, 12.5±0.57 and 80.5), respectively. The study revealed that 40.32, 26.2 and 17.32% of respondents rear chicken for sale, home consumption, and non-defined purpose, respectively. The highest percentage of the interviewed respondent's use of eggs was for selling purposes 30.1% (Mid and 31.7% (Highland). Regarding egg storage conditions in high land and mid land agroecology about 21.5% and 18.3% of the respondents store their eggs inside cold containers, respectively. The major constraints of chicken production in the study areas were the prevalence of disease, high chick mortality, predator attack (Shululla), shortage of feed and grains, and lack of parent stock, respectively. The most economically important disease that attacks chicken Newcastle disease which is locally known as "Kenbesha" in the study areas. All egg quality parameters were statistically similar among the agroecology except significant difference in egg yolk height and albumen height. Shell thickness was comparable to the acceptable eggshell thickness to withstand egg breakage. The yolk index values of the eggs obtained from both agro ranged from 0.54–0.56. The HU value that figures out the quality of albumen was within the range of 70-100 set for good egg quality. Therefore, efforts should be geared to alleviate constraints like prevalence of disease, High chick mortality, predator attack, shortage of feed, and lack of parent stock hampering chicken production, training of smallholder farmers on chicken housing practices,

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and further research was needed on external and internal egg quality determination under different production system.

Keywords Chicken, Constraints, Egg quality, Kenbesha, Shululla, Multi-stage sampling

Background

Ethiopia's diverse agroecological zones and favorable environmental conditions have led to a flourishing poultry farming activity with an estimated population of 57.01 million birds [1]. Indigenous poultry dominate at 78.85%, followed by hybrids at 12.02% and exotic poultry at 9.11%. This sector plays a vital role in supporting household economies, providing food security, creating job opportunities for 85% of the workforce, and contributing significantly to export earnings (90%) and Gross Domestic Product (GDP) (45%) [2, 3]. Poultry farming makes up around 40% of the agricultural output within the national economy, making a notable contribution of 13-16% to the overall GDP [4]. According to [5], the global poultry population is approximately 16.2 billion, of which 71.6% is found in developing countries [6]. In Africa, village poultry, especially indigenous chickens, are crucial for meeting food and protein needs, with Sub-Saharan Africa heavily depends on rural chicken production where indigenous chickens make up 70% of the total population [7]. Ethiopia, representing about 60% of the chicken population in East Africa, boasts a variety of breeds including local, exotic, and hybrid chickens [8].

From the poultry the annual egg production from locally managed chickens typically ranges from 53 to 60 eggs per hen [9]. However, poultry production has shown a growing significance among small and medium-scale farmers existing in rural areas [5]. According to [10], poultry production holds substantial economic importance and is practiced by approximately 80% of the rural population. In the developing world, indigenous chickens are widely distributed in all rural and peri-urban areas, playing a crucial role in income generation and food production [11]. In Ethiopia, rural poultry is a huge part of the national economy, contributing 98.5% and 99.2% to national egg and chicken meat production, respectively [12]. However, despite the large numbers of chickens, the economic contribution of the sector is not proportional, due to constraints such as diseases, predators, inadequate healthcare, feed sources, and poor marketing information, hindering production and productivity in many areas of the country. Diseases are identified as the primary constraints leading to a reduction in total numbers and compromised productivity [13].

On the other hand, chicken eggs are familiar, nutritious, economical, and easy to prepare food, supplying a balanced source of nutrients for humans of all ages [14]. The high-quality protein, low caloric value, and ease of digestibility make eggs valuable in various therapeutic diets for adults [15]. Egg quality encompasses factors related to the shell, albumen, and yolk, categorized as external and internal quality [16]. External factors like cleanliness, freshness, egg weight, and shell quality are crucial for consumer acceptability of shelled eggs [17]. However, the internal quality of eggs starts to decline as soon as they are laid, with management and feeding practices of hens playing a role in this decline. Egg handling and storage practices also significantly affect egg quality. Poultry production is a major contributor to the livelihoods of the majority of rural farmers in Angacha and Damboya Woreda. Additionally, the poultry enterprise has the potential to promote economic growth in developing countries by supplying employment, income, and sustenance for rural populations [18].

Despite its importance, there have been no attempts to assess production performances and constraints, such as poor extension services, disease outbreaks, and traditional management practices, hindering chicken production in the study areas. Although there is a high potential for the distribution of exotic chicken breeds and poultry keeping in the areas, the production system stays traditional. Furthermore, no studies have been conducted about the egg quality traits of both local and exotic chicken breeds in the study area. In districts like Angacha and Damboya, village chicken eggs, like in other parts of the country, may be stored for extended periods along the value chain, leading to quality deterioration. The duration of storage is a significant factor contributing to expected egg quality deterioration. Owners may not be fully aware of these challenges and problems, emphasizing the need for further investigation into the challenges and opportunities influencing chicken production performance in the study areas. Finally, the objective of this study to assess production system, and egg quality of village chicken reared under traditional management system in Angecha and Damboya Districts of Kembata Tembaro Zone, Southern Ethiopia.

Methods

Description of the study area

The research study is conducted in the Angacha and Damboya districts, Kembata Tambaro zone, Southern Ethiopia, situated 250 km southwest of Addis Ababa. Angacha District comprises 21 administrative kebeles, with 17 rural and 4 urban kebeles, covering approximately 380.6 square kilometers and classified into Dega (35%) and Woina Dega (65%) agro-ecological zones. The population of 88,083, with 92.26% residing in rural areas. Damboya District, with 20 administrative kebeles (17 rural and 3 urban), covers around 18,318 hectares. It has a population of 82,622, with 90.17% in rural areas. Damboya's altitude ranges from 1783 to 2503 meters above sea level, with annual rainfall between 700-1200 mm and temperatures from 26 °C to 22 °C. The district is divided into highland ("*Dega*") and mid-altitude ("*Woina Dega*") climatic zones, contributing to its diverse agricultural landscape [8] (Fig 1).

Sampling method and sample size determination

The study employed a multi-stage sampling technique in the Angacha Damboya districts of the Kembata Tambaro zone, southern Ethiopia. Initially, the choice of the two districts is purposive, considering poultry production pssotential and accessibility [19]. Subsequently, the six kebeles in the districts are stratified into two agro-ecologies: highland and midland, with thirteen and twenty-one rural kebeles, respectively. In the third stage, six kebeles (3 from the highland and 3 from the midland) are purposively selected from each stratum based on poultry holder numbers, potential areas for poultry production, and abundance of egg layers.

Specifically, two kebeles are selected from the highland agro and one kebele from the midland agro-ecology in Angacha district. In Damboya district, one kebele is selected from the highland agro and two kebeles from the midland agro-ecology. 186 respondents are then randomly selected from the total poultry owners (2046) in the chosen kebeles. The sample size determination used the proportional sample size determination formula [20], and the sample size (n) is calculated using the formula provided by [21] at 7% level of precision [21].

$$n = \frac{\mathrm{N}}{1 + \mathrm{N}(e)^2}$$

$$n = \frac{2046}{1+2046(0.07)^2} = 2046/11.035 = 186$$

Where,

n= the sample size

N = the population size (total chicken owner)

e= the level of precision i.e. 7 %

In general, a total of 186 households from the two districts is selected for this study (Table 1). After determining total sample size from the districts, selection of chicken owner from each agroecology and kebeles is based on the proportion of population. To do this the following formula are used [20].

