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Research Paper

Egg quality characteristics of different scavenging chicken strains in amuru district of horro guduru wallaga zone, oromia, ethiopia

Chala Feleke Kebede[1*], Dr. Demissu Hundie[2], Firisa Woyessa[3]
[1*]Directorate of Biodiversity, Oromia Environmental Protection Authority, Oromia, Ethiopia.
[2,3]Department of Animal Science, Wallaga University, Oromia, Ethiopia.

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ABSTRACT

This study was conducted to evaluate the egg quality characteristics of different scavenging chicken strains, specifically local and Sasso breeds, in the Amuru District of Horro Guduru Wallaga Zone, Oromia, Ethiopia. A total of 150 eggs were collected from 75 households across three agro-ecologies (lowland, midland, and highland). Both internal and external egg quality parameters were assessed, including egg weight, shell thickness, yolk weight, albumen height, and Haugh Unit. Results indicated that breed and agro-ecology significantly influenced egg quality traits. Sasso chickens produced heavier eggs (53.15±0.50g) and longer eggs (52.33±0.42mm), while local chickens showed superior shell thickness (0.516±0.013mm) and shape index (77.53±0.35%). Albumen height averaged 4.76±0.02mm and yolk height ranged from 14.14 to 15.36mm across agro-ecologies. Haugh Unit was higher in local breeds (73.72±0.45) compared to Sasso (70.08±0.52). Significant positive correlations were observed between internal and external traits. The study concludes that genetic and ecological factors greatly affect egg quality, with implications for breed selection and poultry management strategies.

Corresponding Author:
Chala Feleke Kebede
Directorate of Biodiversity, Oromia Environmental Protection Authority, Oromia, Ethiopia.
Email: chalafeleke2025@gmail.com

1. INTRODUCTION

1.1. Back Ground of the Study

In developing nations, poultry farming contributes significantly to family nutrition and offers major economic, social, and cultural benefits. Estimates reveal that scavenging systems of the past still harbor 80% of Africa's total poultry population [1]. Poultry farming is widespread in Africa, which is the habitat of more than 1.5 billion chickens, 80% of which are local breeds. It is expected that by 2050 chicken will provide 40% of the world's total protein and thus its importance will continue to rise in less developed countries [2].

In Ethiopia, poultry has a huge impact economically and socially, and thereby it affects food security and cash crops, besides, it is used in the religious practice among others [3]. The small-scale backyard or village-level poultry sector has been contributing a considerable portion to the economy of Ethiopia [4]. The agricultural sector employs about 80-85% of the population and contributes to about 40% of the total gross domestic product and chicken production covers 40% of the agricultural output in the national economy and accounts for about 13-16% of the total GDP [5].

According to reports, indigenous chickens raised under a traditional management style provide more than 90% of the nation's chicken and egg production. In addition, scavenging hens require less husbandry control and maximize the utilization of locally accessible resources, such as domestic garbage, and they do not compete with people for feed [6].

Egg quality is composed of two main characteristics, “external” and “internal” quality, which are used to describe it overall [7]. Features like the egg's size, shape, and shell's thickness, strength, and structure determine its external quality [8], while the albumen's quality as measured by the Haugh Units (HU), the relative sizes of its internal components, and the integrity of the shell membrane determine its internal quality. The evaluation of chicken eggs' quality has been the subject of several research [9], [8]. Cleanliness, freshness, egg weight, and shell weight are only a few of the several crucial exterior quality attributes that affect customers' acceptance of eggs [10].

Rising demand for poultry products underscores the need to optimize smallholder chicken production in Amuru district. Scientific data on egg quality characteristics of scavenging chickens’ strains are limited. Traditional practices, disease, predation, poor feeding, and neglect of indigenous breeds, compounded by uncontrolled exotic breed introduction and weak extension services, limit productivity. This study investigates the egg quality of scavenging chicken strains to inform strategies for improving poultry productivity and supporting smallholder livelihoods in Amuru district, Horro Guduru Wallaga Zone, Oromia, Ethiopia.

