Assessment of the prevailing handling, transportation, marketing and quality of eggs collected from local scavenging hens in Bure district, North-West Ethiopia

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Abstract

A repeated and cross-sectional survey together with egg quality analysis was conducted in seven selected farmer's kebele of Bure district, North West Ethiopia. The major objective of the study was to assess the prevailing handling, storage and quality of local/scavenging hen eggs in the district. A formal survey with structured questionnaire was used to collect all the relevant data, using a multi-stage sampling technique (purposive and random). Seven farmer kebeles (2 from highland, 3 from mid-altitude and 2 from lowland agro-ecologies) and a total of 280 village chicken owner households were considered for the study. In addition 1000 local hen eggs were collected in all seasons and egg sources (markets and producer) and used for the study. Internal and external egg quality traits including: egg shell color, egg length (EL), egg width (EWd), shape index (SI), shell weight (EW), shell thickness (ST), Albumen height (AH), yolk height (YH) and Hough units (HU) were measured. The results indicated that 71.4% of village chicken owners stored eggs inside earthen material (clay) together with grains or straws. The majority of village chicken owners (69.3%) of the study district were involved in selling of eggs. Selling of eggs was done in various places including: urban markets, local markets and farm gates. Women & children (43.2%) were the most important members of the household that were involved in marketing of eggs in the district. Large proportion of the chicken owners (66.4%) use hand carrying to transport eggs to markets. Plastic containers (festal) and grass made bags (locally called 'kofeda') were used. The average egg weight was 43g (ranged 34-60g). The mean egg width and egg length measurements were 37.2mm and 50.8mm, respectively. Thus, the average shape index percentage was calculated and found to be 73.2%. The average albumen height and yolk height were 4.1mm and 15.1mm, respectively. The mean Hough unit was calculated using albumen height and egg weight and found to be 66.5 (ranged 36.4-84.8). The average egg shell thickness measurements for sharp region, equatorial region and blunt regions were 0.27mm, 0.26mm and 0.24mm,

respectively. Hence the average egg shell thickness was found to be 0.26 mm. It was generally noted that local hen eggs collected from Bure district were poor in quality as compared to the quality of eggs collected from intensively managed local hens. And this indicated that the quality of local hen egg's of the district could be partially improved by chicken management interventions such as; proper housing, feeding, health care and good handling of eggs.

Keywords: local chicken's ecotypes, scavenging, internal and external egg quality traits, phenotypic correlation.

Introduction

In Ethiopia chickens are the most widespread, and almost every rural family owns village birds, which provide a valuable source of family protein and extra cash incomes (Tadelle *et al.,* 2003). The number of chicken flocks per household of most Ethiopian rural community is small in number and containing birds from each age group (Tadelle and Ogle, 1996). The total chicken population in the country is estimated to be 32.2 million (CSA, 2005). The majorities (94.12%) of these birds are indigenous breeds/ecotypes and maintained under a traditional system with little or no inputs for housing, feeding or health care (CSA, 2005).

Although eggs contain approximately 74% water, they are potentially important and balanced source of essential amino acids as well as some minerals and vitamins. Egg proteins contain all essential amino acids and therefore egg protein is used as standard for measuring the nutritional quality of other food products (FAO, 2003). A typical egg would contribute 3-4% of an adult's average energy requirement per day and has approximately 6.5g of protein (Sparks, 2006). Furthermore, chicken meat and eggs come in small packages and could be stored in hot climates under local conditions more easily than most foods of animal origin. Eggs keep their quality at room temperature without spoilage for at least 10 days to 2 weeks if stored in cool places (Sparks, 2006).

External and internal qualities of eggs are of major importance to the egg industry worldwide. However, they are not being given a due attention in the developing world, where the majority of the eggs are coming from free scavenging village chicken, as compared to that of the developed world (Juliet, 2004). Egg's internal and external quality could be influenced by factors like; genetic factors, environmental factors (such as temperature, relative humidity and the presence of CO_2), hen age, nutrition status, egg storage condition and storage time (Juliet, 2004). A good quality egg should be free from internal blemishes

such as blood spots, pigment spots and meat spots (Hamilton, 1982). In numerous researches, it has been reported that the external and internal quality of chicken eggs had significant effects on the hatchability of fertile eggs, weight and development of the day-old chicks and marketability of eggs (Nordstrom and Ousterhout, 1982).

