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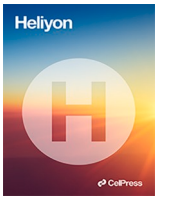

A study on egg quality and hatching traits of indigenous and exotic chickens reared in Silte zone, Southern Ethiopia

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ABSTRACT

The objective of this study was to evaluate egg quality and hatchability of indigenous and exotic chickens in the midland, lowland, and highland agroecological zones of the Silte zone. One district was selected from each agroecological zone, and a total of 399 households (133 from each district) were randomly chosen from six purposefully selected Kebles to collect data on egg hatchability. For external and internal egg quality evaluation, 300 eggs (150 from indigenous and 150 from exotic chickens from each agroecology) were collected. The study found that Sasso chickens had better egg quality in terms of egg weight, yolk width, yolk height, albumen height, yolk index, and Haugh unit compared to indigenous chickens in both the highland and lowland areas. In the highland area, Sasso chickens had higher values for egg weight, yolk width, yolk height, albumen height, yolk index, and Haugh unit compared to the lowland area. This suggests that Sasso chickens performed better in terms of egg quality in both the highland and lowland areas compared to indigenous chickens. The hatchability percentages of Sasso and Koekoek chickens were 70.8 ± 14.1 and 69.7 ± 12.7, respectively, in the midland area. This suggests that Sasso and Koekoek chickens performed well in terms of hatchability, followed by indigenous chicken eggs. However, approximately 68% of respondents did not use exotic chicken eggs for hatching. The study suggests that practicing hatching of exotic chicken eggs could be beneficial in increasing the productivity of indigenous chickens.

1. Introduction

Ethiopia, with its abundant livestock population, including a significant number of chickens, has the potential to improve its poultry production sector and the livelihoods of rural livestock producers [1,2]. Indigenous chickens (i.e,. native to the country) are prevalent in rural and peri-urban areas due to their adaptability and disease resistance, but they have limited productivity [3,4]. The indigenous chicken population in Ethiopia plays a crucial role in the rural and national economy, although it is characterized by low productivity and scavenging [5,6]. However, raising chickens can provide additional income and contribute to improving the nutritional security of vulnerable populations [3].

Understanding the quality of eggs laid by chickens is essential as it serves as an indicator of productivity, overall chicken care, business success, and embryonic development [3]. Exotic chicken breeds (i.e., originate from other countries) have been introduced to smallholder farmers in Ethiopia with the aim of enhancing the performance of indigenous chickens [2]. However, evidence suggests that exotic chickens may not adapt as well as indigenous chickens under intensive management systems [7].

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Before implementing any technological interventions or strategies to enhance indigenous chicken production, it is necessary to study the existing production system [8,9]. Limited research has been conducted in Ethiopia to investigate the relationship between indigenous and exotic chicken egg quality and hatchability performance [2]. Furthermore, no studies have been conducted in the Silte zone, Southern Ethiopia, to assess the egg quality and hatchability of indigenous and exotic chickens.

Therefore, the present study aims to compare the egg quality and hatchability of indigenous and exotic chickens reared in the Silte zone, Southern Ethiopia, with the hypothesis that exotic chicken breeds will demonstrate superior egg quality and hatchability compared to indigenous chicken breeds. The study will contribute to understanding the potential benefits of exotic chicken breeds and their impact on egg quality and hatchability in the region.

2. Materials and methods

2.1. Description of the study area

The study was conducted in the three weredas of the Silte Zone. The Silte zone is 172 km from Addis Ababa and is bounded by the Alaba zone in the south, Hadiya in the west, Oromia in the east, and Gurage in the north. Its altitude extends from 1500 to 3700 m above sea level. The zone has three agro-ecological zones, namely highland (Dega), midland (Woynadega), and lowland (Kola). The minimum and maximum monthly temperatures of the study area varies between 12 and $26^{0C,}$ and the minimum and maximum annual rainfall ranges between 780 and 1818 mm. According to the 2007 census conducted by the central statistical agency of Ethiopia, this zone has a total population of 750, 398 of which 364,108 are males and 386,290 are females. Among the total population of this zone, only 47,097 (6.28%) are urban inhabitants.

2.2. Study design

A cross-sectional study was carried out to evaluate the egg quality and hatchability of indigenous and exotic chickens reared in the Southern Ethiopian districts of Hulbareg (midland), Alicho wuriro (highland), and Lanfuro (lowland).

