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## A STUDY ON THE PATHOGENESIS OF YOLK RETENTION IN BROILER CHICKS

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### ABSTRACT

The present project was designed to identify the factors responsible for yolk retention in broiler chicks. Four different experiments were conducted to find out the effect of four factors (experimental yolk sac infection with *Escherichia coli*, off-feed period between hatching and housing, first feeding time in the poultry house and type of initial feed) on yolk absorption. Results of these experiments showed that yolk sac infection with *E. coli* led to decrease in rate of yolk absorption. Moisture and protein percentage was increased in infected yolk but fat percentage was not affected by yolk sac infection. On the other hand, post hatch starvation due to delay in housing and delay in first feeding did not affect rate of yolk absorption. Moisture percentage was not affected while fat absorption increased and protein absorption decreased due to fasting. It was also observed that feeding ground corn in early life of chick led to slow absorption of yolk contents as compared to feeding commercial starter ration and 2% sugar solution. Yolk composition was not affected by feeding commercial starter ration, ground corn and 2% sugar solution in early life of chick. It is concluded that experimental infection with *E. coli* and ground corn as initial feed leads to slow absorption of yolk sac in young broiler chicks.

**Key words:** Yolk retention, yolk absorption, yolk sac infection, starvation, initial feed, broiler chicks

### INTRODUCTION

The rate of weight gain by broilers has substantially increased during the last few decades. Consequently, slaughter age has decreased such that the final carcass weight, attained at 12 weeks of age in the early 1960s, now occurs by 6 weeks. This trend is continuing and emphasizes the importance of early life of broilers. This is very crucial period, as losses in first 2 weeks of life account for 30-50% of total mortality. Major problems during this period are omphalitis, brooder pneumonia, avian encephalomyelitis, spiking mortality, dehydration, ammonia burns and pullorum disease (Charlton, 1996). Omphalitis is the inflammation of navel and yolk sac and it is the commonest cause of early chick mortality in Pakistan (Anjum, 1997).

When the chick emerges from its shell, yolk not utilized during incubation is present in yolk sac as an extension of small intestine. This residual yolk is absorbed during first week of life. Sometimes its retention occurs due to certain factors. Presence of fat and water in yolk favor the bacterial growth which may lead to yolk sac infection (Anonymous, 2000).

Present project was designed to identify the factors responsible for yolk retention in broiler chicks. This study will hopefully help to understand the pathogenesis of yolk retention, which will contribute to control early chick mortality in broiler flocks.

### MATERIALS AND METHODS

Four experiments with variable treatments were conducted but in all experiments, the same experimental parameters were studied.

#### Experiment No. 1

Effect of experimental yolk sac infection by *Escherichia coli* on yolk absorption was studied.

#### Preparation of inoculum (*Escherichia coli*)

The isolation of a pathogenic strain of *E. coli* was done from the diseased bird. The isolated organisms were identified on the basis of their cultural, morphological and staining characteristics, sugar fermentation and biochemical reactions, as described by Buxton and Fraser (1977), Rehman *et al.* (1996) and Jalil and Das (2001). Pathogenicity was ascertained by the method described by Lee and Arp (1998). Viable count of the isolate was determined by plate count method (Collins *et al.*, 1995).

#### Experimental design

Forty five, day-old broiler chicks were procured from local hatchery and 5 chicks were slaughtered to find out initial yolk sac weight on day-1 (before the start of experiment). Remaining chicks were distributed into two groups A and B having 20 chicks each. Chicks in group A received no bacteria (control) and 0.1 ml of sterile broth was injected per bird into yolk sac of these chicks on day-



1 of the experiment. Chicks of group B received *E. coli* broth inoculations (0.1 ml of the broth per bird containing  $10^4$  c.f.u/ml) into the yolk sac (treatment) on day-1 of the experiment (Kloryga, 1986).

#### Experiment No. 2

Effect of off-feed period between hatching and housing on yolk absorption was studied.

#### Experimental design

Fifty, day-old broiler chicks were procured from local hatchery and 5 chicks were slaughtered to find out initial yolk sac weight on day-1 (before the start of the experiment). Remaining chicks were distributed into 3 groups A, B and C, having 15 chicks each.

Chicks in group A were housed 24 hours after hatching, so that off-feed period was 24 hours.

Chicks in group B were housed 48 hours after hatching, so that off-feed period was 48 hours.

Chicks in group C were housed 72 hours after hatching, so that off-feed period was 72 hours.

#### Experiment No. 3

Effect of first feeding time in the poultry house on yolk absorption was studied.

