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Assessment of the Prevailing Handling and Quality of Eggs from Scavenging Indigenous Chickens Reared in Different Agro-Ecological Zones of Ethiopia

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Abstract: The importance of scavenging poultry production in the national economy of developing countries and its role in improving the nutritional status and income of many smallholders has been very significant. A survey based experiment was conducted in 196 households to assess the production system and egg qualities of scavenging chickens reared in highland, midland and lowland agro-ecological zones of Amhara Regional State of Ethiopia. For egg quality determination, among 196 households 30 of them who keep only local chicken ectypes were identified from each agro-ecology from which 588 eggs (196 eggs from each agro-ecology) were collected. The results indicated that about 95 and 70% of the respondents fumigate day old chicks with smoke and clip tail feathers, respectively. The flock size in highland, midland and lowland agro-ecologies was 8.5, 7.4 and 8.4 chickens, respectively. The average age at first egg lay was 6.94, 6.43 and 6.57 months for highland, midland and lowland agro-ecologies, respectively. The survivability of chickens in highland, midland and lowland agro-ecological zones was 55.0, 61.4 and 55.1%, respectively. On the average 79.1% hatchability, 58.3% chick survivability was found in the study area. The observed values of egg weight, egg length, egg width, yolk height, albumen height and Haugh unit were significantly different ($p<0.05$) between the investigated agro-ecologies. Accordingly, all these traits were ($p<0.05$) higher in midland than highland and lowland agro-ecological zones. However, agro-ecology did not show any significant effect on shape index, shell thickness, yolk width and yolk index. The respective average egg weight, shell thickness and shape index values were 39.6 g, 0.296 mm and 73.2%. The average values of yolk height, yolk width and Haugh unit were 16.1, 36.8 and 73.2 mm, respectively. In conclusion, the midland agro-ecological system appears to favor the survivability and expression of both external and internal egg quality traits of scavenging rural chickens.

Key words: Agro-ecological zones, egg handling, egg quality traits, rural households, scavenging local chickens

INTRODUCTION

The importance of scavenging local poultry production in the national economy of developing countries and its role in improving the nutritional status and incomes of many small farmers and landless communities has been recognized by various scholars and rural development agencies over the last few decades (Copland and Alders, 2009; Aklilu *et al*., 2008; Dana *et al*., 2010; Moges *et al*., 2010; Melesse and Negesse, 2011). Indigenous and local chicken breeds contribute to poultry meat and egg production and consumption in developing countries where they make up to 90% of the total poultry population. This is so because they are well-adapted to the scavenging conditions with very low levels of inputs, under which they are maintained (Besbes, 2009). Moreover, Van der Sluis (2007) reported that poultry meat and egg production is the most environmentally efficient animal protein production system. Scavenging based rural poultry production has also a less detrimental impact on the environment than other livestock and uses less water.

In Ethiopia chickens are the most widespread and almost every rural family owns scavenging birds which provide a valuable source of family protein and extra cash incomes (Tadelle *et al*., 2003; Aklilu *et al*., 2008). The total chicken population in the country is estimated to be 49.3 million (CSA, 2011). The majorities (96.5%) of these birds are indigenous ecotypes which are maintained under Scavenging System with little or no inputs for housing, feeding or health care (CSA, 2011). This figure proves the importance of village chicken production for rural development and feeding.

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Eggs are balanced sources of essential amino acids as well as some minerals and vitamins (Probst and Tapsell, 2005). Egg proteins contain all essential amino acids for human diet and therefore egg protein is used as standard for measuring the nutritional quality of other food products (Bell and Weaver, 2002; FAO, 2003). A single egg would contribute 3-4% of an adult's average energy requirement per day and contains about 6.5 g of protein (Sparks, 2006). Furthermore, chicken eggs could be stored in hot climates under local conditions more easily than most foods of animal origin (Moges *et al*., 2009).

