

## Application of betaine as feed additives in poultry nutrition – a review

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### ABSTRACT

Heat stress is exposing birds to degrees of temperature higher than the optimal, which results in numerous health problems i.e. respiratory deficits decrease feed intake and thus lower weight at marketing age. Heat stress represents one of the most important factor that has negative effects on poultry production. Heat stress also leads to negative effects on the carcass properties and thus lower meat quality, consequently leads to severe shortage in the market. Most important solutions are using feed additives that have positive effects for resisting thermal stress. Betaine that has several other beneficial effects of mild heat stress. Most of the trials were reported slight positive effects; however, systematic results were rare. Since there are almost unlimited possibilities concerning dosage and products of betaine there is still more research required. Nevertheless, there is still further research under more standardized conditions needed to evaluate the right dosage and combination as well as the exact mechanism of actions of anti-stress effects of betaine.

**Keywords:** Betaine, Growth performance, Nutrient digestibility, Intestinal microbial population, Poultry.

### INTRODUCTION

Much research has been conducted to define and explore the importance of using betaine. Many feed additives include betaine have positive effects on heat stressed poultry (Attia et al., 2009). Betaine is not present in large quantities in poultry feedstuffs such as corn and soybean. The dietary betaine supplementation

is necessary to improve the productive performance and reduce the negative impact of heat stress on viability and immune response by improving cell osmoregulation (Graham, 2002; Wang et al., 2004; Attia et al., 2005). Awad et al. (2014) reported that betaine is a multi-nutritional agent that may help birds to resist poor management and heat stress. Additionally, it

has many benefits in improving carcass yield (Neoh and Ng, 2012) increasing breast percentage and decreasing abdominal fat (Jahanian and Rahmani, 2008) as well as decreasing mortality rate (Lukic et al., 2012). Other studies have indicated that betaine can cause improved growth, feed efficiency and breast yield (Waldroup et al., 2006; Rao et al., 2011), improved performance under heat stress and improved dressing percentage (Sayed and Downing, 2011). There is increasing evidence that it is a highly valuable feed additive in the diets of many farm animals (Hassan et al. 2011; Rao et al. 2011). However most previous thermal environment studies were conducted at cyclic or constant-acute heat stress conditions in closed environments which did not explain the effects of betaine on broilers reared at constant-chronic high temperatures that may impose chronic heat stress (Khattak et al., 2012).

Nevertheless, the uses of betaine in diets for poultry have been shown improvement in bird's immunity and increasing performance. In some studies the ability of betaine to be used as feed additives has already been proven and thus started to play a decisive role in nutrition of poultry. Anyhow, only limited research is available, which handicaps full comprehension of physiological and productive responses. Therefore, the purpose of this study is to give an overview on and definition of betaine feed additives such as mode of action, as well as on the use of these betaine in poultry diets with particular attention paid to feed intake, nutrient digestibility, and carcass criteria, intestinal microflora as well as performance characteristics.

#### **BETAINE COMPONENTS MODE OF ACTION**

Betaine has been a known functional nutrient in broiler nutrition that was previously

mainly used as betaine anhydrous extracted from sugar beets. Betaine is also available as betaine hydrochloride from synthetic production. Recent research highlighted that the nutritional properties of these products are equal, unveiling a less-expensive, non-hygroscopic source of betaine for the feed industry that is available year-round (Cretton and Der 2012). However, special care should be taken to ensure that the free-flowing properties of betaine hydrochloride are always maintained, since hygroscopicity may limit its application in feed mills (Cretton and Der, 2012). However, this theoretical application must be subjected to considerable analysis before practical implementation (Matthews et al., 2001; Zhan et al., 2006). The sparing effect of methionine and choline has been thoroughly investigated in poultry and, to a lesser extent, in pigs. Florou-Paneri et al. (1997) showed that between 30% and 80% of the supplemental methionine can be substituted by betaine without negative effects on performance.

