INFLUENCE OF GENOTYPES ON REPRODUCTIVE AND EGG QUALITY TRAITS OF GRAMAPRIYA AND ITS CROSSES WITH DESI CHICKEN OF BIHAR

THESIS

SUBMITTED TO THE

BIHAR AGRICULTURAL UNIVERSITY

(FACULTY OF VETERINARY SCIENCE)

SABOUR (BHAGALPUR) BIHAR

IN PARTIAL FULFILLMENT OF THE REQUIREMENT

FOR THE DEGREE OF

MASTER OF VETERINARY SCIENCE

(Animal Genetics and Breeding)

By

DR. MD. SAMEER ALAM

Registration No. M/AGB /138/BVC/2013-14

Department of Animal Genetics and Breeding

BIHAR VETERINARY COLLEGE, PATNA-14

(BIHAR)

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2015

DEPARTMENT OF ANIMAL GENETICS AND BREEDING
BIHAR VETERINARY COLLEGE, PATNA - 14
Bihar Agricultural University, Sabour (Bhagalpur)

CERTIFICATE - II

We, the undersigned members of the Advisory Committee of **DR. MD. SAMEER ALAM,** Registration No. **M/AGB/138/BVC/2013-14**, a candidate for the Degree of Master of Veterinary Science with major in **Animal Genetics and Breeding** have gone through the manuscript of the thesis and agree that the thesis entitled " **Influence of genotypes on reproductive and egg quality traits of Gramapriya and its crosses with Desi chicken of Bihar** " may be submitted by **DR. MD. SAMEER ALAM** in partial fulfillment of the requirements for the degree.

13.08.2015

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DEDICATED TO

My Dear reverend parents, teachers and those who loves me.

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Place: Patna

Date: 13/08/15

Md. Sameer Alam

(Md. Sameer Alam)

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INTRODUCTION

Poultry production in India has emerged as a fast growing sector among various livestock based vocations as evident from its transformation from traditional backyard system of rearing to organised commercial farming over the last four decades. This sector comprises of low to medium and high input/output systems of rearing and is providing employment to over 7 million people, apart from household income and nutritional security of numerous small poultry keepers in rural and tribal areas of the country. It contributes about 0.5% to the national GDP and about 10% to the livestock GDP. Technological support is, therefore, crucial for the sustained growth of poultry sector. Improved varities of chicken and their crosses need to be introduced and propagated in the rural India to improve the national production.

According to Bihar Basic Animal Husbandry Statistics 2014, poultry population in Bihar estimated to be 14 million and ranked 6th among other states of India. In egg production its rank is 15th and in per capita availability of eggs it is 26th in position and only 8 eggs/ head/annum is available whereas Andhra Pradesh and Tamil Nadu are leading in egg production. Therefore Bihar is egg deficient state and there is great need to increase egg production to cope up with its increasing demand with rapid growth in human population.

Thus above relevant data seems to encourage research workers to do a lot of work for egg production in the state. The number of eggs produced should not be the only criteria but due emphasis should also be given to the egg weight and other egg quality traits too. For example a good internal egg quality can stand preservation better than the poor quality and good external quality egg ensures a good percentage of hatchability, its transportation to the wider area and thus making poultry industry a profitable enterprise. The evaluation of external and internal quality of the egg is essential as consumers prefer better quality eggs. Stadelman (1977) described egg quality as the characteristics of an egg that affects its acceptability to the consumers. And also the success of poultry farming in backyard largely depends upon egg quality. But egg quality traits are greatly influenced by the factors like breed, strain, variety, temperature, relative humidity, rearing practices and season (Sauter *et al.*,1954;Washburn, 1990). The increase production is needed to be supplemented with evaluation of the fertility and hatchability traits of improved breeds suitable for backyard farming.

Gramapriya breed of chicken is newly introduced breed and performance of this breed is very little known in Bihar, Fertility and hatchability are two very important traits and theses traits are determined by many factors such as breed, age, quality of egg, egg storage time and environmental conditions. In most cases, they are related to inadequate incubation technologies rather than the poor egg quality. However, in order to increase overall incubation results, an improvement in incubation technologies must be accompanied by an improvement in the quality of hatching eggs. Aim of this study is to observe the breed effect on the fertility and hatchability in Gramapriya breed of chicken. Gramapriya is a breed of chicken developed by the Directorate on Poultry Research, Rajendra Nagar, Hydrabad. Gramapriya starts laying eggs at an age of 175 days. In 72 weeks a Gramapriya chicken can lay 200-210 eggs.

Gramapriya is a crossbreed chicken developed at Hyderabad under All India Co-ordinated Research Project. Gramapriya chicken have been developed for backyard poultry keeping. They have a high favourability rating among farmers in India. Both internal and external qualities of eggs are important for hatchability and fertility. Success of poultry industry largely depends on egg quality traits which are important economic traits.

Therefore, keeping in view the above facts the present study was undertaken for genetic improvement of desi birds after crossing with improved variety like Gramapriya chicken with the following objectives:

OBJECTIVE

- To estimate the mean, standard error and coefficient of variation percentage of fertility, hatchability, egg production, egg weight and egg quality traits.
- To study the effect of various genetic groups on fertility, hatchability, egg production, egg quality traits and egg weight.
- To study the effect of egg weight on egg quality traits.
- To estimate coefficient of phenotypic correlation among various egg quality traits and egg weight in different genetic groups.

REVIEW OF LITERATURE

REVIEW AND LITRATURE

Egg weight

The number of eggs laid by a bird is not the only criterion to be considered in breeding for egg production. Emphasis must also be given to egg size since it adds equally well to the economics of production. Campos *et al.* (1964) reported that egg weight can be taken as a selection criterion for improving the internal egg quality as its genetic association may be established with the external egg quality traits.

The effect of breed and strain differences on egg weight in chicken has been reported by many workers.

Singh *et al.* (2000) studied the egg weight of indigenous breed like Assel and Naked Neck and compared with the exotic breeds like Dahlem Red and reported significant breed differences for this trait at the age of first egg laid, 40^{th} and 64^{th} weeks of age. The direct crosses of Dahlem Red with Aseel and Naked Neck reported to have significantly heavier egg weight than reciprocal crosses at all the ages.

Devi *et al* .(2005) observed that egg weight in two purelines of WLH strains and 2-way,3-way breed crosses at 28^{th} wk to be ranged from -49 to 53 g and at 40^{th} wk to be ranged from 54.75 to 61 g. Egg weight of crosses were reported to be higher than purebreds.

Parmer *et al.* (2006) and Singh *et al.* (2000) reported lower egg weights in kadaknath to be 40.87 to 45.141 g and in Aseel 41 g under field condition.

Niranjan *et al.* (2008) reported that the average egg weight ranged from 50.94 g in Gramapriya to 52.97 g in Vanaraja . During the early production (24th wk), c_1 and c_2 recorded significantly ($P<0.01$) higher egg weights than Vanaraja and Gramapriya. The authors reported that rural crosses were as good as the exotic varieties/strain which might be due to utilization of exotic germplasm for the development of rural varieties (Sharma *et al.,* 2006).

Zita *et al.* (2009) reported that the egg weight increased with the advancement of age of layer's stain in all genrtic groups.

Islam and Dutta (2010) revealed that the gross egg weight differed significantly ($P<0.001$) among the genetic groups of chicken where RIR had the highest egg weight and Fayoumi did not differ statistically from desi, exotic and crossbreds.

Mohanty *et al.* (2011) reported significantly lower average egg weight (30.79 g) of native fowl followed by Vanaraja, Aseel, Kadaknath, Dahlem Red, RIR, Red Cornish, Charbro , Black rock at 25th week of age . Egg weights were not reported to be significantly different between the breeds except meat type chicken but significant ($P<0.01$) difference were reported among the varieties. However, the author reported that the egg weights of all the genetic groups under this study gradually increased as age advances.

Padhi *et al.* (2013) studied egg weight of Vanaraja birds at 28^{th}wk, 40^{th} wk, 52^{nd} wk, 64^{th} wk and 72^{nd} wk of age and reported significant ($P<0.05$) difference between different age groups and the egg weight reported to be increased as the age of measurement increases.

Jha and Prasad (2013) reported that the average estimate of egg weight in improved varieties like Vanaraja and Gramapriya at 40^{th} wk of age were 53.98 and 54.23 g respectively which was higher than the eggs laid by Aseel birds (42.38 g).

Table -1 Estimates of average egg weight of chicken as reported in literature.

Breed/strain	No. of obs.	Mean	Reference
New Hampshire	92	55.66	Sapra & Aggarwal (1971)
White Plymouth Rock	85	57.39	,,
White Cornish	75	55.51	,,
Desi	85	40.78	,,
Aseel	25	52.80	,,
Kadaknath		40.87-45.41	Parmer *et al.*(2006)
Aseel		41	,,
C_1 cross(at 24^{th}	461	46.1	Niranjan *et*

wk)			*al.*(2008)
C_2 cross	461	46.8	,,
Vanaraja	461	45.3	,,
Gramapriya	461	45.0	,,
Desi	50	40.04	Islam and Dutta (2010)
Exotic (fayomi ,RIR)	50	46.80	,,
RIR X Fayomi	50	56.5	,,
Local fowl	100	30.79	Mohanty *et al.*(2011)
Aseel	12	38.96	,,
Kadaknath	12	39.94	,,
Black rock	10	48.72	,,
Red Cornish	12	43.93	,,
RIR	15	43	,,
Dahlem Red	10	43	,,
Local germplasm Vanaraja	15	36.19	,,

Chabro	15	47.57	,,
Vanaraja	40	47.60	Padhi *et al.*(2013)
At ASM			Jha and Prasad (2013)
Vanaraja		43.15	,,
Gramapriya		38.78	,,
Aseel		32.84	,,

Egg length and egg width

Kumar and Kapri (1966) stated that egg quality is under genetic control and genetic improvement is possible by selection and breeding. They reported that the egg width is more constant in dimension than egg length.

Singh *et al.* (1981) reported that birds produce lesser number of eggs generally have wider and heavier eggs than those producing large number of eggs because of negative correlation between egg number and egg weight. They also reported the existence of significant difference between line crosses for egg width only but not for egg length. They stated that difference in egg weight between the groups was mainly due to egg width.

Niranjan *et al.* (2008) reported that significant breed differences for egg length and egg width .The Vanaraja (53.0mm) birds were reported to have significantly higher egg length than C_1, C_2 cross and Gramapriya, whereas Gramapriya (42.0mm) birds were reported to have significantly higher egg width than C_1, C_2 and Vanaraja.

Islam and Dutta (2010) also reported that the significant breed differences for egg length and egg width. The RIR birds reported to have significantly ($p<0.05$) higher egg length and width than indigenous, exotic and crosses.

The average length and width of chicken eggs reported in available literature is presented in Table-2.

The average length of eggs reported to be ranged from 35.51 mm in Desi breed to 57.8 mm in RIR. The average width of the egg reported to be ranged from 37.1 mm in Desi to 44.3 mm in RIR.

Table – 2 Estimates of average egg length and egg width in chicken as reported in literature.

Breed/strain	No. of obs. (n)	Egg length (mm)	Egg width (mm)	Reference
Desi	85	35.51	39.46	Sapra and Aggarwal (1971)
Black Bengal	68	54.86	39.75	,,
Aseel	25	54.60	41.44	,,
Naked Neck	24	54.33	40.17	,,
New Hampshire	92	57.55	41.54	,,
White Plymouth Rock	85	57.56	42.28	,,
White Cornish	77	56.40	41.71	,,
C 1 cross	461	53.8	41.9	Niranjan *et al.* (2008)
C 2 cross	461	53.6	41.2	,,
Vanaraja	461	54.5	41.4	,,

Gramapriya	461	54.0	42.0	,,
Indigenous	50	48.3	37.1	Islam and Dutta (2010)
Broiler	50	56.9	42.2	,,
Fayomi	50	47.7	37.2	,,
RIR	50	57.8	44.3	,,
RIR X Fayomi	50	54.6	41.2	,,

Shape index

Shape is one of the most important characters of eggs, large deviations from the normal shape increase the tendency towards breakage and to reduce hatchability. Egg shape typically oval in shape. Elliptical, biconical, conical, round and other abnormal shapes occasionally occur. Experimentally, this trait is usually defined by an index which is expressed as 100 times the maximum width divided by maximum length.

It has been observed from the literature that shape of an egg is characteristic of an individual hen. Curtis (1914) was probably the first to report individual variation in egg shape and found this trait to be more variable than the egg weight. In the inheritance of egg shape, neither the round eggs nor the long eggs appear to possess a clear cut dominancy. If dam and sire's dam lay eggs of identical type the progeny also lay eggs of the same shape. However, when parents are derived from strains which produce the extremes of egg shape, the eggs of offspring are intermediate in shape (Banjaminn, 1920). They were also of the opinion that the response to selection for the desirable ovoid shape of the eggs is rapid and marked progress can be achieved within two generations. Marbal (1943) established two strains characterized by round and long eggs. After three generations of selection the two strains were crossed to obtain two F_1 populations. These birds laid eggs of intermediate in shape. Back cross between the F_1 and each parental strain gave pullets which produced eggs of intermediate in shape between the F_1 and the strain concerned. Romanoff and Romanoff (1949) studied the shape index in White Leghorn birds. They also reported that individual hen lays eggs that were more or less uniform in colour and shape.

Chatterjee *et al.* (2006) observed higher shape index, (80.76) for IWK and lower indices for IWI (73.77) and IWH (72.67) strains of White leghorn.

Parmer *et al.* (2006) reported lower shape indices (74.35) in Kadaknath.

Niranjan *et al.* (2008) reported that average shape index in Vanaraja birds to be ranged from 76.18 to 78.13 in C_1 cross. The shape index of C_1 cross was reported to be significantly ($p<0.01$) higher than the other three crosses at 24 weeks of age. At 40 weeks of age C_1 cross reported to have significantly higher (78.88) shape index and Vanaraja had significantly lower (75.67) shape index. The authors did not found significant difference between C_1 cross and Gramapriya for shape index.

Zita *et al* .(2009) reported higher shape indices at early age of laying in all genotypes i.e ISA Brown (78.52), Hisex brown (78.94) and Moravia BSL (78.76) whereas lower shape indices in later weeks of laying that is 75.09, 75.34 and 76.59 in ISA Brown, Hisex brown and Moravia BSL respectively.

Islam and Dutta (2010) demonstrated that the egg shape index of the five chicken breeds was in the following order Fayoumi> Indigenous> RIR> Sonali> Cobb500.

Mohanty *et al* .(2011) studied the shape index and the highest shape index was recorded in eggs of Dahlem Red at 25 weeks of age and Vanaraja at 74 weeks of age (77.80). They reported that shape index did not vary significantly among the genetic groups. However, in native variety it was reported to be significantly lower than the eggs of improved variety birds .

Jha and Prasad (2013) reported that the mean shape index in Vanaraja and Gramapriya were observed to be 74.24 and 74.17 respectively at 40 weeks of age. Shape index in Aseel birds reported to be 73.56 and Parmer *et al* . (2006) reported the average shape index of 73.95 in Kadaknath breed under free range conditions.

Padhi *et al.* (2013) reported no significant effect of age of measurements on shape indices in Vanaraja birds.

The estimates of shape index in different breeds of chicken, their strains and strain crosses as reported in the available literature are presented in table-3.

Among the pure breeds the mean shape index in poultry reported to be ranged from 59.15 in Local Fowl to 87.23 in Dahlem Red (Mohanty *et al.*, 2011). However, the value of shape index is reported to be ranged from 74.24 to 77.45 in Vanaraja birds.

Table -3 Average estimates of shape index in chicken eggs as reported in literature.

Breed/strain	No. of obs.	Mean	Reference
WLH		72.52	Sakuntala devi and Reddy (2004)
WL Strain IWI	-	73.77	Chatterjee *et al.*(2006)
WL Strain IWH	-	72.67	,,
WL Strain IWk		80.76	,,
C1 cross	461	78.1	Niranjan *et al.*(2008)
C 2 cross	461	77.1	,,
Vanaraja	461	76.2	,,
Gramapriya	461	78.0	,,
ISA Brown		75.09 to 78.52	Zita *et al.* (2009)
Hisex Brown		75.34 to	,,

		78.94	
Moravia BSL		76.59 to 78.76	,,
Local fowl		59.15	Mohanty *et al* .(2011)
Aseel		78.84	,,
Kadaknath		76.33	,,
Black rock		80.05	,,
Red Cornish		73.95	,,
RIR		78.23	,,
Dahlem red		87.23	,,
Chabro		79.75	
Vanaraja			Padhi *et al*.(2013)
28th wk		76.49	,,
40th wk		75.29	,,
52nd wk		75.57	,,
64th wk		76.00	,,
72nd wk		77.45	,,
At 40th wk			

Vanaraja		74.24	Jha and Prasad (2013)
Gramapriya		74.17	”
Aseel		73.56	”

Shell thickness :

Since shell thickness of the individual hen's egg is a manifestation of her calcium metabolism, then the relative efficiency in assimilating and secreting calcium and other materials involves in shell formation apparently comes under hereditary control to some extent. Breed and family differences as well as lines difference in shell thickness may be established by selection (Taylor and Lerner, 1939; Quinn *et al.*, 1945).

In an experiment on egg quality traits of Gramapriya , Patel (2013) observed non-significant effect of genetic groups on the average value of shell thickness. However it was reported to be thinner in backyard system (0.34) followed by semi intensive (0.35) and deep litter (0.36) system of management.