Both external and internal qualities of eggs are of major importance to the egg industry worldwide. However, they are not being given 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. To date there are no detailed studies conducted on the description of the existing handling and storage of scavenging local hen eggs and assessment of internal and external quality of marketable eggs in various agro-ecological zones of the targeted study area. Therefore, this study was designed to assess the existing handling and quality of eggs collected from local scavenging chickens reared in highland, midland and lowland agro-ecological production systems.

MATERIALS AND METHODS

Description of the study area: The study was conducted at three agro-ecological zones in Amhara Regional State of Ethiopia. The coverage of the three agro-ecological zones is highland (>2500 masl, 12%), lowland (<1500 m asl, 40%) and midland (1500-2500 masl, 48%). The surveyed area is composed of 37 Peasant Associations (PAs) which are distributed in the three agro-ecological zones.

Data collection procedures

Sampling technique: The study consisted of survey and egg quality examination of local chickens in the three agro-ecological zones of the studied district. The survey part was accomplished through interview using pre-tested structured questionnaires and this was augmented with group discussions and direct observations. To this effect, the surveyed district was stratified into highland, midland and lowland agro-ecological zones. One, two and three PAs were selected randomly from highland, lowland and midland agro-ecological zones, respectively. A total of 196 households who keep a minimum of five or above chickens were selected from land registration book of the PAs using systematic random sampling technique.

Eggs were directly collected from local chickens owned by the interviewed household farmers. During egg sampling, the main intention was to collect eggs from local layers that were approximately similar in age. Accordingly, 150 chicken owners were randomly interviewed from each agro-ecology in order to identify those farmers that had only local chicken layer hens with more than one clutch number. In due regard 30 households were identified from each agro-ecology that satisfied the above intention and 588 eggs (196 eggs from each agro-ecology) were collected from the selected farmers.

Measuring egg quality traits: Eggs were weighed to the nearest of 0.01 g using a battery operated digital weighing balance (Model: DT 5k, LARK®). The length (mm) and breadth (mm) of each egg was measured at midpoint using a digital calliper to nearest of 0.05 mm and egg shape index was calculated using the definition of Panda (1996).

Each egg was then broken out and albumen and yolk height measurements were taken using a tripod micrometer while yolk diameter was measured using digital calliper meter. Haugh unit (albumen height corrected for egg weight) was calculated for individual egg according to Haugh (1937) by the formula:

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

Where:
HU = Haugh Unit
AH = Albumen Height (mm)
EW = Egg Weight (g)

Yolk height and diameter values were used to compute yolk index of the eggs according to the formula described by Panda (1996). Yolk color was measured with a Roche yolk color fan scale (Roche scale). Before measuring shell thickness, the shell was cleaned with tissue paper and air-dried at room temperature for 24 h. Then, three pieces of shell was taken from the narrow side (sharp region), the middle side (equatorial region) and the broad-end side (blunt region) of each egg. First, shell membranes were removed by hand and then measured by a digital caliper to the nearest of 0.05 mm. The shell thickness (mm) was then calculated as an average of the thicknesses of the three pieces.

Statistical analysis: Data were subjected to Analysis of Variance (ANOVA) using the General Linear Models (GLM) Procedure of Statistical Analysis System (SAS, 2002). Single factor ANOVA test was employed to analyze differences among the three agro-ecologies with respect to various quantitative response variables. Where significant differences were observed, treatment means were compared with Duncan's Multiple Range test. All statements of statistical differences were based on $p<0.05$ unless noted otherwise.

RESULTS

Incubation and chick management practices: Incubation and chick management practices in the study area are shown in Table 1. About 59% of the households reported that they clip the tail feathers and some extent wing feathers of their chickens. About 18% of chicken owners fumigate the broody hen or incubating hen with smoke of different herbs to make sure that the hen remains free from external parasites while incubating and brooding the chicks. About 80% of chicken owners allowed the incubating hen to feed and drink every other day and only 20.4% of the respondents do the same every day (Table 1). The common types of incubating materials used are mud made (63.1%), grass made (9.2%), bamboo made (13.9%), clay made (9.5%) and others (4.3%). Among the interviewed households, about 97% of them use bedding material mainly crop residues such as Teff (Eragrostis tef) straw, barley straw and wheat straw. About 95% of the interviewed farmers preferred to incubate eggs during dry season while 4% during both seasons and only 1% during the rainy season (Table 1).

