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Comparing Egg Quality Traits of Crossbred Local Horro Ecotype with Dominant Red Bared D 922 Exotic Chickens: a Step towards Synthetic Breed Development in Ethiopia

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Abstract: This study was designed to evaluate the egg quality traits among local Horro ecotypes (H) and Dominant Red Barred D 922 (DRB) chicken and their direct (DRB× H) and reciprocal (H×DRB) crossbred chicken with the aim of developing synthetic breed for village production system in Ethiopia. A total of 2440 day-old chicks from all genotypes were obtained. The chickens of each pure line and crossbred were divided into three groups as replicates under a completely randomized design and reared in brooding house. After 18 weeks of age, the chickens were transfer to breeding house in deep litter system up to 45 weeks of age. After the start of three month of egg laying, 35 eggs from each genotypes were randomly selected to determine internal and external egg quality traits. The results showed that all egg quality traits are significantly different among the genotypes. Highest egg weight ($P<0.001$) was reported in DRB, DRB×H and H×DRB chicken in comparable weight, however, the least egg weight were reported in Horro ecotype. Egg length width, egg shape index and yolk width were reported highest in DRB genotypes followed by the crossbred chickens and then finally for Horro ecotype. While, highest values for Haugh unit, albumen and yolk height were reported for crossbred chickens followed by DRB and least value for Horro ecotype. However, high quality shell based on thickness was found in Horro and crossbred chicken of H×DRB followed by DRB and DRB×H. Hence, most of internal and external egg quality traits are found to be improved in crossbred chicken than the local Horro ecotypes. There is significant correlation of external egg quality with internal qualities traits. Egg weight was positively ($P<0.01$) related with egg length, egg width, albumen height, yolk height ($P<0.05$), yolk width ($P<0.01$), shell weight ($P<0.01$) and Haugh unit ($P<0.01$). Accordingly, egg shape index was positively ($P<0.01$) correlated with egg width but negatively ($P<0.05$) correlated with egg length and egg weight, shell weight ($P<0.01$). While, egg length ($P<0.01$) and width ($P<0.05$) were positively related with albumen height, Haugh unit ($P<0.05$), yolk width ($P<0.01$) and shell weight ($P<0.01$). Shell thickness was negatively ($P<0.01$) correlated with albumen height and HU ($P<0.01$) but positively ($P<0.01$) correlated to yolk height, width ($P<0.05$) and index. In addition, external egg quality traits of shell weight was positively ($P<0.01$) related to albumen height, Haugh unit but negatively correlated with egg shape index ($P<0.01$). This means that chicken selected for higher external egg quality traits can improve the internal egg quality traits as well.

Key words: Egg Weight · Shell Thickness · Shape Index · Haugh Unit · Yolk · Albumen

INTRODUCTION

The rural poultry system is dominated by indigenous chickens and has made significant contributions to poverty alleviation and household food security in many developing countries [1]. Hence, the local gene pool still provides the basis for poultry sector in many developing countries. The total poultry population in Ethiopia is

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estimated to be about 60 million and with regard to breed, 88.5 percent, 6.25 percent and 5.25 percent of the total poultry were reported to be indigenous, hybrid and exotic, respectively [2]. In Ethiopia village poultry systems with indigenous breeds contributes to more than 90 % of the national chicken meat and egg production [3]. However, egg production levels of the local ecotypes are lower than the exotic as well as crossbred chickens [4-7].

Native rural breeds are valuable genetic resources due to their adaptability to harsh conditions and their resistance against local diseases. In addition, many investigators indicate that Ethiopian chicken ecotypes were rated to have superior merits with regard to traits such as high rate of fertility [4], hard egg shell [8], good test of egg [9]. While, exotic chickens well known for their high egg production with large egg size compared to the local ecotypes [10, 11]. Hence, those genetic resources of local chickens should be considered in developing new breed for village production system in the country. In addition, crossing between the adapted local chicken and exotic standard breeds would allow exploiting the rusticity of first and the productive performances of the later at a time in tropical environment to produce adapted and more productive genetic types [12].

