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Evaluation of egg quality parameters in Bhutanese indigenous chickens vis-a-vis exotic chicken

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ABSTRACT

This study was designed to compare the physical egg quality of 4 Bhutanese indigenous chickens (BIC) namely Seim (SM), Phulom (PL), Khuilay (KL) and Yuebjha Narp (YN) with Hyline Brown (HL). A total of 160 eggs were collected to represent the sample size. The BIC egg shell colour varied from white to brownish however, egg shells with cream (51.50%) and white colour (33.00%) were considerably common. The overall mean egg weight in BIC was 47.44g with the lowest for SM (45.95g) and highest for PL (50.35g). Mean egg weight and volume (43.60±6.35) of BIC eggs were comparatively lower than Hyline Brown. The egg phenotype and correspondingly the crushing strength of five populations increased from YN < SM < KL < PL < HL. The specific gravity was the lowest and greatest for YN (1.03) and KL (1.17), respectively. Moreover, the shell thickness measures among the BIC strains were not significant (P<0.05) and ranged from 0.30mm (PL) to 0.33mm (KL). The statistical evaluation presents non-significant difference among the five chicken populations for yolk index. The albumen height of BIC ranged from 5.98mm (KL) to 6.93mm (PL) with the mean 6.54mm. The yolk weight was the lowest for SM followed by KL. Superior physical property of shell and egg shape reveals that KL is better quality among the BIC strains. Furthermore, the less fat percent content in KL also supports and this information may be used for improving this population to produce a good egg quality for consumers.

Key words: Economic trait, Egg quality, Indigenous chicken

Bhutanese traditional birds are mainly kept for egg (Dorji and Gyeltshen 2012). The eggs from the local poultry farmers are insufficient for non poultry keepers. Therefore, the major source of poultry products (eggs and meat) is India.

Lately, there has been an increase of part-time and/or fulltime poultry keeper meeting the eggs demand domestically. The bird preferred by small scale entrepreneurs is exotic (especially, Hyline Brown) because they are prolific layer. This has lead to a boom in egg production in the country. For instance, Department of Livestock Statistics reports that the egg old has increased from 36% in 2008 to 42% in 2010 (Livestock Statistics 2008 and 2010). This may be responsible for poultry genetic erosion which is concerning currently.

Several workers have attempted to assess qualities of egg in Sudanese (Mohammed *et al.* 2005), Nigerian (Yakubu *et al.* 2008), Indian Naked neck (Rajkumar *et al.* 2009) and Bangladeshi (Islam and Dutta 2010) indigenous chicken. Conversely, there is relative little scientific literature on the egg quality of Bhutanese indigenous chickens and government has initiated to conserve our local birds. In Bhutan, at least 10 different indigenous chicken strains have been reported (http: //dad.fao.org/; http: // sapplpp.org/). Nevertheless, Dorji *et al.* (2012) included 4 different strains namely Khuilay (Naked neck), Yuebjha Narp (Black chicken), Phulom (Frizzle) and Seim (Red Junglefowl-like) for their study based on popularity. It is imperative to screen those indigenous strains with superior egg quality to serve as a general guide and recommendation for breeding purposes to ensure and produce high quality eggs consistently for the consumers. Therefore, the objective of this study was to compare physical egg quality traits among 4 Bhutanese indigenous chickens with 1 commercial layer.

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MATERIALS AND METHODS

Study sites and egg sampling: The indigenous birds' eggs were sampled from Tsirang (Tsholingkha, Dunglagan and Semjong village), Punakha (Zomi, Laptshakah and Walakha village) and Daga (Dagapela village) districts reared under extensive production system. The study followed the procedure of sampling reported by Dorji *et al.* (2012). Moreover, the farmers of this district are being trained with respect to conservation activity. Samples were collected from the farmers who were willing to participate in the study. A total of 120 eggs were collected belonging to four

Bhutanese indigenous chickens namely: Siem (SM, n = 30), Yuebjha Narp (YN, n = 30), Khuilay (KL, n = 30) and Phulom (PL, n = 30).

Hyline Brown eggs (HL, n = 40) used as a control population were collected from the College of Natural Resources Poultry farm. The eggs considered in the current study were not older than five days. The eggs were screened for any damage (including the cracks) by candling method manually. Dirty eggs were cleaned softly with edible oil and only clean eggs were used for egg quality testing.