Devi *et al.* (2005) reported the shell thickness of two WLH strain and two bred crosses within the range of normal values that is 0.36, 0.36, 0.40 and 0.39 in IWD, IWF, 3-WAY and 2-WAY respectively.

Niranjan *et al.* (2008) reported that the shell thickness varies significantly ($p<0.01$) among different genetic groups. Gramapriya and C_2 reported to have similar shell thickness without any significant variation.

The egg shell thickness was more in C_1(0.40mm) and less in Gramapriya (0.394mm).The egg shell of C_1 cross reported to be significantly ($p<0.01$) thicker than the other three crosses at 24th weeks of age. Vanaraja birds reported to have better shell thickness at 32 weeks of age whereas C_1 and C_2 crosses were reported to have significantly thicker shell than the other two crosses.

Zita *et al.* (2009) reported significant difference between genetic groups in egg shell quality. Interaction between genotype and age of hens was also reported in all egg shell quality characteristics. The eggs of ISA Brown reported to have significantly ($p<0.001$) thicker egg shell than the other genotypes in all age groups.

Mohanty *et al.* (2011) reported that the average shell thickness did not vary significantly between the genetic groups and native variety birds at all ages. However the higher shell thickness helps in preventing the damage during handling.

Jha and Prasad (2013) reported the mean shell thicknesses ranging from 0.31 to 0.38mm with an average of 0.35mm in Vanaraja, 0.32mm in Gramapriya and 0.36mm in Aseel eggs.

Padhi *et al.* (2013) reported that shell thickness differ significantly ($p<0.05$) between different age of measurement. The shell thickness was reported to be higher at 52 and 72 weeks of age as compared to other age of measurement . It was reported that egg shell thickness increases with the advancement of age.

Sreenivas *et al.* (2013) reported significant differences in egg shell thickness among different strains of White Leghorn and control. The shell thickness reported to be ranged from 0.336mm in IWH to 0.376mm in IWI strain.

The average shell thickness of different breeds of chicken as reported in the literature is presented in table -4.

Table -4 Estimates of average shell thickness (mm) in chicken egg as reported in literature.

Breed/strain	Mean	Reference
White Leghorn		Devi *et al.*(2005)
IWD	0.36	,,
IWF	0.36	,,
C1 cross	0.40	Niranjan *et al*(2008)
C2 cross	0.39	,,
Vanaraja	0.38	,,
Gramapriya	0.39	,,
Brown layer strain		Zita *et al.*(2009)
ISA	0.37	,,
Hisex	0.35	,,
Moravia	0.32	,,

Aseel	0.34	Mohanty *et al.* (2011)
Kadaknath	0.41	,,
Black rock	0.35	,,
Red Cornish	0.39	,,
RIR	0.39	,,
Dahlem red	0.41	,,
Rural germ plasm Vanaraja	0.43	,,
Chabro	0.47	,,
IWH	0.336	Sreenivas *et al.* (2013)
IWI	0.376	,,
IWK	0.362	,,
WL control	0.365	,,
Vanaraja		Padhi *et al.*(2013)
28th wk	0.34	,,
40th wk	0.34	,,
52nd wk	0.37	,,
72nd wk	0.38	,,

The mean shell thickness reported to be ranged from 0.33 to 0.37 mm in White Leghorn and 0.33 to 0.39 mm in Rhode Island Red. The average shell thickness in Vanaraja reported to be ranged from 0.38 to 0.43mm and in Gramapriya 0.39mm.

Shell weight :

With eggs of same size, younger hens tend to lay eggs with a greater percentage of shell, however, the shell quality of individual hen tends to maintain its relative position with respect to shell quality of other hens throughout the laying period (Marion *et al.*, 1964).

Padhi *et al.*(1998) studied shell weight in different breeds like Nicobari, Nacked Neck and White Leghorn and reported that the breeds had no significant effect on shell weight.

Devi *et al.* (2005) observed 6.0, 5.6, 6.0 and 4.4 g shell weight in different strains of White Leghorn and breed crosses like IWD, IWF, 3-WAY AND 2-WAY respectively.

Chatterjee *et al.* (2007) also reported the non significant effect of breed on shell weight for six indigenous breeds from Andaman.

Niranjan *et al.* (2008) reported that shell weight significantly affected by genetic groups at 24^{th}, 32^{nd} and 40^{th} weeks of age. The shell weight reported to be ranged from 5.24g in C_2 to 5.28g in Vanaraja. Shell weight was reported to be significantly higher in C_1 and C_2 crosses at 24 weeks of age whereas in C_1, C_2 and Vanaraja at 32 weeks and 40 weeks of age respectively.

Zita *et al.* (2009) observed highly significant interaction ($P < 0.0001$) in egg shell quality so as in shell weight. ISA Brown reported to have the highest shell weight in all the age groups and in all genotypes whereas Moravia BSL had the lowest shell weight.

Mohanty *et al.* (2011) reported that the shell weight varied significantly ($p<0.01$) between local fowl and other genetic varieties at 25th week of age. The lowest shell weight (5.02g) was reported in local native fowl. Significant ($p<0.01$) variation was also reported at 54 and 74 weeks of age between the genetic groups and local fowl. The average shell weight in non descriptive variety was reported to be significantly ($p<0.01$) lower than other established breeds at all ages.

Padhi *et al.* (2013) reported significant ($P<0.05$) effect of age on shell weight in Vanaraja. It was reported that as the age increases the shell weight also increases.

Sreenivas *et al.* (2013) reported significant differences in shell weight for different strain of White Leghorn and control. The highest shell weight was reported in IWK strain (5.12g) and lowest in IWH strain (4.32g).

The mean values of shell weight of different breeds of poultry available in the literature are presented in table-5.

Table -5 Estimates of average shell weight (g) and percent shell in chicken as reported in literature.

Breed/strain	Mean	Reference
Shell Weight (g)		
White Leghorn strain		Devi *et al.*(2005)
IWD	6±0.03	,,
IWF	5.6±0.01	,,
3-WAY	6±0.02	,,
2-WAY	4.4±0.01	,,
C_1 cross	5.26	Niranjan *et al.*(2008)
C_2 cross	5.24	,,
Vanaraja	5.28	,,
Gramapriya	5.27	,,
Brown egg layer strain		Zita *et al.* (2009)
ISA Brown	5.86 to 6.6	,,
Hisex Brown	5.5 to 6.3	,,
Moravia BSL	4.9 to 5.8	,,

Indigenous	6.41±1.97	Islam and Dutta (2010)
Broiler	6.80±1.23	,,
Fayuomi	6.14±2.02	,,
RIR	9.10±2.23	,,
Sonali	7.90±1.29	,,
25th week		Mohanty *et al.* (2011)
Aseel	7.44	,,
Kadaknath	6.87	,,
Black rock	7.87	,,
Red Cornish	7.24	,,
RIR	9.07	,,
Dahlem red	7.23	,,
Vanaraja	7.20	,,
V_2,chabro	7.33	,,
Vanaraja		Padhi *et al.*(2013)
At 28th week	3.9±0.08	,,
At 40th week	4.4±0.07	,,
At 52nd week	5.4±0.10	,,
At 64th week	5.0±0.08	,,

At 72nd week	5.3±0.11	,,
White Leghorn strain		Sreenivas *et al.*(2013)
IWH	4.32	,,
IWK	5.12	,,
IWI	4.77	,,
Control	4.72	,,

The average shell weight is reported to be ranged from 4.32 g in WIH to 9.10 g in RIR. The average shell weight in Vanaraja ranged from 3.9 to 5.8 g and in Gramapriya it was reported to be 5.27 g.

Albumen quality :

The physical state of albumen is measured in a number of ways by the percent of thick White, by the height of albumen, by an albumen index, by an index of albumen height to egg size expressed as Haugh unit and by scoring using the Van Wagenen Wilgus Chart.

Wesley and Stadelman (1960) measured the interior quality of fresh eggs and eggs stored for 24 hours for comparison of various measurable characters. They reported that yolk index and thin albumen diameter were most useful parameters for obtaining relatively complete quality description of a normal egg.

Various reports available in the literature have shown strong evidence for inherited differences between breeds and strains, lines and families within breeds for albumen qualities (Knox and Godfrey, 1940; Farnsworth and Nordskog, 1955; Baker and Curtiss, 1958). Lorenz and Taylor (1910) found that it is possible to establish two lines characterised by different amounts of thick albumen.

Devi *et al.* (2005) reported no significant differences in albumen index for different White leghorn strains and cross bred, it ranged from 6 to 7.

Parmer *et al.* (2006) reported the albumen weight as 20.74g in Kadaknath which was within the range.

Chatterjee *et al.*(2007) recorded 26.46g to 26.67g albumen weight in indigenous fowl of Andaman.

Niranjan *et al.* (2008) reported that albumen weight varied from 28.61±0.27g to 31.13±0.18g in rural crosses. The albumen weight reported to be differed significantly ($p<0.01$) among the genetic groups except in C_2 cross and Vanaraja . Albumen weight at 24 weeks of age were reported to be significantly ($p<0.01$) higher in C_1, C_2 and Vanaraja varieties. At 32 weeks of age C_1 and C_2 crosses reported to have significantly higher albumen weight than Vanaraja and Gramapriya whereas at 40 weeks C_1 cross had significantly ($p<0.01$) higher albumen weight than other three crosses.

Zita *et al.* (2009) reported highly significant ($p<0.01$) correlation among the albumen quality characteristics such as albumen weight, albumen percentage and albumen index in all strains laying brown shelled eggs. Albumen weight reported to be increased with the advancement of age but albumen index and percent albumen weight tends to decrease with age in all genotypes.

Mohanty *et al.*(2011) reported statistically significant ($P<0.01$) variations in albumen index among the genetic groups. However, in native variety the albumen index values at 25, 54 and 74 weeks of age were reported to be 0.09, 0.08 and 0.09 respectively, showing significant ($P<0.01$) differences with that of albumen index of improved variety birds. However no significant differences were reported among the improved genetic varieties at all ages. The albumen weight did not vary significantly between the meat type and commercial broiler at 25 weeks. Except dual type and commercial broilers, no significant ($P<0.01$) differences were reported between the improved varieties at 54 weeks of age. However, at all ages non descript local fowl reported to have lowest albumen weight as compared to other improved varieties and suggested eggs with thicker albumen and higher total albumen weight are considered comparatively better eggs.

Jha and Prasad (2013) reported the average albumen index value in improved varieties were higher than the indigenous breed. In Vanaraja and Gramapriya albumin index were reported to be 6.81 and 6.97 respectively which were significantly ($P<0.01$) higher than the Aseel having 6.25 albumen index.

Padhi *et al.* (2013) reported significant ($P<0.05$) difference in albumen index at different age of measurement. The highest albumen index (10.62) was reported at 52 weeks of age and lowest (6.17) at 72 weeks of age in Vanaraja birds. Albumen weight also showed significant ($P<0.05$) difference at different age of measurements, the highest (37.84g) being at 52 weeks and lowest (30.56g) at 28 weeks. Significant ($p<0.05$) effect of age was reported for percent albumen weight, the highest (64.10) percentage was reported to be at 28 weeks and lowest (57.12) percentage were reported at 72 weeks of age.

Sreenivas *et al.* (2013) reported significant ($P<0.01$) difference among White Leghorn strains. IWI (7.2) strain reported to have the highest albumen index and IWK (5.6) had the lowest. The albumen weight was reported to be significantly ($P<0.01$) higher in IWK than IWH, IWI and control which is reported to be differed non-significantly among themselves. The percent albumen weight was reported to be significantly ($P<0.01$) higher in IWH strain (62.96) but did not differ significantly from IWI, IWK and control.

At any time, the albumen quality is primarily a function of age of bird. The decline in albumen quality is attributed by the physiological condition of the individual bird. The physiological characteristics such as intensity of lay and age at sexual maturity have influential effect on albumen quality.

The mean values of albumen index, albumen height and albumen weight reported in the available literature are presented in table - 6.

Table -6 Average estimates of albumen quality in chicken as reported in literature.

Breed/strain	Mean	Reference
Albumen Index		
Brown egg layer strain		Zita *et al.*(2009)
20-26th week		
ISA Brown	11.27	,,
Hisex Brown	11.33	,,
Moravia BSL	10.53	,,
36-42nd week		,,
ISA Brown	8.74	,,
Hisex Brown	9.03	,,

Moravia BSL	9.27	”
54-60TH week		
ISA Brown	7.46	”
Hisex Brown	7.11	”
Moravia BSL	8.40	”
25th week		Mohanty *et al.*(2011)
Local fowl	10	”
Aseel	13	”
Kadaknath	13	”
Black rock	13	”
Red Cornish	12	”
RIR	15	”
Dahlem Red	11	”
Vanaraja	13	”
V2,chabro	19	”
Vanaraja	6.81	Jha and Prasad (2013)
Gramapriya	6.97	”
Aseel	6.25	”
Vanaraja		Padhi *et al.* (2013)

28^{th} week	10.20	,,
40^{th} week	9.36	,,
52^{nd} week	10.62	,,
64^{th} week	8.26	,,
72^{nd} week	6.17	,,
White Leghorn strain		Sreenivas *et al.*(2013)
IWH	7.2	,,
IWI	9	,,
IWK	5.6	,,
Control	8	,,
Albumen weight		
Kadaknath	20.74	Parmer *et al.* (2006)
Indigenous fowl	26.46-26.67	Chatterjee *et al.* (2007)
C1 cross	31.1	Niranjan *et al.* (2008)
C2 cross	30.3	,,
Vanaraja	30.3	,,
Gramapriya	28.6	,,

Brown egg layer 20-26 week		Zita *et al.* (2009)
ISA Brown	34.36	,,
Hisex Brown	35.28	,,
Moravia BSL	32.78	,,
36-42 week		
ISA Brown	38.07	,,
Hisex Brown	37.87	,,
Moravia BSL	36.62	,,
54-60 week		
ISA Brown	37.57	,,
Hisex Brown	38.49	,,
Moravia BSL	38.25	,,
Indeginous	18.92	Islam and Dutta (2010)
Broiler	30.40	,,
Fayoumi	18.51	,,
RIR	36.10	,,
Sonali	19.50	,,
Local fowl	15.42	Mohanty *et al* .(2011)

Aseel	20.28	,,
Kadaknath	18.22	,,
Black rock	24.31	,,
Red Cornish	24.56	,,
RIR	19.07	,,
Dahlem red	22.33	,,
Vanaraja	20.33	,,
V_2 , chabro	24.54	,,
Vanaraja		Padhi *et al.* (2013)
28th week	30.56	,,
40th week	33.53	,,
52nd week	37.84	,,
64th week	36.01	,,
72nd week	34.93	,,
White Leghorn		Sreenivas *et al.* (2013)
IWH	31.53	,,
IWI	31.19	,,
IWK	33.18	,,
Control	30.92	,,

Percent Albumen		
Brown egg layer		Zita *et al* .(2009)
20 – 26 weeks		
ISA Brown	63.85	,,
Hisex Brown	64.15	,,
Moravia BSL	64.57	,,
36 – 42 week		
ISA Brown	60.53	,,
Hisex Brown	60.92	,,
Moravia BSL	59.36	,,
54 – 60		
ISA Brown	59.19	,,
Hisex Brown	59.98	,,
Moravia BSL	58.50	,,
Vanaraja		Padhi *et al.* (2013)
28^{th} week	64.10	,,
40^{th} week	58.91	,,
52^{nd} week	61.18	,,
64^{th} week	59.47	,,

72nd week	57.12	,,
White Leghorn		Sreenivas *et al.* (2013)
IWH	62.96	,,
IWI	61.31	,,
IWK	61.24	,,
Control	61.10	,,

YOLK QUALITY :

Yolk Index :

The physical State of yolk is measured by yolk index which is obtained by dividing the height of yolk by its average diameter.

Of all the structures of eggs, the yolk seems to be least influenced by hereditary factors. Breed differences for yolk index have been reported in the literature (Jeffrey, 1945) but for the most part the yolk quality is environmentally determined. Romanoff and Romanoff (1949) have stated that the value of yolk index was fairly constant in the eggs produced by a particular individual but it may vary considerably from the eggs of one bird to that of another.

Padhi *et al.* (1998) reported yolk indices ranging from 0.41 to 0.45 in Nicobari varieties of Andaman.

Parmer *et al.* (2006) also observed lower yolk index of (0.37) for kadaknath breeds.

Niranjan *et al.* (2008) reported significant (P<0.01) influence OF genetic groups on yolk index at all ages .The yolk indices reported to be ranged from 0.44 in C_2 cross to 0.46 in C_1 cross .The yolk indices among C_2 and Vanaraja were reported to be similar without any significant variation. The yolk indices were significantly higher in Vanaraja at 24 wks of age, C_1 and C_2 crosses at 32 wks of age and Gramapriya at 40 weeks of age respectively.

Zita *et al.* (2009) observed that yolk indices differed significantly (p<0.0001) with age and genotype. Yolk indices were reported to be decreased with the advancement of age. The highest yolk index was of Moravia BSL and lowest was of Hisex Brown.

Islam and Dutta (2010) reported significant (p<0.001) difference between breeds. Yolk weight was reported to be the highest in Sonali (14.88) and the lowest (11.20) in RIR.

Mohanty *et al.* (2011) reported that the yolk index did not vary significantly at all ages between six varieties of birds namely Aseel, Kadaknath, Black rock, Red Cornish, Rhode Island Red, Dehlam Red, Vanaraja, V_2 Chabro while the yolk index values reported to be differed significantly (p<0.01) between genetic groups and native local fowl at 25 weeks indicated spherical nature of yolk.