Various practices of chick management in the study area are shown in Table 2. Almost all households (95%) in the study area fumigate the newly hatched chicks with smoke of herbs known as Tunjit (Ostegia integrifolia). About 70% of chicken owners provide in-water soaked Enjera (local bread prepared from flour of Eragrostis tef) to the chicks at least during the 1st week of age. About 70% of households reported that they remove the tail feathers of the chicks. Among the interviewed households, 49% of them allow their chicks to scavenge when they reach the age of 1 week and earlier.

Reproductive traits of scavenging chickens: As shown in Table 3, the average chicken flock size in the study district was 7.9 chickens per household. Age at first egg of scavenging chickens in the study area was 6.6 months. The average number of eggs incubated per hen in this study was 12.8. Out of the incubated eggs, only 10 chicks were hatched giving an average hatchability of 79.1%. Among the hatched chicks only 5.5 chicks reached market age which implies 58.3% survival rate suggesting high chick mortality during the growing period.

Egg quality traits: Average values of the investigated external and internal egg quality traits are shown in

Table 1: The main incubation practices of chicks observed in highland, midland and lowland agro-ecological zones of the study area (N = 196 households)

Parameters (%)	High land	Mid land	Low land	Overall mean
Hen treatment prior to incubation				
Fumigate with smoke	12.40	30.30	3.10	18.40
Clipping tail feather	81.30	61.60	44.60	59.20
No treatment at all	6.30	8.10	52.30	22.40
Feed and water provision				
Everyday	21.90	25.30	12.30	20.40
Every other day	78.10	74.70	87.70	79.60
Incubation materials				
Clay made	-	3.92	23.80	9.52
Mud made	65.90	66.40	56.30	63.10
Bamboo made	25.00	13.30	8.70	13.90
Grass made	9.10	10.90	6.20	9.15
Others (wood, floor)	-	5.48	5.00	4.33
Incubation seasons				
Rainy season	3.10	-	1.50	1.00
Dry season	96.90	96.00	92.30	94.90
Year round	-	4.00	6.20	4.10

Highland = >2500 masl; Midland = 1500-2500 masl; Lowland = <1500 masl

Table 2: Common chick management practices in scavenging local chickens reared in highland, midland and lowland agro-ecological zones of the study area (N = 196 households)

Parameters (%)	High land	Mid land	Lowland	Overallmean
Fumigating with smoke (yes)	93.80	97.00	93.00	95.40
Type of feed for chicks				
In-water soaked Enjera*	81.30	69.70	64.60	69.90
Ground grains	18.70	29.30	35.40	29.60
Boiled Teff (Eragrostis tef)	-	1.00	-	0.50
Water provision (yes)	28.10	22.20	16.90	21.40
Tail feather clipping (yes)	71.90	72.70	66.20	70.40
Letting to scavenge chicks				
At day old	3.10	9.10	7.70	7.80
After 1-2 weeks	50.00	45.50	55.40	49.50
After 3-4 weeks	43.80	32.30	24.60	31.50
After a month	3.10	13.10	12.30	11.20

Highland = >2500 masl; Midland = 1500-2500 masl; Lowland = <1500 masl; *Local bread prepared from flour of Eragrostis tef

Table 3: Reproductive characteristics of scavenging local chickens reared in highland, midland and lowland agro-ecological zones of the study area (Mean±SD)

