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Egg quality traits and meat composition of indigenous dwarf chicken of Odisha

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Abstract
The present study was conducted to evaluate the egg quality traits and meat traits of an indigenous dwarf chicken population of Odisha maintained at Central Poultry Development Organization, Bhubaneswar under intensive system of management from December 2015 to April 2016 up to 20 weeks of age. Age at first egg was 121±0.90 day and age of sexual maturity was 136±0.90 day. Thirty eggs were collected randomly at 20 weeks to study the egg quality traits. The external egg quality parameters such as egg weight, shape index and internal egg quality parameters such as yolk index, albumen index, Haugh unit and shell thickness were recorded. The average weight of egg was 27.95±0.55g. Eight birds (4 from each male and female birds) were sacrificed to study the chemical composition of breast and thigh muscles. Higher protein % and ash % were recorded in breast muscle (82.92±0.84 and 6.02±± 0.23; respectively) than that of thigh muscle (72.81±4.49 and 5.14±0.36; respectively). Higher fat % and fiber % was observed in thigh muscle (4.67±0.62 and 1.15±0.19; respectively) than that of breast muscle (1.57±0.31 and 0.61±0.11; respectively). Significantly higher (P=0.001) fat% was observed in breast muscle of female birds than male birds

Keywords: Indigenous chicken, egg quality traits, meat composition

1. Introduction
Poultry, particularly chickens are the most widely kept and most numerous livestock species in the world [19, 27]. Local chickens are widely distributed in rural and peri-urban areas where they play the important role of food production, social aspect and source of income, especially to women [19, 20, 36]. Indigenous poultry birds are well adapted to harsh environment of free range and they produce eggs and meat at least possible cost. Poultry eggs are a cheap source of good quality animal protein fulfilling the requirements of the rapidly growing human population. Consumers prefer eggs with better egg quality which is determined by their physical structure and chemical composition. Various factors like rearing, relative humidity, ambient temperature and season of production may affect the egg quality. Similarly, the genotype, diet, age at slaughter and motor activity of birds influence the meat quality. Compared with the commercial broiler, the local chickens are characterized by lower carcass fat [6]. Unique taste and high nutritional value of local chicken in comparison with those of broilers have yet to be clearly evaluated via scientific analyses, and it is important to elucidate the physicochemical factors that influence the taste and nutritional value of these chickens [12]. In addition to its relatively cheaper price, several other factors make chicken meat superior to red meat. Such factors include its health benefits, because it contains less fat and cholesterol; easy to handle portions; and less religious barriers [8]. Rural poultry farming using native breeds is being practiced in many developing and underdeveloped countries throughout the world. Though indigenous birds are being used for rural backyard poultry production, their genetic potential has not been fully exploited. Therefore, the present study has been planned to evaluate the performance of an indigenous dwarf chicken population of Odisha under intensive system with respect to its age of sexual maturity, egg quality traits and meat composition.

2. Material and methods
2.1 Experimental protocol
The present experiment was conducted in the Poultry Complex of the Central Poultry Development Organization, Bhubaneswar, Odisha from December 2015 to April 2016. Indigenous males at the age of 40 weeks were housed in breeding pens in the ratio 8:1 in eight breeding pens each to obtain pure eggs for the lines.

One hundred day-old straight run healthy chicks from a single hatch were collected randomly and were wing banded. Routine medication and vaccination procedures were followed for all the experimental chicks. The feed and water were provided ad libitum. Age at first egg production and age at sexual maturity was recorded. External and internal egg quality traits were measured by collecting thirty eggs at 20 weeks of age. Four male birds and four female birds were sacrificed to evaluate meat traits.

2.2 Measurement of external egg quality traits

First eggs were subjected to the assessment of physical measurements such as egg weight and shape index. Each egg was weighed by electronic top pan balance with 0.1 gram accuracy and the weight was noted up to the milligram. Length and breadth of eggs were measured in millimetre with a digital caliper and the shape index was calculated by using the following formula [32].

