

Histological characteristics of the gastrointestinal tract organs of broilers of the Smena 8 and Cobb 500 crosses

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Abstract. A comparative study of the growth patterns of the layers of the digestive tube was conducted in two broiler crosses, Smena 8 and Cobb 500. Histological studies were performed on days 1, 7 and 42. Sections were stained with hematoxylin and eosin. The size of the layers was measured on sections of the glandular section of the stomach and intestine, and relative values were calculated. In the Smena 8 cross, by the end of the experiment, compared with the daily age, the relative size of the mucous membrane of the glandular section of the stomach (6.1%) and the villi of the proximal part of the cecum (5.9%) decreased, while the relative size of the submucosa of the stomach (2.3%), villi of the duodenum (1.5%) and the muscular membrane of the proximal part of the cecum (7.5%) increased. In the Cobb 500 cross, changes in these structures were in the opposite direction. The villi of the jejunum and proximal part of the cecum increased by 8.2 and 21.6%. In both crosses, the relative size of the crypt layer and the muscular plate of the mucous membrane in the jejunum and proximal part of the cecum decreased. At the age of one week, the submucosa of the glandular part of the stomach in the Cobb 500 cross increased by 9.9%. We assume that better development of the submucosa of the stomach at the beginning of life together with the development of villi of the jejunum and proximal part of the cecum contribute to more effective formation of productive qualities of broilers of the Cobb 500 cross.

1 Introduction

Poultry products occupy a leading position in the meat industry in terms of production volume. Therefore, the most important criteria are the quality and safety of the manufactured products [1]. Safety is determined primarily by compliance with sanitary standards at all stages of production [2]. In addition, the quality of poultry products is influenced by many factors: feeding [3-5], microclimate parameters, conditions of keeping birds [6], etc. But one of the main factors influencing zootechnical indicators is the genetic potential of crosses, which lays the foundation for the formation of productive qualities.

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The study by Zherebtsov N.S. showed that the live weight, average daily gains and survivability of chickens of the Cobb 500 cross were higher than those of the Smena 8 cross [7].

The gastrointestinal tract of birds has a number of adaptive structural features, such as the division of the stomach into glandular and muscular sections. A feature of the histological structure of the glandular part is the location of the glands in the submucosa and, consequently, the predominance of this layer in the structure of the organ wall [8]. In the microstructure of the intestine, the main features are the presence of villi along the entire length of the tube and the absence of duodenal glands in the submucosa. However, some authors believe that there are no villi in the cecum of chickens, and the outgrowths of the mucosa are its folds [9]. Some researchers describe a muscular plate and a submucosa in the structure of the intestinal mucosa [10]. Some authors do not identify these structures [11].

The intestine, participating in digestion and absorption, primarily reacts to feed components. All nutritional factors affect the histostructure of the intestinal wall of birds: the degree of grinding of feed particles [12], the composition and type of nutrition [13, 14], the presence of feed additives [5, 8, 15]. Some authors note that the use of probiotics increases the height of the villi and the depth of the crypts in the jejunum of chickens [16]. Some researchers also note that the response of the intestinal wall to the introduction of additives may be different in different areas. In the Ross 308 cross, when the feed additive vinasse was introduced, the height of the villi in the jejunum did not change, but in the ileum, compared to the control group, it increased. The height of the crypts increased in both the jejunum and ileum [17].

High productivity rates of modern poultry crosses are due to genetic factors that can determine the morphofunctional features of the digestive tract and thus affect the digestion and absorption of nutrients. Studies of different broiler lines have shown reliable significant differences in such parameters as the mass of the glandular stomach, jejunum and ileum, the height of the villi and the number of goblet cells [18]. In Koob 500 cross chickens, compared to Plymouth Rocks, the height of the villi was higher, but the depth of the crypts in the small intestine was smaller [19]. Studies of the small intestine of Ross 308 broilers revealed a three-layer structure of the muscular membrane. It is noted that the villi were more branched in the proximal section, and in particular in the duodenum [11]. The length of the intestine in chickens of this cross is greater than in parental lines [20]. The histological structure in the small intestine is subject to changes in the process of growth and formation; in Ross 308 broilers, it was noted that the height of the villi during the first period of growth significantly increases in the distal part, and by the end of growth - in the proximal part of the duodenum [21]. Different crosses have different rates of formation of the organ wall structures. According to Matveev O.A., by 45 days of age, morphological changes in both the small and large sections of the intestine of Arbor Acres cross chickens are completed [10].