Parameters	Highland	Midland	Lowland	Overall mean (N = 196 Hh)
Flock size/household	8.50±5.10^{a}	7.40±4.34^{a}	8.40±4.70^{a}	7.90±4.60
Age at first egg (months)	6.94±1.60^{a}	6.43±1.60^{a}	6.57±1.50^{a}	6.60±1.60
Number of eggs incubated/hen	13.10±1.60^{a}	12.00±1.90^{b}	13.80±2.80^{a}	12.80±2.30
Number of eggs hatched/hen	10.08±2.40^{a}	9.60±2.30^{b}	10.20±3.00^{a}	10.00±2.30
Hatchability (%)	82.50±13.0^{a}	80.30±16.0^{a}	75.60±20.0^{a}	79.10±17.0
Number of chicks survived	5.63±1.40^{a}	5.60±1.50^{a}	5.30±2.00^{a}	5.50±1.70
Survivability (%)	55.00±2.00^{a}	61.40±5.50^{a}	55.10±2.30^{a}	58.25±2.30

^{ab}Means with different subscript across a raw are significantly ($p<0.05$) different Highland = >2500 masl; Midland = 1500-2500 masl; Lowland = <1500 masl; Hh = Households

Table 4: External and internal egg quality traits of scavenging local chickens reared in highland, midland and lowland agro-ecological zones (n = 196 eggs/agro-ecology)

Parameters	Highland	Midland	Lowland	Overall mean	SEM
Egg weight (g)	39.300[b]	40.200[a]	39.400[b]	39.600	0.259
Egg length (mm)	51.200[b]	51.700[a]	51.100[b]	51.300	0.156
Egg width (mm)	37.400[b]	37.700[a]	37.400[b]	37.500	0.090
Shape index (%)	73.200[a]	73.100[a]	73.200[a]	73.200	0.197
Shell thickness (mm)	0.298[a]	0.295[a]	0.297[a]	0.296	0.002
Yolk width (mm)	36.600[a]	37.100[a]	36.700[a]	36.800	0.175
Yolk height (mm)	16.100[a]	16.400[a]	16.000[b]	16.100	0.111
Yolk index (%)	44.100[a]	44.200[a]	43.700[a]	44.000	0.337
Yolk color	9.380[a]	9.290[a]	9.100[a]	9.260	0.111
Albumen height (mm)	4.300[c]	4.750[a]	4.460[b]	4.510	0.051
Haugh unit	71.800[c]	74.900[a]	73.100[b]	73.200	0.412

[a-c]Means with different superscript across the raw are significantly ($p<0.05$) different Highland = >2500 masl; Midland = 1500-2500 masl; Lowland = <1500 masl; SEM = Standard Error of the Mean

Table 4. Some egg quality parameters such as egg weight, egg length, egg width, yolk height, albumen height and Haugh Unit (HU) were significantly different between the investigated agro-ecologies in which better quality of the parameters was observed in midland agro-ecology. However, there were no significant differences observed between agro-ecological zones in values of shape index, shell thickness, yolk width and yolk index.

The egg weight obtained from midland scavenging chickens was significantly heavier than those of highland and lowland agro-ecological zones. Eggs collected from midland scavenging chickens had significantly higher length and width than those of highland and lowland agro-ecological zones. The overall mean egg length and egg width of the local chickens in the current study was 51.3 and 37.5 mm, respectively. The overall shape index of scavenging local chickens in the present study was 73.2% (Table 4). The average shell thickness in the current study was 0.296 mm.

The yolk height was significantly ($p<0.05$) higher in midland than in highland agro-ecology (Table 4). The overall average yolk width of local chickens was 36.8 mm whereas yolk height was 16.1 mm resulting 44% of yolk index. The albumen height and HU values were significantly higher in scavenging chickens reared midland than those of lowland and highland agro-ecological zones. Chickens from lowland had significantly lower albumen height and HU values than those of both agro-ecological zones. The overall average values of albumen height and HU were 4.51 and 73.2 mm, respectively.

DISCUSSION

Incubation and chick management practices: The most common incubating materials used in the study area were similar to those of Tadelle *et al.* (2003) and Moges *et al.* (2009) reported to other parts of Ethiopia. In agreement with the present finding, Mekonnen (2007) reported that 89.4% of chicken owners in southern Regional State of Ethiopia preferred incubating eggs during the dry season. The possible explanation why the rainy season is not preferred for incubating eggs might be due to shortage of feed and cold stress due to low ambient temperature and high mortality of hatched chicks caused by ground predators.

