Research Paper

Least square means and heritability estimates of egg quality traits in Aseel and Kadaknath chicken

Pallavi Rathi, Devender Singh Dalal, Chandrashekhar Santosh Patil*

Department of Animal Genetics and Breeding, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar-125004, Haryana, India

ABSTRACT

Egg quality parameters are crucial for the egg industry, as they influence grading, pricing, hatchability, and consumer preferences. To improve these traits, the poultry breeding industry is placing greater emphasis on genetic selection. Current study was undertaken to estimate the effect of non-genetic factors and estimation of genetic parameters of egg quality traits in two important Indian breeds Aseel and Kadaknath. Different parameters of external and internal egg quality were measured. Mean values for external characters of Aseel eggs viz., egg weight, shape index, albumen index, yolk index, shell weight and shell percentage were 44.76 g, 75.61%, 0.06%, 0.43%, 3.03 g and 8.8%, respectively and corresponding values for Kadaknath eggs were 40.54 g, 74.42%, 0.06% , 0.44%, 3.69 g and 10.67%, respectively. Yolk-Albumen Ratio, Haugh Unit were 0.71 and 72.42 for Aseel eggs and 0.71 and 72.47 for Kadaknath eggs, respectively. Heritability estimates for egg quality traits in both Aseel and Kadaknath breeds ranged from moderate to high indicating substantial potential for improving these traits through both individual and family selection methods.

Keywords: Chicken, Egg quality, Heritability

***Corresponding author:** dr.cspatil03@gmail.com

INTRODUCTION

The poultry sector is recognized as one of the fastest-growing industries and has undergone significant development in a short period. In developing nations such as India, backyard poultry farming is vital for economic progress, women empowerment, and food security (Kumar *et al.,* 2021a). Indigenous chickens, however, often receive less attention compared to commercial varieties due to their lower production performance (Tajane and Vasulkar, 2014). Nonetheless, backyard rearing of indigenous chickens, producing stress-free and residue-free birds, tends to fetch higher market prices for their eggs and meat compared to commercial products, offering economic advantages (Selvam, 2004). India boasts more than 20 poultry breeds (Panda and Praharaj, 2002), including notable indigenous breeds such as Aseel and Kadaknath, which are valued for their disease resistance, heat tolerance, and high-quality meat with distinctive taste and flavor (Rajkumar *et al.,* 2016). The Aseel breed, native to Andhra Pradesh, is celebrated for its vigor, royal demeanor, and exceptional stamina (Singh, 2001). Kadaknath chickens, popular among the tribals of Madhya Pradesh, are distinguished by their local adaptability, disease resistance, and unique meat flavor. Despite Kadaknath's less attractive appearance, its meat is highly regarded for its flavor (Panda and Mahapatra, 1989). Additionally, Kadaknath meat is notable for its black coloration due to high melanin content and its eggs have a high protein percentage (Mohan *et al.,* 2008a). Although Aseel and Kadaknath chickens are not prolific egg layers, they are known for their robustness and resilience in harsh conditions (Kumar *et al.,* 2021b). The rising interest in these indigenous breeds for backyard farming stems from their adaptability, hardiness, and the desirable quality of their meat and eggs.

Egg quality is crucial in the poultry industry, affecting consumer preferences, hatchability, and overall profitability. Key factors include shell strength, albumen quality, and yolk integrity, which are essential for embryo development and consumer acceptance (Stadelman, 1977; King'ori, 2012). The poultry breeding industry increasingly focuses on genetic selection to enhance egg quality traits (Bain, 2005). Environmental conditions such as temperature and management practices also influence egg quality (Sauter *et al.,* 1954; Washburn, 1979). Specifically, internal egg quality, including albumen thickness and yolk integrity, significantly impact both embryo development and consumer satisfaction (Narushin and Romanov, 2002; Sekeroglu and Altuntas, 2009). Given the importance of egg quality in backyard poultry farming, regular assessment of egg quality parameters is recommended to ensure the production of high-quality eggs (Sreenivas *et al.,* 2013). This study aimed to evaluate various external and internal egg quality parameters in Aseel and Kadaknath chickens.