2. RELATED WORK

2.1. Egg Quality Preferences from Different Chicken

From the European consumer's perspective, egg quality traits such as shell strength, albumen consistency, and yolk color are of prime importance [11]. Preferences vary globally for instance, European consumers favor yellow yolks and brown shells, whereas in the U.S., white shells dominate [12]. Albumen height, measured by Haugh units, is used to assess egg freshness [12]. Internal egg characteristics such inclusions, yolk color, and albumen quality can be influenced by variables like season, genetic background, and food (such as marigold or alfalfa) [13]. While indigenous varieties have larger yolk proportions, commercial hens are genetically selected to produce more albumen [14]. Genetic and dietary factors can influence shell color variation [15].

2.2. Quality of Eggs from Chicken

Chicken eggs are nutrient-dense and crucial in global diets, yet quality traits are often under emphasized in developing nations where most eggs come from village chickens [16].

2.2.1. External Egg Qualities

Show variation based on agro-ecologies and breed. Eggs from midland regions are typically heavier due to better access to grain feed [17]. Shell traits such as thickness, length, and width also differ by breed and agro-ecology [18], and ideal shell thickness for hatchability is between 0.33–0.35 mm.

2.2.2. Internal Egg Quality

Internal egg traits are shaped by both genotype and feed quality [19]. Breed adaptation varies with agro-ecological zones. Sasso chickens perform better in lowlands, while Bovan's suit midlands [20]. Exotic breeds yield significantly higher albumen and yolk weights than local breeds. Reports show local chicken albumen weights ranging from 21.69g to 25.76g, while exotic breeds such as Rhode Island Red and Bovans reach over 30g [21]. Yolk color is more affected by feed pigmentation than breed, with scavenging birds often producing deeper yellow yolks due to natural xanthophylls [18].

3. METHODOLOGY

This study was conducted in the Amuru district of Horro Guduru Wallaga zone, Oromia National Regional State in western Ethiopia. The district was located in the western part of the country, about 386 km west of Addis Ababa the capital city of Ethiopia. The area covered by the study area was about 129,452.0805 ha. This study area is bordered on the east and south by Amhara regional state, on the west by the Kiremu district of East Wallaga Zone, and on the north by the Jardaga Jarte district of Horro Guduru Wallaga Zone, Sampling Techniques and Sample Size determination.

3.1. Sampling Techniques and Sample Size Determination

Multi-stage sampling procedures were followed to select the sample for the study for the egg quality characteristic determination. Accordingly, the zone, the Amuru district, and five 'kebeles' were purposively selected based on the pre-screening information on poultry production practices, populations, and agro ecologies. Households in the selected kebeles were listed for their poultry production practices, and those households that owned more than two chickens were targeted. Among the targeted households, a total sample of 171 chicken owners was randomly selected for the study using Yemane 1967 formula.

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

Where: n = is the sample size,
N =stands for total number of targeted populations
1 =stands for the probability of the event occurring
e =stands for maximum variability 5% (0.05).

$$n = \frac{182}{1 + 182(0.05)2}$$

$$n = \frac{182}{1.455} = 125$$

The number of respondents (farmers) per single selected was determined by proportionate sampling technique as follows:

$$W = \frac{A}{B} X No$$

Where: -W= number of sample respondents selected per kebele
A = Total number of chicken rearing households in the selected kebele.
B = Total sum of households living in sample Kebele
N_o = the total required calculated sample size.

3.2. Evaluation of Internal and External Egg Quality Traits

For external and internal egg quality determination, a total of 150 eggs (<5 days) were bought based on the memorandum of agreement with households keeping both local and exotic breed chicken in the study area. Before the egg collection process, 125 households engaging on chicken rearing both local and exotic (exclusively Sasso) chicken were identified from the five kebeles. Accordingly, 60% of the households (75 HHs), 15 HHs from each five Keble as a sample size for the district were used for egg collection.

3.3. Data Analysis

The study was conducted in five kebeles within Amuru District. A total of 150 eggs were collected from local and Sasso chickens, ensuring all were laid within five days. Eggs were collected from 75 randomly selected households. The egg quality traits were evaluated both internally and externally in a laboratory setting at Jimma University.

The following traits were measured: egg weight, egg length, egg width, shell thickness, shell weight, albumen height, yolk height, yolk color, Haugh unit, and shape index. SPSS version 26 was used for data analysis.