#### **EFFECTS OF BETAINE ON PRODUCTIVE PERFORMANCE OF POULTRY**

Several studies have been conducted to explore the use of prebiotic on poultry performance. Awad et al. (2014) found using betaine at levels of 0, 0.5, 1.0 and 1.5 g/kg diet, had significant effects on live body weights and body weight gain, feed intake, feed conversion ratio and Viability rate (%). Nofal et al. (2015) found that used betaine at 0.1% and 0.2 % to the diet, they claimed that live body weight, body weight gain, feed conversion ratio and mortality rate had improved significantly ( $P \leq 0.01$ ). Also used betaine supplementation by 800 mg/kg to diets with five concentrations of methionine (Met) (15, 18, 20, 22 and 24 g/kg, they claimed that interaction between dietary methionine concentration and betaine

supplementation influenced significantly body weight gain at 21 d of age ( $p < 0.01$ ) and feed conversion efficiency at 42 d of age ( $p < 0.05$ ), while feed conversion efficiency at 21 d of age and body weight gain at 42 d of age were not affected ( $p > 0.05$ ) by the interaction (Rao et al. 2011).

Shaojun et al. (2015) reported that used betaine by (0.1% , 0.2% , 0.4 %) with heat stress in broiler chicks diets, they demonstrated that at the end of the experimental period, birds fed diet with betaine-supplementation had a higher feed intake, body weight gain and lower FCR. Likewise, supplementation of betaine at 0.05% and 0.075%, did not significantly effect on feed intake, body weight gain and feed conversion ratio (Sakomura et al., 2013). However, ElShinnawy, (2015) who found that used betaine by, 1.0, 1.5, 2.0 and 2.5 g/kg; the results obtained indicated that feeding diets supplemented with betaine had significantly increased live body weight, body weight gain. However, diet supplemented with different levels of betaine results in superior of feed conversion ratio (Tolba et al., 2007; Honarbakhsh et al., 2007; Zulkifli et al., 2004).

### **EFFECTS OF BETAINE ON NUTRIENT DIGESTIBILITY**

Ratriyanto et al. (2017) reported that betaine supplementation by 0.06 % and 0.12 % significant ( $P < 0.05$ ) increase in crude protein, crude fiber and have not any significant effects on dry matter. Similarly, dietary betaine supplementation was also shown to improve the digestibility of crude protein (Ezzat et al., 2011; Attia et al., 2016) and ether extract in laying chickens (Ezzat et al., 2011). Moreover, studies with broilers have revealed that betaine improved dry matter (Ratriyanto et al., 2014, Amerah & Ravindran, 2015) crude protein and

crude fiber (El-Husseiny et al., 2007 and Ratriyanto et al., 2014) and ether extract and nitrogen-free extract digestibilities (El-Husseiny et al., 2007).

Ratriyanto et al. (2009) reported that the addition of betaine by 1.5, 3.0 and 6 g/kg affect significantly ( $P < 0.05$ ) on crude protein and have no significant effects on crude fiber, dry matter and ether extract digestibility. Moreover, addition of betaine-rich condensed molasses soluble to the diet of piglets improved ileal digestibility of dry matter but had no effect on total tract dry matter digestibility (Eklund et al., 2006). Supplementation of betaine monohydrate did not improve ileal but faecal dry matter digestibility in piglets (Eklund et al., 2006). Higher ileal or faecal dry matter digestibilities following dietary betaine supplementation have also been reported by (Xu and Yu, 2000) in growing pigs, dietary betaine supplementation had no effect on total tract dry matter digestibility (Øverland et al., 1999; Fernandez-Figares et al., 2008). Also Attia et al. (2016) reported that betaine supplementation by 1000 mg / kg to laying hen diet resulted in significant ( $P < 0.001$ ) improve in crude protein, and there are any significant effects on crude fiber, dry matter and ether extract digestibility.