The significance of the egg as a protein source for the nourishment of humans led the consumers to demand for some qualities in this nutrient (Uluocak *et al*., 1995). External and internal qualities of eggs are of major importance to the egg industry worldwide. However, they are not being given a due attention in the developing world, where the majority of the eggs are coming from free scavenging village chicken, as compared to that of the developed world (Juliet, 2004).

To date there are no detailed studies conducted in the region and the study district targeted on a comprehensive description of the prevailing handling and storage of local hen eggs and assessment of internal and external quality of marketable eggs. Therefore, the study was designed to (1) assess the existing handling, storage, consumption, marketing and transportation of eggs; (2) assess the purpose/function of eggs in the district; and (3) evaluate the external and internal quality of local hen eggs.

Materials and methods

Description of the study district

The study was conducted at Bure district found in Amhara National Regional State (ANRS), North-West Ethiopia. According to ANRS-BoFED (2007), the study district has an agricultural household size of 39,323 (6370 female and 32953 male) and he total human population was estimated to be 281,310 (141,683 males & 139,627 females). From the total human population, 85 % were rural community and 15% were urban dwellers (Bure, 2007). The study district has a total of 27 kebeles, from which 5 are urban and 22 are rural kebeles. Burie, the administrative and commercial center of the district, is located 420 kms North-West of Addis Ababa and 148kms South-West from Bahir-Dar town. The study district has a total land area of 2207.2 km^2. The average altitude is estimated to be 1689masl (ranged 728-2832masl). The mean annual rain fall is estimated to be 1689.4mm (ranged 713-2832mm) and the average temperature is 18.97^{o}c (ranged 13-24^{o}c).

Livestock is considered as an important component of the prevailing crop-live-stock mixed farming systems of the study district. Small holder farmers of the study area owned various livestock species such as; cattle, sheep, goat, chicken and equines. According to Burie (2007), the study district is reported to have a total population of 129,265 for cattle, 39,066 for sheep, 6,895 for goats, 16,335 for donkeys, 479 for mules, 188,310 for chicken and 13,329 bee hives.

The study district contains all the three agro-ecologies: highland (*'Dega'*), mid altitude ('*Woyna daga*') and lowland *('Kola'*) with the higher proportion (77%) of mid altitude agro ecology. The district is known to have highest potential for crop and livestock production in the region. In the study district, crop production is highly related to village chicken production, with high seasonal fluctuation of feeds availability, high prevalence of disease and other production and marketing constraints (Burie, 2007).

Selection of the study sites and sampling techniques

A multi-stage sampling procedure (purposive & random) was applied for the study. Hence, the study district was purposively selected and divided in to three agro-ecologies based on altitude as: highland (>2500masl), mid-altitude (1500-2500masl) and low-land (<1500masl). Then, two rural kebeles from the highland, two rural kebeles from lowland and three rural kebeles from mid altitude were selected based on agro-ecology representation, village chicken production potential and accessibility. Therefore, a total of 7 representative rural kebeles were selected for the study purposively.

All village chicken owner households found in all the selected rural kebeles were freshly registered and then a simple random sampling technique was applied to choose 40 village respondents in each of the selected farmer kebeles by giving equal chance for those farmers having different flock size, chicken husbandry systems and other related practices. Hence, a total of 280 village chicken owner households were interviewed using a pre-tested structured questionnaire.

In addition, 1000 local hen eggs (500 from markets and 500 directly from producers) were collected in different seasons (dry and rainy) of the year and market types (primary and secondary) and transported to Andassa Livestock Research center for analysis. The eggs were collected from all agro-ecologies of the study district and each egg was evaluated for internal and external quality with in 2 days of collection. A representative data from 600 eggs were used for

analysis and the rest of the eggs were removed due to various problems like, rupture of yolk during breakage, presence of very thin shells, etc.