Importance of genetic parameters in poultry breeding

Estimation of genetic parameters, such as heritability, genetic and phenotypic correlations is crucial for effective and successful breeding programs in poultry (Falconer & Mackay, 1996). These parameters provide valuable insights into the heritable nature of traits and the relationships between them.

Optimizing production traits

The aim of poultry breeding is to achieve optimal production parameters during the growth and laying periods. This involves traits related to meat production, egg production, or both. Knowledge of genetic parameters helps breeders select birds with desirable traits and create breeding strategies that maximize genetic progress over generations.

Impact on breeding strategies:

By understanding how traits are inherited (heritability) and how they interact (correlations), breeders can design targeted selection programs. Effective breeding strategies consider both genetic progress in the targeted trait and potential unintended consequences in correlated traits (Falconer and Mackay, 1996; Rajkumar *et al.,* 2018)

MATERIALS AND METHODS

The study followed standards guidelines approved by the Institutional Animal Ethics Committee (IAEC), LUVAS, Hisar.

Source of data

The relevant data for the present investigation was collected from Aseel and Kadaknath population, maintained at the poultry farm of Department of Animal Genetics and Breeding, LUVAS, Hisar. The chicks were brooded and reared hatch-wise. The progenies were produced in different hatches. All the chicks were pedigreed; wing banded at the time of hatching, and reared hatchwise using standard managemental practices. The chicks were vaccinated against Marek's disease, Ranikhet, Gumboro, and Fowl pox.

Considering the non-orthogonality of the data due to unequal sub-class frequencies, Least Squares Maximum Likelihood Computer Programme of Harvey (1990) was utilized to estimate the effect of various non- genetic factors on various traits and to estimate genotypic and phenotypic parameters. Sire and residual variance-covariance components for various performances traits was obtained by using least squares and maximum likelihood computer programme of Harvey (1990) using the following mixed model:

$$Y_{ijkl} = \mu + G_i + H_{ij} + S_{ik} + e_{ijkl}$$

Where, Y_{ijkl}, lth observation of kth sire of jth hatch of ith generation; μ, overall mean; G_i, fixed effect due to ithgeneration (i = 1, 2……g); H_{ij}, fixed effect due to jth hatch in ith generation (j = 1, 2…..h); S_{ik}, random effect due to kth sire in ith generation (k = 1, 2…….s) and e_{ijkl}, random error associated with each and every observation and assumed to be normally and independent distributed with mean zero and variance σ^2_e. Paternal half-sib correlation method was used to estimate heritability of the traits under study. The standard error of heritability was obtained from the formula given by Swiger *et al.,* 1964.

Traits to be studied

Egg quality traits

I.	Egg weight at 40week (g)	VIII.	Yolk weight (g)
II.	Specific gravity	IX.	Albumen weight(g)
III.	Shape Index (%)	X.	Shell weight (g)
IV.	Yolk color	XI.	Yolk percentage (%)
V.	Haugh unit score	XII.	Albumen percentage (%)
VI.	Albumen index (%)	XIII.	Percentage of shell (%)
VII.	Yolk index (%)	XIV.	Yolk to albumen ratio

Egg quality traits were calculated using the following standard procedures (Fayeye *et al.,* 2005). Egg weight was determined using an electronic scale, while egg length and width were measured with a Vernier Callipers. The weights of albumen, yolk and shell were recorded and expressed as gram.

Measurement of external parameters

A digital balance was used to weigh each egg to the nearest 0.01 g accuracy. A digital Vernier calliper was used to measure the length and width of the egg, and the shape index was calculated by multiplying the width to length ratio by 100. The inner shell membranes of the shells were removed and dried for 24 h in the open air so as to estimate the shell weight. All of the dried shells were weighed using a digital balance. Shell ratio was calculated by dividing shell weight by egg weight. The thickness of 4 portions of shells randomly were measured to the nearest 0.01 mm using screw gauze, one from each of the 2 ends (broad and narrow end) and 2 from the body of the eggs, and the average thickness was calculated. Yolk color was measured using DSM Yolk Color.

Measurement of internal parameters

A Vernier caliper was used to measure the length and width of the albumen and yolk in millimetres. Albumen height was measured randomly at 3 or 4 places and averaged.

Shape index: A Vernier calliper was used to measure the width and length of each egg. The shape index was calculated by ratio of maximum width and length of egg multiply by 100.