Shape index = Maximum width/Maximum length × 100

2.3 Measurement of internal egg quality traits

The eggs were broken and the contents were poured carefully on a leveled glass plate placed on a table, so that, the yolk and thick albumen remained intact. The apparatus used for measuring the different characters of the eggs were weighing balance, flat plane glass slab, digital vernier calipers, spherometer and Ames thickness measure. Shell thickness was observed by taking three pieces of dried eggshell from different locations (air cell, equator, and sharp end) and measured by an Ames thickness measure accurately and expressed in mm. The mean of the measurements was taken as the shell thickness of that particular egg. The length and width of the albumen were measured using the digital vernier calipers and expressed in mm. The height of the albumen and yolk were measured at the top by spherometer on a table glass. Yolk diameter was estimated as the average of yolk length and breadth. Albumen weight, albumen index, yolk index and Haugh unit were calculated by using various formulae [32].

Albumen weight = Egg weight - (Yolk weight + Shell weight)

Albumen index = Albumen height (mm)/Albumen width (mm) × 100

Yolk index = Yolk height (mm)/Yolk diameter (mm) × 100

Haugh unit = 100 log (H + 7.57-1.7 $W^{0.37}$)

where, H = albumen height (mm) and W = egg weight (g)

2.4 Proximate composition of thigh and breast meat

Four male birds and four female birds were sacrificed to evaluate meat traits. The selected birds were separated from the flock and fasted overnight but drinking water was provided ad libitum. The birds were slaughtered by severing the jugular vein and carotid artery below the left ear by a single incision and were allowed to bleed for a period of three minutes by holding the bird's head down. For proximate analysis of meat, meat samples were collected from breast and thigh regions.

The proximate composition such as moisture, crude protein, ether extract/crude fat and crude ash content of the chicken meat from the breast and thigh muscles were analyzed in triplicate by a slightly modified method of AOAC [2]. Moisture content was determined by drying 20 g of minced meat in aluminum moisture cups and dried in a hot air oven for 18 h at 104^0C. Crude protein content was measured by the Kjeldahl method (VAPO45, Gerhardt Ltd., Idar-Oberstein, Germany). The amount of N obtained was multiplied by 6.25 to calculate the crude protein content. The crude fat content was measured by the Soxhlet extraction system (TT 12/A, Gerhardt Ltd., Germany). Crude ash content was determined by overnight burning of 2 g meat sample in a muffle furnace at 600 °C.

2.5 Statistical analysis

External and internal egg quality data were expressed as Mean±SE, range and CV%. The correlation values among the external and internal quality traits of the eggs are determined by the Pearson Correlation Analysis [33]. The proximate analysis data of thigh and breast muscles of male and female birds were subjected to t-test to know the significance level of different parameters and were declared significant at $P \leq 0.05$.

3. Results and Discussion

3.1 Age at first egg and age at sexual maturity

The age at sexual maturity (ASM) is considered as an important heredity and fecundity trait. It is one of the important factors in determining the overall profitability of the flocks. It has correlated response on egg production traits such as egg number, egg weight, egg mass and body weight at sexual maturity. Age at first egg of indigenous dwarf chicken was 121±0.90 day and age at sexual maturity (ASM) was 136±0.90 day which is much lower than the values reported in native chickens of other states. The ASM was 157.5 days, 163.34 days, 173 days, 180 days, 176 days, 166 days and 174.73 days in native chickens maintained at Mannuthy, Ludhiana, Agartala, Guwahati, Ranchi, Jabalpur and Udaipur, respectively [1]. The ASM was 200.61 and 213.25 days, respectively for Kadaknath and Aseel breeds [7]. The ASM of indigenous Irani chicken were 157.1±0.8 days and for Naked Neck, Marandy and Public, ASM was 23, 25 and 22 weeks, respectively [21]. The differences in ASM might be due to breed differences. This trait is also affected by various environmental and managemental factors like temperature, lighting intensity and nutrition. The age at first egg is correlated with body weight of hen. The smaller the body weight, the earlier the ASM.