Farmers in the study area believe that fumigation of hatched chicks with smoke of herbs will protect them from the incidence of Newcastle disease. Regardless of their perception, the practice of smoking would provide heat and thus make the chicks strong especially if they are wet. Moreover, the smoke would remove external parasites which the chicks may harbour from the mother hen and the incubation materials used.

Households in the study area believe that when tail feathers are removed from the chicks, they will grow faster and reach market weight at early age. This kind of farmers perception may have some scientific justifications. Feathers contain approximately 90% crude protein (Stilborn *et al.*, 1997) and hence if tail feathers are removed that part of the protein which otherwise goes to tail feather growth may be used to build important parts of the chickens' body tissues.

Reproduction traits of scavenging chickens: The average flock size found in the current study is in line with those of Halima *et al.* (2007) and Melesse and Negesse (2011) who reported average flock size of about 7 chickens for northwest and southern parts of Ethiopia, respectively. In southern Ethiopia, Mekonnen (2007) reported an average flock size of 9.2 chickens per household for scavenging local chickens which is slightly higher than the present result. On the other hand, a relatively higher flock size (12 chickens per household) was reported by Dinka *et al.* (2010) in the Oromia Region of Ethiopia. Similarly, Yakubu (2010) reported an average flock size of 13.9 birds per household in Nigeria which varied between 4 and 48 chickens per household.

Consistent with the findings of the current study, Kugonza *et al.* (2008) and Pampori and Iqbal (2008) reported average maturity age of 5-6 and 6-7 months for male and female chickens, respectively. A relatively long maturity age of local female chickens (6.8-7.6 months) was reported by Tadelle *et al.* (2003) and Mandal *et al.* (2006). These variations could be due to the genetic make of local chickens and management practices used by various communities.

Scavenging System is characterized by high chick mortality in the 1st 2 weeks of life, caused mainly by

predators and Newcastle disease (Melesse and Negesse, 2011). The number of hatched chicks out of the incubated eggs identified in this study was similar to the finding of Yakubu (2010) who reported average hatched chicks of 8.78. According to Pedersen (2002) the number of eggs incubated per clutch was 10.6 with average hatchability rate of 73%. Similarly, Ssewannyana *et al.* (2008) reported higher hatchability (87%) for Ugandan scavenging local chickens. Hatchability of eggs is affected by a number of factors and thus such differences in hatchability values are expected in the literature. In present study, the number of eggs incubated and hatched in midland was significantly lower than found in highland and lowland agro-ecological zones. This might be attributed to better market access to sale eggs to the nearby urban cities. Since, the households set low number of eggs, it is apparent that the number of eggs hatched was lower in midland than highland and lowland agro-ecological zones.

Egg quality traits of scavenging chickens: The overall mean egg weight (39.6 g) obtained from the current study is in good agreement with the findings of Halima (2007) and Mengesha *et al.* (2008) for scavenging local chickens reared in various parts of Ethiopia. The egg weight of Indian backyard chicken reported by Mandal *et al.* (2006) ranged from 35-40 g which finds similarity to the present research. The mean egg weight of scavenging local chickens in Tanzania reported by Nonga *et al.* (2010) is also similar to the current result.

In agreement with the present finding, Malago and Baitilwake (2009) reported average egg length and egg width of 51.4 and 38.3 mm, respectively for Tanzanian local chickens. Moges *et al.* (2009) reported an average egg length of 50.9 mm for scavenging local chickens of Burie district of Western Ethiopia which is consistent with the current findings.

Egg shape is an important parameter in the poultry industry for uniformed package of eggs during transportation over long distances by reducing possible breakage of eggs. Eggs with higher shape index percentages are more circular in shape than that of eggs with lower shape index percentages (Silversides, 1994). In line with the present findings, Bekele *et al.* (2009) and Moges *et al.* (2009) reported an average shape index of 73% for scavenging local chickens found in various parts of Ethiopia. Consistent with the current study, Yakubu *et al.* (2008) reported average shape index values of 74.7 and 72.6% for Nigerian naked-neck and normal feather chickens, respectively. However, Parmar *et al.* (2006) reported an average shape index of 84.0% for indigenous chickens of India which is much higher than found in the present study.