A general linear model (GLM) was applied:

$Yijk = \mu + Ai + Bj + (AB)ij + \epsilon ijk$

Where:

1. Yijk = observed value of the trait,
2. μ = overall mean,
3. Ai = effect of the ith breed (local or Sasso),
4. Bj = effect of the jth agro-ecology (lowland, midland, highland),
5. (AB)ij = interaction between breed and agro-ecology,
6. Єijk = random error.

4. RESULTS AND DISCUSSION

4.1. Egg Quality Evaluation of Scavenging Chickens

4.1.1. Evaluation of External Egg Quality Traits

The mean values of the external egg quality characteristics in different agro ecologies are discussed in Table 1. The average egg weight in the three agro-ecologies of the district was statistically significant ($P<0.05$) different. The eggs collected from midland were heavier than that of lowland and highland for sasso chickens. This finding also indicated that the average weight of the eggs laid by Sasso hens varied across the study agro ecologies with higher values recorded in the midland (54.04±0.34g) than the eggs recorded in the lowlands (52.35±0.73g) and highland (53.064±0.42gThe present study result revealed that there was a highly significant difference ($P<0.001$) between breeds on egg weight.

Table 1. External Egg Quality Traits in Study Area

Parameters	Agro Ecology			Overall Mean
	Lowland	Midland	Highland	
Egg Weight(g)	52.35±0.73[a]	54.04±0.34[b]	53.064±0.42[c]	53.15±0.496
Egg Length(mm)	52.73±0.38[a]	54.51±0.37[b]	51.38±0.52 [c]	52.33±0.423
Shell weight(g)	4.76±0.73[c]	5.12±0.73[b]	5.25±0.73[a]	5.043±0.73
Shell Thickness(mm)	0.44±0.001[b]	0.46±0.13[a]	0.48±0.032[c]	0.46±0.054
Local breed				
Egg Weight(g)	40.62±0.33	41.36±0.66	39 ±0.15	40.32±0.38
Egg Length(mm)	49.34±0.45	52.28±0.68	50.32±0.24	50.646±0.73
Shell weight(g)	3.85±0.037	4.36±0.35	4.18±0.04	4.14±0.142

Shell Thickness(mm)	0.49±0.01	0.51±0.01	0.55±0.02	0.516±0.013

[a-c]=Means with different superscripts within a row are significantly different (P<0.05)

The egg weight of local scavenging chickens varied significantly across agro-ecological zones, with eggs from midland areas (41.36±0.66g) being heavier than those from lowland (40.62±0.33g) and highland (39.00±0.15g). On the other hand, [21] observed a lower mean egg weight of 34.1g for various chicken ecotypes in northwestern Ethiopia. These discrepancies may result from variations in management practices, ecological conditions, and chicken age at egg-laying.

The average egg weight of the exotic Sasso breed was 53.15±0.496g, which was much greater than that of the indigenous breeds (41.36±0.66g). This implies that the majority of eggs from both breeds are classified as small. Similar results were found by [22] in the Chelliya area, where the weight of native chicken eggs was 41.13g. Additionally, a substantial (P<0.05) interaction between agro-ecology and breed on egg weight was noted, which is in line with [18], who connected this variability to environmental factors, breed, and feed quality in Boricha district, Sidama zone. Once more demonstrating breed-based variation, the Sasso breed's egg length (52.33±0.423mm) was significantly larger than that of the local hens (50.646±0.73mm).

Breeds and agro-ecologies also differed in eggshell quality attributes. Sasso chicken eggs had the lowest shell thickness values (0.44±0.001mm in lowland), whereas local chicken eggs had the highest average shell thickness (0.55±0.02mm) in the highlands and the lowest in the lowlands (0.49±0.01mm). For village hens in different agro-ecologies, [16] recorded the lowest shell thickness (0.296mm). As demonstrated by [23] in the North Shoa Zone, environmental and feeding factors have a significant impact on shell thickness.

Additionally, eggshell weight was higher in Sasso chickens (5.25±0.73g in highland) compared to local breeds (4.18±0.04g). Egg shape index (SI) was significantly higher in local chickens (77.53±0.35), indicating rounder eggs compared to Sasso (72.02±0.84), classified as standard-shaped. The current SI values exceeded those of [16], who reported values ranging from 71.9% to 73.2% for local scavenging chickens in different Ethiopian regions. Figure 1 shows the internal egg quality traits briefly on the following bar.

