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ANIMAL HUSBANDRY

Pancreatic Exocrine Function in Chickens

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Abstract—The pancreatic secretory response to the Garlic allicin dietary supplement under the conditions of an experiment with chickens implanted with pancreatic duct chronic fistulas has been studied. The results prove that the amylolytic and proteolytic activities increase the secretion at 1 mL in chickens in the test period (8 days). However, there is no significant change in the total volume of juice for 180 minutes. The analysis of the adaptation mechanism in the postprandial phase indicates an enzyme activity increase in the complex reflective cycle caused by both the receptors responding to the food tastes and the conditioned reflex factors. The adaptation developed within 8 days is associated with a sharp (twofold) increase in the proteolytic activity on the third day and the following proteinase activity decrease up to the initial rate of the enzyme activity.

Keywords: chicken, pancreas, pancreatic juice, digestive enzymes, flavor enhancer

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INTRODUCTION

Taste perception is a very important aspect of developing feed preferences and feeding behavior. The organs responsible for taste perception are taste buds transforming the gustatory stimuli into nerve signals. It was previously considered that the number of taste buds in chickens is small and, therefore, they are characterized by a low taste acuity. However, recent studies can prove that the taste system in chickens is well developed. Moreover, the taste bud number and distribution area in chickens are significantly greater than has been assumed [1].

It was previously reported that there were not any taste buds in chickens [2]. However, approximately 70 such buds were later found in the oral cavity [3]. Compared to mammals, this number is not great. Thus, approximately 1000, 10000, and 15000–20000 buds were found in rats, humans [4], and cows [5], respectively. Subsequent surveys have shown that the number of buds is greater in chickens; it varies in the range of 240–360 units on average, depending on the breed. In addition, their number was greater in the broilers than in the egg-laying hens [6–8].

Chickens rank as one of the most important livestock species and are appropriate models for surveys. Therefore, a clear understanding of the mechanisms of the taste organ's physiology and the effects of the senses of taste on the dietary nutrition and the feeding schedule are very important to increase the efficiency in the poultry industry. In addition, the taste perception of food, which is an important aspect of digestive physiology, is closely related to the pancreatic activity. However, data on the effects of flavor enhancers on the pancreatic secretary function were not found in the scientific literature. The objective of the survey was to study this process in the chronic experiment with the use of I.P. Pavlov's techniques for chickens as the experimental models.

MATERIALS AND METHODS

The experiments were conducted with two 1-year-old High-sex chickens according to the methods of Ts.Zh. Batoev and S.Ts. Batoeva (1970) [9]. The essence of the surgery was to cut off a 4–5-cm-long section from the duodenal gut, to transplant the main pancreatic duct into it, implanting the two G-shaped fistulae and creating the external anastomosis, which could allow the pancreatic juice to flow back into the duodenum in the test-free periods.

The physiological experiment started in the morning with the use of the chickens after 14-h fasting. The chickens were placed into a special box (Fig. 1), where they were kept for 3 h. The microtube for the pancreatic juice collection was attached to the segment fistula with a special rubber adapter. The pancreatic juice was collected in the first 30 min after the fast. Then, the bird was fed with a diet containing 30 mg mixed feeds (Table 1). Thereby, the secretions were collected every 30 for 180 min. Experiments were conducted using the time-period-based method. During the 5–7-day reference period, the chickens were fed with a basal diet. During the experimental period over 7–8 days, the Garlic allicin preparation in the amount of 100 mg/kg of feed was added.

Table 1. Mixed feed composition and nutritional values

Indicator	Percent
Wheat	58.224
Sunflower meal	5.000
Soybean extract	19.784
36-% calcitic limestone	9.137
Soybean oil	1.936
Wheat bran	3.847
Monocalcium phosphate	1.149
Sodium chloride	0.250
Lysine 98	0.073
Sodium sulfate	0.205
Feed-grade methionine	0.214
0.08% mineral blend	0.080
Choline chloride	0.080
0.02% vitamin blend	0.020
Nutritional content in 100 g of feed:	
poultry ME, kcal	270.00
crude fat	6.72
crude cellulose	4.89
crude protein	16.70

The biochemical analyses were performed with the methods listed below. The amylase activity was determined with the method of B.W. Smith and L.H. Roe modified in the laboratory to measure the high activity of the enzyme [10]. The proteases were used in the hydrolysis of casein purified with the Hammerstein method [10]. A Semi-Automatic Biochemistry Analyzer (*Sinnowa*, China) and a veterinary diagnostic test kit (DIAKON-VET, Russia) were used to determine the activity of lipase in the animal blood.

