Effect of non-starch polysaccharides after ultrasonic treatment on the consumption and digestion of nutrients in diets of broiler chickens

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Abstract. Creating a profitable production in the field of livestock requires a large financial investment in the technology of preparing and production of highly nutritious feed mixes including those on the basis of new physical and chemical techniques. At the present stage of the development of livestock, there is the need to develop the technology and equipment that allow processing waste of an agro-industrial complex, containing a large number of hard-to-digest carbohydrates. The application of such natural polymers leads to low efficiency in the use of nutritious feed components, especially in the part of non-starch polysaccharides. In this regard, it is quite relevant to study the cavitation impact on vegetable materials, which will eventually reduce energy costs from the economical point of view and thus will improve productivity. To obtain a quality product on the output, it is necessary to examine into the effect of ultrasonic exposure on the composition of materials. The lead-tin-base bronze of the BrO10S10 grade (Russian grade abbreviation) was used as a material. As part of our experiments, we took model samples that contain the maximum amount of non-starch polysaccharides – sunflower shucks and wheat straw. Based on the obtained data, it can be noted that the increase of the digestibility in the I and II experimental groups was insignificant compared to the control: organic matter by 3.4%; crude protein – by 4.8 and 1.9%; crude fat – by 0.3 and 9.2%. Carbohydrate digestion was highest in the second group, exceeding the control group by 14.9% and the I experimental group – by 10.3%. No significant differences were found.

1. Introduction

Creating a profitable production in the field of livestock requires a large financial investment in the technology of preparing and the production of highly nutritious feed mixes including those on the basis of new physical and chemical techniques [1-2].

Nowadays, there is a decrease in the consumption of simple carbohydrates by farm animals at most farms and it maintains at the level of 40 - 55%.

At the present stage of the development of livestock, there rose the need to develop the technology and equipment that allow processing waste of an agro-industrial complex, containing a large number of hard-to-digest carbohydrates. The application of such natural polymers leads to low efficiency in the use of nutritious feed components, especially in the part of non-starch polysaccharides [3-4].
A solution to this problem can be unconventional, highly efficient, and reagentless ways of processing plant materials. Ultrasonic treatment on the subjected medium may become one of such ways [5-6].

A common function that combines most acoustic methods in cavitation processing is that this effect excites and begins to develop cavitation in a separate area of the liquid, which is scientifically called a cavitation area or cloud [7-8].

In this regard, it is quite relevant to study the cavitation impact on vegetable materials, which will eventually reduce energy costs from the economical point of view and thus will improve productivity. To obtain a quality product on the output, it is necessary to examine into the effect of ultrasonic exposure on the composition of materials.

2. Materials and methods
The lead-tin-base bronze of the BrO10S10 grade (Russian grade abbreviation) was used as a material. As part of our experiments, we took model samples that contain the maximum amount of non-starch polysaccharides – sunflower shucks and wheat straw. The list of technological operations of processing plant raw materials included: grinding to particles with the equivalent size from 1 to 2 mm, preparing a liquor ratio to water 1:7, ultrasonic treatment at a temperature of no more than 35 °C since the increase above the specified temperature leads to the quenching of the centers of cavitation clouds, the intensity of exposure was 27 kHz, the power of 0.2 to 0.4 kW. To conduct ultrasonic processing of plant materials, we used a laboratory installation developed by the authors (Patent No. 2688478 of May 21, 2019; fig. 1) [9-10].

![Figure 1. Scheme of the device for cavitation processing of raw materials](image)

The device consists of a cylindrical body 1, the inner surface of which is a mirror, mounted on the frame 2, through shock absorbers 3, fixed coaxially under the cylindrical body, fittings for loading 5 and unloading 6 of the processed components, a working body 7, rigidly installed in the center of the base of the cylindrical body, made in the form of a pentagonal regular star pyramid made of piezoceramic material, connected to a power source 8 and a vibration device 4.

3. Result and Discussion
In the first stage, we conducted laboratory research on the effects of ultrasound exposure on non-starch components of the chosen material.

The pilot studies determined the dynamics of the change in non-starch polysaccharides and the
nutritional value as a result of ultrasound treatment. The results of the experiments are presented in Table 1.

Table 1. Results of experimental research

| No | Substrate     | Before and after exposure | Total moisture (%) | Cellulose content | Feed units |
|----|---------------|---------------------------|--------------------|-------------------|------------|
| 1  | Sunflower shucks | before 8.5, after 82.4 | 52.6, 31.5        | 0.68, 1.21       |
| 2  | Wheat straw   | before 9.6, after 84.2   | 42.2, 28.5        | 0.94, 1.73       |

The analysis of laboratory studies showed that all samples of plant materials were quite amenable to ultrasound processing, taking into account the use of chosen technological modes. According to the results of the studies, the sunflower shucks treated with ultrasound and water-moisturized had the humidity of 82%, and crushed wheat straw had 84% (it was also mixed with water).

It should be noted that the cavitation on the studied vegetable materials significantly affected the level of cellulose, so, at the beginning of the experimental study, the content of the latter in sunflower shucks was 52.6%, and, after the processing, the parameter decreased to 31.5% - the changes differed 1.67 times. For wheat straw, there was also a decrease from 42.2% to 28.5%, respectively, which is 1.48 times lower than at the beginning of the experiment. Consequently, cavitation can reduce the level of carbohydrates of non-starch nature 2.0 times.

