Newsletter

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> EDITORIAL

Early functions of the gastrointestinal tract (GIT) are vital for the chicken´s growth performance. Therefore, it is crucial to achieve optimal intestinal development and functional capacity. The intestine of hatchlings increases in weight as much as five times more rapidly than most of the other organs or body mass. The fast development of the intestinal mucosa with villi, crypts and enterocytes is essential for absorption of nutrients. Many studies have done histological investigations to determine changes in the intestinal tissue as the mucosal architecture can reveal useful information on the intestinal function. The investigation of intestinal dynamics is important to understand both digestive physiology and the efficiency of animal production. The gastrointestinal tract can adapt and react morphologically to external factors related to dietary changes. For example, an increase of the mucosal surface area could result in an improved capacity of absorption of available nutrients. Recent data from in vivo experiments showed that the addition of the synbiotic products PoultryStar® and Biomin® IMBO to broiler diets had a positive effect on gut morphology which could be connected to better production.

Enjoy reading.

Michaela Mohnl

Biomin® probiotic product line

The development of the gastrointestinal tract (GIT) begins already shortly after epithelial cells form a tube in the embryo. The intestine – including the external muscular layers and the villi - are growing fast and morphology of the small intestine changes rapidly. Immediately after hatching further rapid changes with significant morphological development of the small intestine are observed. The GIT must be ready to take in nutrients that will sustain the birds life and provide a barrier to external changes.

Effects of synbiotic feed additives on intestinal morphology of poultry

Morphology and structure of the small intestine

The inner surface of the small intestine is not flat, but thrown into circular **mucosal folds**, which not only increase surface area, but aid in mixing the ingesta by acting as baffles. The mucosa forms intestinal **villi** which are tiny, finger-like projections that come out from the wall of the small intestine and increase the absorptive area and the surface area of the intestinal wall providing efficient absorption of nutrients in the lumen. **Crypts** are moat-like invaginations of the epithelium around the villi. Towards the base of the crypts are stem cells, which continually divide and provide the source of all the epithelial cells in the crypts and on the villi. Intestinal cells are derived from the crypt and migrate along the length of the crypt-villus axis. The cells undergo differentiation as they migrate, becoming fully functional digestive/absorptive **enterocytes**, mucous secreting **goblet cells**, or peptide hormone producing **entero-endocrine cells** or antimicrobial peptide/protein secreting **paneth cells**. These changes are both structural and functional. As the cells reach the villus tip, they undergo apoptosis and are shed into the intestinal lumen to be come part of the ingesta to be digested and absorbed. The villi are covered predominantly with mature, absorptive enterocytes.