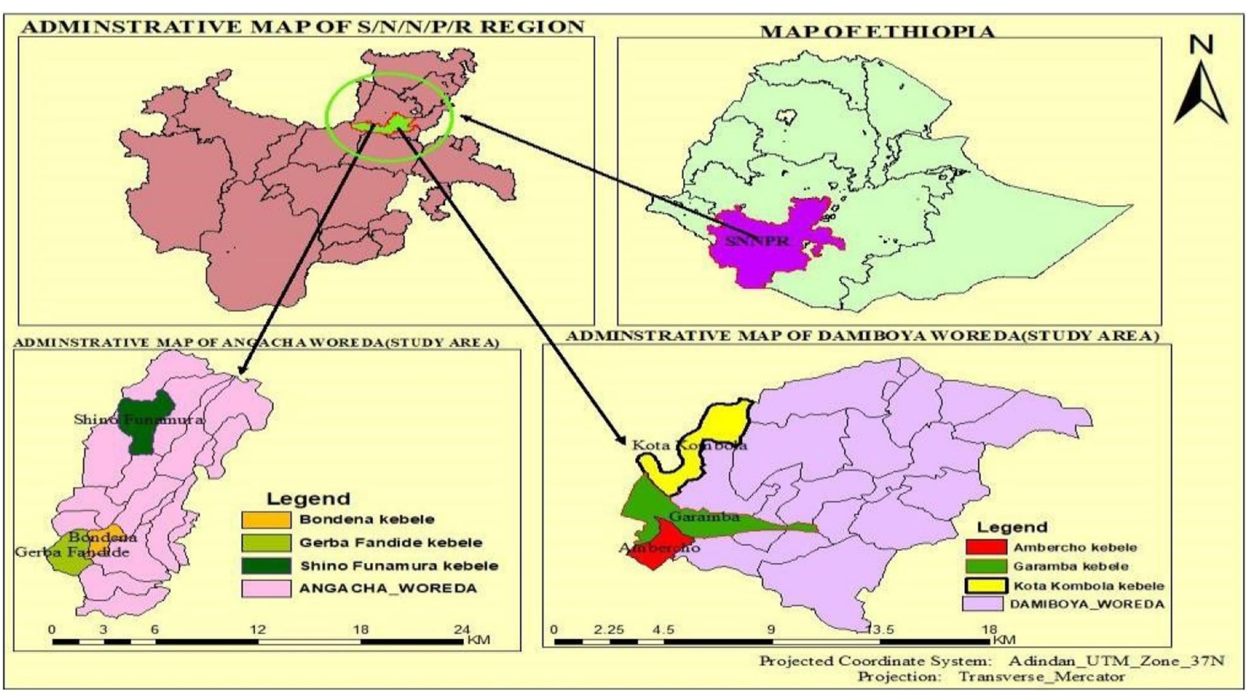

Fig. 1 Location map of the study area

Table 1 Kebeles and proportion of household from each kebeles selected for the study

Districts	Agro-ecology	Kebeles	Poultry holders	Sample households	Proportion
Angacha	High land	Garba Fandide	341	31	16.66
		Bondana	319	29	15.59
	Midland	Shino Funamura	330	30	16.12
Damboya	High land	Hambaricho	264	24	12.90
	Mid land	Garamba	385	35	18.81
		Kota kombola 407		37	19.89
Total		6	2046	186	100

Source: Based on Own Computation, 2022

$$n1 = \frac{n * N1}{N} \text{ And } n2 = \frac{n * N2}{N}$$

Where,

n1 and n2 = is sample size of respondent in each agro-ecology N1 and N2 = is total number of households in each agro-ecology n= total sample size of respondent in two agro ecology

N = is total number of chicken owner in the study area

Out of the 2046 households in the selected kebeles, 186 chicken owners were selected as sample respondents for the study. From this sample 84 and 102 is from high land and mid land, respectively.

Egg quality determination

For egg quality determination, a total of 240 egg samples are collected from both Damboya and Angacha districts, with 120 eggs collected from each study area. The eggs collected from households is taken to the poultry science laboratory of Hawassa University College of Agriculture.

Egg quality is evaluated through various parameters: egg weight, albumen weight, yolk weight, shell thickness, shell weight, yolk color, albumen height, yolk height, yolk diameter, yolk index and Haugh Unit Score (HUS). All weight data are measured using a sensitive balance, while shell thickness is figured out by averaging the thicknesses at blunt, middle, and sharp points using a micrometer gauge. Yolk color was assessed using the Roche color fan, and yolk height and albumen height are measured with a tripod micrometer. Yolk diameter is measured using a ruler after breaking the egg on a flat tray and separating it from the albumen [22].

$$\text{Haugh unit} = \frac{100 \text{ Log}\left[\text{H} - \sqrt{\text{G}}\left(30\text{W}^{0.37} - 100\right) + 1.9\right]}{100}$$

Where; HU= Haugh unit; G= Gravitational constant, 32.2; H= Albumin height (mm) W= Weight of egg

Data source and methods of collection

Both primary and secondary data collection methods are used. Primary data included semi-structured questionnaire interviews, focus group discussions (FGD), household surveys, and direct observations. FGD sessions are conducted to complement and confirm household survey data, involving 6-8 members, including kebele leaders, elders, model farmers, and women leaders. Key informant interviews are also conducted with extension workers. Secondary data were obtained from various sources such as district agricultural offices, zonal agricultural and rural development offices, fishery and livestock resource offices, regional bureaus, NGOs (Non-Governmental Organizations), the internet, and other published and unpublished materials.

A structured questionnaire is developed for the household survey, covering a range of poultry production activities. The questionnaire included dichotomous, multiple-choice, and open-ended questions to address the diverse nature of the topics. Enumerators, trained as development agents (DAs), conducted household surveys in rural areas of the districts. The one-day training included an explanation of the study's goals, scope, and the questionnaire. A pre-test of the survey questionnaire is conducted under researcher supervision, and based on the feedback, the questionnaire was adjusted before the actual data collection.

Data management and statistical analysis

Survey data

The survey data is entered and organized in Microsoft Excel and analyzed using Statistical Package for Social Sciences version 26 (SPSS, 2007). Descriptive statistics such as frequency, means, percentages, and standard error of the means are employed to summarize the collected data from 186 households.

Experimental data

Experimental data, specifically egg quality parameters, underwent analysis of variance using the General Linear

Table 2 Flock size in the study area

Agro-ecology	μ±SE	Overall (μ±SE)	(χ2)	*P*-value
Highland	2.93 ±0.18	2.94 ±0.2	15.51	0.999
Mid-land	2.95 ±0.22			

SE Standard error

Model (GLM) procedure (SAS Institute, 2009). If the analyses of variance showed significant differences, the Turkey method is applied to find means significantly different from each other. Liner regression model used for quantitative data analysis is:

1. $Y_{ij} = \mu + A_i + e_{ij}$, Where:

Y_{ij}= observation of survey data

μ = Overall mean,

Ai = the effect of i^{th} agro-ecology (i= 1-2, midland and highland) eij= Error term

Result

Flock Structure

Flock size and structure

The mean flock size in the study areas was 2.94 ±0.2 is shown on Table 2. From the flock structure highest number was chicks and the second one was hens (Fig. 2).