Shell thickness: After removing the shell membrane, the weight of the egg shell was measured using an electronic weighing balance. Screw Gauge was used to determine the thickness of the shell. Membrane-removed portions of shell were collected from 3 locations for this purpose, and the average shell thickness was used as the final reading.

Albumen index: With the aid of a Vernier Caliper, the maximum length and width of thick albumen were measured. Height of thick albumen was calculated between yolk and the outside border of thick albumen, avoiding chalaza. After correcting for the zero error on the plain glass plate, albumen height was measured with the assistance of a tripod spherometer with a least count of 0.001 mm. The albumen index was calculated by ratio of average height and width of albumen egg multiply by 100.

Yolk index: the yolk's height was measured using a tripod spherometer, and its width was measured using a Vernier calliper. The formula used to calculate yolk index was ratio of average height and width of yolk multiply by 100.

Haugh unit: The Haugh unit is the product of the log of albumin height and egg weight, and it is derived using Raymond Haugh's (1937) formula:

HU = 100 log (H – 1.7w 0.37 + 7.56)

where; H = Albumin Height(cm); W = Egg Weight(g).

RESULTS AND DISCUSSION

The analysis of variance and least squares means along with standard errors to identify the effect of non-genetic factors on the observed on egg quality traits are given in Tables 1, 2 and 3, respectively.

Effect of non-genetic factors:

Non-significant effect of hatch was seen on egg quality traits of both the breeds. Higher yolk index

Table 1: Analysis of variance (MSS) for testing the effect of sire and hatch on various egg quality traits of Aseel and Kadaknath

Source of variation	D f	Shape index	Albumen index	Yolk index	Shell weight	Yolk weight	Albumen weight	Albumen percent	Shell percentage	Specific gravity	Yolk albumen ratio	Haugh unit	Yolk color	Yolk percentage
							Aseel							
Sire	20	7.14	4.59	0.05	0.19	1.06	9.81	11.25	1.05	0.07	103.65	98.76	0.00009	7.54
Hatch	1	7.60	0.35	0.03	0.03	0.56	0.49	0.05	0.04	0.02	5.74	0.11	0.00011	0.16
Error	96	9.66	2.22	1.02	0.22	1.85	8.32	12.27	1.06	0.04	107.84	47.18	0.00005	9.07
							Kadaknath							
Source of Variation	**D f**	**Shape index**	**Albumen index**	**Yolk index**	**Shell weight**	**Yolk weight**	**Albumen weight**	**Albumen percent**	**Shell percentage**	**Specific gravity**	**Yolk albumen ratio**	**Haugh unit**	**Yolk color**	**Yolk percentage**
Sire	20	15.89	0.960	0.01	3746.40	18854.74	78037.97	12.321	0.54	1.66	113.57	24.30	0.56	15.42
Hatch	1	9.81	184.580	0.01	1763.26	122805.60	265518	8.22	0.30	1.23	1.08	5001.59	0.47	0.09
Error	107	14.60	1.334	0.01	2518.47	19681.61	84333.87	18.95	1.15	3.96	168.71	83405.75	0.70	16.15

and yolk percentage in the Kadaknath were observed, whereas the Aseel breed had a higher shape index, higher albumen index and higher yolk-to-albumen ratio, egg specific gravity and higher albumen and shell percentages. The least squares mean and standard error of various egg quality traits are presented in Tables 2 and 3 for Aseel and Kadaknath, respectively.

Table 2: Hatch-wise least-squares means of egg quality traits along with standard errors in Aseel

Trait	μ	Hatch 1	Hatch 2
Egg weight (40wk)g	44.76±0.21	43.21±0.35	44.06±0.12
Shape index (%)	75.61±0.32	75.29±0.38	75.93±0.56
Albumen index (%)	0.06±0.23	0.06±0.25	0.06±0.32
Yolk index (%)	0.43±0.01	0.44±0.01	0.45±0.01
Shell weight (g)	3.93±0.05	3.94±0.06	3.92±0.08
Yolk weight (g)	16.82±0.14	16.73±0.17	16.9±0.25
Albumen weight (g)	23.99±0.32	23.91±0.38	24.07±0.54
Albumen percentage (%)	53.51±0.36	53.49±0.43	53.54±0.63
Yolk percentage (%)	37.74±0.31	37.7±0.37	37.79±0.54
Shell percentage (%)	8.80±0.1	8.83±0.13	8.78±0.19
Specific gravity	1.06±0.03	1.06±0.03	1.06±0.04
Yolk –Albumen ratio	0.71±1.06	0.70±1.28	0.71±1.87
Haugh Unit	72.42±1.07	72.38±1.17	72.46±1.48
Yolk color	8.01±0.03	8.05±0.02	7.8±0.02