3.2 Egg quality traits

The egg quality traits are known to be influenced by genetics, age, feeding, management and environmental factors. Native chickens are known to produce eggs of smaller size and hence, their constituents are significantly lower than those of improved varieties.

3.2.1 External egg quality traits

3.2.1.1 Egg weight

The mean external egg parameters of indigenous dwarf chickens are presented in Table 1. The weight of egg was 27.95±0.55 g. The mean egg weight reported in this study is close to 28.95 g reported by Daikwo et al. [4] and also close to the 29.37 g reported by Mbap and Zakar [16]. The average egg weights in Nigerian local chickens were higher than the present estimates and ranged from 34.25 to 38.98 g in hens of age group 20-32 weeks [18]. The low egg weight correlates with the low body weight of the birds. This dwarf chicken population is not yet well established. So, selection should be carried out for better egg size.

3.2.1.2 Shape index

It is a very good indicator of uniformity in egg size. The higher the shape index, the more uniform the eggs are. In the present study, the average shape index was 74.23±0.38 which

is similar to that reported in Kadaknath breed [26], Vanaraja and Gramapriya [22], naked neck and dwarf chicken genotypes [28], hill fowl [31], and Nigerian local chicken ecotypes [18]. The observed high shape index value indicates better uniformity of the eggs which is important for good hatchability and healthy chick production.

Table 1: External egg quality traits of indigenous dwarf chicken at 20 weeks of age

Parameters	Mean± SE	Range	CV%
Egg Weight (g)	27.95 ± 0.55	20 - 36	13.29
Egg Length (mm)	45.63 ± 0.20	40.34 - 49.79	3.69
Egg Width (mm)	33.86 ± 0.21	29.67 - 36.36	4.34
Shape Index	74.23 ± 0.38	69.26 79.97	3.51

3.2.2 Internal egg quality traits

The mean internal egg parameters of indigenous dwarf chicken are presented in Table 2.

3.2.2.1 Albumen quality traits

Albumen contributes approximately ~ 60% of an egg weight and thus has a major influence on the internal quality of the egg. Albumen index is an indicator of the firmness and viscosity of albumen which is considered as an important factor for quality of eggs. The weight of albumen was 15.86 ± 0.31g. Albumen height, albumen length and albumen width was 4.64 ± 0.08mm, 87.07±0.24 mm and 54.54 ± 0.25mm respectively. The albumen index was 6.5 ± 0.11. Parmar et al. [26] collected 2206 eggs to assess the egg quality characteristics of Kadaknath breed. The mean albumen index and albumen weight were found to be 7.03 and 20.74 g respectively. Nonga et al. [23] reported egg quality of free-range local chickens in Tanzania and the mean values for egg traits were 21.9g and 3.9mm for albumen weight and albumen height, respectively. The values obtained in the present study are in accordance with the results of Yakubu et al. [38] in naked neck. In contrast, higher values were reported by several other workers [18, 22, 28, 31].

3.2.2.2 Yolk quality traits

The weight of yolk was 9.91 ± 0.26g. Yolk height and yolk diameter was 12.11 ± 0.15mm and 35.03 ± 0.24mm respectively. The yolk index was 34.51 ±0.39. The mean yolk index and yolk weight were found to be 37.07 and 14.77 g respectively in Kadaknath breed [26]. The mean values for egg traits were 13.6g, 0.76cm, 2.5cm, 31.6 for yolk weight, yolk height, yolk width, and yolk index, respectively in free-range local chickens in Tanzania Nonga et al. [23]. Higher values were observed in Gramapriya and Vanaraja [22], Aseel and Kadaknath [7], hill fowl [31], Nigerian local chicken [18], naked neck [10, 28, 38], dwarf chicken [28], and indigenous fowls of Andaman [3]. The variation in yolk quality is attributed to the egg size and also the breed/variety/population of the chicken studied.

