Effects of feed form on small intestine histomorphology of broilers

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Abstract. This experiment was conducted to study the effects of different feed forms on small intestine histomorphology of broiler chicken at 35 days of age. A total of 72 unsexed New-Lohman broiler chicks was placed into three treatments with three replications of 8 chicks. Feed treatments were given in two phases: 0-21 days and 22-35 days. The treatments group consisted of T1 (0-21 days: mash form, 22-35 days: mash form, defined as mash: mash), T2 and T3 were crumble:crumble and crumble: pellet form, respectively. Parameters evaluated were small intestine (duodenum, jejunum, and ileum) histomorphology (villus height, villus width, crypt depth, and villus height to crypt depth ratio), as well as their weight (g) and length (cm). Data were analyzed using analysis of variance followed by Duncan’s Multiple Range Test. Villus height, crypt depth, and villus height to crypt depth ratio in the duodenum and jejunum of T1 were lower than T2 and T3. The length and weight of duodenum and jejunum of T2 and T3 were higher than T1. It can be concluded that broilers fed by crumble: crumble and crumble: pellet form could improve the development of small intestine as well as its histomorphology.

1. Introduction

Chicken behavior when pecking the mash forms is different from crumble and pellet form. Chickens tend to spend more time in the process of consuming mash form because it is in the form of flour. The more chickens peck, the more energy is released. Neves et al. [1] added that the pellet form was able to reduce the time during the pecking process of feed because the feed was in a compact form so that the chicken was easily full. Chickens can increase rest time because the energy released for eating becomes less, thus it increases the availability of energy for production.

The crumble and pellet form might improve feed efficiency. Chicken body weight increased during the starter and grower periods given crumble and pellet feed because there was an increase in feed consumption up to 8% in that period [2]. The rapid increase of body weight in the starter period to grower along with the development of digestive organs in chickens. According to Lumpkins [3], the chicken digestive organs that develop are related to the performance of the small intestine as nutrient absorption site. This is also supported by production of digestive enzymes by the pancreas which affects the development of the digestive tract. Based on the description above, this research investigated the histomorphology of the small intestine in chickens for the age of 35 days given different feed forms.
2. Material and methods

2.1. Material
A total of 72 unsexed New-Lohman broiler chicks was randomly placed into three treatments. The feed used for this study were commercial broiler feed with a particle shape which is divided into three forms, namely mash, crumble and pellet.

2.2. Methods
Feed treatment was given in two phases: 0-21 days and 22-35 days. The treatment group consisted of T1 (0-21 days: mash form, 22-35 days: mash form, defined as mash: mash), then T2 and T3 were crumble: crumble, and crumble: pellet, respectively. Each group consisted of three replications and each replication consisted of 8 chicks. Parameters evaluated in the current study were weight (g), length (cm), and small intestine (duodenum, jejunum, and ileum) histomorphology (villus height, villus width, crypt depth, and villus height to crypt depth ratio).

All observed data were analyzed using analysis of variance followed by Duncan’s Multiple Range Test.

3. Results and discussion

3.1. Histomorphology of small intestine
The results of the histomorphology measurements of broiler small intestine in the treatment of different feed forms are listed in Table 1.

|                | T1 (mash:mash) | T2 (crumble:crumble) | T3 (crumble:pellet) |
|----------------|---------------|----------------------|---------------------|
| **Duodenum**   |               |                      |                     |
| Villus height (µm) | 1013 ± 14.17<sup>a</sup> | 1069.67 ± 37.82<sup>ab</sup> | 1131.33 ± 40.46<sup>b</sup> |
| Villus width (µm) | 152 ± 46.51   | 184 ± 18.23          | 142.33 ± 24.01      |
| Crypt depth (µm)  | 140.39 ± 5.59<sup>a</sup> | 155.15 ± 3.94<sup>b</sup> | 154.02 ±4.88<sup>b</sup> |
| Villus height to crypt depth ratio | 7.22 ± 0.18<sup>ab</sup> | 6.90 ± 0.29<sup>a</sup> | 7.35 ± 0.11<sup>b</sup> |
| **Jejunum**     |               |                      |                     |
| Villus height (µm) | 1.649.20 ± 57.82<sup>a</sup> | 1.650.20 ± 10.56<sup>a</sup> | 1.750.90 ± 25.88<sup>b</sup> |
| Villus width (µm) | 154.33 ± 55.18<sup>a</sup> | 229.00 ± 2.65<sup>b</sup> | 193.00 ± 18.36<sup>b</sup> |
| Crypt depth (µm)  | 208.89 ± 7.59<sup>a</sup> | 193.67 ± 3.34<sup>b</sup> | 190.90 ± 10.15<sup>b</sup> |
| Villus height to crypt depth ratio | 7.89 ± 0.07<sup>a</sup> | 8.52 ± 0.13<sup>ab</sup> | 9.19 ± 0.59<sup>b</sup> |
| **Ileum**       |               |                      |                     |
| Villus height (µm) | 1897.00 ± 177.74 | 1761.33 ± 425.79 | 1940.67 ± 199.10 |
| Villus width (µm) | 178.00 ± 34.78 | 159.33 ± 11.55 | 217.00 ± 58.97 |
| Crypt depth (µm)  | 177.65 ± 7.08 | 182.88 ± 6.93 | 170.70 ± 4.30 |
| Villus height to crypt depth ratio | 10.72 ± 1.39 | 9.58 ± 1.91 | 11.39 ± 1.47 |