Table 3: Hatch-wise least-squares means of egg quality traits along with standard errors in Kadaknath

Trait	μ	Hatch 1	Hatch 2	Hatch 3
Egg weight (40wk)	40.54±0.3	39.59±0.47	41.49±0.43	40.49±0.13
Shape index (%)	74.42±0.36	74.72±0.53	74.12±0.49	73.12±0.29
Albumen index (%)	0.067±0.1	0.082±0.16	0.054±0.14	0.064±0.34
Yolk index (%)	0.44±0.01	0.45±0.02	0.43±0.12	0.43±0.12
Shell weight (g)	3.69±0.60	3.73±0.61	3.65±0.16	4.02±0.23
Yolk weight (g)	15.37±1.24	15.03±1.90	15.71±1.27	14.88±1.01
Albumen weigh t(g)	21.58±5.66	21.08±3.34	22.07±3.37	22.07±3.07
Albumen percentage (%)	53.16±0.38	52.88±0.59	53.43±0.55	53.40±0.52
Yolk percentage (%)	37.8±0.36	37.78±0.54	37.83±0.51	36.13±0.45
Shell percentage (%)	10.67±0.09	10.72±0.15	10.62±0.13	9.62±0.15
Specific gravity	1.05±0.03	1.04±0.23	1.06±0.25	1.05±0.42
Yolk –albumen ratio	0.71±0.15	0.71±0.17	0.71±0.16	0.69±0.16
Haugh unit	72.47±0.47	79.26±0.72	68.69±0.67	70.69±0.67
Yolk color	6.73±0.07	6.66±0.11	6.80±0.11	6.80±0.23

Heritability estimates for egg quality traits in Aseel and Kadaknath

Heritability estimate ranged from moderate to high for most of the of egg quality traits traits in Aseel and Kadaknath. Lowest heritability estimate was observed for yolk weight, 0.14±0.15 and albumen percentage 0.14±0.15 in Aseel and Kadaknath, respectively. High heritability estimates were observed for traits like albumen weight, albumen percentage, shell percentage, specific gravity, yolk albumen ratio, haugh unit and yolk colour viz., 0.52±0.24, 0.35±0.2, 0.43±0.21, 0.37±0.28, 0.38±0.21, 0.50±0.31, 0.5 3±0.31, respectively in Aseel. In Kadaknath, high heritability estimates were observed for shape index, yolk index, shell weight viz., 0.42±0.21, 0.44±0.21, and 0.64±0.25, respectively.

Table 4: Estimate of heritability along with their standard errors among various egg quality traits in Aseel and Kadaknath

Trait	Aseel	Kadaknath
Egg weight (40wk)g	0.12±0.14	0.11±0.14
Shape index (%)	0.22±0.18	0.42±0.21
Albumen index (%)	0.19±0.31	0.19±0.16
Yolk index (%)	0.23±0.18	0.44±0.21
Shell weight (g)	0.30±0.19	0.64±0.25
Yolk weight (g)	0.10±0.15	0.34±0.19
Albumen weight (g)	0.52±0.24	0.32±0.19
Albumen percentage (%)	0.35±0.2	0.01±0.11
Yolk percentage (%)	0.29±0.19	0.14±0.15
Shell percentage (%)	0.43±0.21	0.34±0.19
Specific gravity	0.37±0.28	0.01±0.11
Yolk –Albumen ratio	0.38±0.21	0.15±0.15
Haugh unit	0.50±0.31	0.24±0.17
Yolk color	0.53±0.31	0.28±0.18

Least-squares means of egg quality traits along with standard errors in Aseel and Kadaknath