Traits measured: Clean eggs were weighed by digital electronic weighing machine. Egg width and length was measured by electronic vernier caliper.

Egg shell strength was determined by two methods; destructive and nondestructive. Firstly, measuring shell thickness involves destructive method (Anderson *et al.* 2004, Yakubu *et al.* 2008). Secondly, specific gravity indicates the shell quality relative to other egg components (Anderson *et al.* 2004). Specific gravity has been a good measure of the shell strength which is reliable and nondestructive. It was determined by Stadelman and Cotterill (1995) method.

After external quality of eggs was recorded, it was cracked open and the contents were poured on a clean dry petri dish freely. Inner thick albumen height was measured using sensitive electronic vernier caliper according to Silversides and Scott (2001) technique to indicate the interior egg quality parameters. Concurrently, the height and diameter of the yolk was measured by electronic vernier caliper. The yolk was then separated from the other egg components carefully and weighed by digital electronic weighing machine. Weight of the shell was determined after drying at 55°C for 72 h (Anderson *et al.* 2004). Haugh unit for individual egg was estimated as per Monira *et al.* (2003). The thickness of egg shell was measured thrice by sensitive electronic vernier caliper.

Statistical analysis

The data was analyzed using analysis of variance (ANOVA) of SPSS Ver 16. To test the significance of a contrast (P<0.05), Bonferroni method was used.

RESULTS AND DISCUSSION

Egg shell colour

The shell colour does not indicate quality of an egg but it determines consumer's preference. The egg shell colour of Bhutanese traditional birds varied from white to brownish (Table 1) however, egg shells with cream (51.50%) and white (33.00%) were considerably common. Bhutanese prefer brown over white eggs as similarly reported by Odabasi *et al.* (2007). The egg shell colour dominance in our BIC strains was also surveyed for native chicken's egg of Libya (El-Safty 2012) and Bangladesh (Faruque *et al.* 2010). Bhuiyan *et al.* (2005) reported light brown and white eggs in Deshi chicken of Bangladesh. The hens of KL (Naked neck) laid more of brownish egg (77.80%) similar to Bangladeshi Naked neck egg shell colour (Bhuiyan *et al.* 2005). The different management conditions explain for the different findings. Beside, the shell colour is dependent on breed and age of laying birds. The deposition of pigments over the shell surface of larger eggs becomes difficult as the hen ages (Odabasi *et al.* 2007).

Exterior physical qualities

Egg weight (EWT): The overall mean EWT in BIC was 47.44±5.29g with the lowest for SM (45.95±5.84g) and highest for PL (50.35±4.48g). This BIC EWT measure was close to Kashmir local chickens of 46.06±0.48g (Iqbal *et al.* 2009) and falls under medium in Indian classification (Iqbal *et al.* 2009). On the other hand, the averaged BIC EWT was lower than local chickens of Iraq of 60.56±0.11g (Al-Rubaiee 2012) and US and Africa of 49–56g and 55–65g, respectively (FAO 2003). As compared to indigenous chicken of Guwahati (37.20±0.64g, Baishya *et al.* 2008), Bangladeshi (35–39g, Sonaiya and Swan 2004 and 40.04±2.52g, Islam and Dutta 2010), Tanzanian (40.80±5.37g, Nonga *et al.* 2010) and Nigerian (40.00±0.45g, Oke 2011), the EWT of BIC was comparatively heavier.

Previously, studies were conducted in Naked neck population (Islam *et al.* 2001, Yakubu *et al.* 2008, Rajkumar *et al.* 2009). Making comparisons with those authors, BIC KL was higher than Nigerian of 43.04g reared under farmer's management (Yakubu *et al.* 2008) and Bangladeshi of 40.5g (Islam *et al.* 2001) but lower than Indian of 54.41g (Rajkumar *et al.* 2009) and Nigerian of 52.70±1.23g (Isidahomen *et al.* 2013) Naked neck bird group reared under research farm. Moreover, the BIC EWT of PL was lower than Nigerian Frizzle weighing 52.90±0.90g (Isidahomen *et al.* 2013).