2.3. Sampling procedure and sample size determination

One district from each agro-ecology, namely in the midland (Hulbareg), in the highland (Alicho wuriro), and in the Lanfuro (lowland), was chosen on purpose based on the overall population size of chickens being reared. Each district had two rural kebeles chosen at random. Furthermore, the households were chosen using a random sampling method. The sample size of the households was determined using the formula below [10].

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

Where n: sample size is needed,

N: population size of the study area
e: desired precision level (in this case, e = 5%)

Therefore, a total of 399 households (**133** from each district) were included in this study.

To collect data on egg availability, 399 households (133 households from each district) were randomly selected from 6 Kebles. A total of 300 eggs from both indigenous and exotic chickens that were stored within a week of being laid were collected on purpose by identifying households that had both indigenous and exotic chickens. The eggs were labeled correctly based on agro-ecology and breed. The eggs were tested for freshness by immersing them in cold water.

2.4. Method of data collection

Translators fluent in the indigenous language (Siltigna) were chosen from the district's Animal and Fishery office's development agents. A semi-structured questionnaire was used to collect primary quantitative data (hatchability performance, season of hatching practice, selection of egg size, selection of hen size and chicken survivability) in the study area. The secondary data used in this study came from both published and unpublished sources. Eggs were weighed using a triple beam balance during the egg quality evaluation. A digital caliper was used to measure egg length and width, yolk diameter, and shell thickness.

The albumen and yolk heights were measured using a tripod micrometer. The Roche Color Fan was used to determine the color of the yolk. The average thickness of the large end, narrow end, and center of the shell was measured. Debre Zeit agricultural research institute determined all of the egg quality parameters such as shell quality, shell weight, shell porosity, shell shape, egg weight, yolk weight, albumen quality and haugh unit. Individual Haugh units were calculated using the Haugh equation [11]. The egg shape index was computed according to Ref. [12]. The yolk index was calculated according to Ref. [13]. The formula is as follows:

Yolk Index = (2y / d) x 100

Where:

"y" represents the height of the yolk
"d" represents the diameter of the yolk

2.5. Data analysis

Throughout this study, qualitative data was analyzed using a one-way ANOVA technique in SPSS version 21. The three agro-ecologies were treated as independent variables, and the output was described using descriptive statistics. To compare means, the Duncan multiple range test was employed, and significance was determined at $P \leq 0.05$. SAS 9.3 was used for the analysis of egg quality and hatchability parameters.

The model used for the analysis of the egg quality and hatchability

$Y_{ij} = \mu + A_i + B_j + A_i{*}B_j + e_{ij}$, where:
Y_{ij} = the observations of egg quality and hatchability in the *i*th agroecology and *j*th breed
μ = overall mean of the observed variables
A*i* = fixed effect due to *i*th agroecology (*i* = highland, midland and lowland)
B*j* = fixed effect due to *j*th breed of chickens
Ai*Bj = the interaction effects of ith agroecology and jth breed
e_{ij} = random residual error

3. Results and discussion

3.1. Internal egg quality traits of indigenous and Sasso chickens

Table 1 presents the egg weights of Sasso and indigenous chickens in the highland, midland, and lowland areas. The recorded weights were 51.9 ± 2.9 g, 50.7 ± 3.9 g, and 49.5 ± 2.9 g, respectively. It is worth noting that these weights were lower compared to the findings reported by Ref. [14] in the towns of Yirgalem and Hawassa. This difference in egg weights could potentially be attributed to various factors such as differences in breed, environmental conditions, or management practices between the study areas. Furthermore, the yolk width of indigenous chicken eggs was observed to be greater than the measurement reported by Ref. [15], who recorded a value of 36.80 ± 0.175 mm. On the other hand, the Sasso chicken egg width in the study area was consistent with the measurements reported by Ref. [14] in Yirgalem and Hawassa towns. The variation in yolk width could be influenced by genetic factors or dietary differences, which may vary among different chicken populations or regions. In terms of yolk and albumen height, the indigenous chicken eggs showed higher values compared to the findings reported by Ref. [16] in three agro-ecologies of the Western Zone Tigray. This discrepancy in yolk and albumen height could be attributed to differences in management practices or environmental conditions between the study areas. Regarding the average yolk color and yolk index, both indigenous and exotic chicken eggs exhibited results that were similar to the findings obtained by Ref. [17] in the Chelliya District. This similarity suggests that the factors influencing yolk color and index may be consistent across different regions or populations. In general, the results indicate variations in egg weights, yolk width, yolk and albumen height, as well as yolk color and index between the study areas. These differences could be due to various factors such as breed, environmental conditions, management practices, or genetic variations. Comparisons with previous studies provide valuable insights into the consistency or divergence of the current findings with existing literature.