Statistical data processing was performed with the Excel program. The validity of differences was evaluated with the Student's *t*-test. The differences were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

The experimental data proved that the Garlic allicin preparation had some effect on the pancreatic secretory function in chickens (Table 2). In addition, the amount of the pancreatic juice was not significantly changed; a trend of the overall decline by 6.1% on average over the experiment was observed. However, the enzyme activity per 1 mL of juice over the experiment in response to the taste supplement was increased. Thus, the amylolytic and proteolytic **activities** increased by 24.5 and 29.8%, respectively, which can indicate the positive impact of the preparation on the digestive function. In order to understand the mechanism of the pancreatic stimulation, the dynamics of excreting the pancreatic enzymes during the experiment should be analyzed. In addition, no significant change in the enzyme activity of the pancreatic secretion in the amount of juice for this period was revealed.

The pancreatic juice amylolytic activity after feeding in both periods insignificantly increased. However, it had no significant impact on the feed carbohydrate hydrolysis (Fig. 2). The analysis of the proteinase activity showed that the basal level of the enzyme activity with the use of the supplement did not significantly vary during 7–10 days. A sharp increase (by 47.5%, Fig. 3) in the activity of the enzyme can be observed at the 90th minute of the experiment in the postprandial phase, which corresponds to the pancreatic secretion complex reflective regulation. This tendency remained up to the 180th min of the experiment, which corresponds to the neurochemical phase of regulation with supplying the protein-splitting products from the stomach into the intestine. At the 180th minute, no differences among the proteinase activities in the reference and experimental periods were revealed. Therefore, the effects of the flavor enhancer on the taste receptors and the development of the conditioned reflex to the applied supplement taste may be considered exclusive. The adaptation of the pancreatic secretion to this supplement over a long period cannot be evaluated since the basal activity does not vary. In order to understand the mechanism of adaptation within the experiment, the proteolytic

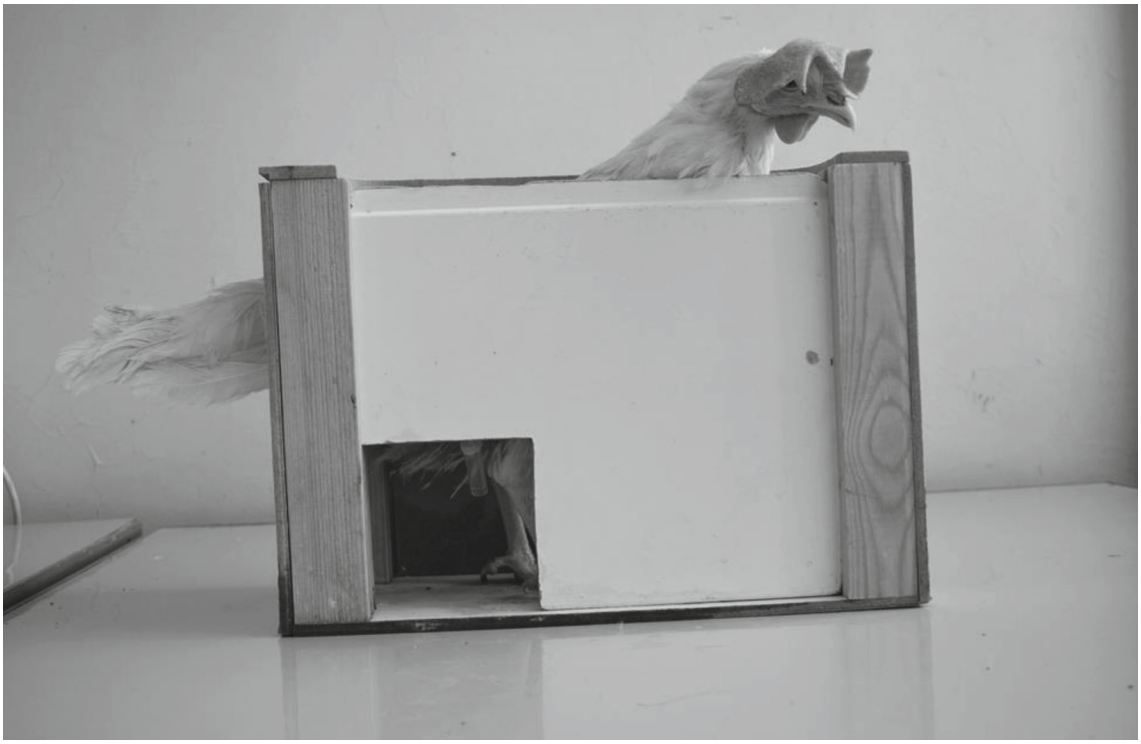

Fig. 1. Chicken implanted with pancreatic duct chronic fistula in the experimental period.

activity level through the whole experiment should be considered.