Knowledge of the microstructure features of different parts of the gastrointestinal tract is necessary for the formation of optimal diets and justification of the use of feed additives. Studying the histological structure of the digestive system of chickens of different crosses will help to understand the relationship between the structure of organs and the formation of productive qualities. This will allow full realization of genetic potential and optimization of feed costs.

2 Materials and methods

To conduct a comparative study of the digestive tract, the Smena 8 and Cobb 500 broiler crosses were used. For histological studies, broilers were selected from among those of

average weight at the age of one day before the start of feeding, three heads at the age of 7 and 42 days. The birds were weighed, killed by decapitation, the glandular section of the stomach, the duodenum, jejunum and the proximal part of the cecum were removed. Fragments from the middle of the organs were fixed in 10% buffered formalin. Wiring, compaction, and preparation of histological sections were carried out according to Suvarna [22]. On the sections, the size of the layers was measured using an ocular ruler, the conversion factor into micrometers was determined using an object-micrometer. The relative size of the mucous, submucosa and muscular membranes was calculated, and in the intestine - also the relative size of the layer of villi and crypts. Statistical processing of data was carried out in Excel.

3 Results

In the glandular section of the stomach we studied the mucous, submucous and muscular membranes. In broilers of the Smena 8 cross in the studied periods (from the first day to 42 days of age) the relative values of the mucous membrane decreased from 24.3 to 17.5% due to the folds of the mucous membrane (Table 1). The relative value of the muscular plate of the mucous membrane throughout the experiment was 4-5% of the wall of the glandular section of the stomach. The relative value of the submucous membrane slightly increased during the experiment from 66.1 to 68.4%. Some increase in the relative value is also characteristic of the muscular membrane.

Table 1. Ratio of the glandular stomach membranes of broilers of the Smena 8 and Cobb 500 crosses, %.

Age, days	Relative value				
	mucosal fold	muscular lamina of the mucosa	mucous membrane	submucous membrane	muscular membrane
Smena 8					
1	24.34±0.61	3.89±0.11	28.23±0.64	66.08±0.68	5.69±0.15
7	20.25±0.41	5.06±0.15	25.32±0.46	68.29±0.47	6.39±0.11
42	17.50±0.44	4.47±0.14	22.11±0.46	68.41±1.92	6.64±0.21
Cobb 500					
1	27.36±0.54	4.96±0.15	32.32±0.54	62.53±0.51	5.15±0.15
7	19.03±0.49	3.45±0.11	22.48±0.52	72.46±0.66	5.06±0.19
42	26.26±0.77	9.30±0.42	35.57±0.71	59.01±0.68	5.43±0.24

In broilers of the Cobb 500 cross, the mucous membrane elements at the age of 7 days tend to decrease in relative value, and at the age of 42 days it increases, especially significantly for the muscular plate. The relative value of the submucosa initially increases, and then falls below the level of the first day. For the muscular membrane, a certain increase in relative value from 5.7 to 6.6% is typical.

Comparing the absolute values of the size of the glandular stomach membranes in broilers of the Smena 8 cross, it is found that the mucous membrane had the largest dimensions at the age of one week, and the submucosa – at six weeks (Table 2). In broilers of the Cobb 500 cross, the largest absolute size of the mucous membrane was noted at the end of the experiment, and the submucosa – at the age of one week.

Table 2. Morphometry of the glandular stomach of broilers of the Smena 8 and Cobb 500 crosses, micrometer

Age, days	Layers					
	mucosal fold	muscular lamina of the mucosa	mucous membrane	submucous membrane	muscular membrane	wall
Smena 8						
1	782.45±22.55	124.22±3.56	906.67±23.82	2124.98±36.25	180.78±4.37	3212.42±41.48
7	868.96±14.82	216.82±5.65	1085.78±15.51	2983.95±54.96	277.27±6.10	4347.00±59.04
42	780.23±16.58	200.19±6.15	989.29±17.62	3051.61±73.95	295.01±8.1	4537.76±64.91
Cobb 500						
1	852.06±28.45	151.55±4.80	1003.61±29.82	1919.79±33.47	156.32±4.59	3079.71±54.71
7	783.71±13.79	143.07±3.92	926.78±14.65	3147.01±96.78	202.95±4.68	4276.73±101.66
42	1228.02±28.06	463.39±26.51	1691.41±41.42	2861.4±90.76	264.68±14.62	4817.48±124.54

In the intestine we studied the villus layer, crypts, muscularis mucosae and muscularis mucosae. The study of age-related changes in the relative size of the villus layer in birds of the Smena 8 cross showed that in the duodenum this layer increased slightly, did not change in the jejunum, and decreased in the proximal part of the cecum (Table 3).

