

# EFFECT OF HATCH WINDOW UPON INTESTINAL DEVELOPMENT, CHICK QUALITY, POST HATCH PERFORMANCE ACCORDING TO ROSS-308 BROILER BREEDER AGE

Adnan Yousaf<sup>1✉</sup>, Nisar Rajput<sup>2</sup>, Aziz ullah Memon<sup>2</sup>, Giran Naz Jagirani<sup>3</sup>, Rehana Shahnawaz<sup>4</sup>, Sadaf Rajpar<sup>5</sup>, Memoona Sarwar<sup>5</sup> and Faiza Habib<sup>6</sup>

<sup>1</sup>Salman Poultry (Pvt) Limited, Rawalpindi, Pakistan

<sup>2</sup>Department of Poultry Husbandry, Sindh Agriculture University Tandojam, Pakistan

<sup>3</sup>Bahria University Medical and Dental Collage Karachi, Pakistan

<sup>4</sup>Department of Veterinary Pharmacology, Sindh Agriculture University Tandojam, Pakistan

<sup>5</sup>Faculty of Animals Husbandry and Veterinary Science, Sindh Agriculture University Tandojam, Pakistan

<sup>6</sup>Livestock and Dairy Development Department, Quetta, Pakistan

✉ Supporting Information

**ABSTRACT:** This study was carried out to find out the effects of breeder age on incubation results, intestinal development during hatch window, chick quality and first week broiler performance. A total of 259280 eggs were obtained from commercial Ross-308 broiler breeder flocks at 32 and 52 weeks old, which were equally divided on the basis of breeder age in two groups, group A (young 32 weeks) and group B (old 52 weeks age). These 32 and 52 weeks old flocks, 30% and 7.0% were hatched 24h before pull time and 50% and 60% were hatched 12h before pull time, respectively. Hatchability of fertile eggs and hatchability of total eggs were found higher in 32 weeks old flock than the other. The chick hatch weight was determined as 39.5g and 42.1g in 32 and 52 weeks old flocks, respectively. Chick weight/initial egg weight rate was found to be higher as 67.3% in the 32 weeks old flocks. On hatching day, chick length was also higher in 52 weeks old flock. Relative yolk-free chick weight was higher in 32 weeks old (86.0%) flock than the other (83.0%). Intestine weight rate was higher as 5.24% in chicks from 32 weeks old than the other (4.96%). At one week of age, the body weights and weight gains were 167.5g and 162.7g, and 128g and 120.6g in 32 and 52 weeks old flocks, respectively. Higher mortality ratio as 1.9% was observed in 52 weeks old flock. In conclusion, intestinal development during hatch window, incubation parameters, chick quality and first week broiler performance is affected by breeder age.

**Keywords:** Incubation duration, Intestinal development, Hatch window, Post-hatch performance, Ross-308 broiler breeder

## INTRODUCTION

Poultry is the second largest industry of Pakistan which plays a dynamic role in *Gross domestic product* GDP of country (Hussain et al., 2015). The value of chicken is further emphasized by its production ability and the increasing demand of its products (Anonymous, 2011).

The different phases, from rearing of grandparents stock till the broilers and eggs are marketed, have their own significance (Khan, 2011). Chick quality has great importance for broiler breeder producer who is paid based on number of saleable chicks and also broiler producer who wants high-quality, fast growing and uniform broilers (Yousaf et al., 2017). The chick quality is affected by some factors, such as breeder age, egg size, hatching time and incubation conditions (Jabbar and Yousaf, 2017). The operation and management of hatchery is vital towards the development of quality day old chicks. Various breeding practices and handling of eggs from egg laying to hatching of egg have an influence on the hatchability, particularly storage condition temperature, along with the age of breeding flock have been the most common variable used to manipulate the fertility, hatchability, livability and consequently effect on the quality of day old chick (Koka, 2002). The studies have declared that hatching egg quality and incubation conditions significantly influence the post-hatch performance of broilers (Almeida et al., 2006; Jabbar and Yousaf, 2017; Yousaf et al., 2017). The incubation period of chicken (*Gallus gallus*) embryo is approximately (506 hours) 21.08 days including drying down, and the gap among first to last chick hatch time is approximately 12 to 24 hours (Tong et al., 2013; Van de Ven et al., 2011). This time interval between first and last chick hatch is called

ORIGINAL ARTICLE  
 PII: S222877011900004-9  
 Received: Dec 26, 2018  
 Revised: Jan 18, 2019

