International Journal of Research Studies in Agricultural Sciences (IJRSAS)
Volume 4, Issue 10, 2018, PP 27-35
ISSN No. (Online) 2454–6224
DOI: http://dx.doi.org/10.20431/2454-6224.0410004
www.arcjournals.org

Assessing the Performance, Egg Quality, and Carcass Characteristics of Indigenous Chickens Reared Under Traditional Management System

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Abstract: *The study was conducted in three districts of Bench Maji Zone in Southwestern Ethiopia with the objective of assessing the production and egg quality traits of indigenous chickens reared under natural production environment. Two hundred seventy households were randomly selected and interviewed using semi-structured questionnaires. For the evaluation of egg quality traits, 450 fresh eggs were collected from indigenous chicken breeds while for the assessment of carcass, 45 representative indigenous male chickens were used. The results revealed that the flock size per household was 10.4 with 1:2.9 cocks to hen ratio. The average age of cockerel at first mating and pullet at first egg laying was 5.9 and 6.4 months, respectively. The average number of eggs per clutch and the annual egg production were 14.8 and 54.6, respectively. The mean number of eggs incubated by hens was 11.8 with 82.2% hatchability and 48.8% survivability rate. The average egg weight and shape index was 43.9 g and 72.7%, respectively. The average shell thickness was about 0.33 mm. The respective average albumen height and the Haugh unit score was 3.4 mm and 61.2. The average yolk height and yolk color were 14 mm and 10.9, respectively. The average slaughter weight of adult male chicken was about 1449 g. The dressed carcass yield was 966 g with 66.7% dressing percentage. The proportions of breast meat, thigh, drumsticks, and wing were 25.4%, 19.5%, 15.4% and 10.2%, respectively. The study revealed variations in different production, egg quality and carcass characteristics among the studied districts which might be due to management difference and genetic dissimilarities of indigenous chicken ecotypes that have to be exploited through improved management and breeding strategies. Further research is recommended to evaluate the performance, egg quality and carcass yield potentials of indigenous chickens of the districts under improved feeding and management systems.*

Keywords: *Bench Maji; carcass yield; egg quality; indigenous chicken; traditional production*

1. INTRODUCTION

Traditional chicken production plays a key role in the livelihood of the rural residents in developing countries being an immediate income source and by improving the nutritional status of the rural household (Melesse, 2014). Chicken products are the primary affordable sources of animal source food in rural household since they cannot inquire the cost of small and large ruminants' price. Chicken production is thus vital to meet food security by producing a high quality animal source protein and being income source to most rural populations (Melesse, 2014). Moreover, traditional chicken production is environmentally friendship and cheap protein producing system to utilize waste scavenging feed resources. Scavenging chicken production is very essential by producing eggs attributed with better quality in some egg quality traits such as shell thickness, yolk colour and albumin index than in commercial production with least cost (Cicek and Kartalkanat, 2009).

In Ethiopia, indigenous chickens are reared for basic social and economic needs in the household (Fisseha *et al.*, 2010). The total chicken population in the country is estimated about 56.9 million of which 95.9% are indigenous chickens (CSA, 2014). The major system of production in the country is traditional scavenging which is characterized by low inputs, poor management, periodic flock devastation with short lifecycle and unorganized marketing system (Melesse, 2014). The most adaptive and dominant chicken types for such traditional production systems are indigenous chicken

ecotypes (Melesse and Negesse, 2011). This is because indigenous chickens are good scavengers, disease tolerant, possess good maternal ability, and are adapted to poor management and harsh conditions.

External and internal egg quality traits are the determinant factors for the embryonic development of an egg and latter for the viability of the new hatched chick (Melesse *et al*., 2005; Onagbesan *et al*., 2007). Moreover, some egg quality traits like eggshell thickness and strength are very important to handle the egg during transportation from time of laying up to consumption (Melesse *et al*., 2005). Other egg quality traits like yolk color have valuable influence on the egg market (Fisseha *et al*., 2010; Dana *et al*., 2010). For this reason, valuable egg quality traits are very important reproductive parameter in chicken production industry and breeding strategies (Veena *et al*., 2015). According to Desalew *et al*. (2015), most of such internal and external egg quality parameters are subjected to the level of chicken management and egg handling techniques. Egg storage technique and storage duration influences most of egg quality parameters such as albumen and yolk height (Farhad and Fariba, 2011). The taste of the meat from indigenous chickens is better than that of modern chicken breeds based on consumers' desire (Dana et al., 2010). Indigenous chickens exhibited better quality meat with low fat content, high protein, and high mineral content over modern commercial broiler strains (Dana et al., 2010; Melesse, 2014).