3.2.2.3 Shell quality trait

Shell thickness an important economic trait that controls the keeping quality, breaking strength and transportability of the egg. The thickness of the egg shell was 0.32±0.02mm. The egg shell thickness of indigenous hens (320 µ) was much larger than that reported in three local types of Sudanese indigenous fowls i.e. Large Baladi (LB), Bare-Neck (BN) and Betwil (BT) [17]. Parmar et al. [26] reported the egg shell thickness of Kadaknath breed to be 0.31 mm. Saleem et al. [29] reported the egg shell thickness of Naked Neck layers to be 0.39 mm. Higher shell thickness was observed in Vanaraja and Gramapriya [22], dwarf chicken [28], Nigerian local chicken [18], hill fowl [31] and naked neck [10, 28, 38]. Lower shell thickness was reported in Nicobari and naked neck [24]. These variations in the shell thickness may be due to differences in breed, feed and climate.

3.2.2.4 HU score

The Haugh unit (HU score) is one of the important criterion for determining the internal quality of the egg. It is one of the widely used measure to evaluate the albumen quality. Better the albumen quality, better the HU score and better the internal egg quality. The HU score of the eggs obtained in the present investigation was 80.45± 0.51 which show the freshness and higher quality of eggs. Lower HU scores were reported in Nigerian chicken [8, 18], Aseel and Kadaknath [7], Vanaraja and Gramapriya [22] and naked neck and Nicobari chicken [24]. Parmar et al. [26] observed a wide range of HU scores from 62.6 to 90.0 in Kadaknath breed under field conditions. The variable HU scores indicate varied albumen quality in different chicken varieties.

Table 2: Internal egg quality traits of indigenous dwarf chicken at 20 weeks of age

Parameters	Mean± SE	Range	CV%
Shell Thickness (mm)	0.32 ± 0.02	0.24- 0.40	4.85
Albumen Weight (gm)	15.86 ± 0.31	11-20	13.34
Albumen Height (mm)	4.64 ± 0.08	3.06- 6.91	15.30
Albumen Length (mm)	87.07 ± 0.24	84.26- 90.43	1.90
Albumen Width (mm)	54.54 ± 0.25	48.56- 58.27	3.19
Yolk Weight (gm)	9.91 ± 0.26	8-14	17.71
Yolk Height (cm)	12.11 ± 0.15	10.27-14.26	8.37
Yolk Diameter (mm)	35.03 ± 0.24	32.13- 38.32	4.66
Albumen Index	6.55 ± 0.11	4.84- 8.16	11.96
Yolk Index	34.51 ± 0.39	29.52- 40.22	7.58
Haugh Unit	80.45 ± 0.51	73.50- 88.85	4.30

3.2.3 Correlation among external and internal egg quality traits

All the external and internal egg quality traits measured in the present experiment were found to have significant correlation among each other at the 0.01 level (2-tailed) (Table 3). So, selection for increased egg weight will ultimately result in increased weight of the various egg components.

Table 3: Correlation among external and internal egg quality traits

Parameter	Egg weight	Egg length	Egg width	Albumen weight	Albumen height	Albumen length	Albumen width	Yolk weight	Yolk height	Yolk width	Shell thickness	Shape index	Albumen index	Yolk index	Haugh unit
Egg weight	1														
Egg length	0.987**	1													
Egg width	0.998**	0.994**	1												
Albumen weight	0.994**	0.964**	0.986**	1											
Albumen height	0.978**	0.933**	0.966**	0.995**	1										
Albumen length	0.874**	0.940**	0.898**	0.816**	0.756**	1									
Albumen width	0.971**	0.996	0.982**	0.939**	0.902**	0.964**	1								
Yolk weight	0.987**	0.948	0.977**	0.998**	0.998**	0.785**	0.920**	1							
Yolk height	0.990**	0.954**	0.981**	0.999**	0.997**	0.797**	0.928**	0.999**	1						
Yolk width	0.997**	0.995**	0.999**	0.985**	0.963**	0.903**	0.984**	0.974**	0.978**	1					
Shell thickness	0.970**	0.920**	0.956**	0.991**	0.999**	0.732**	0.886**	0.996**	0.994**	0.953**	1				
Shape index	0.918**	0.969**	0.938**	0.869**	0.818**	0.995**	0.986**	0.843**	0.853**	0.941**	0.796**	1			
Albumen index	0.982**	0.939**	0.970**	0.996**	0.999**	0.767**	0.909**	0.999**	0.998**	0.968**	0.998**	0.827**	1		
Yolk index	0.998**	0.994**	0.999**	0.985**	0.964**	0.901**	0.983**	0.975**	0.979**	0.999**	0.954**	0.940**	0.969**	1	
Haugh unit	0.897**	0.956**	0.919**	0.844**	0.788**	0.998**	0.976**	0.815**	0.826**	0.923**	0.765**	0.998**	0.798**	0.922**	1