#### Experimental design

Fifty, day-old broiler chicks were procured from local hatchery and 5 chicks were slaughtered to find out initial yolk sac weight on day-1 (before the start of the experiment). Remaining chicks were distributed into 3 groups A, B and C, having 15 chicks each.

Chicks in group A were offered feed and water immediately after arrival in shed.

Chicks in group B were offered water immediately after arrival in shed while feeding was delayed for 24 hours.

Chicks in group C were offered water immediately after arrival in shed while feeding was delayed for 48 hours.

#### Experiment No. 4

Effect of type of initial feed on yolk absorption was studied.

#### Experimental design

Fifty, day-old broiler chicks were procured from local hatchery and 5 chicks were slaughtered to find out initial yolk sac weight on day-1 (before the start of the experiment). Remaining chicks were distributed into 3 groups A, B and C, having 15 chicks each.

Chicks in group A were fed with the commercial starter ration immediately after their arrival in the shed.

Chicks in group B were fed ground corn for first 24

hours followed by commercial starter ration.

Chicks in group C were offered with 2% sugar solution for first 24 hours followed by commercial starter ration.

#### Sampling days

Five chicks from each group were sampled after slaughtering on day-3, 5 and 7 of each experiment.

#### Experimental parameters

**Body weight:** each bird was weighed before slaughtering.

**Yolk weight:** the unabsorbed yolk was removed and weighed.

**Yolk sac/body weight ratio:** yolk sac/body weight ratio was calculated by following formula:

$$\text{yolk sac/body weight ratio} = \frac{\text{Yolk sac weight}}{\text{Body weight}} \times 100$$

**Estimated yolk absorption:** Estimated yolk absorption was calculated by the following formula (Bierer and Eleazer, 1965):

$$\text{Estimated yolk absorption} = \frac{\text{Mean yolk sac weight on day-1} - \text{Yolk sac weight on sampling day}}{\text{Mean yolk sac weight on day-1}} \times 100$$

**Analysis of yolk:** Different yolk contents (moisture, fat and protein) of each group were determined. Moisture was determined by drying the sample in oven (Brammel, 1984), fat by acid hydrolysis method and protein by Kjeldahl's method (Vogel, 1961).

#### Statistical analysis

Data thus collected were analyzed statistically by applying unpaired T-test and one-way analysis of variance (ANOVA) and least significant difference (LSD) test was used for means comparison of significant effects (Steel and Torrie, 1982).

## RESULTS AND DISCUSSION

The birds of group B infected with *E. coli* in experiment No. 1 showed the following type of symptoms: drowsiness, depression, off-feed and distended abdomen. Out of these birds, one died on day-4, two died on day-5 and one died on day-6 of the experiment. When yolks were removed, it was observed that the birds infected with *E. coli* were having larger yolks in their abdomen (Fig. 1). Yolks were having yellow brown colour and watery consistency. Congestion of yolk sac blood vessels was also observed. Results of different experiments are shown in Tables 1 to 4.



### Yolk sac infection

Yolk sac infection is commonest cause of early chick mortality in chicken and most of bacteria casually involved are members of the family Enterobacteriaceae. Among these *Escherichia coli* is most important whose involvement is widely reported (Deeming, 1995; Rehman *et al.*, 1996; Anjum, 1997; Sharada *et al.*, 1999; Anonymous, 2000). This organism was therefore selected to infect the yolk sac of day-old broiler chicks in this study.



Fig. 1: Enlarged septic yolk *in situ*

Body weight of infected chicks was significantly lower than the control chicks. Gross (1964) also observed reduced weight gain in yolk sac infection. This may be justified by the fact that chicks were off-feed after infection. Feed refusal was also reported in yolk sac infection by Bains (1979). It is tempting to speculate that experimental *E. coli* infection adversely affects metabolic activities of the birds which ultimately results in malabsorption and reduced weight gain.

It is also evident that weight of the unabsorbed yolk in infected chicks was higher as compared to control ones. Deeming (1995) also reported that infected yolk sacs were larger in mass than uninfected sacs from poults of same age. Yolk sac/body weight ratio was also higher and

estimated yolk absorption was lower in infected group. These observations show that decrease in rate of absorption occurs due to yolk sac infection. This finding is in line with the work reported by Sander *et al.* (1998). The infected yolks were having yellow brown appearance and watery consistency. Similar observations were reported in natural infection by Jordan (1990), Sainsbury (1992) and Anjum (1997) and in experimental infection by Bhatia *et al.* (1970) and William (1975). It can be thought that *E. coli* infection of yolk sac may cause denaturation of yolk ingredients which ultimately affects their solubility and rate of transportation to blood stream. The changed permeability of blood vessels under the influence of the said bacterial infection can be attributed as another factor for the delayed yolk absorption.

