Effect of organic biological additives on the morphology of the digestive tract in quails

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Abstract. Using morphology and light microscopy, this work shows the positive effect of application of hydroponically grown wheat and an aqueous solution of astragalus as biological food additives on the development of the digestive system: muscular and glandular stomachs in Texas Pharaoh quails (Coturnix). Quails were divided into two groups (control and experimental) of 60 heads each. During the study, both groups were subject to identical keeping and feeding conditions in accordance with the established standards. Hydroponically grown wheat and an aqueous solution of astragalus were added to the diet of the experimental quail group. The data analysis conducted for the control and experimental quail groups using histology, morphometry and light microscopy made it possible to identify common patterns of the organization and development of morphofunctional structures of muscular and glandular stomachs and special aspects expressed in their more intensive development in the experimental group. The research data show that the use of hydroponically grown wheat and a solution of astragalus as organic bioadditives for stimulating the growth and development of production traits in quails and other birds is safe and acceptable. The obtained research data are of both practical and theoretical importance in implementing food programs and ensuring their reliability.

1. Introduction
Organic bird farming is now regarded as a promising and challenging line of activity in agricultural practices [1]. In this regard, the search for and improvement of bird keeping and feeding techniques, taking into account the physiological status of production trends, are becoming increasingly important [2, 3]. In order to ensure genetic bird productivity, it is necessary to use complete and balanced feedstuffs in their feeding, which is possible when adequate feed additives are used in diets [4, 5]. Recently, there has been increasing evidence of the positive effect of application of various organic food additives in bird farming on the improvement of productivity indicators and organoleptic and technological properties of products. A search for new safe and effective biologicals for the purpose of improving the profitability and quality of agricultural products is an important biotechnological task [6, 7]. A ticket to the intensification of modern bird farming is based on the knowledge of bird biology and morphofunctional aspects of bird organs and systems [8, 9]. One of the systems that plays a pivotal role in metabolic and energy processes and ensures the usefulness of feedstuffs and intensity of bird growth is the digestive apparatus. In this regard, the study of development patterns and aspects of the structural organization of the bird's digestive system and its adaptation changes under different living and feeding conditions is one of the fundamental problems faced by modern biology and agricultural practices [10, 11]. Quail farming products, such as eggs and meat, are increasingly in
demand, especially in dietary and clinical nutrition, due to their high gustatory qualities. Besides, quails are notable for high maturation rates and egg productivity, which makes them attractive to bird farmers. At the same time, it should be noted that the issues related to the study of effect of various bioadditives on bird biology and physiology remain open [12].

2. Research materials and methods
Texas Pharaoh quails (Coturnix) were chosen as a subject of research. In addition to a promising outlook on the farming of this meat breed, the choice of such subject of research is also dictated by its physiological aspects, including short egg incubation period, early maturation, rapid growth and high viability, which makes it suitable for scientific research.

This work is dedicated to the comparative morphological study of the digestive system of 60-day old Texas Pharaoh quails that consumed hydroponically grown wheat and an aqueous solution of astragalus so as to improve meat production and quality.

The experiment was carried out on the basis of the Department of Normal and Pathological Anatomy and Physiology of Gorsky State Agrarian University. Quails were divided into two groups (control and experimental) of 60 heads each. During the study, both groups were subject to identical keeping and feeding conditions. The amount of floor, feeding and drinking space, microclimate parameters, light and temperature conditions, humidity, air speed and its gas composition were in line with the standards of All-Russian Scientific Research and Technology Institute for Poultry Industry (VNITIP).

The control group's diet included traditional feed mixtures balanced in density and energy value and water without additives and met the standards of VNITIP.

Hydroponically grown wheat and an aqueous solution of astragalus were added to the experimental group's diet. The aqueous solution of astragalus was prepared by scalding 20 g of ground raw materials in 100 ml of water.

Histological studies were conducted in the Office of Electronic Microscopy of A.N. Severtsov Institute of Ecology and Evolution (IPEE) of the RAS on the basis of the IPEE Common Use Center using the latest sampling and embedding methods. The samples of muscular and glandular stomach and liver tissues for the histological studies were fixed in 10% neutral formaldehyde and poured into paraffin. Histological preparations were produced according to the standard procedures [13] using the semi-automatic specialized histology equipment from Medite (FRG): TPC-15 processing system, TES-99 embedding system, Meditome M 530 microtome. The sample slices of 5 μm thick were gradually stained by Ehrlich's hematoxylin and eosin. The sample slices on the histological preparations were analyzed and photographed using the Keyence Biorevo BZ-9000 motorized microscope (Japan) [13].

3. Research results
The research results show common patterns of the organization of the muscular and glandular stomach wall and liver in both groups that is expressed in the same order of the stomach wall coats, similar morphology of their structures and identical architectonics of liver parenchyma and its functional structures (1, 2, A, B, C, D).

3.1. Glandular stomach
In both groups, the glandular stomach wall had a similar structure: mucous, muscular and serous coats. The main plate is represented by some loose connective tissue rich in cell elements. It contains glands. The gland lobules are separated from each other by an interlobular connective tissue (figure 1).