Table 3. The ratio of layers and membranes of the intestine of broilers of the Smena 8 cross, %

Age, days	Relative thickness of layers and shells			
	villi	crypt	muscle plate	muscular membrane
Duodenum				
1	81.61±0.38	8.78±0.25	3.04±0.05	6.56±0.22
7	81.55±0.46	12.48±0.36	1.17±0.05	4.81±0.34
42	83.09±0.35	8.47±0.20	1.41±0.06	6.63±0.12
Jejunum				
1	74.05±0.65	10.47±0.50	3.21±0.14	12.27±0.33
7	68.99±0.50	17.29±0.49	3.20±0.11	10.52±0.25
42	74.70±0.55	9.10±0.30	2.66±0.10	13.55±0.31
Proximal cecum				
1	68.16±0.68	14.07±0.41	3.60±0.21	14.17±0.45
7	68.15±1.85	16.24±1.40	2.11±0.25	13.50±1.31
42	62.29±1.11	13.56±0.57	2.48±0.10	21.68±0.74

The relative size of the crypt layer in all studied areas is characterized by an increase in the relative size at 7 days of age and a decrease at the end of the experiment to values lower than those of day-old broilers.

The relative size of the muscular plate of the mucous membrane in broilers of the Smena 8 cross decreased with age throughout the intestine. The muscular membrane, having decreased its relative size by the age of 7 days, increased again in the duodenum at 42 days, reaching the values of the first day, and exceeding them in the jejunum and cecum.

In Cobb 500 broilers, the relative size of the intestinal villi increases during the first week of life, especially in the jejunum and cecum (Table 4). By the age of 42 days, the value of this indicator in the duodenum is significantly reduced compared to 7 and 1-day ages. In the jejunum, by the 42nd day, the relative size of the villus layer is less than at 7 days, but does not exceed the indicator at 1 day of age. In the proximal part of the cecum, by the end of the experiment, the relative size of the villus layer continues to increase.

Table 4. The ratio of layers and membranes of the intestine of broilers of the Cobb 500 cross, %

Age, days	Relative thickness of layers and shells			
	villi	crypt	muscle plate	muscular membrane
Duodenum				
1	81.19±0.42	9.64±0.27	2.09±0.07	7.08±0.23
7	83.18±0.56	8.68±0.27	1.59±0.06	6.55±0.47
42	77.14±0.49	12.25±0.40	1.95±0.21	8.66±0.26
Jejunum				
1	67.60±0.73	13.74±0.31	3.94±0.14	14.72±0.46
7	77.51±0.51	9.49±0.24	2.85±0.10	10.15±0.32
42	75.71±0.56	11.97±0.34	3.07±0.08	9.26±0.29
Proximal cecum				
1	51.84±0.80	15.19±0.31	6.38±0.22	26.60±0.68
7	65.55±0.66	10.98±0.29	3.14±0.13	20.33±0.45
42	73.43±1.01	11.86±0.62	2.14±0.16	12.56±0.53

The relative size of the crypt layer in Cobb 500 broilers is characterized by a decrease in all parts of the intestine at the age of 7 days. By the end of the experiment, the relative size of the crypt layer increases compared to the week-old age, but in the duodenum this value exceeds the level of the 1st day, and in the jejunum and proximal part of the cecum - no.

The maximum value of the relative size of the muscular plate of the mucous membrane is noted at the age of one day in all parts of the intestine, with age this indicator decreases. The relative values of the muscular membrane in the duodenum decrease in the first week of the experiment and then increase. In the jejunum and proximal part of the cecum this indicator decreases in all the studied periods.