Table 1
Internal egg quality traits and effect of agroecology, breed and their interaction (Mean ± SD).

AE	Breeds	Parameters						
		EW	YW	YH	AH	YI	HU	YC
Highland	Indigenous	40.2 ± 4.8^{c}	38.2 ± 1.9^{c}	16.1 ± 1.2^{d}	6.3 ± 0.7^{c}	44.1 ± 4.6^{b}	72.3 ± 5.9^{d}	9.4 ± 1.7^{b}
	Sasso	51.9 ± 2.9^{a}	37.3 ± 4.2^{c}	18.2 ± 1.1^{a}	7.5 ± 0.9^{a}	48.5 ± 10.0^{a}	85.6 ± 5.4^{a}	9.0 ± 1.7^{b}
Midland	Indigenous	38.4 ± 4.8^{d}	37.5 ± 3.1^{c}	16.6 ± 1.4^{c}	6.2 ± 0.6^{c}	44.3 ± 4.7^{b}	70.8 ± 5.3^{d}	8.8 ± 1.5^{b}
	Sasso	50.7 ± 3.9^{ab}	40.01 ± 2.3^{b}	17.6 ± 0.9^{b}	6.5 ± 0.8^{b}	42.8 ± 4.2^{cb}	78.8 ± 6.4^{b}	7.7 ± 1.7^{c}
Lowland	Indigenous	37.8 ± 2.8^{d}	37.8 ± 2.6^{c}	15.3 ± 1.3^{e}	5.9 ± 0.5^{d}	40.6 ± 4.5^{c}	68.2 ± 4.1^{e}	10.0 ± 1.3^{a}
	Sasso	49.50 ± 2.9^{b}	41.5 ± 3.6^{a}	16.8 ± 1.5^{c}	6.2 ± 0.6^{c}	41.0 ± 4.9^{c}	76.1 ± 4.8^{c}	10.2 ± 1.4^{a}
Agroecology		<.0001	<.0001	<.0001	<.0001	0.1249	<.0001	0.0126
Breed		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
AE*Breed		0.8159	<.0001	0.0118	<.0001	0.0014	0.0003	0.0182

[a-e] Means between agroecologies within breeds bearing different superscript letters are significant at $p < 0.05$, AE = Agroecolog, EW = Egg weight, YW=Yolk width, YH=Yolk height, AH=Albumen height, YI=Yolk index, HU=Haugh unit, YC=Yolk colour.

3.2. External egg quality traits of indigenous and Sasso chickens

Table 2 presents the external egg quality traits and the impact of agroecology, breed, and their interactions. The breed of chickens plays a significant role in determining various aspects of external egg quality. It is observed that except for the egg shape index, both the agroecology and the interaction between breed and agroecology had a significant effect on the measured parameters. The indigenous chicken egg shape index did not show significant differences across different agroecologies. This suggests that the shape of indigenous chicken eggs remains relatively consistent regardless of the specific agroecological conditions. On the other hand, Sasso chickens exhibited a significantly higher egg shape index compared to indigenous chickens. This difference in egg shape index may be attributed to genetic variations between the two breeds.

Furthermore, Sasso chickens also displayed significantly greater shell thickness compared to indigenous chickens. This finding suggests that Sasso chickens may have a stronger and more robust eggshell compared to indigenous chickens. The variation in shell thickness could be due to genetic differences or potential differences in dietary factors between the two breeds. In terms of egg size, it was observed that the length and width of indigenous chicken eggs were smaller compared to the measurements reported by Ref. [14] in Yirgalem and Hawassa. This discrepancy in egg size could be influenced by various factors, including genetic variations, environmental conditions, or management practices specific to the study area. Interestingly, both indigenous and exotic chicken eggs exhibited greater shell thickness compared to the report mentioned. This discrepancy in shell thickness could be due to differences in environmental conditions or management practices between the study area and the location of the previous report.