On statistical evaluation of EWT, all BIC strains were comparatively lighter than HL at P=0.00 (Table 2). Among

Table 1. Egg shell colour variations in 5 chicken populations

Shell colour	Strain (in percent)					BIC Overall (percent)
	Seim	Phulom	Yuebjha Narp	Khuilay	Hyline Brown	
Cream	84.40	78.90	17.40	22.20	-	51.50
White	15.60	21.10	78.30	-	-	33.00
Brownish	-	-	4.30	77.80	-	15.50
Brown	-	-	-	-	100	-

Seim (Jungle-fowl like), Phulom (Frizzle), Yuebjha Narp (Black-feathered), Khuilay (naked neck), BIC (Bhutanese indigenous chicken).

Table 2. Exterior egg physical characteristics among five different populations (mean±SD)

Traits	SM	PL	YN	KL	HL
Egg weight (g)	45.95±5.84^{a}	50.35±4.48^{b}	46.08±3.86^{a}	49.15±5.05^{b}	62.79±3.49^{c}
Egg shape index	74.45±3.37^{a}	75.82±4.64^{ab}	72.78±3.46^{a}	74.50±2.98^{ab}	76.68±2.07^{b}
Volume (cm3)	41.72±5.86^{a}	46.40±5.93^{b}	45.321±7.04^{ab}	42.31±5.62^{ab}	56.37±3.78^{c}
Specific gravity (g/cm3)	1.11±±0.09^{a}	1.09±±0.07^{ab}	1.03±0.09^{b}	1.17±0.09^{c}	1.12±0.03^{d}
Yolk index	42.96±6.73^{a}	46.16±5.51^{a}	44.58±6.99^{a}	43.24±6.69^{a}	45.83±4.71^{a}
Albumen height (mm)	6.57±1.10^{a}	6.93±1.09^{a}	6.60±1.26^{a}	5.98±1.06^{a}	11.21±1.21^{b}
Haugh unit	73.14±3.29±^{a}	73.72±2.89^{a}	73.11±3.52^{a}	70.97±3.35^{a}	81.52±1.89^{b}
Shell thickness(mm)	0.31±0.030^{a}	0.30±0.02^{a}	0.32±0.03^{a}	0.33±0.03^{a}	0.49±0.06^{b}
Yolk percentage	33.93±3.01^{c}	31.48±1.35^{b}	32.27±2.60^{bc}	31.79±1.94^{b}	24.05±1.55^{a}
Albumen percentage	56.52±3.34^{a}	58.74±1.69^{ab}	59.50±7.10^{b}	58.30±2.46^{ab}	66.29±1.60^{c}
Shell percentage	9.54±0.89^{a}	9.62±0.75^{a}	9.63±1.41^{a}	9.95±1.20^{a}	9.68±0.63^{a}
Yolk weight (g)	15.62±3.34^{a}	15.96±1.84^{a}	14.80±1.25^{a}	15.57±1.58^{a}	15.03±1.14^{a}
Albumen weight (g)	26.22±4.08^{a}	29.55±2.47^{b}	27.48±4.43^{ab}	28.69±3.91^{ab}	41.57±2.85^{c}
Shell weight (g)	4.37±0.56^{a}	4.85±0.56^{b}	4.44±0.75^{ab}	4.86±0.51^{b}	6.07±0.37^{c}

$^{a-d}$means within a same column containing no common superscript differs significantly (P<0.05). SM, Seim (Red Junglefowl-like); PL, Phulom (Frizzle); YN, Yuebjha Narp (Black-feathered); KL, Khuilay (Naked neck); HL, Hyline Brown; BIC, Bhutanese indigenous chicken; SD, Standard deviation

BIC, there were no significant difference observed between SM and YN (P =1.00), SM and KL (P =0.18), PL and KL (P =1.00) and YN and KL (P =0.37) except for PL and YN (P =0.04) and SM and PL (P =0.01). This was also noted by Isidahomen *et al.* (2013) and Oke (2011) for Frizzle and Naked neck of Nigerian local fowls. But, Yakubu *et al.* (2008) reported a significant difference between Naked neck and normal feather which was contradicting with the present study. These controversies about effect of plumage modifier genes on EWT may be attributed to different management practices, local environmental conditions, parental average body weight and age of hen (Yakubu *et al.* 2008, Baishya *et al.* 2008).