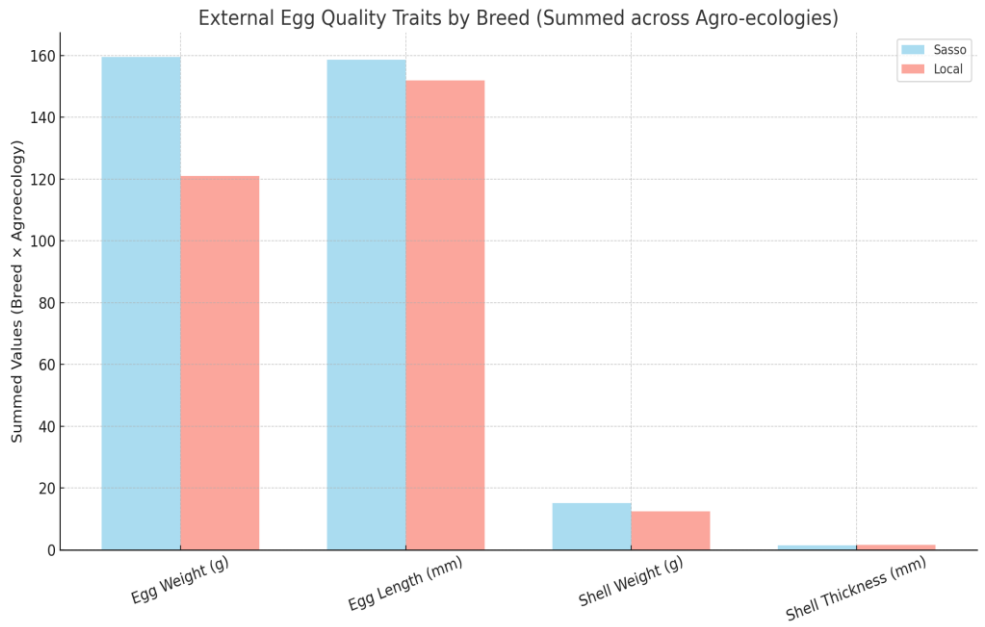

Figure 1. External Egg Quality Traits by Breed (Summed Across Agro Ecologies)

4.1.2. Evaluation of Internal Egg Quality Traits

The internal quality of eggs in the study was assessed using albumen height, albumen weight, yolk height, yolk weight, yolk color, and Haugh Unit (HU), which is calculated based on egg weight and

albumen height. The average albumen height for local scavenging chickens varied significantly (P<0.05) among agro-ecologies, with values of 4.33±0.01 mm in lowland, 4.53±0.027 mm in midland, and 5.42±0.02 mm in highland, leading to a district average of 4.76±0.019 mm. This discrepancy is probably the result of the differences in environmental temperature and storage conditions rather than the breed since no significant breed-related differences (P>0.05) were found. Likewise, albumen weight also showed significant differences (P<0.05) across agro-ecologies, breeds, and their interactions, with an overall mean of 24.441±0.41 g. The highest value (24.84±0.32 g) was found in midland chickens.

The average yolk height was also a parameter that exhibited a great deal of variation (P<0.05) among the different agro-ecologies and breeds. In the case of local hens, the yolk height was between 14.14 mm in the lowland and 14.92 mm in the highland areas, whereas, for Sasso, the chickens had an even higher range of 15.01 mm to 15.36 mm in the same regions. Moreover, yolk weight also showed to be significantly different (P<0.05) across both breeds and agro-ecologies with local and Sasso chickens having average weights of 14.27 g and 16.64 g, respectively. Yolk color, which is an important determinant of egg quality and the birds' diet, indicated through the study that there were no significant differences (P>0.05) amongst the different agro-ecologies or breeds, although scavenging behavior might have played a part in the high pigmentation that was noticed. The overall mean yolk color values were 11.3±0.272 for the district, with 11.89±0.46 for local and 11.44±0.35 for Sasso chickens. However, they exceed the yolk color values reported by [22], who recorded 10.9 and 9.26, respectively. Similarly, the current findings surpass those of The Haugh Unit score, another key indicator of internal egg quality, showed no significant variation across agro-ecologies (P>0.05), but there was a significant breed difference (P<0.05). Local chickens had higher HU (73.72±0.45) compared to Sasso (70.08±0.52), possibly due to differences in albumen height and age. As shown on Figure 2 Internal egg quality traits are shown briefly on the following bar.