To this end to improve production level of indigenous chicken in Ethiopia, pure breeding program has been taken as one of the options to improve body weight and egg production through mass selection with in the ecotypes. The first ecotypes that selected for this program is Horro ecotype [5]. Comparative analysis undertaken by Wondmeneh [6] indicated that Horro ecotype at 45 weeks of mass selection for egg number through generation interval has been shown successful performance. However, even the local ecotypes show positive response in selection program, the ecotypes still show lower performed than to their crossbreds as well as the pure exotic chickens in comparative analysis. This result confirms the previous reports of the positive impact of cross breeding program on improving the performance of local chicken [4 , 10, 11, 13, 14]. However, egg quality performance of local ecotype compared to the exotic as well as their crossbred chicken is limited to be reported even though quality of an egg ascertains the success of a poultry business because it is associated with the acceptability among the consumers. Based on consumer's choice, the eggs are categorized in respect of shell color, albumen quality and yolk characteristics. Crossbreeding is one of alternative mechanism in improving chicken egg quality traits. Different reports indicate that crossbred chicken performs better in egg quality traits than their respective pure line [10, 11].

Therefore, the objective of the present study is to evaluate egg quality traits of Horro ecotype, Dominant Red Barred D 922 chicken and their direct and reciprocal crossbred chicken in the aim of developing suitable synthetic breed for village production system in Ethiopia.

MATERIALS AND METHODS

The study was undertaken at Debre Zeit Agricultural Research Center (DZARC) which is located 45 km south east of Addis Ababa, at an altitude of 1900 meters above sea level and at 8.44ºN latitude and 39.02ºE longitude. The area has a bimodal rainfall pattern with a long rainy season from June to October and a short rainy season from March to May. The average annual rainfall and average maximum and minimum temperature for the area are 1100 mm and 28.3°C and 8.9°C, respectively [16].

Breeding Plan: The present work was done based on the previous pure breed selection scheme initiated in 2008 to improve growth and egg production of Horro ecotypes. Exotic breed of Dominant Red Barred D 922 (DRB) chickens were imported from Check Republic by DZARC. Hence, the project was started with the crossing of already imported DRB with the improved local Horro (H) ecotype obtained from the ninth generation of selection in direct and reciprocal crosses. The crossbreeding study was started by randomly picking 180 hens and 36 cocks as a foundation from each of the two strains. Each strain was randomly divided into two groups of 90 hens each to be mated with their own or the other strain. The two groups were pure line (H?×H? and DRB? × DRB?), while the other two groups were local crossed with exotic birds in direct and reciprocal crosses (H ? × DRB? and DRB? × H?) to produce the first filial (F_1) generation. The four genotype groups were managed in different pens.

Eggs from the four genetic groups were collected on a daily basis and marked and stored for 10 days to be incubated to get uniform age groups. A total of 2440 unsexed day-old chicks were obtained from all genetic groups. Chicks from each genotype were randomly distributed between pens using completely randomized design with three replications. The day-old chicks were penned in a brooding house and reared for 8 weeks. At week 8, sexing and separation of the males from the females was performed phenotypically via external characteristics (comb size and tail, feather shape) and kept in the ratio of 1 male to 5 females in each pen. The chickens were reared in growing house to 18 weeks of age and then both male and female were transferred to breeding pen.

Table 1: Number of sires and dams used for the analysis of growth traits of chickens

Genotypes*	Sires	Dams	Number of progenies
H×H	18	90	700
DRB×DRB	18	90	420
H×DRB	18	90	630
DRB×H	18	90	690
	72	360	2440

*Sires are listed first in the crosses

Management of the Experimental Chicken: All chickens were managed by one person to minimize environmental variation. The birds were provided with water ad libtum and standard feed were provided as per the requirement at each specific growth stage (age). Starting chicks were fed on ration of 20% CP and 2, 950 kcal/kg for up to 8 weeks and the growers ration were 18% CP and 2, 850 kcal/kg and provided from 8-18 weeks. The chickens were provided with natural lighting after 8 weeks of age. From 18 weeks on ward the birds were reared in deep litter house and provided with layer's ration (17–18% CP and 2, 750 kcal/kg). All chickens were inspected daily for their health status and vaccinations were provided against Newcastle and Marek's diseases at one day old, Gumboro at 1 week and fowl pox at 10 weeks of age.