Jha and Prasad (2013) reported yolk indices of Vanaraja, Gramapriya and Aseel differed significantly (p<0.01). Yolk indices of Gramapriya (36.68) were reported to be higher than Vanaraja (36.12), and Aseel had the lowest (35.84) magnitude.

Padhi *et al.* (2013) experimented on eggs at different weeks of age on Vanaraja birds and found that yolk indices showed significant ($p<0.05$) difference between different age of measurements. However, no specific trend was reported and the yolk indices were not significantly different between 40 and 72 weeks of age.

Sreenivas *et al.* (2013) reported significantly ($P<0.01$) higher yolk indices in IWI strain of White leghorn than other strains and control groups where as IWH, IWK and control did not differ significantly.

Yolk height and yolk diameter :

Potentially yolk width could be the easiest and most convenient criterion of internal quality, since it involves only one direct measurement, with a simple but accurate tool, the Vernier Calipers. Bornstein and Lipstein, (1962) obtained the existence of very high and negative correlation between yolk index and yolk width, since the horizontal yolk diameter increases with decreasing yolk quality. They also reported that eggs from older chicken had consistently a greater yolk height than those of younger layer, in contrast to the lower interior quality of eggs from older hens on the basis of Haugh unit scores and yolk index values. The effect of age of layer and size of egg on yolk height is reported to be highly significant.

Niranjan *et al.* (2008) reported that yolk height varied from 16.2 in C_2 cross to 16.9 in C_1 and Vanaraja birds. Yolk height of c2 cross was reported to be significantly ($p<0.01$) lower than other breeds whereas yolk height of C_1, Vanaraja and Gramapriya did not differ significantly.

Mohanty *et al.* (2011) reported significant effect of genetic groups on yolk weight. At 25 weeks of age significant differences were reported between the native local fowl and the improved varieties . Highest yolk weight was recorded by the author in meat type birds as 16.45g and lowest in rural germplasm Vanaraja as 8.7g, whereas the native local fowl reported to have comparatively higher yolk weight as 10.36g. Yolk weight at both 54^{th} and 74^{th} weeks was reported to be the highest in meat type birds as 20.51g and 23.32g and lowest in native local fowl as 14.03g and 16.01g respectively.

Padhi *et al.* (2013) reported highly significant ($p<0.05$) effect of age on yolk weight at different ages of laying in Vanaraja birds. Yolk weight reported to be increased with the advancement of age of laying. The highest yolk weight (20.81-0.44g) and the lowest yolk weight (13.05-0.19g) was reported at 72 and 28 weeks of laying respectively.

Sreenivas *et al.* (2013) experimented on three strains of White Leghorn and control group , reported that yolk weight of IWH, IWK and control differed significantly whereas IWI and control did not differ significantly. IWK strain had the highest (15.58-0.12g) yolk weight and IWH had the lowest (14.16-0.13g).

The mean values of yolk index, yolk width, yolk height, yolk weight and yolk percentage reported in the available literature are presented in table 7.

Table -7 Average estimates of yolk quality in chicken as reported in literature.

Breed/strain	Mean	Reference
Yolk Index		
C_1 cross	46	Niranjan *et al* .(2008)
C_2 cross	44	,,
Vanaraja	44	,,
Grampriya	45	,,
Brown egg layer strain		Zita *et al* .(2009)
ISA Brown(20-26wk)	48.12	,,
Hisex Brown	47.22	,,
Moravia BSL	48.19	,,
ISA Brown(36-42)	44.36	,,
Hisex Brown	43.93	,,
Moravia BSL	46.56	,,
ISA Brown(54-60)	43.63	,,
Hisex Brown	42.91	,,
Moravia BSL	45.12	,,
Native fowl	20	Mohanty *et al*. (2011)
Aseel	38	,,

Kadaknath	45	,,
Black rock	41	,,
Red Cornish	34	,,
RIR	40	,,
Dahlem Red	29	,,
Vanaraja	23	,,
V_2, Chabro		
Vanaraja		Padhi *et al.* (2013)
28th week	41	,,
40th week	37	,,
52nd week	43	,,
64th week	39	,,
72nd week	35	,,
White Leghorn		Sreenivas *et al* .(2013)
IWH	34.3	,,
IWI	35	,,
IWK	34.1	,,
Control	37.0	,,
Yolk weight		
Kadaknath	15.18	Parmer *et al* .(2006)
C_1 cross	11.5	Niranjan *et al.* (2008)

C_2 cross	11.9	,,
Vanaraja	12	,,
Gramapriya	13.5	,,
Native variety	10.36	Mohanty *et al.* (2011)
Aseel	10.92	,,
Kadaknath	14.90	,,
Black rock	16.61	,,
Red Cornish	16.21	,,
RIR	15.23	,,
Dahlem Red	14.52	,,
Vanaraja	8.7	,,
V_2,Chabro	16.28	,,
Indigenous	14.65	Islam and Dutta (2010)
Broiler	9.6	,,
Fayoumi	14.88	,,
RIR	11.2	,,
Sonali	16.4	,,
Vanaraja		Padhi *et al.*(2013)
28th week	13.05	,,
40th week	17.18	,,
52nd week	18.48	,,

64th week	19.40	,,
72nd week	20.81	,,
White Leghorn		Sreenivas *et al.* (2013)
IWH	14.16	,,
IWI	14.70	,,
IWK	15.58	,,
Control	14.84	,,
Percent yolk weight		
Brown egg layer strain		Zita *et al.*(2009)
ISA Brown(20-26)	23.12	,,
Hisex Brown	23.53	,,
Moravia BSL	23.42	,,
ISA Brown(36-42)	26.94	,,
Hisex Brown	26.93	,,
Moravia BSL	29.23	,,
ISA Brown(54-60)	28.12	,,
Hisex Brown	27.76	,,
Moravia BSL	30.13	,,
Vanaraja		Padhi *et al.* (2013)

28th week	27.50	,,
40th week	31.17	,,
52nd week	30.01	,,
64th week	32.21	,,
72nd week	34.13	,,
White Leghorn		Sreenivas *et al.*(2013)
IWH	28.28	,,
IWI	29.17	,,
IWK	29.15	,,

Age and body weight at the age of sexual maturity (ASM)

Age and body weight of chicken at the age of sexual maturity affects the size and weight of egg. Heavy breeds, in general, produces larger eggs compared to light breeds. Differences also exist among strains/lines of the same breed and even between families and individuals with respect to egg weight. The birds which mature early produces smaller size eggs because of low body weight.(ICAR, Hand book) The literature on ASM and body weight at ASM presented in table 8.

Table-8 Average estimates of age and body weight at the ASM as reported in the literature.

Breed	Age at ASM (in days)	Body weight at ASM(g)	Reference
WLH strain			Devi *et al.*(2005)
IWD	150	1348	,,
IWF	153	1271	,,
3-WAY	145	1596	,,
2-WAY	152	1448	,,
Vanaraja	164.79	-	Niranjan *et al.(*2008*)*
Gramapriya	160.89	-	
Gramapriya	179.50	-	Haunshi *et al.*(2009)
Vanaraja	197.70	-	
Gramapriya	138		Giri and Sahoo(2012)
Vanaraja	142		,,

MM	168.31	1459.33	Taha *et al.*(2013)
SS	173.50	1519.86	,,
MS	166.65	1492.50	,,
SM	163.14	1524.25	,,
Vanaraja	161.58	-	Jha and Prasad (2013)
Gramapriya	155.32	-	,,
Aseel	192.83	-	,,

MM – Mandarah

SS – El – Salam

DB – Dominant Black

MS – Mandarah X El-Salam

SM – El-Salam X Mandarah

FE – Fulani Ecotype

Devi *et al.*(2005) reported that the average age at first egg lay among the crosses was significantly different and average age at first egg lay was reported to be 145 days in 3- way cross which is 5-8 days earlier to 2-way cross and pure strains.

Panda and pasupalak (2007) observed that age at first egg of Gramapriya at Orissa state's climatic condition was 5 months and egg weight was 55-56g.

Niranjan *et al.* (2008) reported that the age at sexual maturity was 164.79 days for Vanaraja and 160.89 days for Gramapriya birds

Haunshi *et al.* (2009) reported 179.50 and 197.70 days of age at sexual maturity in Gramapriya and Vanaraja respectively.

Giri and Sahoo (2012) reported that age at first egg in Grampriya chicken was 138days and 142 days respectively under intensive and extensive condition of rearing.

Jha and Prasad (2013) reported that the average age at sexual maturity was lower in Vanaraja and Gramapriya as compared to Aseel.

Taha *et al.*(2013) reported that the cross of El-Salam x Mandarah recorded to have significantly the highest averages for egg weight at sexual maturity, reaching sexual maturity at earlier ages than other lines.

Phenotypic correlation

A brief review on phenotypic correlations between various egg quality traits in pure and crossbred chickens as reported in the available literature is presented in table 9.

Table -9 The Phenotypic correlation coefficients between various egg quality traits in pure and crossbred chicken as reported in the available literature.

Traits	r_p	Reference
Egg weight x Egg shape/shape index		
Indigenous	-0.17	Islam and Dutta (2010)
Broiler	-0.21	,,
Fayoumi	-0.21	,,
RIR	-0.49	,,
Sonali	-0.05	,,
Egg Weight x Albumen weight		
Indigenous	0.45	Islam and Dutta (2010)
Broiler	0.82	,,
Fayomi	0.13	,,
RIR	0.96	,,
Sonali	0.70	

Kazak layers	0.90	Alipanah *et al.*(2013)
IWH strain	0.964	Sreenivas *et al.*(2013)
IWI Strain	0.892	,,
IWK Strain	0.965	,,
Control Strain	0.953	,,
Egg weight × Shell weight		
Indeginous	0.10	Islam and Dutta (2010)
Broiler	0.37	,,
Fayoumi	0.2	,,
RIR	0.47	,,
Sonali	0.24	,,
Vanaraja at 28th wk	0.20	Padhi *et al* .(2013)
Vanaraja at 40th wk	0.44	,,
Vanaraja at 52nd wk	0.38	,,
Vanaraja at 64th wk	0.23	,,
Vanaraja at 72nd wk	0.55	,,

IWH Strain	0.531	Sreenivas *et al.*(2013)
IWI Strain	0.294	,,
IWK Strain	0.054	,,
Control Strain	0.546	,,
Egg weight × Shell thickness		
Brown egg layer strain(pooled)	-0.152	Zita *et al.*(2009)
Vanaraja at 28th week	0.02	Padhi *et al.*(2013)
At 40th week	0.25	,,
At 52nd week	0.27	,,
At 64th week	0.27	,,
At 72nd week	0.43	,,
IWH Strain	-0.229	Sreenivas *et al.*(2013)
IWI Strain	0.580	,,
IWK Strain	0.111	,,
Control Strain	0.137	,,

Egg weight x Egg length		
Cobb500 broiler	0.468	Amankwah (2013)
Yolk weight x Albumen weight		
Indigenous	-0.31	Islam and Dutta (2010)
Broiler	0.20	,,
Fayoumi	-0.51	,,
RIR	0.65	,,
Sonali	-0.39	
Cobb500 broiler	-0.114	Amankwah (2013
Egg weight x Albumen weight		
Exotic ISA Brown	0.91	Olawumi and Ogunlade (2008)
Cobb500 broiler	0.712	Amankwah (2013)
Egg weight x Albumen height		
Exotic ISA Brown	0.51	Olawumi and Ogunlade (2008)

Kazak layers	-0.03	Alipanah *et al.* (2013)
Cobb500 broiler	0.435	Amankwah (2013)
Egg weight x percent albumen		
Brown egg layer strain(pooled)	-0.039	Zita *et al* .(2009)
Egg weight × Yolk weight		
Exotic ISA Brown	0.55	Olawumi and Ogunlade (2008)
Indigenous	-0.59	Islam and Dutta (2010)
Broiler	-0.28	,,
Fayoumi	0.66	,,
RIR	0.72	,,
Sonali	0.12	,,
Kazak layers	0.59	Alipanah *et al.*(2013)
Cobb500 broiler	0.271	Amankwah (2013)

IWH Strain	0.768	Sreenivas *et al.*(2013)
IWI Strain	0.611	
IWK Strain	0.023	
Control Strain	0.578	
Egg weight × Yolk Height		
Exotic ISA Brown	0.45	Olawumi and Ogunlade (2008)
Cobb500 broiler	0.385	Amankwah (2013)
Egg weight × Yolk width		
Exotic ISA Brown	0.42	Olawumi and Ogunlade (2008)
Cobb500 broiler	0.299	Amankwah (2013)
Egg length x Albumen height		
Cobb500 broiler	0.364	Amankwah (2013)
Egg width x Albumen		

height		
Cobb500 broiler	0.196	Amankwah (2013)
Egg length x Shape Index		
Cobb500 broiler	-0.788	Amankwah (2013)
Egg length × Shell thickness		
Cobb500 broiler	0.028	Amankwah (2013)
Egg length × Shell weight		
Cobb500 broiler	-0.185	Amankwah (2013)
Egg width x Egg length		
Cobb500 broiler	0.407	Amankwah (2013)
Egg width x Shape index		
Cobb500 broiler	0.218	Amankwah (2013)
Egg width × Shell thickness		
Cobb500 broiler	-0.008	Amankwah (2013)
Egg width × Shell weight		
Cobb500 broiler	-0.135	Amankwah (2013)

Shape index × Shell thickness		
Cobb500 broiler	0.040	Amankwah (2013)
Shape index × Shell weight		
Cobb500 broiler	0.132	Amankwah (2013)
Shape index x Albumen height		
Exotic ISA Brown	-0.14	Olawumi and Ogunlade (2008)
Kazak layers	0.05	Alipanah *et al.*(2013)
Cobb500 broiler	-0.264	Amankwah (2013)
Shape index x Albumen weight		
Indigenous	0.27	Islam and Dutta (2010)
Broiler	0.10	,,
Fayoumi	-0.15	,,
RIR	-0.44	,,
Sonali	-0.13	,,

Shape index × Yolk weight		
Exotic ISA Brown	-0.03	Olawumi and Ogunlade (2008)
Kazak layer	-0.20	Alipanah *et al.*(2013)
Cobb500 broiler	0.009	Amankwah (2013)
Shape index × Yolk index		
Cobb500 broiler	-0.226	Amankwah (2013)
Shellthickness x Albumen height		
Exotic ISA Brown	-0.23	Olawumi and Ogunlade (2008)
Cobb500 broiler	0.030	Amankwah (2013)
Shellthicknes x Albumen weight		
Exotic ISA Brown	-0.03	Olawumi and Ogunlade (2008)
Cobb500 broiler	-0.028	Amankwah (2013)
IWH Strain	-0.301	Sreenivas *et al.*(2013)
IWI Strain	0.312	,,

IWK Strain	0.053	,,
Control Strain	0.116	,,
Shell thickness × Yolk weight		
Exotic ISA Brown	-0.09	Olawumi and Ogunlade (2008)
Cobb500 broiler	0.003	Amankwah (2013)
IWH Strain	-0.035	Sreenivas *et al.*(2013)
IWI Strain	0.648	,,
IWK Strain	0.016	,,
Control Strain	0.096	,,
Shell thickness × Yolk index		
Cobb500 broiler	0.066	Amankwah (2013)
IWH Strain	-0.097	Sreenivas *et al.*(2013)
IWI Strain	0.037	,,
IWK Strain	-0.183	,,
Control Strain	-0.018	,,

Shell thickness × Shell weight		
Cobb500 broiler	0.038	Amankwah (2013)
IWH Strain	0.354	Sreenivas *et al.*(2013)
IWI Strain	0.336	,,
IWK Strain	0.318	,,
Control Strain	0.352	,,
Albumen Height x Albumen weight		
Cobb500 broiler	0.578	Amankwah (2013)
Albumen Height × Yolk Height		
Cobb500 broiler	0.684	Amankwah (2013)
Shell weight × Yolk index		
Cobb500 broiler	-0.178	Amankwah (2013)
Shell weight × Yolk weight		
Kazak layers	0.32	Alipanah *et al.*(2013)
Cobb500 broiler	-0.069	Amankwah (2013)

Shell weight x Albumen height		
Kazak layer	-0.11	Alipanah *et al.* (2013)
Cobb500 broiler	-0.236	Amankwah (2013)

Phenotypic Correlation between the External Egg Quality Traits

Egg weight is the most important external quality trait of the egg influencing the weight of newly hatched chicks and hatching performance (Farooq *et al.*, 2001). The existence of significant positive correlation between egg weight, shell weight and shell thickness has been reported by Farooq *et al.* (2001). This provides an indication for better prediction of egg shell weight and thickness from other quality traits (Khurshid *et al.*, 2003).

Zita *et al.*(2009) found that there was significant ($p<0.05$) and positive correlation between egg weight and egg shell thickness, yolk percentage. However, they have also reported significant ($p<0.05$) negative correlation of egg weight with albumen percentage and egg shell percentage. The authors have also reported positive and significant correlation between egg shell percentage and egg shell thickness.

Phenotypic correlation between external egg quality traits from five breeds of chicken presented by Islam and Dutta (2010) revealed that there exist significant ($p<0.05$) and positive correlation between shell weight and shell ratio for all the breeds. They also found a significant ($p<0.05$) and positive phenotypic correlation between egg weight and egg volume (egg length and egg width) for the Sonali breed.

Amankawah (2013) reported significant ($p<0.01, p<0.05$) and positive correlation among different external egg quality traits except the correlation between shape index and shell weight which were negatively correlated to egg length . Shell thickness and shell weight also reported to be negatively correlated with egg width.