3.3. Hatchability of chicken egg

Based on the figure presented (Fig. 2), it is evident that a significant proportion of respondents in the study area, specifically 68%, did not hatch exotic chicken eggs (see Fig. 1). This finding suggests that there may be certain factors or challenges that deter respondents from hatching exotic chicken eggs, which could include limited access to appropriate incubation facilities, lack of knowledge or experience in hatching exotic eggs, or preference for other productive uses of the eggs.

On the other hand, more than half of the total respondents did engage in hatching indigenous chicken eggs. This indicates a higher level of interest or familiarity among respondents in hatching indigenous eggs, which could be attributed to several factors such as cultural significance, perceived higher success rates in hatching indigenous eggs, or the availability of traditional hatching methods that are better suited for indigenous eggs. In comparison, previous studies conducted in Yirgalem and Hawassa reported that the majority of respondents in those areas did not keep eggs for hatching [18]. This difference in findings between the study area and the aforementioned locations could be due to variations in cultural practices, economic factors, or specific preferences of the communities in each area.

Based on the findings (Table 3), it is evident that a significant proportion, approximately 58.1%, of respondents in the study area prefer to practice hatching during the dry season. This preference can be attributed to several logical reasons. Firstly, during the dry season, there is typically better access to feed resources for the chickens. This can result in improved nutrition for the hens, which in turn can lead to better egg quality and higher chances of successful hatching. Secondly, the dry season is often associated with lower environmental humidity, which can reduce the risk of bacterial or fungal contamination in the eggs and subsequently decrease chick mortality rates [15].

Moreover, the majority of respondents in the study area chose to hatch medium-sized eggs using large-sized hens. This preference can be justified by previous studies conducted in the North Wollo zone, where approximately 88.24% of village chicken owners also selected egg size as a criterion for hatching [19]. The preference for large-sized eggs can be attributed to the belief that larger eggs are associated with better egg quality, higher hatchability rates, and potentially stronger and healthier chicks. This preference aligns with the findings reported in another study [20], which stated that large-sized eggs were preferred over medium-sized and small-sized eggs.

Generally, the preference for hatching during the dry season is driven by the benefits of better feed access and reduced chick mortality. The selection of medium-sized eggs and large-sized hens for hatching is based on the belief that it leads to better outcomes in terms of egg quality, hatchability rates, and chick health. These findings are consistent with previous studies conducted in the North Wollo zone and further support the logical reasoning behind the preferences observed in the study area.

Table 2
External egg quality traits and effect of agroecology, breed and their interactions.

Agroecologies	Breed	Parameters			
		Egg length (mm)	Egg width (mm)	Egg shape index (%)	Shell thickness (mm)
Highland	Indigenous	49.5 ± 5.2^{c}	35.8 ± 3.7^{d}	72.6 ± 4.9^{b}	0.31 ± 0.03^{b}
	Sasso	54.1 ± 2.5^{a}	41.8 ± 1.9^{a}	77.5 ± 4.7^{a}	0.34 ± 0.03^{a}
Midland	Indigenous	50.5 ± 3.6^{cb}	36.2 ± 2.9^{d}	71.8 ± 4.9^{b}	0.3 ± 0.02^{c}
	Sasso	51.4 ± 2.1^{b}	40.2 ± 3.3^{b}	78.3 ± 7.4^{a}	0.35 ± 0.02^{a}
Lowland	Indigenous	43.9 ± 4.3^{d}	30.9 ± 1.8^{e}	70.7 ± 4.6^{b}	0.32 ± 0.02^{b}
	Sasso	50.8 ± 2.9^{cb}	38.8 ± 2.3^{c}	76.5 ± 5.8^{a}	0.35 ± 0.03^{a}
Breed		<.0001	<.0001	<.0001	<.0001
Agro-ecology		<.0001	<.0001	0.1059	0.0028
AE*Breed		<.0001	<.0001	0.5768	0.0015

[a-e] Means between agroecologies within breeds bearing different superscript letters are significant at $p < 0.05$.

