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In Ovo feeding in poultry: A review

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Abstract
In ovo supplementation of nutrients is a technique to enhance the productivity of broiler chickens. Currently, more focus is being given to research works on *in ovo* supplementation of nutrients to augment hatchability and increase market weight at early age in broilers. Literatures pertaining to *in ovo* supplementation of nutrients are reviewed hereunder.

Keywords: *In ovo*, poultry, supplementation

Introduction

In Ovo Feeding

The first *in ovo* delivery of exogenous material was reported in 1980's for vaccination against Marek's disease (Sharma and Burmester, 1982) [41]. Uni and Ferket (2003) [19] invented and patented the concept of administrating a nutritive solution into the amniotic fluid so as to feed supplemental nutrients to the embryo which consumes the amniotic fluid prior to hatch (Romanoff, 1967) [32]. Therefore, delivering essential nutrients into the embryo intestine can be made possible by the addition of a nutrient solution to the embryonic amniotic fluid. Injected substances can be actively or passively ingested by the embryo *via* the amniotic fluid and can be subsequently absorbed into various organs prior to hatch (Jochemsen and Jeurissen, 2002; Uni *et al.,* 2005) [21, 47]. The *in ovo* feeding solution can be prepared with many potential nutrient supplements. The administration of nutrients into hatching eggs is called *in ovo* feeding (Uni *et al*., 2005) [21]. This *in ovo* feeding may 'jump-start' development, improving the nutritional status of the perinatal chick or poult (Ferket, 2011) [11].

Significance of *In ovo* Feeding

The nutrient content of the hatching egg influences the development and growth of embryos during incubation and the post-hatch performance of chicks (Al-Murrani, 1982; Shafey *et al.*, 2013) [2, 39]. The growth performance and meat yield of commercial poultry has improved linearly each year with greater input efficiency (Havenstein *et al.*, 2003) [19]. As the time it takes for meat birds to achieve market size decreases, the period of embryonic development becomes a greater proportion of a bird's life. Today, the 21 day incubation period and the 10 day post-hatch period of the chick composes about 50 per cent of a 2 kg broiler's life span, consequently early survival problems will increase as the poultry industry moves toward more fast-growing strains (Foye *et al.,* 2006a) [12]. *In ovo* feeding technology has established a new science of perinatal nutrition that will open opportunities for greater production efficiency (Ferket, 2011) [11].

Hamadani *et al.* (2013) [18] reviewed that *in ovo* feeding is expected to yield several advantages, among them reduced post hatch mortality and morbidity; greater efficiency of feed-nutrient utilization at an early age; improved immune response to enteric antigens; reduced incidence of developmental skeletal disorders; improved hatchability; increased muscle development and breast-meat yield and finally shortened the period required to reach target market weight. These benefits will ultimately reduce the production cost per kg of the consumable poultry meat.

In ovo feeding in different species of poultry

In ovo feeding has been carried out in broiler chicken to a large extent (Bhanja *et al.,* 2015; Kita *et al.,* 2015; Oliveira *et al.,* 2015) [4]. *In ovo* supplementation of nutrients has also been studied in ducks (Tangara *et al.*, 2010; Liu *et al.*, 2011; Selim *et al.*, 2012; Gaafar *et al.*, 2013) [14, 27, 38, 44], in turkeys (Gore and Quershi, 1997; Coles *et al.*, 2001; Foye *et al.*, 2006b) [7, 13, 17], in Japanese quail (Al-Daraji *et al.*, 2012) [1] and in pigeons (Dong *et al.*, 2013) [9].

Various routes of *in ovo* feeding

Various routes were adopted for *in ovo* feeding of nutrients in different species of poultry. Al-Murrani (1982) [2] was the first to attempt improving embryo body weight by adding amino acids to the yolk sac of chicken embryos at 7 days of incubation. Many other researchers have also attempted to study the administration of nutrients through yolk sac (Kadam *et al.*, 2008; Chamani *et al.*, 2012; Gaafar *et al.*, 2013; Moghaddam *et al.*, 2013; Salmanzadeh *et al.*, 2015; Shafey *et al.*, 2014; Bhanja *et al.*, 2015) [4, 5, 14, 23, 30, 40]. Intra amnionic nutrient administration accelerated small intestine development and had an enhanced effect on the function of enterocytes in chicken (Tako *et al.*, 2004; Uni and Ferket, 2004) [43, 46]. The embryonic avian amnion has proven to be an efficient site for *in ovo* injection (Zhai *et al*., 2008; Keralapurath *et al*., 2010; Dooley *et al.*, 2011; McGruder *et al.*, 2011a; Chamani *et al.*, 2012; Coskun *et al.*, 2014) [5, 8, 10, 24, 29, 49]. Substances in the amnion enter the embryo through the mouth and can be subsequently absorbed through the intestine, respiratory tract and lungs (Jochemsen and Jeurissen, 2002). The other routes of *in ovo* feeding is through albumen (Liu *et al.*, 2011; Salmanzadeh, 2012) [27, 35], allantoic cavity (Gonzales *et al.*, 2013) and air cell (Coles *et al.*, 2001; Al-Daraji *et al.*, 2012; Kita *et al.*, 2015; Madej *et al.*, 2015) [7].