Data Collected for Egg Quality Traits: Egg was weighed per pen every day immediately after collection. Then average egg weight per hen was calculated to obtain monthly average egg weight. Egg quality was evaluated against internal and external quality traits. It was determined three month after the start of egg laying period. Randomly 30 fresh eggs were randomly selected from each genotype. Eggs were weighed to the nearest of 0.01 g using a digital weighing balance (Model: DT 5k, LARK®). Length (mm) and width (mm) of each egg were measured at midpoint using a digital caliper and egg shape index was calculated using the definition of Panda [16].

$$Egg\ shape\ index = \frac{Width\ of\ egg}{Length\ of\ egg} X100$$

The eggs were broken one by one on a flat glass plate then albumen and yolk height were measured using tripod micrometer. Measurements of albumen heights were taken from at the highest and lowest points of the albumen. The average of two measurements was taken and average values were calculated. Yolk diameter was measured using digital caliper meter. Yolk color was measured using Roche scale. The yolks were separated from the albumen and individual weights were recorded. Yolk index was calculated using yolk height and diameter values according to the formula described by Panda [16]. Haugh unit (albumen height corrected for egg weight) was calculated for individual egg according to Haugh [17] by the formula:

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

where: HU= Haugh unit, AH= albumen height in mm and EW= egg weight in grams.

The shells of the broken eggs were washed under gently flowing tap water to release albumen residues and were then air-dried and weighed. Shell thickness was determined from each treatment group without the shell membranes. The measurement was carried out with a digital caliper with a sensitivity of 0.001 mm by taking three samples at three points of the egg shell such as narrow, the middle and the broad-end side. The shell thickness (mm) was calculated as an average of the thicknesses of the three pieces.

Correlations were analyzed for the following variables: egg weight, length, width, egg shape index, shell thickness, shell weight, yolk height and width, yolk index, albumin height and width, using Bivariate two tailed correlation.

Statistical Analysis: Data were analyzed using General Linear Model procedure of SPSS version 21 [19]. All means were tested using an Independent Sample T-test to separate the means with statistical difference at level of $P \leq 0.05$.

$$Y_{ij} = m + t_i + e_{ij}$$

where:
Y_{ijk} = The observed dependent variable
m = Overall mean;
t_i = fixed effect of the i^{th} genotype (i=1-4);
e_{ijk} = The random residual error

RESULTS

Egg quality traits of chicken among the genotypes are presented in Table 2. Significant different among the genotype for all egg quality traits were found, except for yolk color. In comparing the pure genotypes, significantly higher (P<0.001) egg weight, egg length, egg width, egg shape index (P<0.01), HU, AH and YW (P<0.01) were found for pure line DRB chicken than Horro ecotype,

Table 2: Means + SE for egg quality traits for chicken genotypes

Egg quality traits	Horro	DRB	DRB^K×Horro	Horro×DRB	P-value
Egg weigh	47.81±0.75^b	55.28±1.98^a	54.05±1.16^a	53.46±0.64^a	0.000
Egg Length (mm)	52.42±0.66^c	56.97±1.03^a	55.07±0.53^b	54.56±0.35^b	0.000
Egg width (mm)	39.18±0.55^c	44.54± 0.76^a	42.53±0.37^b	41.45±0.27^b	0.000
Egg shape index	74.82±0.79^c	78.36±1.08^a	77.28±0.54^b	76.03±0.37^b	0.004
Yolk color	4.06±.13	4.95±0.16	4.20±0.16	4.21±0.09	0.458
HU	88.49±0.43^c	91.79±0.64^b	95.93±1.31^a	93.94±0.52^a	0.000
AH (mm)	5.19±0.09^c	6.08±0.14^b	6.91±0.29^a	6.46±0.10^a	0.001
YH (mm)	17.73±0.33^b	16.29±0.44^c	20.13±0.68^a	19.52±0.47^a	0.000
YW (mm)	40.42±0.63^b	43.46±0.87^a	42.49±0.54^a	42.29±0.41^a	0.008
YI	0.44±0.01^c	0.38±0.01^d	0.46±0.01^b	0.47±0.10^a	0.000
Shellthickness (mm)	0.36±0.01^a	0.34±0.01^b	0.20±0.02^c	0.36±0.02^a	0.000