Flock productivity

The result of eggs per clutch per hen, age at first lay (AFL months), age of sexual maturity and number of clutches per hen/year was described on Table 3. The overall mean number of eggs per clutches was (15.82 ±0.55) and was not significantly different across the agro ecology. According to the respondents, the average age at first lay of village chicken was (6.40 ±0.47) and was not significantly different across study agro ecology. The Overall mean number of clutches per hen per year was (5.26 ±0.25) and was not significantly different across the study agro ecology.

Table 3 Eggs per clutch per hen, Age at first lay (AFL months), Age of sexual Maturity, and number of clutches per hen/year

	Agro ecology		
Parameters	**Highland**	**Midland**	**Overall**
Eggs/clutch	15.77 ±0.47	15.87 ±0.62	15.82 ±0.55
Clutches/hen/year	5.13 ±0.25	5. 39 ±0.25	5.26 ±0.25
Total Egg/hen/year	59.7 ±10.8	61.1 ±11.6	60.4 ±11.2
Age at first laying	6.43 ±0.44	6.37 ±0.50	6.40 ±0.47
Age of sexual Maturity			
Male	7.46 ±0.313	7.89 ±0.299	7.67 ±0.306

Table 4 Breed composition

	Breed composition		
Agro ecology	**Local (μ±SE)**	**Exotic (μ±SE)**	**Cross breed (μ±SE)**
High land	0.210 ±0.074[a]	4.43 ±0.535[b]	0.43 ±0.278[a]
Mid land	0.55 ±0.157[a]	6.27 ±0.792[a]	1.67 ±0.503[a]
Over all	0.38 ±0.115	5.35 ±0.66	1.05 ±0.38

SE Standard error

[a,b] Means in a row with different superscripts are significantly different

Breed composition

The breed composition was presented on Table 4, the chicken population of all the study agro ecology were dominated by exotic breed with having of the percentage of 59.6% (Fig. 3), despite the fact that the Agricultural Office of the both agro ecology was said to be involved in the distribution of exotic breeds of chickens.

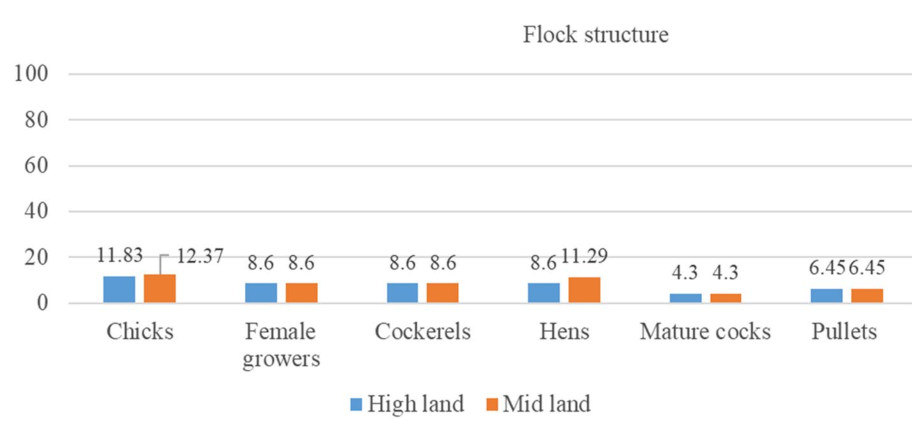

Fig. 2 Flock structure in the study area

Chicken production system

The chicken production system study agro ecology was presented (Fig. 4). The most dominant in (93.9 and 94.3%) chicken production system was identified in the study areas were a village chicken production system, semi-intensive (5.3 and 5.4%), and with (0.8 and 0.3%) of intensive for High land and Mid-land agro ecology, respectively.

Village chicken husbandry practice

Chicken housing practices

The chicken housing practices in the study areas were shown on Table 5.

About 50.55% of the respondents' households keep poultry in Perch at one corner in common house which might be due to low priority given to chicken production as compared to other livestock production activity, small flock size, lack of awareness on the importance of housing and risk of predators. On the other side 7.71% of household had Partition with/without perch in the house,

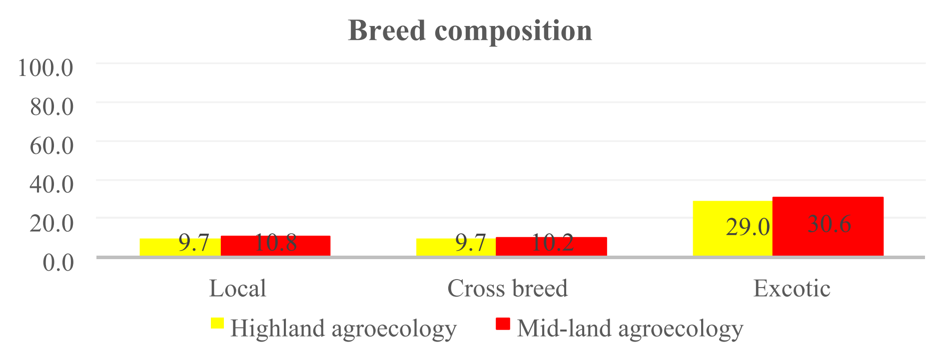

Fig. 3 Breed composition

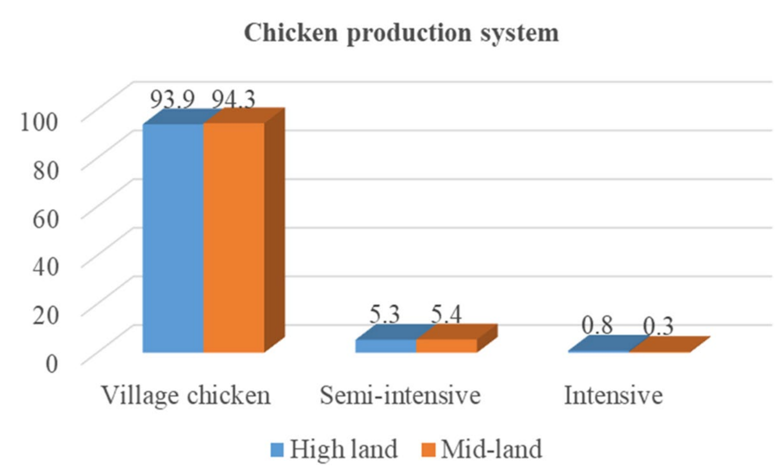

Fig. 4 Chicken production system study agro ecology

Table 5 Chicken housing practices in the study areas

Housing	Highland	Mid land	Overall
Perch at one corner in Common house	49.7	51.25	50.55
Partition with/without perch in the house	8.32	7.17	7.71
Share the same room with family and Livestock	25.65	28.34	26.75
Separate house for chicken	2.94	3.82	3.38
Have a different shelter for night only	10.61	12.6	11.61

Table 6 Chicken feeding and watering practices in the study areas

	Agro ecology		
Feed sources	**High land (%)**	**Mid-land (%)**	**Overall (%)**
Households food leftovers	74%	75.4%	74.7%
Grains	22%	22.4%	22.2%
Kitchen wastes	3.3%	2.2%	2.85%
Provision time of feed			
Morning	10.2%	8.4%	9.3%
After noon	78%	81.3%	79.65%
Evening	11.8%	10.3%	11.05%
Water source			
River	93.3%	94.3%	93.8%
Pipe Water	0.5%	0.3%	0.4%
Borehole Water	6.2%	5.4%	5.8%
Frequency of Watering			
Free access	11.2%	8.3%	9.75%
Two times/day	3.5%	1.5%	2.5%
Once/day	85.3%	90.2%	87.75%

3.38% had Separate house for chicken, 11.61% had a different shelter for night only and 26.75% Share the same room with family over the study agro ecology.