“Hatch Window” (Romanini et al., 2013). In commercial hatcheries incubation times of chicken is approximately 504 hours (Almeida et al., 2006). The large scales of chicks pulling are extended up to 510 to 526 hours (Laughlin et al., 2007). Chicks that remained longer in the hatcher show worse live performance. The time period in hatcher after hatching is critical for the development of the gastrointestinal systems and nutrient absorption (Yalcin et al., 2013). Post hatching fasting impairs chick’s weight gain and breast muscles deposition capacity (Careghi et al., 2005; Halevy et al., 2000). During the first days of the chick’s life, the small intestine grows five times faster than the rest of the body, and small intestine microvilli grow significantly faster in birds supplied with water and feed immediately after hatching (Almeida et al., 2006). There is a correlation between chick qualities at hatch; broiler performance (Ipek and Sozcu, 2015).

The aim of the current study was to determine the effects of breeder age on incubation results, intestinal development during hatch window, chick quality parameters and first week broiler performance. So in this study, to evaluate the development of intestine, samples were taken during hatch window, in times of 24h and 12h before pull and at hatch time (0h).

## MATERIALS AND METHODS

### Ethical approval

This experiment was performed according to all ethics and animal rights (Sindh Agriculture University Tandojam, Pakistan).

### Experimental site

The study was carried out at Salman Poultry (Pvt) limited, Chakri hatchery Rawalpindi which is situated five km from Chakri interchange on motorway. The hatchery contains latest heating ventilation and air conditioning automation. This is the one of largest eggs capacity hatchery of south Asia, which is producing best quality of chicks through single stage incubation system (Avida G4, Chick Master USA).

### Selection and handling of eggs

Eggs (52-60g) from commercial broiler breeders group A (Ross-308, 32 weeks of age) and Group B eggs (60-64g, 52 weeks of age) with broiler breeder diet with 2750 kcal ME/kg and 14.50% Crude Protein (CP) was selected for current study. Both flocks were kept under the same management conditions according to the breeding company’s recommendations. Each experimental group was consisting of 134640 eggs, which were graded upon their quality, poor shell, elongated eggs, crack were isolated, only standard eggs were set in the incubator machine Advida4 chick master USA (Yousaf, 2016). These eggs were collected at farm at 20 °C and 75% relative humidity until used in hatching trial (Yousaf et al., 2017). Before, trial eggs were fumigated with 20g KMnO<sub>4</sub> and 40ml formalin (40%) and 40ml of water for 100ft<sup>3</sup> areas for 15 minutes through automatic fumigation process provided by Chick Master (Yousaf et al., 2017).

### Incubation regime

Both groups were pre-heated at 82°F for five hours inside incubators. After completion of pre-warming the setter started automatically the age wise incubation stage profile (recommended by Chicks Master USA). Incubation duration for both groups was remaining same 456h in setter and 50h in hatchers (Yousaf et al., 2017).

### Hatchery analyses

Before transfer to hatchers water loss of both groups was measured. Water loss was measure after 456 hours as given formula:

$$\text{Water Loss \%} = \frac{\text{Full tray weight at setting} - \text{Full tray weight at transfer}}{\text{Full tray weight at setting} - \text{Empty tray weight}} \times 100$$

Eggs from were transferred to hatchers after 456h of incubation in setter. For both groups during transfer from setter to hatchers candling was performed through candling tables. As hatch out immediately the chick’s weight and yield was measure through electrical weight balance by using following formula:

$$\text{Chick Yield \%} = \frac{\text{Weight of chicks} \times 100}{\text{Egg weight}}$$

Unhatched eggs were opened to macroscopically determine fertility and embryonic mortality (early, middle- and late-term embryonic mortality) (Table 1).

### Hatch window and intestine analysis

The hatched chicks in time of 482 h, 492h and 503-506 h were counted, and the rate of hatching chicks according to these times was calculated. In these times, after chicks were counted, chicks were transferred to another hatching basket. During hatch window, to determine development of intestine, chicks (n=20 chicks/sampling time/breeder. age) were randomly sampled in the sampling times [24h before pull time (-24 h), 12h before pull (-12 h) and at hatch (0h)]. In sampling times for -24h and also -12h before pull time, chicks were randomly sampled from hatcher. The sampled chicks were weighed and euthanized by cervical dislocation, and then the intestine was dissected. The intestine weight and length were measured, and the ratio of intestine weight to chick weight was calculated. The length of intestine was measured from the beginning of small intestine to the end of the cloaca.