Padhi *et al.* (2013) found that in Vanaraja birds there was negative correlation between egg shape index and egg weight upto 52 weeks of age and thereafter correlation was positive. However, shell weight and shell thickness were reported to be positively correlated at all ages of measurement. Shell percent was reported to be negatively correlated at all ages of measurement except at 40th week of age.

Phenotypic Correlations between Internal Egg Quality Traits

Kul and Seker (2004) reported significant negative correlation between the albumen height and the yolk ratio. They found statistically significant positive correlations of albumen index with albumen height, albumen weight, haugh unit and yolk height. It indicates that an improvement of the albumen index will result in improvement of albumen weight and the albumen ratio (Ozcelik, 2002).

Olawumi and Ogunlade (2008) observed highly significant ($p<0.01$) and positive correlation between yolk weight, yolk width, albumen weight and yolk height. However, negative correlation between yolk height, albumen height and albumen width was reported by the authors.

Islam and Dutta (2010) reported that phenotypic correlation between yolk weight and albumen weight was non- significant in different breeds.

Amankawah (2013) found that all internal egg quality traits were significantly ($p<0.01$) and positively correlated among themselves except albumen weight which was negatively correlated with yolk width and yolk weight, and yolk index which was reported to be negatively correlated to yolk weight and yolk diameter.

Phenotypic Correlation between External and Internal Egg Quality Traits

In laying flock of poultry it is very important to obtain a large number of eggs with normal structure, normal morphological composition and interior quality. These elements have very significant influence on biological value of the egg which determines normal development of the embryo. Weight of the egg albumen was predicted with accuracy from the egg weight, egg width and length due to significant correlation between them (Khurshid *et al.*, 2003). They were also able to predict with accuracy the weight of the yolk from the egg weight, length and width due to significant and positive correlation between them. However, a negative correlation has been reported between shell weight and albumen ratio and there were no significant correlations between the shape index and internal quality traits with the exception of the albumen weight and yolk weight (Olawumi and Ogunlade, 2008). These findings were supported by Ozcelik (2002) and Kul and Seker (2004). Oluwami and Ogunlade (2008) reported negative but non -significant correlation between shell thickness and almost all the internal quality traits of the egg. They also reported that all the internal quality traits of the egg such as albumen height, albumen weight, yolk diameter, yolk height and yolk weight were significantly and positively correlated with egg weight, in general.

Olawumi and Ogunlade (2008) reported highly significant ($P<0.01$) and positive correlation between egg weight, egg length, egg width, shell weight and yolk weight, yolk height, yolk width whereas non-significant negative correlation with shell thickness and shape index. Similarly albumen weight had highly significant ($P<0.01$) and positive correlation with egg weight, egg length, egg width and shell weight whereas non-significant correlation with shell thickness and shape index. Albumen height reported to be positively correlated with egg weight, egg length and egg width whereas negatively correlated with shell weight, shell thickness and shape index. However, these correlations were statistically non-significant. Albumen width had highly significant ($p<0.01$) and positive correlation with egg weight and shell weight.

Islam and Dutta (2010) reported significant and positive phenotypic correlations of egg weight with yolk weight ·and albumen weight. They also reported negative but non-significant phenotypic correlation between egg weight and both albumen ratio and yolk ratio. Yolk weight and albumen weight were reported to be negatively correlated with the egg weight but it was statistically non-significant.

Padhi *et al.*(2013) reported that in Vanaraja birds at different weeks of measurement there was positive correlation between egg weight and yolk index whereas albumen index showed positive correlation up to 52^{nd} weeks of age. Yolk weight, albumen weight and shell weight repoted to have positive correlation with egg weight. The correlation of egg weight with albumen percent was reported to be higher than that of yolk weight and shell weight.

Alipanah *et al* .(2013) reported positive correlation of egg weight with egg shell weight, egg width, egg length yolk weight and albumen weight whereas egg weight was reported to have negative correlation with shape index, yolk weight and albumen weight.

Amankawah (2013) reported significant ($P<0.05$) phenotypic correlation between internal and external egg quality traits in Cobb500. However, there were significant ($P<0.05$) positive correlations of egg weight with albumen weight, albumen height, albumen ratio, haugh unit, yolk diameter, yolk height, yolk weight, and yolk index. Almost all internal quality traits of the egg were reported to be correlated positively and significantly ($p<0.05$). They also reported negative phenotypic correlation of shell weight with albumen height, albumen weight and yolk ratio. Highly significant ($p<0.01$) but negative phenotypic correlation were reported between shape index and all the internal quality traits except with yolk width and yolk diameter.

Fertility :

Fertility has been reported to be influenced by various factors such as time of mating (Parker, 1950), Sex ratio (Trehen *et al.*, 1983), Social dominance (Guhl and Warren, 1946), Season and environmental temperature (Hays and Sanborn, 1939; Parker and Mespadden, 1942), age of breeds (Singh, 1961), laying capacity of strains (Bernier *et al.*,1951), Stage of laying cycle (Tomohave, 1958) etc.

The breeding system is also reported to have a significant effect on fertility. The difference in fertility between various type of mating system is either a function of the strain of male and females used for crossing or is due to preferential matings or the tendency of male and female to mate more frequently with certain birds of opposite sex in a flock as demonstrated by Lamoreux (1940) and Funk and Irwin (1955).

The fertility depends on various factors such as breed, season, pre – incubation holding period, lighting, level of nutrition, mating and time of mating (Silversides and Scott, 2001). It has been reported that temperature is major factor for the production of fertile eggs.

Islam *et al* .(2002) reported highest fertility percentage in WLH (94.78%) and lowest in RIR (88.29%)

Ahmed *et al.*(2012) found that hatchability from fertile eggs was higher for Naked neck (90.6%) than the RIR(87%), Fayumi (84.6%), Desi (82.6%) and in Aseel (55%)

Miazi *et al.*(2012) reported that fertility of crossbred Sonali (RIR x Fayoumi) to be ranged from 83 to 94.4%. The fertility rate of Fayoumi and Sonali did not vary much between two breeds. This was reported to be due to the nutritional facilities as well as management procedure, although the weather condition were same for all eggs from where the eggs were collected.

The average fertility percentage of various pure and crossbred chickens reported in available literature is presented in Table -10.

Table -10 Fertility percentages in various pure and crossbred chicken reported in the available literature.

Breed	Fertility percentages	Reference
PURE BREED		
Barred Plymouth Rock	95.10	Islam *et al.* (2002)
White leghorn	96.70	,,
Rhode Island Red	94.03	,,
White Rock	94.94	,,
Kadaknath	70.44	Bhardwaj *et al* .(2006)
Aseel	73.22	,,
RIR	75.21	,,
Brown Cornish	71.92	,,
FE x FE	54.12	,,
Fayoumi	88.6	Miazi *et al* .(2012)
CROSS BRED		
Kadaknath x Brown Cornish	62.61	Bhardwaj *et al* .(2006)
Brown Cornish x Kadaknath	71.35	,,
Aseel x RIR	74.43	,,

RIR x Aseel	76.39	,,
WLH x NN	90.6	Ahmed *et al.* (2012)
WLH x Fayoumi	84.6	,,
WLH x RIR	87	,,
WLH x Aseel	55	,,
WLH x Desi	82.6	,,
Sonali	89.8	Miazi *et al.* (2012)

NN – Naked Neck FE – Fulani Ecotype

RIR – Rhode Island Red DB – Dominant black

The average fertility percentage in various pure breeds of chicken reported to be ranged from 54.12 in Fulani Ecotype to 96.70 in White Leghorn. Among the crossbreds the fertility percentages reported to be ranged from 62.61 in Kadaknath x Brown Cornish crosses to 90.6 in WLH x NN crosses.

Hatchability :

Generally the term hatchability is used to mean the number of chicks hatched out per 100 eggs incubated, but from the research points of view the term hatchability means the number of chicks hatched out of 100 fertile eggs incubated.

Hatchability of fertile eggs depends upon several factors starting from frequency of collection of eggs, seasons, methods and length of storing eggs prior to incubation, temperature, humidity and condition of the incubator during incubation, egg size and shape, shell thickness and its porosity, time of laying, age of breeds, genetic background of the breeding stock etc. (Arora, 1970).

The average sized eggs give better hatchability than that of large sized eggs as reported by many workers (Skoglund *and mumford* 1948). They also found the lower hatchability in extremely large and small sized eggs. Obenko and Antakov (1956) in White Russian birds found that eggs weighing 48-50 g had only 75% hatchability. Olsen and Haynes (1949) found the highest hatchability in eggs of White Leghorn weighing from 46-64 g and concluded that normal shaped eggs had 87% hatchability against 49% of unshaped eggs. Czarnecka (1954) observed good hatchability percentage (74.8%) from the large sized eggs weighing over 65 g although medium sized eggs weighing between 60-65 g had the better hatchability (81.1%).

Breed effect

The existence of breed differences and different breeding systems on hatchability have been reported by many authors in the available literatures.

Islam *et al.* (2002) reported that hatchability percentage is influenced by different breeds. The hatchability percentage of normal chicks was reported to be highest in RIR (98.56%) followed by those of WLH (97.70%), BPR (97.73%) and WR (96.49%).

The percent hatchability on fertile eggs set basis to be ranged from 49.49 to 84.93 . Bhardwaj *et al.* (2006) reported the highest hatchability percentage on fertile eggs in RIR and Aseel crosses and lowest in Brown Cornish.

Miazi *et al.*(2012) reported that the overall fertility rate was 86.0% in Fayoumi, which was lower than Sonali (87.5%) but did not vary significantly.

Jha and Prasad (2013) reported 87.58% hatchability on fertile eggs set basis in Vanaraja birds and a lower value of 79.42% and 68.97% in Gramapriya and Aseel respectively.The average hatchability percentage reported in this available literature have been depicted in table 11.

Table – 11 Hatchability percentages of pure and crossbred chicken as reported in the available literature.

Breed	Hatchability percentages	Reference
PURE BREEDS		
Barred Plymouth rock	88.59	Islam *et al* .(2002)
White leghorn	90.15	,,
Rhode island red	88.37	,,
White rock	91.93	,,
Kadaknath	57.75	Bhardwaj *et al* .(2006)
Aseel	58.00	,,
RIR	50.39	,,

Brown Cornish	49.49	,,
Fayoumi	86.0	Miazi *et al.* (2012)
Vanaraja	87.58	Jha and Prasad (2013)
Gramapriya	79.42	,,
Aseel	68.97	,,
CROSS BRED		
Kadaknath x Brown Cornish	78.82	Bhardwaj *et al.* (2006)
Brown Cornish x Kadaknath	79.13	,,
Aseel x RIR	78.33	,,
RIR x Aseel	84.93	,,
WLH x NN	85.3	Ahmed *et al.* (2012)
WLH x Fayoumi	84.6	,,
WLH x RIR	83.9	,,
WLH x Aseel	57.5	,,
WLH x Desi	76.2	,,
Sonali	87.5	Miazi *et al.* (2012)

MATERIALS AND METHODS

MATERIALS AND METHODS

Gramapriya breed of poultry developed at Directorate of Poultry Research,Hyderabad is being maintained at Instructional Livestock Farm Complex, Bihar Veterinaty College , Patna on random mating has been constituted as one of the genetic material for the present study. Further Gramapriya females were crossed with desi male native to Muzaffarpur and Gaya districts of Bihar. Thus, Gramapriya and its crosses with desi chicken native to Muzaffarpur and Gaya districts have been constituted the genetic material for this study. Various parameters like egg production, egg weight and egg quality traits were recorded from of three genetic groups of chicken. The three genetic groups were as follows:

1. GP♂♂ x GP ♀♀
2. Muz desi♂♂ x GP♀♀
3. Gaya desi♂♂ x GP♀♀

Twenty males and 100 females were taken from each genetic group and maintained separately under deep litter system in a flock with a mating ratio of 1 male : 5 females during the experimental period. To study the genetic effect on egg weight and egg quality traits a total of 150 eggs were collected at random at the rate of 50 eggs from each genetic group at 40 weeks of age. Daily egg production was also recorded to study the hen-day egg production. Egg weight and body weight were also taken at the age of sexual maturity. To study the effect of egg weight on egg quality traits all the eggs were divided into four groups according to the egg weight with the difference of 6 g from each group. These groups were designated as group I (34-40 g), Group II (41-47 g), Group III (48-54 g) and group IV (55 g and above).

The eggs were weighed with the help of electronic balance to the nearest of 0.01 g. Eggs were collected from each genetic group at 40 weeks of age group and stored in the cold storage for a period of 7 days at 15^{0}C prior to the incubation. The eggs were set in the incubator and incubated for 18 days at 100^{0}F temperature with relative humidity of 60-70%. The eggs were candled on 7th day of incubation and removed the unfertile eggs. On 18th day of incubation the eggs were transferred to the hatcher maintained at the temperature of 98^{0}F with relative humidity of 80-90% until the chicks hatched out. As such six hatches were taken to study the fertility and hatchability percentage.

During the entire period of experiment, the chicks were kept under uniform managemental conditions and standard balanced poultry ration. Feed and water was provided *ad lib* throughout the experimental period.

2. Following traits were taken.

- Egg weight
- Egg production upto 40 weeks of age
- Hatchability percentage
- Fertility percentage
- Egg quality traits :

External egg quality traits

* Egg length(mm)
* Egg width(mm)
* Egg Shape index
* Egg shell weight(g)
* Egg shell thickness(mm)

Internal egg quality traits

* Albumen diameter(mm)
* Albumen height(mm)
* Albumen weight(g)
* Albumen index
* Yolk diameter (mm)
* Yolk height (mm)
* Yolk weight(g)
* Yolk index

MEASUREMENT OF TRAITS

Egg Weight : Eggs were weighed with the help of electronic balance to the nearest of 0.01 g accuracy at the age of sexual maturity and at different weeks of age.

Body weight at the ASM: The body weights were taken with the help of electronic balance to the nearest of 0.02g at the age of sexual maturity.

Age at sexual maturity (ASM): It is the age at which three percent of the pullets of the flock started to lay the eggs.

Egg Length and Width : The length and width of the egg were measured with the help of Vernier Callipers to the nearest of 0.01 cm.

Shape Index : The shape index was calculated as the ratio of egg width to the egg length as given by Olawumi and Ogunlade (2008).

$$Shape\ Index = \frac{Egg\ Width}{Egg\ Length} \times 100$$

Egg Shell Thickness : The shell was separated from the vitelline membrane and thickness was measured by Screw Gauge. The shell thickness was measured at three places, first at the broaden end, second at narrow end and third at the middle part of the body of the egg shell. The mean of these three measurements was considered as shell thickness of the egg.

Shell Weight and Percent Shell: For taking shell weight the vitelline membrane was separated from the egg shell and then it was washed in running tap water and kept for a period of 24 hrs, after that weight of egg shell was taken with the help of electronic balance with accuracy of 0.01 g. The percent egg shell was calculated as the ratio of shell weight to the total egg weight and expressed as percentage.

Albumen Height : The egg was broken on a perfectly leveled glass plate. The height of thick albumen was measured by Spherometer at the highest and lowest point of the albumen. The average of two measurements was taken as mean height.

Albumen Index: Albumen index was calculated by the following formula, given by Olawumi and Ogunlade (2008).

$$Albumen\ Index = \frac{Height\ of\ albmen}{Width\ of\ albumen} \times 100$$

Albumen and Yolk Weight and Percentage : The egg albumen and yolk were separated with the help of spatula and poured in two clean beakers after cleaning the residual albumen from the shell and weighted by Top pan sartorius balance with accuracy of 0.01g. The percent albumen was calculated as the ratio of albumen weight to the total egg weight and percent yolk was calculated as the ratio of yolk weight to the total egg weight and expressed as percentage.

Yolk Height: The yolk height was measured using the Spherometer. The height was taken at the highest point of egg yolk.

Yolk Index: Yolk index was calculated as per the formula given by Olawumi and Ogunlade (2008).

$$Yolk\ Index = \frac{Height\ of\ the\ yolk}{Width\ of\ yolk} \times 100$$

Height was measured with the help of Spherometer and diameter of egg yolk was measured with the Vernier Calipers. The width was multiplied by 10 to convert it into millimeter and the average of three measurements was taken for each observation.

Fertility: The fertility of eggs was estimated as the ratio of number of fertile eggs to the total number eggs set and expressed as percentage.

$$Fertility\ \% = \frac{Total\ no.of\ fertile\ eggs}{Total\ no.of\ eggs\ set} \times 100$$

Hatchability : The hatchability was calculated on the basis of total number of eggs set as well as on the basis of total number of fertile eggs set.

(i) On the basis of total number of eggs set, the hatchability is the number of chicks hatched out of the total number of eggs set and expressed as percentage.

$$Hatchability\ \% = \frac{No.of\ chicks\ hatched}{Total\ no.of\ eggs\ set} \times 100$$

(ii) On the basis of fertile eggs the hatchability is the ratio of number of chicks hatched to the total number of fertile eggs set and expressed as percentage.

$$Hatchability\ \% = \frac{No.of\ chicks\ hatched}{Total\ no.of\ fertile\ eggs\ set} \times 100$$

STATISTICAL ANALYSIS :

Data were analyzed by MIXED MODEL LEAST-SQUARES AND MAXIMUM LIKELIHOOD COMPUTER PROGRAM PC-2 in the Department of Animal Genetics and Breeding, Bihar Veterinary College, Patna-. The least squares means, standard error and coefficient of correlation were calculated through least squares models (Harvey,1990) and some of the minor calculations were carried out by a programmable scientific calculator $CASIO_{fx\text{-}100s}$ as per standard statistical method (Snedecor and Cochran,1994).