<sup>a,b,c</sup> Different superscripts in the same column show significant differences (P <0.05)

The small intestine histomorphology showed that villus height and cryptic depth of T2 and T3 were higher than T1 (P<0.05). Zang et al. [4] explained that chickens fed pellets showed longer villi than mash forms. The villi length could increase because of intestinal mucosal activity elevation in chickens given pellet form compared to mash form. The increase of villus height in chicken given pellet form corresponds to an increase of growth performance. The higher villus could increase the
surface area of absorption in the luminal capillaries and subsequently produce sufficient digestive enzymes and their nutrients transport on the surface of the villi.

The small intestinal histomorphology showed that villus height, villus width and cryptic depth of T2 and T3 were higher than T1 (P<0.05). The villi width significantly increased in the small intestine of the chicken fed crumble-pellet rather than mash-mash, but these results were not different with the crumble-crumble treatment. The surface area of the small intestine is influenced by the length and width of the intestinal villi. The surface area of the small intestine can affect the ability to digest and absorb the feed, thus an increase in broiler chicken productivity can be associated with the increase in absorption activity in the small intestine. The increase in weight and length of the small intestine might be accompanied by the increase in surface area of the small intestine [5].

The villi height, villi width, crypt depth, and their ratio were not affected by different feed forms (P> 0.05) in the. This shows that nutrient absorption has been maximally applied to the duodenum and jejunum. Svihus et al. [6] stated that the ileum is the last segment of the small intestine and ends in ileo-caeca-colic. Ileum plays a role as water and mineral absorption site, while the absorption of starch, fat, and protein is mostly present in the jejunum.

3.2. Length and weight of small intestine
The weight and length of small intestine in the treatment of different feed forms are listed in Table 2.

|                  | T1 (mash:mash) | T2 (crumble:crumble) | T3 (crumble:pellet) |
|------------------|----------------|----------------------|---------------------|
| **Duodenum**     |                |                      |                     |
| Length (cm)      | 25.13 ± 1.3a   | 28.63 ± 0.58b        | 30.23 ± 0.45c       |
| Weight (g)       | 7.9 ± 0.05a    | 9.41 ± 0.05b         | 10.43 ± 0.45c       |
| **Jejunum**      |                |                      |                     |
| Length (cm)      | 56.87 ± 0.47a  | 56.8 ± 0.85          | 58.27 ± 1.08        |
| Weight (g)       | 15.72 ± 0.06a  | 16.29 ± 0.05b        | 16.37 ± 0.13b       |
| **Ileum**        |                |                      |                     |
| Length (cm)      | 49.77 ± 0.04b  | 46.47 ± 2.20a        | 51.43 ± 1.25b       |
| Weight (g)       | 11.05 ± 0.57b  | 8.68 ± 0.28a         | 12.46 ± 0.84c       |

*a,b,c* Different superscripts in the same column show significant differences (P <0.05)

The length and weight of duodenum and jejunum of T2 and T3 were higher than T1 (P<0.05), while T2 was not significantly different compared to T3. This shows that the form of crumble-pellet feed stimulated the optimal absorption of nutrients and stimulated the development of the digestive tract. The growth of the morphology of the small intestine might be faster, thus influencing the development of intestinal villi.

Intestinal development is related to gizzard development. The coarse particle in the feed causes the bigger the gizzard, but this particle increases digestive efficiency due to increased permeability to digestive enzymes. The digesta contains a mixture of large and small particles, with small particles occupying space between larger particles. These results could decrease the empty space cavity available for permeation. Thus, increasing the number of coarse particles can cause an increase in enzyme absorption [7].

4. Conclusion
It can be concluded that forms of crumble:crumble and crumble:pellet form could improve the development of small intestine and histomorphology of broiler chickens.
5. References

[1] Neves D P, Banhazi T M and Naas A I 2014 *Braz. J. Poult. Sci.* 21–16
[2] Lv M, Yan L, Wang Z, An S, Wu M and Lv Z 2015 *J. Anim. Nutr.* 1 252–6
[3] Lumpkins B S 2007 *Evaluation of intestinal development and the bacterial community in the gastrointestinal tract of poultry* (Athens: Ph.D. Thesis. University of Georgia)
[4] Zang J J, Piao X S, Huang D S, Wang J J, Ma X and Ma Y X 2009 *J. Anim. Sci.* 22 107–112
[5] Yamauchi K 2002 *J. Poult. Sci.* 39 229–242
[6] Svihus B, Hetland H, Choct M and Sundby F 2010 *British Poult. Sci.* 43 662–668
[7] Roger G, Lente R G, Ravindran V, Ravindran G and Thomas D V 2006. *J. Poult. Sci.* 43 135–142