The information on egg quality traits in Aseel and Kadaknath chickens is scanty due to less availability of eggs and low production potential of hens. Non-significant effect of hatch was seen on egg quality traits of both the breeds. Higher yolk index and yolk percentage in the Kadaknath were observed which is accordance to the established fact that the smaller the size of eggs, the higher will be the proportion of yolk and the smaller will be the proportion of albumen (Tharrington *et al.,* 1999) whereas the Aseel breed had a higher shape index, higher albumen index and higher yolk-to-albumen ratio and higher albumen percentage. Eggs from the Aseel breed had a higher specific gravity, indicating a better shell quality, and this was reflected in a higher percentage of shell weight. Similar results were observed by Singh *et al.,*(2000b), Ali and Anjum (2014) for shape index, Pandian *et al.,* (2011), Premavalli *et al.,* (2016) for yolk index, Pandian *et al.,* (2011), Rajkumar *et al.,* (2017) for albumen percentage, Sohail *et al.,* (2013) for Haugh unit score, Rajkumar *et al.,* (2017) for yolk color in Aseel. On the contrary higher estimates were observed by Pandian et al (2011), Haunshi et al (2011), Sohail *et al.,* (2013), Rajkumar *et al.,* (2017) for shape index, Pandian *et al.,* (2011), Premavalli *et al.,* (2016) for albumen index, Haunshi *et al.,* (2013) for yolk index, Haunshi *et al.,* (2011) for albumen weight, yolk weight. The overall value of these parameters reported in our study was not very high as compared to previous studies, which may be reduced as age of the bird advances (Niranjan *et al.,* 2008; Rajkumar *et al.,* 2010). Pandian et al., (2011) observed higher specific gravity than the present study in Aseel. Higher shape index in the present study indicates more uniform egg shape and size while lower albumen weight was due to the lower egg weights observed in the present study. Chatterjee *et al.,* (2007) and Pandian *et al.,* (2014) observed similar values for shell weight, albumen percentage, shell percentage, haugh unit score. Higher haugh unit score was observed by Usman *et al.,* (2014). Similar results were observed by Jaishankar *et al.,* (2020) for shape index, Haunshi *et al.,* (2013) for yolk index and Parmar *et al.,* (2006) for haugh unit score. On the contrary higher values were observed by Jaishankar *et al.,* (2020) for albumen index, yolk index, albumen weight, yolk weight, shell weight, albumen percentage, yolk percentage, shell percentage and haugh unit score for Kadakanth.

Heritability estimate of egg quality traits in Aseel and Kadaknath

Heritability estimate ranged from moderate to high for most of the of egg quality traits in Aseel and Kadaknath. Lowest heritability estimate was observed for yolk weight, 0.14±0.15 and albumen percentage 0.14±0.15 in Aseel and Kadaknath. High heritability estimate was observed for traits albumen weight, albumen percentage, shell percentage, specific gravity, yolk albumen ratio, haugh unit and yolk color viz.,0.52±0.2 4,0.35±0.20,0.43±0.21,0.37±0.28,0.38±0.21, 0.50±0.31, 0.53±0.31 in Aseel. In Kadaknath highest heritability estimates were observed for Shape Index, Yolk Index, Shell Weight viz., 0.42±0.21, 0.44±0.21, 0.64±0.2. Zhang et al (2005) observed higher estimates of heritability of albumen weight, egg shell index, egg shell thickness, egg shell weight, egg weight, haugh units, and yolk weight. Higher estimates of heritability were observed by John-Jaja *et al.,* (2018) for shape index in exotic laying chicken. Alipanah *et al.,* (2013) also observed higher heritabilities of albumen weight, yolk color, egg shell index, shell weight, egg weight, haugh units, and yolk weight which were 0.61, 0.19, 0.30, 0.54, 0.50, 0.46, and 0.32, respectively.

CONCLUSION

Data must be standardized for various performance traits to nullify the effect of non-genetic factors. Moderate to high estimates of heritability for various performance traits indicated that enough scope exists for the improvement of these traits through individual as well as family selection. The results of this study will assist poultry breeders to identify superior quality eggs for breeding and improvement in next generation and selecting high-quality eggs for consumption.

ACKNOWLEGEMENT

The authors are indebted to the Vice Chancellor, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana for providing the required infrastructure facilities.

