STUDIES ON PRODUCTION PERFORMANCE AND EGG QUALITY TRAITS IN IMPROVED VARIETIES OF CHICKEN DURING FIRST PHASE OF PRODUCTION CYCLE

THESIS

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CERTIFICATE-I

This is to certify that the thesis entitled "**Studies on production performance and egg quality traits in improved varieties of chicken during first phase of production cycle"** submitted in partial fulfillment of the requirements for the degree of **" Master of Veterinary science"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), is a record of bonafide research work carried out by **Sandeep Kumar** under my guidance and supervision. The Student's Advisory Committee and the Director of Instructions have approved the subject of the thesis.

No part of the thesis has been submitted for any other degree or diploma or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations has been duly acknowledged by him.

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(Sandeep Kumar)

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LIST OF ABBREVIATIONS

Abbreviation	Full Form
AI	Albumen Index
AW	Albumen Weight
cm	Centimeter
CV	Coefficient of Variation
Df	Degree of freedom
ESW	Egg shell weight
et al.	et alli (other)
EW	Egg Weight
g	Grams
HU	Haugh Unit
Kcal	Kilo calorie
kg	Kilogram
Max	Maximum
ME	Metabolic energy
mg	Milligram
Min	Minimum
ml	Milliliter
mm	Millimeter
NS	Non-significant
r	Coefficient of relationship
RIR	Rhode Island Red

SE	Standard error
SI	Shape Index
SS	Sum of Squares
Wt	Weight
WLH	White Leghorn
YI	Yolk Index
%	Percentage

CHAPTER-I

INTRODUCTION

The rapid growth of poultry sector in our country during the last 3 to 4 decades has been almost exclusively dependent on appearance of intensive or commercial type poultry enterprise, often located in urban or periurban areas. Rural and tribal areas have received little attention in this sector, creating a large gap in the availability of highly nutritious egg and chicken meat between urbanites and malnourished rural / tribal people. Only the solution is backyard farming in rural and tribal areas. Importance of backyard poultry production has been globally recognized to overcome the worsening problems of poverty, hunger and malnutrition in developing countries. Traditional backyard poultry production in India is practiced since time immemorial which was the primary source of animal protein and supplementary income for the down trodden rural poor people. No doubt, poultry industrialization in the country in recent two decades has assured the availability of eggs and meat in the urban areas but the first problem observed from the change in the poultry production system was neglect of the traditional poultry husbandry in villages, which was the primary source of animal protein.

Development of rural household poultry production is still being neglected in India. China ranks 1st in egg production and 2nd in broiler and most of the poultry is in the forms of household poultry and it contributes 70% of the total poultry production. In the country like Bangladesh, 75% production counts from the household poultry itself. It is seriously noted that in India only 30% of poultry production comes from household poultry, which reflects the poor extension services in rural areas (Shinde, 2005).

The villagers supplied the city dwellers with eggs and poultry for centuries but this direction was reversed within a period of less than two decades. More than 75% of eggs and

almost 100% of the broilers produced in the organized farms around the urban areas are consumed in cities and towns and also sold at rural areas at high prices.

Village chicken production under the free range and semi-intensive system is one of the viable alternative systems for improving the livelihood of rural households which provide additional income and supplement protein intake in rural and tribal folks. Wide gap exists in per capita consumption of egg and meat among the rural and urban people. The per capita availability of egg and meat is 45.0 and 2.0kg against the recommended level of 180 egg and 9.00kg of meat by ICMR. To meet the growing demands of the population and to improve the per capita consumption among the rural/tribal people, backyard poultry farming in rural/tribal areas is the best alternative. Traditionally *desi* varieties are used for backyard poultry production whose production potential is very low. Dr. Branckaert (1995), Animal Production Officer, FAO reported that an indigenous hen produces an average of 40 eggs of 45 to 50 g in two cycles a year. A local hen, bred traditionally can produce 8 chickens annually and 8-10 eggs for consumption or marketing, thus making the backyard poultry less economical.

Main constraint on backyard poultry farming is lack of suitable birds for rural poultry farming which productive performance, disease resistance and viability under rural condition should satisfactory and economic. To full fill these demand several high yielding germplasm suitable for backyard production have been developed by different agencies like Vanaraja developed by Project Directorate on Poultry Hyderabad, Giriraja and Girirani developed by the Bangalore-based agriculture university, Krishna-J developed by the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Nandanam-99 developed by Chennai-based Veterinary university, Grama Laxmi developed by Kerala agricultural university and Kalinga Brown developed by the Bhuvaneshwar-based poultry organisation (CPDO) which are suitable for backyard poultry

farming. The economic return from these birds depends largely on characters like age at sexual maturity, egg production, feed conversion efficiency and egg weight. Thus knowledge of production parameters for these characters is essential to decide selection programme for overall improvement. The economic value of an egg is known for years as a function of rate of lay, egg size and egg weight. To this shell thickness and internal egg quality to be added as they are related to hatchability of incubated and fertile eggs and development of chicks, (Altinel *et al*., 1996 and Sogut *et al.,* 2001).

The egg of chicken is a biological structure intended by nature for reproduction and it also provides a complete diet for the developing embryo. However, in the developing countries, egg is more affordable by the common man than other sources of animal protein and as such this gives poultry more advantage over other livestock. Egg quality traits have significant and direct effects on the prices of egg. In egg processing enterprises, the weight of shell, albumen and yolk that form the egg as well as their percentage affect the amount and price of the product (Altan *et al*., 1998). Eggshell has a vital importance for the laying force, embryo growth and the chick quality. It is also important for transportation purpose and influence the economic loss by breaking of egg. The albumen both protects the embryo against microorganism until growing of the immune system and allows a source of nutrition. On the other hand, the yolk meets the feeding needs of the chicks in the first days and the eggshell protects the embryo against external effects. All eggs are not equal and need to be routinely checked for quality to meet the specifications being increasingly demanded by today's quality conscious retailers. The egg size and internal quality of eggs are important for both table and hatching eggs. Among them, egg weight is an important trait that influences egg quality as well as grading. Egg weight is a direct proportion of albumen, yolk and shell. Egg weights are classified according to

Canadian egg size standards: small (42.0–48.9 g), medium (49.0–55.9 g), large (56.0– 63.9 g), extra-large (64.0–69.9 g) and jumbo (70.0 g or higher). These egg size grades are very similar to those used in the USA: jumbo (=70 g), extra-large (65–70 g), large (56–65 g), medium (49–56 g) and small (42–49 g). Small, medium and large classifications are the most commonly available. There have been some studies (Cook and Briggs, 1977; Marion *et. al.*, 1964; Jackson *et al.*, 1986) which looked at breed, strain and age and their impact on egg composition. The general conclusion was the proportion of yolk tended to be greater and the proportion of albumen smaller in small eggs than in larger eggs. Other studies (Rodda *et al.*, 1977.; May and Stadelman, 1960; Rose *et al.*, 1966; Akbar *et al.*, 1983; Hill *et al.*, 1966) have reported that selected commercial strains weighed more and contained higher percentages of albumen, albumen solids and albumen protein. However, this variation among strains has often been related to variation in egg size. In the older literature, more variability was seen in the component parts of eggs from younger hens than eggs from older hens. In general, there was a smaller percentage of yolk (Asmundson, 1933; Olsson, 1936) and a larger percentage of albumen (Olsson, 1936) in eggs from younger birds than in eggs from older birds. Romanoff and Romanoff (1949) reported that during the first few months of lay, the relative amount of yolk in the egg gradually increases, whereas that of the shell decreased rapidly and the percentage of albumen remained the same.

The success of poultry farming largely depends on the total number of good quality eggs produced especially in layers and dual purpose birds. The knowledge of performance of economic traits in chicken is important for the formulation of breeding plans for further improvement in production traits. Growth and production traits of a bird indicate its genetic constitution and adaptation with respect to specific environment (Ahmed and Singh, 2007). In the present study some improved varieties used in Chhattisgarh state namely CARI-Shyama,

Vanaraja, Kalinga Brown, and Black Rock, developed for backyard farming are evaluated. A large volume of literature is available in growth, production performance and egg quality parameters of commercial hybrid variety, but data on production performance and egg quality characters is scanty on crosses/varieties developed for rural/free range farming. Thus proposed study was undertaken to accomplish these objectives and to assess the egg production parameters and egg quality traits in above four varieties with following objectives:-

1) To study egg production performance in improved varieties of chicken.

2) To find out effect of varieties and age on egg production parameters.

3) To quantify exterior and interior egg quality characters with respect to varieties and age.

4) To find out correlation amongst egg quality traits, if any.

CHAPTER-II
REVIEW OF LITERATURE

2.1 EGG PRODUCTION TRAITS:

Hens kept for egg production must have ability to lay large number of eggs. Selection of hens for rate of lay is probably the uppermost objective in the mind of poultry breeder. The production traits considered to be of economic importance included age at first egg, body weight at first egg, age at 50% egg production, hen house egg production, hen day egg production, feed consumption per dozen of egg, laying house mortality etc. These all must be given weightage in breeding system. Breed and varieties comparison demonstrate the presence of genetic variation

on these production traits. Different production traits were reviewed by various workers [Niranjan *et al*. (2008), Mohan *et al*. (2008), Rangareddy *et al*. (1989), Singh *et al*. (2000), Kumaresan *et al.* (2008), Chatterjee *et al.* (2007)].

Kumaresan *et al.* (2008) studied village chicken production system and performance of improved dual purpose chicken and found that Vanaraja chicken achieved 3.6kg at 18 months of age. The age at first egg was 154 days in the back yard system and 196 days under intensive system. The annual egg production was reported as 176 eggs under back yard system and 152 eggs under intensive system of rearing in the same study. Mortality of adult birds was 12% and predation accounted for 1.67 percentages.

Mohan *et al.* (2008) studied production characteristics of Aseel Peela desi hens under normal rearing system. The mean value for body weight during 23-26 week of age was found to be 1658g, the mean values for average age of first egg production, average eggs/hen/week, daily egg production and total eggs/hen (23-78 weeks) was reported to be 173 days, 2.85eggs, 40.60% and 160 eggs, respectively. The peak egg production from this breed was reported at the age of 55-58 week. A significant increase in body weight and egg weight was recorded from the initial to the peak of egg production stage, there after no changes was recorded in these parameters till to the end of study.

Niranjan *et al.* (2008) compared growth and production performance of four chicken varieties and found the mean value for age of sexual maturity as 154.67, 145.72, 164.79 and 160.89 days for C_1 cross (cross of broiler pure line 1 and a tinted egg layer), C_2 cross (cross of broiler pure line 2 and a tinted egg layer), Vanaraja and Gramapriya, respectively. The body weight of Vanaraja and Gramapriya at 20^{th} week of age was 2086.67g and 1648.84g and for 40^{th} week of age it was 2561.30g and 2304.25g, respectively. The average value for egg production

up to 40week of age was found to be 99.88, 88.59, 56.15 and 89.19 eggs, respectively for C_1 cross, C_2 cross, Vanaraja and Gramapriya, respectively.

Chatterjee *et al.* (2007) studied the production performance and egg quality traits of Nicorock chicken. Nicobari fowls are selected for better growth and production performance and are being used as parent lines of Nicorock. They reported mean values for the average age and weight at sexual maturity and were 193.12 days and 1487.46g, respectively. The average annual egg production and egg weight were 142.66 in number and 50.85g, respectively under backyard. Laying period mortality was 9.12% in these birds.

Panda *et al.* (2006) investigated influence of probiotic feeding during late stage of laying (65 to 76 week) in White Leghorn layers. The mean values for body weight, hen day egg production, feed/dozen egg and feed intakes/bird/day was found to 1657g, 56.97%, 2.188kg and 102.42g, respectively for control group and 1644g, 65.4%, 1.938kg and 104.29g for treatment group of probiotic supplement.

Singh and Prasad (2005) studied egg production curves of Kadakanath and its crosses with CARI-Red. During their study they found annual egg production of Kadakanath, Kadakanath X CARI-Red and CARI-Red X Kadakanath and it was 93.6, 205.9 and 195.7 eggs, respectively.

Balvir singh *et al.* (2000) measured parameters of growth, egg production and egg quality traits in White Leghorn and found the value of 12 week, 36 week body weight, age at sexual maturity and egg production up to 280 days of age.these values were 802.04g, 1579.18g, 155.38 days and 118.64 eggs number, respectively.

Singh *et al.* (2000) reported reproduction and production performance of Aseel, an indigenous breed of chicken and found that age at which Aseel birds started laying eggs ranged

from 28.41 to 31.19 weeks with an overall of 28.94 weeks and average egg production of 10.72, 11.32 and 11.13 eggs during first, second and third laying cycle, respectively. Over all average egg production of 33.17 eggs per year was also reported.

Muthusamy and Viswanathan (1998) observed henday egg production, feed consumption (bird/day) and egg efficiency (percentage egg) traits and it was found to be 99.03g and 103.94g, 1.65kg and 1.64kg, and 2.68kg and 2.75kg, respectively in cage and deep litter system. They also studied effect of age on the performance of commercial layer was also studied. The values for hen day egg production (%) was 47.14, 84.84 and 86.95; feed consumption (g/bird/day) were 83.47g, 102.78g and 112.57g; feed efficiency (per dozen egg) was 2.22, 1.46 and 1.55kg and feed efficiency (per kg egg mass) was 4.05, 2.32 and 2.37kg at different age group i.e. 21-24, 29-32 and 37-40 weeks, respectively.

Brah *et al.* (1997) demonstrated evaluation of randombred control population of commercial layers and found means for different economic traits over the eight generations. They noted body weight at 20 weeks of age ranged from 975 to 1118g; 40 week body weight ranged from 1428 to 1518g; age at first egg varied between 164 and 186 days; egg number up to 40 weeks ranged between 72 and 95 eggs and rate of lay varied between 65 and 82%.

Chaudhary *et al.* (1997) evaluated pure and cross line White Leghorn. The values for body weight at 20 weeks of age, 40 weeks of age, age at bird lay egg and egg numbers to 40 week of age was found to be 1105g, 1445g, 153days and 93.5 eggs, respectively in pure line. The corresponding figures for crosses were 1140g, 1450g, 151 days and 96.4 eggs number for cross line.

Singh *et al.* (1997) compared the growth and production performance of various chicken genotype namely CARI-Shyama, CARI-Nirbheek, Hitcari and Upcari under scavenging system

and recorded body weight at 20 week of age, age at first egg and annual egg production as 1205g, 165 days and 165 eggs, respectively for CARI-Shyama; 1382g, 173 days and 158 eggs, respectively for CARI-Nirbheek; 1450g, 167 days and 168 eggs, respectively for Hitcari and 1250g, 162 days and 172 eggs, respectively for Upcari chicken.

Johari *et al.* (1992) evaluated economic traits of White Leghorn up to 15 generation and found that body weight at 20 weeks ranged from 920 to 1154g ; at 40 weeks body weight ranged from 1473 to 1679g; age at sexual maturity ranged from 166.4 to 193.6 days and egg production to 280 days ranged from 54.7 to 76.6 eggs in different generations.

Qudratullah and Eshwaraiah (1992) found that henday egg production ranged from 56.5% to 75.3%; feed efficiency ranged from 1.58 to 2.17 kg for per dozen egg; body weights at 44 week ranged from 1380g to 1690g at different level of protein and energy in diet. In their study, it was concluded that combination of 18% dietary protein and 2500 kcal ME /kg diet appeared adequate for sustaining significantly superior egg production in caged White leghorn parents.

Thakur *et al.* (1992) obtained 54.07 to 61.67 percent henday production in commercial egg type laying chicken. The average egg weight was found to be 48.22 to 50.01g, whereas feed efficiency (egg mass/kg feed intake) was ranged between 0.323 to 0.240 using paddy and maize as a energy source in commercial egg type laying chicken.

Brah *et al.* (1991) observed inheritance of egg specific gravity and related egg characters and it was found that body weight at 20 week ranged from 1053g to 1125g, body weight at 40 week ranged from 1511g to 1686g, age at sexual maturity ranged from 167.06 days to 169.7 days and egg number produced up to 40 weeks of age ranged from 84.8 to 92.8 eggs, respectively in two White Leghorn strains.

Rangareddy *et al.* (1989) performed comparison between production practices on five commercial layer strains at egg pocket of Tamil Nadu. During their investigation they found age at first egg ranged from 125.35 days to 141.56 days, age at 50% egg production from 159.53 days to 171.70 days, hen day egg production from 66.55 to 70.44 percent, hen housed egg production from 222.66 to 250.69 eggs, feed efficiency in terms of feed consumed (kg) per dozen eggs laid from 1.82kg to 2.05 kg, feed consumption from 106.33 to 112.75g/bird/day and layer house mortality from 4.66 to 7.49 percent.

Satyanarayana reddy *et al.* (1989) studied production performance of egg type chicken and found that age at first egg ranges from 162 days to 182 days, age at 50% egg production ranges from 182 days to 198 days and percentage hen day egg production ranges from 49.6% to 60.5% at different level of dietary protein.