Feeding and watering

The chicken feeding and watering practices in the study areas as indicated by the respondents are summarized on Table 6. The feed sources in the study agro ecology, 74, 22 and 3.3% of the respondents of highland depended on household food leftover, grain and kitchen wastes, respectively. About 75.4, 22.4 and 2.2% of the respondents of Mid-land depended on household food leftover, grain and kitchen wastes, respectively.

Disease prevention and predator control

The disease and predator controlling and treating measures practiced by households are shown on Table 7 and Fig. 5. Prevention measures taken by households to minimize losses due to disease and predator were the same across the study areas. Around 45.70% of respondent

Table 7 Disease Prevention methods and Measure against predator in the study areas

Disease Prevention methods	High land n (%)	Mid-land n (%)	Overall (%)
Plugging of feather	32(35.5)	11(11.8)	23.65
Feeding mixtures of garlic with food	38(41.9)	21(21.5)	31.7
Piercing of the blood vessel for bleeding	11(11.8)	32(33.3)	22.6
Fumigation with leaves	10(10.8)	32(33.3)	22.05
Measure against predator	n (%)	n (%)	(%)
Protecting of the chicken house	27(30.1)	28(29.0)	29.55
Hanging frustrating materials on fences	26(28.5)	22(23.1)	25.8
Growing of hedges	20(22.6)	26(26.9)	24.75
Killing of predators	17(18.8)	20(21.0)	19.9

NB Numbers in parenthesis are percentage while others indicate frequency

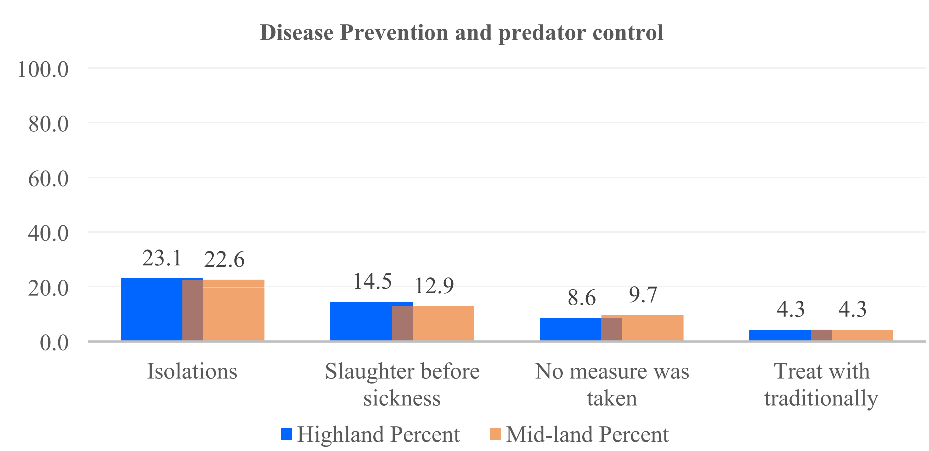

Fig. 5 Disease Prevention and predator control in the study areas

were practicing isolation of sick birds from healthy to prevent disease transmission to other flock of chickens in the study areas. Moreover, around 27.42% of the respondent households were slaughtering of chickens immediately before sickness to minimize chicken losses due to diseases. On the other hand, around 18.3% of the respondent households did not take any measures as to prevent disease risk on chickens. Only 8.60% of the respondent households were treat the diseases outbreak by using traditional methods (Fig. 8). About 63.4, 47.3 and 45.2% of the respondents uses feeding mixtures of garlic with food, plugging of feather, piercing of the blood vessel for bleeding, respectively while 44.1% of respondents were used fumigation the infected chicken with leaves.

Production and reproduction performance

Egg hatchability

The study finding of the eggs incubated, hatched and hatchability percentages are shown on Table 8. The overall mean of eggs incubated, hatched and hatchability of percentages were (14.8 ±0.55, 12.5 ±0.57 and 80.5), respectively.

Table 8 Eggs incubated, hatched, hatchability and Age at sexual maturity in the study areas

Parameters	Highland	Mid Land	Overall
Eggs incubated	15.1 ±0.58	13.87 ±0.52	14.48 ±0.55
Eggs hatched	12.13 ±0.51	11.97 ±0.63	12.5 ±0.57
Hatchability	80	81	80.5
Age of sexual Maturity			
Female	8.33 ±0.291	7.93 ±0.311	8.13 ±0.301
Male	7.46 ±0.313	7.89 ±0.299	7.67 ±0.306

Purpose of keeping poultry

The study finding revealed that about 40.32, 26.2 and 17.32% of the respondent's rear chicken for sale, home consumption and non-defined purpose respectively (Fig. 6).

Village chicken management practices

Egg utilization

The egg utilization practices of the respondents in the study areas were shown below on Fig. 7.

Methods of breaking broodiness

The methods of breaking broodiness of chicken in the study areas were shown below on Fig. 8. From the study result, respondents were break broodiness by hang upsides down the broody hens (22.0 and 23.7%), taking broody hen to neighborhoods (13.4% and 13.4%), replacing the adapted place with other materials (8.6% and 9.6%), and piercing feather' s shank into nostril of the broody hen (4.3% and 4.8%) in mid-land and high land agro-ecology, respectively.

Egg storage condition

The egg storage conditions in the study agro ecology was indicated on Fig. 9. Study result showed that the respondents were stored egg in cold places (4.3%), inside cold container (18.3%), warm places (6.5%), inside grains (8.6%), any place (8.6%) and cold places covered with clothes (2.2%), in high land agro ecology. While the respondents were stored egg cold places (4.3%), inside cold container (21.5%), warm places (6.5%), inside grains

