

# Meat quality of quail fed diets enriched with probiotic lactobacilli

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**Abstract.** The article describes the effect of probiotic strains *Lactocaseibacillus rhamnosus* AG16, *Limosilactobacillus fermentum* HFD1, and *Lactiplantibacillus plantarum* LS-4.4 on the meat quality of quail. The strains were grown on a whey-based nutrient medium, and in the form of suspension were introduced into the diet of birds for two months. The use of these feed additives, especially *L. fermentum* HFD1, resulted in a decrease in the pH of the quail breast meat. All tested strains induced a decrease in water holding capacity and cooking loss of quail breast meat compared to the control variant. The meat of quail fed with probiotic lactobacilli was less stiff, that resulted in less chewing effort in the raw meat and less cutting effort in the cooked meat.

## 1 Introduction

Probiotics have gained popularity due to their positive effects on many organ systems of macroorganisms, including birds [1]. Probiotics affect the intestinal microbiota and can reduce the number of pathogens, as a result improving the immunity and sensory properties of broiler meat [2]. Changes at the level of gut microbiota contribute to the improvement of meat quality in terms of microbiological parameters [3]. The addition of probiotics has a significant impact on technological parameters, in particular carcass yield, live weight gain, immune response and a marked increase in the meat portion of the carcass [4]. It was found that administration of probiotic cultures to poultry diets can help create a protective barrier of bacteria in the digestive tract and prevent the growth of pathogenic microorganisms [5].

Different groups of scientists have tested a wide range of bacteria as probiotic supplements to the basic diet. For example, *Aspergillus oryzae* PXN 68, *Lactobacillus acidophilus* PXN 35, *L. rhamnosus* PXN 54, *L. plantarum* PXN 47, *L. bulgaricus* PXN 39, *Bifidobacterium bifidum* PXN 23, *Enterococcus faecium* PXN 33, *Streptococcus thermophilus* PXN 66 and *Candida pintolopesii* PXN 70 were used in experiments with

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quail [6]. Two species of *L. lactis* ssp. *lactis* IBB SL1 and *L. lactis* ssp. *cremoris* IBB SC1 were tested in experiments with chickens [7].

The aim of this study was to study the effects of feed additives based on new probiotic strains *Lactiplantibacillus plantarum* LS-4.4, *Limosilactobacillus fermentum* HFD1, and *Lacticaseibacillus rhamnosus* AG16 on the quail meat quality.

## 2 Materials and methods

The experiments were carried out on 15-day old Texas beef quails in accordance with EU Directive 2010/63/EU for animal experiments and were approved by the Local Ethics Committee of Kazan Federal University (Protocol No. 40, date 9 March 2023). Birds were housed in cages with holding capacity 15 heads per cage, had free access to water and were fed three times a day with feed-staff PC5 (JSC Bogdanovich Feed Mill, Russia) (weeks 1-4) and DK-52 for quails (Glazovsky Feed Mill, Russia) (from week 5).

The birds were randomly divided into four groups (n = 8): three experimental groups, which got three different probiotic strains as feed additives, and one control group. *Lacticaseibacillus rhamnosus* AG16 previously described as *Lactobacillus fermentum* AG16 [8], *Limosilactobacillus fermentum* HFD1 [9], and *Lactiplantibacillus plantarum* LS-4.4 previously described as *Ligilactobacillus salivarius* LS-4.4 [10] were grown in de Man-Rogosa-Sharpe (MRS) broth or MRS agar (HiMedia, India) at 37 °C. To obtain the LAB biomass for quail feed, we used an optimized low-cost whey-based nutrient medium (WBNM) of the following composition: dried whey – 10%, sucrose – 0.5%, yeast extract – 1%. The WBNM was inoculated with 2% (v/v) of overnight LAB cultures grown on MRS broth. Incubation was carried out at 40 °C for 12 h. The resulting suspension of LAB with cell density  $10^9$ - $10^{10}$  CFU/mL was cooled at +2 °C and introduced into the quail diet in the amount 0.5-1% of quailfeed. Weighing was carried out every 10 days. After 69 days the birds were slaughtered, exsanguinated, and plucked.

For further analyses, intact skinless breast muscle at 24-h postmortem was used. For pH measurement, 5 g of each meat sample was blended with 45 mL of sterilized water, and the pH of the suspension was measured using a glass pH electrode.

