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General Performance Observations in Broiler Chickens Experimentally Inoculated with *Salmonella enteritidis* and Its Amelioration with Vitamin C

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A B S T R A C T

The present study was conducted to evaluate the effect of Vitamin C on the pathogenesis of Salmonellosis in broiler chickens. Seventy two, day old broiler chicks were divided into 4 groups-I, II, III and IV. Group I served as control. Group II was administered *Salmonella enteritidis* (LD_{50}=2x10^8 organisms) orally. Group III was administered *Salmonella enteritidis* (LD_{50}=2x10^8 organisms) orally and Vitamin C mixed with water @200ppm. Group IV was administered with Vitamin C mixed with water @ 200ppm. Clinical signs developed up to 3rd week PI (Post-infection) with decreased severity in group III. A mortality of 44.44% and 27.78% was recorded in group II and III respectively. Infected birds showed significant decrease in body weight, weekly body weight gain, feed intake and increase in FCR. Vitamin C significantly improved these parameters from 3rd week PI.

Introduction

Poultry meat and eggs are a leading source of animal protein for human consumption in many countries. Owing to the implementation of greater numbers of monitoring and testing programmes in the poultry industry, isolation of *Salmonella* is reported more often from poultry and poultry products than any other animal source (Gast, 2003). Among the different diseases occurring in poultry, incidence of diseases caused by the genus *Salmonella* are most common, causing serious losses to the poultry industry in terms of mortality, reduced growth and loss of egg production. The diseases caused by *Salmonella* have got zoonotic importance (Lax *et al.*, 1995). Poultry flocks are reservoirs of *Salmonella enteritidis*, whose incidence in the human population has increased considerably since the beginning of the 1990 (Lahuerta *et al.*, 2011). Environmental and pathological stressors are known to alter Vitamin C use or synthesis or both in the fowl (Pardue and

Thaxton, 1986). Several researchers have reported beneficial effects of Vitamin C supplements given either in diets or in drinking water. Supplements enhanced performance of broiler chickens with reduced stress related response (Pardue and Thaxton, 1984) and improved disease resistance of the birds (Amakye-Anim *et al.,* 2000).

Vitamin C plays a major role in the biosynthesis of corticosterone (Bains, 1996), a primary glucocorticoid hormone involved in gluconeogenesis to enhance energy supply during stress (Frandson, 1986).

The *Salmonella enteritidis* was prevalent in the R.S.Pura region which was isolated from the poultry by us and hence this study was done.

Materials and Methods

The present study was carried out in the Division of Veterinary Pathology, F.V.Sc and A.H, SKUAST-J, R. S. Pura, Jammu. This study was conducted on 72, day old broiler chicks which after acclimatization for a period of seven days, were randomly divided into four groups viz. group I, II, III and IV of 18 birds in each group. Group I chicks were served as control. Group II chicks were challenged orally with 2×10^8 organisms of *Salmonella enteritidis*. Group III chicks were challenged orally with 2×10^8 organisms of *Salmonella enteritidis* and vitamin C mixed in water @ 200 ppm. Group IV birds were administered vitamin C @ 200 ppm.

Parameters studied

Clinical signs and mortality pattern

Birds of all the groups were closely observed at least thrice daily throughout the experimental period for clinical signs and mortality, if any.

General performance

The following parameters were studied to evaluate the effect of Vitamin C on general performance of *Salmonella* infected birds.

Body weight (gms)

In order to determine the body weight of birds, six birds were weighed at 0, 7, 14, 21 and 28 days post infection (DPI) in each group.

Weekly body weight gain (gms)

On first day of experiment, initial body weight of birds was recorded. Subsequently, body weights were recorded at various intervals up to the end of experiment in each group and weekly body weight gain was calculated.

Feed consumption (gms)

Average weekly feed consumption in all groups was recorded up to the end of the trial.

Feed conversion ratio

FCR was calculated by the formula mentioned below (NRC, 1981).

$$\text{FCR} = \frac{\text{Feed consumed by birds (gms)}}{\text{Body weight gain (gms)}}$$

Results and Discussion

The observations of the present study with respect to the clinical signs, mortality pattern and growth response are as follows.