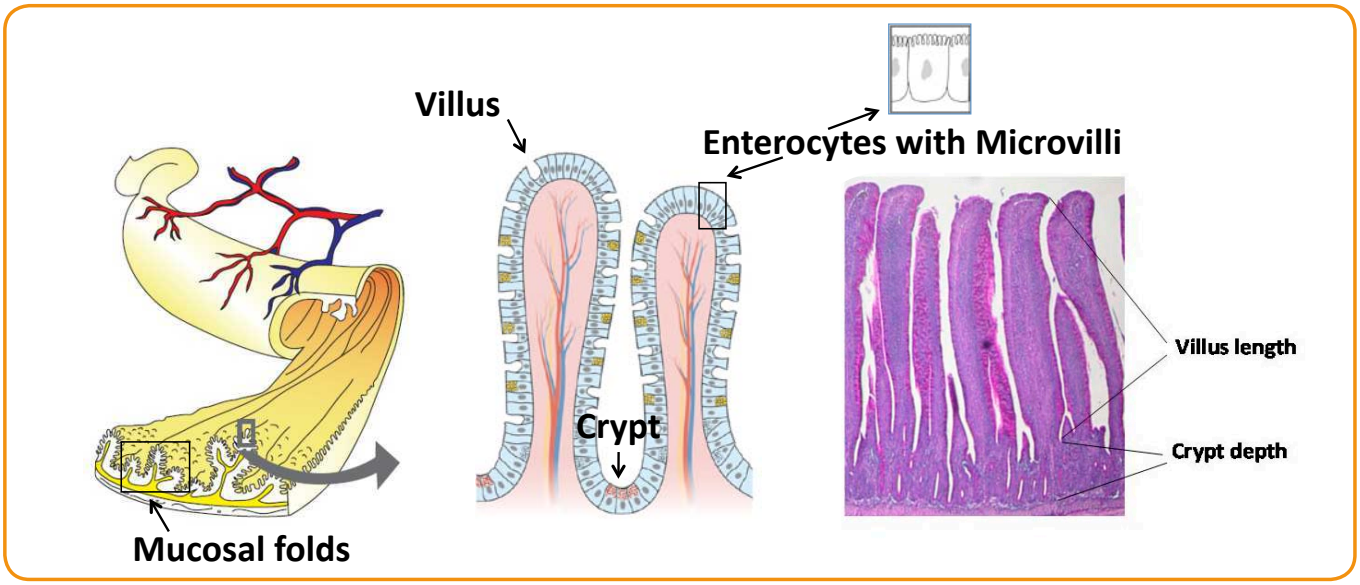

Figure 1: *Gut morphology*

Microvilli on the apical surface of enterocytes increase surface area for the digestion and transport of molecules from the intestinal lumen. The epithelium renews itself faster than any other tissue in the body, replacing itself in as little as 2 days (*Figure 1*).

In addition to performance parameters feeding trials can be evaluated by histological examination of the gastrointestinal tract. It is well known that many substances can affect the intestinal villi development. The GIT can adapt and react morphologically to external factors related to dietary changes, i.e. addition of probiotics and prebiotics (Huisman *et al.*, 1990; Van der Klis and Van der Voorst, 1993). Many studies have done histological investigation to determine changes in the intestinal tissue as the intestinal mucosal architecture can reveal useful information on the intestinal function. Enterocyte enzymatic activity and structure are two of the most important features of the intestinal mucosal physiology. It was reported that the intestine can change its surface by growing in length, and/or by increasing or decreasing the height of its villi (Iji *et al.*, 2001). By growing in length, and/or by increasing or decreasing the height of villi and microvilli, it is possible to change its effective surface area. Fusion and shortening of villus can lead to a loss of surface for digestion and absorption of nutrients and lower performance (Xu *et al.*, 2003). Increasing the villus height suggests an increased surface area capable of greater absorption of available nutrients (Caspary, 1992) and enterocytes, which are generated in the crypts and travel along the crypt-villus axis, have more time to fully differentiate and to fulfill their digestive and absorptive functions. The villus crypt is considered as the villus factory and deeper crypts indicate fast tissue turnover to permit renewal of the villus as needed in response to normal sloughing or inflammation from pathogens or their toxins and high demands for tissue (Yason *et al.*, 1987). The gut epithelium has the fastest rate of renewal of any tissue in the body. Because energy required to maintain the gut accounts for about 25 % of the total basal metabolic needs of an animal (Croom *et al.*, 2000), any reduction of need for renewal of gut tissue can have a significant impact on the amount of energy available for growth and caloric conversion efficiency.

Methodology of gut morphology measurements

For gut morphology measurements samples from intestinal gut sections of interest like duodenum, jejunum or ileum are taken and fixed in a fixative (eg. glyoxal, formalin, Bouin solution) to preserve the soft and delicate structures. After histological procedure and cutting with a microtome the samples are fixed on slides and stained with hematoxylin and eosin. With the PAS (Periodic acid Schiff)-staining, morphological characteristics, like villus height and crypt depth, can be evaluated, additionally goblet cells are stained magenta. The slides are examined with a light microscope and software for image analysis. Villus height is measured from the tip of the villus to the villus-crypt junction, while crypt depth is defined as the depth of the invagination between adjacent villi (*Figure 1*).