Among external egg quality traits, shell thickness as a measure of shell strength is an important bio-economic trait that primarily breeder of egg laying flock incorporate in their breeding programmes to reduce egg shell breakages. The average shell thickness values obtained from the current study are in close agreement with the findings of Parmar *et al.* (2006) for Indian and Bekele *et al.* (2009) for Ethiopian scavenging local chickens. Shell thickness of 0.370 mm was reported by Melesse *et al.* (2010) for Ethiopian naked-neck chickens under on-station research and by Kartalkanat and Cicek (2009) for village chickens of Turkey. A high shell thickness value of 0.580 mm was also reported by Fayeye *et al.* (2005) for Fulani ecotype chickens of Nigeria. These variations in shell thickness observed in different regions could be attributed to the quality, quantity and nutrient composition of scavengable feed resources available in different localities. Rajkumar *et al.* (2009) reported that smaller eggs have stronger shells than larger ones as hens have a limited capacity to deposit calcium in the shell and as a result, the same amount of calcium is spread around over a large area.

Although, the external shell provides a unique package for the distribution of the egg contents, it is in fact the internal quality of the egg that is most important to the consumer (Okeudo *et al.*, 2003). The average yolk width and height values found in the present study are consistent with the findings of Melesse *et al.* (2010). The same author reported 45.0% of yolk index for Ethiopia naked-neck chicken which is in good agreement with current results. Similarly, Pampori and Iqbal (2008) reported yolk index value of 45.5% for indigenous chickens of Kashmir. In India, Parmar *et al.* (2006) and Baishya *et al.* (2008) respectively, reported yolk index of 37.1 and 39% for indigenous chickens which are lower than observed in the current study. Much lower yolk index values (31.6%) were also reported by Nonga *et al.* (2010) for free range local chickens. The variations observed in yolk quality of various regions might be caused by the storage conditions of eggs before they are being assessed for quality traits.

Although, yolk color is a key factor in any consumer survey relating to egg quality (Okeudo *et al.*, 2003), consumer preferences for yolk color are highly subjective and vary widely from country to country. The average yolk color value observed in the present study was slightly higher than that of Moges *et al.* (2009) but considerably higher than reported by Bekele *et al.* (2009) for scavenging local chickens. However, higher yolk color values were reported for local chickens of Turkey (Kartalkanat and Cicek, 2009) and for naked-neck chickens of Ethiopia (Melesse *et al.*, 2010). The low yolk color

value observed in this study might be attributed to the period of the experiment (dry season) where there was shortage of green plant materials for the scavenging chickens.

Fayeye *et al.* (2005) reported albumen height of 4.91 and HU of 73.4% for Fulani chicken ecotypes of Nigeria which are consistent with the current findings. On the other hand, Kartalkanat and Cicek (2009) reported higher HU values (85.82) for village chickens. The albumen height and HU values of Ethiopian naked-neck chickens reported by Melesse *et al.* (2010) were 5.5 and 81.8 mm, respectively which were slightly higher than those of the current findings. These observed variations could be attributed to various factors such management differences, age of the birds, quality and quantity of feed and production environments in which the animals were maintained. In general, egg quality traits of scavenging chickens reared in the midland agro-ecology was much better than other agro-ecologies. The midland production system is dominated by crop production which would provide to scavenging chickens better access to feed resources such as grains and cereals.

CONCLUSION

The midland agro-ecological production system appears to favor the survivability and expression of both external and internal egg quality traits of scavenging rural chickens. It is thus recommended that appropriate intervention packages such as feeding, housing, breeding and health care may focus on those scavenging chickens reared in the midland agro-ecology. Although, the general performance of scavenging local chickens is low, they still possess some desirable traits such as better egg quality, tolerance to parasitic diseases and adaptability to harsh environments which cannot be found in commercial chicken breeds. They easily fit to the existing Farmers Management System and serve as a means of food security to the poor rural families.

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