Nevertheless, the indigenous chicken breeds in most African countries are little studied and the existing reports lack consistency. Lack of recorded data on the characteristics of chicken products and other aspects of management makes difficult to assess the importance and contributions of the past attempts to improve the sector (Fisseha *et al.*, 2010). Assessing and understanding the characteristics of the production, egg quality and carcass traits of indigenous chickens is of great importance to design intervention strategies in the sector (Farhad and Fariba, 2011). There are no detailed studies conducted in the study area on the assessment of egg quality and carcass characteristics of indigenous chickens reared in Bench Maji zone under traditional management system. Therefore, the current study was designed to assess the production, egg quality and carcass characteristics of indigenous scavenging chicken populations under the existing traditional management system.

2. Materials And Methods

2.1. Description of the Study Area

The study was conducted in Bench Maji zone of Southern Nations, Nationalities and People Regional State, Ethiopia, which consists ten districts and one administration town (BMZLFDO, 2015). The study zone lies between 5°40' and 7°40' North Latitude and 34°45' and 36°10' East Longitude. Agro-ecologically, Bench Maji Zone consists 52 % lowland (500-1500 m a.s.l), 43 % midland (1500-2300 m a.s.l) and 5 % highland (> 2300 m a.s.l). The annual temperature ranges from 20°C to 40°C and the annual rainfall from 1,200 to 2,000 mm (BMZLFDO, 2015). The main livestock species reared in the zone are cattle, sheep, goats and poultry (CSA, 2014).

2.2. Sampling Methods and Data Collection

The study consisted of a survey part, egg quality and carcass component assessment of indigenous chicken ecotypes in the traditional production system. The survey part was conducted in three districts namely South Bench, Sheko and North Bench, which were purposively selected based on their potential for chicken production and accessibility. Then, three kebeles (the smallest administration unit) from each district were purposively selected where exotic breeds were not distributed. From each kebeles, 30 households (with a total of 270 households) who possess at least 5 indigenous adult chickens were purposely selected and interviewed using semi-structured questionnaire augmented with focal group discussions.

For the evaluation of external and internal egg quality traits, 450 fresh eggs were collected from indigenous chicken owners in the 9 kebeles (50 eggs from each kebele). The collected eggs were then transported to the poultry laboratory of College of Agriculture and Veterinary Medicine (Jimma University) using appropriate portable refrigerator to avoid possible quality deteriorations during collection and transportation. Soon after arrival, each egg was individually weighed using sensitive balance. Egg width and egg length were then measured using digital caliper. After external quality

trait measurement, each egg was carefully opened on a flat glass plate to measure the most valuable egg quality traits. Shell thickness (in mm) was measured using digital caliper by removing the inner shell membrane. Albumen weight (gm) and yolk weight (gm) was measured using sensitive balance. Albumen and yolk height (mm) was determined using tripod micrometer. Yolk colour was measured using colour fan of 1–15 leveled colour fans. Egg shape index was computed by dividing egg width with egg length. Haugh unit was calculated according to Haugh (1937) by fitting the average albumen height and egg weight in to the following the equation: $100 \times \log [\text{albumen height} + 7.57 - 1.7 (\text{egg weight}^{0.37})]$.

For the assessment of carcass characteristics, five indigenous male chickens between 10 and 12 months age from each kebele (15 from each district) were purchased at household level. After overnight fasting, each bird was weighed (considered as pre-slaughter weight) and manually eviscerated. The dressed carcass weight was taken after defeathering and removal of feet, head and the viscera while the skin is included. The dressed carcass, breast, thighs and drumsticks were weighed inclusive of bones. The wings were removed by a cut through the shoulder joint at the proximal end of humerus. The thigh and drumstick portions were obtained by cutting through the joint between the femur and ilium bone of the pelvic girdle. The drumstick was separated from the thigh by a cut through the joint formed by the femur, fibula and tibia. The dressing percentage was calculated from dressed carcass weight as a percentage of the pre-slaughter weight.

2.3. Statistical Analysis

Quantitative data were subjected to analysis of variance in General Linear Model procedure of SAS (SAS institute, 2012; ver. 9.4). Single factor ANOVA was employed to analyze differences among the studied districts with respect to quantitative response variables. Duncan multiple range test was used for multiple mean comparison of the district effect on quantitative traits. Variations in the qualitative data were analyzed using chi-square test.