The quantitative analyses of fat, protein, and moisture were performed on the InfraLUM® FT-12 equipment (Russia) with the software and calibration data recommended for the product “minced meat”.

The color of breast meat was measured using a colorimeter (CR20, China) to evaluate the meat color of the exterior surface.

The water holding capacity (WHC) of breast muscle was measured as described in [11].

The cooking loss of breast muscle was measured as described in [12].

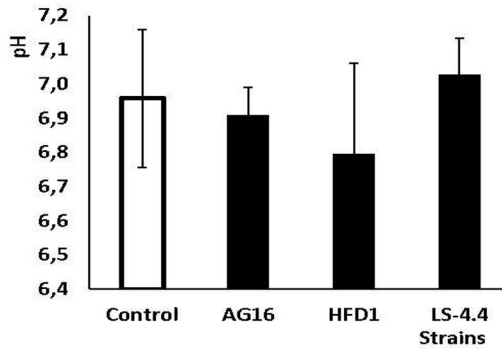
The texture profile of breast muscle was analyzed using ST-2 texture analyzer (Quality Laboratory JSC, Russia) according to the instructions of the manufacturer. The cylindrical probes of 36 mm in diameter and 35 mm in height were used. The following factors were determined: hardness (g), springiness (%), cohesiveness (%), chewiness (g), gumminess (g), adhesion force (g), adhesiveness (g×mm).

The meat samples (without skin) were analyzed for lipid oxidation by measuring as described by Lee et al. (2017) [11].

## 3 Results

The study aimed to explore the effects of dietary probiotics supplementation on the quail meat quality. Three lactobacilli strains, namely *L. rhamnosus* AG16, *L. fermentum* HFD1, and *L. plantarum* LS-4.4, were grown on the whey-based nutrient medium, and the

resulting cultures were mixed with feed and introduced as feed additives into the diet of quails. The application of *L. rhamnosus* AG16 and *L. fermentum* HFD1 in the diet resulted in decrease in pH of quail breast meat, while the pH increased in the variant with *L. plantarum* LS-4.4 (Figure 1).



**Fig. 1.** Effects of lactobacilli strains administration on the pH of quail breast meat.

The study revealed no effect of probiotic strains on the chemical composition of quail meat. Protein content, fat, and humidity of quail breast meat in experimental groups did not differ from the control variant (Table 1). The water holding capacity (WHC) was significantly higher in the experimental groups as compared to the control and was the highest in the variant with *L. plantarum* LS-4.4. Besides, the introduction of LABs into the quail diet led to the formation of meat with reduced cooking loss on 4-5 %.

**Table 1.** Chemical and technological parameters of quail breast meat.

Strains	Fat, %	Protein, %	Moisture, %	WHC, %	Cooking loss, %
Control	11.58±0.37	15.76±0.85	72.66±0.5	76.73±2.58	20.83±2.59
<i>L. rhamnosus</i> AG16	11.28±0.78	15.93±1.12	72.79±0.44	77.58±5.64	16.12±1.31
<i>L. fermentum</i> HFD1	11.44±0.58	15.68±0.83	72.88±0.31	80.15±4.25	16.53±1.12
<i>L. plantarum</i> LS-4.4	11.42±0.76	16.06±1.2	72.52±0.46	82.33±6.16	16.92±2.45

Probiotics in the diet of quail had no effect on the breast meat color. The L, a, and b values in the groups which received LABs as feed additives did not differ from those in the control (Table 2).

**Table 2.** Color indexes of breast quail meat.

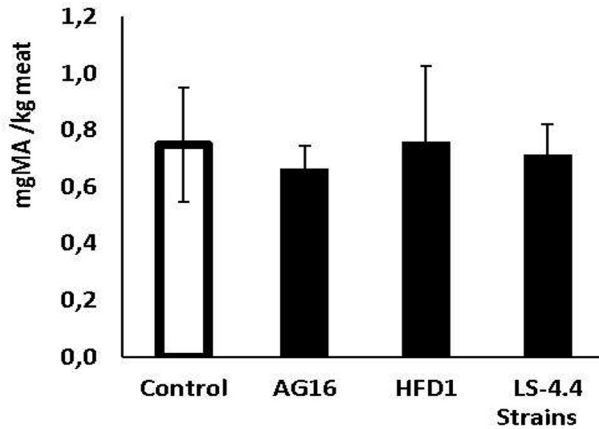
Strains	L	a	b
Control	55.28±0.89	5.47±1.09	21.19±0.48
<i>L. rhamnosus</i> AG16	55.98±0.67	5.23±0.9	21.33±0.63
<i>L. fermentum</i> HFD1	55.33±0.48	5.23±1.2	21.38±1.14
<i>L. plantarum</i> LS-4.4	54.94±1.34	4.86±0.95	21.16±0.77