DRB=Dominant Red Barred D 922; ^{k}= sires are presented first in crosses; $^{a, b, c, d}$ Means with different letters within a row and within breed indicate statistically significant differences at (P<0.05); (P<0.01); (P<0.001); SE=standard error of the means; HU Haugh unit; AH=albumen height; YH=yolk height; YW=yolk width; YI=yolk index;

Table 3: Correlations between external and internal egg quality traits

	EW	EL	EWd	ESI	AH	YH	YW	YI	SW	ST	HU
EW	1										
EL	0.718**	1									
EWd	0.564**	0.756**	1								
ESI	-0.106	-0.19*	0.498**	1							
AH	0.478**	0.305**	0.271**	.006	1						
YH	0.212*	0.112	0.104	0.018	0.148	1					
YW	0.367**	0.414**	0.374**	0.002	0.019	0.327**	1				
YI	0.072	-0.053	-0.041	0.023	0.139	0.913**	-.074	1			
SW	0.648**	0.430**	0.209*	-0.259**	0.379**	0.045	0.103	0.000	1		
ST	-0.026	-0.021	-0.028	-0.007	-0.245**	0.474**	0.176*	0.428**	0.027	1	
HU	0.306**	0.182*	0.176*	0.028	0.980**	0.115	-0.071	0.141	0.274**	-0.261**	1

**, .* Correlation is significant at the 0.01 level and at 0.05 level (2-tailed), respectively; EW=egg weight (g); EL= egg length(mm); EWd= egg width (mm); ESI = egg shell index; AH= albumen height(mm); YH=yolk height (mm); YWd = yolk width; YI= yolk index; SW= Shell Weight (g); ST= Shell Thickness; HU= Haugh Unit

whereas, significantly higher (P<0.001) YH, YI and shell thickness were reported for Horro ecotype than DRB genotype.

Likewise in comparing the crossbred chickens, DRB×H and H×DRB genotype showed comparable results in egg weight, egg length, egg width, egg shape index, HU, AH, YH and YW. Whereas, higher (P<0.001) YI and shell thickness were found in H×DRB genotype.

In comparing the whole genotype, significantly highest (P<0.001) egg weight, egg length, egg width, egg shape index (P<0.01) were found for pure line DRB chicken followed by crossbred chickens (DRB×Horro and Horro×DRB) and Horro ecotype. Likewise, significantly highest (P<0.001) HU, YH and AH were reported for both crossbred chicken DRB×Horro and Horro×DRB genotype, while highest strength in shell thickness were reported for Horro ecotype and Horro×DRB genotypes. However, egg weight and YW were found comparable result among the crossbreds of DRB×Horro, Horro×DRB and pure line DRB, but the least performance for these traits was reported for Horro ecotypes. While, highest YI was found for Horro×DRB genotype.

Correlation between internal and external egg quality traits are presented in Table 3. Egg weight was positively (P<0.01) correlated with egg length and width. Egg shape index was positively (P<0.01) correlated with egg width and negatively (P<0.05) correlated with egg length. Albumen height was positively related with egg weight (P<0.01), egg length (P<0.01) and egg width (P<0.05). Yolk height was positively (P<0.05) correlated to egg weight. Yolk width was positively (P<0.01) related to egg weight, egg length, egg width and yolk height. Yolk index was positively related to yolk height (P<0.01) but negatively related to yolk width (P<0.05). Shell weight was positively (P<0.01) related to egg weight, length and width (P<0.05) and albumen height but negatively correlated with egg shape index (P<0.01). Shell thickness negatively (P<0.01) correlated with albumen height but positively (P<0.01) correlated to yolk height, width (P<0.05) and index. Haugh unit was positively (P<0.01) related to egg weight, length (P<0.05), width (P<0.05), albumen height and shell weight but negatively (P<0.01) correlated with shell thickness.

DISCUSSION

Genotype had significant effect on egg quality traits, except for yolk color, which were agreed with many authors [10-20]. Non-significant difference in egg yolk color among the genotypes was similar with findings of Markos *et al*. [20] but disagreed with the result of Alewi *et al.* [10]. In the current report highest egg weight was reported in DRB (55.28g), DRB×H (54.05g) and H×DRB (53.46g) followed by Horro ecotype (47.81g). The higher egg weight for these chickens could relate to their higher body weight than the local Horro ecotype. Similar to the current report, Alewi *et al.* [10] found the higher egg weight of RIR-crosses and Fayoumi-crosses than local chickens. Hence, the current report indicates that egg weight of local Horro ecotypes could be improved through crossbreeding.