BIOMIN´s synbiotic products, **Biomin IMBO®** and **PoultryStar®**, were designed to improve gut health and make animals more resistant to pathogenic infections. With the development of this product line which combines the beneficial effects of probiotics, prebiotics and defense strengthening substances on the gastrointestinal tract BIOMIN served the needs of the industry for natural feed additives which can improve the gut health, well-being and performance of animals and are well received by consumers. To get a better insight into the mode of action of this product line the effect on the histomorphological structure of the GIT of chickens was studied in the course of feeding trials.

Effects of PoultryStar® sol and Biomin® IMBO on gut morphology and growth performance of broilers

A study was conducted by the Faculty of Agriculture, University Novi Sad, Serbia to evaluate the effect of the synbiotic products PoultryStar® sol and Biomin® IMBO on performance and gut morphology of broilers (Peric *et al.*, 2010). 456 day-old broiler chicken (mixed-sexed; Cobb 500) were randomly divided into 2 groups with 6 replicates per group and 38 birds per replicate. Animals of both groups were fed a standard corn-soy based diet in a three diet feeding program (starter 0-21 days, grower 22-35 days and finisher 26-42 days). Feed and water was provided to all broilers *ad libitum*. The experimental group received PoultryStar® sol via the drinking water on day 1, 2 and 3 and Biomin® IMBO via the feed in the amount of 0.1 % during the starter phase, 0.05 % during the grower phase and 0.025 % during the finisher phase, while the control group was given diets without the stated preparation. The birds were kept under observation for 42 days and performance parameters and gut histomorphology were determined. The results of the histomorphological investigations of the jejunum revealed a beneficial effect of the synbiotic feed additives causing a significant increase ($P<0.005$) in villus height and villus surface area compared to the control group (*Table 1*).

Table 1: *Effect of synbiotic feed additives in broiler diets on the jejunum morphology in broilers (measured after 42 days)*

PoultryStar® sol & Biomin® IMBO	گروه شاهد	
۱۴۷۴/۵^{b}	۱۱۳۳/۱^{a}	ارتفاع پرز
۲۸۱/۹۵	۲۴۵/۸۱	عمق کریپت (میکرومتر)
۵/۳۲	۴/۶۹	نسبت پرز/ کریپت
۰/۱۷۶^{b}	۰/۱۲۰.^{a}	سطح تماس پر ز (میلی متر مربع)
۱۱۳/۸۶	۱۰۴/۷۹	عرض پرز (میکرومتر)
۱۸۱/۴۸	۱۷۰/۵۲	عرض غشای ماهیچه ای (میکرومتر)

[a, b] Means within a row with different superscripts differ significantly (P<0.005)

This could be connected to better production results because of a better capacity for absorption of available nutrients. By the addition of PoultryStar® sol and Biomin® IMBO the body weight was significantly (P<0.01) increased and feed conversion ratio numerically decreased (P>0.05) in comparison to control. Through the application of these synbiotic products the European Production Efficiency Factor (EPEF) which summarizes all performance data could be clearly improved in comparison to the control group (*Table 2*).

Table 2: *Effect of synbiotic feed additives in broiler diets on the zootechnical performance of broilers*

	Control group	PoultryStar® sol & Biomin® IMBO
Live weight day 21 (g)	646^{a}	688^{b}
Live weight day 42 (g)	2135^{a}	2184^{b}
FCR day 21	1.52	1.48
FCR day 42	1.91	1.89
Mortality (%) day 42	3.07	3.07
EPEF*	258	267

[a, b] Means within a row with different superscripts differ significantly (P<0.01)
* EPEF (European Production Efficiency Factor) = Liveability [%] x Live weight [kg]/age [d] / FCR x 100

These data indicate that synbiotic products added to broiler diets can positively influence gut histomorphology and performance, thus potentially contributing to overall productivity.