Gill and Gangwar (1984) observed effect of heat stress on egg production and feed consumption on White Leghorn chicken. Mean value for feed consumption was reported to be 82.38g/bird under natural summer conditions and 84.40g/bird under air conditioned rearing system. The value for egg production was 4.76% under natural summer condition and 56.83% under air conditioned rearing system.

The AICRP centre, Agartala has evaluated performance of Vanaraja and Giriraja chicken varieties and reported that Vanaraja birds matured earlier than Giriraja. It was also revealed that the Vanaraja birds produce more eggs compared to Giriraja on farm (38.13 Vs 32.63) and at farmer's door (29.64 Vs 23.74 eggs) up to 40 week of age. Giriraja has marginally higher mortality than Vanaraja and it was primarily (30-40%) due to predators, (ICAR annual report, 2003-04).

As per study made at Central Poultry Breeding Farm, Bhuvaneshwar , the average age at 50% egg production, hen house production, hen day production, average daily feed intake and laying house mortality was 20 weeks, 262 eggs, 272 eggs, 109g/bird/day and 0.75%/month, respectively in Kalinga Brown chicken variety.

As per study made at Central Avian Research Institute, Izatnagar the performance of different desi type/back yard type of layer chicken is given in table

Tabe- :- Performance of different desi type/backyard type of layer chicken in Central Avian Research Institute, Izatnagar

Traits	**Breed**			
	ILI-80	**CARI Golden**	**CARI Priya**	**CARI Sonali**
First egg in flock (days)	119-126 days	126-133 days	119-126 days	126-133 days
50% egg in flock (days)	150 days	155 days	150 days	155 days
72 week egg production (No)	270	265	290	275
Average egg weight (g)	54 g	54 g	57 g	54 g
Peak production (%)	92%	90%	92%	90%
Feed efficiency (kg feed/dozen of egg)	2.1 kg	2.2 kg	2.1 kg	2.2 kg

2.2 EGG QUALITY TRAITS:

The ability of hen to lay large number of eggs is not enough if eggs are small with poor shells, have watery albumen and contains numerous blood or meat spots. Such hens will not be valuable for production of market eggs. The quality of chicken eggs may vary according to breed/strain, rearing temperature and season **(**Sauter *et al.,* 1954; Washburn, 1990**).** Age of hen is also an important factor having considerable effect on egg quality characteristics (Adegbelo and Olatoke, 1998). Egg shell quality affects shell breakage and influences the hatchability of eggs (Washburn, 1982). Egg quality characters has been reviewed by several researchers in exotic and improved varieties of chicken (Mohan *et al*., 1990b; Pandey *et al.,* 1989; Shrestha *et al.,* 2004; Chatterjee *et al*., 2007; Haunshi *et al.,* 2006; Curtis *et al*., 2005).

Sekerog lu and Altuntas (2009) observed effect of egg weight on egg quality characteristics of Lohmann strain of hens which is a brown egg layer. During study it was found the shell thickness was highest in medium egg (0.400mm) and lowest in extra-large egg (0.382mm). Albumen height was significantly affected by egg weight. Yolk height and yolk index increased with egg size. Breaking strength was highest in the medium weight egg. There were significant positive correlations between egg weight and albumen height; egg weight and yolk height, egg weight and yolk index, egg weight and yolk colour, but egg weight had significant negative correlations with shell thickness in overall eggs.

Shi *et al.* (2009) observed effect of egg weight on some quality traits of chicken eggs. It was classified as small (48.937g), medium (54.885g) and large (60.385g). The mean shape index, shell thickness, shell weight, yolk weight, albumen weight, albumen height and haugh unit was found to be 76.27%, 0.341mm, 14.53%, 24.0%, 61.47%, 10.27mm and 102.64, respectively

for small size eggs; 76.87%, 0.362mm, 14.17%, 23.33%, 62.51%, 9.79mm and 99.15, respectively for medium size eggs and 79.51%, 0.373mm, 13.97%, 21.39%, 64.64%, 10.52mm and 101.19, respectively for large size eggs. In study it was concluded that it is feasible to asses some egg quality traits high having high egg weight.

Egg quality traits in chicken varieties developed for backyard poultry farming in India has been studied by Niranjan *et al.* (2008). The study was conducted at Project Directorate on Poultry, Hyderabad. The performance of egg quality traits of four chicken varieties i.e. C_1 cross1 (cross of broiler pure line 1 and a tinted egg layer), C_2 cross (cross of broiler pure line 2 and a tinted egg layer), Vanaraja and Gramapriya were evaluated to assess the effect of genetic group and age on important egg quality traits. The analysis of data revealed that the genetic group had significant effect on all the traits studied at different ages. Significant higher egg weight was observed in Vanaraja and C_1 cross. The shape indices ranged from 76.18 in Vanaraja to 78.33 in Gramapriya. The haugh unit score were between 74.64 and 79.42 indicating the superior albumen quality in rural varieties. The yolk weight was higher in Vanaraja and Gramapriya, the proven varieties for backyard farming. The yolk indices ranged from 0.44 to 0.46 among the rural varieties. The shell thickness was significantly influenced by genetic groups; it varied between 0.394 in Gramapriya to 0.401mm in C_1 cross. The breaking strength was significantly higher (41.79) in Gramapriya. The better egg quality parameters in the rural varieties is a positive sign to withstand the handling damages in rural areas as the birds are maintained under free range system.

Mohan *et al.* (2008) studied production characteristics of Aseel Peela desi hens under normal rearing system. The mean value for shell weight was found to be 5.1g. The mean value for shell thickness and haugh unit was reported to be 0.37mm and 82.17, respectively.

Chatterjee *et al.* (2007) studied the production performance and egg quality traits of Nicorock (Black rock X Black Nicobari chicken) chicken. The mean value for egg weight was 53.25g. The shell weight, shell thickness, albumen percentage, yolk percentage and shell percentage were 6.71g, 0.50mm, 54.23%, 32.08% and 12.60%, respectively.

Haunshi *et al.* (2006) compared certain egg quality traits of Vanaraja and White Leghorn chicken and noted means of egg quality traits such as egg weight, shape index, specific gravity, shell thickness, albumen index, yolk index and haugh unit of Vanaraja chicken at 40 week of age and were found to be 60.79g, 75.45, 1.098, 0.427mm, 0.080, 0.3686 and 80.26, respectively. Whereas, means of egg weight, shape index, specific gravity, shell thickness, albumen index, yolk index and haugh unit of White Leghorn chicken were 54.29g, 73.55, 1.086, 0.342mm, 0.084, 0.365 and 81.85, respectively. There were significant differences between Vanaraja and White Leghorn chicken for egg weight, shape index, specific gravity and shell thickness. No significant differences were observed for albumen index, yolk index and haugh unit.

Parmar *et al*.(2006) evaluated egg quality traits in indigenous Kadaknath breed of chicken. The mean shell thickness, shape index, albumen index, haugh unit, yolk index, yolk weight and albumen weight were found to be 0.31mm, 73.93, 7.03, 73.77, 37.07, 14.77g and 20.74g, respectively. Most of the egg quality traits studied at farmers door were found to be inferior when compared with Kadaknath birds maintained at poultry breeding farms.

Curtis *et al.* (2005) studied effect of age on egg quality characteristics of commercial strain of layers and found egg weights generally increase as the bird ages. However, once hen reached the six month of production, egg size became more consistent. Egg weight was reported lowest at first month of production (44.5g) and highest at 12^{th} month of production period

(64.0g). It was noted albumen percentage decreases about ten percent over time and yolk percentage increased. Shell percentage was recorded highest (10.3%) at 1st month of production period, whereas lowest (9.0%) at 12th month of production period.

Fayeye *et al.* (2005) studied egg traits of the Fulani-ecotype chicken a native breed of Nigeria. Mean values for egg traits were 40.73g, 20.25g, 4.92mm, 75.53%, 13.03g, 14.27mm, 24.68mm and 0.58 for egg weight, albumen weight, albumen height, haugh unit, yolk weight, yolk height, yolk width and yolk index, respectively. Mean value for shell weight, shell thickness, egg length, egg width and egg index were 5.12g, 0.58mm, 34.98mm, 23.59mm and 1.48, respectively. They suggested that Fulani-ecotype chicken has good potential for meat and egg production.

A study was conducted by Shrestha *et al.* (2004) to assess the effect of different space density groups, viz 0.20, 0.25 and 0.30m^2/bird on egg quality traits in White Leghorn strain. Under these floor space densities, the values for average egg weight (g) were 48.3, 51.3 and 51.4; for albumen index 0.10, 0.12 and 0.17; for yolk index 0.42, 0.47 and 0.47; for shell thickness (mm) 0.49, 0.39 and 0.38; for shell weight (g) 6.2, 6.3 and 6.8; for yolk weight (g) 16.6, 15.1 and 13.6 and for albumen weight (g) 25.8, 30.9 and 30.9, respectively. The significant differences were observed for the egg weight, albumen index, yolk index, yolk weight, shell thickness, shell weight and albumen weight. They concluded caged eggs had significantly higher egg weight and shell thickness. The shape index, yolk index and percentage of albumen had significantly higher values in deep litter eggs.

Ashraf *et al.* (2003) compared egg quality characteristics of Rhode Island Red and Lyallpur Silver Black a local chicken breed of Pakistan. It is reported that egg weight, haugh unit, yolk index and egg shell thickness were 47.23g, 102.24, 0.450 and 0.383mm for Lyallpur

Silver Black chicken and 53.10g, 102.57, 0.446 and 0.367mm for Rode Island Red chicken. It was concluded that Lyallpur Silver Black layers produce significantly thicker shelled eggs than their counter part.

The egg quality characters in Barred Plymouth rock (BPR), White Leghorn (WL), Rhode Island Red (RIR) and White Rock (WR) were studied by Monira *et al.* (2003). The study was ascertained in one, seven, fourteen and twenty one day holding period. It was reported egg weight was highest in White Leghorn (58.38g); egg length was highest in White Leghorn (5.91cm) and lowest in White Rock (5.62cm); shape index was highest in White Rock (74.10) and haugh unit was highest in White Rock (58.68), intermediate in White Leghorn (45.81) and Barred Plymouth Rock (54.20) and lowest in Rhode Island Red (45.81). There were significant difference among the breed and holding period for all the egg quality traits except egg width. The egg weight, egg length, egg width albumen height and haugh unit of all breeds were higher in fresh egg.

Singh *et al.* (2000) measured egg quality traits in White Leghorn chicken and found the value of egg weight, egg specific gravity and shape index. These values were 54.17g, 1.09 and 73.53%, respectively.

Padhi *et al.* (1998) assessed egg quality in different breeds of chicken. Mean egg weight, shape index, albumen index, yolk index, shell thickness, haugh unit, yolk percentage, albumen percentage and shell percentage were found to be 52.45g, 71.04, 0.985, 0.4075, 0.3378mm, 75.15, 31.14%, 57.76% and 11.0%, respectively for White Nicobari chicken; 46.70g, 71.70, 0.1158, 0.4459, 0.3325mm, 84.27, 31.18%, 58.46% and 10.20%, respectively for Brown Nicobari chicken; 47.72g, 74.68, 0.121, 0.4232, 0.3378mm, 85.05, 30.77%, 58.22% and 11.20%, respectively for Black Nicobari chicken; 56.31g, 75.36, 0.0705, 0.4323, 0.3062mm, 73.16,

33.18%, 55.80% and 10.08%, respectively for Naked Neck chicken and 62.86g, 73.56, 0.1084, 0.4388, 0.3127mm, 84.52, 26.86%, 63.10% and 10.00%, respectively for White Leghorn chicken.

Johari *et al.* (1993) studied time trend in egg quality traits and their inheritance in control population of White Leghorn. During their study they analysed eggs at 40 weeks of age in each generation and found albumen index ranged from 0.085 to 0.160; yolk index ranged from 0.390 to 0.500; haugh unit ranged from 82.38 to103.10; albumen height ranged from 5.85 to 10.10mm and egg shell thickness ranged from 0.254 to 0.370mm in different generations.

Qudratullah and Eshwaraiah (1992) found that egg weight ranged from 50.6g to 54.1g; haugh unit score ranged from 89.0 to 94.0; albumen index ranged from 0.101 to 0.123; yolk index ranged from 0.398 to 0.426; shell weight ranged from 8.67 %to 9.88% and shape index ranged from 71.0 to 74.0 at different level of protein and energy in diet.

Brah *et al.* (1991) observed inheritance of egg specific gravity and related egg characters in chicken and it was found that egg specific gravity ranged from 1.122 to 1.131, egg weight ranged from 49.2g to 50.8g, egg length ranged from 54.6mm to 55.5mm, egg width ranged from 40.0mm to 40.5mm and shape index ranged from 73.0% to 73.2%, respectively in two White Leghorn strains.

Dutta *et al.* (1991) evaluated some egg quality characteristics of Miri birds, White Leghorn and their crossbreds under different system of management and recorded mean egg weight, shape index, haugh unit, yolk index and shell thickness as 50.17g, 73.54, 84.52, 44.52 and 0.252mm for White Leghorn; 41.59g, 75.82, 94.09, 48.74 and 0.248mm for Miri bird and 45.46g, 74.31, 85.58, 47.60 and 0.286mm for their crossbreds, respectively. It has been found that genetic group significantly influenced egg weight and quality traits studied, whereas haugh

unit and shell thickness were affected by system of management. Significantly higher egg weight was recorded for White Leghorn than Miri bird and crossbreds. However, the Miri eggs were superior for shape index, haugh unit score and yolk index than others.

Mohan *et al.* (1991)a observed effect of different housing systems on the physical qualities of commercial chicken eggs and revealed that caged eggs had higher egg weight and shell thickness. On the other hand shape index yolk index and percentage of albumen had inferior values in deep litter eggs.

Mohan *et al*. (1991)b assessed the quality of chicken eggs marketed in Namakkal town, a major egg producing area in Tamil Nadu. During their investigation they collected and analysed eggs from an organised egg outlet located at Namakkal. The mean egg weight, shape index, albumen index, yolk index, haugh unit, shell thickness shell percentage, albumen percentage and yolk percentage were 49.75g, 72.08, 0.034, 0.246, 60.0, 0.37mm, 11.33%, 58.19% and 30.48%, respectively.

Kumararaj *et al.* (1990) observed mean shape index, albumen index, haugh unit, yolk index, shell thickness and egg weight as 58.82, 0.074, 76.25, 0.386, 0.360mm and 48.0g for Meyer strains of White Leghorn and 59.72, 0.064, 73.72, 0.379, 0.341mm and 48.0g for Forsgate strain of White Leghorn chicken, respectively.

Mahapatra *et al.* (1989) performed physicochemical evaluation of egg quality of native (Nondescript, Kadaknath and Aseel) and farm bred (White Leghorn and Red Cornish) chicken. In study it was revealed that Farm-bred chicken eggs excelled in egg weight, albumen index, haugh unit, weight of egg components, percent albumen, yolk ratio and vitamin A content. Differences were not significant for shape index, specific gravity, yolk index shell thickness, shell weight per unit surface area. The detail of study is given in table

Table- :- Mean for physical quality of egg in different breeds of chicken

Breed	Physical quality traits							
	Egg weight (g)	**Shape index**	**Specific gravity**	**Albumen index**	**Haugh unit**	**Yolk index**	**Shell thickness (mm)**	**Egg surface area (cm^2)**
Kadaknath	41.1	74.8	1.104	0.083	81.7	0.419	0.333	55.6
Aseel	40.7	75.1	1.101	0.088	81.7	0.448	0.347	55.2
Non-descript	45.8	75.1	1.086	0.067	73.8	0.420	0.335	59.7
White Leghorn	51.3	75.5	1.097	0.094	86.9	0.438	0.326	64.4
Red Cornish	57.9	76.3	1.101	0.082	85.8	0.425	0.355	69.9

Changes in egg weight, quality traits and component yields due to strain and age of birds and season of year were evaluated by Pandey *et al.* (1989). Mean egg weight, shape index, specific gravity, shell thickness, shell weight and shell percentage were reported to be 43.00g, 73.25, 1.105, 0.317mm, 4.54g and 10.59% at 20-24 week of age; 47.65g, 73.92, 1.103, 0.330mm, 4.82g and 10.18% at 28-32 week of age and 51.88g, 74.83,1.097, 0.332mm, 5.31g and 10.06% at 38-40 week of age, respectively. In the study it was concluded that egg weight, shape index, shell thickness, shell weight and egg component yields increased and specific gravity, shell percentage and albumen percentage decreased with advancement of age.

Genetic analysis of egg quality was conducted by Singh *et al*. (1988) on meat type chicken between 38-40 weeks of age and noted mean values for egg weight, shape index, haugh unit, yolk index and shell thickness, these values were 58.3g, 73.1, 87.3, 48.3 and 0.333mm, respectively. They concluded that shape index may be a reliable guide for assessing the internal egg quality traits after studying correlation among these traits.