Significant differences between means were tested by Duncan multiple range test and modified by Kramer, 1957. The coefficient of phenotypic correlation between any two traits were estimated as per standard statistical methods (Snedecor and Cochran, 1994) as per the following formula.

To observe the effect of genetic group on the aforesaid traits the following mathematical model was used:

$$Y_{ij} = \mu + G_i + e_{ij}$$

Where,

Y_{ij} is the measurement of a trait on the j^{th} bird of i^{th} genetic group.

μ is the overall population mean

G_i is the effect of i^{th} genetic group

e_{ij} is the random error assumed to be normally and independently distributed with mean 0 and variance

σ^2_e i.e. NID $(0, \sigma^2_e)$.

Correlation Co-efficient:-

The simple correlation eoefficient on the basis of the phentypic values among different characters were computed by using the formula given by Snedecor and Cochran(1998):

$$r_{xy} = \frac{Covariance\ xy}{sd_x \cdot sd_y}$$

Where,

χ = represents one trait.

γ = represents another trait.

$r_{\chi Y}$ = Coefficient of correlation between χ and γ traits.

sd_χ = Standard deviation of the trait χ

sd_y = Standard deviation of the trait γ

n = paired number of observations.

$$r_{xy} = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{n}}{\sqrt{[\Sigma x^2 - \frac{(\Sigma x)^2}{n}]\,[\Sigma y^2 - \frac{(\Sigma y)^2}{n}]}}$$

The correlation coefficients were tested for their significance through 't' test as below :

$$t_{(N-2)d.f.} = \frac{r}{S.E.(r)}$$

Where S.E. (r) = $\sqrt{\frac{1-r^2}{N-2}}$

r = Estimate of phenotypic correlation coefficients between two traits

N = Paired number of observations.

RESULTS AND DISCUSSION

RESULT AND DISCUSSIONS

Age at sexual maturity of Garampriya and its crosses with desi chicken native to Bihar is presented in table -12. As the females where kept under randam matting in the flock the average sexual maturity of hens was determind when three percent of total flock size start to lay the eggs. The average age at sexual maturity of GPXGP was found to be 148 days which is the lowest as compared to Muz desi X GP and Gaya desi X GP by 17 days and 14 days respectively . Sinha (2014) observed the age of sexual maturity of GPxGP to be 145.28 days. The average sexual of maturity GP XGP reported by Sinha (2014) is similar to the finding of the present study. The information on age at sexual maturity of Gramapriya in crosses with desi chicken native to Bihar is very scanty in the literature. Hence the finding of present study could not be compared.

Table -12 Age at sexual maturity of Garamapriya and its crosses with desi chicken native to Bihar.

Genetic groups	Age of sexual maturity (days)
GP♂♂ x GP♀♀	148
Muz desi♂♂ x GP♀♀	165
Gaya desi♂♂xGP♀♀	162

Egg weight(g):

The least square means along with their standared error (SE) and coefficient of variation percentage (CV%) of egg weight at the age of sexual maturity and at 40 weeks of age of Gramapriya and its crosses with desi chicken native to Bihar have been presented in table 13. The average egg weight of GP XGP, Muz desi X GP and Gaya desi X GP were found to be 40.65±0.265, 34.95±0.458 and 35.78±0.255, respectivvaly. The average egg of weight GPxGP observed in the present study is in conformatry with the findings of Sinha (2014). The average egg weight of Muz desi X GP and Gaya desi X GP observed in the present study could not be compared due to scanty in the available literature. The average estimate of egg weight of GP X GP, Muz desi and Gaya desi X GP were observed to be 53.86±0.636,44.52±0.636 and 44.02±0.636 g respectivally. The averge egg weight of GP XGP at 40 weeks of age was reported to be 54.23 g which is in accordence with the finding of the present study. The averge egg weight of GP XGP was found to be increased by 13.21gm over the egg weight at the age of sexual maturity. The egg weight at 40 weeks of age was found to be increased by 32.5% over the egg weight at ASM. Similarly the average egg weight of Muz desi X GP at 40 weeks of age was found to be increased by 9.57 g. The average egg weight of Gaya desi X GP at 40 weeks of age was found to be increased by 8.24 g. The percentage increase in egg weight at 40 weeks of age over the egg weight at the age of sexual maturity of MUZ desi X GP and Gaya desi X GP was found to be 27.38 and 23.03 % respectivally. The analysis of varience for the effect of genetic groups on egg weight is depicted in table 14.

Table 13: Least square mean ± SE and CV% of egg weight (g) at ASM and 40 weeks of age in Gramapriya and its crosses.

Genetic group	No of obs	Egg weight(g) ASM	Egg weight (g) at 40 weeks of age	% increase in egg weight
GP♂♂ x GP♀♀	50	40.65^{a}±0.265	53.86^{a}±0.636	32.50
Muz desi♂♂ x GP♀♀	50	34.95^{b}±0.458	44.52^{b}±0.636	27.38
Gaya desi♂♂xGP♀♀	50	35.78^{b}±0.255	44.02^{b}±0.636	23.03

Means with different superscripts (column wise abc) differed significantly (P<0.01).

The analysis of variance revealed significant (P<0.05) effect of genetic groups on the egg weight in Gramapriya and its crosses with desi chicken. The hen of GP XGP genetic group laid the heaviest egg at age sexual maturity which was significantly (P<0.05) heavier than the eggs laid by Muz desi X GP Gay desi X GP by 5.70 and 4.87 gm respectively. Similarly at 40 weeks of age the hens of GP X GP genetic group also laid the largest egg which was significantly (P<0.05) larger than the eggs laid by Muz desi X GP and Gaya desi X GP genetic groups by 9.34 and 9.84 g respectively. However, the average estimates of egg weight laid by Muz desi X GP did not differ significantly from the eggs laid by Gaya desi X GP both at ASM and at 40 weeks of age.

Table 14 Analysis of variance showing the genetic effect on egg weight in Garamapriya and its crosses.

Traits	Source of variation	D.F	M.S
Egg wt. at ASM	Between genetic groups	2	446.23**
	Error	147	26.85
Egg wt. at 40 weeks of age	Between genetic groups	2	523.93**
	Error	147	19.62

** Significant at ($P<0.01$).

Least squares mean and ± SE and CV % of body weight of Garampriya and its crosses with desi chicken native to Bihar at the age of sexual maturity have been presented in table- 15. The average estimates of body weight of GP X GP, Muz desi X GP and Gaya desi X GP were found to be 1570.65 ± 3.78, 1205.64 ± 3.54 and 1235.84 ± 4.28 g respectively. The average estimate of body at ASM of GP X GP of observed in the findings of the present study was also reported by Jha and Prasad (2013) and Sinha (2014). The information on body weight at sexual maturity of Garampriya and its crosses with indigenous /desi chicken is very scnty in the available literature. However, Sharma (2014) reported that the average body weight of Gramapriya Muz desi and Garampriya Gaya desi at 50 % level of genetic inheritrence to be 1191.67 ± 24.89 and 1150.00± 21.81 g respectively which is closer to the findings of the present study.

able 15 Least squares mean ± SE and CV% of body weight of ɪaramapriya and its crosses at the age of sexual maturity.

Genetic group	Mean±SE(g)	cv%
GP♂♂ x GP♀♀	1570.65[a]±3.78	0.695
Muz desi♂♂ x GP♀♀	1205.64[b]±3.54	0.458
Gaya desi♂♂xGP♀♀	1235.84[b].65[c]±4.28	1.25

⁄leans with different superscripts (column wise abc) did not differ ignificantly

The analysis of varience for the effect of genetic group on body veight at the age of sexual maturity (ASM) is presented in table 16. The nalysis of variance revealed highly significant (P <0.01) effect of genetic ;roup on body weight at ASM. The averge estimate of body weight of GP XGP vas found to be significantly (P<0.05) higher than Muz desi X GP and Gaya lesi X GP by 365.0 and 334.8 g respectively. The effect of genetic group on ody weight observed in the present study have also been reported by authors, harma (2014). Sinha (2014) Hazra *et al.* (2014) and Jha and Prasad (2013).

Table 16 Analysis of variance for the effect of genetic group on body weight of chicken at ASM.

Source of variation	df	M.S
Between group	2	869.8936**
Error	147	84.62

** Significant at (P<0.01).

External Egg Quality Traits:

Least squares means along with their SE and CV% of egg length (cm) egg width (cm) shape index and shell thickness (mm) of Gramapriya and its crosses with desi chicken have been presented in table-17.

Egg Length:

The average estimates of egg length in GP×GP, Muz desi × GP and Gaya desi × GP were observed to be 52.34±0.27, 50.90±0.27 and 50.70±`0.27 (mm) respectively. The average egg length reported in the available literature by Sapra and Aggrawal (1971) Niranjan *et al.* (2008), Islam and Dutta (2010) to be lengthier than the findings of the present study. Sinha (2014) also reported lengthier eggs in Gramapriya (GP×GP). Sharma (2014) reported lengthier eggs in GP×Gaya and GP×Muz desi chicken native to Bihar at 50% level of genetic inheritance than the findings of the present study.

The analysis of variane (Table-18) revealed significant (P<0.05) effect of genetic groups on egg length in Gramapriya and its corsses with desi chicken native to Bihar. The egg length of GP×GP was found to be significantly (P< 0.05) lengthier than the eggs laid by Muz desi × GP and Gaya desi × GP by 1.44 and 0.2 (mm) respectively. Significant (p<0.05) effect of genetic group of on egg length observed in the present study has also been reported by Sapra and Agarwal (1971), Niranjan *et al.* (2008) Islam and Dutta (2010), Sharma (2014) and Sinha (2014).

Egg width (mm):

The least squares mean ±SE and CV% of egg width have been presented in table- 17. The average estimates of egg width in GP × GP, Muz desi × GP and Gaya desi × GP were found to be 40.79±0.28, 39.18±0.28 and 39.28±0.28mm respectively. The analysis of variance revealed significant ($P<0.01$) effect of genetic group on egg width. The average egg length of GP×GP was found to be significantly ($P<0.05$) wider than the eggs laid by Muz desi × GP and Gaya desi × GP by 1.61 and 1.51mm respectively. The results obtained in the present study are in accordance with the findings of Sapra and Agarwal (1971), Niranjan *et al.* (2008) and Islam and Dutta (2010). However, Sharma (2014) reported the higher estimate for egg width than the finding of the present study at 50% genetic inheritance when Gramapriya was crossed with desi chicken native to Gaya and Muz. Significant ($P<0.01$) effect of genetic group on egg width as observed in the findings of the present study also reported by Sapra and Agarwal (1971), Niranjan *et al.* (2008), Islam and Dutta (2010) and Sharma (2014).

Shape Index:

The least squares means ±SE and CV% of shape index have been presented in table-17. The average estimates of shape index in GP×GP, Muz desi × GP and Gaya desi × GP were found to be 76.36±0.47, 77.33±0.47 and 77.25±0.47 respectively. The analysis of variance revealed the genetic group had no significant effect on shape index. The average estimates of shape index among the crosses were more than the shape index of GP×GP but did not differ significantly. The values obtained in the findings of the present study were higher than the values obtained by Sharma (2014). Significantly lower estimate of shape index has also been reported by Sakuntala Devi and Reddy (2004), Chatterjee *et al.* (2006). However, the findings of the present study is in accordance with the findings of Niranjan *et al.* (2008), Zita *et al* (2009), Padhi *et al.* (2013) and Sinha (2014). The average estimates of shape index obtained by Mohanthi *et al.* (2011) in indigenous breed of chicken were similar to the findings of the present study.

Shell Thickness (mm):

The least squares means along with their SE and CV% of shell thickness (mm) have been presented in table-17. The average estimates of shell thickness in GP×GP were observed to be 0.42±0.01, 0.38±0.005 and 0.037±0.005mm respectively. The analysis of variance table – 18 revealed significant ($P<0.05$) effect of genetic group of shell thickness. The average shell thickness of GP×GP was found to be significantly ($P<0.05$) thicker than the shell thickness of the eggs laid by Muz. Desi × GP and Gaya desi × GP by 0.04 and 0.01mm respectively. The mean shell thickness obtained in the findings of the present study is in close proximity with the findings of Niranjan *et al.* (2008), Mohanthi *et al.* (2011) and Sinha (2014). However, Parmar *et al.* (2006), Jha and Prasad (2013) and Alewi *et al.* (2012) reported lesser shell thickness than the findings of the present study. Significant ($P<0.005$) effect of genetic group on shell thickness observed in the findings of the present study have also been reported in the literature by many workers. Niranjan *et al,* 2008, Zita *et al,* 2009, Jha and Prasad 2013, Sinha 2014 and Sharma 2014.

Table -17. Least squares means, SE and CV% of egg length, egg width, shape index and shell thickness in different genetic groups of chicken at 40 weeks of age.

Genetic group	No. of Obs.	Egg length (mm)		Egg width (mm)		Shape Index		Shell thickness (mm)	
		Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV %	Means ± S.E.	CV%
GP♂♂ X GP♀♀	50	$52.34^{a} \pm 0.27$	3.647	$40.79^{a} \pm 0.28$	4.853	$76.390^{a} \pm 0.479$	4.433	$0.42^{a} \pm 0.01$	8.417
Muz desi♂♂ X GP♀♀	50	$50.90^{b} \pm 0.27$	3.750	$39.18^{b} \pm 0.28$	5.053	$77.33^{a} \pm 0.479$	4.379	$0.38^{b} \pm 0.005$	9.304
Gaya desi♂♂ X GP♀♀	50	$50.70^{b} \pm 0.27$	3.765	$39.28^{b} \pm 0.28$	5.040	$77.25^{a} \pm 0.479$	4.384	$0.37^{c} \pm 0.005$	9.304

NB: Means with similar superscripts (column wise-abc) didnot differ significantly

thickness in chicken.

Traits	Source of variation	df	M.S.
Egg length (mm)	Between groups	2	0.4003**
	Error	147	0.0369
Egg width (mm)	Between groups	2	0.4110**
	Error	147	0.0416
Shape index	Between groups	2	13.682
	Error	147	11.498
Shell thickness (mm)	Between groups	2	0.0230**
	Error	147	0.0013

** Significant at $P<0.01$

NS = Non significant

INTERNAL EGG QUALITY TRAITS:

Albumen Height:

The least squares means ± SE and CV% of albumen height have been presented in table – 19. The average estimate of albumen height in GP×GP, Muz desi × GP and Gaya desi × GP were estimated to be 5.176±0.655, 4.569±0.2027 and 5.109±0.293(mm) respectively. The average albumen height for GP×GP obtained in the present study is in accordance with the findings of Niranjan *et al.* (2008) and Sinha (2014). The average estimates of albumen height of the cross bred obtained in the present experiment were found to be lower than the findings reported by Sinha (2014). The variation in the traits may be due to variation genetic make up of the chicken as well as variation due to feeding and management practices. The average albumen height of GP×desi Gaya reported by Sharma (2014) was lower than the findings obtained in the present study wereas the author reported the higher estimates of albumen height for GP×Muz. Desi genetic group.

The analysis of variance showing the genetic effect on albumen height (table 20) revealed significant ($P<0.05$) effect of genetic group on albumen height. The mean albumen height of GP×GP was found to be significantly ($P<0.05$) higher than the Muz. Desi × GP by 0.607mm but did not differ significantly from Gaya desi × GP. The significant ($P<0.05$) effect of genetic group on albumen height obtained in the findings of the present study have also been reported by Niranjan *et al.* (2008) Alewi *et al.* (2012) Kumar *et al.* (2014) and Sinha (2014).

Albumen Index:

The least square mean ± SE and CV% of albumen index have been presented in table 19. The average estimates of albumen index were calculated to be 8.027±0.671, 8.202±0.232 and 8.045±0.300 in GP × GP, Muz. Desi × GP and Gaya desi × GP respectively. The average albumen index obtained in the present study is in close proximity with the findings of Zita *et al.* (2009) and Padhi *et al.* (2013) in different breeds of chicken. However, Mohanty *et al.* (2011) reported higher estimates of albumen index in various indigenous breeds of chicken. The mean albumen index obtained in the findings in the present study are in agreement with the findings of Sharma (2014) at 50% genetic inheritance of Desi chicken.

The analysis of variance for the effect of genetic group on albumen index has been depicted in table-20 which revealed significant ($P<0.05$) effect of genetic group on this trait. The average albumen index of Muz. Desi × GP was found to be significantly ($P<0.05$) higher than the GP×GP and Gaya desi×GP by 0.175 and 0.157 respectively. The average albumen index of Gaya desi × GP was though found to be higher than the GP×GP but did not differ significantly ($P<0.05$). Significant ($P<0.05$) effect of genetic group on albumen index obtained in the present study have also been reported by Parmer *et al.* (2006), Zita *et al* (2009), Sinha (2014). Sharma (2014) has also reported significant ($P<0.05$) effect of genetic group on albumen index but did not find significant difference between GP×Gaya desi and GP×Muz desi.

Yolk Height:

Least square mean ± SE and CV% of yolk height have been presented in table-19. The average estimates of yolk height were found to be 16.984±1.670, 16.479±0.578 and 15.402±0.746 (mm) of GP×GP, Muz. Desi × GP Gaya desi × GP genetic group respectively. The findings of the present study is corroborated with the findings of Niranjan *et al.* (2008) to reported the average Yolk height to be vary from 16.2 in C_2 cross to 16.9mm in C_1 cross and Vanraja, Alewi *et al.* (2012) in RIR and its crosses and Kumar *et al.* (2014) in RIR and Sinha (2014) in Gramapriya, Vanaraja and their reciprocal crosses. However, the higher estimates of yolk height have been reported by Sharma (2014) than the values obtained in the present study.