Clinical signs

The clinical signs in group II birds appeared within 4 days PI and included dullness, depression, inappetance and reluctance to move with both eyes closed. After one week

of infection, birds showed progressive weakness, anorexia, increased thirst, diarrhoea, drooping of wings, ruffled feathers and lowering of head. Diarrhoea in the birds ranged from watery type (4th to 10th DPI) to haemorrhagic type (11th to 21st DPI). The birds continued to show these symptoms with increasing severity up to 21st DPI. The severity of clinical signs were decreased after 22nd DPI and the surviving birds were appeared weak and failed to attain mature body weight throughout the entire period.

The birds of group III showed similar clinical signs of low intensity as observed in group II birds. The clinical signs were observed up to 21st DPI, thereafter surviving birds appeared normal and had increased appetite than group II. General body conditions of birds after 21st DPI were good and birds performed better than that of group II.

The birds of group IV appeared normal with normal appetite without showing any clinical signs of pathological significance

Mortality pattern

A high mortality of 44.44% starting from 5th day to 24th DPI was observed in group II birds. A mortality of 27.78 % in group III birds starting from 5th day up to 19th day PI was observed. However, group I and IV birds did not show any mortality throughout experimental period. Pattern of mortality has been depicted in Table 1.

Growth response

All the growth response parameters are depicted in Table 2.

Weekly feed consumption (gms)

Non-significant difference was observed in average weekly feed consumption in birds of all treatment group upto 2nd week PI. The average weekly feed consumption was significantly decreased in group II and III birds than group I and IV birds. At the end of experimental trail, highest feed consumption was observed in group IV birds (800.50 ± 5.70 gm) followed by group I (799.17 ± 5.68 gm), group III (605.33 ± 4.01 gm) and group II (601.23 ± 3.80 gm).

Weekly body weight (gms)

A significant decrease in average body weight was observed in group II and III birds as compared to group I and group IV birds from 1st week PI up to the last observation.

The average body weights of group IV (1342.20 ± 1.57 gm) and group I (1339.20 ± 1.40) birds were significantly higher than group III (1005.80±4.72 gm) and group II (984.67 ± 2.76) birds at the end of trail.

Weekly body weight gain (gms)

A better growth rate starting from 1st week PI up to the end of experiment was observed in group I and IV birds which was significantly higher than group II and group III birds.

A significant decrease in weekly body weight gain was observed in the group II and III birds as compared to group IV and group I birds from 1 week PI up to the end of trial.

The average weekly body weight gain of group IV (442.83 ± 3.10 gm) and group I (441.33 ± 1.83 gm) were significantly higher than group III (276.97 ± 5.88 gm) and group II (268.83 ± 5.61 gm) birds at the end of trail.

Feed conversion ratio

Non-significant difference was observed in average weekly feed conversion ratio in all treatment group birds in 1st week PI.

Table.1 Mortality pattern (%) in different groups at different intervals

Week PI	Group I	Group II	Group III	Group IV
1st	0	2	2	0
2nd	0	3	2	0
3rd	0	2	1	0
4th	0	1	0	0
Total	0	8	5	0
Per cent	**0**	**44.44%**	**27.78 %**	**0**

Birds of group II died each on 4th, 10th, 17th and 24th DPI.
Birds of group III died each on 4th, 10th and 19th DPI.