### Hatch pulling

Hatch pulling was performed through conventional method of hatch pulling in Pakistan. First pull at 494h (456h in setters and 38h in hatchers). For second hatch pull the remaining pips and unhatched eggs were again shifted to hatcher for next 12h. After 12h again pulling of un-hatch eggs was performed to determine the effects of incubation results on intestinal development during hatch window. Grading of chicks was performed on conveyer, automatic grading table. Only stranded (shining eyes, soft legs and nose, healed naval and healthy chicks) were shifted to chick's box after counting, while under weight, weak, and unhealed naval chicks were removed as international standard.

### Analysis of residual yolk in chicks

Chicks from each group were measured for chick weight and chick length and then euthanized by cervical dislocation to determine residual yolk sac weight and yolk-free chick weight. Chick length was measured from the tip of the beak to the tip of the longest toe by placing the chick face down on a flat surface and straightening the left leg.

### Delivery to poultry house

Total n=56000 (group A; n=28000, group B; n=28000) day old chicks were send to Salman broiler farm Khilari-Chakri, Rawalpindi. Environmentally control vehicles (75 °F temperatures, 65% humidity) are used to deliver the chicks to control poultry house in the 102 chicks/box with dimensions of plastic chick's box (27×19.5×6.5 inches). Poultry house condition was remained same for both groups. At farm, chicks of both groups were offered water and feed diets (3020 Kcal ME/kg, 22% CP) ad libitum. The diet was formulated according to the recommendations of the NRC (1994) using windows user-friendly feed formulation (WUFFDA) software program. Intake of feed and water was record daily, while body weight and total feed consumed were recorded on weekly basis. After seven days chicks 'weights were measured for both group, mortality was recorded during the first week. For ventilation viper touch (Big Dutchman, Co., Germany) system was installed.

### Statistical analyses

All data were analyzed by using Statistical Analysis System package software (SAS version 9.2, SAS Institute Inc., Cary, NC, USA). All means were compared using Duncan's multiple range test and results were presented as mean± SEM (standard error of mean). Results were considered significant if exist (P<0.05).

## RESULTS AND DISCUSSION

The hatch window results of 32 and 52 weeks old broiler breeder flocks are presented in table 1. Hatch window was found that 30% and 7% of the chicks were hatched in the time of 482 h,

50% and 60% of the chicks between 492h, and 23% and 27% of the chicks between 504h to 506h in 32 and 52 weeks old broiler breeder flocks, respectively. Incubation period was completed in 504h in 32 weeks old breeder flock, whereas it was completed in 510h in 52 weeks old breeder flock. The effects of breeder age on incubation results and cloacal temperature are presented in table 2. The effects of breeder age on egg weight was found to be significant (P=0.001). Egg weight was 57.1 g and 63.7 g in 32 and 52 weeks old flocks, respectively. Fertility was similar in breeder age groups, whereas hatchability of fertile eggs and hatchability of total eggs were found to be higher in 32 weeks old flock than the other (P=0.001). Hatchability of fertile eggs and hatchability of total eggs were 90.1% and 87.67% in 32 and 52 weeks old flock, respectively. Early, middle and late-term embryo dead and cull chick rate were found to be higher in 52 weeks old flock (P=0.001). The cull chick rate was 0.81% and 1.7% in 32 and 52 weeks old flocks, respectively. Water loss was found higher with a rate of 13.1% in 52 weeks old flock than the other (P=0.001). Chick hatch weight was 39.5g and 42.1g in 32 and 52 weeks old flocks, respectively (P=0.015). Chick weight/initial egg weight rate was found to be higher with a value of 68.3% in the 32 weeks old flock (P=0.035). The cloacal temperature was found to be similar between flocks (P=0.058).

The effects of breeder age on the development of intestine development during hatch window are presented in table 3. The intestine weight rate was only found to be significant in breeder age groups. It was higher with a value of 5.24% in chicks from 32 weeks old flock than the other (4.96%; P=0.046).

During the hatch window, the chick weight, the weight and length of intestine and the intestine weight ratio were similar in sampling times. The effects of breeder age on the chick weight, chick length, residual yolk sac weight, relative residual yolk sac weight, yolk-free chick weight and relative yolk-free chick weight are presented in table 4. On hatching day, chick weight and length were found as 39.5g and 42.1g, and 18.5cm and 19.4cm in 32 and 52 weeks old flocks, respectively. Higher residual yolk sac weight and relative residual yolk sac weight were observed in 52 weeks old flock with a value of 7.1g and 18.2%. Although yolk-free chick weight was similar between flocks, relative yolk-free chick weight was higher in 32 weeks old flock (86.0%) than the other (83.0%).