The analysis of variance for the effect of genetic group have been depicted in table-20. Table 20 revealed highly significant (P<0.01) effect of genetic group on yolk height. The average estimates of yolk height in GP×GP and Muz desi ×GP were significantly (P<0.05) higher than the value observed in Gaya desi × GP by 1.582 and 1.077, respectively. The significant (P<0.05) effect of genetic group on yolk height have been reported in the literature by Niranjan *et al.* (2008) Alewi *et al.* (2012), Kumar *et al.* (2014), Sinha (2014) and Sharma (2014) in different breeds of chicken .

The average estimates of yolk height in the crosses of Gramapriya with desi chicken in Bihar reported to be varied from 26.3 to 27.0mm Sharma (2014). The lesser height of yolk observed in the present study as compared to the value as reported by Sharma

(2014) may be due to storage of eggs for a longer period the keeping quality of eggs has been reduced.

Yolk Diameter:

Mean ± SE and CV% of yolk diameter have been presented in table-19. The average estimates of yolk diameter in GP×GP, Muz desi×GP and Gaya desi × GP were observed to be 35.412±0.420, 36.472±0.145 and 38.25±0.187(mm) respectively. The average estimates of yolk dia as observed in the present study were in agreement in the findings of Sinha (2014). However, the higher estimates of yolk diameter in the crosses with GP in desi chicken in Bihar.

The analysis of variance for the effect of genetic group on yolk diameter has been shown in table-20. Table-20 revealed highly significant (P<0.01) effect of genetic group on yolk diameter. The average estimates of yolk diameter in Gaya desi × GP were found to be significantly (P<0.05) higher than the values obtained in GP×GP and Muz desi × GP by 2.838 and 1.778mm respectively. The average estimates of yolk diameter of Muz desi × GP was found to be higher than the GP×GP but did not differ significantly. The significant effect of genetic group on yolk diameter have also been reported in the literature by Niranjan *et al.* (2008), Alewi *et al.* (2012), Sharma (2014) and Sinha (2014).

Yolk Index:

Mean ± SE and CV% of yolk index have been presented in table - 19. The average estimates of yolk index in GP×GP Muz desi

× GP and Gaya desi × GP were reckoned to be 46.66±1.714, 49.380±0.593 and 45.400 ± 0.766 respectively. The results obtained in the present study are corroborated with the findings of Niranjan *et al.* (2008) Zita *et al.* (2009) Padhi *et al.* (2013) in various breeds of chicken. However, the higher estimates of yolk index as compared to the values obtained in the present study were reported by Sharma (2014) in the crosses of GP with local desi chicken in Bihar as well as in the crosses of Vanaraja with local desi chicken. In contrast to the findings of the present study the lower estimates of yolk indices of various indigenous breeds of chicken have been reported by Mohanty *et al.* (2011). The variation in yolk indices observed in the present study as compared to the values reported in the literature may be due to variation in storage duration and keeping quality of eggs.

The analysis of variance (Table- 20) revealed highly significant ($P<0.01$) effect of genetic group of yolk index. The average estimates of yolk index of Muz desi × GP was found to be significantly ($P<0.05$) higher than the GP×GP and Gaya desi × GP by 2.72 and 3.986 respectively. The significant ($P<0.01$) effect of genetic group on yolk index have been reported in the literature by Niranjan *et al.* (2008) Zita *et al.* (2009) and Sinha (2014). However, the non significant effect of genetic group on yolk index have been reported in the literature by Sharma (2014).

and yolk index in different genetic groups of chicken.

Genetic group	No. of Obs.	Albumen height (mm)		Albumen Index		Yolk height (mm)		Yolk diamter (mm)		Yolk Index	
		Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%
GP♂♂XGP♀♀	50	$5.176^{a} \pm 0.655$	89.481	$8.027^{a} \pm 0.671$	5.910	$16.984^{a} \pm 1.670$	69.52	$35.412^{a} \pm 0.420$	8.386	$46.666^{a} \pm 1.714$	25.97
Muz desi♂♂XGP♀♀	50	$4.569^{b} \pm 0.227$	35.130	$8.202^{b} \pm 0.232$	2.001	$16.479^{a} \pm 0.578$	24.80	$36.472^{a} \pm 0.145$	2.811	$49.386^{b} \pm 0.593$	8.490
Gaya desi♂♂XGP♀♀	50	$5.109^{a} \pm 0.293$	40.552	$8.045^{b} \pm 0.300$	2.636	$15.402^{b} \pm 0.746$	34.24	$38.25^{b} \pm 0.187$	3.456	$45.400^{a} \pm 0.766$	11.930

NB: Means with similar superscripts (column wise-abc) didnot differ significantly.

Table – 20 Analysis of variance showing the genetic effect on albumen height, albumen index, yolk height, yolk diameter and yolk index in chicken.

Traits	Source of variation	df	M.S.
Albumen height (mm)	Between groups	2	8.626*
	Error	147	3.866
Albumen index	Between groups	2	31.532**
	Error	147	4.054
Yolk height (mm)	Between groups	2	507.83**
	Error	147	25.107
Yolk diameter (mm)	Between groups	2	22.128**
	Error	147	1.589
Yolk Index	Between groups	2	473.032**
	Error	147	26.441

*Significant of P<0.05

** Significant at P<0.01

Albumen Weight:

The least squares mean along with their SE and CV% of albumen weight have been presented in table-21. The average estimates of albumen weight in GP×GP, Muz desi × GP and Gaya desi × GP were found to be 30.66±0.89, 25.91±0.31 and 25.44±0.40 (g) respectively. The average estimates of albumen weight obtained in the present study for GP × GP is in agreements with the findings of Niranjan *et al.* (2008) and Sinha (2014). The average estimates of albumen weight for the crosses of GP with local desi chicken is in close proximity to the findings of Chatterjee *et al.* (2007) who reported the average albumen weight to be ranged from 26.46 to 26.67g in indigaous fowl. However, Zita *et al.* (2009) obtained higher estimates of albumen weight in various commercial strains of broiler chicken. The variation in albumen weight observed in the present study may be due to genetic origin.

The analysis of variance (Table- 21) revealed highly significant ($P<0.01$) effect of genetic group on albumen weight. The average estimates of albumen weight of GP×GP was found to be significantly ($P<0.05$) heavier than the values obtained in Muz desi × GP and Gaya desi × GP by 4.75 and 5.22 respectively. Significant effect of genetic group on albumen weight have been reported by many workers. Niranjan *et al.* (2008), Zita *et al.* (2009), Islam and Dutta (2010), Sreenivas *et al.* (2013) and Sinha (2014).

Yolk Weight:

Least squares means along with their SE and CV% of yolk weight have been shown in table 21. The average estimates of yolk weight were found to be 17.89±0.48, 14.34±0.16 and 14.44±0.22 g of GP×GP, Muz desi × GP and Gaya desi × GP respectively. The average estimates of yolk weight observed in the present study are in agreement with the findings of Mohanty *et al.* (2011) Islam and Dutta (2010) and Sreenivas (2013) in various indigenous and exotic breeds of chicken. However, Padhi *et al.* (2013) reported the higher estimates of yolk weight as compared to the findings of the present study in Vanraja from 40 to 72 weeks of age.

The analysis of variance for the effect of genetic group on yolk weight have been presented in table-22. The table revealed that the genetic group had highly significant (P<0.01) effect on yolk weight. The average estimates of yolk weight of GP×GP was found to have significantly (P<0.05) higher value than the values obtained in Muz desi × GP and Gaya desi × GP by 3.55 and 3.45 g respectively. However, the mean yolk weight of Muz. Desi × GP did not differ significantly from Gaya desi × GP. The significant (P<0.01) effect of genetic group on yolk weight observed in the present study have also been reported by Niranjan *et al.* (2008), Zita *et al.* (2009), Islam and Dutta (2010), Mohanty *et al.* (2011), Sreenivas *et al.* (2013) and Sinha (2014).

Shell weight:

Least squares mean ± SE and CV% of Shell weight have been presented in table – 21. The average estimates of shell weight were reported to be 4.88±0.093, 4.27±0.03 and 4.14±0.093g in GP×GP Muz desi × GP and Gaya desi × GP respectively. The average estimates of shell weight observed in the present study are in close agreement with the findings of Niranjan *et al.* (2008), Sreeniwas *et al.* (2013) and Sinha (2014.

The analysis of variance (table- 22) revealed highly significant (P<0.01) effect of genetic group on shell weight in chicken. The average estimates of shell weight in GP×GP genetic group was found to have heaviest shell weight which was found to be significantly (P<0.05) heavier than the egg shell of Muz desi × GP and Gaya desi × GP by 0.61 and 0.72 g respectively. However, there was no significant difference between Muz. Desi × GP and Gaya desi × GP for mean shell weight. The significant effect of genetic group observed in the present investigation was also reported by Niranjan *et al.* (2008), Sinha (2014).

genetic groups of chicken.

Genetic group	No. of Obs.	Albumen weight (g)		Yolk weight (g)		Shell weight (g)		Yolk : albumen ratio
		Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%	
GP♂♂ X GP♀♀	50	$30.66^{a} \pm 0.89$	20.73	$17.89^{a} \pm 0.48$	19.32	$4.88^{a} \pm 0.093$	13.10	0.58
Muz desi♂♂ X GP♀♀	50	$25.91^{b} \pm 0.31$	8.48	$14.34^{c} \pm 0.16$	9.50	$4.27^{b} \pm 0.093$	15.54	0.55
Gaya desi♂♂ X GP♀♀	50	$25.44^{b} \pm 0.40$	11.18	$14.44^{b} \pm 0.22$	9.56	$4.14^{c} \pm 0.093$	15.77	0.57

NB: Means with similar superscripts (column wise-abc) didnot differ significantly.

Table -22 Analysis of variance showing the genetic effect on albumen weight, yolk weight and shell weight in chicken.

Traits	Source of variation	D.F.	M.S.
Albumen weight (g)	Between groups Error	2 147	511.896** 7.288
Yolk weight (g)	Between groups Error	2 147	227.920** 215.127
Shell weight (g)	Between groups Error	2 147	11.197** 0.4398

** Significant at P<0.01.

Percentage of albumen weight, yolk weight and shell weight

Least squares mean ± SE and CV% of angles corresponding to percentage of albumen weight, yolk weight and shell weight have been presented in table 23. The average percentage of albumen weight, yolk weight and shell weight in GP×GP were observed to be 62.2, 29.5 and 9.6% respectively. In Muz desi × GP the corresponding percentages were 63.2, 28.0 and 8.9% respectively. In case of Gaya desi × GP the average percentage of albumen weight, yolk weight and shell weight were estimated to be 60.10, 31.00 and 9.10% respectively. The average percentage of albumen weight observed with the findings of Zita *et al.* (2009), Pardhi *et al.* (2013) and Sreenivas *et al.* (2013). However, Sinha (2014) reported the lower average percentage of albumen weight in GP and its crosses with Vanraja compared to the percentages observed in the present study.

The analysis of variance revealed significant (P<0.01) effect of genetic group on the angles corresponding to the percentage of albumen weight in Muz desi × GP genetic group was found to have the highest percentage of albumen weight was significantly (P<0.05) higher than the percentages of GP×GP and Gaya desi × GP by 1.0% and 3.1% respectively. GP×GP genetic group had significantly (P<0.05) higher percentage of albumen weight than the Gaya desi × GP by 0.5%. significant effect of genetic group on albumen percentage observed in the present study has also been reported by Sinha (2014).

The analysis of variance (table-22) revealed highly significant (P<0.01) effect of genetic group on percentage of shell weight GP×GP was found to have the highest percentage of shell weight which was significantly (P<0.05) higher than the Muz desi × GP by 0.7 g percent but did not differ significantly from Gaya desi × GP. Gaya desi × GP was found to have higher percentage of shell weight than the Muz desi × GP but did not differ significantly. The significant ($P<0.05$) effect of genetic group on the percentage of shell weight observed in the present investigation has also been reported by Sinha (2014).

Table - 23. Least squares means, SE and CV% of angles corresponding to percentage (Angles = Arcsin√ Percentage) of albumen weight, yolk weight and shell weight of different genetic groups of chicken.

Genetic group	No. of Obs.	Albumen weight (g)		Yolk weight (g)		Shell weight (g)	
		Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%
GP♂♂ X GP♀♀	50	54.468^{a}±0.083 (62.2)	1.077	33.746^{a}±0.008 (29.5)	0.167	17.956^{a}±0.008 (9.6)	0.315
Muz desi♂♂X GP♀♀	50	53.146^{b}±0.082 (63.2)	1.091	32.325^{b}±0.008 (28.0)	0.174	17.267^{b}±0.008 (8.9)	0.327
Gaya desi♂♂X GP♀♀	50	51.348^{c}±0.080 (60.1)	1.101	34.852^{a}±0.008 (31.0)	0.162	18.005^{ab}±0.009 (9.1)	0.353

NB : 1. Values present within the parentheses indicating actual percentage.

2. Means with similar superscripts (column wise-abc) didnot differ significantly

Table -24 Analysis of variance showing the genetic effect on angles (Angles = Arcsin Percentage) corresponding to the percentages of albumen weight, yolk weignht and shell weight in chicken.

Traits	Source of variation	D.F.	M.S.
Albumen weight (g)	Between groups	2	511.896**
	Error	147	7.288
Yolk weight (g)	Between groups	2	227.920**
	Error	147	215.127
Shell weight (g)	Between groups	2	11.197**
	Error	147	0.439

* * Significant at $P<0.05$.

:T OF EGG WEIGHT ON EXTERNAL EGG QUALITY TRAITS

'he least squares means along with their SE and CV% of egg length egg ;hape index and shell thickness have been presented in table 25. The s of variance for the effect of egg weight on the aforesaid traits have ꞓpicted in table -26.

:ngth:

Γhe average estimates of egg length in 34-40g egg weight group, 41-47, and 55 and above egg weight groups were observed to be 48.85, 50.80, and 53.77mm respectively. The analysis of variance (Table 26) revealed cant (P<0.01) of egg weight on egg length. The average egg length of 41- -54, 55g and above egg weight groups were observed to be increase cantly (P<0.05) over 34-40g egg weight group. The egg length of 41-47, and 55 and above egg weight groups were significantly (P<0.05) ier than the 34-40g egg weight groups by 1.95, 3.97 and 4.92 mm but id not differ among themselves for this character. Significant effect of eight on egg length observed in the present study has also been reported ha (2014).

'idth:

The average estimates of egg width in 34 – 40g egg weight group was to be 37.04±0.033mm which was the shortest egg width as compared to ıer egg weight groups. The average estimates of egg width in 48 – 54 g and above egg weight groups were found to be increased significantly 5) by 4.11 and 5.84mm respectively. The average egg width of 41-47g eight group though have wider eggs than the 34-40g egg weight groups 1 not differ significantly (P<0.05) The analysis of variance (Table 26) :d highly significant (P<0.01) effect of egg weight on egg width. The e estimates of egg width in 48-54 and 55g and above egg weight groups ound to have significantly (P<0.05) wider eggs than the 41-47g egg groups by 1.86 and 3.59mm respectively, but they did not differ cantly among themselves. The significant effect of egg weight on egg as observed in the present investigation has also been reported by Sinha

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Index

The average estimates of shape index was found to be ranged from ±0.738 in 34-40g egg weight group to 77.91±0.504 in 48-54g egg weight The 48-54g egg weight group though had the highest shape index but ot differ significantly from rest of the groups. However, Sinha (2014) ed significant effect of egg weight on shape index of eggs in chicken. ignificant effect of egg weight on shape index is also observed in the is of variance (Table- 26

Thickness:

The average estimates of shell thickness in 34-40, 41-47, 48-54 and 55g bove egg weight groups were measured to be 0.364±0.005, 0.382±0.002, ±0.003 and 0.501±0.008mm respectively. The analysis of variance (Table revealed highly significant (P<0.01) effect of egg weight on shell ess. The average shell thickness in 34-40g of egg weight group was to have the thinnest shell which was found to be significantly (P<0.05) r than the 48-54 and 55g and above egg weight groups by 0.053 and nm but they did not differ significantly from 41-47g egg weight groups. verage estimates of shell thickness in 41-47g egg weight group was found significantly (P<0.05) thinner than the egg shell of 48-54 and 55g egg groups by 0.035 and 0.119mm respectively. Significant effect of egg on shell thickness observed in the present study has also been reported ha (2014).

Table - 25. Least squares means, SE and CV% of external egg quality traits in different egg weight groups pooled over genetic groups of chicken.

Egg weight (g) groups	No. of Obs.	Egg length (mm)		Egg width (mm)		Shape index		Shell thickness (mm)	
		Means ± S.E.	CV%	Means ± S.E.	CV %	Means ± S.E.	CV %	Means ± S.E.	CV%
34-40	21	48.85^{a}±0.032	3.001	37.04^{a}±0.033	4.082	75.82^{a}±0.738	4.460	0.364^{a}±0.005	6.294
41-47	75	50.80^{b}±0.017	2.898	39.29^{a}±0.017	3.747	77.27^{a}±0.390	4.371	0.382^{a}±0.002	4.534
48-54	45	52.82^{b}±0.022	2.794	41.15^{b}±0.022	3.586	77.91^{a}±0.504	4.340	0.417^{b}±0.003	4.826
55 & above	9	53.77^{b}±0.049	2.733	42.88^{b}±0.051	3.568	77.75^{a}±1.128	4.352	0.501^{c}±0.008	4.790

NB: Means with similar superscripts (column wise-abc) didnot differ significantly.