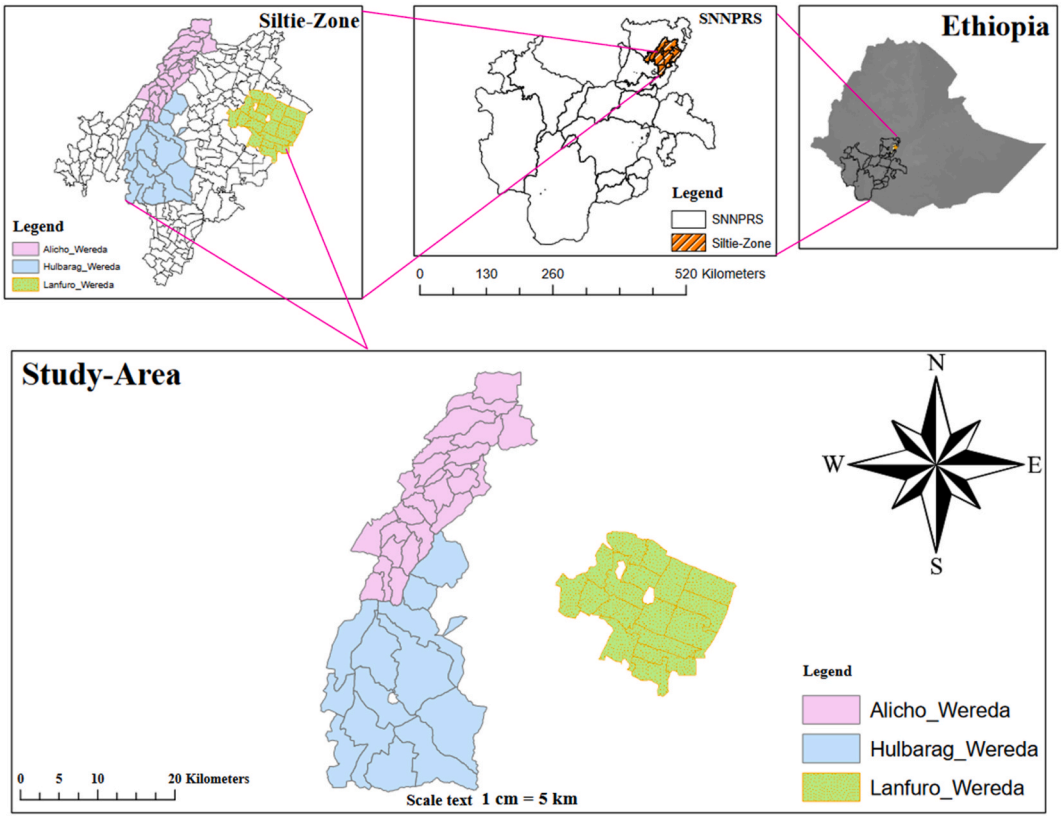

Fig. 1. Study area location map.

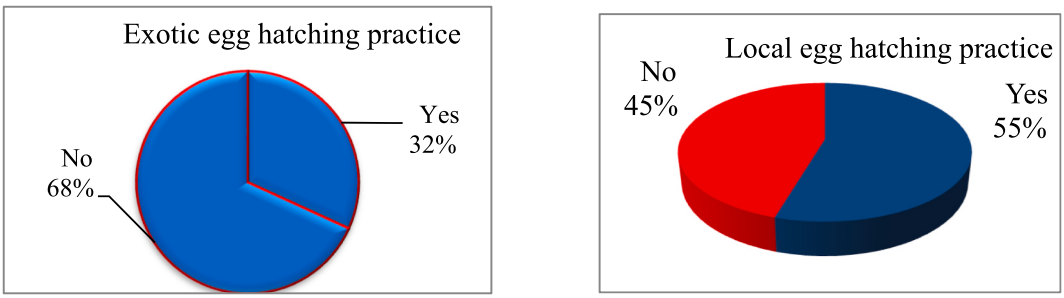

Fig. 2. Indigenous and exotic chicken egg hatching practice.

Based on the results presented in Fig. 3, it is evident that the majority of respondents in the midland and lowland areas did not clean their eggs before hatching. This practice, or lack thereof, may have implications for the hatchability of the eggs. The reason behind this could be attributed to factors such as limited access to clean water in these areas or lack of awareness about the importance of egg cleanliness in ensuring successful hatching. In contrast, respondents in the highland area were observed to clean their eggs with water followed by dry materials. This practice may be influenced by factors such as better access to clean water sources or greater awareness of the importance of maintaining egg cleanliness in the highland area. Interestingly, a previous study conducted in the Wolaita zone [20] reported that the majority of farmers in that area clean their eggs with a cloth. This variation in cleaning practices between the study area and the Wolaita zone could be attributed to regional variations in cultural practices, availability of resources, or differences in knowledge and awareness.