Egg shape index (ESI): ESI denotes the shape of an egg and resistance to crushing forces (Anderson *et al.* 2004, Altuntas and Sekeroglu 2008). These different shapes are categorized tentatively as sharp (<72%), normal or standard (72-76%) and round (<76%) by Altuntas and Sekeroglu (2008). Based on the criterion, BIC eggs are normal in shape and were insignificantly different at P<0.05 as studied in Nigerian local fowls (Oke 2011). Average BIC ESI of 74.50±3.33% was slightly higher than 73.54% of Kashmir local chicken (Iqbal *et al.* 2009) but lower than 75.88% of Guwahatti indigenous birds (Baishya *et al.* 2008). The egg phenotypes and correspondingly the crushing strength of five chicken populations increased from YN<SM<KL<PL<HL (Table 2). The result indicates that the eggs from PL and KL were of good external egg quality (Yakubu *et al.* 2008) and are more resistance to crushing forces during handling and transportation (Anderson *et al.* 2004, Altuntas and Sekeroglu 2008, Melesse *et al.* 2010). When the egg shape is elongated, it will not fit in pre-made packaging. Therefore, ESI is very important in commercial poultry industry (Anderson *et al.* 2004, Altuntas and Sekeroglu 2008) and to produce uniform egg size for the consumers. KL ESI in this study equalled with Nigerian Naked neck (Yakubu *et al.* 2008) but was lower than Indian Naked neck (Rajkumar *et al.* 2009) estimates. In addition, the normal feathering birds egg shape of BIC were more round than Nigerian (Yakubu *et al.* 2008) but less round than Makurdi-Nigerian birds (Egahi *et al.* 2013).

As expected, the highest ESI was estimated for HL among five fowl populations and this hen has laid rounder eggs because of genetic change over time (Anderson *et al.* 2004, Altuntas and Sekeroglu 2008). A significance of difference existed between SM and HL (P =0.03) and YN and HL (P =0.00). It is therefore possible for breeders to consider KL and PL to be improved for egg type because no significance of difference was observed between KL and PL versus HL at P <0.05 (Table 2). Nevertheless, other egg quality parameter such as shell quality must be monitored to strengthen the statement further.

Egg volume (EV): In respect of EV, HL measured highest among the fowl populations (P =*0.00*) followed by PL (Table 2). A highly significant of difference was observed between HL and all BIC strains and is in agreement with Islam *et al.* (2010) study. EV of BIC strains was comparatively greater than 34.99±5.72cm^3 of Bangladeshis chicken (Islam *et al.* 2010). Among four BIC strains, a significant relationship was noted for SM and PL (P =0.03) only.

Shell quality (specific gravity, SPG and shell thickness, STH): The mechanical and physical property of an egg shell quality (a measure of shell strength) is an important bio-economic trait. This is a core component for breeding in layers to reduce egg breakage (Anderson *et al.* 2004, Altuntas and Sekeroglu 2008, Alewi *et al.* 2012). The mean SPG of BIC strains was lower than referenced population (Table 2) and this was consistent with Offiong *et al.* (2006) experiment. The SPG derived was lowest and greatest for

YN (1.03±0.09) and KL (1.17±0.09), respectively, with the mean of 1.10±0.10 (Table 2). The BIC SPG was higher than Nigerian local birds of 1.06±0.05 (Offiong *et al.* 2006).

The STH should be at least 0.35mm to withstand from handling and transportation (Sonaiya and Swan 2004) and for good hatching results (Altuntas and Sekeroglu 2008, Egahi *et al.* 2013). Our BIC strains shell was thicker than indigenous chickens of Guwahatti (Baishya *et al.* 2008) and Libyan (El-Safty 2012) but lower than Tanzanian (Nonga *et al.* 2010) and Sudanese (Mohammed *et al.* 2005). The STH measures among the four BIC strains were not different and ranged from 0.30±0.02mm (PL) to 0.33±0.03mm (KL) at P <0.05 (Table 2). This may be attributed to similar feed she obtains. However, KL has better shell quality informing that this strain may be developed for egg type and Dorji *et al.* (2012) reports that the genetic distance between the KL and layer was closer. Furthermore, this is in support with the findings of Islam *et al.* (2001), Yakubu *et al.* (2008) and Rajkumar *et al.* (2009) on the superiority of STH in Naked neck than other non-naked neck counterparts. By contrast, the significance of difference was noted for Nigeria local birds (Yakubu *et al.* 2008, Oke 2011, Egahi *et al.* 2013).