Moisture content in yolk was higher for infected chicks which could be explained by inflammatory exudates secreted by cell lining of yolk sac in response to metabolic products and lysis of bacteria, as described by Harry (1957). Fat content in yolk was not affected appreciably by yolk sac infection. Protein absorption was lower in treatment group as compared to control group, possibility due to alteration in protein structure or change in permeability of yolk sac membrane.

### Post-hatch starvation

It was observed that starvation, whether it was due to delay of housing or delay in first feeding, caused substantial body weight loss in chicks. Wang *et al.* (1994) and Noy and Sklan (1999) also observed weight loss due to starvation in early life of chicks.

Yolk sac weight and estimated yolk absorption did not differ significantly between the treatment groups. Yolk sac/body weight ratio was higher in chicks subjected to 24-48 hours starvation after housing. This was not due to yolk retention but was due to loss in body weight. So it is concluded that yolk absorption is not affected by post-hatch starvation, whether due to delay in housing or delay in first feeding to chicks.

These results corroborate with those reported by Chamblee *et al.* (1992) and Murakami *et al.* (1992), who concluded that offering feed on starvation did not affect disappearance rate of yolk in abdomen. Al-Rawashdeh *et al.* (1995) observed non-significant difference in yolk sac weight after subjecting day-old chicks to 5-day starvation. Baiao *et al.* (1988) also reported that off-feed period between hatching and housing did not affect yolk absorption.

This finding is not in agreement with the findings of Bierer and Eleazer (1965), Feher and Gyuru (1971), Moran and Reinhart (1980), Noy *et al.* (1996) and Santos and Silversides (1996), who reported reduced yolk uptake in starved chicks while better utilization in fed chicks. Present result is also against the finding of Pisarski *et al.* (1998b), who showed efficient utilization of yolk contents



Table 1. Effect of experimental yolk sac infection on body weight and different yolk parameters

Sampling days	Groups	Body weight (g)	Yolk sac weight (g)	Yolk sac: body weight ratio	Estimated yolk absorption (%)	Yolk composition		
						Moisture (%)	Fat (% of DM)	Protein (% of DM)
Day-1	-	-	6.12	-	-	-	-	-
Day-3	A	55.7*	1.30*	2.33*	78.85*	49.63	38.17	42.50
	B	47.1*	2.92*	6.21*	52.29*	58.63	39.78	44.88
Day-5	A	70.5*	0.70*	1.30*	88.17*	55.36	35.95	40.94
	B	52.3*	2.55*	4.89*	58.33*	59.97	34.11	42.31
Day-7	A	124.6*	0.56*	0.45*	90.85*	45.39	38.90	44.19
	B	65.0*	2.70*	4.16*	55.82*	61.10	38.26	45.81

\*Significant difference ( $P < 0.05$ )

Table 2. Effect of off-feed between hatching and housing on body weight and different yolk parameters

Sampling days	Groups	Body weight (g)	Yolk sac weight (g)	Yolk sac: body weight ratio	Estimated yolk absorption (%)	Yolk composition		
						Moisture (%)	Fat (% of DM)	Protein (% of DM)
Day-1	-	-	3.01	-	-	-	-	-
Day-3	A	42.1 <sup>a</sup>	0.94 <sup>a</sup>	2.25 <sup>a</sup>	68.57 <sup>a</sup>	42.73	43.36	22.17
	B	38.0 <sup>a</sup>	0.79 <sup>b</sup>	2.08 <sup>b</sup>	73.82 <sup>b</sup>	40.46	31.17	39.32
	C	31.5 <sup>a</sup>	0.81 <sup>c</sup>	2.58 <sup>c</sup>	72.96 <sup>c</sup>	44.24	29.23	41.64
Day-5	A	62.9 <sup>d</sup>	0.63 <sup>d</sup>	1.00 <sup>d</sup>	79.07 <sup>d</sup>	41.29	54.61	24.04
	B	55.8 <sup>d</sup>	0.60 <sup>e</sup>	1.08 <sup>e</sup>	80.33 <sup>e</sup>	42.32	42.43	36.45
	C	42.3 <sup>d</sup>	0.65 <sup>f</sup>	1.59 <sup>de</sup>	78.41 <sup>f</sup>	39.71	39.71	46.97
Day-7	A	95.3 <sup>g</sup>	0.45 <sup>g</sup>	0.47 <sup>g</sup>	85.05 <sup>g</sup>	39.08	39.08	47.73
	B	76.3 <sup>g</sup>	0.40 <sup>h</sup>	0.53 <sup>h</sup>	86.78 <sup>h</sup>	38.67	38.67	57.52
	C	59.7 <sup>g</sup>	0.51 <sup>i</sup>	0.86 <sup>gh</sup>	83.05 <sup>i</sup>	40.16	40.16	58.27