Nair and Elizabeth (1983) observed effect of age and season on quality of chicken eggs and found albumen index were ranged from 0.095 to 0.126 and it was lowest at 63-74 week of age and highest at 39-50 week of age; yolk index were ranged from 0.436 to 0.469 and it was lowest at 63-74 week of age and highest at 39-50 week of age; haugh unit were ranged from 82.97 to 92.82 and it was lowest at 63-74 week of age and highest at 39-50 week of age; shell thickness were ranged from 0.292mm to 0.328 mm and it was lowest at 63-74 week of age and highest at 26-38 week of age. In this study it was further reported that no significant differences between the season with regard to egg weight and shape index was observed. Albumen index, haugh unit score, differed significantly with four seasons. Yolk index was significantly different between Rainy-I (South west monsoon- June to August) and Rainy-II (North East monsoon- September to November) and Hot (March to May) and Cold (December to February) seasons. There was significant reduction in shell thickness from Rainy-I to Hot season.

Mahapatra *et al.* (1982) evaluated egg quality traits in Desi birds and their crosses with exotic breeds and found mean egg weight, shape index, albumen index, haugh unit, yolk index and shell thickness were 40.08g, 73.78, 0.074, 76.76, 0.43 and 0.33mm, respectively for Karaknath breed; 46.52g, 75.08, 0.090, 84.74, 0.41 and 0.33mm, respectively for Aseel Peela and 48.32g, 73.65, 0.090, 83.37, 0.41 and 0.34mm, respectively for Aseel Kagar breed of indigenous chicken.

CHAPTER - III

MATERIALS AND METHODS

3.1 SOURCE OF DATA:-

Estimation of different egg quality and egg production parameters were undertaken on four improved varieties of chicken namely CARI-Shyama, Vanaraja, Black Rock, Kalinga Brown developed for backyard poultry farming. The CARI-Shyama is developed by CARI (Central Avian Research Institute) Izzatnagar, Vanaraja is developed by Project Directorate on Poultry Hyderabad, Kalinga Brown developed by the Bhuvaneshwar-based Central poultry breeding farm (CPBF) Bhuvaneshwar. These birds were maintained in research poultry unit, Deptt. of LPM, College of Vety. Science and A.H. Anjora Durg (C.G.) under deep litter system of housing. These birds were of same age group and maintained under identical feeding and managemental condition. In present study 27, 20, 22 and 22 number of birds were taken initially i.e. CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock breeds/varieties, respectively. They were fed layer mash (C.G. State Marketing Federation Limited) with following composition.

Protein (Min) 18%

Fibre (Max) 07%

Fat/Oil (Min) 04%

Sand/Silica (Max) 03%

Energy (ME) 2740 Kcal/kg

A lighting schedule of 16 hour per day was given to laying birds. The birds were allowed *ad libitum* access of feed and remaining part of feed at next day was subtract in

this value to determine the daily feed consumption. Water was also given *ad libitum* to these birds.

For production performance daily eggs were collected in two time of day and separately breed wise number of eggs were recorded every day. The study was carried out from 16th week of age and was continued up to 40th week of age. The experimental period was divided in to three different age group of each breed as below:-

1) Age group 1st i.e. 16-24th weeks of age
2) Age group 2nd i.e. 24-32nd weeks of age
3) Age group 3rd i.e. 32- 40th weeks of age

To determine egg quality traits 100 eggs from each breed were collected randomly in each age group. Thus total 400 eggs in each age group and 1200 eggs up to 40th week of age were analyzed for determining egg quality traits. Soft shelled, cracked, jumbo, very small sized, and abnormal eggs were not taken in sampling.

3.2 DETERMINATION OF EGG PRODUCTION TRAITS:

Data on following production parameters collected up to 40th week of age in each varieties of chicken under study were –

1) Age at first egg in flock.
2) Body weight at first egg (g).
3) Body weight at 20th, 30th and 40th week of age (g).
4) Total No of egg laid up to 40th week of age.
5) Feed consumption (g)/bird/day
6) Percentage egg production at 20th week, 30th week, and 40th week of age.

1) **Age at first egg in flock:** That was calculated as the age of birds of particular breed/variety in days at which first egg was laid in flock.
2) **Age at 50% egg production:** That was noted as age of particular breed in days at which its hen day egg production (%) was first time reached up to 50%.
3) **Body weight at first egg (g):** It was calculated as average body weight of particular flock on that day it laid first egg.
4) **Body weight at 20th, 30th, and 40th week of age (g):** It was recorded as average body weight of each flock at 20th, 30th and 40th week of age. Body weight was taken at last day of the particular week.
5) **Total No of eggs laid up to 40 week of age:** Daily egg production of each breed was recorded separately from starting to end of 40th week. Total No of egg are expressed as total No of eggs laid by flock up to end of 40th week and No of eggs laid/bird in each flock up to end of 40th week.
6) **Feed consumption (g) at 20th, 30th and 40th week of age:** daily feed intake by each breed was recorded. Average feed intake of 7 days of particular week was taken to determine this trait.
7) **Percentage egg production at 20th, 30th and 40th week of age:** Percentage hen day egg production of seven day of particular week of each variety were calculated and average value of seven days was taken.

3.3 DETERMINATION OF EGG QUALITY TRAITS:

The following egg quality traits recorded in three different age group i.e. 16-24th, 24-32nd and 32- 40th week and four different varieties were -

1) Egg weight (g).
2) Shell thickness (mm) (Chowdhury, 1987).
3) Shape index (Shultz, 1953).
4) Albumen index (Heiman and Carver, 1936).
5) Yolk index (Funk, 1948).
6) Haugh unit score (Haugh, 1937).
7) Weight of different egg components i.e. Shell, Albumin and Yolk (Gilbert *et al.*, 1978).

Required numbers of egg from each breed were collected randomly in each age group. The collected eggs were labelled to identify breed, date of sampling and serial number. After that egg quality traits were measured as follows:-

1) EGG WEIGHT:-

Individual egg was weighed with 0.01g sensitive electronic scale.

2) SHAPE INDEX (%):-

The length and width of an egg were measured with Vernier Calipers with minimum unit reading up to 0.01 cm. The egg width was recorded and the average value was considered. The shape index was calculated according to Shultz, 1953.

$$\text{Shape} = \frac{\text{Width of egg}}{\text{Length of egg}} \times 100$$

3) ALBUMEN INDEX (%) :-

The egg shell was broken at the middle with the help of the blunt end of a knife. The egg contents were poured on a plate placed on a perfectly leveled glass table. Height and mean diameter of the thick albumen were measured with the help of spherometer and vernier caliper respectively. The height of thick albumen was taken by help of spherometer (least count 0.01 mm) at two spots between the yolk and the outer border of the thick albumen avoiding the chalaza. Similarly width of thick albumen at the broadest point and the length of the thick albumen at the longest point were taken with the varnier calipers up to 0.01 cm accuracy and the average was used as the diameter of the albumen for measurement of the albumen index. Albumen index was calculated by using the formula proposed by Heiman and Carver (1936).

$$\text{Albumen index (\%)} = \frac{\text{Height of thick albumen}}{\text{Mean diameter of thick albumen}} \times 100$$

4) YOLK INDEX (%):-

The yolk index which is an indirect measurement of the spherical shape of the yolk and the strength of the yolk membrane is calculated by the procedure of Funk (1948). After measuring the height of the albumen, the height of the yolk was taken at its highest point with the help of spherometer with minimum unit reading up to 0.02 accuracy when the yolk was still in the firm albumen. Diameter of the yolk was measured at two different

places with the same vernier calipers. The average diameter of the yolk was consider for calculation. Yolk index was calculated by using the following formula.

$$\text{Yolk index} = \frac{\text{Yolk height}}{\text{Mean yolk diameter}} \times 100$$

5) HAUGH UNIT SCORE :-

Individual Haugh unit (Haugh, 1937) score was calculated using the egg weight and albumen height (Doyon *et al.*, 1986). The Haugh unit values were calculated for individual egg using following formula.

$H.U. = 100 \log (H- 1.7 W^{0.37} + 7.57)$

Where

H.U. = Haugh unit

H = Albumen height in mm

W = Weight of egg in grams

6) YOLK RATIO (%) :-

The yolk was carefully separated from the albumen, adherent albumen was removed by rolling the yolk over a filter paper and yolk weight was recorded according to the procedure described by Gilbert *et al.* (1978). After that the yolk ratio was calculated by the help of following formula.

$$\text{Yolk ratio (\%)} = \frac{\text{Yolk weight}}{\text{Egg weight}} \times 100$$

7) ALBUMEN RATIO (%);-

The difference between egg weight – (shell weight + yolk weight) was recorded as albumen weight and albumen ratio was calculated by following formula.

$$\text{Albumen weight (g)} = \text{Egg weight} - (\text{shell weight} + \text{yolk weight})$$

$$\text{Albumen ratio (\%)} = \frac{\text{Albumen weight}}{\text{Egg weight}} \times 100$$

8) SHELL RATIO (%):-

The eggs were broken out and the contents were removed. The shell was washed; air dried and individually weighed in the weighing balance. Shell ratio was calculated by given formula.

$$\text{Egg shell ratio (\%)} = \frac{\text{Egg shell weight}}{\text{Egg weight}} \times 100$$

9) EGG SHELL THICKNESS:-

Shell thickness was measured with the help of screw gauge with 0.01 mm precision. Four pieces of the shell, one each from broad end, narrow end and two from sides were taken. The shell thickness was measured from each piece. The average thickness was calculated and recorded as the thickness of the shell according to Chowdhury (1987).

3.4 STATISTICAL ANALYSIS :-

The data on different production performance and egg quality traits were analyzed as per standard methods (Snedecor and Cochran, 1994). Analysis of variance was made using two way classification. The effect of breed/variety and age group on different egg quality traits were studied. The individual means among breed/variety and age group were tested by Duncan's multiple range test modified by Kramer (1956) for their significance.

CHAPTER-IV
RESULTS AND DISCUSSION

4.1.1 PRODUCTION PARAMETERS :-

The average values for different production parameters i.e. Age at first egg in flock (days), hen day egg production (%) at 20^{th}, 30^{th} and 40^{th} weeks of age, Age at 50% egg production (days) and egg production up to 280 days (Number) have been presented in Table 1. The average age at first egg in flock ranged from 108 days (Kalinga Brown) to 120 days (CARI-Shyama), while it was found to as 116 days in Black Rock and 118 days in Vanaraja breed/varieties of back yard chicken. The birds of Kalinga Brown start laying egg at lower age as compared to remaining varieties. The age at first egg in flock in present study was quite low as reported by Singh *et al.* (2003). They reported 162 to 173 days in Upcari, Hitcari, CARI-Shyama and CARI-Nirbheek genotype under scavenging system. Kumaresan *et al.* (2008) found 154 days of age at first egg in back yard system while it was 196 days under intensive system in Vanaraja breed. The lower age at first egg in flock in present study was might be due to better growth rate of birds reared in intensive management conditions where balanced feed was made available to them. These birds were reared under deep litter housing. In addition to age in days at first egg in flock, sexual maturity was also measured as age at 50% egg production. There was wide range in this traits and it was reported to have between 132 days to 162 days in different varieties of chicken at CARI Izatnagar. These values were 162, 146, 132 and 142 days in CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock varieties, respectively. This is in agreement with finding of Chatterjee *et al.* (2005), who reported 161 days of sexual maturity in intensive system in Nicorock bird of Andaman. Studies indicated that the age at 50% egg production ranged from

150 to 160 days in various egg type of commercial stock i.e. Cari gold-92, Cari Priya, Cari Devendra and CARI-Shyama maintained at CARI Izatnagar (http://www.icar.org.in/cari/layer.html). The variation in age at sexual maturity between breed/varieties of back yard poultry were also reported by Singh *et al.* (2003) and perhaps varieties are to be reckoned as an important source of variations in any system of housing, feeding and management.

In present study egg production was measured only up to 40 weeks (280 days) of age. Egg production (Number) up to 40 weeks of age were found to be 55.04, 64.83, 62.78 and 62.95 in CARI-Shyama,Vanaraja, Kalinga Brown and Black Rock varieties of chicken, respectively. The hen day egg production (%) were calculated at 20^{th}, 30^{th}, and 40^{th} weeks of age. At 20^{th} weeks of age, hen day egg production (%) was ranged between 10.44 to 36.43 % in different varieties. At 30^{th} weeks of age, hen day egg production (%) was recorded as 29.17% in CARI-Shyama to 40.41% in Black Rock chicken variety. By the age of 40^{th} week, hen day egg production (%) was 36.84% in Black Rock where as it was 53.33% in Kalinga Brown breed/variety of back yard bird. Means comparison study revealed significant difference of variety on percent hen day egg production. No literature is available at the age of 20^{th}, 30^{th} and 40^{th} weeks of age on this traits i.e. hen day egg production in back yard poultry, therefore comparison with other study could not be made. Most of the studies has been conducted based on annual egg production (Kumaresan *et al.*, 2008; Singh *et al.*,2003; Chatterjee *et al.*,2005). The present study revealed that total egg production up to 280 days of age were higher in Vanaraja, while it was on lower side in CARI-Shyama breed/variety. Egg production performance (up to 280 days) which ranged from 55.04 to 64.83 for different genotypes of present study were found to be significantly lower than the 158 to 172 eggs (500 days) of Cari Nirbheek, CARI-Shyama,

Hitcari and Upcari genotypes developed at C.A.R.I. Izatnagar as reported by Singh *et al* (2003). Annual egg production which ranged from 158 to 172 egg for different genotypes were also found to be significantly higher than the present findings (Tadelle *et al.*, 2000). In the same way Kumaresan *et al.* (2008) observed 176 and 152 egg annually under back yard and intensive system of rearing. However our results are more or less similar with finding of Rao *et al.* (2007) who reported 55-65 egg by the 280 days of production period in Vanaraja breed. Egg production performance of back yard chicken strongly depends on nutrition and managements. Under scavenging condition they can lay smaller number of eggs, where as under improved condition egg production will be better. Further egg number at moderate temperature was not affected but at high temperature lower egg production might be observed. During present experiment (period 15th February to 14th August) birds were exposed in the summer stress in the month of April, May, June and July. Hence it was reflected to lower feed consumption as evident in Table 2. Probably this might be one of the reason of lower egg production in this experiment.

4.1.2 GROWTH PARAMETERS :-

The average values for different growth parameters i.e. body weight at first egg, body weight at 20th, 30th and 40th weeks of age along with average feed consumption have been given in Table 2. The average body weight at first egg in different varieties of chicken were found to as 1587.45, 1559.63, 1159.30 and 1460.91g for CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock, respectively. There were significant difference between breeds in body weight at first egg. The body weight at first egg was lowest in Kalinga Brown while it was highest in CARI-Shyama. It has been observed that both parameters for sexual maturity i.e. age and body weight they showed the similar trends in these varieties. The age and weight at sexual maturity was lowest in Kalinga Brown. The body weight at different ages were also studied at 20th, 30th

and 40th weeks of age. From the results it is evident that Kalinga Brown had shown lower body weight in subsequent ages also as the body weight at first egg, probably this breed has developed basically for egg production. Body weight at sexual maturity was also studied by Chatterjee *et al.* (2005) and it was reported 1487.48g in Nicorock, a dual purpose chicken of Port Blair. Studies made on project directorate on poultry showed 2134g (20 weeks) and 2734g (40 weeks) body weight in Vanaraja breed. As per report of Central Avian Research Institute Izatnagar body weight of pullets at 20th weeks of age were found to be 1205g to 1450g in different genotypes developed under scavenging system. Thus it can be said that there was wide variation in body weights and growth pattern of different breeds/varieties of present study and studies made earlier in different centers. This indicates genetic variation between birds from different localities.

The average feed consumption at 20th, 30th and 40th weeks of age were recorded. The average feed consumption at 20th weeks of age ranged from 71.84g to 93.85g/bird/day. The feed consumption was higher in Black Rock. Where as it was 80.33g in CARI-Shyama and 86.16g in Vanaraja. Means comparison study revealed significant difference between different varieties. In general Kalinga Brown had shown lower feed consumption and Black Rock had shown higher feed consumption, probably due to their body weight. It appears that feed consumption/bird/day is directly proportion to their body weight. No detailed published information is available in literature for improved varieties of chicken on average daily feed consumption at different age, hence it was not possible to compare the data. However most of studies (Christmas *et al.*, 1979; Koel beck and Cain, 1983 and Johri *et al.*, 1984) reported feed efficiency in terms of feed consumed per dozen egg in commercial strains of poultry. Rangareddy *et al.* (1989) revealed 106.33 to 112.75g/bird/day feed consumption from 22 to 72 weeks of age in different strains of commercial chicken. In general, average feed consumption was more or less same in different

age group. This might be due to higher environmental temperature of June and July month during study period, hence restricted the daily feed consumption.