The texture of quail breast meat changed significantly in the variants with LABs (Table 3). The breast of quails, which received LABs as feed additives, was softer and chewed better, as evidenced by lower hardness, gumminess, and chewiness scores compared to the control. Moreover, the cooked quail breast cut better, as evidenced by the low Cutting force score in the variants with LABs.

**Table 3.** The textural parameters of breast quail meat (TPA).

Testing meat	Parameters	Control	<i>L. rhamnosus</i> AG16	<i>L. fermentum</i> HFD1	<i>L. plantarum</i> LS-4.4
Raw quail breast meat	Hardness, g	3492±449	2011±221	2348±398	2094±470
	Springiness, %	77.42±5.51	69.61±5.68	71.42±0.94	66.98±3.38
	Cohesiveness, %	59.68±6.39	55.73±5.26	55.03±3.83	60.07±5.91
	Chewiness, g	1661±581	791±198	930±206	862±281
	Gumminess, g	2114±621	1125±195	1300±285	1278±389
	Adhesion force, g	32.75±3.67	37.28±8.67	29.2±2.59	30.93±3.05
Cooked quail breast meat	Adhesiveness, g×mm	496±45	530±83	491±40	445±19
	Cutting force, g	3976±425	3715±379	2878±515	3363±445

Lactobacilli are known to have antioxidant properties. However, introduction of probiotic bacteria *L. rhamnosus* AG16, *L. fermentum* HFD1, and *L. plantarum* LS-4.4 into the diet had no effect on the accumulation of malonic aldehyde in the quail breast muscle.



**Fig. 2.** Effects of lactobacilli strains administration on the lipid oxidation measured by thiobarbituric acid-reactive substance (TBARS) values in the quail breast meat.

## 4 Discussion

Our results confirmed an improvement in the textural properties of quail breast meat in birds fed a diet enriched with probiotics *L. rhamnosus* AG16, *L. fermentum* HFD1, and *L. plantarum* LS-4.4. Our results are consistent with earlier studies. Mohammed et al. (2021) [13] showed that the introduction of a probiotic strain of *Bacillus subtilis* into the diet reduces the pH value of broiler meat. For example, it is known that for broiler, the pH range is 5.9 to 6.2 15 minutes after slaughter, with values of 5.8 referring to pate, soft and exudative meat, and 6.3 referring to dark, hard and dry meat [14]. Thus, the key to reducing the Hardness index was to reduce the pH of the meat when introducing the diet of lactobacilli strains. A positive thing we found was an increase in WHC and a decrease in cooking loss. Previously, a similar effect of probiotics on broilers was found. In particular, a dietary probiotic supplement (*B. subtilis* B2A) improved the WHC in the breast meat of chickens [15]. The increase in WHC in meat may be another benefit of probiotic dietary supplements because that WHC of meat is affected by the amount of muscle proteins [16]. In addition, feeding probiotic dietary supplements to quail may affect intramuscular fat content. In support of this hypothesis, the probiotic (*Clostridium butyricum*) was previously shown to increase the levels of omega-3 fatty acids, especially docosahexaenoic acid and

eicosapentaenoic acid, in the breast muscles of broilers. Changes in fatty acid composition are associated with improved WHC and contribute to meat tenderness [17].

## 5 Conclusion

The results indicate that the probiotic supplement in the form of a suspension of probiotic bacteria *L. rhamnosus* AG16, *L. fermentum* HFD1, or *L. plantarum* LS-4.4 in 10% milk whey positively affected the meat quality of quail. Probiotics had favorable effects on WHC, cooking loss, hardness, and chewiness. This trend of improved textural and processing characteristics should have a positive effect on the sensory qualities of quail when consumed in dishes. Overall, the results showed that feeding probiotics can be a strategy to manage the valuable meat of quail and improve its meat quality to meet the increasing demand for poultry meat products.

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