Efficacy of betaine as carcass modifier in female broiler chickens to produce leaner carcass for human consumption

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Abstract. Betaine is a methyl group donor which involved in protein and energy metabolism, offering an opportunity to the poultry producers to satisfy consumer needs by producing leaner carcass. This study was conducted to investigate the efficacy of betaine as carcass modifier in female broiler chickens fed diet containing sufficient methyl group donor. Two hundred female day-old chicks (DOC) were allotted to four assay diets with 5 replicates of 10 birds. The starter and finisher diets contained 0.50 and 0.38% methionine as methyl group donor, respectively. The basal diets were fed without supplementation or supplemented with 0.10, 0.20 and 0.30% betaine. The assay diets were fed from the age 8–42 days. Two birds per replicate were slaughtered at the age of 42 days to measure the carcass characteristics. The fat content was derived from breast meat samples. Supplementation of betaine did not influence the slaughter weight, carcass and breast yield, indicating similar growth and carcass production. Furthermore, administration of betaine produced 29.8–42.5% lower abdominal fat pad deposition and 9.2–35.9% lower meat fat content than those without betaine administration (P<0.05). It can be concluded that betaine can modify carcass characteristic in female broiler chickens by lowering fat deposition.

1. Introduction
Broiler chickens have a high growth rate, good feed efficiency and can be slaughtered at a relatively young age between 35–42 days. To obtain optimal growth performance and good carcass quality, the broilers have to be provided with sufficient nutrient content in their diet. The nutritional requirements in intensive livestock farming are well known and can be met through a precise formulation [1]. However, there is a room to improve the growth rate or carcass characteristics by supplementation with a specific feed additive which influence the nutrient digestion or metabolism. For instance, betaine (trimethyl glycine) has been considered to improve growth rate and carcass characteristics in poultry [2] and pigs [3].

Due to its role as methyl group donor, betaine is involved in protein and energy metabolisms and has a potential to produce leaner carcass with low fat content [4]. In this regard, betaine is categorized as “carcass modifier” which refers to a substance that can modify and improve carcass composition and quality through specific metabolic pathway [4]. Therefore, it is expected that betaine may offer an interesting opportunity to the poultry producers to satisfy consumers need in term of leaner carcass for human consumption [5]. However, previous studies revealed that responses to the mode of actions of betaine as carcass modifier are still inconsistent [6,7]. Several studies reported improvement in carcass yield or breast yield in poultry [6,8] and reduction in carcass fat [9]. In contrast, other investigations indicated less pronounced responses of carcass traits or fat deposition following addition of betaine in the diet [7,10].
It is well known that the role of betaine as methyl group donor is associated with the present of methyl group originated form other sources in the diet. Thus, the level of other methyl group donors, such as methionine and choline, would affect its efficacy [4,11]. Furthermore, growth rate and carcass production in poultry are categorized as sex-related traits and exist a sexual dimorphism between male and female. Investigation with a certain gender would result a more accurate response rather than using unsexed birds. Therefore, this study was performed to investigate the efficacy of betaine as carcass modifier in female broiler chickens fed diet containing sufficient methyl group donor.

2. Materials and methods

2.1. Animals and diets

This study used 200 female day-old chicks (DOC) of broiler chickens of New Lohmann (MB 202) strain produced by PT. Japfa Confeed Indonesia with average body weight of 44.4±0.8 g. During adaptation for 7 days after arrival, the birds were kept with a standard brooding management according to the breeder. At 8 days, the birds with an average body weight of 149.5±2.5 g were allotted to 4 dietary treatments and 5 replicates with 10 birds per replicate. The 4 dietary treatments included a basal diet and a basal diet supplemented with 0.1, 0.2, and 0.3% anhydrous betaine (Betafin 96%, Danisco-Finnland). The diets were formulated based on maize and soybean meal to meet the nutrient requirements of broiler chickens according to Nutrition Research Council [12]. The starter and finisher diets contained sufficient level of methionine as methyl group donor amounting 0.50 and 0.38% methionine, respectively (Table 1). Betaine was supplemented to the diet at the expense of maize [13].

| Nutrients                  | Starter Diet | Finisher Diet |
|----------------------------|--------------|---------------|
| Metabolizable energy (kcal/kg) | 3200.51      | 3226.38       |
| Crude protein (%)           | 22.00        | 20.06         |
| Calcium (%)                 | 1.10         | 1.14          |
| Phosphorus (%)              | 0.47         | 0.57          |
| Lysine (%)                  | 1.19         | 1.10          |
| Methionine (%)              | 0.50         | 0.38          |

2.2. Data collection

The birds were raised on litter cages with the size 1.0 × 1.0 m for each replicate. The assay diets were given ad libitum from the age of 8 to 21 days during starter period, while the assay diets for finisher period were fed thereafter until 42 days. Accordingly, the birds have free access to water during the experiment. The ND B1, Gumboro and ND La Sota vaccines were applied according to standard from the producers.