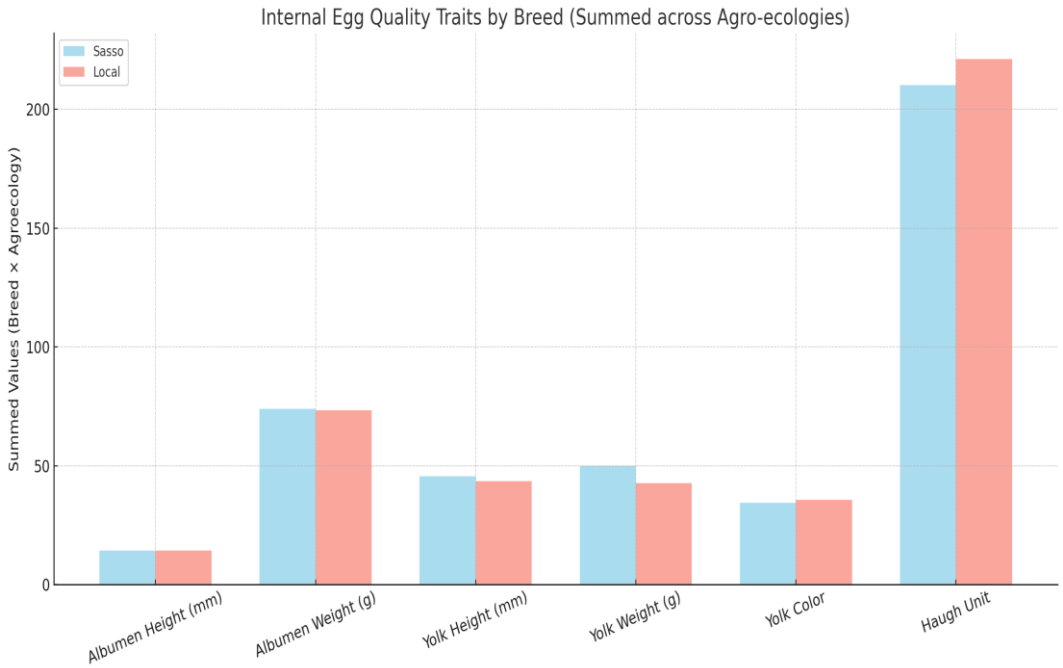

Figure 2. Internal Egg Quality Traits by Breeds (Summed Across Agro-Ecologies)

4.1.3. Correlation among External Egg Quality Characteristics

In Table 2 the external egg quality traits of scavenging native and exotic (Sasso) chicken eggs are correlated phenotypically. The findings showed a substantial and positive association between egg weight and egg length, egg width, egg weight and shell weight, and egg weight and egg surface area. In accordance with the current study was reported by [24] who found that in native chicken ecotypes of Tigray, egg weight has a strong positive association with shell weight, egg length, and egg breadth. The

study found a strong positive correlation between egg weight and egg width, egg length, and shell weight in various poultry species. Egg weight has a negative relationship with shell thickness and percentage. The relationship between egg length and egg breadth was both favorable and significant.

Table 2. Correlation of External Egg Characteristics of the Study Area

	Egg Weigh	Egg Width	Egg Length	Shell Weight	Shell %	Shell Thickness	Shape Index	Surface Area
Egg weigh	1							
Egg width	0.753	1						
Egg length	0.734	0.382	1					
Shell weight	0.452	0.372	0.341	1				
Shell %	-0.479	-0.153	-0.163	0.005	1			
shell thickness	-0.033	-0.739	0.374	0.119	0.214	1		
shape index	-0.033	0.374	-0.739	0.119	0.165	0.214	1	
surface area	0.765	0.843	0.548	0.388	-0.323	-0.218	-0.055	1

The relationship between egg length and egg breadth and shell weight and surface area was positive and significant. Reports on various poultry species by [25] concur with the findings of the present study. In three separate strains of Tswanan chickens, there was no discernible positive link between egg length and shell weight or between egg width and shell weight [26]. There is a strong positive correlation between egg width and shape index, while a significant negative correlation exists between egg length and shape index. In other words, the egg will become wider, and its shape index will increase when the egg is of a rounded shape that is difficult to handle and package. This is similar to the situation found with indigenous Tswana dwarf, normal, and necked neck chickens which exhibited a significant negative association between egg length and shape index and a strong positive correlation between egg width and form index [26].