Mean with different superscripts in a row differ significantly (**P<0.001)

3.3 Meat quality traits

Meat quality is a function of the interaction of genotype and other environmental factors. Xlong et al. [37] reported that breeds affected chemical composition of chicken meat. Meat quality can be assessed on the basis of parameters such as protein and fat contents. A statistically significant negative correlation exists between fat and protein contents in muscles [15]. From nutritional and technological aspects, proteins are the most important components of meat [34]. The protein content in muscles is variable and depends on the function of a particular tissue [9]. The fat content in meat depends on many factors such as animal species, breed, gender, anatomical origin of muscles etc. [14].

3.3.1 Chemical composition of thigh meat

The proximate composition of thigh muscles is presented in Table 4. Higher moisture content in thigh meat was observed in male birds (76.74 ± 0.24 %) than female birds (74.1 ± 1.66 %). The crude protein (%) also followed the similar trend; the corresponding values were 79.86 ± 1.50 and 65.76 ± 4.38 for male and female birds, respectively. Similar trend was observed for crude fat % in thigh meat of birds. Lower crude fat % in thigh meat was observed in male birds (4.72 ± 1.01) than that in female birds (4.62 ± 0.24). The crude fiber contents in thigh meat followed the similar trend to that of crude protein and moisture. Higher crude fiber % was observed in thigh meat of male birds (1.18 ± 0.18) than that of female birds (1.12 ± 0.43). Lower total ash and acid insoluble ash content was observed in thigh meat of male birds (4.87 ± 0.31 and 0.03 ± 0.01 %, respectively) than that of female birds (5.41 ± 0.74 and 0.14 ± 0.04 %, respectively). The crude protein% and was crude fat% were found to be 67.65±1.85 and 17.60±0.24 in thigh meat of desi birds of Pakistan [13].

Table 4: Proximate composition of thigh muscle of indigenous dwarf chicken at 20 weeks of age

Parameters≠	Mean± SE		P value
	Male	Female	
Moisture %	76.74 ± 0.24	74.1 ± 1.66	0.256
Crude protein %	79.86 ± 1.50	78.99 ± 2.39	0.78
Crude fat %	4.72 ± 1.01	4.62 ± 0.24	0.931
Crude fiber %	1.18 ± 0.18	1.12 ± 0.43	0.909
Total ash %	4.87 ± 0.31	5.41 ± 0.74	0.571
Acid insoluble ash %	0.03 ± 0.01	0.14 ± 0.04	0.104

≠% as on dry matter except moisture

3.3.2 Chemical composition of breast meat

The proximate composition of breast muscles is presented in Table 5. Moisture content was lower in breast meat of male birds (74.15 ± 0.55) than that of female birds (74.59 ± 0.37 %). The crude protein % was higher in breast meat of male birds (83.90 ± 0.21) than that of female birds (81.93 ± 1.50). Crude fat% was significantly (P=0.001) lower in breast meat of male birds (1.04 ± 0.01) than that of breast meat of female birds (2.11 ± 0.05) Crude fiber content was lower in breast meat of male birds (0.44 ± 0.04 %) than that of female birds (0.77 ± 0.15 %). In contrast to that of the ash content in thigh meat, the total ash content and acid insoluble ash content in breast meat followed a reverse trend. The total ash % was 6.35 ± 0.13 and 5.70 ± 0.30 for male and female birds, respectively. Acid insoluble ash content was significantly (P<0.05) higher in breast meat of male birds (0.09 ± 0.01 %) than that of female birds (0.01 %). De Marchi et al. [5] studied the quality of breast meat of the Padovana breed, a native fancy bird of Italy. Poultry birds are slaughtered at 150 and 180 days of age. Percentage of moisture, proteins, lipids and ash were 75, 23, 1.5, and 1.2; respectively. The crude protein% and was crude fat% were found to be 82.68±2.00 and 6.90±02.80 in breast meat of desi birds of Pakistan [13].