Table.2 Growth response pattern in different groups at different intervals

	Week PI	Group I	Group II	Group III	Group IV
Average feed consumption (gms)	1st	255.50 ± 2.97^{aA}	251.83 ± 2.38^{aA}	252.67 ± 2.66^{aA}	254.50 ± 3.44^{aA}
	2nd	374.33 ± 4.99^{aB}	355.17 ± 3.78^{aB}	356.17 ± 3.94^{aB}	374.67 ± 4.70^{aB}
	3rd	682.67 ± 4.91^{aC}	535.33 ± 5.67^{bC}	547.54 ± 4.36^{bC}	682.83 ± 7.67^{aC}
	4th	799.17 ± 5.68^{aD}	601.23 ± 3.80^{bD}	605.33 ± 4.01^{bD}	800.50 ± 5.70^{aD}
Average weekly body weight (gms)	0	132.50 ± 0.99^{aA}	131.50 ± 0.56^{aA}	131.50 ± 0.76^{aA}	132.17 ± 0.87^{aA}
	1st	317.83 ± 1.55^{aB}	296.83 ± 3.60^{bB}	299.17 ± 4.36^{bB}	318.17 ± 0.60^{aB}
	2nd	529.27 ± 0.94^{aC}	465.83 ± 5.38^{bC}	467.17 ± 4.36^{bC}	530.50 ± 0.92^{aC}
	3rd	897.83 ± 1.79^{aD}	715.84 ± 5.54^{cD}	728.83 ± 3.87^{bD}	899.33 ± 1.54^{aD}
	4th	1339.20 ± 1.40^{aE}	984.67 ± 2.76^{cE}	1005.80 ± 4.72^{bE}	1342.20 ± 1.57^{aE}
Average weekly body weight gain (gms)	1st	185.33 ± 2.02^{aA}	165.33 ± 3.68^{bA}	167.67 ± 4.87^{bA}	186.00 ± 0.89^{aA}
	2nd	211.44 ± 1.14^{aB}	169.00 ± 7.02^{bB}	168.00 ± 3.65^{bB}	212.33 ± 1.28^{aB}
	3rd	368.56 ± 1.96^{aC}	250.01 ± 5.77^{cC}	261.66 ± 6.46^{bC}	368.83 ± 2.00^{aC}
	4th	441.33 ± 1.83^{aD}	268.83 ± 5.61^{cD}	276.97 ± 5.88^{bD}	442.83 ± 3.10^{aD}
Average feed conversion ratio (%)	1st	1.37 ± 0.01^{aA}	1.44 ± 0.02^{aA}	1.46 ± 0.04^{aA}	1.36 ± 0.02^{aA}
	2nd	1.77 ± 0.02^{bB}	2.11 ± 0.08^{aB}	2.07 ± 0.03^{aB}	1.76 ± 0.02^{aB}
	3rd	1.85 ± 0.03^{bC}	2.14 ± 0.09^{aB}	2.09 ± 0.05^{aB}	1.83 ± 0.04^{bC}
	4th	1.91 ± 0.01^{cD}	2.23 ± 0.04^{aC}	2.18 ± 0.05^{bC}	1.90 ± 0.01^{cD}

Mean bearing at least one common superscript (a, b, c and A, B, C, D, E) did not differ significantly between groups and weeks ($P<0.05$), respectively.

The average weekly feed conversion ratio was significantly increased in group II (2.11±0.08) and group III (2.07±0.03) birds than groups I (1.77±0.02) and IV (1.76 ± 0.02) birds from 2nd week PI up to the end of the trial. Between group II and group III birds, the average values of FCR did not differ from 1st week PI up to the 3rd week PI. At 4th week PI, FCR was significantly decreased in group III (2.18±0.05) than group II (2.23±0.04) birds. There was evidence suggesting an association between ascorbic acid and resistance to

bacterial infections (Gross *et al.,* 1988b). Ascorbic acid ameliorated stress-induced suppression of antibody responsiveness and expression of cell-mediated immunity (Murray *et al.,* 1988). These studies suggest that the addition of ascorbic acid to chicken diets might be useful against other conditions and diseases. *Salmonellosis* is becoming a major problem with its increasing incidence among birds. The increase in incidence of *Salmonellosis* among birds is more due to intensive raising of poultry. The need for prevention and if possible, eradication among birds is highly essential to achieve greater economic progress.

The present study was undertaken to investigate the clinical signs, mortality pattern, feed consumption, growth response and feed conversion ratio in experimentally induced *Salmonella enteritidis* infection and to examine effect of Vitamin C in modulating the disease process in broiler chicken. For this purpose, Vitamin C was added in water @ 200 ppm. The experimental birds were divided into four groups viz. Group I birds served as control; Group II infected with LD_{50} (2×10^8/0.5ml) of *Salmonella enteritidis*; Group III birds were infected with same dose of *Salmonella enteritidis* along with Vitamin C @ 200 ppm; while group IV birds were given Vitamin C @ 200 ppm.

Clinical signs

Following oral infection of one week old chicks with LD_{50} (2×10^8/0.5ml) of *Salmonella enteritidis*, clinical signs developed as early as 4 days PI, which increased progressively. The affected chicks of group II exhibited dullness, marked depression, closed eyes and reluctance to move. After first week of infection, the birds showed progressive weakness, inappetance, increased thirst, ruffled feathers, drooping of wings, lowering of head and diarrhoea. Similar clinical signs of were reported earlier (Ghosh and Chatterjee, 1960; Dwivedi and Malhotra, 1973 and Palaniswamy *et al.,* 1989) in young chicks; in adult chicken (Lennek *et al.,* 1962); in 1-3 week old quail (Sah *et al.,* 1987) and in different breeds of chickens (Barrow *et al.,* 1987). Likewise, Kaura *et al.,* (1990), Shivaprasad (2000) and Chacana and Terzolo (2003) reported similar signs in *Salmonella gallinarum* infected chickens akin to our observations. Baishya *et al.,* (2008) also reported in birds due to *Salmonella enteritidis*. Akhtar *et al.,* (2011) and Nazir *et al.,* (2012) found similar clinical signs in broilers. Most of the signs exhibited by the birds could be attributed to a severe loss of body fluids owing to diarrhoea, which itself arose of a direct consequence of the pathogen. It is understandable that *Salmonella* manifests its toxigenic effects mostly through expression of their endotoxins after adhering to the gut epithelium. This has been amptly demonstrated by Koupal and Deibel (1975) in day-old chicks after oral inoculation with *Salmonella*. They further observed that organisms adhere to epithelial cells at the tips of villi, and express their enterotoxins, inducing a secretory response by the gut epithelial cells, resulting in fluid accumulation in the intestinal lumen. The invasion of intestinal epithelium cells by Salmonellae leads to a series of pathological changes that affects intestinal fluid and electrolyte regulation. This process ultimately can cause cell death and thereby produce and exacerbate diarrhoea (Desmidt *et al.,* 1997).

The severity of clinical signs in group III birds was less as compared to group II birds. It is evident that incorporation of Vitamin C has effectively diminished the severity and manifestation of clinical signs in the infected birds, however, the exact mechanism of protection conferred could only be speculated. Vitamin C is a well-known antioxidant and immunomodulator. The infection induced

stress in the birds may aggravate the manifested signs. It is postulated that Vitamin C reduces the severity of the stress to manifest milder clinical signs. Besides, it may also stimulate the immune mechanism to reduce the severity of infection. Scarpa *et al.,* (1983) observed that ascorbic acid increased the production of the superoxide radical in phagocytes, thus increasing the defense against phagocytized bacteria. Although oxidative stress was not measured in the present study, there is a plausible explanation that macrophage activity may have increased in the chicks from the group treated with Vitamin C.

Mortality pattern

Maximum mortality of 44.44% was observed in group II birds with highest mortality observed during 2nd week PI. Similar mortality pattern had been reported in chicks (Dwivedi and Malhotra, 1973).

Varying mortality rates has been reported in the literature. Reportedly, *Salmonella enteritidis* related mortality in broiler chicks range between 20-96% (Barrow, 1991); those induced by *Salmonella typhimurium* may reach ~50% (Murphy, 1969) which could rise to 80% in day-old chicks (Henderson *et al.*, 1960) and 72% due to *Salmonella enteritidis* (Osman *et al.,* 2010). Young birds with immature immune system are said to have less ability to withstand diarrhoea particularly in acute Salmonellosis (Lax *et al.*, 1995). The birds which survived the acute phase of disease in the present study appeared weak and emaciated.

The primary cause of mortality was inappetance, seconded by dehydration due to diarrhoea, in addition to the involvement of other vital functions. Severe damage of vital organs viz. liver, kidneys, heart and intestine was also responsible for high mortality as evidenced by pathological changes in tissue sections. Endotoxic shock (Williams, 1967) might also be another cause of mortality amongst *Salmonella* infected birds.

In group III, the mortality was 27.78%, considerably lower than Group II. Seemingly, Vitamin C could bring about a reduction in mortality rates. This is reasonable as there had been a reduction in the severity of infection and clinical signs in Vitamin C treated group. There is evidence suggesting an association between ascorbic acid and resistance to bacterial infections (Gross *et al.,* 1988) and consequently on mortality rates. Chickens infected with fowl typhoid had reduced levels of ascorbic acid in the blood and the administration of ascorbic acid resulted in reduced early but not late mortality (Satterfield *et al.,* 1940). This may be because the quantity of superoxide radical present in phagocytes is increased by an optimum level of ascorbic acid (Scarpa *et al.,* 1983; Som *et al.,* 1983). Contrarily, in the present study it was found that administration of ascorbic acid resulted in reducing late, but not early mortality of the chicks. This could be because the severity of infection may wane off after a period of time countered by a rise in immune response, or probably that Vitamin C may require an interim period to manifest its protective effects since its assimilation.

Weekly feed consumption

Studies on the weekly feed consumption revealed a significant decrease in group II as compared to control group from 1st week PI till the end of experiment. Understandably this is due to inappetance after infection. This has been widely reported in the literature with *Salmonella typhimurium* infection (Dwivedi and Malhotra, 1973; Boonchuvit and Hamilton, 1975; Brown *et al.,* 1975; Sah *et al.,* 1987) and *Salmonella Gallinarum* infection (Kaura *et al.,* 1990; Shivaprasad, 2000) in chickens.

Group III birds showed marginal improvement in feed consumption particularly significant in the 4th week PI when compared to Group II; but it is difficult to attribute whether this is due to a loss in infection severity or a direct effect of Vitamin C in increasing feed consumption.

Growth response

Studies on the growth response (Body weight and weekly body weight gain) revealed that there was reduction in body weight of birds of group II form 1st week PI up to the last observation and the difference in comparison to control group was significant. A similar depression in growth response had been reported by Dwivedi and Malhotra (1973); Boonchuvit and Hamilton (1975); Barrow *et al.,* (1987) in chickens, Sah *et al.,* (1987) and Kumar *et al.,* (2001) in Japanese quail infected with *Salmonella typhimurium* and Madhuri and Sadana (2000) and Shivaprasad (2000) in *Salmonella Gallinarum* infection in chickens.

Dhillon *et al.,* (2001) also observed in *Salmonella enteritidis*.

The depression in growth response can be attributed to reduced feed intake, poor feed conversion ratio and dehydration due to diarrhoea as reported by Hall *et al.,* (1949) and Kaura *et al.,* (1990). In present study also decreased feed consumption, poor FCR and diarrhoea was observed.

The group III birds showed significant decrease in FCR than group II at 4th week PI in our study. This may due to conversion of body proteins and fat into energy by Vitamin-C for production and survival through increased corticosterone secretion (Marshall and Hughes, 1980; Bains, 1996). Vathana *et al.,* (2002) also reported that there was improvement in FCR.

Feed conversion ratio

Studies on the FCR revealed significant increase from 2nd week PI up to the last observation. FCR increased because of decrease in feed intake and lower feed efficiency in *Salmonella* infected birds. The group III birds showed decrease in feed efficiency as compared with group I that means there was increase in the feed conversion ratio. Our study was also similar with Gross (1992a) who reported that there was decrease in feed efficiency.

After infecting chicks orally with LD_{50} of *Salmonella enteritidis*, mortality started within 5 DPI and maximum mortality of 44.44% was observed in group II while as mortality of 27.78% was observed in group III. Clinical signs observed were dullness, depression, ruffled feathers, drooping of wings, increased thirst, anorexia and diarrhoea.

A significant decrease in feed intake from 1st week PI in the group II birds indicated that *Salmonella enteritidis* has deleterious effect on feed intake as well as feed conversion ratio. Vitamin-C showed improvement in FCR in group III birds when compared with group II.

A significant decrease in body weight starting from 1st week PI was observed in the group II indicating that *Salmonella enteritidis* has deleterious effect on growth of birds. A significant increase in body weight was observed in group III than group II from 3rd week PI indicated that Vitamin-C have positive influence on growth response in *Salmonella enteritidis* infected birds.

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