REFERENCES

Alipanah M, Deljo J, Rokouie M, and Mohammadnia R. 2013. Heritabilities and genetic and phenotypic correaltions of egg quality traits in Khazak layers. *Trakia J. Sci,* 2:175-180.

Ali A and Anjum R. 2014. Evaluation of egg quality traits among different breeds/strains of chicken locally available in Pakistan. Scientific. *J. Ani. Sci,* 3(1):27-34.

Bain MM. 2005. Recent advances in the assessment of egg shell quality and their future application. *Worlds Poult. Sci. J,* 61:268–277.

Chatterjee RN, Sharma RP, Reddy MR, Niranjan M, and Reddy BLN. 2007. Growth, body conformation and immune responsiveness in two Indian native chicken breeds. *Livest. Res. Rural,* 19(10):37.

Falconer DS, and *Mackay*, TFC. *1996.* Introduction to Quantitative Genetics. 4th Edition, Addison Wesley Longman, Harlow.

Fayeye TR, Adeshiyan AB, and Olugbami AA. 2005. Egg traits, hatchability and early growth performance of the Fulani ecotype chicken. *Lives. Res. Rural. Dev,* 17(8):1-7.

Harvey WR. 1990. Mixed model least squares and maximum likelihood computer program, January.

Haugh RR. 1937. The Haugh unit for measuring egg quality. *US. Egg. Poult. Mag,* 43: 522-555.

Haunshi S, Niranjan M, Shanmugam M, Padhi MK, Reddy MR, Sunitha R, and Panda AK. 2011. Characterization of two Indian Native chicken breeds for Production, Egg and Semen quality, and Welfare Traits. *Poultry Science,* 90(2):314-320.

Haunshi S, Padhi MK, Niranjan M, Rajkumar U, Shanmugam M, and Chatterjee RN. 2013. Comparative evaluation of native breeds of chicken for persistency of egg production, egg quality and biochemical traits. *Indian J. Anim. Sci,* 83(1): 59-62.

Jaishankar S, JyothiPriya R, Sheeba A, and Ilavarasan S. 2020. Productive and Reproductive Performance of Kadaknath Chicken under Semi-intensive System*. Int. J. Curr. Microbiol. App. Sci,* 9(4):513-517.

John-Jaja SA, Abdullah AR, and Nwokolo SC. 2018. Heritability estimates of external egg quality traits of exotic laying chickens under the influence of age variance in the tropics. *J. Saudi Soc. Agric. Sci*, 17(4):359-364.

King'ori A. 2012. Poultry egg external characteristics: egg weight, shape and shell colour. *Res. J. Poult. Sci*, 5:14–17.

Kumar M, Dahiya SP, and Ratwan P. 2021. Backyard poultry farming in India: a tool for nutritional security and women empowerment. *Biol. Rhythm Res*, 52:1476-1491.

Mohan J, Sastry KVH, Moudgal, RP, and Tyagi JS. 2008. Performance profile of Kadakanathdesi hens under normal rearing system.*Indian J. Poult.Sci***,** 43(3):379-381.

Narushin VG, and Romanov MN. 2002. Egg physical characteristics and hatchability.*Worlds Poult. Sci. J*, 58:297-303.

Niranjan M, Ramachandran KS, and Ramesh KV. 2008. Studies on Egg Quality Traits in Commercial Layers.*J. Appl. Poult. Res,* 17(3):321-326.

Panda B, and Praharaj NK. 2002. Conservation of indigenous chicken germplasm in India: Past, present and future scenario. Proceedings of National Workshop on characterization and conservation of indigenous poultry germplasm, CARI, Port Blair, Andaman, India. 17-27.

Panda B, and Mahapatra SC. 1989. Common breeds of poultry in Poultry Production. ICAR, New Delhi, India.6-18.

Pandian C, Kumaravelu N, Sundaresan A, Rajendran R, Babu M, Thyagarajan D, and Prabakaran R. 2011. Evaluation of Egg Quality Traits of Chicken Reared Under Intensive System of Management. XXVII Annual Conference and National

Symposium of Indian Poultry Science Association, Poultry Products Technology, Economics and Marketing.