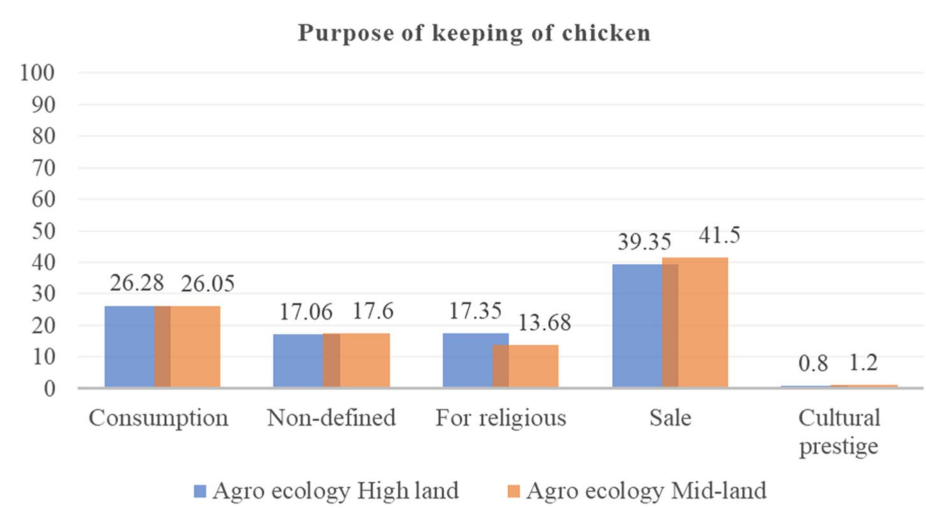

Fig. 6 Purpose of keeping of chicken

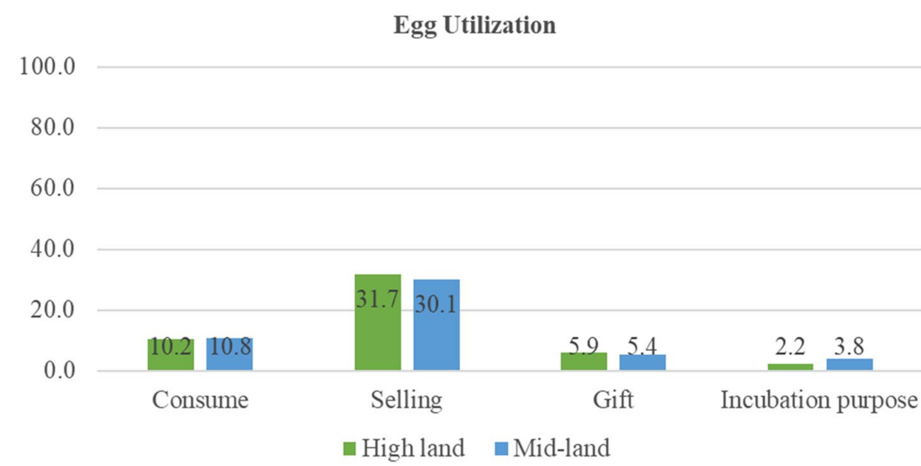

Fig. 7 Egg utilization practices in the study areas

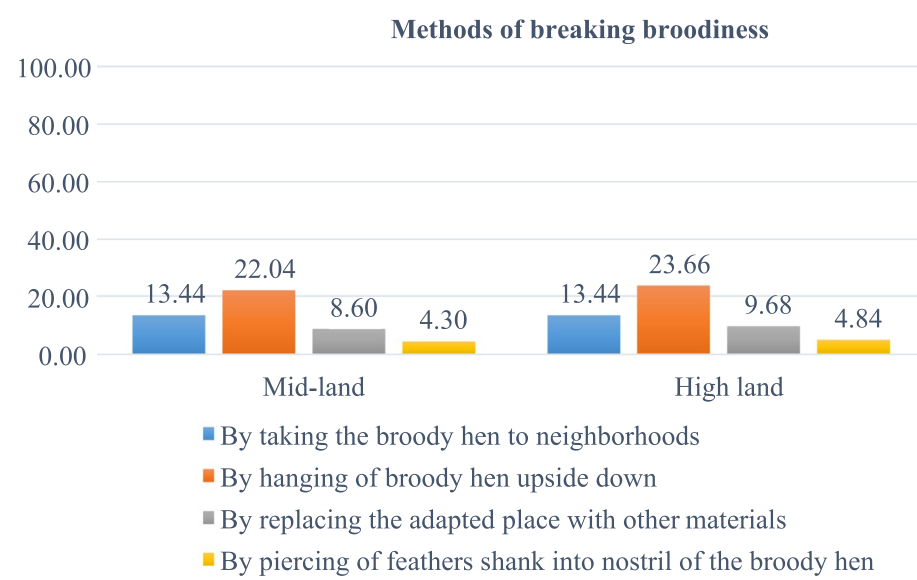

Fig. 8 Traditional Methods of breaking broodiness in the study areas

(8.6%), any place (8.6%) and cold places covered with clothes (2.1%) mid-land agro ecology. The finding of current study revealed that, egg storage condition inside cold container in mid land (21.5%) was higher than high land (18.3%).

Setting and bedding materials

The egg setting and bedding materials of chicken in study areas were shown on Fig. 10. The different setting and bedding materials used by respondent households were from this clay pot with straw bedding was most preferred by the majority of the respondents followed by sac and straw bedding with percentage value of 16.1% (High land), 14.0% (Mid-land) and 12.0% (Highland), 14.0% (Mid-land), respectively.

Constraints of village chicken production

The constraints of chicken production prioritized by the respondents in the study areas described on Table 9 and Fig. 11.

Opportunities chicken production

The opportunity of chicken production the study areas were presented on Table 10. From the study result revealed that the three major opportunities are market access, credit services and payment for social gathering, respectively.

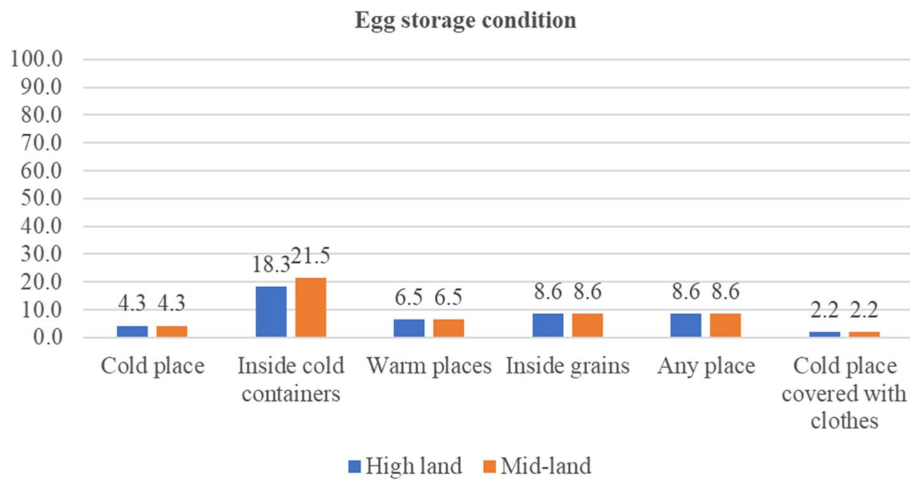

Fig. 9 Egg storage condition in the study areas

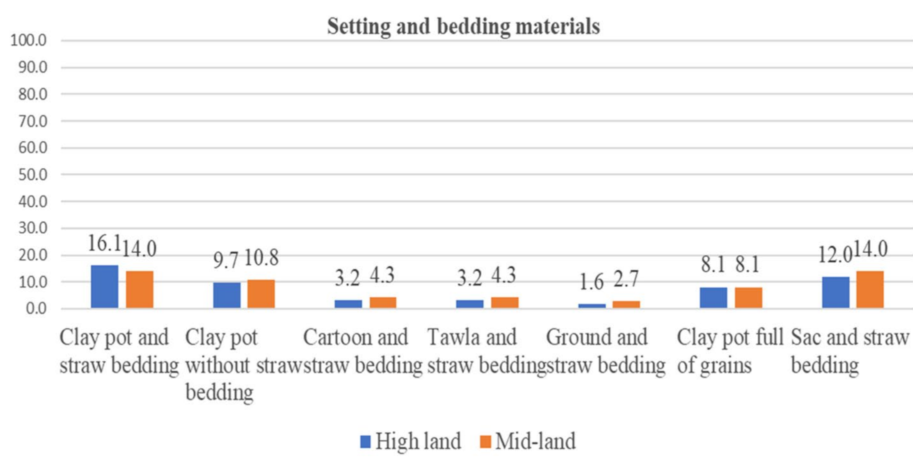

Fig. 10 Setting and bedding materials in the study areas

Table 9 Relative index for Chicken Production Constraints in the study agro ecology areas