4.2 EGG QUALITY TRAITS :-

4.2.1 EGG WEIGHT (g) :-

The overall mean for egg weight is given in table 3 (a), while analysis of variance from different sources under study are detailed in table 3 (b) and graphically exhibited in figure 1. The over all mean for egg weight was 48.792±0.09g. In this study the average value that is determined related to egg weight indicated similarities with the findings of Padhi *et al.* (1998) who reported 46.70 and 47.72g egg weight in brown and black Nicobari, respectively. Most of the workers reported higher egg weight than the present study. (Haunshi *et al.*, 2006 reported 60.79g in Vanaraja, Chatterjee *et al.*, 2005 found 53.20g in Nicorock and Negi, 2008 observed 52.24g in Kalinga Brown breeds raised in back yard poultry farming). Since egg weight is highly heritable trait, the differences among the varieties developed by crossing might be expected in different rural varieties. It is also considered that differences between results of this study and results of other workers might have resulted from genetic structure and differences in care and management conditions of birds. The analysis of variance revealed that egg weight was significantly influenced by varieties of back yard poultry/chicken. In present study egg weight was lowest in Kalinga Brown and highest in CARI-Shyama. Where as it was found to be medium i.e. 48.71 g and 48.43 g in Black Rock and Vanaraja varieties. Niranjan *et al.* (2008) while working with four different chicken varieties developed for back yard poultry revealed that egg weight were significantly higher in Vanaraja (53.0 g) and Gramapriya (51.0). On the other hand Chaudhary (1997) reported 49 to 53 g egg weight in different varieties of back yard chicken developed at Central Avian Research Institute i.e. CARI Nirbheek, CARI-Shyama, Hitcari,

Upcari. Padhi *et al.* (1998) also observed significant difference in egg weight amongst different breeds of chicken at Port Blair.

The analysis of variance showed that their was significant effect of age group on egg weight. The values of egg weight in different age group are varied from 45.111 g to 54.141 g. The age of bird exhibited significant influence of egg weight. As the age increased egg weight also increased gradually. This finding is in line with established fact that as the age of bird increases the size of egg increase. Premavalli and Vishwanathan (2004) also reported significant difference in egg weight at 20 and 40 weeks of age in commercial White Leghorn chicken.

4.2.2 ALBUMEN WEIGHT (g) AND ALBUMEN RATIO (%) :-

Descriptive statistic was obtained for internal quality traits of albumen weight and albumen ratio and is presented in table 4 (a) and 5 (a). Analysis of variance to see the effect of varieties and age has been shown in table 4 (b) and 5 (b), respectively. The over all mean of albumen weight was found to be 30.485 g. The average value of trait i.e. albumen weight in different varieties were within the range which was reported by previous worker (Niranjan *et al.*, 2008 in Vanaraja and Gramapriya and Negi, 2008 in Kalinga Brown). However Parmar *et al.* (2006) reported lower albumen weight i.e. 20.20 g in indigenous Kadaknath breed of poultry. While working with the Fulani ecotype chicken Fayeye *et al.* (2005) reported 20.33 g albumen weight. Lower albumen weight (23.46 to 26.67g) than the present study were recorded by Chatterjee *et al.* (2005) in indigenous fowl of Andman. These differences among the reports for trait with albumen weight could be expected because of difference in genetic constitution and age of flock and also might be due to the variation in weight of the egg.

In present study higher albumen weight was reported in Vanaraja whereas no significant difference was observed amongst CARI Shyama, Kalinga Brown and Black Rock breeds of chicken. Means comparisons study also revealed much difference in the albumen weight between age group and it was found to be highest in 3rd age group i.e. 32 – 40 week of age. These values were found to as 28.258, 29.391 and 33.806 g in 1st, 2nd and 3rd age group, respectively. Analysis of variance also showed highly significant ($P<0.01$) effect of varieties and age group on albumen weight. The mean values for albumen ratio were reported to as 61.087, 62.288, 63.492 and 62.829 in CARI Shyama, Vanaraja, Kalinga Brown and Black Rock varieties of chicken. Albumen ratio was highly influenced by breed/varieties; however it was not influenced by age group of birds as indicated in analysis of variance on table 3(b). Niranjan *et al.* (2008) recorded breed and age differences in albumen weight while working with four rural varieties (crosses) developed for back yard poultry. Padhi *et al.* (1998) also revealed significant differences between breeds and albumen ratio was found to as 56.80 to 58.46 percent in different breeds of back yard chicken in their study.

4.2.3 YOLK WEIGHT (g) AND YOLK RATIO (%) :-

The mean value of yolk weight and yolk ratio are presented in table No 6 (a) and 7 (a). where as analysis of variance are presented in table No 6 (b) and 7 (b) and graphically shown on figure 4 and 5, respectively. From the table it is evident that mean yolk weight was 13.048 g and it was lower than the value reported by other workers. Chatterjee *et al.* (2005) reported 17.081 g yolk weight in Nicorock a dual purpose chicken for back yard while Parmar *et al.*(2006) reported 14.36 g yolk weight in Kadaknath breed of chicken. Lower yolk weight in present study might be due to lower egg weight of the back yard varieties selected in present study. Inspite of lower egg weight in present study yolk weight ratio was more or less similar with other studies (Chatterjee

et al., 2005 and Parmar *et al,.* 2006). A higher estimation of yolk weight (15.18g) was observed in Kadaknath (Parmar *et al.,* 2006) than the present study. Similarly Niranjan *et al.* (2008) reported higher yolk weight in Vanaraja and Gramapriya, proven varieties for back yard farming. Analysis of variance showed highly significant ($P<0.01$) of varieties in yolk weight and yolk ratio. While yolk ratio was influenced only by breed and not by age group. Studies indicated that yolk weight was highest in CARI Shyama followed by Vanaraja and Black Rock, where as it was lowest in Kalinga Brown. Trend of yolk weight showed the similar trend as that of egg weight indicating strong relationship between egg weight and yolk weight. The mean values for yolk weight were recorded as 13.90, 13.01, 12.40 and 12.86g in CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock breed of poultry. In present study yolk weight contributed 12.054 g to 14.535 g in different age group and it was found to be highest in the third age group i.e. 32 – 40 week of age. The means comparison study also revealed significant difference of yolk weight in different age group.

The over all mean for yolk ratio was reported to be 26.78%. The yolk ratio in different back yard poultry varieties were 25.926 % in Kalinga Brown, 26.528 % in Black Rock, 26.901 % in Vanaraja and 27.792 % in CARI Shyama. Contrary to this Niranjan *et al.* (2008) observed 31.27, 31.26, 32.88 and 33.06 % yolk ratio in C_1 cross, C_2 cross, Vanaraja and Gramapriya varieties, respectively. The effect of breed on yolk ratio was highly significant where as effect of age on yolk ratio was non significant. Since no information is available on yolk ratio in different age group of back yard poultry, no comparison could be made.

4.2.4 EGG SHELL WEIGHT (g) AND SHELL RATIO (%) :-

Over all mean for egg shell weight and shell ratio are shown in table No 8 (a) and 9 (a). While analysis of variance of these traits are shown in 8 (b) and 9 (b), respectively. Results are also presented in figure 6 and 7. The over all mean for shell weight in four varieties of chicken developed for back yard poultry farming was found to be 5.261 g. The present estimation is lower than reported by Chatterjee *et al.,* (2005) who reported 6.71g in Nicorock breed of chicken, while it is more or less similar with Niranjan *et al.* (2008) as reported in Vanaraja and Gramapriya varieties of back yard chicken. The shell weight in present study varies amongst varieties, it was found to be highest in Kalinga Brown. Where as it was lowest in the CARI Shyama variety. Analysis of variance also showed highly ($P<0.01$) significant difference of varieties for egg shell weight. The present estimation of egg shell weight (g/egg) is higher than reported by Islam and Nishibori (2009), who reported 3.6 to 4.2 g egg shell weight/ egg in different season and genotype of indigenous Naked Neck chicken of Bangladesh. In present study significant differences were observed due to variation on varieties of chicken. Chatterjee *et al.* (2005) also reported non significant breed difference in egg shell weight for 6 indigenous chicken breed from Andman. As expected, in present study shell ratio was also higher in CARI-Shyama and lower in Kalinga Brown and Black Rock breed/ varieties of chicken. Egg shell weight and shell ratio has followed the same trend.

Influence of age group was reported to be significant in present study. The mean shell weight was highest in the third age group i.e. 32 – 40 week of age.

The present study showed that CARI-Shyama had higher in shell ratio than the other varieties of chicken. Further higher ratio was observed in the 2nd age group i.e. 24 – 32 week of

age. The over all shell ratio was found to as 10.788 percent. Contrary to our results, Padhi *et al.* (1998) did not observed any significant differences in different indigenous chicken for shell weight ratio.

4.2.5 SHELL THICKNESS (mm) :-

The overall mean and means comparison as influenced by varieties and age group are given in table 10 (a). The analysis of variance is presented in table No 10 (b). means are also graphically presented in figure 8. The over all mean for egg shell thickness was found to be 0.32. This is an agreement with the report of Monira *et al.* (2003) as reported in Barred Plymouth Rock and White Rock breeds of chicken. Negi (2008) also reported the similar finding in Kalinga Brown breed of chicken. It was lower than the value reported by earlier workers (Haunshi *et al.,* 2006 in Vanaraja; Mohan *et al.,* 2008 in Aseel chicken and Asharaf *et al.,* 2004 in Lyall pur silver black). In our study this parameter is influenced by age group and not by the breed/varieties. The egg shell thickness varies from 0.320 to 0.327 mm in different varieties. The higher shell thickness in the birds developed for rural/back yard poultry is a better indicator for their suitability for free range farming. However it was reported as 0.314 mm in second age group and it was little higher (0.328) than first and third age group. A gradual decrease in general in egg shell thickness was observed with advancement of age from 16 to 32 week of age. Decrease in egg shell thickness due to increase in age observed in this study was also reported by Akbas *et al.* (1996). In the present study the lower egg shell thickness of 24 – 32 week duration was falling during the summer. Alfred (1974) and Ronald (1979) pointed out reduction in egg shell thickness to increase in environmental temperature. Probably this was the main cause of decline egg shell thickness due to increase in environmental temperature of May month in the present study.

4.2.6 SHAPE INDEX (%) :-

The over all mean for shape index and means for different sources are detailed in table 11 (a), while least square analysis of data is shown in table 11 (b). Pictorial presentation of shape index has been given in figure 9. The over all shape index was reported to as 73.68 % in present study. The average values of trait were within the range which was reported by previous workers. Haunshi *et al.* (2006) reported shape index (70.67) in Vanaraja, where as Parmar *et al.* (2006) reported 74.35 % shape index in Kadaknath breed. Contrary to this Niranjan *et al.* (2008) showed 76.2 % and 78.0 % shape index in Vanaraja and Gramapriya varieties of back yard poultry.

As presented in table 9 (b) the effect of breed/varieties was highly significant ($P<0.01$). Shape index was highest in CARI-Shyama and Vanaraja varieties (74.897 % and 74.727 %); inter mediate in Kalinga Brown (73.243 %) and lowest in Black rock (71.890 %). Monira *et al.* (2003) also observed significant difference in shape index due to breed of chicken in commercial breed of chicken. Niranjan *et al.* (2008) while working with Vanaraja, Gramapriya, broiler pure line 1 (C_1 cross) and broiler pure line 2 (C_2 cross) also observed differences in the shape index due to the genetic group.

Shape index was 72.388 in the 3rd age group i.e. 32 – 40 week of age where as it was higher (74.22 to 74.45 %) in the 1st and 2nd age group. The decreased shape index with increasing age was probably due to increased egg weight of the egg. Premavalli and Vishwanathan (2004) also reported decreasing trend of shape index as per advancement of age. This decrease in shape index was due to increase egg weight and length of the egg.

4.2.7 ALBUMEN INDEX (%) :-

The over all mean for albumen index is presented in table 12 (a) while analysis of variance for different sources under study are detailed in 12 (b). Albumen index are also showed graphically in figure 10. The over all mean for albumen index was 8.83. Haunshi *et al.* (2006) reported albumen index (8.0) in Vanaraja breed of chicken, Parmar *et al.* (2006) reported albumen index (8.52) in Kadaknath breed. Where as Negi (2008) calculated albumen index (5.0 %)in Kalinga Brown. These results from different researches are quite lower to the result reported in present study. It is considered that differences between results of other study and present study might have resulted from the genetic make up of the breed/varieties and differences in the managemental practices. The analysis of variance indicated that albumen index was significantly influenced by varieties and age group of chicken. Albumen index was highest in the CARI-Shyama and was lowest in the Vanaraja, where as it was highest (10.210 %) in 16 – 24 week of age. Our results are contradictory to those of Padhi *et al.* (1998) who reported 9.85, 11.58, 12.12 and 7.05 % albumen index in White Nicobari, Brown Nicobari, Black Nicobari and Naked Neck varieties of chicken, respectively. However, they observed significant differences in albumen index values between the breeds. Premavalli and Vishwanathan observed linear decrease in the albumen index with advancing the age. The mean albumen index at 16 to 24 week of age is significantly higher from those values observed in 24 to 32 week of age and 32 to 40 weeks of age. The declining trend in albumen index with advancing the age is observed in this study is in accordance with the Sarda (1998), Pandey *et al.* (1986) and Akbas *et al.* (1986). Albumen quality is affecting by age of bird, varieties and possibly by the environmental temperature.

4.2.8 YOLK INDEX (%) :-

The over all mean for yolk index is shown in table 13 (a) while analysis of variance is given in table 13 (b). Yolk index are also shown graphically in figure 11. The over all mean for yolk index was found to be 44.47 in different varieties of back yard chicken under present study. The present estimation are in agreement with the report of Negi (2008) who reported 44.90 % in Kalinga brown and Ashraf *et al.* (2004) who reported 45.0% in Lyallpur Silver Black chicken. However lower estimation than the present study has been reported by many workers. Haunshi *et al.* (2006) reported 36.8 % of yolk index in Vanaraja, where as Parmar *et al.* (2006) reported 37.53 % yolk index in Kadaknath breed of poultry. Padhi *et al.* (1998) reported lower yolk indices in White Nicobari and black Nicobari breed, where as shown similar finding in Brown Nicobari and Naked Neck varieties of poultry. Higher value of yolk index in present study was probably due to better quality of albumen and yolk which resulted in its consistency and height leading to higher yolk index. The yolk index percentage was found to vary with breed/varieties and age group of the chicken. Higher yolk index was noticed almost in all varieties, however it was little lower in CARI-Shyama. As observed by analysis of variance and means comparison study, higher yolk index was noticed in 1^{st} and 2^{nd} age group i.e. from 16 to 32 week of age and it was lower in the third age group i.e. 32 to 40 weeks of age. This is with accordance with the Sarda (1988), Akbas *et al.* (1986) and Premavalli and Vishwanathan (2004). Yolk index and albumen index followed the same trend i.e. lower value as per advancement of age. The decrease in yolk index may be due to increase in value of yolk with increase in age of bird and same has been exhibited in the results.

4.2.9 HAUGH UNIT SCORE :-

Haugh unit has been considered the best objective mathematical expression to major internal egg quality. The descriptive statistic obtained in this study is shown in table 14 (a) and analysis of variance is given in table 14 (b). Means are also graphically presented in figure 12. The over all mean are found to be 80.77. Haunshi *et al.* (2006) in Vanaraja, Parmar *et al.* (2006) in Kadaknath breed and Niranjan *et al.* (2008) reported similar finding in indigenous and backyard poultry. Where as some of researches indicated difference in it. Chatterjee *et al.* (2005) reported 59.62 to 71.62 H.U. in White Leghorn strain, Mohan *et al.* (2008) reported 82.17 H.U. in Aseel, Negi (2008) observed 71.02 H.U. in Kalinga Brown, Ashraf *et al.* (2004) reported 102.24 in Lyallpur silver black chicken and Niranjan *et al.* (2008) observed 74.6 H.U. in Gramapriya. As indicated earlier like albumen weight, albumen index, yolk weight, yolk index, and egg weight, these observable differences might be due to genetic structure , health condition, age of the flock, feeding practices, care and managemental conditions in different studies. The higher haugh unit reported in present study indicated the superior quality of albumen in four varieties used in the study. Further presence of exotic inheritance in rural varieties might be the reason for higher haugh unit score in our study. This trait was highly influenced by breed/ varieties and age group of the chicken used in the study. Eggs of CARI-Shyama showed highest haugh unit followed by Kalinga Brown, Black Rock and Vanaraja. This difference between breed/varieties is in agreement with the report of Curtis *et al.* (2005) and Padhi *et al.* (1998), who observed the significant difference in haugh unit between the breeds. Parmar *et al.* (2006) observed wide range of haugh unit value for Kadaknath birds starting from 62.58 to 90.00 in western part of India under field condition. Niranjan *et al.* (2008) also showed a wide variation of haugh unit in different age groups i.e. 24, 32 and 40 weeks of age. Haugh unit score has been

well accepted as a measure of internal egg quality, after correlating for difference with egg size. Since it is measures of albumen height and allows comparing of eggs of unequal size, gives weightage should give to internal quality measures in a selection and breeding programme for back yard poultry farming.

4.3 CORRELATION STUDY :-

Inter relationship between egg weight with its major components and internal egg quality traits has been worked out in present study and it is given in Table 15.