Furthermore, the majority of households in the study area were found to keep the eggs for two to three weeks before hatching. This practice aligns with the findings reported by Ref. [21], which stated that the majority of respondents stored eggs for up to three weeks for brooding. The reason behind this practice could be to accumulate a sufficient number of eggs for a more efficient and effective hatching process or to align the hatching period with specific production or market demands.

The hatchability percentage and egg setting per hen for hatching indigenous chicken eggs were found to be approximately 74.7 ±

Table 3
Hatching season, eggs and hen selection (%).

	Lowland	Midland	Highland	Total	P value
Season of hatching practice					
Dry	39.8	64.7	69.9	58.1	.000
Not hatch	52.6	29.3	27.1	36.3	
Any time	7.5	6.0	3.0	5.5	
Egg size selection for hatching					
Medium	38.1	29.8	76.5	50.2	.000
Large	11.1	22.3	6.9	13.5	
Not select	50.8	47.9	16.7	36.3	
Hen size selection for hatching					
Medium	12.7	50.0	53.9	42.5	.000
Large	68.3	37.2	41.2	46.3	
Not select	19.0	12.8	4.9	11.2	

There is significant difference among agroecologies on different parameters at $P < 0.05$.

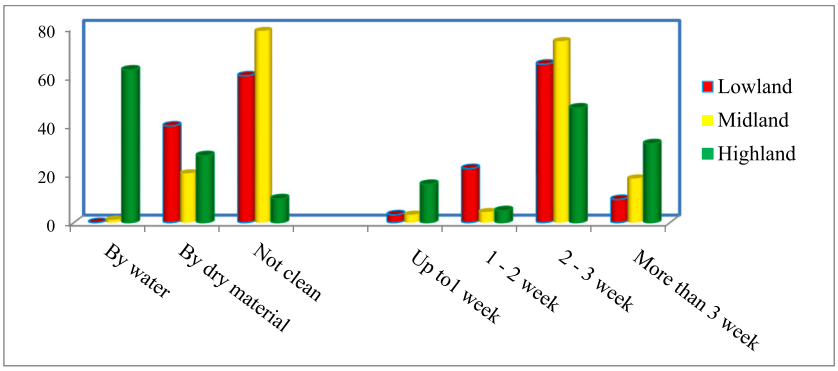

Fig. 3. Cleaning and storage duration of eggs for hatching.

8.6 and 12.1 ± 2.3, respectively (Table 4). In comparison, the hatchability percentage and egg sitting per hen for hatching Sasso chicken eggs were approximately 67.6 ± 11.5 and 10.0 ± 1.7, respectively. This result indicates a significant difference between the two chicken breeds in terms of their eggs' hatchability and egg sitting per hen. This difference suggests that the breed of the chicken can have an impact on the hatchability percentage of the eggs, with indigenous chickens showing a higher hatchability percentage compared to Sasso chickens.

However, it is worth noting that the hatchability percentages observed in this study were lower than the findings reported by Ref. [22]. The previous study discovered a hatchability rate of 82.74% and a higher number of eggs incubated per hen (11.32) in a different location. This difference in hatchability rates could be attributed to various factors such as genetic differences between the chicken breeds, variations in management practices, or differences in environmental conditions. Also, the successful hatching of a Koekoek chicken egg in the research area indicates the adaptability and potential hatchability of this breed in the study area.

Furthermore, Table 4 demonstrates that indigenous chickens had higher survival rates compared to Sasso and Koekoek chickens in all environments of the study area. This finding is consistent with the results reported by Ref. [15], which stated that 58.3% of indigenous chickens survive to market age. Another study conducted in the Amhara region's East Gojam zone reported an average of 65.91% of chicks surviving to market age [23]. These findings highlight the higher resilience and survival rates of indigenous chickens compared to exotic breeds in the study area.

There is a negative correlation between altitude and egg size, with smaller eggs observed at higher altitudes [24]. Additionally, studies have indicated that altitude can impact eggshell quality, particularly in terms of shell thickness, with a decrease in thickness as altitude increases [24]. Moreover, several studies have shown that hatchability rates tend to decrease with increasing altitude, possibly due to factors such as changes in temperature, humidity, and oxygen levels [25]. It is important to note that the effects of altitude on egg traits and hatchability can vary depending on factors such as breed, management practices, and specific environmental conditions.