3. Results And Dicussion

3.1. Flock Dynamics and Composition

The average chicken flock size per household as presented in Table 1, was in agreement with those reported by Melesse and Negesse (2011) in southern Ethiopia and by Deneke *et al.* (2014) in southeastern Oromia region of Ethiopia. However, it was higher than that of Moreda *et al.* (2013) who reported 4.85 average flock sizes in southwest and southern parts of the country. On the other hand, the flock size in the present study is lower than Fisseha *et al.* (2010) who reported flock size of 13 in Amhara region, Ethiopia. These variations could be due to differences in the conception of the farming communities for poultry rearing and availability of feed resources and access to market the products.

There was also a significant variation in flock size among the studied districts. Accordingly, the flock size observed in Sheko district was lower than the flock size in the rest two districts. The variation in flock size in different districts might be attributed to the difference in the availability of scavengeable feed resources, chicken management and flock off take rate (Fisseha *et al.*, 2010).

Table1. *Flock dynamics and composition of chickens reared in the study districts (Mean±SD)*

Number of chickens	South Bench (N = 90)	Sheko (N=90)	North Bench (N = 90)	Overall mean (N = 270)
Hen	3.9±1.6^{a}	3.8±1.4^{a}	3.3±1.2^{b}	3.6±1.4
Cock	1.1±0.8	1.3±0.9	1.2±1.0	1.2±0.9
Pullet	2.1±1.5^{a}	1.4±1.3^{b}	2.0±1.5^{a}	1.8±1.4
Cockerel	1.2±1.3^{a}	0.8±1.0^{b}	1.1±1.4^{ab}	1.0±1.3
Chicks	3.1±3.4^{a}	1.8±2.7^{b}	2.7±2.9^{ab}	2.5±3.0
Overall	11.5±5.1^{a}	9.2±3.5^{b}	10.4±4^{a}	10.4±4.3
Hen to cock ratio	3.0±1.7	2.8±1.5	2.7±1.2	2.9±1.5

^{ab} *Row means with different subscript letters are significantly different at p<0.05, N = number of respondents, SD = standard deviation*

In agreement with Moreda *et al.* (2013), the flock composition indicated that hens were the most abundant followed by young chicks along with small number of cocks and cockerels (Table 1). The result was somewhat different from the national flock composition, which is dominated by chicks followed by hens (CSA, 2014). This might be due to low culling rate of aged hens and high occurrence of disease and predators in the area as chicks are more susceptible than the other age groups. In addition to this, large proportion of hens in the flock might justify the need of households to increase egg production by increasing the number of hens in the flock (Moreda *et al.*, 2013). The average cock to hen ratio (Table 1) was similar with the reports of Deneke *et al*. (2014) who reported cock to hen ratio of 1:2.9 in southeastern Oromia region of Ethiopia. However, it was higher than the value reported in southern Ethiopia (Nebiyu *et al*., 2013).

3.2. Performance of Indigenous Chickens

The performance characteristics of indigenous chickens in the studied districts are presented in Table 2. Consistent with the current result, Melesse *et al*. (2013) and Nebiyu *et al*. (2013) also reported the age of pullets at firs egg laying 6.6 and 6.5 months, respectively. On the other hand, Melkamu and Andargie (2013) reported a longer pullet age (7 months) at first egg and a shorter age of cockerels at first mating (4.7 months).

The average number of eggs per clutch (14.8), number of clutches per year (3.7) and the mean annual egg production of indigenous chicken (54.6) in the current study was comparable with those reported by Fisseha et al. (2010). However, these values were slightly higher than those reported by Alem (2014) in Tigray region. These differences might be due to the breed type used in various locations as well as type and frequency of feed provided to the chickens.