Data Collection

All the relevant data were collected through personal and house to house interviews using structured questionnaire and laboratory analysis. Some of the internal and external egg quality traits measured and the method of measurement/calculation were presented as follows:

I. External egg quality parameters:

1. Egg weight (g), (measured using digital weighing material/balance)
2. Shell thickness (mm), (measured using digital caliper)
3. Dried Shell weight (g), (measured using digital balance after drying with drying oven)
4. Egg shape index (%), [calculated using the formula: (Egg width/Egg length)*100]
5. Egg shell color (evaluated using visual observation)

II. Internal egg quality parameters:

1. Yolk height (mm), (measured using tripod micrometer)
2. Albumen height (mm), (measured using tripod micrometer)
3. Presence of blood spot and meat spot, (using visual observation)
4. Yolk color (measured using yolk color fun, ranged 1-15)
5. Hough Unit (HU), [calculated using the formula: $HU = 100\log (AH - 1.7EW^{0.37} + 7.6)$ where; HU = Hough unit, AH = Albumen height and EW = Egg weight] (Haugh, 1937)

Data management and statistical analysis

The qualitative and quantitative data-sets were analyzed using appropriate statistical analysis software (SPSS, 2002). The Duncan multiple range test and LSD were used to locate treatment means that are significantly different. The phenotypic correlation values related to egg quality traits were determined by the Pearson Correlation Analysis (Snedecor and Cochran, 1980). More specifically descriptive statistics and general linear model (GLM) were

used for the study. Tables and figures used to present summary statistics such as mean, standard deviation and percentages.

The following regression models were employed as applicable to each case: $Y = a + bx$ (simple linear regression); $Y = a + b_1X_1 + b_2X_2 + \ldots b_kX_k$ (multiple regressions). Where; Y = dependent/response variable (egg weight), a = intercept (the value of the dependent variable when the independent is zero), b = regression coefficient and x = the independent variable (egg length, egg width).

The following linear models used during analysis of quantitative data: Model statement regarding the effect of egg source on various egg quality parameters:

$$Y_{ij} = \mu + m_i + \varepsilon_{ij}$$

Where: Y_{ij} is the egg quality performance parameter estimate for egg j in egg source i, μ is the overall mean, m_i is the fixed effect of independent variable, egg source (i=2; market and farm gate) and ε_{ij} is the error. The effect of agro-ecology was not considered when analyzing data

Results and discussion

Purpose of village hen eggs

According to interviewed village chicken owners egg hatching for replacement (71.7%) was the first function/purpose of eggs in the study district (Table 1). The second and the third purpose of eggs in the study district were sale for cash income (58%) and home consumption (68.6%), respectively. Tadelle and Ogle (1996) reported that the major uses of eggs in rural societies of central Ethiopian high lands were hatching for replacement (51.8%), sale for cash income (22.6%) and home consumption (20.2%).

Table 1. Purpose of local hen eggs in Bure district, North-West Amhara, Ethiopia (N=280).

Agro-ecology / Purpose of eggs	High-land (N=80)			Mid-altitude (N=120)			Low-land (N=80)			Total (Study district)		
	1st (%)	2nd (%)	3rd (%)	1st (%)	2nd (%)	3rd (%)	1st (%)	2nd (%)	3rd (%)	1st (%)	2nd (%)	3rd (%)
Sale for income	15	60	17.5	18.3	42.9	27.5	7.5	70	18.8	14	58	21.4
Hatching for replacement	70	25	12.5	70.8	31.3	9.2	75	22.5	6.3	72	26	9.6
Home con-sumption	15	15	70	10.8	25.8	63.3	17.5	7.5	75	14	16	69

1st = First purpose eggs; 2nd = Second purpose eggs; 3rd = Third purpose eggs

Consumption of eggs in the study district

The current study identified that 52.8% of village chicken owners of the study district consumed eggs only during religious/cultural holidays, 42.5% consumed every time when needed and available, 2.5% when only they got sick and 2.2% reported that they never eat eggs. The result of the current study also showed that there were no any cultural/religious taboos against rearing a special type of chicken, not to eat chicken products and not to sell chicken & eggs. This was similar with the findings of Tadelle et al., (2003), who reported that there were no any cultural/religious taboos relating to consumption of eggs and chicken meat, like those for pig meat, in central high lands of Ethiopia.