	Relative degree of importance of both ecology					agro		
Major constraints	**1**	**2**	**3**	**4**	**5**		**Index**	**Rank**
Prevalence of disease	104	34	68	39	52		0.342	1st
High chick mortality	64	21	42	52	5		0.221	2nd
Predator Attack	40	13	26	35	0		0.138	3rd
Shortage of feed and grains	24	8	16	10	11		0.080	4th
Lack of parent stock	16	5	10	11	3		0.054	5th
Poor hatchability	10	3	9	8	10		0.040	6th
Spoilage of eggs	11	5	2	3	1		0.030	7th
Poor extension services	8	6	3	7	0		0.030	8th
Lack of veterinary service/vaccination	9	4	3	5	1		0.028	9th
Inadequate equipment	8	2	4	5	2		0.025	10th

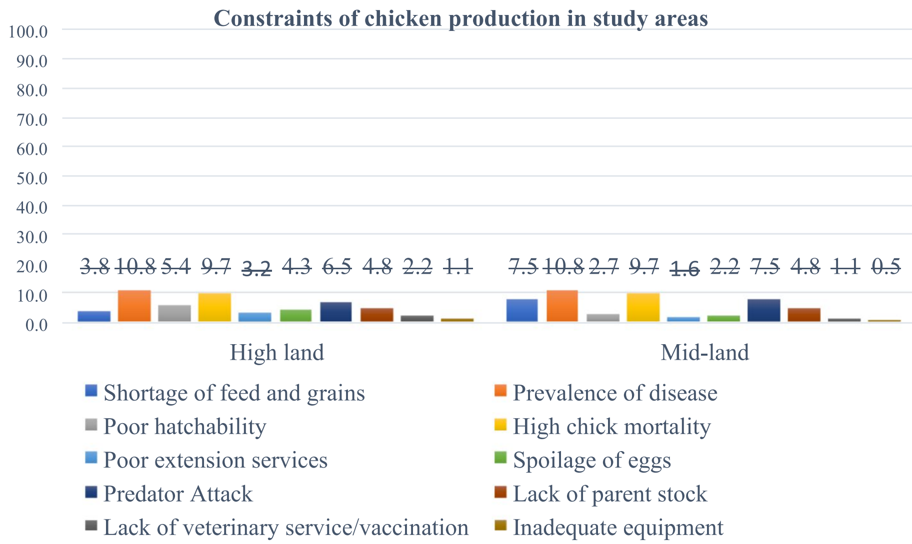

Fig. 11 Chicken Production Constraints in the study agro ecological areas

Table 10 Opportunity chicken production in the study agro ecology areas

Opportunities	Relative degree of importance			Index	Rank
	1	2	3		
Market access	22	14	10	0.3363	1 st
Credit services	8	18	7	0.2221	2nd
Payment for social gathering	5	11	17	0.1915	3rd
Child malnutrition	4	13	11	0.1593	4 th
Youth and women's empowerment	7	8	5	0.0977	5 th

Table 12 Measurement of egg yolk quality parameters in each agro ecology

Egg quality parameter	High land	Mid-land	Overall	Probability
YH	16.5 ± 0.11	15.50 ± 0.43	16.00 ± 0.27	***
YWt	16.1 ± 0.50	16.28 ± 0.47	16.18 ± 0.49	Ns
YDr	27.9 ± 0.36	28.00 ± 0.37	27.97 ± 0.37	Ns
YI	0.6 ± 0.01	0.55 ± 0.01	0.55 ± 0.01	Ns
YC	3.2 ± 0.17	3.21 ± 0.18	3.22 ± 0.18	Ns

YH yolk height, *YWt* yolk weight, *YDr* yolk diameter, *YI* yolk index, *YC* yolk color, *Sig* significance, *ns* not significant

[*] Significant ($P < 0.05$)

Table 11 Measurement of external egg quality parameters in each kebele

Egg quality parameter	High land (μ±SE)	Mid-land (μ±SE)	Overall (μ±SE)
EWt	36.47 ± 0.84[a]	37.17 ± 0.86[a]	36.82 ± 0.85
Esw	3.63 ± 0.19[a]	3.44 ± 0.19[a]	3.54 ± 0.19
ST	0.35 ± 0.01[a]	0.34 ± 0.01[a]	0.35 ± 0.01

EWt egg weight, *Esw* egg shell weight, *ST* shell thickness

[a] Means with in a row with different superscripts are significantly different

External and internal egg quality parameter measurements

External egg quality traits

Egg weight and egg shell thickness were no significantly ($P > 0.05$) difference among agro ecology (Table 11).

Internal egg quality traits

There was no significant ($P > 0.05$) difference in egg yolk traits measurement among the eggs obtained from each agro ecology except for egg yolk height (Table 12).

Agro ecology effect on egg quality parameter measurements

There was no significant ($P > 0.05$) difference in all egg quality parameter measurement across the agro ecology except yolk height and albumen height, in which higher ($P < 0.01$) value of yolk height was recorded in highland over Mid land agro ecology and the higher albumen height was recorded in Mid land over Highland agro ecology (Table 13).

Discussions

The observed flock structure, which has chicks as the largest number and hens as the second-highest in the study locations, may be caused by a combination of

Table 13 Measurement of egg quality parameters by agro ecology. Agro- EWt Esw ST YH YWt YDr YI YC Alwt Alht HU ecology

Midland	37.40 ± 0.5	3.58 ± 0.13	0.34 ± 0.01	15.38 ± 0.036[b]	16.01 ± 0.27	27.96 ± 0.21	0.55± 0.004	3.23 ± 0.103	19.05 ± 0.27	5.24 ± 0.23[a]	77.61 ± 0.87
Highland	6.14 ± 0.48	3.48 ± 0.12	0.35 ± 0.01	15.52 ± 0.024[a]	16.4 ± 0.28	27.96 ± 0.2	0.56± 0.004	3.22 ± 0.101	19.22 ± 0.28	4.73 ± 0.17[b]	78.23 ± 0.82
Sig	1	0.67	0.99	0.04	0.99	0.866	0.995	0.854	0.993	0.05	0.999

EWt egg weight, *Esw* egg shell weight, *ST* shell thickness, *YH* yolk height, *YWt* yolk weight, *YDr* yolk diameter, *YI* yolk index, *YC* yolk color, *Alwt* albumen weight, *Alht* albumen weight, HU: Haugh unit, *ns* not significant

[*] Significant ($P < 0.05$)