Table2. *Performance characteristics of indigenous chicken populations reared in three districts of Bench Maji zone (Mean±SD)*

Performance parameters	South Bench (N=90)	Sheko (N=90)	North Bench (N=90)	Overall mean
Age of cockerels (months)	5.91±0.9^{a}	6.15±0.9^{a}	5.64±0.9^{b}	5.92±0.9
Age of pullets (months)	6.62±1.1^{a}	6.65±1.1^{a}	6.04±1.0^{b}	6.45±1.1
Number of eggs/clutch	15.7±3.9^{a}	14.9±3.5^{ab}	13.9±2.7^{b}	14.8±3.5
Number of clutches/year	3.60±0.7	3.91±2.2	3.53±0.5	3.74±1.3
Number of eggs per year	56.4±2.3^{ab}	58.5±2.0^{a}	48.8±12^{b}	54.6±13
Number of eggs incubated	11.8±2.6	11.3±2.2	11.7±2.1	11.8±2.6
Hatchability (%)	81.3±10	82.1±8.3	83.0±8.4	82.2±8.9
Survival rate (%)	47.8±13^{ab}	51.2±11^{a}	46.8±19^{b}	48.8±13
Brooding length (months)	2.81±0.8	3.02±1.3	2.84±0.7	2.90±1.0

^{ab} *Row means with different subscript letters are significantly different at p<0.05; SD = standard deviation; N = number of respondents*

Average number of eggs incubated and hatchability percentage in the current study (Table 2) were in good agreement with those findings reported by Melesse *et al*. (2013) and Nebiyu *et al*. (2013). In contrary, very low hatchability value (22%) was reported in Gomma Woreda, southwestern Ethiopia (Meseret, 2010). On the other hand, Matiwos *et al*. (2015) reported higher hatchability (98.6%) than current result. These variations might be associated with in culling practices, nutritional management and incubation management in different locations. The mean survival rate of chicks to marketable age (48.8%) in the current study was higher than the value reported by Meseret (2010) but lower than that reported by Melese and Melkamu (2014) in other parts of Ethiopia. Low survival rate of chicken in the current study suggests high chick mortality due to disease and predation.

As indicated in Table 2, significant variations were also observed in some performance traits of indigenous chickens among the studied districts which might be attributed to the differences in management systems, availability of adequate feed resources in terms of quantity and quality, variations in disease prevalence and veterinary services (Melesse, 2014). Moreover, factors related to the genetic dissimilarities of chicken ecotypes reared at different locations might be responsible for the observed differences. It is thus worthwhile to note that the existence of such genetic variations in key performance traits will give better opportunities to breeders to improve the genetic potentials of indigenous chickens through selection and systemic breeding.

3.3. Egg Quality Parameters

3.3.1. External egg qualities

The external and internal egg quality parameters of the indigenous chicken populations are presented in Table 3. The mean egg weight in the current study (43.9 g) was in good agreement with the findings of Melesse et al. (2010) and Meseret (2010). Getachew et al. (2016) also reported comparable egg weight value of 41.1 g for indigenous chicken western Shewa zone of Oromia region, Ethiopia. On the contrary, Halima (2007) reported lower egg weight values (34.1 g to 41.7 g) for different chicken ecotypes in northwestern part of the country. This could be attributed the type of chiekcn ecotype, feed availability and the agro-ecological location of the study sites. Consistent with the reports of Melesse et al. (2013), the egg width and egg length in the current study were 52.1 mm 37.8 mm and with 72.7% shape index.

The shell thickness in the present study was comparable with that of Desalew *et al*. (2015), who reported 0.31 average shell thicknesses in East Shewa, Ethiopia. On the other hand, Fisseha et al. (2010) reported lower value of shell thickness (0.26 mm) in northwestern Ethiopia whereas Melesse *et al*. (2010) observed a relatively higher shell thickness value (0.37 mm) in Ethiopian Naked neck chickens reared under improved production system. These variations in shell thickness among the indigenous chicken ecotypes reared in various parts of the country might be due to the availability of mineral calcium in the feed material, type of management (intensive vs. scavenging), and type of chicken breed. According to King'ori (2012), shell thickness is influenced by calcium availability in layer nutrition and ability of the hen to absorb calcium by the shell gland. Higher value of shell thickness in the present study might be due to better calcium content of the available scavenging feed resources in the study area like taro, which has been reported to be rich in calcium containing about 11% (USDA, 2016). Hence, it would be worthwhile to do further feed analysis of the scavenging feed resources in the study area.