The absolute values of the layers and membranes of the intestine of broilers of the Smena 8 cross increased with age, with the exception of the muscular plate of the mucous membrane, which was smaller at the age of 7 days than at the age of one day (Table 5). The greatest height of the villi and the depth of the crypts in each of the periods are characteristic of the duodenum.

Table 5. Morphometry of the intestines of broilers of the Smena 8 cross, micrometer

Age, days	Layers				
	villi	crypt	muscle plate	muscular membrane	wall
Duodenum					
1	598.54±9.13	63.74±1.84	21.97±0.24	47.56±1.49	731.82±9.35
7	1306.27±13.42	199.6±5.93	18.67±0.73	79.87±8.35	1604.4±17.27
42	1805.46±28.54	182.59±4.44	30.23±1.19	143.28±2.87	2168.62±29.20
Jejunum					
1	290.45±4.20	42.45±2.45	12.59±0.55	48.27±1.52	393.76±5.78
7	340.43±8.19	85.92±3.16	15.36±0.49	50.51±0.97	492.21±10.09
42	902.28±17.46	110.10±4.30	31.63±1.15	162.73±4.49	1206.74±20.95
Proximal cecum					
1	291.73±4.54	60.21±1.91	14.47±0.10	60.64±2.04	428.05±5.23
7	547.20±25.56	134.40±10.88	16.81±1.96	108.32±8.45	806.73±38.98
42	746.06±25.19	159.84±8.62	28.49±1.22	245.55±7.59	1179.94±29.66

The absolute values of the intestinal layers of Cobb 500 broilers in the duodenum increased with age (Table 6). In the jejunum and proximal part of the cecum at 7 days of age, compared with the daily age, there is a decrease in the value of the crypt layer, the

muscular plate of the mucous and muscular membrane. The largest values of villi and crypts are characteristic of the duodenum.

Table 6. Morphometry of the intestines of broilers of the Cobb 500 cross, micrometer

Age, days	Layers				
	villi	crypt	muscle plate	muscular membrane	wall
Duodenum					
1	965.54±16.95	112.27±2.71	24.39±0.75	81.61±2.01	1183.80±16.17
7	1411.48±25.86	146.07±4.89	26.56±0.96	113.24±2.38	1697.35±29.32
42	1761.58±10.72	281.04±10.52	44.91±4.99	198.47±6.57	2285.99±19.08
Jejunum					
1	550.01±18.03	109.13±3.11	31.39±1.29	115.89±3.76	806.42±20.84
7	715.40±19.34	85.71±2.39	25.11±0.84	91.51±3.14	917.73±21.12
42	1242.23±26.22	196.47±7.23	50.22±1.52	153.56±6.27	1644.48±34.33
Proximal cecum					
1	376.65±9.12	109.13±2.43	45.63±1.65	191.47±5.36	722.89±11.63
7	613.03±24.62	98.03±3.64	27.28±1.01	180.60±5.07	918.94±30.11
42	1330.60±58.46	207.88±10.03	36.94±2.36	218.02±5.16	1793.45±60.24

4 Discussion

Comparing the data on the relative values of the glandular section of the stomach of broilers of two crosses, differences in the ratio of membranes in each of the periods are visible. For day-old and 42-day-old birds of the Smena 8 cross, compared to the Cobb 500 cross, a larger relative value of the submucosa and a smaller one of the mucous membrane are characteristic. In broilers of the Smena 8 cross, the relative value of the mucous membrane decreases smoothly during the experiment at 7 and 42 days, and in the Cobb 500 cross, after a decrease at 7 days, this indicator increases by the 42nd day. The relative value of the submucosa in broilers of the Smena 8 cross, having increased by the age of one week, remains at this level at the end of the experiment, and in the Cobb 500 cross, after an increase at the beginning of the experiment, by the end of the experiment it decreases. The greatest absolute value of the submucosa in the Smena 8 cross was noted at the end of the experiment, and in the Cobb 500 cross at the age of one week. The data we obtained show uneven changes in the structural elements of the stomach wall in both crosses during ontogenesis. This is especially noticeable in the Cobb 500 cross. In the glandular stomach, the submucosa is functionally more significant, since components of gastric juice are produced here. Probably, a significant growth of this wall layer in the Cobb 500 cross at the beginning of growing stimulates the development of the musculoskeletal system and affects productive indicators.