In ovo supplementation of various nutrients

After the introduction of *in ovo* technique different nutrients were supplemented into the poultry species at various doses through different routes. Almost all the nutrients were given along with sterilized normal saline (Shafey *et al.*, 2014) [40].

Tako *et al.* (2004) [43] injected carbohydrates and β-hydroxy β-methyl butyrate supplementation through *in ovo* and studied their performance. The effect of maltose, dextrin, sucrose and β-hydroxy β -methyl butyrate (Uni *et al.*, 2005); maltose, sucrose, dextrin and sodium chloride (Smirnov *et al.*, 2006); sucrose and maltose and arginine (Tangara *et al.*, 2010) [44]; maltose (Jia *et al.*, 2011); dextrin and β-hydroxy β-methyl butyrate (Kornasio *et al.*, 2011); IGF-1 (Liu *et al.*, 2011) [27] and glucose, fructose, maltose, sucrose and dextrin (Zhai *et al.*, 2011) [10] were experimentally inoculated and studied.

Amino acids that were supplemented through *in ovo* includes arginine
(Foye *et al.*, 2006a; Al-Daraji *et al.*, 2012), threonine (Kadam *et al.*, 2008; Salmanzadeh *et al.*, 2011) [23, 35], glutamine (Chen *et al.*, 2010), lysine and arginine (Al-Asadi, 2013), arginine, histidine, methionine, phenylalanine, threonine, valine, lysine, tryptophan, leucine, isoleucine, proline, serine, alanine and cysteine
(Gaafar *et al.*, 2013) [14], glutamine (Shafey *et al.*, 2013) [39], lysine, arginine, glutamine, glycine and proline (Shafey *et al.*, 2014) [40], lysine, threonine, arginine, methionine and cysteine (Bhanja *et al.*, 2014) and isoleucine, leucine and valine (Kita *et al.*, 2015). Improved performance on supplementing vitamin E (Gore and Qureshi, 1997) [17], vitamins A, B_1, B_6, C and E (Bhanja *et al.*, 2006), vitamin E (Selim *et al.*, 2012) [38], vitamin D (Gonzales *et al.*, 2013) [16], vitamins A, B_1, B_2, B_6 and E (Goel *et al.*, 2013) [15] and vitamin E (Salary *et al.*, 2014) was reported. Minerals including iron, zinc, manganese, calcium, copper and phosphorus (Yair and Uni, 2011) [48], zinc, manganese and copper (Oliveira *et al.*, 2015) [31] and nano forms of copper, zinc and selenium (Joshua *et al.*, 2016) [22] were also administered *in ovo*.

In ovo supplementation of various nutrients: maltose, multivitamin supplements, zinc-glycine, glutamine (Santos *et al.*, 2010) [37], amino acids, trace elements, fatty acids and vitamins (Bakyaraj *et al.*, 2012) [3] and dextrose, amino acid mixture and albumin (Chamani *et al.*, 2012) [5] were also studied. Other nutrients or additives that were supplied through *in ovo* route includes L-carnitine (Dooley *et al.*, 2011) [10], theophylline and electrolytes (McGruder *et al.*, 2011a and 2011b) [29], royal jelly (Moghaddam *et al.*, 2013) [30], pollen extract (Coskun *et al.*, 2014) [8] and prebiotics and synbiotics (Madej *et al.*, 2015). *in ovo* feeding of fertile broiler eggs (18th day incubation, amniotic route) with 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) dissolved in normal saline along with control (*in ovo* fed only with normal saline) was found to improve the performance of broiler chicken (Chandiranathan *et al.*, 2015) [6].

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