The mean shell measures of KL (0.33mm) were thinner than Indian (0.40-0.41mm in Rajkumar *et al.* 2009) and Nigerian (0.38mm in Yakubu *et al.* 2008) Naked neck birds. The mean STH of 0.33mm observed for Makurdi-Nigerian Naked neck birds (Egahi *et al.* 2013) was comparable to our KL STH values. Bhutanese PL STH mean value was lower than Nigerian Frizzle (0.49±0.23mm in Isidahomen *et al.* 2013, 0.36±0.01mm in Egahi *et al.* 2013). The mean STH for normal feather of BIC were also thinner than Nigerian (Yakubu *et al.* 2008) but nearly as thick as Makurdi-Nigerian (Egahi *et al.* 2013) normal plumage birds. Evidently, the variation in the value is possibly due to difference in feed stuffs and the local climatic conditions as suggested by Yakubu *et al.* (2008), Rajkumar *et al.* (2009) and Nys 2009).The egg with better SPG and STH means better shell quality (Ingram *et al.* 2008). Therefore, the assessed shell quality parameters indicated that KL was superior to the rest BIC populations.

Relatively, a thicker STH was recorded for HL against BIC populations (P=0.00) and this is in line with Offiong *et al.* (2006), Melesse *et al.* (2010) and Moula *et al.* (2010) documentation. The greater STH in HL may be attributed to her diet containing essential minerals for egg shell formation. Moreover, STH of a cross from dominant black strain with Fulani (Sola-Ojo 2011) and local Kei cross with Fayoumi and Rhode Island Red (Alewi *et al.* 2012) were significantly different (P <0.05). Hence, selection may also be the reason for thicker STH in HL (Tharringtom *et al.* 1999, Anderson *et al.* 2004).

Interior physical qualities

Yolk index (YI): In terms of statistical evaluation, five chicken populations for yolk index (YI) showed non-significant difference (P *<0.05*) and was consistent with Offiong *et al.* (2006) and Al Rubaiee (2012) claim. But, Baishya *et al.* (2008) reported higher YI for commercial eggs (P *<0.05*). Overall averaged YI of four BIC strains was higher than Guwahati (Baishya *et al.* 2008) and Tanzanian (Nonga *et al.* 2010) native birds but lower than Iraqi local breeds (Al-Rubaiee 2012). The Indian Naked neck birds laid YI of 36.79% which was lower than normal feathering (Rajkumar *et al.* 2009) corresponding with our BIC populations. On the other hand, Nigerian Naked neck was demonstrated to contain higher YI% than its counterparts (Yakubu *et al.* 2008).

Albumen height (AH) and Haugh Unit (HU): The AH of 8-10mm is considered as better interior quality (Ziedler 2002) and HL has superior interior egg quality with the AH of 11.21±1.21mm (Table 2). The overall mean AH of BIC strains was 6.54 ±1.15mm that ranged from 5.98 ±1.06mm (KL) to 6.93 ±1.09mm (PL) and the variation was not significant (P <0.05). Thus, AH mean of BIC strains may be regarded as inferior quality but, AH measure ranged from 3.90 to 9.50mm. Furthermore, mean AH of BIC egg was taller than Tanzanian local birds (Nonga *et al.* 2010) but shorter than Sola-Ojo (2011) experimental birds. Makurdi-Nigeria native normal plumage, Frizzle and Naked neck AH of 4.64±0.61mm, 6.04±0.58mm and 5.99±0.72mm, respectively (Egahi *et al.* 2013) was lower than our BIC counterparts. Our BIC KL had thicker albumen than Nigerian Naked neck albumen but PL albumen spread was less than Nigerian Frizzle (Oke 2011). This comparison is suitable considering age of eggs (Silversides and Scott 2001, Silversides and Budgell 2004) and age of the hen (Silversides and Scott 2001). In addition, the height of albumen can be measured by different techniques resulting to different AH recordings (Silversides and Budgell 2004).