Each lobule contained a central cavity covered with a single-layer glandular epithelium merged into a superficial epithelial layer. The gland lobule epithelium was immersed deep down, thereby forming the gastric pits into which the tubular glands opened. Close to each other, the glands were situated radially around a collective cavity (figure 1).
Figure 1. Morphology of the lobules and differentiation of the glandular stomach wall in 60-day old quails, a, c - control, b, d - experiment. Hematoxylin and eosin staining.

The tubular glands are formed from one type of glandular cells. The excretory ducts of the glands opened on the surface of the eminences of the mucous membrane, known as glandular sacs. The glands were separated from each other by the thin interlayers of a connective tissue (figure 1 a, b). The muscular layer of the mucous membrane of the glandular stomach is underdeveloped. The submucosa consisted of a loose connective tissue. The muscular coat is represented by two layers of smooth muscle cells: inner circular and outer longitudinal. The serous coat is formed from a loose connective tissue and mesothelium (figure 1 a, b).

The glandular lobules are well differentiated in both quail groups. In the experimental group, the glands had a larger length and a clearer structure (figure 1 c, d). This quail group was marked by a larger quantity of glandular secretions in the central cavity of the lobules (figure 1 c, d). The structure of the glands was better expressed. The interstitial connective tissue is more developed. The epithelium of the glands was well defined (figure c, d). The epithelial cells are clearly differentiated, the nuclei are centered, and the apical edge is well expressed. The individual lymphocytes and nerve cell clusters are clearly seen in the interstitial connective tissue (Figure 1 c, d). The main plate was tightly attached to the glandular base and was clearly seen (figure 1 c, d).

3.2. **Muscular stomach**

In both groups, the muscular stomach wall had a similar structure: it consisted of three coats: mucous, muscular and serous. The mucous membrane formed large folds, consisted of the epithelial layer, mucosa, main plate and submucosa (figure 2 a, b). The epithelial layer of the mucous membrane consisted of a single-layer cubical epithelium. The experimental group's muscular stomach coats are more developed, the mucous membrane folds are larger, the cuticle and the mucous plate are a little bit thicker. The surface of the muscular stomach wall is covered with a solid keratin layer (cuticle)
formed from the secretions of the tubular glands and those of the cells of the gastric pits and the superficial epithelium (figure 2 a, b).

![Figure 2](image)

**Figure 2.** Morphology of the wall and the muscular clusters of the muscular coat of the muscular stomach in 60-day old quails, a, c - control, b, d - experiment. Hematoxylin and eosin staining.

The muscular layer of the mucous membrane was absent. The submucosa consisted of a dense fibrous connective tissue. The muscular coat is represented by two layers: inner circular and outer longitudinal. The inner circular layer of the muscular coat consisted of strong clusters of smooth muscle cells. The outer longitudinal layer of the muscular coat is less developed. The serous coat is formed from a connective-tissue layer and mesothelium. (figure 2 a, b). The experimental group was marked by a larger quantity of muscle fibers in the inner circular muscular layer, by more developed connective interlayers between them. The cells of the muscle fibers, those of both layers of the muscular coat and of the connective-tissue interlayers were larger with large nuclei (figure 2).

The invaginations of the epithelium into the mucous membrane represented gastric pits. The excretory ducts of the simple tubular glands located in the main plate opened in these pits. The glands consisted of bottoms, bodies and necks, and were cubic in shape (figure 2 a, b). The coats and folds of the mucous membrane of the muscular stomach are more developed, as well as the cuticle and the mucous plate, in the experimental group. The surface of the muscular stomach wall is covered with a solid keratin layer (cuticle) formed from the secretions of the tubular glands and those of the cells of the gastric pits and the superficial epithelium (figure 2 a, b).

4. **Discussion**

The obtained research results show that the control and experimental groups have common patterns of the organization and development of muscular and glandular stomachs expressed in the presence of
identical morphological structures and similar nature of their development, which indicates that the used bioadditives are safe. At the same time, the experimental group was characterized by special aspects expressed in the higher development of morphofunctional structures. In the glandular stomach: Large sizes of the glandular lobules with an expressed structure and clearer outlines, more developed connective tissue between the glandular lobules and a larger quantity of secretions in the central cavity of the lobules (figure 1). In the muscular stomach: more developed muscular coats of the wall with a large quantity of muscle fibers in the inner circular muscular layer and connective-tissue interlayers between them, thicker folds of the mucous membrane, cuticle and mucous plate, which considerably increased the total capacity of the stomach. The cells of the muscle fibers, those of the muscular coat and of the connective-tissue interlayers were larger with large nuclei (figure 2).

5. Conclusion
Thus, the obtained research results show that the use of organic bioadditives, such as hydroponically grown wheat and an aqueous solution of astragalus, as natural phytostimulants in the diet of Texas Pharaoh quails has a positive effect on metabolic processes and contributes to the growth and development of their digestive system. This information correlates with our data on the positive effect of these bioadditives on the development of pectoral and cardiac muscles. This enables us to recommend hydroponically grown wheat and an aqueous solution of astragalus as safe and effective bioadditives in quail farming.

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