At the end of experiment, 2 boiler chickens from each replicate (10 birds per treatment) were slaughtered after an overnight (12 hours) fast to measure the carcass characteristics [14]. Prior to slaughtering, the birds were individually weighed. Eviscerated carcass was obtained after the birds being sacrificed by removing the blood, feather, head, neck, shank and internal organs. Carcass and breast yield were determined as percentage of live body weight at slaughtering. The fat present in abdomen and attached at the gizzard was removed and weighed to measure abdominal fat deposition [14]. Samples of breast meat were collected and analyzed to measure the fat content according to the procedure of AOAC [15].

2.3. Statistical analysis

The data were checked for homogeneity and then analyzed with analysis of variance the effect of treatments. If the treatments showed significant effect, it was continued to Duncan’s test to analyze the difference between treatments [18]. The following mathematical model was applied: Y_{ij} = μ + α_i + e_{ij}
where μ was the grand mean, αᵢ was the deviation from the grand mean due to the treatment levels and εᵢⱼ was the error term. The R program was applied for statistical analyses [16].

3. Results and discussion

3.1. Slaughter weight, carcass and breast yield
Supplementation of betaine in the diet containing sufficient methionine did not affect slaughter weight, carcass and breast yield indicating similar growth and carcass production (Table 2). This result indicated that betaine is less efficient in improving protein deposition during carcass production when supplemented in the diet containing high level of methyl group donor. Efficacy of betaine as a carcass modifier is still inconsistent, which may be influenced by several factors such as methyl group donor level in the diet, betaine level and source, as well as age and species of the animal [4].

Betaine as a methyl group donor is expected to increase the availability of methionine for protein synthesis to produce optimal growth [17]. During the transmethylation reaction, betaine donates its labile methyl group to form methionine or other substances involved in protein and energy metabolism [4], as has been shown by Apicella et al. [18] that betaine enhanced protein synthesis. It is hypothesized; however, the betaine effect in this study may be masked by the high methionine content in the diet. Previous observation revealed that betaine showed higher efficacy under sub-optimal conditions [19], although Wang et al [8] did not find any effect of betaine supplementation in low-methionine diet on carcass yield in meat duck. In addition, Matthews et al. [20] reported that response to betaine was higher in broilers received coccidiosis challenge.

This study is in line with observation of Waldroup and Fritts [7], in which, supplementation of 0.1% betaine from ages 0 to 49 days to the diet containing sufficient methionine did not affect the body weight gain and carcass characteristics of male broilers. Moreover, other authors showed that body weight of broilers at 42 days was lower when the diet supplemented with 0.2% betaine [21], which may be due to lower availability of methyl acceptor than methyl group donor, resulting in lower efficacy of betaine [11]. Different to this study, previous observation showed that supplementation of 0.14% betaine to the diet containing 20, 21.5 and 23% protein enhanced carcass and breast yield without affecting body weight of unsexed broilers [2]. In addition betaine improved carcass composition, especially breast yield in broilers fed diet deficient in methionine [6].

| Parameters          | Betaine Supplementation (%) |
|---------------------|-----------------------------|
|                     | 0.0  | 0.1  | 0.2  | 0.3  |
| Slaughter weight (g) | 2002.42 | 2048.20 | 2012.19 | 2008.80 |
| Carcass yield (%)    | 67.83 | 69.91 | 68.46 | 68.25 |
| Breast yield (%)     | 36.31 | 37.49 | 36.09 | 36.14 |

3.2. Abdominal fat deposition and meat fat content
Supplementation of betaine in the diet containing sufficient methionine produced produced 29.8–42.5% lower abdominal fat pad deposition and 9.2–35.9% lower meat fat content than those without betaine administration (P<0.05). Supplementation of 0.1 and 0.2% betaine generated in a similar efficacy while 0.3% betaine showed the highest efficacy in lowering fat deposition (Table 3). This finding supports the hypothesis in which betaine has a potential role as carcass modifier [4,11]. Zhan et al. [22] reported that supplementation of betaine in the diet deficient in methionine decreased abdominal fat deposition in broiler chickens. A lower in abdominal fat deposition was also reported in broiler chickens and turkey due to betaine supplementation [9,23].