To further verify the albumen quality among the strains, HU was estimated (Table 2). From these groups of indigenous birds, the mean HU presented the similar pattern as AH with PL (73.72±2.89) ranking above all BIC strains. There could be no influence of Na and F genes (F gene in PL and Na gene in KL) on AH and HU because differences were non-significant except with HL (P =*0.00*). This was also supported in Rajkumar *et al.* (2009) and Oke (2011) study and these local flocks are mating randomly (Rajkumar *et al.* 2009). By contrast, Egahi *et al.* (2013) and Yakubu *et al.* (2008) informed plumage modifier genes have an effect on egg traits. The significantly better albumen quality in commercial layer has also been documented in scientific literatures (Offiong *et al.* 2006, Baishya *et al.* 2008). Nys (2009) stated that the HU has improved to H”80 since 2001 because the heritability is high. The HU value generated from Indian (Rajkumar *et al.* 2009), Tanzanian (Nonga *et al.* 2010), Guwahati (Baishya *et al.* 2008) and Nigerian (Egahi *et al.* 2013) local birds were either lower or higher than BIC HU score. Besides genetic differences, rearing system and age of laying hen explains for this disparity (Baishya *et al.* 2008, Rajkumar *et al.* 2009, Nys 2009).

Shell weight (SWT) and percentage (SP): Mean SWT among BIC birds was greater for KL (4.86±0.51g) and lower for SM (4.37 ±0.56g) with overall mean of 4.57±0.63g (Table 2). The egg shell weighed in current study was lighter than those reported for eggs laid by native hen of Indian (Rajkumar *et al.* 2009), Bangladeshis (Islam and Dutta 2010), Iraqi (Al-Rubaiee 2012) and Nigerian (Isidahomen *et al.* 2013) but heavier than Libyan (El-Safty 2012). On the other hand, comparable values were studied in free range local hen's egg of Tanzania (Nonga *et al.* 2010).

There were no difference in SWT observed between SM and YN (P =1.00), PL and YN (P =0.18), PL and KL (P =1.00) and YN and KL (P =0.16), except SM versus PL (P =0.02) and SM versus KL (P *=0.02*). The feather modifier gene relatively presents heavier shell than normal feathered birds and is in line with Rajkumar *et al.* (2009) but challenging Yakubu *et al.* (2008) observation. This finding further consolidated that KL has better external egg quality than normal plumage birds (Yakubu *et al.* 2008). Isidahomen *et al.* (2013) investigated and reported that Frizzle birds SWT was heavier among traditional birds. The mean SWT of BIC strains in the present study weigh less than 6.39±0.01g (normal plumage), 7.02±0.01g (Fz) and 8.39±0.02g (Na) for Nigerian local chicken types (Egahi *et al.* 2013). Offiong *et al.* (2006) and Moula *et al.* (2010) mentioned that shell in exotic birds weighed more than traditional informing that the selection has influenced over SWT (Anderson *et al.* 2004). As expected, a difference prevailed between commercial and BIC hen laid eggs (P =0.00) and was in support with Moula *et al.* (2010) and Islam and Dutta (2010) but disagreeing with Offiong *et al.* (2006) study.

SP on the other hand, non-significant difference was examined for these groups of birds and is consistent with Islam and Dutta (2010) and Al-Rubaiee (2012) documentation. By comparison, in our averaged BIC population SP was marginally lower than Kashmir native flock with 9.83% (Iqbal *et al.* 2009) but relatively higher than Libyan birds with 6.90±0.13% (El-Safty 2012). The other investigators such as Moula *et al.* (2010) and Islam and Dutta (2010) reported higher percentage of shell than present findings.

Yolk weight (YWT) and percentage (YP): In terms of yellow egg component, YWT ranged from 14.80±1.25 307g (YN) to 15.96±1.84g (PL). Among BIC strains, YN followed by KL contain lower fat percentage than other BIC strains because their yolk mass weighed low (Table 2). The overall mean of BIC was 15.37±2.04g which was close to Nigerian (Offiong *et al.* 2006) and Guwahhati (Baishya *et al.* 2008) and higher than traditional birds of Rajshahi (Islam and Dutta 2010) and Tanzania (Nonga *et al.* 2010) but, lower than Nigeria birds (Yakubu *et al.* 2008, Isidahomen *et al.* 2013) report.