The relationship between shell weight, shell percentage, and egg surface area is positive and strong. Several studies have found a substantial positive link between shell weight and shell ratio in various poultry species [26]. The ratio of shell weight to total egg weight is known as shell percentage, and as shell weight grows, so does shell percentage. Egg weight and surface area are strongly inversely correlated with shell percentage. Furthermore, there was a non-significant negative association between the percentage of the shell and the length and width of the eggs. The findings of [26] concur with this finding.

4.1.4. Correlation among Internal Egg Quality Traits

Table 3 displays the phenotypic relationships between internal egg quality traits. The findings showed that albumen weight and yolk weight, as well as albumen weight and yolk diameter, had a significant and positive correlation.

In the highland, midland, and lowland ecotypes of Tigray hens, albumen weight and yolk weight showed a significant positive correlation [26]. In Tswana's native chickens, including necked, normal, and dwarf varieties, albumen weight and yolk weight were found to be strongly positively correlated [27]. This result is in agreement with the findings of the current study.

The Haugh unit and albumen height have a strong positive correlation. In accordance with the findings of the present study, [28] observed correlation values between albumen height and Haugh units of 0.98, 0.91, and 0.90 for native hens with frizzle, necked neck, and smooth feathers in Adamawa state of Yola, respectively. Figure 2 shows how strongly the albumen height influences the Haugh unit of egg. Fresh eggs have a higher albumen height, which decreases with longer storage times and higher storage temperatures.

However, among local Cameroon barred hens, there was no statistically significant negative association seen between albumen height and yolk height [29], [30]. However, the relationship between albumen height and yolk diameter was strongly inverse. In a related study, [28] found a weak negative

non-significant link between albumen weight and yolk weight for indigenous Yola frizzles and smooth feathered chickens, but a large positive correlation between albumen height and yolk height for necked neck chickens.

Table 3. Correlations among Internal Egg Characteristics in the Study Area

Parameters	Albumin Weight	Album Height	Yolk Weight	Yolk Height	Yolk Diameter	Yolk Index	HU
Albumin weight	1						
albumen height	-0.03842	1					
Yolk weight	0.443	-0.15236	1				
yolk height	0.09256	0.6853	0.07026	1			
Yolk diameter	0.3945	-0.27829	0.69453	-0.25815	1		
yolk index	-0.09492	0.46	-0.6547	0.7813	-0.60384	1	
HU	-0.14374	0.87352	-0.166	0.6271	-0.25411	0.52341	1

The yolk index and yolk weight had a strong negative correlation and the yolk weight had a strong positive correlation with the yolk diameter. This suggests that yolk diameter rises together with egg yolk weight. This outcome is in line with the findings of [26]. In addition, there was a bad association between Haugh units and yolk weight.

The relationship between yolk height and Haugh units was quite favorable. Other scientists [26] have come to the same conclusions as our study has come to. This indicates that the heights of yolk and albumen are synchronous. When we conducted our study, egg albumen height and yolk height were the earliest indicators of the egg's quality when we broke the egg open. When an egg that had been preserved for a long time was cracked open, the albumen and yolk immediately expanded, and measures of both albumen height and yolk height fell. The yolk index and Haugh unit have a substantial negative correlation with yolk diameter. This might happen because the yolk grows and its diameter rises as its height drops as a result of several reasons. The yolk index and Haugh unit have a high degree of positive correlation. Research results published by [28] corroborate this finding.

4.1.5. Correlations between Internal and External Egg Quality Traits

The current study findings demonstrate an albumen height, egg weight, length, width, and shell weight negative correlation that is statistically significant ($p<0.05$). Albumen height and shell thickness showed a weakly positive connection ($p>0.05$). This suggests that albumen height might be influenced by shell strength since a thicker shell can regulate the entry of micro-organisms inside the egg and has superior temperature resistance.