Local Horro ecotype reported in the current study had higher egg weight than the weight obtained by Alewi *et al.* [10], Sonaiya and Swan [21] and Mube *et al*. [22] for Ethiopian Local Kei chicken (38.30g) and Bangladesh local chicken (35-39g), Cameroon local barred chicken (46.8 g), respectively, but lower than Bhutanese indigenous chicken (50.63g) managed on station [23].

Likewise, egg weight in the current report for DRB was lower than RIR chicken (58g) and higher than Fayoumi chicken (42.5g) as reported by Bekele *et al*. [11]. Average egg weight for crossbred chicken reported in the present study is higher than the crossbred chicken reported by Alewi *et al.* [10] for Fayoumi (40g) and Rode Island Red (RIR) crosses (44.2g) with Local Kei chicken, Ajayi, [24] for crosses between White Leghorn and Nigerian Indigenous chickens (41 g) and Bekele *et al*. [11] for Fayoumi crossed with Necked Neck (43.7g) and RIR crossed local white (45.7g).

Egg width and length are the main factor for external egg quality traits based on the egg shape index. 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 [10] because the shapes that are abnormal do not fit in prepackaging and hence eggs with higher shape index are more rounds in shape [24].

Significant different in egg width, length and egg shape index obtained among the genotype in the present result are agreed with the report of Alewi *et al.* [10] and Sinha *et al.* [19]. However, Bekele *et al*. [11] found significant different for egg length and width but non-significance different for egg shape index among the genotype. In comparing the pure genotypes, significantly higher (P<0.001) egg length, egg width and egg shape index (P<0.01) were found for pure line DRB chicken than Horro ecotype, likewise in comparing the crossbred chickens, comparable performance were found between the crossbred chickens in these traits. Egg shape index reported in the present report for Horro ecotype (74.82) was higher than Ethiopian Local Kei, 72.8 [10]; Butaness chicken, 71.54 [23]. Likewise, egg shape index in the current study reported for pure DRB genotype (78.36) was comparable with the report of Bekele *et al*. [11] for Fayoumi chicken (76.9). Similarly, egg shape index reported in crossbred chicken of DRB×Horro (77.28) and Horro×DRB (76.23) are consistent with findings of Sinha *et al*. [19] who obtained 77.27 for crossbred chickens of VR (Vanaraja) x G (Gramapriya). However, lower egg shape index was reported by Bekele *et al*. [11] for crossbred chicken of Fayoumi×Necked Neck (75.3) and RIR× local white feather chicken (75.6) than the current findings. Accordingly, Alewi *et al*. [10] obtained egg shape index for crossbred chicken of RIR×local Kei (76.0) was comparable with the current report for crossbred chicken of HxDRB (76.23).

In comparing the whole genotype, significantly highest (P<0.001) egg length, egg width and egg shape index (P<0.01), were obtained in pure line DRB chicken followed by DRB×H and H× DRB then Horro ecotype. The higher egg shape index of the crosses than the local Horro ecotypes in the current report is similar to the findings of Alewi *et al.* [10] who indicates that higher egg shape index was found in crossbred chicken of Fayouni×Local Kei followed by RIR cross then Local Kei.

Genotype has significant effect on egg quality traits of HU and AH. Significantly highest (P<0.001) HU and AH were reported for both crossbred chicken (DRB×Horro and Horro×DRB) genotypes followed by pure line DRB and then for Horro ecotype. In contrary to the current report of lowest performance of local Horro ecotypes in HU compare to the crossbreds, however, Alewi *et al*. [10] found comparable result of local Kei with Fayoumi-crosses chickens but significantly (p<0.05) higher Haugh Unit (HU) values than RIR-crosses.