Parmar SNS, Thakur MS, Tomar SS, and Pillai PVA. 2006. Evaluation of egg quality traits in indigenous Kadaknath breed of poultry. *Livest. Res. Rural Dev*, 18(132).

Premavalli K, Omprakash AV, Sangilimadan K, Ashok A, Rajendra R, Thyagarajan, and Babu M. 2016. Egg quality traits of different Native chickens Reared under Intensive system in Tamil Nadu. *Indian Vet. J*, 93(06).

Rajkumar U, Reddy BLN, Rajaravindra KS, Niranjan M, Bhattacharya TK, Chatterjee RN, Panda AK, Reddy MR and Sharma RP. 2010. Evaluation of Naked neck broiler genotypes under tropical environment.*Indian J. An. Sci*, 80: 463–67.

Rajkumar U, Haunshi S, Paswan C, Raju, MVLN, Rama Rao SV, and Chatterjee RN. 2016. Comparative evaluation of carcass traits and meat quality in native Aseel chickens and commercial broilers.*Br. Poult. Sci*, 57:339-347.

Rajkumar U, Haunshi S, Paswan C, Raju MVLN, Rama Rao SV, and Chatterjee RN. 2017. Characterization of indigenous Aseel chicken breed for morphological, growth, production, and meat composition traits from India. *Poult. Sci*, 96(7):2120-2126.

Rajkumar U, Padhi MK, Haunshi S, and Chatterjee RN. 2018. Genetic and Phenotypic response in PD-1 (Vanraja Male line) line chicken under short term selection experiment. *Indian J.Anim. Sci,* 86:1287-1296.

Sauter EA, Homs JV, Stadelman WJ, and Melaren BA.1954. Seasonal variation in quality of eggs measured by physical and functional properties. *Poult. Sci*, 33:519-524.

S Selvam. 2004. An economic analysis of free-range poultry rearing by rural women. *Indian J. Poult. Sci*, 39:75-77.

Şekeroglu A, and Altuntaş E. 2009. Effects of egg weight on egg quality characteristics. *J. Sci. Food Agric.,* 89:379-383.

Singh DP. 2001. Aseel of India.In: Proc. of the National Seminar on Appropriate Poultry for Adverse Environment, Hyderabad, India, 96– 100.

Singh M, Singh U, and Ourung BS. 2000. Evaluation of egg weight and its various measurements to attributes in indigenous Aseel breed of chicken. *Indian J. Poult. Sci*, 35(3):312-314.

Sohail A, Muhammad A, Hussain J, Iqbal A, Usman M, Rehman A, and Hussnain F. 2013. Comparative study on productive performance, egg quality, egg geometry, and hatching traits of three age groups of indigenous Peshawari Aseel chickens. *J. Vet. Adv*, 2(2):21-25.

Sreenivas D, Manthani GP, Mallam M, and Chatterjee R. 2013. Genetic analysis of egg quality traits in White Leghorn chicken. *Veterinary World,* 6:263-266.

Stadelman WJ. 1977. Quality identification of shell eggs Egg Science and Technology (2nd ed.), AVI Publishing Company Inc, Westport, CT.

Swiger LA, Harvey WR, Everson DO, and Gregory KE. 1964. The variance of interclass correlation involving groups with one observation. *Biometrics,* 20:818-826.

Tajane SB, and Vasulkar R. 2014. Development of rural backyard poultry. *Poultry Punch,* 30:30–35.

Tharrington JB, Akin RB, McDaniel CW, and Parks CR. 1999. Effect of Egg Size on the Proportions of Yolk and Albumen in the Egg of the Kadaknath Hen. *Poult Sci,* 78(3): 489-492.

Usman M, Bashir A, Akram M, Zahoor I, and Mahmud A. 2014. Effect of age on performance, Egg geometry and Quality traits of Lakha Variety of Aseel Chicken in Pakistan. *J. Basis Appli. Sci,* 10(1):384-386.

Washburn KW. 1979. Genetic variation in the chemical composition of egg, *Poultry Science*, 58(3):529-535,

Zhang LC, Ning ZH, Xu GY, Hou ZC, and Yang N. 2005. Heritabilities and Genetic and Phenotypic Correlations of Egg Quality Traits in Brown-Egg Dwarf Layers. *Poult. Sci*, 84:1209-1213.