The proteinase activity in the reference period significantly varied. However, it gradually decreased due to the adaptation to the dietary composition, despite the wave pattern of enzyme secretion (Fig. 4). Adding a flavor enhancer caused the larger curve oscillations without any significant change in the trend line. The proteinase activity on the third day reached its maximum, increasing twofold, when compared to its initial value. Its activity gradually declined up to the eighth day of adding the supplement.

The survey results can prove that chickens' perception to the taste stimuli of various types is different. For instance, chickens are more tolerant to a sour taste compared to mammals. However, they are highly sensitive to a bitter taste, despite the fact that there are less bitter taste receptor subtypes in chickens than in mammals [11]. Thus, only two or three of these subtype receptors actually participate in the perception of bitter taste [12]. In addition, the chickens quite well responded to the stimuli of the umami taste of the mixtures of inositol-5'-monophosphate and monopotassium L-glutamate. This can indicate the fact that the ability to perceive the umami taste may be inher-

Table 2. Exocrine pancreatic function in chickens

Item	Reference period	Experimental period	% to reference
Pancreatic juice amount for the experience, mL	9.8 ± 0.17	9.2 ± 0.34	93.9
Enzyme activityin 1 mL juice:			
amylase, mg/(mL min)	3895 ± 232.8	4850 ± 323.4*	124.5
proteinases, mg/(mL min)	201 ± 14.8	261 ± 24.4*	129.8
lypase, μmol/(L min)	8950 ± 61.25	9084 ± 466.1	101.5
Enzyme activity in juice volume for experiment:			
amylase, mg/(mL min)	40194 ± 2878.6	47346 ± 4059.2	117.8
proteinases, mg/(mL min)	1990 ± 163.2	2371 ± 239.2	119.1
lypase, μmol/(L min)	89210 ± 7888.7	85902 ± 6336.9	96.3

* $p < 0.05$.

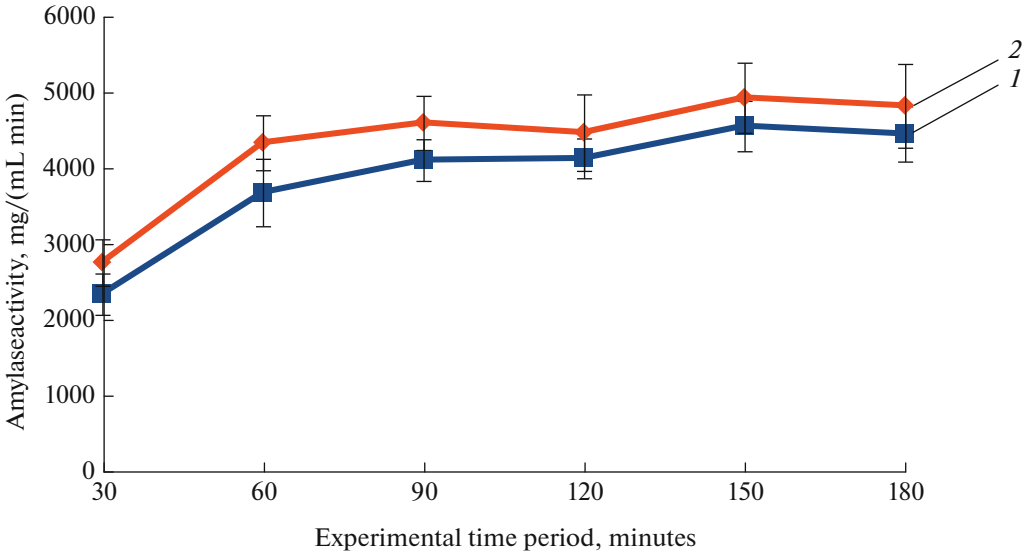

Fig. 2. Amylase activity in (*1*) reference and (*2*) experimental periods.