3.3.2. Internal Egg Qualities

As shown in Table 3, the mean albumen height and Haugh unit (HU) was lower than the average albumen height reported by Melesse *et al*. (2010; 2013); but was higher than observed by Halima (2007) and Meseret (2010). Melesse *et al*. (2010) and Getachew *et al*. (2016) reported relatively higher HU value in different parts of Ethiopia. The low albumin height and the resulting HU in the current study might be due to the age of hen and duration of the egg storage after being collected. The investigated yolk height in the current study was in agreement with Halima (2007). However, Melesse *et al*. (2010) reported higher (16.9 mm) yolk height in eggs of naked neck indigenous chicken. In contrary, Meseret (2010) reported 11 mm yolk height for fresh eggs and 9.1 for market purchased eggs, which are lower than the current result. These differences might be attributed to the duration and storage temperature as well as the age of the hens. The genetic potentials of individual chicken ecotypes may also contribute to the observed variations. The mean yolk color in the current study was comparable with the findings of Melesse *et al*. (2010), Meseret (2010) and Getachew *et al*. (2016). However, it was much higher than that of Halima, (2007) who reported a yolk color ranging from 3.0 to 4.0 for different indigenous birds in northwestern Ethiopia. High value of yolk color in the current study and in another place in the country might be attributed to the quality and availability of greenish scavengeable feeds in the free-range production system**.** It is generally assumed that since indigenous chickens get their feed merely by scavenging heir eggs contain appreciable amounts of xanthophylls, which is responsible for deep yellow color of the yolk. It would also worthwhile to note that some of the works with low yolk color might have been conducted under intensive management system.

Table3. *External and internal egg quality parameters of eggs collected from indigenous chickens reared in three districts of Bench Maji zone (Mean±SD)*

Egg quality parameters	South Bench district	Sheko district	North Benchdistrict	Overall mean
External egg qualities				
Egg weight (g)	44.0±3.8	44.3±5.3	43.4±4.7	43.9±4.7
Egg length (mm)	51.7±3.8^{b}	53.6±3.6^{a}	50.9±3.6^{b}	52.1±3.8
Egg width (mm)	36.9±3.2^{b}	39.3±3.0^{a}	37.2±2.2^{b}	37.8±2.9
Egg shape index (%)	71.5±4.9^{b}	73.3±4.1^{a}	73.3±3.4^{a}	72.7±4.3
Shell thickness (mm)	0.34±0.03^{a}	0.31±0.04^{c}	0.33±0.03^{b}	0.33±0.03

Internal egg qualities				
Albumen weight (g)	23.1±2.8	23.1±3.4	23.0±3.3	23.1±3.2
Yolk weight(g)	15.1±1.7^{ab}	15.3±2^{a}	14.8±1.8^{b}	15.1±1.8
Albumen height (mm)	3.3±0.7^{b}	3.4±0.8^{b}	3.6±0.7^{a}	3.4±0.7
Haugh unit	59.5±6.8^{b}	60.7±7.2^{b}	63.4±6.8^{a}	61.2±7.1
Yolk height (mm)	14.1±1.7	14.1±1.7	13.9±1.7	14.0±1.7
Yolk color	11.2±1.8^{a}	11.1±1.6^{a}	10.3±1.8^{b}	10.9±1.7

^{ab} *Row means with different subscript letters are significantly different at p<0.05; SD = standard deviations*

There were significant variations in most egg quality parameters among the three districts (Table 3). Eggs from Sheko district were significantly higher in egg length, egg width and yolk height than those of the two districts. Eggs from South Bench were higher in shell thickness while low in shape index. Eggs from North Bench were better in albumen height and HU but lower in yolk weight and yolk color. These differences might arise from variations in nutrient composition of the available feed resources, culling practice, egg handling, and storage techniques.

3.4. Carcass Components

The carcass yields of indigenous chickens reared in the studied districts are presented in Table 4. The live weight of matured male chicken in the current study was in good agreement with the body weight reported by Melesse and Negesse (2011) in southern Ethiopia. Raphulu et al. (2015) reported 1531 g body weight for mature Venda scavenging chickens in South Africa, which is slightly higher than in the present study. Halima (2007) reported slaughter weights ranging from 1045 g to 1292 g for different indigenous male chicken ecotypes in northwestern Amhara of Ethiopia, which is lower than in the current result. The existence of differences in matured body weight of indigenous scavenging chickens might be attributed to variations in genetic makeup, management system, and season of the year. The carcass yield value in the current study is in line with the findings of Melesse et al. (2013).