The role of betaine as carcass modifier in lowering fat carcass content can be attributed to several mechanisms associated with lipotropic activity. For instance, methyl group donated by betaine improves the synthesis of lecithin, carnitine, creatine and hormone-sensitive lipase activity which function to
prevent fat deposition [22,24]. Furthermore, since betaine is an oxidation product of choline, provision of betaine in the diet would improve choline availability. Choline is a precursor of very-low-density lipoprotein which can prevent deposition of fat in the body [25]. The more recent observation revealed that betaine has antioxidant function which prevent lipid peroxidation, associated with a better meat quality of broilers [26].

| Table 3. Abdominal fat and meat fat content of female broiler chickens fed diet containing sufficient methyl group donor and supplemented with betaine |
|-----------------------------------------------|
| Parameters                        | Betaine Supplementation (%) |
|-----------------------------------------------|
| Abdominal fat percentage (%)                      | 0.0 | 0.1 | 0.2 | 0.3 |
| 1.81a                                                   | 1.27b      | 1.24b      | 1.04c |
| Meat fat content (%)                             | 2.06a      | 1.87b      | 1.74b      | 1.32c |

a,b,c Means within a row followed by different superscripts differ significantly (P<0.05)

4. Conclusion
Supplementation of betaine in the diet containing sufficient methionine showed a high efficacy in decreasing fat deposition although less efficient in improving carcass yield, which associated with a high methyl group donor availability in the diet. This finding meets the consumers need in providing the leaner carcass. Betaine effect would be more pronounced when supplemented in the diet containing low level of methyl group donor.

References
[1] Li Y X, Wang Y Q, Pang Y Z, Li J X, Xie X H, Guo T J and Li W Q 2011 Int. J. Poult. Sci. 10 110–2
[2] Ratriyanto A, Indreswari R and Sunarto 2014 Int. J. Poult. Sci. 13 575–81
[3] Huang Q C, Xu Z R, Han X Y and Li W F 2008 Anim. Feed Sci. Technol. 140 365–75
[4] Ratriyanto A, Mosenthin R, Bauer E and Eklund M 2009 Asian-Australasian J. Anim. Sci. 22 1461–76
[5] Hassan R A, Attia Y A and El-Ganzory E H 2005 Int. J. Poult. Sci. 4 840–50
[6] McDevitt R M, Mack S and Wallis I R 2000 Br. Poult. Sci. 41 473–80
[7] Waldroup P W and Fritts C A 2005 Int. J. Poult. Sci. 4 442–8
[8] Wang Y Z, Xu Z R and Feng J 2004 Anim. Feed Sci. Technol. 116 151–9
[9] Amerah A M, Gimenez-Rico R D and Ravindran V 2013 Worlds. Poult. Sci. J. 69 1–3
[10] Esteve-Garcia E and Mack S 2000 Anim. Feed Sci. Technol. 87 85–93
[11] Ratriyanto A and Mosenthin R 2018 J. Anim. Physiol. Anim. Nutr. (Berl). In Press
[12] Nutrition Research Council 1994 Nutrient Requirements of Poultry (Washington DC: National Academic Press)
[13] Ratriyanto A, Mosenthin R, Jezierny D, Sauer N and Eklund M 2009 J. Anim. Feed Sci. 18 453–64
[14] Sun H, Yang W R, Yang Z B, Wang Y, Jiang S Z and Zhang G G 2008 Am. J. Anim. Vet. Sci. 3 78–84
[15] AOAC 2001 Official Methods of Analysis of the Association of Official Analytical Chemists (Washington DC)
[16] R Core Team 2015 R: A Language and Environment for Statistical Computing (Vienna: R Foundation for Statistical Computing)
[17] Eklund M, Bauer E, Wamatu J and Mosenthin R 2005 Nutr. Res. Rev. 18 31–48
[18] Apicella J M, Lee E C, Bailey B L, Saenz C, Anderson J M, Craig S A S, Kraemer W J, Volek J S and Maresh C M 2013 Eur. J. Appl. Physiol. 113 793–802
[19] Spreeuwenberg M, Hees H M J, Smits C H M, Paterson J E and Barker J A 2007 Manip. pig Prod. XI 14 186
[20] Matthews J O and Southern L L 2000 Poult. Sci. 79 60–5
[21] Konca Y, Kirkpinar F, Mert S and Yaylak E 2008 J. Anim. Vet. Adv. 7 930–7
[22] Zhan X A, Li J X, Xu Z R and Zhao R Q 2006 Br. Poult. Sci. 47 576–80
[23] Al-Shukri A Y, Kaab H T and Abdulwahab H M 2012 Kufa J. Vet. Med. Sci. 3 12–20
[24] Saunderson C L and Mackinlay J 1990 Br. J. Nutr. 63 339–49
[25] Yao Z and Vance D E 1989 J. Biol. Chem. 264 11373–80
[26] Alirezaei M, Gheisari H R, Ranjbar V R and Hajibemani A 2012 Br. Poult. Sci. 53 699–707