There was positive and significant correlation between egg weight with its components i.e. albumen weight, yolk weight and shell weight because of part and whole relation ship. This suggest that genes responsible for high egg weight is also responsible for high albumen, yolk and shell weight. Literature also revealed high correlation of eggweight with albumen, yolk and shell weight (Baumgartner, 1994; Narahari *et al.,* 1988). Zhang *et al.* (2005) reported positive and significant correlation between egg weight and albumen weight, yolk weight and egg shell weight (0.67 to 0.97). shi *et al.* (2009) also observed positive and significant correlation between egg weight and albumen weight (0.603). In the study statistically significant correlation was obtained between egg weight and shell weight. The egg weight has an indirect relation with shell quality of egg. Thus from this study it is considered that egg shell quality would be determined by using egg weight values due to positive and significant correlation exit between egg weight and shell weight.

In the study negative correlation value (-0.177) was determined between egg weight and shape index. The results are in conformity with finding of Abanikannda *et al.* (2007). Contrary to this Balvir Singh *et al.* (2000) and Sekerog lu and Altuntas (2009) reported positive correlation between these two egg quality characters.

In present study no correlation exist between egg weight and shell thickness. However most of workers (Mahapatra *et al.* 1982; Unver *et al.* 2001 and Mohanty *et al.* 1986) reported negative association between egg weight and shell thickness. The difference found between results may be partially attributed to the difference in breed, nutrition, age and environment, which are also related to shell quality. Specially age of birds (16 to 40 weeks of age) and higher temperature of summer in this experiment would contribute to difference from forenamed studies (Mahapatra *et al.* 1982; Unver *et al.* 2001 and Mohanty *et al.* 1986).

The correlation between egg weight with Haugh unit was found to as -0.362. Haugh unit is an expression relating egg weight and height of thick albumen. It is generally accepted that the higher the Haugh unit value, better the quality of egg. Generally a negative association was reported between egg weight and Haugh unit (Van Tijen *et al.,* 1970; Sekerog lu and Altuntas, 2009). However, Emsley *et al.* (1977) demonstrated that heavy eggs had higher Haugh unit. The negative correlation between egg weight and Haugh unit in this study is in agreement with literature (Jposu *et al., 1994;* Sekerog lu and Altuntas, 2009). These correlation studies between egg weight and egg quality traits suggest that it could be possible to asses some egg quality traits through egg weight.

CHAPTER-V

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH WORK

The present experiment was conducted to study egg production performance and egg quality traits in improved varieties of chicken during first phase of production cycle. The study was conducted in improved varieties of chicken namely CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock developed for backyard poultry. The study was carried out from 16th weeks of age and was continued up to 40th weeks of age under identical feeding and managemental conditions. The data on production parameters was collected and analysed in each varieties. Different external and internal egg quality traits were examined to see the effect of breed and age groups.

The average age at first egg in flock ranged from 108 days (Kalinga Brown) to 120 days (CARI-Shyama), while it was found to as 116 days in Black Rock and 118 days in Vanaraja breed/varieties of back yard chicken. The birds of Kalinga Brown start laying egg at lower age as compared to remaining varieties.

The henday egg production (%) were calculated at 20th, 30th, and 40th weeks of age. At 20th weeks of age, hen day egg production (%) was ranged between 10.44 to 36.43 % in different varieties. At 30th weeks of age, hen day egg production (%) was recorded as 29.17% in CARI-Shyama to 40.41% in Black Rock chicken variety. By the age of 40th week, hen day egg production (%) was 36.84% in Black Rock where as it was 53.33% in Kalinga Brown breed/variety of back yard bird. Means comparison study revealed significant difference of variety on percent hen day egg production.

The average body weight at first egg were found to as 1587.45, 1559.63, 1159.30 and 1440.29g for CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock, respectively. There were significant differences between breeds in body weight at first egg.

The average feed consumption at 20^{th}, 30^{th} and 40^{th} weeks of age were recorded. The average feed consumption at 20^{th} weeks of age ranged from 71.84g to 93.85g/bird/day. Means comparison study revealed significant difference between different varieties.

The overall mean for egg weight was 48.792±0.09g. In present study egg weight was lowest in Kalinga Brown and highest in CARI-Shyama, where as it was found to be medium i.e. 48.71g and 48.43g in Black Rock and Vanaraja varieties. The analysis of variance showed that there was significant effect of age group on egg weight.

The overall mean of albumen weight was found to be 30.485 g. Means comparisons study also revealed much difference in the albumen weight between age group and it was found to be highest in 3^{rd} age group i.e. 32 – 40 week of age. These values were found to as 28.258, 29.391 and 33.806 g in 1^{st}, 2^{nd} and 3^{rd} age group, respectively. Analysis of variance also showed highly significant ($P<0.01$) effect of varieties and age group on albumen weight.

The mean yolk weight was found to as 13.048 g. The mean values for yolk weight were recorded as 13.90, 13.01, 12.40 and 12.86g in CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock breed of poultry. In present study yolk weight contributed 12.054 g to 14.535 g in different age group and it was found to be highest in the third age group i.e. 32 – 40 week of age.

The over all mean for shell weight in four varieties of chicken developed for back yard poultry farming was found to be 5.261 g. The shell weight in present study varies amongst varieties, it was found to be highest in Kalinga Brown. Where as it was lowest in the CARI

Shyama variety. Analysis of variance also showed highly ($P<0.01$) significant difference of varieties for egg shell weight.

The over all mean for egg shell thickness was found to be 0.32mm. The egg shell thickness varies from 0.320 to 0.327 mm in different varieties. A gradual decrease in general in egg shell thickness was observed with advancement of age from 16 to 32 week of age.

The over all shape index was reported to as 73.68 % in present study. The effect of breed/varieties was highly significant ($P<0.01$). Shape index was highest in CARI-Shyama and Vanaraja varieties (74.897 % and 74.727 %); inter mediate in Kalinga Brown (73.243 %) and lowest in Black rock (71.890 %). Shape index was 72.388 in the 3^{rd} age group i.e. 32 – 40 week of age where as it was higher (74.22 to 74.45 %) in the 1^{st} and 2^{nd} age group.

The over all mean for albumen index was 8.83. The analysis of variance indicated that albumen index was significantly influenced by varieties and age group of chicken. Albumen index was highest in the CARI-Shyama and was lowest in the Vanaraja, where as it was highest (10.210 %) in 16 – 24 week of age.

The over all mean for yolk index was found to be 44.47 in different varieties of back yard chicken under present study. The yolk index percentage was found to vary with breed/varieties and age group of the chicken. Higher yolk index was noticed almost in all varieties, however it was little lower in CARI-Shyama.

The over all mean for Haugh unit are found to be 80.77. The higher Haugh unit reported in present study indicated the superior quality of albumen in four varieties used in the study. This trait was highly influenced by breed/ varieties and age group of the chicken used in the study.

There was positive and significant correlation between egg weight with its components i.e. albumen weight, yolk weight and shell weight because of part and whole relation ship. In the

study negative correlation value (-0.177) was determined between egg weight and shape index. In present study no correlation exist between egg weight and shell thickness. The correlation between egg weight with Haugh unit was found to as -0.362.

Conclusions :-

From the above study it can be concluded that-

1) The age at sexual maturity was measured as age at 50% egg production and it was reported to have between 132 to 162 days in different varieties of chicken. The age at sexual maturity was lowest in Kalinga Brown while it was highest in CARI-Shyama.
2) The henday egg production were calculated at 20^{th}, 30^{th} and 40^{th} weeks of age. The study revealed that total egg production up to 280 days of age were higher in vanaraja while it was lower in CARI-Shyama.
3) The average feed consumption at 20^{th} weeks of age were ranged from 71.84g to 93.85g/bird/day. There was significant difference between varieties. The feed consumption was lowest in Kalinga Brown and highest in Black Rock variety of chicken.
4) Study revealed that egg weight was significantly influenced by varieties of backyard chicken. Egg weight was lowest in Kalinga Brown and highest in CARI-Shyama.
5) The values of egg weight in different age group varied from 45.111 to 54.141g. As the age increased, egg weight also increased gradually.
6) The mean values for albumen ratio were reported to be 61.087 to 63.492 in different varieties. This trait was not influenced by age group of birds.
7) Studies indicated that yolk weight was highest in CARI-Shyama followed by Vanaraja and Black Rock, where as it was lowest in Kalinga Brown. Trend of yolk weight showed

similar trend as that of egg weight indicating strong relationship between egg weight and yolk weight.

8) The egg shell thickness varies from 0.320 to 0.327 mm in different varieties. The higher shell thickness in the birds developed for rural/backyard poultry is a better indicator for their suitability for free range farming.
9) There was decreasing trend of shape index with increasing age. This decrease in shape index was due to increase egg weight and length of egg.
10) The overall mean for Haugh unit was 80.77, indicated thick and consistent albumen in four varieties of chicken used in present study. This trait was highly influenced by breed and age group of chicken.
11) Correlation studies between egg weight and egg quality traits suggest that it would be possible to asses some internal egg quality traits through egg weight, without breakage of egg due to significant relationship between two traits.

Suggestions for future work :-

1) Efforts should be made to study egg production parameters and egg quality traits in different housing and management system.
2) There may also be need to work with larger number of birds. Such an increased sample size may help to reveal the true potential of improved varieties/breeds of chicken.

ABSTRACT

Studies on Production Performance and Egg Quality Traits in Improved Varieties of Chicken During First Phase of Production Cycle

By

Sandeep Kumar

The present study was carried out to study egg production performance and egg quality traits in improved varieties of chicken namely CARI-Shyama, Vanaraja, Black Rock and Kalinga Brown developed for back yard poultry. The study was conducted in 3 age groups i.e. 16^{th} to 24^{th}, 24^{th} to 32^{nd} and 32^{nd} to 40^{th} weeks of age. Production parameters were studied in different varieties where as different external and internal egg quality traits were examined to see the effect of breed/variety and age groups. The age at sexual maturity was measured as age at 50% egg production and was reported to be 162, 146, 132 and 142 days in CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock variety, respectively. The average body weights at 20th weeks of age were recorded as 1692.62, 1608.05, 1199.33 and 1466.91g, in CARI-Shyama, Vanaraja, Kalinga Brown and Black Rock variety, respectively. Overall mean value for egg weight, albumen weight, yolk weight, shell weight, shell thickness, shape index and Haugh unit were 48.793g, 30.485g, 13.048g, 5.261g, 0.323mm, 73.689 percent and 80.770, respectively. The mean value for albumen ratio, yolk ratio, egg shell ratio, albumen index and yolk index were reported as 64.424, 26.787, 10.789, 8.831% and 44.474%, respectively. The effect of variety and age group had significant effect on egg weight, yolk weight, egg shell weight, egg shell ratio, shape index, albumen index, yolk index and Haugh unit. Where as variety did not exert any effect on albumen weight and egg shell thickness. There were increasing trend of egg weight and albumen weight as per age advances. The

Haugh unit were higher in CARI-Shyama and Kalinga Brown (82.669 and 82.434) however it was slightly low in Vanaraja and Black Rock (78.612 and 79.364).

In the study there was positive and significant correlation between egg weight with albumen weight, yolk weight and shell weight, however it was negative and significant between egg weight with shape index and Haugh unit.

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Table No 1 :-Means and S.E. of production parameters in different breeds/varieties of backyard chicken

Traits		**CARI-Shyama**	**Vanaraja**	**Kalinga Brown**	**Black Rock**
Age at first egg in flock (days)		120	118	108	116
Age at 50% egg in flock (days)		162	146	132	142
Percent hen day egg production (%)	20th week	10.44 ^{a}±1.82	36.43 ^{c} ±2.61	21.29 ^{b} ±0.19	22.73 ^{b}±4.09
	30th week	29.17 ^{a}±1.58	31.09 $^{a\,b}$±3.33	38.21 ^{bc}±2.75	40.41^{c} ±3.20
	40th week	50.34 ^{b}±3.09	51.79 ^{b} ±3.79	53.33 ^{b} ±2.52	36.84 ^{a} ±3.98
Total egg up to 280 days (egg/bird)		55.04..	64.83	62.78	62.95

Means superscripted by different letters in a row differed significantly (P<0.05) from each other

Table No 2:- Means and S.E. of growth parameters in different breeds/varieties of backyard chicken

Traits		**CARI-Shyama**	**Vanaraja**	**Kalinga Brown**	**Black Rock**
Body weight at first egg (g)		1587.45	1559.63	1159.30	1440.29
Body weight (g) at	20th week	1629.62^{c}±49.83	1608.05^{c}±52.30	1199.33^{a}±39.77	1466.91^{b}±39.77
	30th week	1770.92 ^{b}±54.22	1769.77 ^{b}±61.35	1369.13 ^{a} ±56.50	1639.42 ^{b} ±45.18
	40th week	1941.24 ^{b}±46.44	1949.25 ^{b}±82.30	1615.67 ^{a} ±54.13	1744.06 ^{a} ±51.81
Average feed consumption (g/Bird)	20th week	80.33 ^{b} ±0.95	86.16 ^{b} ±2.07	71.84 ^{a} ±1.95	93.85 ^{c} ±1.03
	30th week	82.69 ^{b} ±4.72	85.11 ^{b} ±6.06	76.62 ^{a} ±4.26	87.63 ^{b} ±3.20
	40th week	82.50 ^{b} ±2.87	81.63 ^{b} ±3.75	72.89 ^{a} ±5.72	89.77 ^{b} ±3.40

Means superscripted by different letters in a row differed significantly (P<0.05) from each other

Table 3 (a):- Overall, Breed wise and Age group wise mean egg weight (g) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	50.093 ± 0.31^{c}	10.60
	2) VANARAJA	$48.438 \pm 0.29^{a\ b}$	10.29
	3) KALINGA BROWN	47.927 ± 0.29^{a}	10.35
	4) BLACK ROCK	48.712 ± 0.31^{b}	10.94
AGE GROUP	I^{ST} (16 – 24 WEEK)	45.111 ± 0.19^{x}	8.50
	II^{ND} (24 – 32 WEEK)	47.126 ± 0.16^{y}	6.94
	III^{RD} (32 – 40 WEEK)	54.141 ± 0.17^{z}	6.11
OVER ALL MEAN		48.793 ± 0.15	10.67

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 3 (b):- Analysis of variance for egg weight (g) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	80.078	11.433**
AGE GROUP	2	635.227	90.693**
ERROR	1194	7.004	
TOTAL	1200		

** Significant at (P<0.01)

Table 4 (a):- Overall, Breed wise and Age group wise mean albumen weight (g) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	30.618 ± 0.21 $^{a\,b}$	11.60
	2) VANARAJA	30.185 ± 0.20 ^{a}	11.26
	3) KALINGA BROWN	30.462 ± 0.21 $^{a\,b}$	11.95
	4) BLACK ROCK	30.675 ± 0.24 ^{b}	13.30
AGE GROUP	I^{ST} (16 – 24 WEEK)	28.258 ± 0.17 ^{x}	11.78
	II^{ND} (24 – 32 WEEK)	29.391 ± 0.14 ^{y}	9.82
	III^{RD} (32 – 40 WEEK)	33.806 ± 0.10 ^{z}	5.91
OVER ALL MEAN		30.485 ± 0.11	12.06

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 4 (b):- Analysis of variance for albumen weight (g) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	14.426	1.853^{NS}
AGE GROUP	2	3437.152	441.537**
ERROR	1194	7.785	
TOTAL	1200		

** Significant at (P<0.01)
^{NS} Nonsignificant

Table 5 (a):- Overall, Breed wise and Age group wise mean albumen ratio (%) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	61.088 ± 0.14 [a]	3.84
	2) VANARAJA	62.289 ± 0.14 [b]	3.85
	3) KALINGA BROWN	63.492 ± 0.16 [d]	4.48
	4) BLACK ROCK	62.829 ± 0.15 [c]	4.20
AGE GROUP	I^{ST} (16 – 24 WEEK)	62.512 ± 0.16	5.01
	II^{ND} (24 – 32 WEEK)	62.277 ± 0.14	4.40
	III^{RD} (32 – 40 WEEK)	62.484 ± 0.11	3.46
OVER ALL MEAN		62.424 ± 0.08	4.34

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 5 (b):- Analysis of variance for albumen ratio (%) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	310.833	47.262**
AGE GROUP	2	6.596	1.003 [NS]
ERROR	1194	6.577	
TOTAL	1200		

** Significant at (P<0.01)
[NS] Nonsignificant

Table 6 (a):- Overall, Breed wise and Age group wise mean yolk weight (g) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	13.904 ± 0.10 ^{c}	12.18
	2) VANARAJA	13.020 ± 0.09 ^{b}	12.14
	3) KALINGA BROWN	12.401 ± 0.09 ^{a}	13.04
	4) BLACK ROCK	12.866 ± 0.08 ^{b}	10.49
AGE GROUP	I^{ST} (16 – 24 WEEK)	12.054 ± 0.06 ^{x}	9.70
	II^{ND} (24 – 32 WEEK)	12.554 ± 0.06 ^{y}	9.12
	III^{RD} (32 – 40 WEEK)	14.535 ± 0.07 ^{z}	9.99
OVER ALL MEAN		13.048 ± 0.05	12.69

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 6 (b):- Analysis of variance for yolk weight (g) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	118.479	91.042**
AGE GROUP	2	688.613	529.142**
ERROR	1194	1.301	
TOTAL	1200		