Storage/handling of eggs in the district

Concerning storage of eggs for incubation, sale and consumption purposes; 71.4% of village chicken owners (mainly rural women) stored eggs inside earthen material (clay) together with grains or straws. It is observed that the use of grains and straws with eggs protect eggs from breakage and provide suitable environment while storage. Regarding duration of egg storage, it is observed that 95% of village chicken owners in the study district stored eggs until the end of 1 clutch period and the hen started broodiness characteristics. Figure 1 showed some pictures of various locally made containers used for egg storage in the district.

Earthen pot with grains

Earthen pot with straws

Mud made container with grain

Figure 1. Locally made containers used for egg storage in the district.

Egg transportation and marketing

The result of the current study indicated that 69.3% of village chicken owners of the study district were involved in selling of eggs. Selling of eggs was done in various places of the study area including: urban markets, local markets and farm gates. Women & children (43.2%) were the most important members of the household that were involved in marketing of eggs in the district. Most consumers of the study area (75%) preferred to buy and consume scavenging hen eggs as they were considered to be tasty and the dark colored yolk was commonly favored.

Urban market was the first priority place for most chicken owners (70%) of the study area for sale of eggs followed by nearest local markets and farm gate sales. The price of eggs was not similar during the year; it was gener-

ally low during the Orthodox Christian fasting months. In addition to selling, exchange of fertile eggs (mainly eggs from exotic chicken breeds) with other village chicken producers was common in the study area.

The result of the current study revealed that majority of chicken owners (66.4%) used hand carrying (using piece of cloths with grains/straw) to transport eggs to markets. Plastic containers (festal) and grass made bags (locally called *'kofeda'*) were also used to transport eggs to markets. Figure 2 showed some pictures of egg transportation and marketing in the district.

Transport of eggs with a piece of cloth & grain

Marketing of eggs in local markets

Figure 2. Egg transportation and Marketing in the district

External egg quality

The result of the study revealed that 49% of eggs collected from the study district were white shelled, 45% were light brown shelled and 6% were cream color shelled (Table 2). The result indicated that local chicken ecotypes of the study district were producing eggs with a mixture of shell colors. Similarly, Halima (2007) reported that the shell color of eggs collected from local hens of North West Ethiopia were a mixture of white, light brown and cream colors. The result also indicated that only 34% of the eggs collected from the study area were with clean shells.

The result of the current study showed that the average weight of eggs was 43g (ranged 34-60g). There was no any significant difference in average weight of eggs collected from different sources. The result was similar with the reported
42.9g by Hallima (2007), for eggs collected from seven local chicken ecotypes of North West Ethiopia. Teketel (1986) also reported an average egg weight of 46g for Ethiopian local chicken. Similar results were also reported by Asuquo *et al*. (1992) for eggs of Nigerian local breed chicken, which was 40.6g. Olori and Sonaiya (1992) also reported an average egg weight of 38.9g, 37.1g, & 37g for Brown, Light Brown & White Nigerian local chicken, respectively. However; the average egg weight result (43g) obtained from this study was higher than the reported egg weight range of 35-39g by Ahmed (1994) for Bangladesh indigenous scavenging chicken eggs.

The result of the current study indicated that the average dry shell weight of local hen eggs of the study district was 3.3g. However, a relatively higher average dry shell weight of 3.95g and 5.7g were reported by Halima (2007) for eggs collected from intensively managed local hens of North West Ethiopia and RIR chicken breeds, respectively.

Table 2. External qualities of eggs collected from Bure district, North West Ethiopia, (N=600)