The effects of breeder age on the post-hatch first week broiler performance parameters are presented in table 5. The initial body weight on day one was higher in the 52 weeks old flock (42.1g) than the 32 weeks old flock (39.5g). At one week of age, the body weights and body weight gains were determined as 167.5g and 162.7g, and 128g and 120.6g in 32 and 52 weeks old flocks, respectively. Feed consumption and feed conversion rate were similar between treatments for the first week. Higher mortality ratio as 1.9% was observed in 52 weeks old flock.

**Table 1 - Hatch window results of flocks at different ages**

Groups	Chicks hatch out after incubation duration (%)		
	After 482h	After 492h	After 506h
A (32 weeks)	30%	50%	23%
B (52 weeks)	7%	60%	27%

**Table 2 - The effects of breeder age on incubation results**

Incubation results	32 week	52 week	P Value
Egg weight (g)	57.1 ± 1.4	63.7 ± 1.5	0.001
Fertility (%)	95.2 ± 0.8	96.0 ± 0.9	0.001
Hatchability of fertile eggs (%)	90.1 ± 2.5	87.67 ± 2.1	0.001
Hatchability of total eggs (%)	88.3 ± 1.3	84.2 ± 2.2	0.001
Early term embryo dead (%)	2.2 ± 0.5	4.0 ± 1.4	0.001
Middle-term embryo dead (%)	0.88 ± 0.4	1.7 ± 0.4	0.001
Late-term embryo dead (%)	4.2 ± 1.4	6.6 ± 1.5	0.001
Cull chicks (%)	0.81 ± 0.3	1.7 ± 0.2	0.001
Water loss (%)	11.2 ± 1.1	13.1 ± 1.2	0.001
Chick hatch weight (g)	39.5 ± 1.2	42.1 ± 1.0	0.015
Chick weight/initial egg weight (%)	67.3 ± 1.2	65.2 ± 1.4	0.035
Total incubation period (h)	504	510	–
Cloacal temperature (°C)	38.8 ± 1.7	39.0 ± 1.5	0.058

**Table 3 - The effects of breeder age on intestinal development during hatch window**

Breeder age (weeks)	Chick weight (g)	Intestine weight (g)	Intestine weight rate (%)	Intestine length (cm)
32	39.5	2.07	5.24	39.9
52	42.1	2.09	4.96	41.2
<b>Sampling time (h) before hatch</b>				
-24	40.8	2.14	5.24	41.3
-12	40.6	2.07	5.09	41.1
0	40.1	2.06	5.13	41.00
<b>Age (weeks)×Time (h)</b>				
32 × -24	39.7	2.11	5.31	40.7
32 × -12	39.4	2.08	5.27	40.5
32 × 0	39.2	2.07	5.28	41.00
52 × -24	42.3	2.13	5.03	41.6
52 × -12	39.9	2.11	5.28	41.4
52 × 0	40.00	2.12	5.3	41.5

**Table 4 – Effect of breeder age upon yolk in Ross-308 chick**

Characteristics	32 week	52 week
Chick weight (g)	39.5±0.56	42.1±0.52
Chick length (cm)	18.5±0.3	19.4±0.3
Residual yolk sac weight (g)	5.7±1.15	7.1±1.75
Relative residual yolk sac weight (%)	15.3±2.5	18.2±2.1
Yolk-free chick weight (g)	32.5±1.5	33.3±1.7
Relative yolk-free chick weight (%)	86±0.5	83±0.5

**Table 5 - Post hatch performance parameters of first week Ross-308 broiler breeder ages**

Parameters	32 week	52 week
Initial weight, g/bird	39.5± 0.2	42.1± 0.2
Body weight, g/bird	167.5± 1.2	162.7± 1.2
Body weight gain, g/bird	128± 2.2	120.6± 2.5
Feed consumption, g/bird	116 ± 3.2	118± 3.5
Feed conversion ratio	0.95 ± 0.5	1.05 ± 0.5
Mortality %	0.85	1.9

This study has investigated the effects of breeder age on incubation results, intestinal development during hatch window, chick quality parameters and first week broiler performance. In 52 weeks old flock, the actual hatching rate at 12h and 24h of pull time was lower than expected, so it caused longer time range between the first and last hatched chicks. In other studies, hatch window range was found as 24–48h (Decuyper et al., 2001), 28h (Careghi et al., 2005) and 30h (Van De Ven et al., 2011). Similarly, it was observed that eggs laid by 32weekoldbreeders hatched 9h early than those laid by 52weekoldbreeders (Pedroso et al., 2005). In this study, egg weight was 57.1g and 63.7g in 32and 52 weeks flocks, respectively. The time required for hatching increased in heavy eggs as compared to lighter eggs of older age breeders.