In general, the study found significant differences in hatchability and egg sitting between indigenous and Sasso chicken eggs. The hatchability percentages were lower than in previous studies, suggesting variations in genetic, management, or environmental factors. The successful hatching of a Koekoek chicken egg indicates its adaptability. Indigenous chickens had higher survival rates compared to exotic breeds, aligning with previous findings. Altitude can affect egg traits and hatchability, with smaller eggs and potential decreases in hatchability rates at higher altitudes. However, the effects of altitude can vary depending on other factors.

Table 4
Hatchability percentage of exotic and indigenous chicken eggs (Mean ± SD).

Agro ecology	Breed	Parameters				
		No. egg set/hatching	No. of chicks hatched	Hatchability %	No. of chickens survive	Survival %
Lowland	Indigenous	12.1 ± 2.3^{a}	8.9 ± 1.5^{a}	74.7 ± 8.6^{b}	5.1 ± 1.6^{a}	57.7 ± 16.7
	Sasso	10.0 ± 1.7^{b}	6.7 ± 1.03^{cb}	67.6 ± 11.5^{cb}	3.7 ± 0.8^{cb}	55.2 ± 9.9
	Koekoek	9.0 ± 2.0^{bc}	5.2 ± 1.2^{e}	61.02 ± 16.7^{c}	2.8 ± 1.2^{c}	51.9 ± 16.2
Midland	Indigenous	9.4 ± 2.01^{b}	7.5 ± 1.7^{b}	80.4 ± 14.2^{a}	4.4 ± 1.3^{b}	58.8 ± 13.2
	Sasso	7.4 ± 0.7^{d}	5.3 ± 1.2^{c}	70.8 ± 14.1^{bc}	3.2 ± 0.8^{c}	57.1 ± 9.9
	Koekoek	7.8 ± 1.3^{cd}	5.4 ± 1.1^{cde}	69.7 ± 12.7^{bc}	3.0 ± 0.7^{c}	55.4 ± 5.1
Highland	Indigenous	9.3 ± 1.1^{bc}	7.04 ± 1.2^{b}	76.04 ± 9.5^{b}	4.3 ± 1.1^{b}	61.3 ± 14.6
	Sasso	8.4 ± 1.2^{c}	5.8 ± 1.1^{cde}	68.6 ± 12.1^{cb}	3.4 ± 0.8^{c}	60.5 ± 11.9
	Koekoek	10.0 ± 1.5^{b}	6.6 ± 1.3^{cb}	67.0 ± 9.6^{c}	3.8 ± 0.9^{cb}	57.1 ± 9.6
Agroecology		0.0157	0.5731	0.1838	0.4796	0.3044
Breed		<.0001	<.0001	<.0001	<.0001	0.4148
AE*Breed		<.0001	<.0001	0.8935	0.0113	0.8765

[a-e] Means between agroecologies within breeds bearing different superscript letters are significant at $p < 0.05$.

4. Conclusion and recommendation

In conclusion, the study findings indicate that internal egg quality traits were generally more valuable in the highland area compared to the midland and lowland areas. The egg quality of Sasso chickens was consistently good across all agro-ecological zones in the study area. The internal and external egg quality traits were influenced by factors such as agro-ecology, breeding, and their interaction. The results also showed that indigenous chickens outperformed Sasso and Koekoek chickens in terms of hatchability and survival percentage. However, it is worth noting that approximately 68% of households in the study area did not hatch Sasso and Koekoek chicken eggs. Given the good hatching performance of Sasso and Koekoek chicken eggs, it is recommended that households in the study area should practice hatching these eggs to enhance chicken productivity. Based on these findings, the following recommendations can be made: 1. Farmers in the study area should pay attention to internal egg quality traits, particularly in the midland and lowland areas, to improve overall egg quality. 2. Breeders and poultry farmers should continue to prioritize the breeding and selection of Sasso chickens due to their consistently good egg quality across different agro-ecological zones. 3. Efforts should be made to promote and educate households about the benefits of hatching Sasso and Koekoek chicken eggs, as they have shown good hatching performance. This can contribute to increasing chicken productivity in the study area. 4. Further research can be conducted to explore the specific factors influencing internal and external egg quality traits in different agro-ecological zones and breeding programs, with the aim of improving overall egg quality and hatchability.

Author contribution statement

Belete Kuraz Abebe; Serkalem Assefa; Ahmed Hussen Gobena: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data included in article/supp. material/referenced in article.

Additional information

No additional information is available for this paper.

Declaration of competing interest

We declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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