** Significant at (P<0.01)

Table 7 (a):- Overall, Breed wise and Age group wise mean yolk ratio (%) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	27.792 ± 0.12^{d}	7.71
	2) VANARAJA	26.901 ± 0.12^{c}	7.59
	3) KALINGA BROWN	25.926 ± 0.15^{a}	9.90
	4) BLACK ROCK	26.528 ± 0.13^{b}	8.79
AGE GROUP	I^{ST} (16 – 24 WEEK)	26.821 ± 0.13	9.85
	II^{ND} (24 – 32 WEEK)	26.722 ± 0.13	9.86
	III^{RD} (32 – 40 WEEK)	26.817 ± 0.09	6.49
OVER ALL MEAN		26.787 ± 0.07	8.87

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 7 (b):- Analysis of variance for yolk ratio (%) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	183.112	35.207**
AGE GROUP	2	1.247	0.240^{NS}
ERROR	1194	5.201	
TOTAL	1200		

** Significant at (P<0.01)
^{NS} Nonsignificant

Table 8 (a):- Overall, Breed wise and Age group wise mean egg shell weight (g) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	5.573 ± 0.04 ^{c}	12.40
	2) VANARAJA	5.234 ± 0.04 ^{b}	12.75
	3) KALINGA BROWN	5.064 ± 0.04 ^{a}	12.03
	4) BLACK ROCK	5.172 ± 0.03 ^{b}	10.73
AGE GROUP	I^{ST} (16 – 24 WEEK)	4.800 ± 0.03 ^{x}	11.67
	II^{ND} (24 – 32 WEEK)	5.181 ± 0.02 ^{y}	7.54
	III^{RD} (32 – 40 WEEK)	5.801 ± 0.03 ^{z}	9.93
OVER ALL MEAN		5.261 ± 0.02	12.55

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 8 (b):- Analysis of variance for egg shell weight (g) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	14.498	62.919**
AGE GROUP	2	101.940	442.418**
ERROR	1194	.230	
TOTAL	1200		

** Significant at (P<0.01)

Table 9 (a):- Overall, Breed wise and Age group wise mean egg shell ratio (%) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	11.120 ± 0.04 ^{c}	5.81
	2) VANARAJA	10.811 ± 0.05 ^{b}	8.26
	3) KALINGA BROWN	10.582 ± 0.05 ^{a}	8.43
	4) BLACK ROCK	10.643 ± 0.04 ^{a}	7.30
AGE GROUP	I^{ST} (16 – 24 WEEK)	10.667 ± 0.06 ^{x}	10.84
	II^{ND} (24 – 32 WEEK)	11.001 ± 0.03 ^{y}	4.85
	III^{RD} (32 – 40 WEEK)	10.698 ± 0.03 ^{x}	5.91
OVER ALL MEAN		10.789 ± 0.02	7.73

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 9 (b):- Analysis of variance for egg shell ratio (%) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	17.423	27.566**
AGE GROUP	2	13.608	21.530**
ERROR	1194	.632	
TOTAL	1200		

** Significant at (P<0.01)

Table 10 (a):- Overall, Breed wise and Age group wise mean egg shell thickness (mm) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	0.327 ± 0.00 ^{b}	16.30
	2) VANARAJA	0.324 ± 0.00 $^{a\ b}$	7.21
	3) KALINGA BROWN	0.320 ± 0.00 ^{a}	7.78
	4) BLACK ROCK	0.322 ± 0.00 $^{a\ b}$	7.41
AGE GROUP	I^{ST} (16 – 24 WEEK)	0.328 ± 0.00 ^{y}	14.81
	II^{ND} (24 – 32 WEEK)	0.314 ± 0.00 ^{x}	7.90
	III^{RD} (32 – 40 WEEK)	0.328 ± 0.00 ^{y}	5.57
OVER ALL MEAN		0.323 ± 0.00	10.47

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 10 (b):- Analysis of variance for egg shell thickness (mm) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	2.625E-03	2.388 ^{NS}
AGE GROUP	2	2.679E-02	24.366**
ERROR	1194	1.099E-03	
TOTAL	1200		

** Significant at (P<0.01)
^{NS} Nonsignificant

Table 11 (a):- Overall, Breed wise and Age group wise mean shape index (%) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	74.727 ± 0.23 ^{c}	5.37
	2) VANARAJA	74.897 ± 0.19 ^{c}	4.34
	3) KALINGA BROWN	73.243 ± 0.22 ^{b}	5.17
	4) BLACK ROCK	71.890 ± 0.25 ^{a}	5.90
AGE GROUP	I^{ST} (16 – 24 WEEK)	74.456 ± 0.19 ^{y}	5.02
	II^{ND} (24 – 32 WEEK)	74.224 ± 0.19 ^{y}	5.09
	III^{RD} (32 – 40 WEEK)	72.388 ± 0.21 ^{x}	5.84
OVER ALL MEAN		73.689 ± 0.12	5.46

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 11 (b):- Analysis of variance for shape index (%) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	596.996	42.889**
AGE GROUP	2	513.611	36.898**
ERROR	1194	13.920	
TOTAL	1200		

** Significant at (P<0.01)

Table 12 (a):- Overall, Breed wise and Age group wise mean albumen index (%) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	9.356 ± 0.15 ^{b}	28.21
	2) VANARAJA	8.352 ± 0.16 ^{a}	34.09
	3) KALINGA BROWN	9.192 ± 0.18 ^{b}	34.43
	4) BLACK ROCK	8.424 ± 0.15 ^{a}	31.71
AGE GROUP	I^{ST} (16 – 24 WEEK)	10.210 ± 0.14 ^{z}	27.42
	II^{ND} (24 – 32 WEEK)	8.543 ± 0.12 ^{y}	28.76
	III^{RD} (32 – 40 WEEK)	7.740 ± 0.14 ^{x}	35.83
OVER ALL MEAN		8.831 ± 0.08	32.49

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 12 (b):- Analysis of variance for albumen index (%) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	80.078	11.433**
AGE GROUP	2	635.227	90.693**
ERROR	1194	7.004	
TOTAL	1200		

** Significant at (P<0.01)

Table 13 (a):- Overall, Breed wise and Age group wise mean yolk index (%) along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	43.851 ± 0.23 [a]	9.06
	2) VANARAJA	44.764 ± 0.23 [b]	9.09
	3) KALINGA BROWN	44.650 ± 0.25 [b]	9.79
	4) BLACK ROCK	44.631 ± 0.25 [b]	9.67
AGE GROUP	I^{ST} (16 – 24 WEEK)	45.976 ± 0.21 [y]	9.31
	II^{ND} (24 – 32 WEEK)	45.799 ± 0.18 [y]	7.67
	III^{RD} (32 – 40 WEEK)	41.647 ± 0.16 [x]	7.68
OVER ALL MEAN		44.474 ± 0.12	9.43

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 13 (b):- Analysis of variance for yolk index (%) showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	52.732	3.899**
AGE GROUP	2	2401.301	177.562**
ERROR	1194	13.524	
TOTAL	1200		

** Significant at (P<0.01)

Table 14 (a):- Overall, Breed wise and Age group wise mean Haugh unit score along with standard error

GROUP		MEAN ± S. E.	C. V.
BREED/ VARIETIES	1) CARI SHYAMA	82.669 ± 0.67 ^{b}	14.06
	2) VANARAJA	78.612 ± 0.73 ^{a}	16.19
	3) KALINGA BROWN	82.436 ± 0.75 ^{b}	15.73
	4) BLACK ROCK	79.364 ± 0.76 ^{a}	16.65
AGE GROUP	I^{ST} (16 – 24 WEEK)	88.276 ± 0.49 ^{z}	11.05
	II^{ND} (24 – 32 WEEK)	81.029 ± 0.44 ^{y}	10.88
	III^{RD} (32 – 40 WEEK)	73.005 ± 0.71 ^{x}	19.34
OVER ALL MEAN		80.770 ± 0.37	15.80

Means superscripted by different letters differed significantly (P<0.05) from each other

Table 14 (b):- Analysis of variance for Haugh unit score showing effect of Breed and Age group

SOURCE OF VARIATION	Df	MEAN SQUARE	F- VALUE
BREED/ VARIETY	3	1301.573	10.744**
AGE GROUP	2	23341.553	192.675**
ERROR	1194	121.145	
TOTAL	1200		

** Significant at (P<0.01)

Table 15:- Correlation coefficient between egg weight and quality traits of backyard chicken egg

Egg quality traits	**Correlation (r)**
Albumen weight	0.938**
Yolk weight	0.738**
Shell weight	0.809**
Shape Index	-0.177**
Egg shell thickness	0.056^{NS}
Haugh unit	-0.362**

** Significant at (P<0.01)
^{NS} Nonsignificant

Fig. 1 Means comparison for egg weight (g)

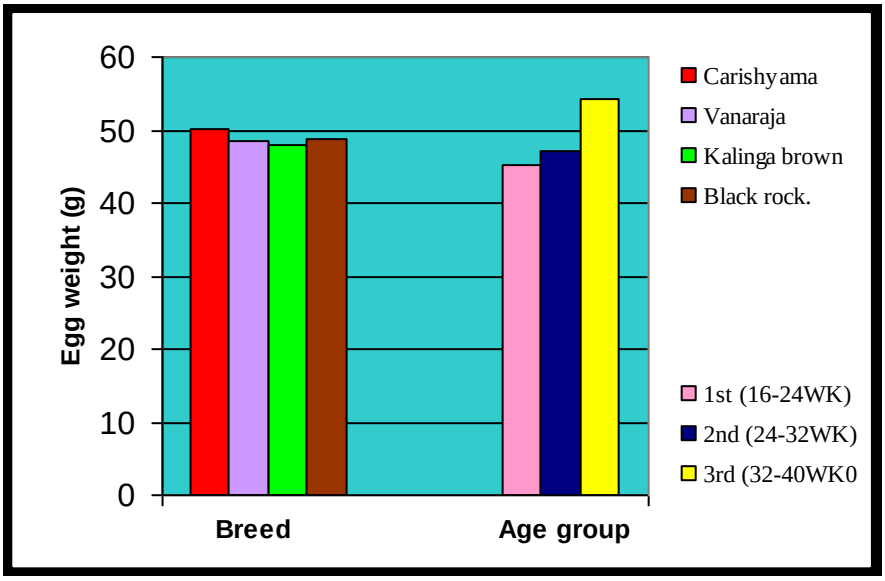

Fig. 2 Means comparison for albumen weight (g)

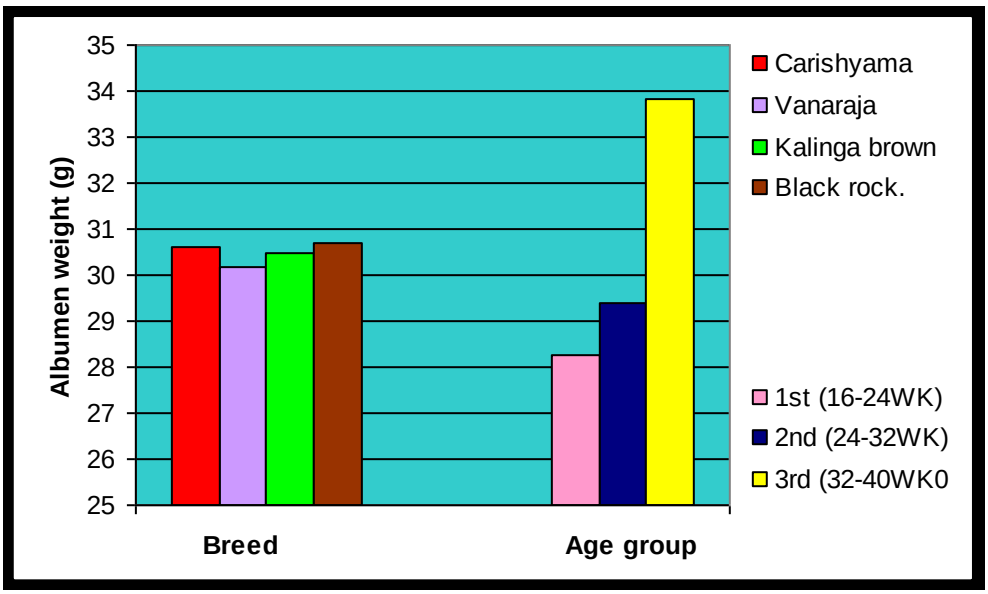

Fig. 3 Means comparison for albumen ratio (%)

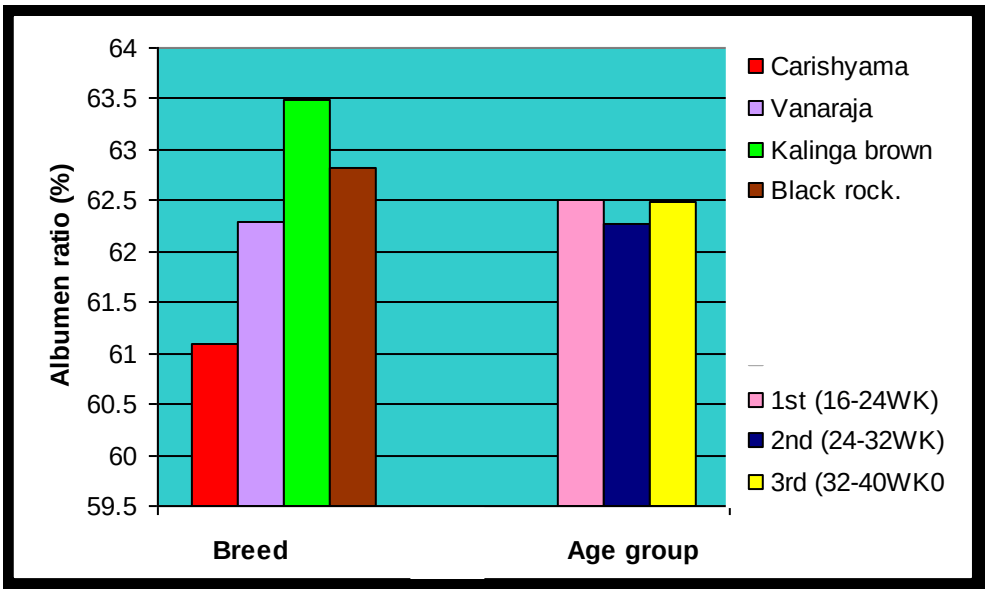

Fig. 4 Means comparison for yolk weight (g)

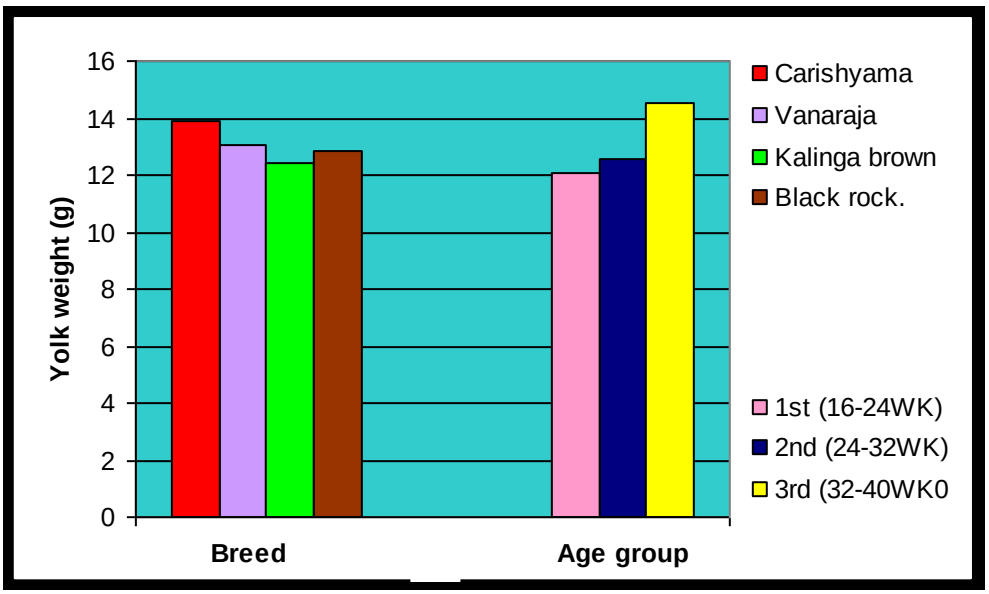

Fig. 5 Means comparison for yolk ratio (%)