The existence of mean YWT differences was not found among the five flocks in the study (P <0.05). This study is in line with Islam and Dutta (2010) who earlier reported that there is no significance of difference among the local and layer birds (P <0.05). On contrary, few authors noted for significant differences between exotic and native chickens (Offiong *et al.* 2006, Moula *et al.* 2010). The strains differences on YWT among local birds were not observed and were in agreement with Rajkumar *et al.* (2009), Moula *et al.* (2010) and Isidahomen *et al.* (2013) document. On contrast, Al-Rubaiee (2012) and Yakubu *et al.* (2008) was not according to our results. Isidahomen *et al.* (2013) reported that YWT of egg laid by Nigerian Naked neck (18.20±0.24g) and Frizzle (17.45±0.32g) was greater than KL and PL birds. Moreover, the yolk mass of 16.95g in Nigerian Naked neck and 16.05g in normal feathered (Yakubu *et al.* 2008) was heavier than BIC counterparts. This probably indicates that BIC hen laid eggs of lower fats than Nigerian (Rajkumar *et al.* 2009). Nevertheless, 13.10g from Bangladeshis Naked neck (Islam *et al.* 2001) weighed lower than KL yolk.

Among the studied population, the mean YP was significantly greater in eggs of four BIC strains than exotic at P =0.00 (Table 2). This was also responding between Belgian local and exotic birds (Moula *et al.* 2010). The SM presented the largest yolk percentage (33.93±3.01%) followed by YN (32.27±2.60%) and was close to 33.68% of Kashmir native flocks (Iqbal *et al.* 2009). This variation in YP has been observed by Al-Rubaiee (2012) for local Iraqi brown and white eggs with 28.71±0.25% and 26.25±0.26%, respectively.

Albumen weight (AWT) and percentage (AP): The approach here was to describe the AWT for BIC strains (Table 2). The mean AWT for HL (41.57±2.85g) outweighed any BIC strains and were described in the reports stated by Moula *et al.* (2010), Baishya *et al.* (2008) and Islam and Dutta (2010) study because EWT and AWT are positively correlated (Moula *et al.* 2010). A very high significance of difference was observed between BIC strains and controlled population with respect to AWT at P *=0.00* (Table 2). There were no significant differences between SM and PL (P=0.02), SM and YN (P=1.00), SM and KL (P=0.22), PL and YN (P=0.68), PL and KL (P=1.00) and YN and KL (P=1.00) except for SM and YN (P=0.03). The KL contained lighter AWT than selected Naked neck birds of India (Rajkumar *et al.* 2009) and Nigerian normal feathered (Isidahomen *et al.* 2013) but higher than free-range Naked neck birds of Nigeria (Yakubu *et al.* 2008). In addition, normal plumage birds of BIC contained lower albumen mass than 32.10±1.26 g of Nigeria (Isidahomen *et al.* 2013). The differences in AWT in different groups of studied birds may be attributed to the differences in genotypes, age of the birds, management conditions (Baishya *et al.* 2008, Isidahomen *et al.* 2013) and EWT.

The lowest EWT for SM contained greater YP but smaller AP. On the other, yolk content was smaller with larger albumen portion for the larger eggs of HL. This corresponds with Tharrington *et al.* (1999) investigation. Moula *et al.* (2010) reported similar findings that the smallest egg (50.10±0.44g) of Ardennaise strain contains largest portion of YP (33.40±0.21%) and smallest portion of AP (54.00±0.23%). Data from this parameter allow us to generalize that the eggs that are larger in size also contain lager AP but lower YP.

The AP for HL outscored our BIC populations significantly (P=0.00) and it was also reported between Belgian local birds and commercial layers (Moula *et al.* 2010). Furthermore, AP of BIC was comparable with traditional birds of Belgian (Moula *et al.* 2010), Kashmir (Iqbal *et al.* 2009) but lower than Iraqi brown laid eggs (Al-Rubaiee 2012).

This study was designed to compare the physical egg quality traits of four Bhutanese indigenous chickens with Hyline Brown strains. Among Bhutanese indigenous chickens, Khuilay and Phulom hen laid comparatively larger and heavier eggs. The physical property of shell explains that Khuilay and Phulom have better quality. Moreover, considering ESI estimates, these two BIC strains can resist a significant proportion of crushing strength. Khuilay and Phulom also presented superior interior quality with the lower yolk percent. Therefore, it may be suggested that Khuilay and Phulom may be developed for egg type. This will improve the living standard of the rural dwellers and encourage the conservation of the indigenous birds. In addition, the cultural practice in the local community will be preserved.

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