In this study, the hatchability of fertile eggs and hatchability of total eggs of old breeders' eggs were lower than those of young breeders, which were found significantly different. In this study, higher ratio of embryo mortalities was observed in older flock. Rate of cull chicks (%) was found to be higher as 1.7% in 52 weeks old group. The reason of higher rate of cull chicks in 52 weeks old group could be attributed to longer hatch window. The average egg weight loss should be between 11.5% and 13% to obtain the highest hatchability of chicken eggs. Weight loss was higher as 13.1% in 52 weeks old flock. Chick hatch weight and chick weight/initial egg weight rate were found to be significant. Chick hatching weight was found higher in 52 weeks old flock, and chick weight/initial egg weight rate was affected by breeder age. Embryo uses the nutrients from the yolk sac to initiate body growth (Meijerhof, 2009), for development of the small intestine and other organs. Residual yolk sac comprises approximately 14% of the chick's body weight at the time of hatching (Meijerhof, 2009). Before hatching, absorption of the yolk sac into the abdomen of the embryo provides nutrients for the chicks during the first few days of life. Chick weight is a combination of the real chick weight and the remaining yolk residual. On the hatching day, the residual yolk sac weight and relative residual yolk sac weight were found higher as 7.1g and 18.2% in old flock, respectively. After subtracting yolk sac weight from chick weight, there were no differences between groups. Relative yolk-free chick weight was found to be higher in young flock. The quality of the day old chick is important for a good start of the chick and also for the final performance of broiler (Meijerhof, 2009). Breeder age, egg weight, egg age, climatic conditions of both hatchery spaces and incubators, and some other factors predominantly affect hatch window and therefore chick quality (Vargas et al., 2009). On hatching day, chick weight and length were found as 39.5g and 42.1g, and 18.5cm and 19.4cm in 32 and 52 weeks old groups, respectively. In this study, heavier and longer chicks in old flock were resulted from heavier egg weight. It was stated that chick length has a substantially higher positive correlation with broiler performance than day old chick weight, especially when corrected for egg size (Meijerhof, 2009). Initial body weight was lower in young flock, after a week post-hatch, body weight and body weight gain were found higher than old flock. It could be explained by yolk sac absorption, and development of intestine of the chicks in this group was higher than the other. Intestine weight was heavier in chicks from young than from old flock in this study. Feed consumption and feed conversion rate were not influenced by breeder age. The mortality during first week was found significantly higher as 1.9% in 52weeks old flock. The time range after hatching is vital for the development of immune and gastrointestinal systems. While early term chick feeding stimulated the development of bursa and production of lymphocytes (Bigot et al., 2001), long fasting times stimulate corticosterone production that has a

strong inhibitor effect on immune cells. These cause a decrease in growth rate and an increase in early term chick mortalities (Decuypere et al., 2001).

## CONCLUSION

Intestinal development during hatch window, incubation parameters, chick quality and first week broiler performance is affected by breeder age. It is recommended that the older flock eggs chicks had better development of intestine as compared to younger flock age eggs. The health status of younger broiler breeder eggs broiler perform very best in overall conditions.

## DECLARATIONS

### Corresponding author

E-mail: dr.adnan011@gmail.com

### Consent to publish

The author(s) grant(s) the publisher the sole and exclusive license of the full copyright in the contribution. Consequently, the publisher shall have the exclusive right throughout the world to publish and sell the contribution in all languages, in whole or in part, including, without limitation, any abridgement and substantial part thereof, in book form and in any other form including, without limitation, mechanical, digital, electronic and visual reproduction, electronic storage and retrieval systems, including internet and intranet delivery and all other forms of electronic publication now known or here in after invented.

### Competing interests

The authors have declared that no competing interest exists.