The experiments were conducted on broiler chickens of cross “Smena-7” to study the ultrasonic effects on vegetable materials. Three experimental groups were formed by the method of analogs, and the birds were in the preparatory period for two weeks. Beginning from week 15, the mode was switched to the accounting period, where the control group received a starter diet, the experimental groups had 20% of the grain part of the diet replaced with processed sunflower shucks and wheat straw, respectively. Feeding the bird was carried out with the combination fodder developed on the recommendations of “All-Russian Research and Technological Poultry Institute” of the Russian Academy of Sciences (2004).

For this experiment, we formed feed mixes containing 49% wheat-barley-corn grain mixture for the starter and 63% for the growth diet.

The experiments included recording changes in nutrient uptake during the research and the feed consumption by experimental poultry (table 2).

As a result of the tests of simulated feed substances, it was determined that the food palatability in the first period was less for the experimental groups than that for the control one by 85 and 110 g/head, respectively. In the second two weeks, the same parameter in the experimental groups was higher than in the control group by 137 and 152 g/goal, respectively.

Table 2. The consumption of feed mixes by broilers by growing periods, g/head

| Parameter          | contr ol | Group           |
|--------------------|----------|-----------------|
|                    | Exp. I   | Exp. II         |
| Starter feed mix   | 930      | 845, 820        |
| Growth feed mix    | 1350     | 1480, 1502      |
| Total              | 2280     | 2325, 2322      |

The feed palatability was higher in the experimental groups during the entire period of the experiment than in the birds of the control group. The difference was 45 g/head in group I, 42 g/head
in group II, which is higher than in the control group by 1.93 and 1.80%, respectively.
Thus, the introduction of processed substrates in the form of sunflower shucks and wheat straw into
the feed insignificantly affected the palatability of feed by experimental broiler chickens.
Feeding the studied fodder to the bird led to a change in the digestion of substances (table 3).

Table 3. Nutrient digestion ratios of the starter (%)

| Group | Organic matter | Crude protein | Crude fat | Carbohydrates on average |
|-------|----------------|---------------|-----------|--------------------------|
| Control | 74.2±1.96 | 84.2±0.97 | 75.5±1.01 | 70.4±1.95 |
| I | 77.7±1.26 | 83.9±1.12 | 72.1±0.98⁺ | 78.5±1.35 |
| II | 79.3±1.99 | 82.0±2.01 | 68.1±1.93⁺⁺ | 85.3±1.99⁺⁺ |

⁺ P≤0.05 compared to the control group;
⁺⁺ P≤0.05 compared to group I;
⁺⁺⁺ P≤0.05 compared to group II

The organic matter digestion of the starter feed in the experimental groups exceeded the parameter
in the control group by 2.4-3.7%, but the difference was statistically insignificant.
The amount of crude protein consumed by the bird was highest in the control group (84.2%) and
exceeded this parameter in the first experimental group – by 0.3%, in group II – by 2.2%. However,
these differences were statistically insignificant.
The highest degree of crude fat digestion during the initial period was observed in the control group
– 75.5%, which exceeded the same parameter in the first experimental group by 3.4% (P≤0.05), in the
second one – by 7.4%. When comparing this parameter between the experimental groups, the
following significant differences were found: fat digestion in the II experimental group was 4.0% lower than in the I experimental group and 7.4% lower than in the control group.
The digestibility of carbohydrates of the starter diet in all the experimental groups exceeded this
parameter of the control group. The difference from the first group was 21.0%, from group II – 11.5%
(P≤0.05).
Other results were noted in the degree of digestion of nutrients and feeding the growth feed (Table
4).

Table 4. Nutrient digestion ratios of the growth feed (%)

| Group | Organic matter | Crude protein | Crude fat | Carbohydrates on average |
|-------|----------------|---------------|-----------|--------------------------|
| Control | 77.2±1.48 | 86.0±1.31 | 72.8±1.15 | 73.4±1.72 |
| I | 80.6±2.11 | 90.8±1.73 | 73.1±1.26 | 78.0±2.40 |
| II | 89.8±2.17 | 87.9±1.94 | 82.0±1.34 | 88.3±2.36 |

Based on the obtained data, it can be noted that the increase of the digestibility in the I and II
experimental groups was insignificant compared to the control: organic matter by 3.4%; crude protein
– by 4.8 and 1.9%; crude fat – by 0.3 and 9.2%. Carbohydrate digestion was highest in the second
group, exceeding the control group by 14.9% and the I experimental group by 10.3%. No significant
differences were found.

4. Conclusion
After conducted studies of the lead-tin-base bronze structure of the BrO10S10 grade, it can be
concluded that the introduction of broiler chickens of ultrasonic processing of sunflower shucks and
wheat straw in the diet has a positive effect on the amount of carbohydrate digestion in the starting and
growth period.
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References
[1] Bykov A V, Kvan O V, Duskaev G K, Popov V P and Sidorenko G A 2019 Proc. Conf. on Innovations in Agricultural and Rural development AgroCON-2019 18-19 April 2019 (Kurgan, Russian Federation) vol 341 (Kurgan: Kurgan State Agricultural Academy named after T.S. Maltsev)
[2] Bykov A V, Mezhueva L V, Kvan O V, Sizentsov A N and Bykova L A 2019 RU, Patent No 2688599 Device to produce homogeneous mixtures (21, May, 2019)
[3] Sala S et al. 2017 In quest of reducing the environmental impacts of food production and consumption. