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Effect of *in ovo* supplementation of various nutrients on poultry performance: A review

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Abstract
In Ovo supplementation, a recent technique to exploit the genetic potential of improve strain broilers since in the broiler chicks at the last period inside the egg found to deficit in nutrients. Supplementation of aminoacids and other nutrients enhance the growth performance. The research conducted with various nutrients on supplementation imrpoiving the performance are reviewed hereunder.

Keywords: *in ovo* supplementation, nutrients, broiler performance

Introduction
The literatures pertaining to the effect of *in ovo* supplementation of various nutrients on performance of poultry has been reviewed and is presented hereunder.

Hatch Record
Amino acid concentrations in the egg, such as glycine and proline were reported to be not sufficient to support embryonic development during the final stage of the incubation and *in ovo* administration of amino acids (53 mg) at later stage of incubation enhanced the body weight of chick at hatch (Ohta *et al.*, 1999) [27].

Jia *et al.*, (2011) [20] reported that *in ovo* feeding of maltose solutions to the chicken embryo increased the weight of hatchling.

Bakyaraj *et al.*, (2012) [5] reported that the hatchability, death after piping, death after *in ovo* feeding and per cent chicks hatched late were found to be 81.3, 3.1, 1.6 and 4.7 per cent, respectively on *in ovo* feeding of selenium (0.3 µg), zinc (80 µg), copper (16 µg) and manganese (120 mg) per egg. The hatchability, death after piping, death after *in ovo* feeding and per cent chicks hatched late were found to be of 61.3, 13.8, 6.2 and 1.5 per cent, respectively on *in ovo* feeding of selenium (0.3 µg), zinc (80 µg), iron (160 µg) and iodine (0.7 µg) per egg. They also reported higher hatchability percentage of 91.70 on *in ovo* feeding of lysine (22 mg), arginine (25 mg), methionine (10 mg), leucine (24 mg) and isoleucine (16 mg). The hatchability found to be 92.60 per cent on *in ovo* feeding of arginine (25 mg), glycine (12.5) mg, serine (12.5 mg), valine (18 mg), methionine (10 mg) and threonine (16 mg).

In ovo injection of 0.50 ml of amino acids mixture into the yolk of fertilized Muscovy duck's eggs at day twelve of incubation increased hatchability percentage as compared to the control group (Gaafar, 2009) [16].

Al-Asadi (2013) [2] reported that early feeding (*in ovo* injection) of amino acids such as lysine and arginine improves hatchability in broilers.

Administration of L-Glutamine into amniotic fluid, up to 10 mg/egg on 17th day of incubation in layer-type breeder eggs produced at 26 or 32 weeks of age decreased or increased chick weight at hatch and hatching time, respectively (Shafey *et al.*, 2013) [33].

Shafey *et al.*, (2014) [32] subjected fertile broiler eggs to *in ovo* administration of amino acids and noticed increased chick weight at hatch without affecting hatchability traits and also observed increased incubation period when compared with those of control treatments.

In ovo administration of branched chain amino acids, especially leucine and valine accelerated embryo growth resulting in the acceleration of hatching time of chicks (Kita *et al.*, 2015) [22].

In ovo feeding of carbohydrates and arginine in duck embryos resulted in increased hatchability in treatment groups than control group (Tangara *et al.*, 2010) [11, 37].

Early supplementation of nutrients such as amino acids mixture through *in ovo* injection improved hatchability percentage of Muscovy ducks (Gaafar *et al.*, 2013) [17].

Bottje *et al.,* (2010) [8] injected dextrin-iodinated casein into fertile turkey eggs and reported a 2.4 per cent increase in chick weight and a 4.3 per cent increase in hatchability than the control group.

Salmanzadeh *et al.,* (2015) [29] reported that *in ovo* supplementation of butyric acid increased the hatch weight of turkey poults.

Al-Daraji *et al.,* (2012) [4] indicated that the *in ovo* injection with different levels of (1, 2 and 3 per cent) arginine into Japanese quail eggs significantly elevated hatchability 86.93, 90.24 and 91.45 per cent, respectively compared with control (81.31 per cent).

In ovo feeding of carbohydrates (1.5 per cent maltose + 1.5 per cent sucrose or 2.5 per cent maltose + 2.5 per cent sucrose) in domestic pigeons on 14.5 day of incubation improved the hatchability to 85.00 per cent or 88.75 per cent, respectively whereas that of control is 82.50 per cent (Dong *et al .,* 2013) [14].

In ovo feeding of amino acids [(Glycine – 3.22 mg + Proline – 3.24 mg) and (Lysine – 5.16 mg + Arginine – 5.04 mg + Glutamine – 12.10 mg)] in combination with nano form of selenium (0.3 µg) per egg at 18th day of incubation through amniotic route does not harm the developing embryo and was found to improve chick weight to egg weight ratio (Chandiranathan *et al.,* 2015) [10].

Post-Hatch Performance

The literature pertaining to post hatch performance has been reviewed and is presented below.

Body weight and weight gain

In ovo feeding of a solution containing maltose, sucrose, dextrin and β-hydroxy- β-methyl butyrate (HMB) in late-term embryos of broiler chicken increased hatching weights by 5 to 6 per cent over controls, improved liver glycogen by 2 to 5 fold and elevated relative breast muscle size by 6 to 8 per cent which was sustained throughout the experimental period (Uni *et al.,* 2005) [38].

In ovo injection of lysine and methionine into the chorio-allantois of broiler eggs at day 10 of incubation had significant (P<0.01) increase in body weight in comparison to positive and negative controls (Abdul-Sahib, 2008) [1].

In ovo feeding at last period of incubation into amnion increased body weight and feed intake of chicks in comparison to *in ovo* feeding into yolk sac at first period of incubation (Chamani *et al.,* 2012) [9].

Al-Asadi (2013) [2] studied the effect of early feeding (*in ovo* injection) amino acids such as lysine and arginine which resulted in increased live body weight and final body weight.

In ovo supplementation of 25(OH)D_3 into broiler chicken embryos improved the broiler chicken performance without affecting neonate qualities (Gonzales *et al.,* 2013) [18].

On conducting *in ovo* trial in broiler chicken, Kornasio *et al.* (2011) [23] observed increased body weight and average daily weight gain than that of the control group.

Salmanzadeh *et al.,* (2011) [28] injected different levels of L-threonine into albumen of broiler breeder eggs and recorded higher body weight of chicks at hatch on injecting 35 mg threonine.

Zhou and Wang (2011) [40] fed chicken with nano elemental selenium supplemented diet and reported improved body weight and body weight gain.

In ovo administration of royal jelly found to increase chicks' body weight, chicks' internal organs weight, luteotrophic hormone and follicle stimulating hormone secretion rate without deleterious effect on hatchability (Moghaddam *et al.,* 2013) [25].

Bhanja *et al.,* (2014) [7] concluded that amino acids, particularly arginine and threonine, enhanced the expression of growth related genes during pre and post-hatch periods.

An *in ovo* study was carried out by Coskun *et al.,* (2014) [13] by injecting pollen extract into fertile broiler eggs and they reported increased chick weight/initial egg weight according to the control and the negative control groups.

Shafey *et al.,* (2014) [32] subjected fertile broiler eggs to *in ovo* administration of amino acids and noticed increased body weight gain when compared with those of control treatments during the entire experimental period.

In ovo supplementation of disaccharides and alanyl-glutamine dipeptide into duck embryos showed positive correlation between body weight and liver glycogen content (Chen *et al.,* 2010) [11, 37].

In ovo feeding of carbohydrates and arginine in duck embryos resulted in increased body weight after hatch (Tangara *et al.,* 2010) [11, 37].

An *in ovo* trial was carried out by Selim *et al.,* (2012) [31] and reported that *in ovo* injection of vitamin E and ascorbic acid improved the embryonic and post hatch growth of Muscovy ducks.

Gaafar *et al.,* (2013) [17] studied the effect of *in ovo* administration with two levels of amino acids mixture on the performance of Muscovy ducks and concluded that early supplementation of amino acids mixture through *in ovo* injection improved body weight at hatch and marketing weights of Muscovy ducks.

Gore and Qureshi (1997) [19] reported that the *in ovo* exposure of turkey eggs to vitamin E improved post hatch poult performance.

In ovo administration of a gastrointestinal peptide enhanced growth in turkey poults during the early post hatch period and also attenuated the differences in body weight between male and female poults during the early post-hatch period (Coles *et al .,* 2001) [12].

Foye *et al.,* (2006a) [15] subjected turkey embryos to *in ovo* feeding of arginine and β-hydroxy- β-methyl butyrate and enhanced hepatic liver reserves was observed by providing the fuel needed for rapid subsequent growth during the critical post hatch period.

Bottje *et al.,* (2010) [8] injected dextrin-iodinated casein into fertile turkey eggs and reported a 1.8 per cent increase in weight gain in 6-day old poult weight.

Al-Daraji *et al.,* (2012) [4] found that Japanese quail chicks produced from eggs injected with different levels of arginine (1, 2 and 3 per cent) had significant increase on body weight at 7 and 42-day post hatch and body weight gain.

Dong *et al.,* (2013) [14] concluded that *in ovo* feeding of carbohydrates (2.5 per cent maltose + 2.5 per cent sucrose) in domestic pigeons on 14.5 day of incubation improved the body weight and pectoral muscle weight by elevating the pectoral muscle glycogen reserves at hatch.

Feed conversion ratio

Bhanja *et al.,* (2004b) [6] reported that apparently better FCR was found in amino acid injected chicks than that of control.

On conducting *in ovo* trial in broiler chicken, Kornasio *et al.,* (2011) [23] reported *in ovo* fed chicks showed optimal feed conversion ratio of 1.60 than that of the control group (1.72).

Zhou and Wang (2011) [40] fed chicken with nano elemental selenium supplemented diet containing 0.1, 0.3, 0.5 mg/kg of

selenium and reported improved feed conversion ratio value of 3.11, 2.89 and 2.90, respectively than that of control (3.31).
Bakyaraj *et al.,* (2012) [5] reported better feed conversion ratio of 2.17 at third week in mixture of amino acids (methionine, threonine, arginine, glycine, serine and valine) than sham control (2.21) in broiler.
In ovo injection of silver nano particles 10 mg/kg and 20 mg/kg and subsequent provision in the drinking water during the post hatch period reduced feed intake by about 5.0 g/day and body weight by about 41.0 g/day. However, no concurrent effect on feed conversion ratio was observed (Pineda *et al.,* 2012) [30].

Livability
Bakyaraj *et al.,* (2012) [5] conducted *in ovo* trial in broilers and reported that no significant difference was observed in livability percentage between treatment groups during the experimental period.

Histomorphology of Intestine
The administration of exogenous nutrients into the amnion enhanced the intestinal development by increasing the size of the villi thereby increasing the intestinal capacity to digest nutrients which probably leads to higher body weight in *in ovo* fed chicks (Tako *et al.,* 2004) [36].
Smirnov *et al.,* (2006) [34] conducted *in ovo* trial in Cobb embryos and reported that the administration of carbohydrates into amniotic fluid increased villus surface area in the small intestine at day of hatch and 3 days post-hatch by 27 and 21 per cent, respectively and also observed that the proportion of goblet cells containing acidic mucin increased 36 hrs after injection by 50 per cent compared to that of controls.
In ovo feeding of maltose solutions to the chicken embryo promoted the development of the villus of jejunum and thereby enhanced the absorption of nutrients (Jia *et al.,* 2011) [20].
In ovo supplementation of butyric acid increased the hatch weight of turkey poults, villi length of duodenum and jejunum at hatch as well as at the end of the starter period (Salmanzadeh *et al.,* 2015) [29].
In ovo feeding of carbohydrates (2.5 per cent maltose + 2.5 per cent sucrose) in domestic pigeons on 14.5 day of incubation increased the yolk sac nutrient utilization and enhanced the enteric development (Dong *et al.,* 2013) [14].

Carcass Characteristics
Upton *et al.,* (2008) [39] reported that selenium yeast influenced the carcass weight of broilers where the yield of legs and thighs were increased and pectoralis major decreased slightly in selenium treated birds compared to birds from the non-selenium supplemental group.
Zhou and Wang (2011) [40] fed chicken with nano elemental selenium supplemented diet and reported improved meat quality.
Sawosz *et al.,* (2012) [30] observed that nanoparticles of silver and the complex of silver with glutamine increased the number of nuclei per cell number, fibre area and increased the muscle mass in chicken.
In ovo feeding of broiler eggs with nano form of selenium at graded levels revealed significantly ht alighest (P<0.05) dressing percentage in control and 50 per cent inclusion (0.15 µg/egg) level of nano form of selenium. No significant variation (P>0.05) existed in breast muscle percentage between control and graded levels of nano form of selenium supplemented group (Joshua *et al.,* 2016) [21].
In ovo administration of IGF-1 to poultry eggs can mediate the expression of myogenic muscle regulatory factors (MyoG and MRF4), induce myoblast proliferation, and finally influence muscle development during the secondary muscle development in duck embryos (Liu *et al.,* 2011) [24].
Gaafar *et al.,* (2013) [17] reported higher dressing percentage in ducks injected with 0.5 ml of amino acid mixture.
Al-Daraji *et al.,* (2012) [4] injected L-arginine through *in ovo* route in Japanese quails and found that significant difference was appreciated in the proportional weights of the carcass, breast, legs, liver, heart and gizzard.
In ovo feeding of carbohydrates (2.5 per cent maltose + 2.5 per cent sucrose) in domestic pigeons on 14.5 day of incubation improved the pectoral muscle weight by elevating the pectoral muscle glycogen reserves at hatch (Dong *et al.,* 2013) [14].

Haematological Parameters
Abdul-Sahib (2008) [1] demonstrated that the *in ovo* injection of lysine and methionine in broiler breeder eggs resulted significant (P<0.01) increase in packed cell volume and total erythrocyte count as compared with those chicks hatched from control but no significant effect on haemoglobin and total leukocyte count in the treatment group.
Al-Daraji and Salih (2012) [3] reported that RBC, PCV, haemoglobin and WBC were improved significantly as a result of dietary supplementation of L-Arginine.
Tako and Glahn (2012) [35] reported that inulin administration into the amniotic fluid of the developing embryo followed by dietary regimen had improved the iron status of iron deficient broiler chickens, as indicated by the increased haemoglobin values.
Al-Asadi (2013) [2] observed that *in ovo* injection of amino acids had increased packed cell volume, total erythrocyte count, total leukocyte and haemoglobin concentration compared with control groups.
Mohapatra *et al.,* (2014) [26] recorded increased haemoglobin concentration and packed cell volume (PCV) percentage on feeding chicken with nano selenium supplemented diet.

Serum Biochemical Profile
Al-Daraji *et al.,* (2012) [4] injected L-arginine through *in ovo* route in Japanese quails and observed that different levels of arginine increased blood serum glucose, protein and total protein concentration.
Mohapatra *et al.,* (2014) [26] recorded increased serum glucose, total protein whereas total cholesterol decreased significantly than that of the control group when fed with nano selenium supplementation in diet.

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