[a,b] Means with in a row with different superscripts are significantly different

natural breeding cycles producing more chicks and the economic importance of hens in egg production. The result agreed with the findings of [23] stated that in Bishoftu (Ethiopia) flocks were, 36.5% reared chicks while hens were the largest flock type followed by pullets, chicks, cockerels, and cocks, respectively and [24] who stated that in Northern Gonder (Ethiopia) flocks were dominated by chicks (47.0%), hen (20.2%), cocks (9.5%), pullets (14.8%), and cockerels (8.5%). The study finding was in line with reported by [25] from Jamma woreda (2 ± 0.04) of northern Ethiopia. Similarly, [17] stated that most common flock size of family poultry ranging from 5 to 15 birds seems to be the limit that can be kept by a family without special inputs in terms of feeding, housing and labor. The flock productivity, it can be justified that each hen produced an average of 60.4 eggs annually (15.82 eggs per clutch multiplied by 5.26 clutches annually). This implies that, on average, 60.4 eggs were produced annually by each hen in the study area. The management strategies intended to enhance egg production in nearby chicken populations can be informed by these findings, which offer insightful information on the reproductive capabilities of village chickens. The study result was in line with 60 eggs per year reported in Bure district by [26]. The study result was in line with [25] who reported that eggs per clutch per hen (15.4 ± 0.4) and age at first lay (5.35 ± 0.7) months from Jimma woreda (Ethiopia). Similarly, [27] stated that the average age at first lay in local birds was 6.5 ± 0.93 months which was similar to age at first lay in the Central Highlands of Ethiopia.

The breed composition of the study showed that indigenous chickens make up about 20.5% of the total chicken population of the overall study areas. The remaining 19.9% of the total chicken population of the study areas are assumed to cross breed. The study results of this study clearly showed that there has been intensive distribution of exotic breeds in the study agro ecological areas. This result of the study in comparable with result of by [25] was (0.2 ± 0.04), [28], was the breed composition of the flock was local ecotypes (7.43 ± 0.05) from Jimma and Dire Dawa town (Ethiopia), respectively. Chicken production system is may be attributable to its small-scale farmer compatibility, affordability, incorporation with traditional farming techniques, and adaptation to local conditions. This study was in line with [17, 29] they reported that the most dominating poultry production system in rural areas of Africa is extensive system and relying on scavenging feeding systems. Many African countries produce chicken through village production system [30–32]. The village chicken production system is characterized by extensive scavenging, no immunization programs, high prevalence of disease and predators, and uncontrolled natural mating and hatching of eggs using broody hens [33].

It may be explained by the low importance assigned to chicken production relative to other livestock operations. This implies that these households might not prioritize raising hens over other agricultural pursuits, and as a result, they might not set aside a substantial amount of money. The selection of chicken house may also be influenced by a lack of knowledge about the value of housing and the threat posed by predators. Households may not prioritize investment if they are unaware of the advantages of giving hens appropriate shelter or the dangers posed by predators. This report agrees with the report of [34] who reported that the majority of farmers were housed their chickens by sharing the same room with perch 65% and chicken's mortality accounts due to predators because of lack of proper housing. The differences in feed resource availability in the study area agroecology may be the highland area could have easier access to leftover food from the home because of possibly larger families or distinct eating patterns. On the other hand, because of its agricultural output and grain availability, the mid-land area can have a greater proportion of families depending on grain as a feed source. This result seems to be in line with that of [35] who reported that cereal grains (maize and sorghum) and household scraps are the major supplementary feeds offered, the amount of each being dependent on seasons of the year and the quantity and availability of the resources at the household level. The major water source for chicken were river for both Highland (93.3%) and Mid-land (94.3%). About 3.5, 11.2 and 85.3% of the overall respondents supplement their chicken twice, free access and once a day respectively in Highland. About 1.5, 8.3 and 90.5% of the overall respondents supplement their chicken twice, free access and once a day respectively in Mid-land. The most predominate watering frequency were once/day of Highland (85.3%) and Mid-land (90.3%). This is agreed with the study of [26] in Burie district of North West Ethiopia.

Common traditional practices and restricted access to veterinary services it can be answerable for the observed similarities in preventive measures implemented by families throughout the study areas. The significant proportion of respondents who practiced isolating sick chickens and killing hens right before they were ill demonstrate a practical approach to disease prevention and loss minimization. This practice is probably motivated by a combination of lack of access to veterinary care and medications, as well as farmer's knowledge and experience. Using modern medicine, in the study districts were lower because of lower veterinary infrastructure and lack of awareness and adaptability across the study agro ecology. The most commonly used measure against predator control in the study areas were Protecting of the chicken house (59.1%), Hanging frustrating materials on fences (51.6%), Growing of hedges (49.5%), Killing of predators (39.8%). This is in line with the reports of [25] (Jamma woreda, south Wollo, Ethiopia), who reported that about 77.70% of the households were using different means of protecting chickens from predators, and [27] (Central Highlands of Ethiopia) who reported that housing played a major role in decreasing mortality of chicken due to reduce predations.

The egg hatchability were in line with the reports of [36] agreed the present study on different breeds of poultry that with 78% of hatchability of eggs, eggs incubated (15.5 ± 0.45) and hatched (13.5 ± 0.47). According to [17], hatchability using broody hen around 80% to be normal, but a range of 75% to 80% is considered to be satisfactory. However, [37] report in Ethiopia lower (70.5 ± 10%) result of hatchability [37, 38] report in Ethiopia indicated that the average number of eggs set for incubation per hen was around 14 and 13 ± 0.19, respectively. The overall mean age of sexual maturity for male and female were 7.67 ± 0.306 and 8.13 ± 0.301 across the study agro ecology, respectively. On purpose of keeping poultry, from this most of the respondent householder farmers in the study areas gives highest priority for selling and household home consumption. In line with this result [25] who reported that for home consumption and selling (44.7 and 46.8%), from Jamma woreda (Ethiopia) [39] reported that about 50 and 27% of the respondents keep poultry as source of family income and food respectively, from *Nole Kabba* Woreda (Ethiopia). The highest percentage of the interviewed household respondent's utilization of eggs were for selling purpose in mid-land (30.1%) and high land (31.7%), with having (61.8%) from the study population. While in high land (10.2%) and mid-land (10.8) utilize the eggs for household home consumption, high land (5.9%) and mid-land (5.4%) for gift purpose and the rest for incubation purpose, respectively. This result was agreed with the report of [25], from Jamma (Ethiopia) in which farmers were utilize the eggs for consumption (32.2%) and selling (28.4%).

The respondents were break broodiness by hang upsides down the broody hens (22.0 and 23.7%), taking broody hen to neighborhoods (13.4% and 13.4%), replacing the adapted place with other materials (8.6% and 9.6%), and piercing feather' s shank into nostril of the broody hen (4.3% and 4.8%) in mid-land and high land agro-ecology, respectively. This finding was agreed with the reports of [39] most of the farmers were used to break broodiness of broody hen through hang upsides down the broody hens, taking broody hen to neighborhoods, by replacing the adapted place with other materials, and piercing feather' s shank into nostril of the broody hen from *Nole Kabba* Woreda (Ethiopia).

Egg storage condition was in line with the reports of [40] in which more than half of the respondents store their eggs in cold places (under their bed) and inside cold container (like clay pot) while the remaining farmers store their eggs in warm places (on perch where cooking takes place), inside grains and cold places covered with cloths from Selected Zones of Ethiopia.

Setting and bedding materials result agreed with the reports of [40] from Selected zones of Ethiopia in which clay pot with straw bedding is most preferred by the majority of the respondents (15.9 %) followed by cartoon and bamboo basket with straw bedding (12.6%). Similarly, [27] reported that farmers were used clay pots, cartoons, bamboo basket and even simply depression in the ground in central highlands of Ethiopia. In the same report they also indicated that the bedding materials used in all study villages were crop residues, usually *teff* (*Eragrostic tef)* and wheat straw.