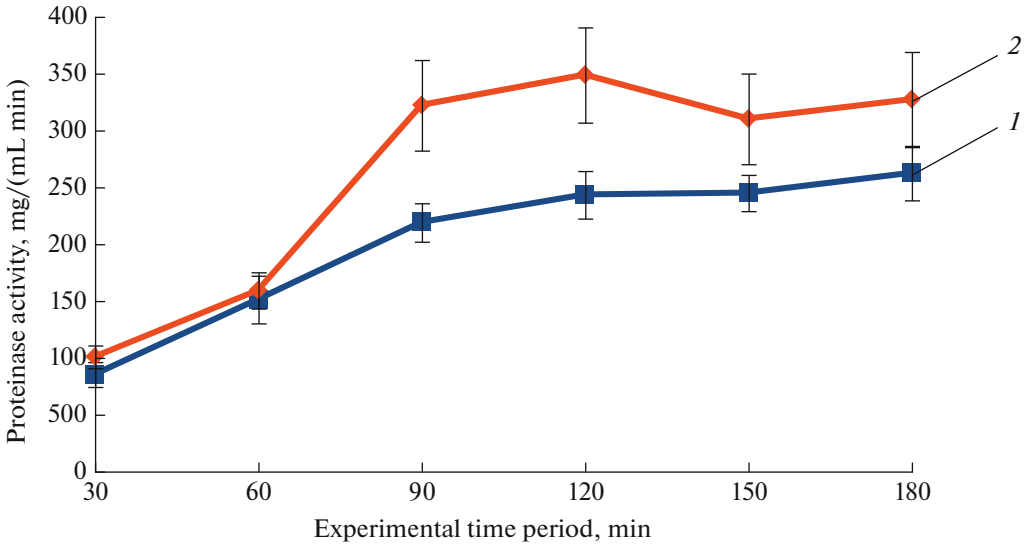

Fig. 3. Dynamics of pancreatic juice proteolytic activity in postprandial phase in (*1*) reference and (*2*) experimental periods.

ited from birds by mammals during evolution [13]. However, the chickens responded to the stimuli of the sweet and salty tastes only with a high concentration of the taste substance (for instance, the concentration of the sucrose solution of five score is considered normal) [14, 15]. In order to study the taste bud reaction to the different tastes (bitter, salty, and umami), the technique of mapping the ionic calcium concentrations in real time in the isolated taste buds was used [16]. This technique is one of the possible functional approaches to the analysis of the taste perception in chickens. In addition, a simpler method with the use of the molecular markers has recently been proposed to identify the taste buds on the surface of epithelium [17]. This method may offer the opportunity to determine both the total number of buds and their distribution in the oral cavity more precisely. In addition, it can provide a more complete explanation of the relationship between their total quantity and the behavioral reactions in chickens. A method that can allow us both to study the taste perception regulation and to determine the bird taste responses to various flavoring via the pancreatic secretory function has been proposed.

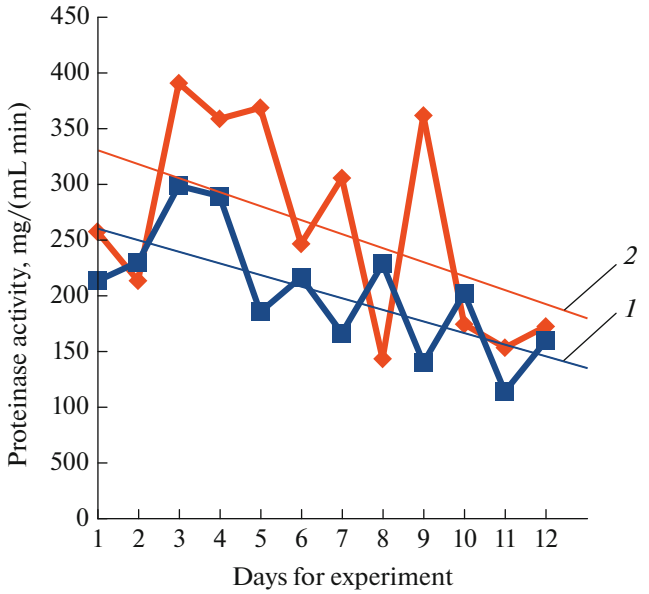

Fig. 4. Protease activity adaptation to Garlic allicin supplement over the (*1*) reference and (*2*) experimental periods.

CONCLUSIONS

Therefore, the results of the conducted experiments allow us to make a conclusion that chickens respond to the dietary supplement enhancing the palatability of the feeds. This proves the presence of taste receptors in their oral cavity once more. The amylolytic and proteolytic activities in pancreatic secretion in a volume of 1 mL increase with the Garlic allicin supplement in the experimental period (8 days), while no significant change in the total amount of juice for 180 minutes is revealed. The analysis of the adaptation mechanism in the postprandial phase indicates some enzyme activity increase in the complex reflective cycle, which is caused by the receptor reactions to the feed tastes and the conditioned reflex factors. The adaptation for 8 days is related with a sharp (twofold) increase in the proteolytic activity on the third day and the following decline in the proteinase activity up to the level of the enzyme's initial activity.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests. The authors declare that they have no conflict of interest.

Statement on the welfare of animals. This article does not contain any studies involving animals performed by any of the authors.

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