Values with different superscripts in the column differ significantly ( $P < 0.05$ )

Table 3. Effect of first feeding time in the poultry house on body weight and different yolk parameters

Sampling days	Groups	Body weight (g)	Yolk sac weight (g)	Yolk sac: body weight ratio	Estimated yolk absorption (%)	Yolk composition		
						Moisture (%)	Fat (% of DM)	Protein (% of DM)
Day-1	-	-	6.13	-	-	-	-	-
Day-3	A	53.3 <sup>a</sup>	0.79 <sup>a</sup>	1.48 <sup>a</sup>	87.08	44.26	45.63	40.75
	B	54.8 <sup>b</sup>	2.59 <sup>ab</sup>	4.71 <sup>ab</sup>	57.57	48.92	45.02	45.00
	C	53.9 <sup>c</sup>	0.84 <sup>b</sup>	1.56 <sup>b</sup>	86.23	44.43	46.62	43.81
Day-5	A	69.5 <sup>d</sup>	0.47 <sup>d</sup>	0.66 <sup>d</sup>	92.36	52.26	58.81	44.75
	B	71.5 <sup>e</sup>	1.18 <sup>de</sup>	1.65 <sup>de</sup>	80.62	52.97	52.14	46.94
	C	69.6 <sup>f</sup>	0.49 <sup>e</sup>	0.71 <sup>e</sup>	91.87	52.58	49.83	49.19
Day-7	A	105.6 <sup>g</sup>	0.20 <sup>g</sup>	0.19 <sup>g</sup>	96.72	57.52	51.96	49.00
	B	101.4 <sup>h</sup>	0.65 <sup>gh</sup>	0.63 <sup>gh</sup>	89.37	56.53	54.48	45.50
	C	101.9 <sup>i</sup>	0.13 <sup>h</sup>	0.12 <sup>h</sup>	97.87	54.25	52.71	46.69

Values with different superscripts in the column differ significantly ( $P < 0.05$ )

Table 4. Effect of type of initial feed on body weight and different yolk parameters

Sampling days	Groups	Body weight (g)	Yolk sac weight (g)	Yolk sac: body weight ratio	Estimated yolk absorption (%)	Yolk composition		
						Moisture (%)	Fat (% of DM)	Protein (% of DM)
Day-1	-	-	6.13	-	-	-	-	-
Day-3	A	53.3 <sup>a</sup>	0.79 <sup>a</sup>	1.48 <sup>a</sup>	87.08 <sup>a</sup>	44.26	45.63	40.75
	B	54.8 <sup>b</sup>	2.59 <sup>ab</sup>	4.71 <sup>ab</sup>	57.57 <sup>ab</sup>	48.92	45.02	45.00
	C	53.9 <sup>c</sup>	0.84 <sup>b</sup>	1.56 <sup>b</sup>	86.23 <sup>b</sup>	44.43	46.62	43.81
Day-5	A	69.5 <sup>d</sup>	0.47 <sup>d</sup>	0.66 <sup>d</sup>	92.36 <sup>d</sup>	52.26	58.81	44.75
	B	71.5 <sup>e</sup>	1.18 <sup>de</sup>	1.65 <sup>de</sup>	80.62 <sup>de</sup>	52.97	52.14	46.94
	C	69.6 <sup>f</sup>	0.49 <sup>e</sup>	0.71 <sup>e</sup>	91.87 <sup>e</sup>	52.58	49.83	49.19
Day-7	A	105.6 <sup>g</sup>	0.20 <sup>g</sup>	0.19 <sup>g</sup>	96.72 <sup>g</sup>	57.52	51.96	49.00
	B	101.4 <sup>h</sup>	0.65 <sup>gh</sup>	0.63 <sup>gh</sup>	89.37 <sup>gh</sup>	56.53	54.48	45.50
	C	109.1 <sup>i</sup>	0.13 <sup>h</sup>	0.12 <sup>h</sup>	97.87 <sup>h</sup>	54.25	52.71	46.69

Values with different superscripts in the column differ significantly ( $P < 0.05$ )



in starved chicks.