Age-related changes in the relative sizes of the intestinal membranes revealed common and distinctive features in birds of two crosses. In the intestinal mucosa, we observe differences in the development of the villus layer. In broilers of the Smena 8 cross, with age, there is an insignificant increase in the relative size of the villus layer of the duodenum and a decrease in the proximal part of the cecum, and in birds of the Cobb 500 cross, on the contrary, at the beginning of the intestine, the relative size of the villi decreases with age, and at the end (the proximal part of the cecum) it increases. Opposite changes in birds of the two crosses also occur in the crypt layer. Throughout the intestine, in broilers of the Smena 8 cross, the relative value of this indicator increases in the first week and decreases by the 42nd day, and in the Cobb 500 cross, it first decreases and then increases. These studies demonstrate uneven growth of different parts of the intestinal tract of birds, both within the same cross and in comparison between crosses.

For both crosses, a decrease in the relative size of the muscular plate of the mucous membrane is characteristic from 1 to 42 days of life. The muscular membrane (as well as the muscular plate of the mucous membrane) at the age of one week in all birds in all parts of the intestine is relatively reduced. By the 42nd day, the muscular membrane increases only in birds of the Smena 8 cross.

The villus layer increased in absolute value in all birds throughout the experiment. The crypt layer in Smena 8 broilers also increased in absolute value. In Cobb 500 broilers, the absolute value of the crypt layer in the jejunum and proximal part of the cecum decreased by the age of one week. The muscular plate of the mucous membrane, with the exception of the duodenum in the Smena 8 cross, is characterized by a decrease in the absolute value by the age of one week with a further increase in this indicator with age. The muscular membrane (except for the jejunum and proximal part of the cecum of the Cobb 500 cross) increased in absolute value throughout the experiment. The muscular membrane of the jejunum and proximal part of the cecum in Cobb 500 broilers was lower at one week of age than at one day of age. In the intestine, the mucous membrane in general and the height of the villi in particular are of greatest interest to researchers. It is here that the transition of nutrients from the diet into the blood occurs to build the body of broilers. In the Smena 8 cross, the formation of the villi layer occurs more smoothly, while in the Cobb 500 cross, the histogenesis processes in the jejunum and cecum are more intense. The bulk of the intestine is formed by the jejunum together with the cecum, perhaps a significant increase in the surface area of digestion and absorption accelerates the formation of productive qualities of birds of this cross.

For the Cobb 500 cross, a connection is observed between the development of the submucosa of the stomach and the villi of the duodenum. In the glandular section of the stomach, the largest size of the submucosa (in absolute and relative terms) is characteristic of the age of 7 days. At the same time, Cobb 500 cross are also characterized by the largest relative size of the villi layer of the duodenum. By the end of the experiment, the relative and absolute size of the submucosa decreases, and the relative size of the duodenum also decreases.

Histological parameters of the intestine characterize the digestion processes and affect the growth of the body of birds [10]. According to literary data, broilers of the Cobb 500 cross are superior to chickens of the Smena 8 cross in terms of productivity indicators [7], the data obtained by us reveal differences in the development of the submucosa of the glandular part of the stomach and intestinal villi in broilers of the two crosses, which can explain the differences in the productive qualities of these crosses.

5 Conclusion

The data of the study showed unevenness of the processes of histogenesis of the morphological structures of the wall of the glandular stomach and intestinal tube, both within one cross and in comparison of these crosses. The cross Smena 8 was characterized by smoother changes in the studied indicators, and the cross Cobb 500 by sharper changes in relative indicators at the beginning of growing and at the end of the experimental period.

In broilers of two crosses, age-related changes in the relative sizes of the specified structures occur differently. In broilers of the Cobb 500 cross, the submucosa had a maximum relative size at the age of one week, in the Smena 8 cross - at 42 days. In the Smena 8 cross, the villi relative to the organ wall increase in the duodenum, in the jejunum and proximal part of the cecum - they decrease or do not change with age. In the Cobb 500 cross, on the contrary, in the initial part of the intestine - the duodenum - the relative size of the villi decreases, and in the middle and final parts it increases.

A sharp increase in the intestinal submucosa at the beginning of rearing can give a positive impetus to the growth of muscle mass, and a significant increase in the relative height of the villi in the jejunum and cecum may indicate a greater role of these intestinal sections in the formation of the productive qualities of birds in the Cobb 500 cross.

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