Table4. *Live and carcass weights (g) along with proportions of carcass yield (%) of indigenous chickens reared in three districts of Bench Maji zone (Mean±SD)*

Carcass components	South Bench	Sheko	North Bench	Overall mean
Live weight	1358±108^{b}	1545±133^{a}	1445±137^{b}	1449±146
Carcass weight	897±76.5^{b}	1056±103^{a}	947±78^{b}	966±108
Dressing percentage	66.1±1.9^{b}	68.3±2.5^{a}	65.6±2.8^{b}	66.7±2.7
Breast	24.9±1.6^{b}	26.1±1.3^{a}	25.1±1^{b}	25.4±1.4
Thigh	19.4±1.2	19.2±0.8	19.8±1	19.5±1
Drumstick	15.4±0.4	15.6±0.8	15.1±0.7	15.4±0.7
Back	11.9±0.4	11.9±0.7	11.7±0.8	11.8±0.6
Wings	10.3±0.7	10.0±0.6	10.2±0.7	10.2±0.7
Neck	5.4±0.4^{a}	4.9±0.3^{b}	5.4±0.4^{a}	5.2±0.4
Skin	7.3±0.7	7.2±0.8	7.5±0.6	7.3±0.7
Gizzard	2.4±0.3	2.2±0.3	2.3±0.3	2.3±0.3
Liver	2.3±0.2^{a}	2±0.2^{b}	2.1±0.3^{ab}	2.1±0.3
Heart	0.6±0.1	0.7±0.1	0.7±0.1	0.7±0.1

^{ab} *Row means with different subscript letters are significantly different at p<0.05*

As shown in Table 4, the dressing percentage of 66.7 was observed in the current study, which is consistent with the finding of Halima (2007), who reported 64 %, 65.3% and 66.8% for Melo Hamusit, Mecha and Gelila indigenous chicken ecotypes, respectively. Tadelle and Ogle (2000) also reported 65.5% of dressing in hens reared in central highlands of Ethiopia which are in good agreement with the current findings. The dressing percentage of indigenous chicken reported by various scholars was somehow comparable with that of exotic chicken breeds reared under the hot tropical climate. For instance, Tera et al. (2009) reported 67% dressing percentage values for Rhode Island Red chickens reared under intensive management system. Melesse et al. (2013) reported dressing percentage of Koekoek chickens ranging from 59-63.3%, which is slightly lower than the findings observed in the present study. On the other hand, Kefyalew et al. (2015) reported a relatively higher dressing percentage of 71.1% for commercial broilers. Such differences might be attributed to

the breed, production environment and the age of the birds when they were slaughtered as well as the carcass parts included or excluded during the calculation of the dressing percentage values.

The weight of carcass yield in the current study is in line with the findings of Melesse et al. (2013). The proportions of breast, thigh and drumstick are the most valuable meat parts that determine the chicken meat quality (Holcman et al., 2003). The proportion of such valuable meat parts in the current study were in good agreement with the reports of (Melesse et al., 2013) but higher than those of Magala et al. (2012). In most carcass traits, chickens reared in Sheko district had significantly higher weights of carcass components than chickens kept in the other two districts. This might due to dissimilarities of chicken ecotypes in the study area that reveal the possibility to improve meat production by selection.

4. CONCLUSION

Under the existing management system, indigenous chickens exhibited relatively better quality in most egg quality traits except for Haugh unit score that was comparatively lower than expected. The carcass traits of indigenous chickens were generally good with relatively high dressing percentage along with better proportions of valuable carcass components under the existing traditional production system. The indigenous chickens also showed significant variations among the studied districts in their performance, egg quality, and carcass traits that indicate the genetic variation among indigenous chickens in the study area that have to be exploited through improved management and breeding strategies. We recommend testing the general performance potentials of the studied indigenous chickens under improved management system to be able to formulate proper intervention strategies for better utilization of these resources.

ACKNOWLEDGEMENTS

The authors express their appreciation to the Bench Maji Zone Agricultural Office in general and that of the Animal and Fishery Resource Office in particular for their unreserved technical support provided during the course of this study. Federal Ministry of Agriculture is highly acknowledged for sponsoring the study leave of the first author and providing the required research fund. We also extend our appreciation to College of Agriculture and Veterinary Medicine, Jimma University, for allowing us to carry out the egg quality evaluation using their laboratory. We are further grateful to all households participated in this study during the interview process.

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Citation: *Welelaw Edmew. et.al, (2018). "Assessing the Performance, Egg Quality, and Carcass Characteristics of Indigenous Chickens Reared Under Traditional Management System" International Journal of Research Studies in Agricultural Sciences (IJRSAS), 4(10), pp.27-35, http://dx.doi.org/10.20431/2454-6224.04010004*