Percent moisture content in yolk did not show any persistent trend due to post-hatch starvation but it is against the evidence reported by Moran and Reinhart (1980), who showed better moisture mobilization from yolk due to starvation. Feher and Gyuru (1972) also reported better resorption of water due to fasting in duck and goose.

Fat content was lower and protein content was higher in starved chicks compared with fed chicks. It indicates that starvation leads to better fat utilization while decreased protein absorption. These observations are the same as described by Moran and Reinhart (1980). It indicates that chick has some ability for selective nutrient withdrawal from yolk or/and this might be due to increased energy demand resulting from starvation.

#### Type of initial feed

It was observed that yolk sac weight and yolk sac/body weight ratio was higher for the group fed with ground corn in first 24 hours of life while estimated yolk absorption was lower for this group. So it is concluded that feeding ground corn in early life leads to slow absorption yolk of yolk sac. This finding was also reported by Pisarski *et al.* (1998a). The slower yolk absorption may be due to lack of protein-energy balance, since corn supplies mainly energy and the yolk contains massive amount of dietary fat, though the relative shortage of protein could be the factor impairing utilization of energy from yolk. Moisture, fat and protein contents in yolk were not affected by type of initial feed.

It can be inferred that experimental infection of *E. coli* and type of initial feed affect the rate of yolk absorption in young broiler chicks. The use of ground corn as initial feed can be assumed as a factor for slowing down yolk absorption. Further studies are required to establish these observations which are very essential for health status of baby chicks.

#### REFERENCES

- Al-Rawashdeh, O.F., S.Q. Lafi, N.Q. Hailat, T. A. Abdul-Aziz, K.T. Freifij and A.Y.M. Nour, 1995. Effect of feed deprivation on the blood levels of glucose, beta-hydroxybutyrate, triglycerides and cholesterol and on body weight and yolk sac weight in one-day-old broiler chicks. *Acta Veterinaria Reograd*, 45(4): 175-186.
- Anjum, A.D., 1997. "Poultry Diseases", 5th Ed., VetAg Publications, Faisalabad-Pakistan, pp 178-180.
- Anonymous, 2000. Controlling yolk sac infection. *Intl. Hatchery Pract.*, 14(6): 27-28.
- Baiao, N.C., S.V. Cancado and C.G. Lucio, 1998. Effect of period of feed withdrawal between hatching and housing of the broilers on absorption of the yolk sac. *Arquivo Brasileiro de Medicina Veterinaria e Zootecnia*, 50(4): 473-474.
- Bains, B.S., 1979. *A Manual of Poultry Diseases*. F. Hoffmann-La Roche Company, Basle, Switzerland, pp 105-106.
- Bhatia, K.C., U. K. Sharma and S. Chandra, 1970. Studies on persistent yolk sac condition in chicks. Pathologic lesions in experimentally infected baby chicks with *Salmonella* species. *Bihar J. Vet. Sci. Anim. Husband.*, 1(3): 65-68.
- Bierer, B.W. and T.H. Eleazer, 1965. Effect of feed and water deprivation on yolk utilization in chicks. *Poult. Sci.*, 44: 1008-1009.
- Brammell, W.S., 1984. *Egg and egg products in: Official Method of Analysis*, 14th Ed., Assoc. Off. Anal. Chem. Inc., USA, pp 320-321.
- Buxton, A. and G. Fraser, 1977. *Animal Microbiology*, Vo. 1 Blackwell Scientific Publishers, Oxford, pp 93-95, 354-355.
- Chamblee, T.N., J.D. Brake, C.D. Schultz and J.P. Thaxton, 1992. Yolk sac absorption and initiation of growth in broilers. *Poult. Sci.*, 71: 1811-1816.
- Charlton, B.R., 1996. *Avian Disease Manual*, Am. Assoc. Avian Pathologists, Pennsylvania, U.S.A., pp 220.
- Collins, C.H., P.M. Lyne and J.M. Grange, 1995. *Collin's and Lyne's Microbiological Methods*, 7th Ed., Butterworth Heinemann, Oxford, U.K., pp 93, 129-131.
- Deeming, D.C., 1995. Possible effect of microbial infection on yolk utilization in ostrich chicks. *Vet. Rec.*, 136 (11): 270-271.
- Feher, G. and F. Gyuru, 1971. Postembryonal changes in the yolk sac in poultry, I. The Fowl. *Magyar Allatorvosok Lapja*, 26(7): 353-360.
- Feher, G. and F. Gyuru, 1972. Postembryonal changes in the yolk sac of poultry, II. Duck and goose. *Magyar Allatorvosok Lapja*, 27(6): 297-306.
- Gross, W.B., 1964. Retained careous yolk sac caused by *Escherichia coli*. *Avian Dis.*, 8: 438-441.
- Harry, E.G., 1957. The effect on embryonic and chick mortality of yolk contamination with bacteria from the hen. *Vet. Rec.*, 69: 1433-1439.
- Jalil, H. and P. Das, 2001. Biochemical and serological characterization of *Escherichia coli* from commercial poultry. *Pakistan J. Sci. Res.*, 53(1-2): 10-14.
- Jordan, F.T.W., 1990. "Poultry Diseases", 3rd Ed., ELBS and Bailliere Tindall, London, U.K., pp 40.
- Kloryga, M. A., 1986. Pathogenicity of five rough mutants of *Escherichia coli* isolated from broilers. *Avian Pathol.*, 15(4): 749-759.