'able – 26 Analysis of variance showing the effect of egg weight on xternal egg quality traits in chicken.

Traits	Source of variation	D.F.	M.S.
Egg length (mm)	Between groups	2	0.400**
	Error	147	0.036
Egg width (mm)	Between groups	2	0.411**
	Error	147	0.041
Shape index	Between groups	2	13.682
	Error	147	11.498
Shell thickness (mm)	Between groups	2	0.0230**
	Error	147	0.0013

** Significant at $P < 0.01$ NS= Non- Significant

:FFECT OF EGG WEIGHT ON INTERNAL EGG QUALITY TRAITS

The least squares means, SE and CV% of internal egg quality traits in lifferent egg weight groups pooled over genetic groups have been presented in able 27. The analysis of variance for the effect of egg weight on internal egg quality traits has been depicted in table - 28.

Albumen Height:

The average estimates of albumen height in 34-40, 41-47, 48-54 and 55g and above egg weight groups were observed to be 3.850±0.429, 4.569±0.227, 5.109±0.293 and 5.176±0.655mm respectively. The analysis of variance (Table- 28) did not reveal significant ($P<0.05$) effect of egg weight on albumen height. It means height of albumen and egg weight are independent characters. The average albumen height in 41-47, 48-54 and 55g and above egg weight groups were found to have more albumen height than the 34-40g egg weight group by 0.719, 1.259 and 1.326mm respectively but did not differ significantly. However, Sinha (2014) reported significant effect of egg weight on albumen height but the trend of increase in albumen height with the increasing egg weight group reported by Sinha (2014) has also been observed in the present study.

Albumen Index:

The average estimates of albumen index in 34-40, 41-47, 48-54 and 55g and above egg weight groups were calculated to be 8.228±0.439, 8.200±0.232, 8.045±0.300 and 8.027±0.671 respectively. The average albumen index was found to be decreased gradually with the increase in egg weight groups but did not differ significantly. The analysis of variance did not reveal significant effect of egg weight on albumen index. However, Sinha (2014) reported significant effect of egg weight on albumen index which is in contrary to the findings of the present study. However, the trend of increasing the magnitude of albumen index with the increase in egg weight groups observed in the present study has also been reported by Sinha (2014).

Yolk Height:

The average estimates of yolk height in 34-40, 41-47, 48-54 and 55g above egg weight groups were observed to be 16.436±1.093, 15.76±0.578, 18.18±0.746 and 19.78±1.670mm respectively. The mean yolk height was found to be increased significantly (P<0.05) with the increase in egg weight except in 41-47g egg weight group in which the mean yolk height was found to be decreased. The analysis of variance (Table- 28) revealed significant (P<0.01) effect of egg weight on yolk weight. The mean yolk height in 41-47g egg weight group was found to be the lowest which is significantly (P<0.05) lower than the average yolk height of 48-54 and 55g and above egg weight groups by 2.42 and 4.02mm but did not differ significantly from 34-40g egg weight group. Significant (P<0.05) effect of egg weight on yolk height observed in present investigation has also been reported by Sinha (2014). The trend of increase in yolk height with the increasing egg weight groups observed in a present study has also been reported by the above scientist.

Yolk Diameter:

The average estimates of yolk diameter in 34-40, 41-47, 48-54 and 55g and above egg weight groups were found to be 36.475±0.385, 38.485±0.155, 40.285±0.395 and 40.251±0.228mm respectively. The 34-40g egg weight group was found to have the lowest yolk diameter which is significantly (P<0.01) lower than the 41-47, 48-54 and 55g and above egg weight groups by 2.01, 3.81 and 3.78mm respectively. Similarly 41-47g egg weight group also found to have significantly (P<0.05) lesser yolk diameter than the 48-54 and 55g and above egg weight groups by 1.8

ıd 1.77mm respectively. The average estimates of yolk diameter were ›und to be increased significantly with the increase in egg weight groups ut did not differ significantly between 48-54 and 55g and above egg ⁄eight groups. Significant effect of egg weight on yolk diameter observed n the present study have also been reported by Sinha (2014). The trend of ncrease in yolk diameter observed in the present investigation was in .greement with the findings of above authors.

⁄olk Index:

The average yolk index in 34-40, 41-47, 48-54 and 55g above egg veight groups were calculated to be 45.09±1.122, 40.38±0.593, ł5.40±0.766 and 46.66±1.714 respectively. No definite trend could be ›bserved in respect to yolk index. The analysis of variance (Table 28) evealed highly significant (P<0.01) effect of egg weight on yolk indices. ⁼ifty five (g) and above egg weight group was found to have the highest ⁄olk index which was found to be significantly (P<0.05) higher than the ł1-47 g egg weight group by 6.28 but did not differ significantly from ınd 34 to 40 and 48-54g egg weight groups. Fourty one to fourty seven ·gg weight groups was found to have the lowest yolk index which was ;ignificantly (P<0.05) lower than the 34-40 and 48-54 g egg weight ;roups. The significant (P<0.05) effect of egg weight on yolk index ›bserved in the present investigation has also been reported by Sinha 2014).

Table - 27. Least squares means, SE and CV% of internal egg quality traits in different egg weight groups pooled over genetic groups of chicken.

Egg weight (g) groups	No. of Obs.	Albumen height (mm)		Albumen index		Yolk height (mm)		Yolk diameter (mm)		Yolk index	
		Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%
34-40	21	3.850±0.429	51.06	8.228±0.439	2.445	16.436^{a}±1.093	30.47	36.475^{a}±0.385	4.836	45.09^{b}±1.122	9.333
41-47	75	4.569±0.227	43.02	8.200±0.232	2.450	15.76^{a}±0.578	31.76	38.485^{b}±0.155	3.679	40.38^{a}±0.593	10.40
48-54	45	5.109±0.293	38.47	8.045±0.300	2.501	18.18^{b}±0.746	27.52	40.285^{c}±0.295	4.912	45.40^{b}±0.766	11.31
55 & above	9	5.176±0.655	37.96	8.027±0.671	2.507	19.78^{b}±1.670	25.32	40.25^{c}±0.228	1.699	46.66^{b}±1.714	11.02

NB: Means with similar superscripts (column wise-abc) didnot differ significantly.

'able -28 Analysis of variance showing the effect of egg weight on nternal egg quality traits in chicken.

Traits	Source of variation	D.F.	M.S.
Albumen height (mm)	Between groups	2	8.626
	Error	147	3.866
Albumen index	Between groups	2	9.532
	Error	147	4.054
Yolk height (mm)	Between groups	2	507.830**
	Error	147	25.107
Yolk weight (mm)	Between groups	2	2276.920**
	Error	147	2150.127
Yolk index	Between groups	2	473.032**
	Error	147	26.441

**Significant at P<0.01

NS=Non-Significant

lbumen weight:

The least square mean ± SE and CV% of albumen weight in lifferent egg weight groups pooled over various genetics groups of chicken have been presented in table 29. The average estimates of albumen weight in 34-41, 41-47, 48-54 and 55g and above egg weight groups were observed to be 19.76±0.58, 27.80±0.31, 29.55±0.42, 30.55±0.89 g respectively. The analysis of variance revealed significant (P<0.01) effect of egg weight on albumen weight (Table 30). The average estimates of albumen weight was found to be lowest in 34-40g egg weight group which was found to be significantly lower than the 41-47, 48-54 and 55g and above egg weight groups by 8.04, 9.79 and 10.79g respectively. The average albumen weight was found to be increased significantly (P<0.05) and proportionately increased with the increase of egg weight. The mean albumen weight of 41-47g and 48-54 g egg weight groups were found to have significantly (P<0.05) lower albumen weight than the 55g and above egg weight group by 6.75 and 5.0 g respectively but they did not differ significantly among themselves . The significant effect of egg weight on albumen weight observed in the present study has also been reported by Sinha (2014). The trend of increase in egg weight observed in the findings of the present study has also been reported by Sinha (2014).

Yolk weight:

The least square mean ± SE and CV% of yolk weight in different egg weight groups pooled over various genetic groups of chicken have been presented in table- 29. The average estimates of yolk weight in 34-40, 41-47, 48-54 and 55g and above egg weight groups were observed to e 12.765±0.17, 13.145±0.007, 14.658±0.13 and 17.275±0.10 g espectively. The analysis of variance (Table- 30) revealed significant P<0.01) effect of egg weight on yolk weight. Thirty four to fourty g egg veight group was found to have the least mean yolk weight which is significantly (P<0.05) lighter than the 55g and above egg weight groups. Fourty one to fourty seven and 48-54 g egg weight groups though found o have more yolk weight than the 34-40g egg weight group but did not differ significantly. However, 41-47 and 48-54g egg weight groups found to have significantly (P<0.05) lesser yolk weight than the 55g and above egg weight group but did not differ significantly. The significant (P<0.05) effect of egg weight on yolk weight as observed in the findings of the present study have also been reported by Sinha (2014). The trend of increase in yolk weight with the increase of egg weight reported by Sinha (2014) has also been observed in present study.

Shell weight:

The least squares mean ± SE and CV% of shell weight in different egg weight groups pooled over various genetic groups of chicken have been presented in table 29. The average estimates of shell weight in 34-40, 41-47, 48-54 and 55g and above egg weight groups were observed to be 3.281±0.10, 4.376±0.05, 4.942±0.07 and 5.722±0.15 g respectively. The analysis of variance (Table- 30) revealed significant (P<0.01) effect of egg weight on shell weight. Shell weight was found to be the lowest in 34-40g egg weight group which was found to be significantly (P<0.05) lower than the 41-47, 48-54 and 55g and above egg weight groups by .095, 1.661 and 2.441 g respectively. The average estimates of shell weight were observed to be increased gradually and significantly (P<0.05) ith the increase in egg weight. The trend of increase in egg weight has .so been reported in the literature by Sinha (2014) which is similar to the ndings of the present study.

Table - 29. Least squares means, SE and CV% of albumen weight, yolk weight and shell weight of different egg weight groups pooled over various genetics groups of chicken.

Egg weight (g) groups	No. of Obs.	Albumen weight (g)		Yolk weight (g)		Shell weight (g)	
		Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%
34-40	21	$19.76^{a}\pm0.589$	13.65	$12.765^{a}\pm0.176$	6.318	$3.281^{a}\pm0.103$	14.38
41-47	75	$27.80^{b}\pm0.311$	9.688	$13.145^{a}\pm0.075$	4.941	$4.376^{b}\pm0.054$	10.68
48-54	45	$29.55^{bc}\pm0.42$	9.125	$14.658^{a}\pm0.138$	6.777	$4.942^{b}\pm0.070$	9.501
55 & above	9	$34.55^{c}\pm0.899$	8.828	$17.275^{b}\pm0.105$	1.723	$5.722^{c}\pm0.157$	8.231

NB: Means with similar superscripts (column wise-abc) didnot differ significantly.

able -30 Analysis of variance showing the effect of egg weight on albumen weight, yolk weight and shell weight in chicken.

Traits	Source of variation	D.F.	M.S.
Albumen weight (g)	Between groups	2	511.896**
	Error	147	7.288
Yolk weight (g)	Between groups	2	2276.920**
	Error	147	2150.127
Shell weight (g)	Between groups	2	11.197**
	Error	147	0.439

** Significant at $P < 0.01$

rcentag of albumen weight,yolk weight and shell weight.

rcentage of albumen weight, yolk weight and shell weight as well as ean ± SE and CV% of the angles corresponding to percentage of bumen weight, yolk weight and shell weight of different egg weight oups pooled over various genetics groups of chicken have been esented in table -31. The analysis of variance for the effect of egg eight an angles corresponding to the percentages of albumen weight, lk weight and shell weight have been depicted in table -32.

lbumen Percentage.

The average percentage of albumen weight in 34-40, 41-47, 48-54 d 55g and above egg weight groups were found to be 46.85, 46-45, '.19 and 48.19· respectively. The percentage of albumen weight was und to be increased linearly with the increase in egg weight. The alysis of variance (Table- 32) revealed highly significant (P<0.01) fect of egg weight group on the angles corresponding to the percentage albumen weight. The 55g and above egg weight group was found to ve significantly (P<0.05) higher percentage of albumen than the 34-40, -47 and 48-54 egg weight groups by 1.34,1.74 and 1.0 percentage. The erage estimates of albumen percentage observed in the present study re lower than the findings of Zita *et al.* (2009), Padhi *et al.* (2013) and eeniwas (2013). However, the findings of Sinha (2014) is in agreement th the findings of present study.

Yolk percentage:

Mean ± SE and CV% of the angles corresponding to percentage of yolk weight have been presented in table -31. The average estimates of yolk percentage of 34-40g egg weight group was found to be 34.65 percent. The percentage of yolk weight was estimated to be ranged from 33.75 in 48-54g egg weight group to 35.57 percent in 55g and above egg weight group. Percentage of yolk weight in 55g and above egg weight group was found to have significantly ($P<0.05$) higher than the 34-40g and 48-54g egg weight groups by 0.92 and 1.82 percentage respectively. The findings of the present study is an aggrement with the findings of Sinha (2014).

Shell weight percentage:

Mean ± SE and CV% of the angles corresponding to percentage of shell weight have been presented in table- 31. The average percentage of shell weight of 34-40g egg weight group was found to be 24.68 percent. The average percentage of shell weight was found to be the lowest in 34-40g egg weight group and it was found to be increased gradually with the increased in egg weight but did not differ significantly. The findings of the present study are in close proximity with the findings of Sinha (2014).

Table - 31. Least squares means, SE and CV% of angles corresponding to percentage (Angles = Arcsin √ Percentage) of albumen weight, yolk weight and shell weight of different egg weight groups pooled over various genetic groups of chicken.

Egg weight (g) groups	No. of Obs.	Albumen Weight		Yolk Weight		Shell Weight	
		Means ± S.E.	CV%	Means ± S.E.	CV%	Means ± S.E.	CV%
34-40	21	$52.578^{a} \pm 0.192$ (46.85)	1.673	$32.325^{a} \pm 0.159$ (34.65)	2.254	$18.345^{a} \pm 0.135$ (24.68)	3.372
41-47	75	$53.595^{ab} \pm 0.078$ (46.45)	1.260	$31.735^{ab} \pm 0.075$ (34.25)	2.046	$17.465^{b} \pm 0.055$ (25.08)	2.727
48-54	45	$53.085^{a} \pm 0.145$ (47.19)	1.832	$30.840^{b} \pm 0.145$ (33.75)	3.153	$18.135^{c} \pm 0.105$ (25.15)	3.883
55 & above	9	$54.345^{b} \pm 0.110$ (48.19)	0.655	$33.840^{c} \pm 0.108$ (35.57)	0.957	$18.005^{c} \pm 0.075$ (25.16)	1.249

NB: 1. Values present within the parentheses indicating actual percentage.

2. Means with similar superscripts (column wise-abc) didnot differ significantly.

Table –32 Analysis of variance showing the effect of egg weight on angles (Angles = Arcsin √ Percentage) corresponding to the percentages of albumen weight, yolk weight and shell weight in chicken.

Traits	Source of variation	D.F.	M.S.
Albumen weight	Between groups	3	511.896**
	Error	146	7.2886
Yolk weight	Between groups	3	2276.920
	Error	146	2152.0983
Shell weight	Between groups	3	18.155**
	Error	146	0.2232

** Significant at $P<0.01$.

NS – Non significant.

Coefficient of phenotypic correlation:

The coefficient of phenotypic correlation among various egg quality traits of chicken pooled over genetic groups have been presented in table-33.

Correlation between egg weight and egg quality traits:

The estimates of coefficient of correlation between egg weight and egg quality traits were, in general, found to be highly significant (P<0.01), positive and moderate to very high in magnitude except the correlation between egg weight and shape index as well as between egg weight and albumen index where the coefficient of correlation were found to be non significant. Highly significant (P<0.01) and positive correlation of moderate to very high in magnitude between egg weight and other egg quality traits observed in the findings of the present study have also been reported in the literature by Sapra and Agarwal (1971), Amenkwah (2013) and Sinha (2014). Non- significant, positive and very low magnitude of phenotypic correlation between egg weight and shape index. Observed in the present study have also been reported by Islam and Dutta (2010) and Padhi *et al.* (2013). However, contrary to this, negative and significant correlation coefficient between egg weight and shape index were observed by Ali Panah *et al.* (2013), Amankwah (2013) and Sinha (2014). Significant, positive and very high magnitude of phenotypic correlation of egg weight with egg length egg width, shell thickness and shell weight observed in the findings of the present study have also been reported by Sapra and Agarwal (1971), Kumar (2000), Alipanah *et al.* (2013) and Sinha (2014). Highly significant (P<0.01), positive and very high magnitude of phenotypic correlation of egg weight with albumen weight and yolk weight observed in the findings of the present study have also been reported in the literature by Born Stein and Lipstein (1962) Olawumi and Ogunlade (2008), Islam and Dutta (2010), Alipanah *et al.* (2013), and Sinha (2014).