Awad et al. (2014) found that betaine supplementation by 0.5, 1.0 and 1.5 g/kg diet to domyati ducks resulted in no significant effects on dry and organic matter coefficient as well as ether extract due to betaine supplementation as compared to the control, in contrast crude protein, nitrogen free extract and crude fiber coefficients were significantly improved for the groups fed 1.0 and 1.5 g betaine /kg diet as compared to those fed the control diet. El-Husseiny et al. (2007) reported that digestion coefficient of crude protein; crude fiber and nitrogen free extract were significantly improved by

betaine supplementation to broiler chicken diets. Also, Ezzet et al. (2011) reported that the digestion coefficient of crude protein significantly increased by supplementing layer diet with betaine (1g/kg diet). Ratriyanto et al. (2009) found that using betaine by 4.5 g per kg in piglets diets effect significantly ( $P<0.05$ ) on ileal dry matter digestibility, but betaine supplementation did not affect ileal and total tract digestibilities of ether extract and crude protein. Supplementation of 0.8 g betaine or 2.5 g betaine monohydrate per kg diet improved total tract dry matter digestibility in piglets (Xu and Yu, 2000; Eklund et al., 2006).

In growing pigs, dietary supplementation of 5.0g anhydrous betaine per kg diet had no effect on total tract dry matter digestibility (Fernandez- Figares et al., 2008). Ratriyanto et al. (2009) used betaine by 0.2 they found that the supplementation of betaine alone or combined with inulin did not affect the ileal digestibilities of dry matter, crude protein, ether extract ( $P>0.05$ ). There is speculation if these effects can be attributed to improvements in enzymatic digestion of nutrients, a higher absorption capacity of the intestinal epithelium and/or to enhanced fermentation activity of intestinal microflora (Eklund et al., 2006; Ratriyanto et al., 2007).

### **EFFECTS OF BETAINE ON CARCASS CRITERIA**

Sakomura et al. (2013) said that, there was no significant effect on carcass, breast yield and internal organs of adding betain with negative control diet. However, Rao et al. (2011) found that breast weight at 21 day of age was significantly ( $p<0.01$ ) influenced by betaine addition. Nofal et al. (2015) reported that dietary betaine effects on carcass characteristics that carcass weight, dressing, thigh, breast

and giblets percentages were improved significantly ( $P\leq 0.01$ ) by betaine supplementation at levels of 0.1 or 0.2%. In contrary, Waldroup and Fritts (2005) did not find any improvements in breast meat yield of broilers fed diet containing 0.1% betaine. Breast yield improved significantly for ducklings fed diet supplemented with 1.5 g B/kg, 0.5 and 1.0 g B/kg, thigh yield was improved but without significant (Awad et al., 2014). Similar, ElShinnawy, (2015) reported that birds fed on rations supplemented with betaine showed significantly ( $P<0.05$ ) higher percentages of carcass yield, total edible parts and breast yield. On the other hand, the percentages of liver, gizzard and giblets were not affected by dietary treatments, the abdominal fat decreased significantly by the addition as reported by (Zhan et al., 2006).

### **EFFECT OF BETAINE ON MICROBIAL POPULATION**

Used betaine at 1.0 g/kg, they found that betaine supplementation did not affect *Eimeria* oocyst output or intestinal lesion scores or *Clostridium perfringens* in their ceca (Waldenstedt et al. 1998). Also Ratriyanto et al. (2009) used betaine at 4.5 g/kg, they reported that betaine supplementation resulted in increased ileal SCFA concentrations by 77.6 mmol/kg dry matter compared with the control treatment ( $P<0.05$ ), indicating intensified bacterial activity in the small intestine, however, betaine supplementation had no effect ( $P>0.05$ ) on ileal concentrations of lactic acid. Betaine is an effective osmolyte in many Gram-positive and Gram-negative bacteria, which can be accumulated by *de novo* synthesis or by transport from the environment (Csonka, 1989); dietary betaine can be considered as an efficient stimulus for the proliferation of bacteria harboring the digestive tract of pigs (Csonka, 1989).

## CONCLUSION

Generally, it can be concluded that betaine has the potential to be considered as an alternative to in feed-additives and improving productive performance and health status of poultry. Nevertheless, there is still further research under standardized conditions needed to evaluate the exact mechanism of action and to determine the optimal dietary inclusion level in order to optimize growth performance, nutrient digestibility and maintain healthy birds.

## CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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