The correlation of albumen weight with egg weight, egg length, egg width and shell weight were positive and statistically significant ($p<0.05$). These findings were supported by [26]. Albumen weight was significantly and negatively correlated with shell thickness ($p>0.05$). There was a statistically non-significant positive correlation between albumen weight and shape index ($p>0.05$).

Egg weight, egg length, egg width, and shell weight all demonstrated a significant negative connection with the Haugh unit ($p< 0.05$). This occurred as a result of the substantial negative association between these parameters and albumen height.

Yolk height and the external egg quality measures seen in this study revealed a negative but not statistically significant connection ($p>0.05$).

Yolk diameter had a strong positive correlation with egg weight, egg length, egg width and shell weight ($p<0.01$). Yolk weight had a strong positive correlation with egg weight, egg length and egg width ($p<0.01$). Egg weight, length and width increase with different factors, such as the age of the hen, breed and strain, feed and other environmental factors. At the same time, the weight of the egg increased.

Egg weight, egg length, egg width, and shell weight were significantly correlated negatively with the yolk index ($p <0.05$). The yolk index and shell thickness all showed a weakly positive correlation ($p>0.05$).

5. CONCLUSION

This study shows that Sasso and indigenous chicken breeds raised in the Amuru District using scavenging strategies differ significantly in terms of egg quality characteristics. Egg weight, shell thickness, and form index were examples of external egg quality characteristics that differed greatly by breed and agro-ecology. One of the internal traits that changed and were affected by the combination of genetics and environment was the height of the albumen, the weight of the yolk, and the Haugh Unit score. While local chickens produced eggs with thicker shells and higher shape index values, Sasso fowl had the advantage in egg weight and yolk height.

The study results point to the need for taking the ecological context and breed type into consideration in the development of local poultry production and egg quality control methods. The dissemination of food security and income for farmers in rural Ethiopia can be facilitated through the application of these findings in breeding and management techniques tailored to agro-ecological zones.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Chala Feleke Kebede	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
Dr. Demissu Hundie		✓			✓	✓				✓			✓	
Firisa Woyessa					✓	✓				✓		✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

There are no competing interests or personal relationships that could have influenced the work reported in this paper.

Informed Consent

Informed consent was obtained from all individuals who participated in this study. Participants were informed about the objectives, procedures, and their right to withdraw at any time.

Ethical Approval

This research complied with all relevant institutional policies and national regulations regarding human subjects. The study was approved by the Institutional Review Board of Wallaga University and adheres to the tenets of the Helsinki Declaration.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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BIOGRAPHIE OF AUTHORS

Chala Feleke Kebede, holds a Bachelor of Science degree in Animal Science from Ambo University and a Master of Science degree in Animal Production from Wallaga University. He is currently serving at the Oromia Environmental Protection Authority. His primary research interests lie in the production systems and performance of scavenging chicken strains under rural Ethiopian conditions. He has contributed to poultry development through academic research and practical field-based insights focused on improving indigenous poultry productivity in Ethiopia. Email: chalafeleke2025@gmail.com

	**Dr. Demissu Hundie**, is an Assistant Professor of Animal Production and a lecturer at Wallaga University. He holds a PhD and MSc in Animal Production, a BSc in Animal Sciences, and a Diploma in Animal Health. He is a well-published researcher with over 29 peer-reviewed journal articles in reputable international journals. His academic expertise and applied research focus on improving productivity and health in livestock systems, particularly under smallholder farming conditions in Ethiopia. He has played a key role in training, curriculum development, and livestock improvement programs. Email: dhsenbeta@gmail.com
	**Firisa Woyessa**, earned his Bachelor of Science in Animal Production and Health from Jimma University. He initially served as a college instructor before obtaining an MSc in Animal Production from Wallaga University in 2012. He joined Wallaga University as a lecturer and was promoted to Assistant Professor in 2017. He is currently pursuing a PhD in Animal Product Handling Technology at Jimma University while continuing his teaching and research roles. Firissa has authored and co-authored approximately 10 scholarly publications. His research focuses on poultry production, meat and egg quality, and animal handling technologies. Email: firisawoyessa@gmail.com