Effects of Biomin® IMBO on intestinal structure and growth performance of broilers

An experiment was conducted in cooperation with the Institute of Nutrition, Department of Veterinary Public Health and Food Science, University of Veterinary Medicine, Vienna, Austria to evaluate the effects of the synbiotic product Biomin® IMBO on growth performance and intestinal histomorphology of broiler chickens (Awad *et al.*, 2009). 400 day-old broiler chicken (mixed-sexed; Ross 308) were split into 2 groups and randomly allocated to 8 replicates per group with 25 birds each. The birds were housed in floor pens with concrete floor and wire nettings on wood shavings. All pens were equipped with nipple drinkers and automatic feeders. Animals of both groups were fed a standard corn-soy based diet. Feed and water was provided to all broilers *ad libitum*. The experimental group was fed diets with added Biomin® IMBO in the amount of 0.1 % during starter phase and 0.05 % during grower phase, while the control group was given diets without the stated preparation. The birds were kept under observation for 35 days and performance parameters and intestinal histomorphology were determined. Results showed that the dietary treatment influenced the histomorphological measurements of the small intestinal villi. The addition of Biomin® IMBO increased (P<0.001) the villus height and villus height/crypt depth ratio and decreased the crypth depth in ileum compared with controls (*Table 3*).

Table 3: *Effects of dietary inclusion of Biomin® IMBO on the intestinal morphological parameters of broilers*

Parameter	Control group	Biomin® IMBO
Duodenum		
Villus height (µm)	1640 ± 26	1647 ± 11
Crypt depth (µm)	149 ± 32	149 ± 46
Villus height/crypt depth	11.45 ± 0.25	12.00 ± 0.28
Ileum		
Villus height (µm)	614^{b} ± 15	774^{a} ± 10
Crypt depth (µm)	128^{a} ± 2	117^{b} ± 2
Villus height/crypt depth	4.86^{a} ± 0.11	7.13^{b} ± 0.15

[a, b] Means within a column with different superscripts differ significantly (P<0.001). Independent sample t-test, n=10/treatment

The increase in the villus height and villus height /crypt depth ratio was associated with improvement of growth performance. By the addition of the Biomin® IMBO daily weight gain (+5.4 %) could be significantly increased in comparison to the control group (P<0.05). Furthermore FCR was 7.4 % lower in the experimental group. Through the application of Biomin® IMBO the European Production Efficiency Factor (EPEF) was clearly improved by 13 % (*Table 4*). This indicates that the synbiotic Biomin® IMBO can be used as a growth promoter in broiler diets and can improve gut health.

Table 4: *Effect of dietary inclusion of Biomin® IMBO on zootechnical performance of broilers after 35 days*

	Control group	Biomin® IMBO
Daily weight gain (g)	49^{b}	52^{a}
Live weight (g)	1754^{b}	1847^{a}
FCR	1.89	1.75
Mortality (%)	3.5	3.5
EPEF*	256	291

[a, b] Means within a column with different superscripts differ significantly (P<0.05) Independent sample t-test, n=200/treatment
* EPEF (European Production Efficiency Factor) = Liveability [%] x Live weight [kg]/age [d] / FCR x 100

Conclusion

The present studies showed that addition of the synbiotic products PoultryStar® and/or Biomin® IMBO to broiler diets had a positive effect on gut morphology. These changes were represented by elongated villi and a higher villi/crypt ratio, which indicates a lower rate of enterocyte-cell migration from the crypt to the villus. When less energy is needed for renewal of the gut ephitelium more energy is available for growth efficiency. Feeding of the synbiotics increased the villus surface area which consequently may lead to higher nutrients absorption. Thus, it can be speculated that increased integrity of the gastrointestinal tract associated with a higher surface area of the villi, resulted in improved production results. It is suggested that synbiotics could reduce both the damage of enterocytes and the need for cell renewal in the gut.

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