- Lee, M. D. and L.H. Arp, 1998. Colibacillosis. In: A Laboratory Manual for the Isolation and Identification of Avian Pathogens, 4th Ed., Am. Assoc. Avian Pathologists, Pennsylvania U.S.A., pp 14-16.
- Moran, E.T. and B.S. Reinhart, 1980. Poultry yolk sac amount and composition upon placement: Effect of breeder age, egg weight, sex and subsequent change with feeding or fasting. Poul. Sci., 59: 1521-1528.
- Murakami, H., Y. Akiba and M. Horiguchi, 1992. Growth and utilization of nutrients in newly hatched chick with or without removal of residual yolk. Growth, Dev. Aging, 56 (2): 75-84.
- Noy, Y., Z. Uni and D. Sklan, 1996. Routes of yolk utilization in the newly hatched chick. Brit. Poul. Sci., 37(5): 987-995.
- Noy, Y. and D. Sklan, 1999. Energy utilization in newly hatched chicks. Poul. Sci., 78 (12): 1750-1756.
- Pisarski, R. K., H. Malec and L. Malec, 1998a. Effect of initial feeding of broilers on the growth rate, yolk sac absorption and selected blood chemical parameters. Medycyna Weterynaryjna, 45(6): 409-412.
- Pisarski, R.K., L. Malec, B. W. Borzemska and H. Malec, 1998b. Effect of first feeding time of broiler chicks upon the body weight, yolk sac absorption and some constituents of blood plasma. Medycyna Weterynaryjna, 54(9): 607-611.
- Rammnoff, A.L., 1960. The Avian Embryo, MacMillan Co., New York, pp 1077.
- Rehman, R., M. Rabbani, S.A. Khan and C. M. Saleem, 1996. Pathological aspects of early chick mortality due to bacterial infections. Pakistan J. Sci. Res., 48(3-4): 101-107.
- Sainsbury, D., 1992. "Poultry Health and Management", 3rd. Ed., Blackwell Scientific Publications, London, UK., pp 116.
- Sander, J.E., E.M. Willingham, J.L. Wilson and S.G. Thayer, 1998. The effect of inoculating *Enterococcus faecalis* into the yolk sac on chick quality and maternal antibody absorption. Avian Dis., 42 (2): 359-363.
- Santos, G. A. and F. G. Silversides, 1996. Utilization of the sex-linked gene for imperfect albinism (S\*ALS). I. Effect of early weight loss on chick metabolism. Poul. Sci., 75: 1321-1329.
- Sharada, R., G. Krishnappa, R. Raghavan, R.N.S. Gowda and H. A. Upendra, 1999. Isolation and serotyping of *Escherichia coli* from different pathological conditions in poultry. Indian J. Poul. Sci., 34(3): 366-369.
- Steel, R.G.D. and J.H. Torrie, 1982. Principles and Procedures of Statistics, 2nd Ed., McGraw Hill Book Co. Inc., New York, pp 137-171.
- Vogel, A.I., 1961. A Text Book of Quantitative Inorganic Analysis, 3rd Ed., ELBS and Langmans Green & Co., London, pp 254-257.
- Wang, H., Q.G. Huo and S.B. Li, 1994. Nutrient transfer in yolk sac of feeding chick. Acta Veterinaria et Zootechnica Sinica, 25 (2): 97-104.
- William, F.K., 1975. Omphalitis in poult. Poul. Digest, 12: 49.