parameters (N=300)	Egg Souce: Market purchase	Egg Souce: Farm gate (N=300)	Grand Mean (N=600)
Shell color (%)			
White (W)	50	48	49
Light Brown (LB)	44	47	45
Cream (C)	6	5	6
Sanitary status of eggs (%)			
Clean	22	45	34
Dirty	88	55	66
Crackness of eggs (%)			
Normal	100	100	100
Egg weight (g) (Mean ± SD)	43.2±5.0[a] (35-60)*	43.2±3.5[a] (34-54)	43.2±4.3 (34-60)
Dry shell weight (g) (Mean ± SD)	3.3±0.1[a] (2-2.6)	3.2±0.2[a] (2-2.7)	3.3±0.2 (2-2.7)
Egg width (mm) (Mean ± SD)	37.9±2.8[a] (31.6-45.9)	36.3±3.2[a] (31.6-54.5)	37.2±3.1 (31.6-54.5)
Egg length (mm) (Mean ± SD)	51.6±3.5[a] (42.9-59.8)	49.8±4.1[a] (39.0-59.8)	50.8±3.9 (39.0-59.8)
Shape index (%) (Mean ± SD)	73.5±3.2[a] (63.9-82.4)	73.1±4.9[a] (64.7-100)	73.2±4.2 (63.9-100)
Average shell thickness (mm)			
sharp region (Mean ± SD)	0.30 ±.04	0.27±.03	0.27 ±03
equatorial region (Mean±SD)	0.26 ±.03	0.27 ±.03	0.26 ±.03
blunt region (Mean ± SD)	0.24 ±.03	0.24±.03	0.24 ±.03
Average egg shell thickness (Mean ± SD)	0.25 ±.03[a] (0.18-0.34)	0.26 ±.03[a] (0.20-0.34)	0.26 ±0.03 (0.18-0.34)

[ab]Least squares means with different superscripts with in a raw are significantly different ($P < 0.05$); * Numbers in brackets are range values

The result of the study indicated that the mean width and length of local hens eggs collected from different sources of the study district were 37.2 mm and 50.8 mm, respectively. Accordingly, the average shape index percentage was calculated and found to be 73.2%. The result did not show any significant difference between eggs collected from different sources with regard to average shape index percentage. The shape index percentage result (73.2%) obtained from this study was higher than the reported 66.9% for eggs of Nigerian Fulani chicken ecotypes (Fayeye *et al.,* 2005) and this indicated that local hen eggs collected from the study district were more circular than that of Nigerian Fulani eggs. The "normal" chicken egg is elliptical in shape. Eggs that are unusual in shape, such as those that are long and narrow, round, or flat-sided cannot

be placed in Grades AA or A. The higher and lower shape index measurement showed the deviation of eggs from its normal (oval) shape, which has an influence on hatchability performance. In addition, round eggs and unusually long eggs have poor appearance and do not fit well in cartons so are much more likely to be broken during shipment than are eggs of normal shape.

The average shell thickness measurements of eggs for sharp region, equatorial region and blunt region were 0.27 mm, 0.26 mm and 0.24 mm, respectively. The result also revealed that the sharp region shell was relatively thicker than both the blunt region and equatorial region shell. Based on the above shell thickness measurements, the average shell thickness was calculated and found to be 0.26 mm. The result was lower than the reported 0.71mm & 0.69mm by Halima (2007) for eggs collected from intensively managed local chicken ecotypes of North-West Ethiopia and RIR chicken breeds, respectively. Similarly, Teketel (1986) reported a mean egg shell thickness of 0.35mm for Ethiopian local breed chicken eggs. Asuquo *et al.* (1992) also reported an average egg shell thickness of 0.30 mm and 0.35 mm for Nigerian local breeds and Isa-Brown breed chicken eggs, respectively.

The result of the current study also showed that there was no significant difference between eggs collected from different sources of the study area, with respect to average egg shell thickness. The recognized lower average shell thickness (0.26 mm) might be attributed to deficiency of calcium and phosphorus sources in scavenging feed resource basis, which was the major feed source for village birds of the study area.

Internal egg quality

The average yolk height and albumen height measurements of local hen eggs collected from different sources of the study area were 15.1mm and 4.1mm, respectively (Table 3). The average Hough unit value was calculated using albumen height and egg weight measurements and found to be 66.5. The result revealed that there was no significant difference between eggs collected from markets and farm gates with related to average Hough unit values.

The average Hough unit value obtained from this study was higher than the reported 61.1 by Halima (2007) for eggs collected from local chicken ecotypes of North-West Ethiopia and lower than the reported 81.0 by the same author for eggs collected from intensively managed RIR chicken breeds. Asuquo *et al*. (1992) also reported higher Hough unit values of 79.8 and 89.9 for eggs collected from Nigerian local hens and Isa-Brown chicken breeds, respectively.