### Author's contribution

Dr. A.Yousaf was the main researcher, Dr. N.Rajput was research coordinator, Dr. A.Memon was research supervisor, Dr. R.Shahnawaz revised the article, Dr. G.NazJagirani and Dr. F.Habib contributions in statistics while Dr. S.Rajpar and Dr. M.Sarwar assisted in results analysis and other activities related to the research.

## REFERENCES

- Almeida JG, Vieira SL, Gallo BB, Conde ORA and Olmos AR (2006). Period of Incubation and Posthatching Holding Time Influence on Broiler Performance. *Brazilian Journal of Poultry Science*. 8 (3): 153-158.
- Anonymous (2011). Food and Agriculture Organization of the United Nations. FAOSTAT.
- Bigot K, Tesseraud S and Taouis M (2001). The relation of eggweight to chick weight at hatching. *Prod Anim*. Volum14 Page 219-230.
- Careghi C, Tona K, Onagbesan O, Buyse J, Decuypere E and Bruggeman V (2005). The effects of the spread of hatch and interaction with delayed feed access after hatch on broiler performance until seven days of age. *Poultry Science*. 84:1314-1320.
- Decuypere E, Tona K, Bruggeman V, Bamelis E (2001). The day-old chick: a crucial hinge between breeders and broilers. *World's Poultry Science Journal*, 57:127-138.
- Halevy O, Geyra A, Barak M, Uni Z and Sklan D (2000). Early posthatch starvation decreases Satellite cell proliferation and skeletal muscle growth in chicks. *Journal of nutrition*. 82:858-864.
- Hussain J, Rabbani I, Aslam S and Ahmad HA (2015). An overview of poultry industry in Pakistan. *World Poultry Science Journal*. 71(4): 689-700.
- Ipek A and Sozcu A (2015). The effects of broiler breeder age on intestinal development during hatch window, chick quality and first week broiler performance, *Journal of Applied Animal Research*, 43:4, 402-408.
- Jabbar A and Yousaf A (2017). Effect of age wise incubation programme on broiler breeder hatchability and post hatch performance. *Online Journal of Animal Feed Research* 7(1): 13-17.
- Khan MJ (2011) Effect of storage, preheating, and turning during storage on Hatchability, 1<sup>st</sup> Edition. VDM Verlag Dr. Muller GmbH and Co. Germany
- Koka TD (2002) Effect of storage and pre heating during storage on hatchability, *Poultry Science*, 12(8), 21-23
- Meijerhof R (2009). The influence of incubation on chick quality and broiler performance. In: Proceedings of 20<sup>th</sup> Annual Australian Poultry Science Symposium, 2009 Feb9-11; Sidney (Australia); Poultry Research Foundation Faculty of Veterinary Science, University of Sydney.
- Pedroso AA, Stringhini JH, Leandro NSM, Xavier AS, Lima FG, Barbosa CE (2005). Desempenho e biometria de órgãos digestórios de frangos provenientes de matrizes jovens após Post hatching Holding Time Influence on Broiler Performance. *Brazilian Journal of Poultry Science*. 8 (3): 153-158.

- Romanini CEB, Exadaktylos V, Tong Q, McGonnel I, Demmers TGM, Bergoug H, Eterradossi N, Roulston N, GarainP, Bahr C, Berckmans D (2013). Monitoring the hatch time of individual chicken embryos. *Poultry Science*, 92:303–309.
- Tong Q, Romanini C, Exadaktylos V (2013) Embryonic development and the physiological factors that coordinate hatching in domestic chickens. *Poultry Science*, 92: 620–628.
- Van de Ven LJF, Wagenberg a V, Debonne M, Decuypere E, Kemp B, et al. (2011) Hatching system and time effects on broiler physiology and posthatch growth. *Poultry Science*, 90: 1267–1275
- Vargas FSC, Baratto TR, Magalhaes FR, Maiorka A, Santin E (2009). Influences of breeder age and fasting after hatching on the performance of broilers. *Journal of Applied Poultry Research*18:18–24.
- Yalcin S, Izzetoglu GT, Aktas A (2013). Effects of breeder age and egg weight on morphological changes in the small intestine of chicks during the hatch window. *Poultry Science*, 54:810–817.
- Yousaf A, Jabbar A, Ditta YA (2017). Effect of pre-warming on broiler breeder eggs hatchability and post-hatch performance. *J Animal Health Production* 5(1): 1-4.
- Yousaf A (2016). Impact of gender determination through vent sexing on Cobb-500 broiler performance and carcass yield. *Online Journal of Animal Feed Research*, 6(6): 125-129.