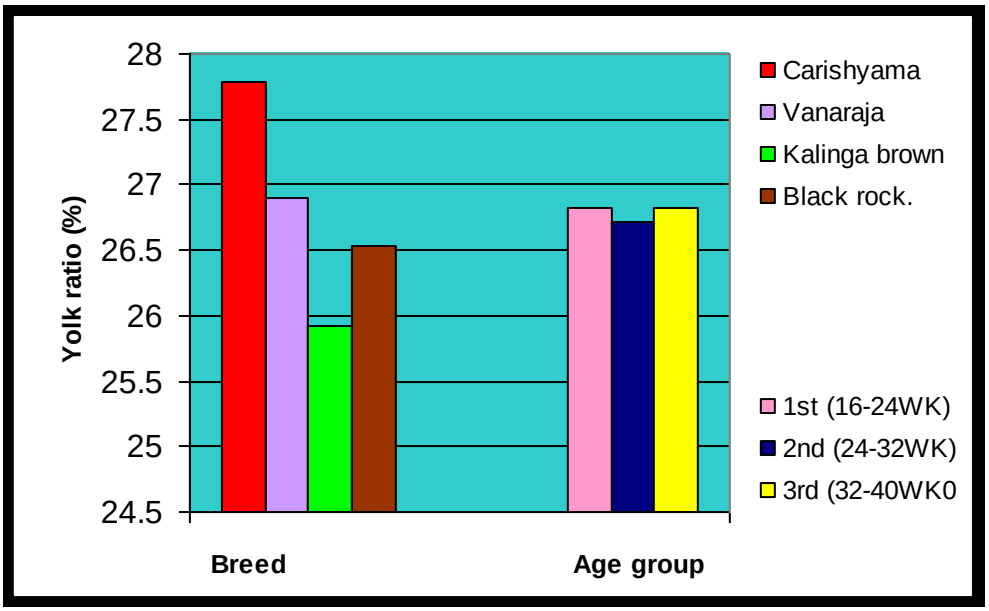

Fig. 6 Means comparison for egg shell weight (g)

Fig. 7 Means comparison for egg shell ratio (%)

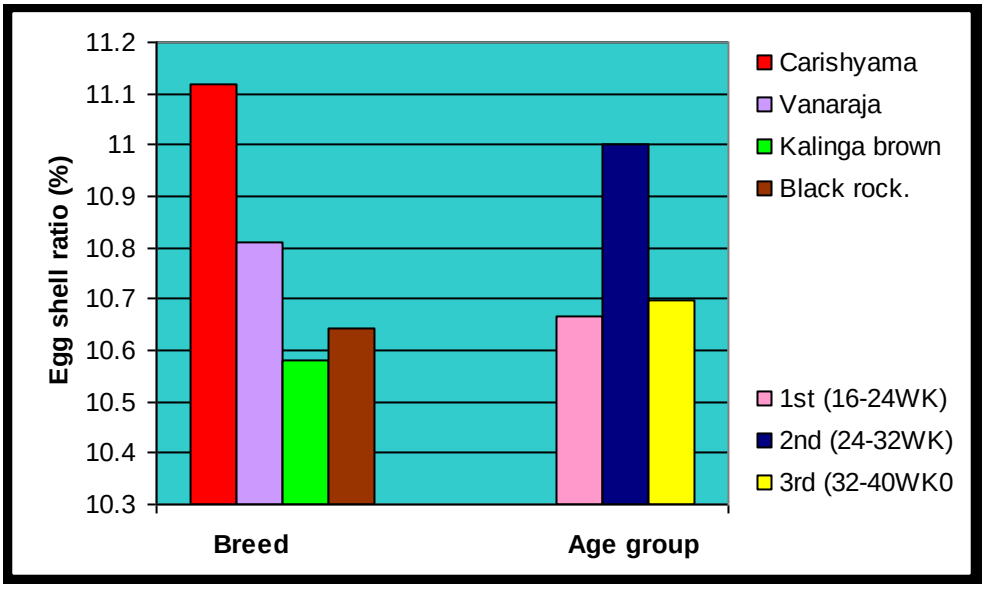

Fig. 8 Means comparison for egg shell thickness (mm)

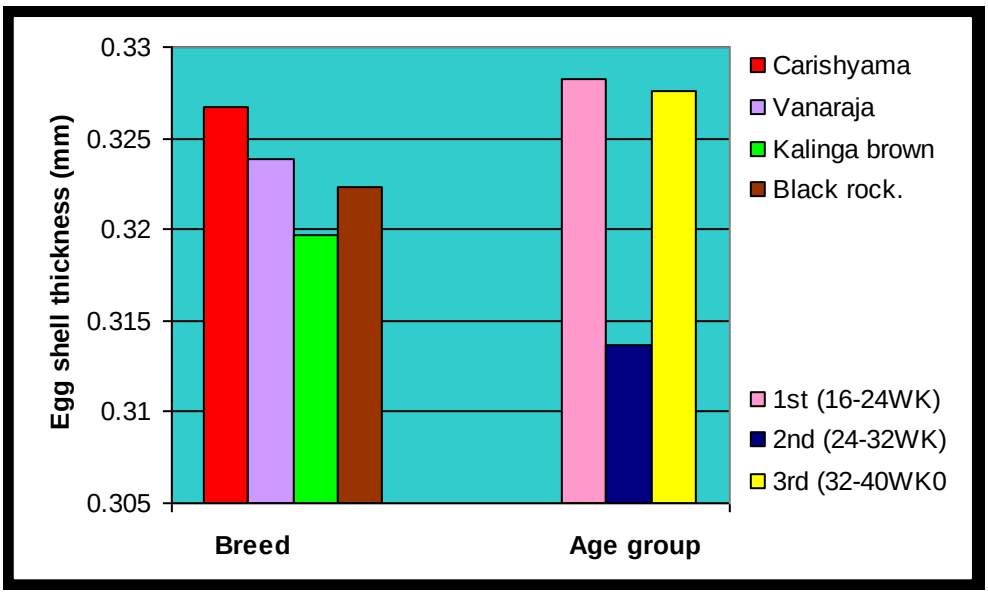

Fig. 9 Means comparison for shape index (%)

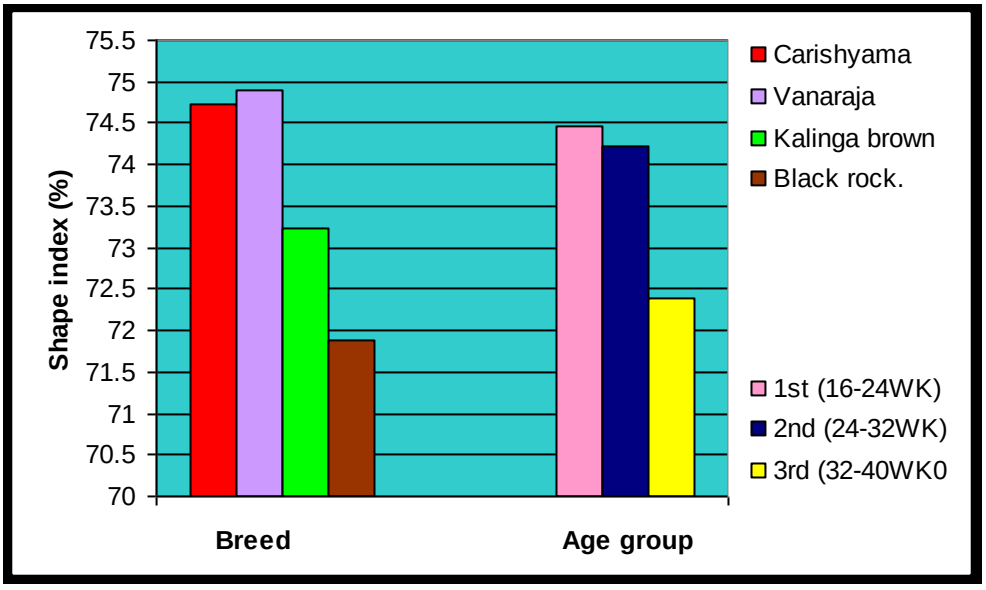

Fig. 10 Means comparison for albumen index (%)

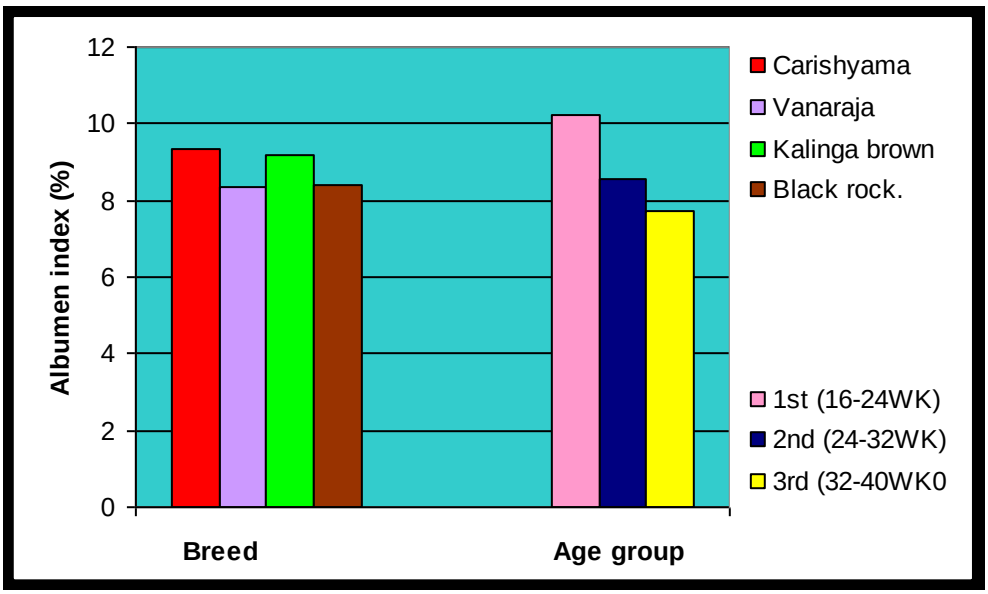

Fig. 11 Means comparison for yolk index (%)