The current study indicated that local hen eggs of the study district could not be categorized as best in quality based on the obtained average Hough unit value (<72). The lower Hough unit value recorded in this study might be attributed to poor handling and storage of eggs until sale or hatching. Therefore, technological interventions focused in increasing awareness of village chicken owner farmers on proper handling and storage of eggs could be important.

The yolk color of local hen eggs was estimated using roach color fun (ranging 1-15). Each egg was examined by 3 observers and the average value was calculated and recorded. Accordingly, the mean yolk color of local scavenging hen eggs of the study district was calculated to be 8.6. The average yolk color result (8.6) indicated that local scavenging hens of the study area are producers of yellow yolk colored eggs. The survey also indicated that yellow yolk colored eggs were more favored by consumers of the study district.

The mean yolk color result (8.6) obtained from this study was higher than the reported 3.48 and 4.0 by Halima (2007) for eggs collected from intensively managed local hens of North-West Ethiopia and RIR chicken breed hens, respectively. Pavlovski *et al.* (1981) also reported that the yolk color score of free range local hens was higher compared to eggs collected from hens managed under intensive chicken management condition. The higher yolk color value obtained from the current study indicated that scavenging feed resource bases of the study area were rich in xanthophylls, some of which are precursors of vitamin A.

Table 3. Internal quality of local hen eggs in Bure district North West Ethiopia, (N=600)

Traits/Variables (N=300)	Egg Source		Grand mean (N=600)
	Market purchase	Farm gate (N=300)	
Yolk height (mm) (Mean ± SD)	15.1±1.2	15.2±1.4 [a]	15.1±1.3
	(8.4-18.4)*	(11.3-17.5)	(8.4-18.4)
Albumen height (mm) (Mean±SD)	3.9±0.74 [b]	4.2±2.60 [a]	4.1±1.93
	(2.3-6.7)	(2.1-7.6)	(2.1-7.6)
Hough Unit (HU) (Mean±SD)	60.2±6.8 [b]	66.9±7.5 [a]	66.5±7.2
	(45.2-84.8)	(36.4-81.7)	(36.4-84.8)
Average yolk color (1-15)	8.5±1.3 [b]	8.7±1.4 [a]	8.6±1.5
	(5.3-11.3)	(6-11.7)	(5.3-11.7)

[ab]Least squares means with different superscript with in a raw are significantly different ($P < 0.05$); *Numbers in brackets are range values

Phenotypic correlation of external egg quality traits

The results of this study revealed that egg weight (EWt) was significantly and positively correlated (P<0.01) with most external egg quality traits like; egg width (EWd), egg length (EL), egg shape index (SI), egg shell thickness (ST) and dry shell weight (SW) (Table 4). The result was inline with the findings of Farooq *et al.* (1989) and Abanikannda *et al.* (2007), who reported positive correlations between egg weight and other external egg quality traits like; shell weight, egg width, egg length, shape index and shell thickness. However, the significant positive correlation value (0.12) between the egg weight & egg shape index obtained in this study was in disagreement with the negative correlation reported by Iscan and Akcan (1995).

Egg width was also positively correlated with other external egg quality traits like; egg length, egg shape index and dry shell weight. Egg length was negatively correlated with shape index and positively correlated with shell weight. Shell thickness showed a significant positive correlation with dry shell weight.

Table 4. The phenotypic correlations between external egg quality traits, (N=600)

External egg quality traits	EWt (g)	EWd (mm)	EL (mm)	SI (%)	ST (mm)	SW(g)
EWd (mm)	**0.49****					
EL (mm)	0.45**	0.78**				
SI (%)	0.12	0.44**	-0.22			
ST (mm)	0.16	0.04	0.1	-0.05		
SW (g)	0.52**	0.09	0.09	0.12	0.38**	

EWt = Egg weight, EWd= Egg width, EL= Egg length, SI= Shape index, SD= Shell density, ST= shell thickness, SW= Shell weight

** Correlation is significant at the 0.01 level (2-tailed)

Phenotypic correlation of internal egg quality traits

A detail of the phenotypic correlation of internal egg quality traits is presented in Table 5. Statistically significant positive correlation (P<0.01) was observed between albumen height and other egg quality traits like; yolk height and Hough unit. Similarly, significant and positive correlation was recorded between yolk height and Hough unit. Akbas *et al.* (1996) also reported significant positive correlations between internal egg quality traits including, yolk height and the albumen height (0.48), yolk height and Hough unit (0.52) and albumen height and Hough unit (0.97). Likewise, Ozcelik (2002) reported significant positive correlation between albumen height and the Hough unit (0.97).