Haugh unit reported in the current report for Horro ecotype (88.49) was higher than the report of Alewi *et al*. [10], Dorji [23] and Mube *et al*. [22] in Ethiopian local Kei (83.3), Butaness local (72.67) and Cameroon local barred chicken (78), respectively. Hence, local Horro ecotype with the higher HU has preferable internal egg quality compared to these local chickens. Accordingly, the Haugh unit value found for crossbred chickens (DRB×Horro, 95.93 and Horro×DRB, 93.94) in the current report is higher than the report of Alewi *et al*. [10] in crossbred chicken of Fayoumi×local Kei (90.3) and RIR×local Kei (76.5). Similarly, Bekele *et al*. [11] found lower Haugh unit than the current findings in crossbred chicken of Fayoumi× Ethiopian Necked Neck (73.5) and RIR×local whit (81.1). Accordingly, Haugh unit value found by Sinha *et al*. [19] was lower than the present result in crossbred chicken. Likewise, Haugh unit value for exotic DRB chicken reported here is higher than the Fayoumi (78.1) but lower than the RIR (96.8) chickens reported by Bekele *et al*. [11]. Hence, highest Haugh unit in the crossbred chicken than their respective pure line indicates the presence of performance improvement through crossbreeding in this trait.

As cited in Mube *et al.* [22], Ihekoronye and Ngoddy [25] described that high quality egg generally have Haugh unit of 70 and above. Hence, all chicken genotype reported in the present studied are categorized in to high quality egg but superior egg quality was crossbred chicken of DRB×Horro and Horro×DRB.

Genotype had significant effect on yolk index. Similarly, Sarica *et al*. [27], Alewi *et al*. [10] and Sinha *et al*. [19] who found the existence of breed difference for yolk index. Highest (P<0.001) yolk index was found in crossbred chicken of Horro×DRB followed by DRB×Horro and Horro in comparable value and then lowest for DRB genotype. Yolk index obtained in Horro×DRB (0.47) was higher than the value reported in Sinha *et al*. [19] but comparable with value report in Alewi *et al*. [10] for crossbred chickens. Yolk index found in local Horro ecotype (0.44) in the present result was lower than Ethiopian local Kei chicken [10] and comparable with Ethiopian Nacked Neck chicken Melesse *et al*. [8] and higher than Butaness chicken [23].

Genotype differences in egg shell thickness was found and significantly (p<0.001) higher thickness was obtained in Horro and Horro×DRB genotypes followed by DRB and DRB×Horro. Accordingly, Melesse *et al*. [8], Bekele *et al*. [11] and Sinha *et al*. [20] found significant genotype differences for egg shell thickness. However, Alewi *et al*. [10] found non-significant difference for shell thickness among the genotypes. Similarly, Melesse *et al*. [8] found significantly higher shell thickness in Ethiopian naked neck than commercial chicken breeds. In the current report, the egg thickness of Horro and Horro×DRB had comparable thickness value with local Necked Neck [8], crossbred of pure line chicken of VR×VR [19] but higher than Local Kei [10], local Butaness chicken [23] and local Cameroon barred chicken [22]. This is an indicator of external egg quality, which helps to reduce the percentage of cracked eggs [10 & 22]. Hence, Horro ecotype and crossbred chicken of Horro×DRB preferable chicken in this trait since this is an important quality in village production system.

In the present result albumen height was reported higher in crossbred chicken followed by DRB and Horro ecotypes. In contrast to the present result, in other comparative analysis higher albumen height was reported in Ethiopian local Kei chicken than crossbred chicken of Fayoumi-crosses as well as RIR-crosses [10]. Albumen height found in this study for local Horro ecotypes (5.19 mm) was lower than value reported for Local Kei [10] and Butanese local chicken [23]. However, value of Albumen height for crossbred chickens found in the present result are higher than the report of Bekele *et al*. [11] for Fayoumi×local Necked Neck (4.9 mm) and RIR× local White chicken (6.2 mm) and Alewi *et al.* [10] for Fayoumi× Local Kei (5.45 mm) and RIR× Local Kei (5.19 mm) but comparable with findings of Sinha *et al*. [19] for crossbred chicken of GP × VR (6.75) and VR × GP (6.55). This variation in values for egg quality traits could be associated with genotypes differences.

Bekele *et al*. [11] indicates that egg number and egg quality traits of egg weight, length and color were improve through crossing of Fayoumi and RIR chicken with Necked Neck and while feather local chicken. In addition in other report Alewi *et al*. [10] found that egg quality traits such as egg weight, length and width, was higher in RIR crosses while egg shape index, shell thickness and yolk height in Fayoumi cross whereas yolk weight was higher in both crosses than tier respective pure line. Similarly in the current report significantly highest (P<0.001) HU, YH and AH were reported for DRB×Horro genotype than the pure DRB and Horro ecotype. Shell thickness was also improved through crossing since, H×DRB showed similar shell thickness with Local Horro ecotype.