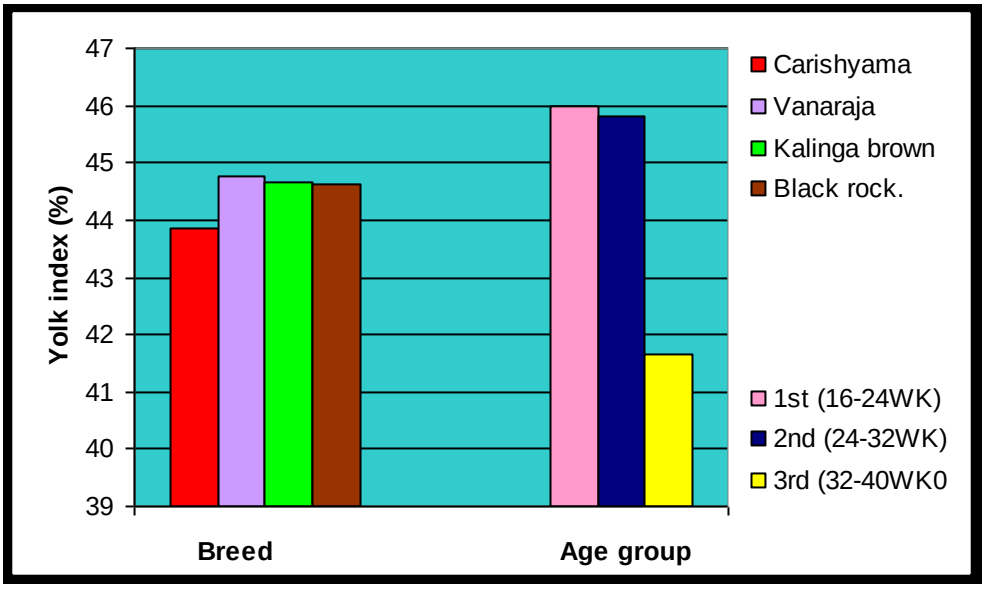

Fig. 12 Means comparison for Haugh unit score

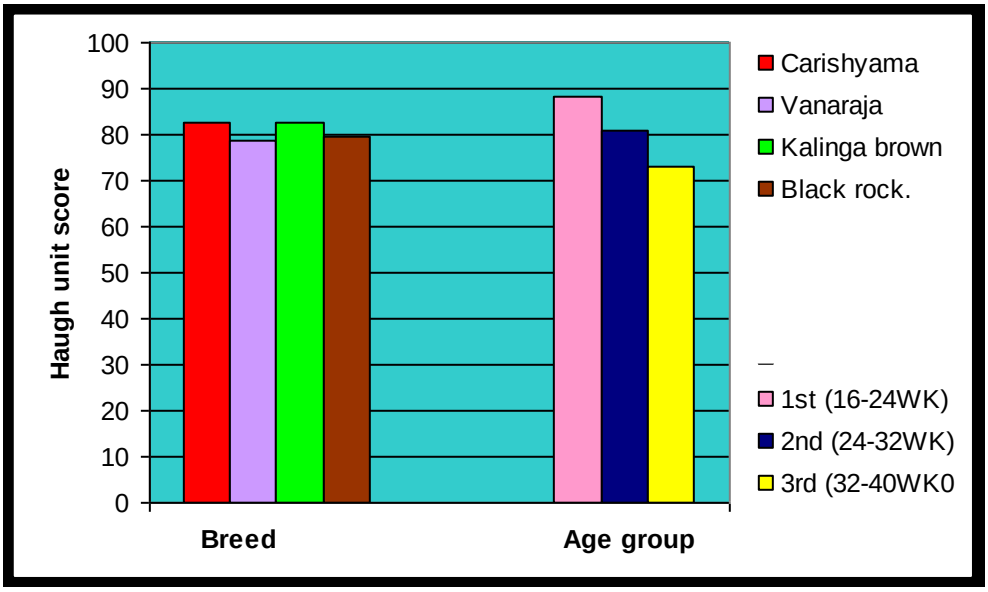

Fig. 1 Kalinga Brown female and male

Fig. 2 Black Rock male and female

Fig.3 Vanaraja male and female

Fig.4 CARI-Shyama male and female

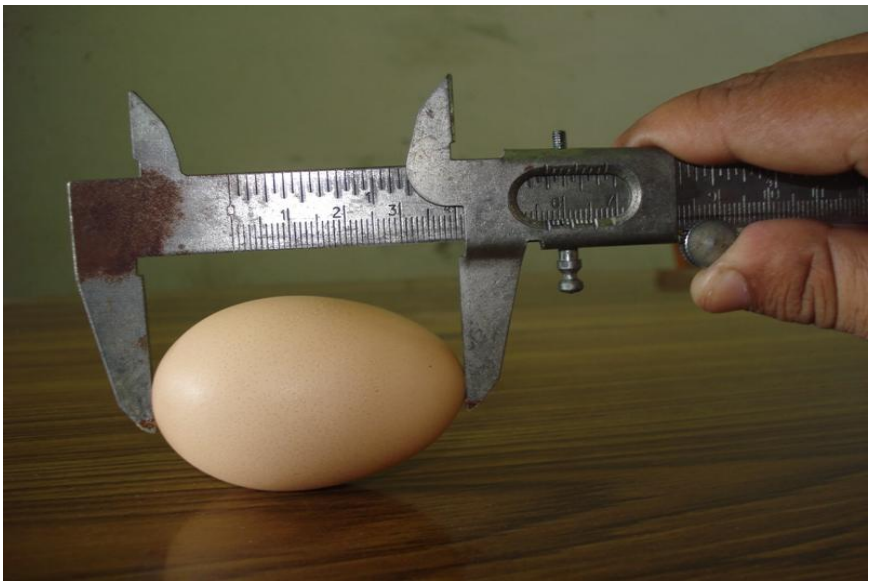

Fig. 5 Measurement of egg length for shape index

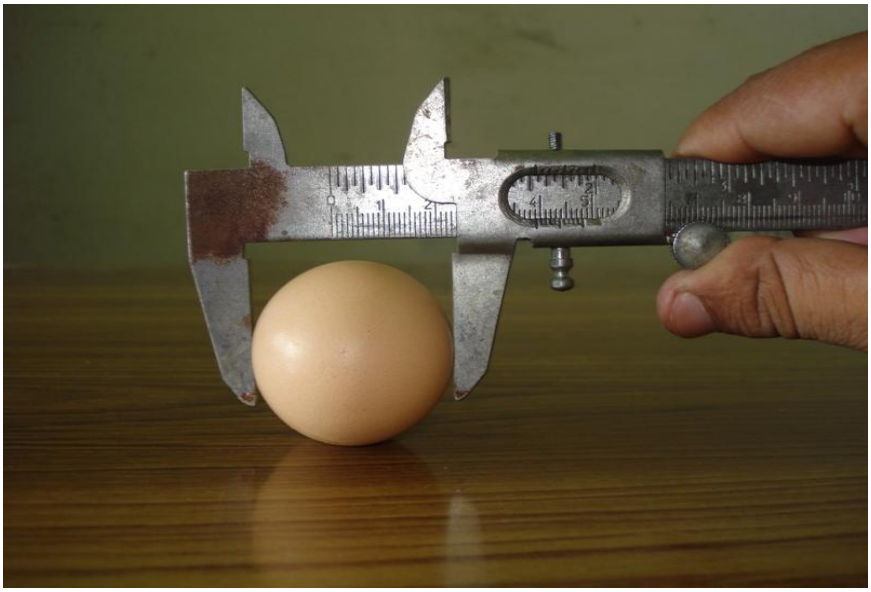

Fig. 6 Measurement of egg width for shape index

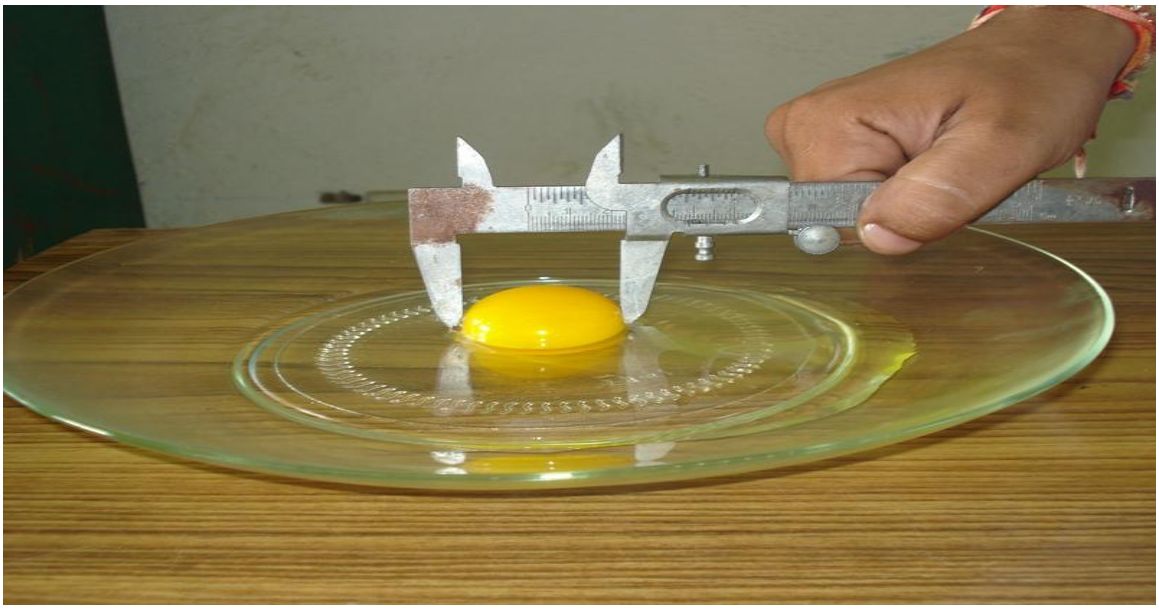

Fig. 7 Measurement of yolk diameter by Vernier Calipers

Fig. 8 Measurement of yolk height by spherometer

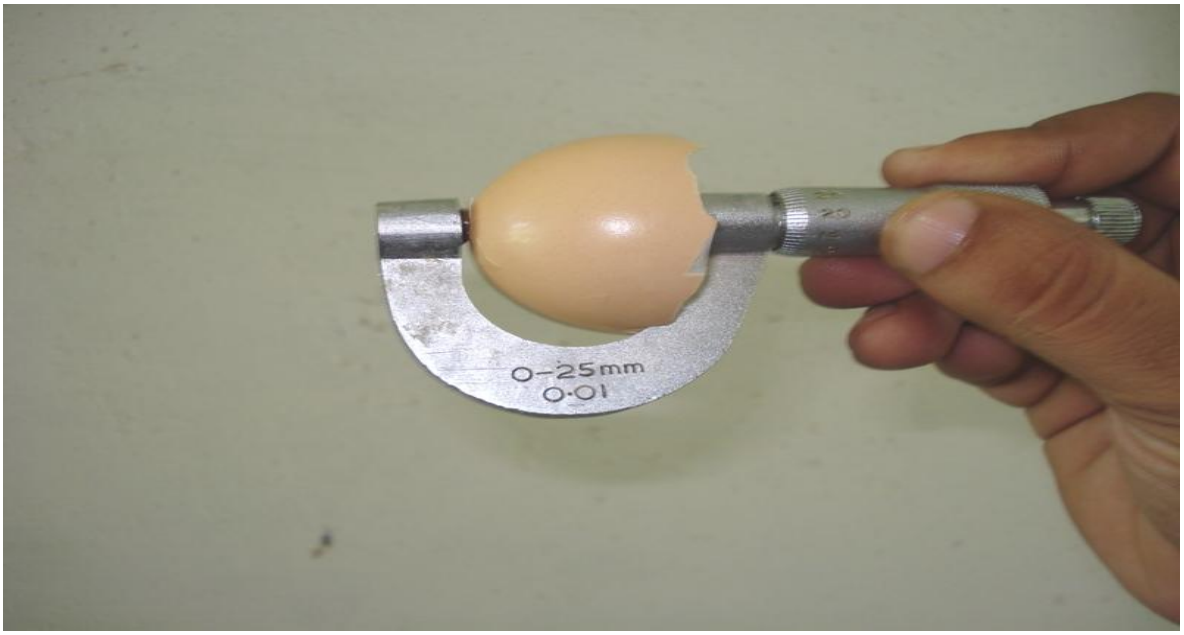

Fig.9 Measuring shell thickness by screw gauge

Fig. 10 Sampling of eggs from different varieties of chicken

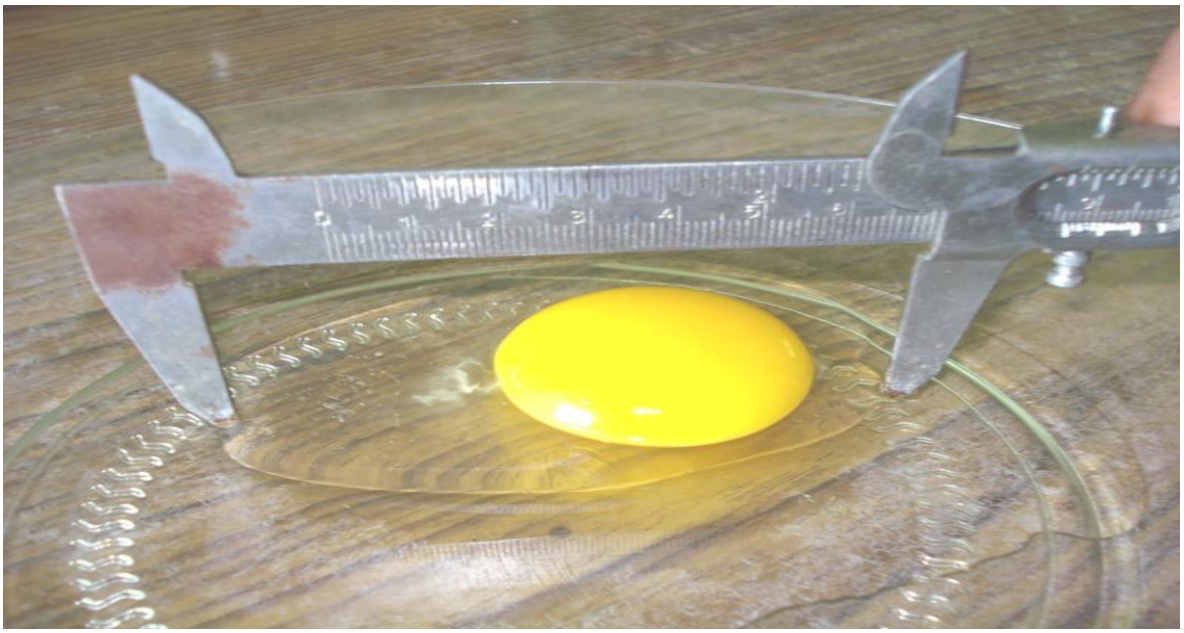

Fig. 11 Albumen length measuring by Vernier Calipers
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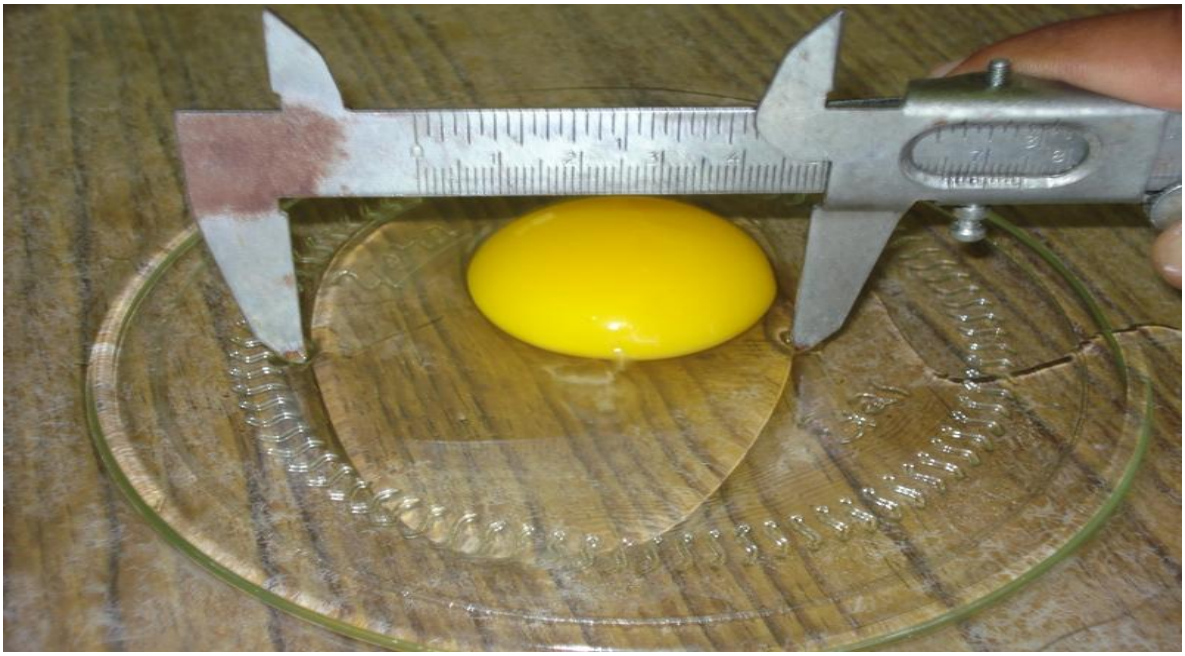

Fig. 12 Albumen width measuring by Vernier Calipers

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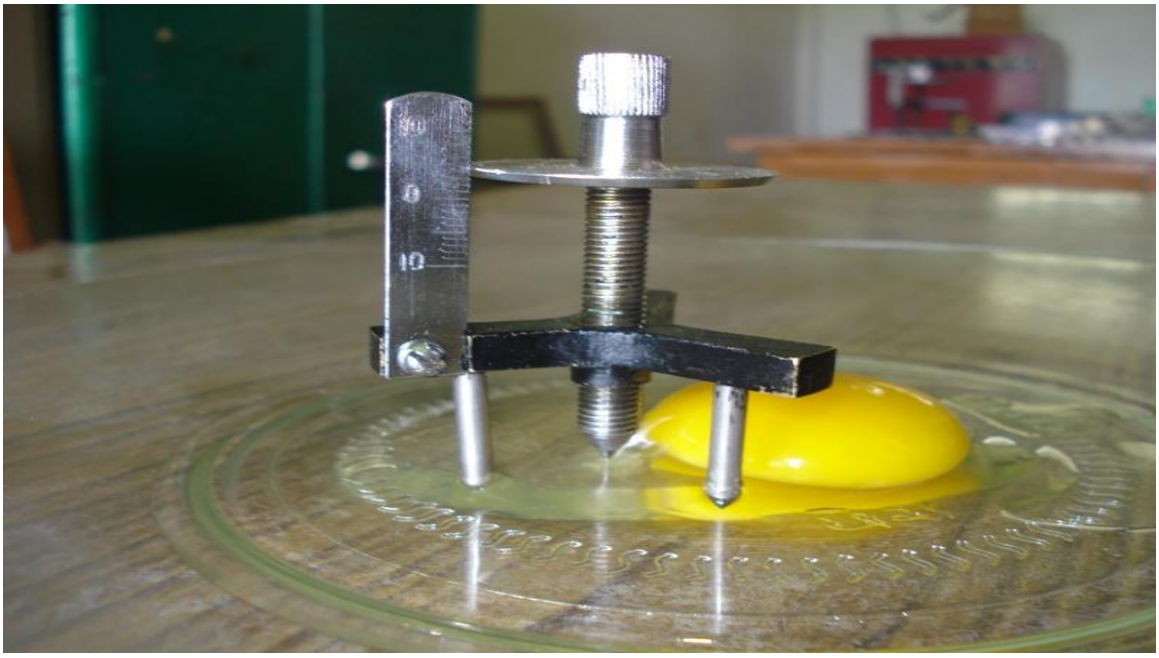

Fig. 13 Albumen height measuring by Spherometer

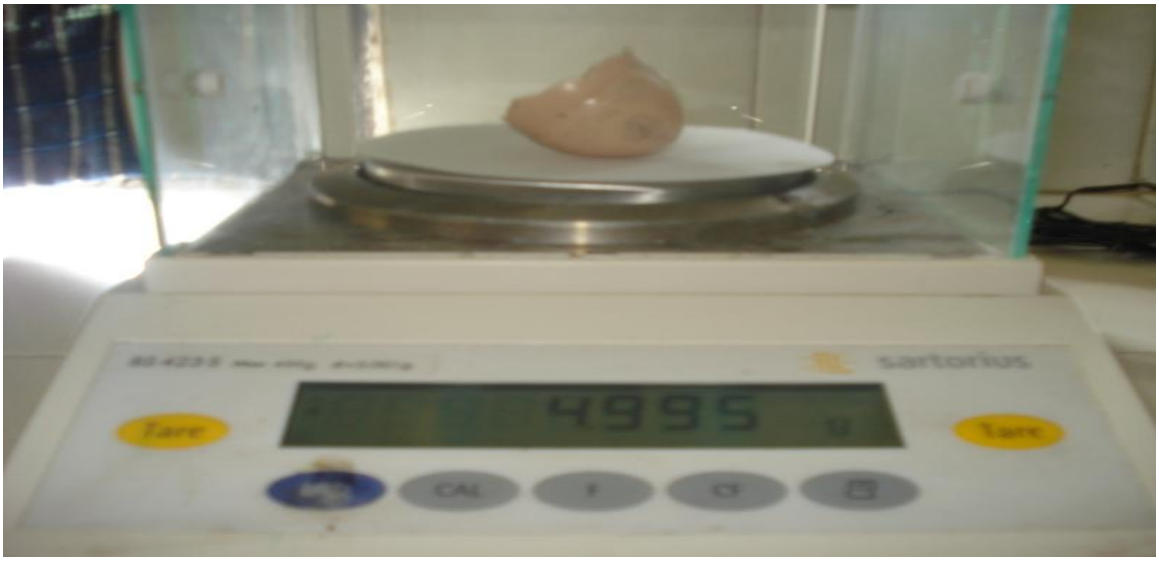

Fig. 14 Measuring of egg shell weight by electronic weighing balance

Fig. 15 Measuring of egg weight by electronic weighing balance

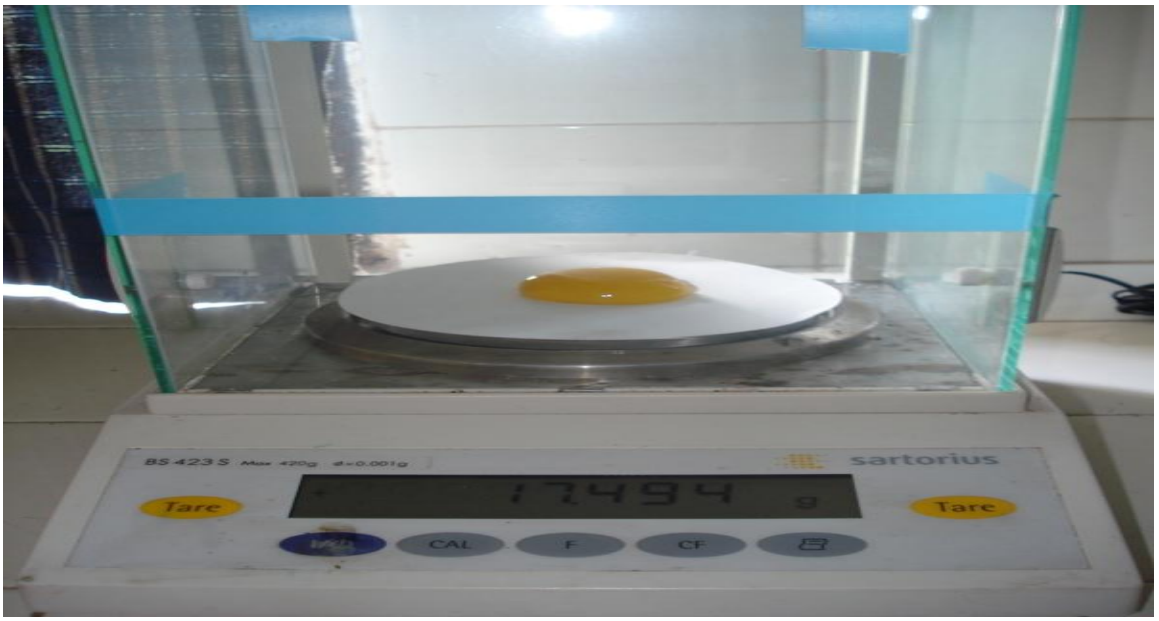

Fig. 16 Measuring of yolk weight by electronic weighing balance