Table 5. The phenotypic correlations between internal egg quality traits, (N=600)

Internal egg quality traits	Albumen height (mm)	Yolk height (mm)	Hough unit (HU)
Albumen height (mm)	1.0		
Yolk height (mm)	0.19	1.0	
Hough unit (HU)	0.41**	0.38**	1.0

** Correlation is significant at the 0.01 level (2-tailed)

Phenotypic correlation between internal and external egg quality traits

The result of the current study indicated that egg width (EWd) showed significant and negative correlation with yolk height (-0.27) and Hough unit (-0.23) (Table 6). A significant negative correlation was also recorded between egg weight (EWt) and Hough unit (-0.13). Correspondingly, Ozcelik (2002), Iposu *et al.* (1994) and Shawkat (2002) reported significant negative correlations between Hough unit (HU) and egg weight (EWt).

Positive correlation was observed between egg weight (EWt) and other internal egg quality traits including, albumen height (0.1) and yolk height (0.1). Likewise, Silversides (1995) & Zhang *et al.* (2005) reported significant positive correlation between egg weight (EWt) and albumen height. In this study, significant negative correlation was observed between egg length and other internal egg quality traits including, yolk height (-0.24) and Hough unit (-0.27).

Table 6. The phenotypic correlations between external and internal quality traits, (N=600).

Traits	EWt (g)	EWd (mm)	EL (mm)	SI (%)	AH (mm)	YH (mm)
EWd (mm)	0.49**					
EL (mm)	0.45**	0.78**				
SI (%)	0.12	0.44**	-0.2			
AH (mm)	0.1	0.02	0.01	0.01		
YH (mm)	0.1	-0.27	-0.24	-0.069	0.19**	
HU	-0.13	-0.23	-0.27**	0.034	0.41**	0.38**

EWt = Egg weight, EWd= Egg width, EL= Egg length, SI= Shape index, AH = Albumen height, YH= Yolk height, HU= Hough Unit

** Correlation is significant at the 0.01 level (2-tailed)

Prediction equations of selected egg quality traits

The result of the current study indicated that egg weight (EWt) could be predicted from egg length (EL) and egg width (EWd) measurements separately with sufficient reliability (R^2 = 20.3% and 24.3%, $p<0.05$). However, a better and more reliable estimate was obtained when both egg length (EL) and egg width (EWd) were fitted into the model (R^2 = 25.4 %) (Table 7). The result of the present study was in line with the findings of Yakubu *et al*. (2008) with regard to the positive estimation of egg weight (EW) from egg length (EL) and egg width (EWd).

Table 7. Prediction equations of selected egg quality traits, (N=600)

Functions	R^2 (%)	Significance
$Y_1 = 0.69X_1 + 18.03$ *	20.3	* (+ve)
$Y_1 = 0.5X_2 + 17.55$ *	24.3	* (+ve)
$Y_1 = 0.18X_1+0.51X_2+14.98$ *	25.4	* (+ve)

Y_1 = Egg weight; X_1= Egg length; X_2=Egg width R^2 = Coefficient of determination; *p < 0.05

Conclusions

- The current study indicated that local/scavenging hen eggs were more preferred for the existing domestic market mainly due to the presence of yellow colored yolks.
- The lower internal and external quality trait measurements (like; egg weight, shell thickness, Hough unit) recorded in this study, as compared to the observed results in intensively managed local hen eggs in other studies, indicated that the quality of eggs could be improved by relatively simple changes in management interventions such as, proper housing, feeding, health care of local birds and good management/handling of eggs.
- As most of village chicken husbandry (feeding, housing, and health care), egg storage/handling and marketing activities of the study district are implemented by women, provision of successive trainings to rural women would be essential for future improvement of the sector.

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