The major constraints of chicken production in the study areas were prevalence of disease, high chick mortality, predator attack, shortage of feed and grains and lack of parent stock. The high rate of chick mortality and disease prevalence lower overall flock size and health, and predator attacks further reduce numbers, all of which impede the expansion of the chicken production in the study area. Additionally, a shortage of feed and grains contributes to the problem by reducing the availability of nutritional resources, essential for healthy growth and resistance to disease. A cycle of restricted production capacity is created when there is insufficient parent stock, making it difficult to restock and grow the flock. Constraints were not different from those reported by others in Ethiopia such as [41] who reported that the main constraint of traditional chicken production system was disease at Jimma (Ethiopia). The most prevalent and economically important disease that attacks chicken population specifically Newcastle disease which is locally known as "*Kenbesha* (Pronounced as '*Keen.bee.sha*')" in the study areas. The second and third major constraints were high chicken mortality and predator attack, respectively, this might be because of poor housing system, and free scavenging feeding. Among predators like baboons, and wild cat which is locally known as ("*shululla*") were more predominated one in the study areas. The finding of study were in line with [42] who reported about 70% of the respondents were ranked disease as the most important constraint to rural poultry production in Haramaya District (Ethiopia), [28] who ranked predation and disease as the major problem of chicken production in Dire Dawa town (Ethiopia) and [4] who reported that predator, feed shortage, flock mortality and low production as first, second, third and fourth constraints, respectively at Gonder Zuria Woreda (Ethiopia). From the study result revealed that the three major opportunities are market access, credit services and payment for social gathering, respectively.

The higher egg weight value was recorded in Mid-land agro ecology than the High land. The result of the current work was in line with the finding of [43] who reported uniform egg weight measurement in South Bench, Sheko and North Bench areas, however, the mean egg weight values (36.82 ± 0.85 g) of the current study was lower than their findings. In contrary to this finding [44] reported significant variation in egg weight and shell thickness of eggs collected from farm gate and market as well as from exotic and local chickens. Shell thickness (0.35 ± 0.01) of the current finding was comparable to the acceptable egg shell thickness to withstand egg breakage. However, there were no significance difference in egg shell weight, egg weight, and shell thickness among the different agro ecology [45] reported that shell weight increases as the age of chicken advances and age of hen is a factor for the variation of chicken egg shell weight. In addition, it may be due to breed difference in where an egg is collected. difference on egg shell weight for different breeds. In agreement with this result, [46] reported significant difference in egg shell weight of chicken eggs for different agro ecology for farmer managed chicken. However, it was different from the finding of [47] who reported uniform egg shell weight in different agro ecology of southern Ethiopia. Significantly ($P< 0.001$) higher yolk height value were obtained by mid-land than high land agro ecology. In agreement with the current study, significant variation of yolk height was reported by [48] for different agro ecology in Sidamo region. The yolk index values of the eggs obtained from all kebeles ranged from 0.55–0.6, which is above the accepted range of 0.33–0.50 for fresh eggs [49]. This value indicated that eggs from all agro ecological areas are of desirable quality type, as index is the best indicators of internal egg quality showed by [50] who stated yolk index values of fresh eggs vary between 0.33 and 0.5 mm. The yolk index and yolk color of the current finding was different from the report of [51] who explained significant difference for different agro ecology's in Amhara region. There was no significance ($P>$ 0.05) differences in egg albumen weight and Haugh unit of eggs collected from each kebeles (Table 14). Similarly, [52] reported that nonsignificant difference in egg albumen weight in East Shewa zone. Contrary to the current finding [6] reported that significant difference in HU values. There was significance difference in albumen height across each agro ecology (Table 14). It is reported that agro ecology has an effect on internal quality of chicken egg [48]. The albumen height, HU and albumen viscosity significantly decreased with increasing storage time and it is concluded that storage time is the major factors affecting egg quality. The finding of the current work was similar with [6],who reported significant difference in egg albumen height of chickens reared in Hawassa and Yirgalem town. Contrary to the current finding [46] noticed significant difference in albumen weight and HU of chicken under farmer managed conditions. The physiological development of eggs is influenced by the unique climatic condition and nutritional availability in each agroecological zone, which might be the reason for these variances. Higher yolk heights in highlands may result from region-unique genetic adaptations in chickens or better-quality feed. On the other hand, variations in diets or environmental stresses that promote albumen production may be responsible for the higher albumen height in the midlands. It is essential to comprehend these variations to optimize egg production tactics that are specific to each agroecological zone. This finding was similar with the report of [47] who report uniform results of chicken egg internal quality but their finding was not in line with the finding of current study for albumen height and yolk height. However, [48] reported significant difference in yolk weight, albumen weight and height, and HU in Sidama region across different agro ecology. The HU value that determine the quality of albumen is was within the range of 70-100 set for good egg quality.

Table 14 Measurement of egg albumen quality parameters in agro ecology

	Highland	Mid-land	Overall	Sig.
Egg quality parameter	(μ±SE)	(μ±SE)	(μ±SE)	
Alwt	19.1 ± 0.47	19.16 ± 0.47	19.13 ± 0.47	0.75
Alht	4.73 ± 0.17^{b}	5.24 ± 0.23^{a}	4.98 ± 0.20	0.05
HU	76.58 ± 1.42	79.9 ± 1.4 7	77.83 ± 1.45	0.99

Alwt albumen weight, *Alht* albumen weight, *HU* Haugh unit, *Sig* significance, *ns* not significant

[*] Significant ($P< 0.05$)

Conclusion

The study reveals that chicken production in the study area is dominated by exotic breeds, with the majority of households using eggs for selling purposes. The top five major constraints in chicken production are disease prevalence, high chick mortality, predator attacks, and lack of parent stock. Egg quality parameters such as egg weight, shell weight, yolk weight, yolk diameter, yolk index, yolk color, albumen weight, and Haugh unit were statistically similar among agro ecologies. However, yolk height and albumen quality showed significant differences across districts.

Recommendations

- Efforts should be geared to alleviate constraints like disease outbreaks, increased chick mortality, and predator attacks, as well as issues related to shortages of feed
- Smallholder farmers in the study areas should undergo training in chicken housing practices.
- Further research is needed to investigate the assessment of both external and internal egg quality across diverse production systems.

Supplementary Information

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Supplementary Material 1

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Additional information
No additional information is available for this paper.

Authors' contributions
Desalegn Amanuel Write up, data collection Eskindir Amanuel Write-up, data collection, analysis, Supervision Edao shanku Data collection.

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Data availability
Yes

Declarations

Ethics approval and consent to participate
The necessary consent for the study involving chickens was obtained in accordance with ethical guidelines. The informed consent of the chicken owner was obtained as part of the Ethics approval and Consent to participate process, which was approved by Wachemo University Ethical board members. The owner of the chickens provided written informed consent for their chickens to be included in the study. All procedures involving the chickens were carried out in accordance with ethical guidelines and regulations. The welfare of the chickens was a top priority throughout the study. The study was approved by Wachemo University Ethical board members.

Consent for publication
Not applicable

Competing interests
The authors declare no competing interests.

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