Table 5: Proximate composition of breast muscle of indigenous dwarf chicken at 20 weeks of age

Parameters≠	Mean±SE		P Value
	Male	Female	
Moisture %	74.15 ± 0.55	74.59 ± 0.37	0.575
Crude protein %	83.90 ± 0.21	81.93 ± 1.50	0.323
Crude fat %	1.04 ± 0.01[b]	2.11 ± 0.05[a]	0.001
Crude fiber %	0.44 ± 0.04	0.77 ± 0.15	0.167
Crude ash %	6.35 ± 0.13	5.70 ± 0.30	0.185
Acid insoluble ash %	0.09 ± 0.01[a]	0.01 ± 0.00[b]	0.015

≠% as on dry matter except moisture

[a, b]Mean with different superscripts in a row differ significantly (P<0.05)

3.3.3 Comparison of chemical composition of thigh and breast meat

The results of proximate analysis in the present study clearly demonstrated that the breast and thigh muscles significantly differ in their nutritional composition (Table 6). Overall comparison of moisture between thigh and breast muscles revealed that there was higher percentage of moisture in thigh muscle than breast in male birds whereas in female birds, higher percentage of moisture was observed in breast muscle than thigh muscle. It was observed that there was high content of crude protein and low content of crude fat in breast meat than that of thigh meat in all birds (Table 5). The thigh meat contained 72.81± 4.49% protein and breast meat contained 82.92± 0.84% protein. Similar to the present findings, Ekka et al. [6] found 76.35±0.60% protein in thigh meat and 86.92±0.42% protein in breast meat of native Hansli birds. They have reported higher protein and lower fat content in both thigh and breast meat of Hansli birds than coloured broilers [6]. In the present study, the protein % is also higher and fat% is lower in the indigenous dwarf chicken than the values reported in commercial broilers [6, 13, 25] . The contents of proteins in breast and thigh muscles we determined agree with the results reported by Simeonovova et al. [30]. There was also higher percentage of crude fibre in thigh meat than breast meat in all birds. The crude ash analysis showed that breast contained higher ash contents than thigh in all birds. In contrast to the present findings, Zollitish et al. [39] demonstrated no difference of fat between both. Our results support the findings of other authors [6, 13, 15, 25, 35] who found differences between thigh and breast muscles.

Table 6: Comparison of proximate composition between thigh muscle and breast muscle of indigenous dwarf chicken at 20 weeks of age

Parameters≠	Mean±SE	
	Thigh	Breast
Moisture %	75.42 ± 1.02	74.37 ± 0.30
Crude protein %	72.81 ± 4.49	82.92 ± 0.84
Crude fat %	4.67 ± 0.62	1.57 ± 0.31
Crude fiber %	1.15 ± 0.19	0.61 ± 0.11
Total ash %	5.14 ± 0.36	6.02 ± 0.23
Acid insoluble ash %	0.08 ± 0.04	0.05 ± 0.02

≠% as on dry matter except moisture

4. Conclusions

This study provides a baseline data of egg and meat quality traits of an indigenous dwarf chicken population of Odisha. Crossing this dwarf chicken with other improved germplasm

can delay its age of sexual maturity which will result in better egg size and production. The indigenous dwarf chicken population, compared with the commercial broilers has an advantage in terms of meat quality traits such as high protein and low fat content which is better accepted by the consumers. Further, long term studies should be carried out on this dwarf chicken population.

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