There is significant correlation of external egg quality with internal qualities traits. Hence, it helps to predict the internal egg quality of egg based on external characteristics of egg weight, length and width. Egg weight was positively (P<0.01) related with external egg qualities of egg length, egg width and shell weight (P<0.01) and with internal qualities of albumen height, yolk height (P<0.05), yolk width (P<0.01) and Haugh unit (P<0.01). This means that chicken selected for higher egg weight can improve the internal egg quality traits simultaneously. Similarly, Mube *et al*. [22] found that egg weight in Cameroon local barred was highly correlated with egg length and egg width but weak correlations with shape index. The present result of positive correlation of egg weight with egg length, width, shell weight, yolk and albumen height and Haugh unit was exactly agreed with the findings of Markos *et al*. [20] who reported for Lowland Ethiopian chicken ecotypes. Accordingly, Yemane [27] reported that the presence of statistical significant (P<0.01) positive correlation between egg weight and the external egg quality traits such as egg length (0.571), egg width (0.785) and shell thickness (2.88) in Bovan Brown exotic chickens.

Likewise, external egg quality traits of egg shape index was positively (P<0.01) related with egg width but negatively (P<0.05) related with egg length and shell weight (P<0.01). Similarly Markos *et al.* [20] reported the positive and negative correlation of egg width and length with egg shape index, respectively in egg of lowland ecotypes chickens. Accordingly, Yemane [27] found the positive and negative correlation of shape index with egg width and egg length in Bovan Brown exotic chicken, respectively. While, egg length (P<0.01) and egg width (P<0.05) were positively related with albumen height, yolk width (P<0.01) and shell weight (P<0.01). However, Markos *et al*. [20] found the positive correlation of egg shape index with yolk height in both lowland and highland Ethiopian chicken ecotypes. In addition, Haugh unit was positively (P<0.01) related to the external egg quality of length (P<0.05) and width (P<0.05). However, Markos *et al.* [20] found the negative correlation of Haugh unit with egg width in Midland but the opposite was true in Highland Ethiopian ecotypes chicken, the later finding was similar to the current report. Haugh unit was positively (P<0.01) related to albumen height and this result was agreed with the report of Markos *et al*. [20] and Mube *et al*. [22] in Ethiopian ecotypes and in Cameroon local barred chicken, respectively.

The current report of negative correlation of egg shape index with egg weight was agreed with report of Momoh *et al*. [28] and Mube *et al*. [22] in the local Nigerian and local Cameroon barred chickens, respectively. Shell thickness was negatively (P<0.01) correlated with albumen height and HU (P<0.01) but positively (P<0.01) correlated to yolk height, width (P<0.05) and index. In addition, external egg quality traits of shell weight was positively (P<0.01) related to albumen height, Haugh unit but negatively correlated with egg shape index (P<0.01).

Yolk index was positively related to yolk height (P<0.01) but negatively related to yolk width (P<0.05). In addition, yolk width was positively (P<0.01) related to yolk height. Yolk index is the one helps to judge the internal egg quality of chicken. Likewise, as cited in Sinha *et al*. [19], Bornstein and Lipstein [29] observed the existence of very high and negative correlation between yolk index and yolk width and stated that yolk width increased at the cost of yolk quality and the birds laid eggs with lesser yolk width having better yolk quality.

CONCLUSION

Genotypes had significant effect on most egg quality characteristics, except for egg yolk color. Most of egg quality traits were improved in crossbred chickens. Crossbred chicken of HxDRB had comparable performance with DRB×H chicken in most internal and external egg quality traits but HxDRB had superior strong egg shell thickness like Horro ecotype and found preferable genotype since such traits is the most important characteristics in village production system. This shows the positive impact of crossbreeding on improving egg quality traits in local chicken. External egg quality traits had significant correlation with internal egg quality characteristics. Hence, quality egg can be selected base on the type of genotype and external characteristics preferably by their egg weight, width and length.

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