Correlation between egg length and other egg quality traits:

The estimates of phenotypic correlation of egg length with egg width, shape index, shell thickness, shell weight, albumen weight, yolk height and yolk weight were in general found to be very high in magnitude, positive and highly significant ($P<0.01$). Results observed in the findings of the present study have also been reported in the literature of Sinha (2014). The presence of highly significant ($P<0.01$) and positive correlation with high magnitude observed in the present study revealed that albumen weight and yolk weight may be improved simultaneously by considering the egg length as a selection criteria. Egg length was found to have negative phenotypic correlation with albumen index, yolk index and albumen diameter. The results obtained in the findings of the present study have also been reported in the literature by Kumar (2000) and Sinha (2014).

Correlation between egg width and other egg quality traits:

Egg width was found to have, in general, highly significant ($P<0.01$) and positive correlation with shell thickness, shell weight, albumen weight, yolk height and yolk weight and moderate to high in magnitude. Positive and significant phenotypic correlation coefficeents of egg width, albumen weight, yolk weight observed in the findings of the present study have also been reported by Amankwah (2013) and Sinha

2014). However, egg width was found to be negatively correlated with yolk diameter and yolk index. Similar to the findings of the present study, the non significant and negative phenotypic correlation of egg width with yolk diameter and yolk index also reported by Kumar (2000).

Correlation between Shape Index and Other egg quality traits:

The coefficient of correlation of shape index with other egg quality traits were, in general, positive but satistically non significant but positive phenotypic correlation of shape index with shell thickness, albumen weight, albumen index, yolk diameter and yolk index observed in the findings of the present study has also been reported by Sinha (2014). However, shape index was observed to have non significant and negative phenotypic correlation with albumen height, yolk height and yolk weight. The non significant and negative correlation of shape index with albumen height, yolk height and yolk weight observed in the findings of the present study have also been reported by Kumar (2000) and Sinha (2014).

Correlation between Shell Thickness and Other egg quality traits:

Shell thickness was found to have, in general, highly significant and positive phenotypic correlation with shell weight, albumen weight, yolk height and yolk weight. The magnitudes were found to be moderate to high. However, the estimates of phenotypic correlation of shell thickness with albumen index, yolk diameter and yolk index were negative but significant and low to moderate in magnitude. The results obtained in the findings of the present study have been also reported by Amankawh (2013), Kumar (2000), Sreeniwas (2013) and Sinha (2014).

Correlation between Shell Weight and Other egg quality traits:

The estimates of phenotypic correlation of shell weight with albumen weight, yolk height and yolk weight were observed to be highly significant ($P<0.01$) positive and moderate to very high in magnitude. The estimates of phenotypic correlation of shell weight with yolk diameter and yolk index were found to have highly significant ($P<0.01$) but negative phenotypic correlation and moderate in magnitude. Highly significant ($P<0.01$) and positive phenotypic correlation of shell weight with albumen weight yolk weight and yolk height observed in the findings of the present study have also been reported by Olawumi and Ogunlade (2008), Sreeniwas *et al* (2013) and Sinha (2014).

Correlation between Albumen Height and Other egg quality traits:

The albumen height was found to have significant ($P<0.05$) and positive phenotypic correlation with yolk height and yolk width but it was negatively correlated with albumen index, yolk diameter and yolk index. The findings of the present study is in close proximity with the findings of Kumar (2000), Amankawah (2013) and Sinha (2014).

Correlation between Albumen Weight and Other egg quality traits:

The albumen weight was found to have, in general, negative phenotypic correlation with yolk diameter and yolk index were as the correlation between the albumen weight with yolk weight was found to be highly significant ($P<0.01$) and positive correlation with yolk weight. The phenotypic correlation between albumen weight with yolk height and yolk weight were positive and significant. The magnitudes of correlation were, in general, observed to be low to moderate in magnitude. Highly ignificant (P<0.01) and positive phenotypic correlation between albumen ıeight and yolk weight observed in the present study have also been ·eported by Kul and Seker (2004), Olawumi and Ogunlade (2008) Alipanah (2013), Sreeniwas (2013) and Sinha (2014).

Correlation between Albumen Index and Other egg quality traits:

The albumen index was found to have significant (P<0.01) phenotypic correlation with all the egg quality traits like yolk height, yolk diameter, yolk weight and yolk index. However, the albumen index was found to be negatively correlated yolk height and yolk weight wereas positively correlated with yolk diameter and yolk index. The similar findings have also been reported by Sreenivas *et al.* (2013), Amankwah (2013) and Sinha (2014).

Correlation between Yolk Height and Other egg quality traits:

The estimates of phenotypic correlation yolk height with yolk weight and yolk diameter were positive significant and moderate to high in magnitude. The phenotypic correlation between yolk height and yolk index was found to be highly significant (P<0.01), negative and moderate in magnitude. The significant (P<0.05) and positive phenotypic correlation of yolk height with yolk weight and yolk diameter observed in the findings of the present study has also been reported by Sinha (2014). However, Sinha (2014) reported significant and positive phenotypic correlation between yolk height and yolk index which is not in agrement with the findings of present study. Highly significant (P<0.01) and negative phenotypic correlation between yolk height and Yolk index observed in the present study has suggested that with the decrease in yolk diameter, the yolk height may be increased.

Correlation between Yolk Weight and other egg quality traits:

The yolk weight was found to have highly significant ($P<0.01$) and positive phenotypic correlation with yolk index and magnitude of correlation was very high. But the correlation with yolk diameter was positive but not significant. Significantly ($P<0.01$) very high and positive phenotypic correlation between yolk weight and yolk index and yolk diameter suggested that by decreasing the yolk diameter as one of the selection criterion the yolk weight may be reduced which is most desirable. The significant and positive phenotypic correlation of yolk weight with yolk diameter and yolk index observed in the findings of the present study has also been reported by Sinha (2014).

Correlation between Yolk Diameter and Yolk Index:

Yolk width was found to have highly significant and negative phenotypic correlation with yolk index and the magnitude is very high which suggested that the yolk index may be increased or decreased by decreasing or increasing the yolk diameter but higher yolk index is the indication of good yolk quality. The results obtained in the present study has also been reported by Sinha (2014).

'able -33. Coefficient of phenotypic correlation between various egg quality traits of chicken pooled over genetic groups.

Traits	
	r_p ± SE
Egg weight × Egg length	0.761**±0.105
× Egg Width	0.699**±0.104
× Shape index	0.114±0.112
× Shell thickness	0.768**±0.125
× Shell weight	0.822**±0.065
× Alb. Height	0.211*±0.135
× Alb. Weight	0.722**±0.105
× Alb. Index	-0.290±0.118
× Yolk height	0.565**±0.119
× Yolk weight	0.861**±0.063
× Yolk diameter	-0.510±0.120
× Yolk index	-0.538±0.114
Egg length x Egg width	0.608**±0.115
x Shape index	0.506**±0.123
× Shell thickness	0.574**±0.112
× Shell weight	0.790**±0.085

× Alb. Height	0.149±0.141
Traits	
	r_p ± SE
× Alb. Weight	0.440**±0.125
× Alb. Index	-0.229±0.138
× Yolk height	0.382*±0.132
× Yolk weight	0.644**±0.106
× Yolk diameter	-0.354±0.130
× Yolk index	-0.469±0.123
Egg width x Shape index	0.025±0.139
× Shell thickness	0.550**±0.116
× Shell weight	0.596**±0.113
× Alb. Height	0.107±0.138
× Alb. Weight	0.492**±0.115
× Alb. Index	-0.164±0.135
× Yolk height	0.393*±0.132
× Yolk weight	0.603**±0.118
× Yolk diameter	-0.339%*±0.130
× Yolk index	-0.346*±0.135
Shape index × Shell thickness	0.104±0.138
× Shell weight	0.388*±0.130

× Alb. Height	-0.051±0.139
Traits	
	r_p ± SE
× Alb. Weight	0.066±0.130
× Alb. Index	0.194±0.135
× Yolk height	-0.082±0.137
× Yolk weight	-0.008±0.145
× Yolk diameter	0.127±0.135
× Yolk index	0.060±0.140
Shell thickness × Shell weight	0.632^{**}±0.110
× Alb. Height	0.127^{*}±0.139
× Alb. Weight	0.472^{**}±0.134
× Alb. Index	-0.151±0.138
× Yolk height	0.541^{**}±0.130
× Yolk weight	0.696^{**}±0.094
× Yolk diameter	-0.433**±0.125
× Yolk index	-0.272±0.131
Shell weight × Alb. Height	0.211^{*}±0.137
× Alb. Weight	0.620^{**}±0.098
× Alb. Index	-0.241±0.128
× Yolk height	0.548^{**}±0.114

× Yolk weight	0.695**±0.125
Traits	
	r_p ± SE
× Yolk diameter	-0.502**±0.123
× Yolk index	-0.513**±0.127
Alb. height × Alb. Weight	0.027±0.135
× Alb. Index	-0.482**±0,134
× Yolk height	0.435**±0.130
× Yolk weight	0.265*±0.136
× Yolk diameter	-0.447**±0.132
× Yolk index	-0.504**±0.136
Alb. Weight xAlb.index	-0.075±0.145
× Yolk height	0.172±0.141
× Yolk weight	0.490**±0.128
× Yolk diameter	-0.130±0.137
× Yolk index	-0.386*±0.130
Albumen index × Yolk height	-0.300*±0.135
× Yolk weight	-0.346*±0.132
× Yolk diameter	0.344*±0.130
× Yolk index	0.483**±0.134
Yolk height × Yolk weight	0.719**±0.100

× Yolk diameter	0.344*±0.130
× Yolk index	-0.489**±0.125
Yolk weight × Yolk diameter	0.192±0.043
× Yolk index	0.454**±0.131
Yolk diameter × Yolk index	-0.784**±0.088

Fertility and Hatchability percentage of different genetic groups of chicken:

Fertility:

The fertility and hatchability percentage of Gramapriya and its crosses with desi chicken native to Bihar were studied during the month of summer. Fertility percentage of Gramapriya and its crosses have been presented in table 34. It revealed the presence of very high fertility percentage in all the genetic groups ranging from 78.36 in GP×GP to 84.78 in Muz desi × GP. The highest fertility was observed in Muz desi × GP by 6.42 percent than the GP×GP and 3.14 percent than the Gaya desi × GP. The values obtained in the present study were higher than the values obtained by Bharadwaj *et al.* (2006). Findings of the present study were similar to the findings of Ahmed *et al.* (2012) in the crosses of white Leghorn with Fayomi, RIR and Aseel. However, Ahmad *et al.* (2012) reported higher fertility percentage than the findings of the present study in the crosses of White Leghorn in with Necked Neck. Miazi *et al.* (2012) also observed higher percentage (89.8%) of fertility than the value observed in the findings of the present study.

[atchability:

The hatchability percentage on the basis of total number of eggs set nd on the basis of total number fertile eggs set of various pure and rossbred chicken have been presented in table- 34. In Gramapriya GP×GP) the hatchability percentage on the basis of total number of eggs et was found to be 72.32% which was lower in comparision to Muz desi : GP and Gaya desi × GP by 4.22 and 1.84 percent respectively. The ıatchability percentage was found to be very high and ranged from 90.34 ›ercent in Muz desi × GP to 92.39 percent in Gaya desi × GP. The ıatchability percentage on the basis of total number of eggs set were in :lose proximity with the findings of Sinha (2014).

Table 34 Fertility and hatchability percentage of different genetic groups of chicken.

Genetic groups	Number of eggs set	No. of fertile eggs	Total no. of chicks hatched	% fertility	% hatchability on total no. of eggs set	% hatchability on fertile eggs basis
GP♂♂ x GP♀♀	2266	1776	1639	78.36	72.32	92.39
Muz desi♂♂ x GP♀♀	2264	1919	1733	84.78	76.54	90.34
Gaya desi♂♂ x GP♀♀	1798	1458	1333	81.64	74.16	91.44

Table No.: 35. Monthly egg production of different genetic groups of chicken upto 40 weeks of age.

Gnetic group	20-24 weeks	24-28 weeks	28-32 weeks	32-36 weeks	36-40 weeks	Total
GP × GP	252	381	524	717	724	2598
Muz desi × GP	193	349	531	714	835	2622
Gaya desi × GP	141	290	394	591	666	2082

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present study was conducted on Gramapriya and its crosses with desi chicken native to South and North Gangatic plane of Bihar. Gramapriya was maintained in the Instruction Livestock Farm Complex (ILFC), Bihar Veterinary College, Patna on random mating. Male birds of desi chicken were brought into the farm from different districts of Bihar for crossing with the females of Gramapriya. Thus, the three genetic groups so constituted were as follows:

Purebreds	Crossbreds
1. GP♂♂ x GP♀♀	Muz desi♂♂ × GP♀♀
	Gaya desi ♂♂ × GP♀♀

The following traits were taken:

- Egg weight
- Egg production upto 40 weeks of age
- Hatchability percentage
- Fertility percentage
- Egg quality traits :

External egg quality traits

* Egg length(mm)
* Egg width(mm)
* Egg Shape index
* Egg shell weight(g)
* Egg Shell thickness(mm)

Internal egg quality traits

* Albumen diameter(mm)
* Albumen height(mm)
* Albumen weight(g)
* Albumen index
* Yolk diameter (mm)
* Yolk height (mm)
* Yolk weight(g)
* Yolk index

The work was done with the following objectives:

1. To estimate the mean, standard error and coefficient of variation percentage of fertility, hatchability, egg production, egg weight and egg quality traits.
2. To study the effect of various genetic groups on fertility, hatchability, egg production, egg quality traits and egg weight.
3. To study the effect of egg weight on egg quality traits.
4. To estimate coefficient of phenotypic correlation among various egg quality traits and egg weight in different genetic groups.

Twenty (20) males and hundred (100) females were taken from each genetic group and maintained separately under deep litter system with a mating ratio of 1 male : 5 females to study genetic effect on egg weight and egg quality traits. To study the genetic effect on egg quality traits a total of 50 eggs from each genetic groups were collected at random from each of three genetic groups. To find out the effect of egg weight on egg quality traits all the eggs were divided into four different groups with a difference of 6 g from each group.

FINDINGS

- The age at sexual maturity was found to be shorter in GP × GP as compared to its crosses with the local desi/local chicken of Bihar.
- Eggs laid by Gramapriya were significantly ($P<0.05$) heavier than the eggs laid by Muzaffarpur (Muz) desi × GP and Gaya desi × GP both at the age of sexual maturity and at 40 weeks of age. There was no significant difference in average egg weight laid by both the crosses.
- The genetic group was found to have highly significant ($P < 0.01$) effect on egg weight both at ASM and at 40 weeks of age.
- The genetic group had highly significant ($P<0.01$) effect on body weight at the sexual maturity. Gramapriya was found to be significantly heavier than its crosses with desi chicken native to Bihar.
- The analysis of variance revealed highly significant ($P<0.01$) effect of genetic group on egg length, egg width and shell thickness.
- Gramapriya laid the lengthier and wider eggs than its crosses with desi chicken of Bihar.
- There was no significant difference between the genetic group for shape index.

- Egg laid by Gramapriya had significantly ($P<0.05$) thicker egg shell than the eggs laid by its crosses with the desi chicken.
- The genetic group was found to have significant ($P<0.05$) effect on albumen height, albumen index, yolk height and yolk index. Eggs laid by Gramapriya had significantly ($P<0.05$) thicker albumen and egg yolk than its crosses with the desi chicken.
- The genetic groups had significant ($P<0.05$) influence on albumen weight, yolk weight and shell weight. Eggs laid by Gramapriya had significantly ($P<0.05$) higher albumen weight, yolk weight and shell weight as compared to its crosses with the desi cheicken. The GP × GP had significantly ($P<0.05$) higher percentage of albumen, egg yolk and shell weight as compared to Muz desi × GP and Gaya desi × GP genetic groups.
- The egg weight group had significant ($P < 0.01$) influence on egg length, egg width and shell thickness. The eggs of 55 g and above groups had significantly ($P<0.05$) lengthier and wider eggs and thicker shell than the eggs of 34-40, 41-47 and 48-54g egg weight groups.
- The egg weight was found to have, in general, highly significant ($P<0.01$) and positive phenotypic correlation with all the egg quality traits except with shape index and

albumen index. The magnitudes of coefficient of phenotypic correlation were moderate to high.

- The coefficient of phenotypic correlation among the egg quality traits were, in general, positive, highly significant (P<0.01) and moderate to high in magnitude.
- Muz desi × GP produced large number of eggs as compared to GP×GP and Gaya desi × GP. The hen day egg production percentage between 36-40 weeks of age was higher in Muz desi × GP (42 percent) followed by GP×GP (38 percent) and Gaya desi × GP (39 percent).
- Muz desi × GP had the highest fertility percentage followed by GP×GP and Gaya desi × GP.
- On total number of eggs set basis the Muz desi × GP was found to have the highest (76.54 percent) percentage of hatchability followed by Gaya desi × GP (74.16 percent) GP×GP (72.32 percent) wereas on the basis of fertile eggs set the GP×GP genetic group had the highest percentage (92.39 percent) of hatchability followed by Gaya desi × GP and Muz desi × GP.

CONCLUSION

- The genetic group had significant ($P<0.05$) effect and egg weight on egg quality traits.
- GP×GP had significantly ($P<0.05$) heavier eggs than the Muz desi × GP and Gaya desi × GP at 40 weeks of age.
- There was no significant difference between Muz desi × GP and Gaya desi × GP for egg weight.
- The genetic group also found to have significant ($P<0.05$) difference for egg weight at ASM and body weight of ASM.
- GP×GP was found to have superiority over Muz desi × GP and Gaya desi × GP, in general, for all the egg quality traits.
- There was no significant difference between Muz desi × GP and Gaya desi × GP
- It may be concluded that desi/local varieties received from Muz and Gaya are equal in all respect.

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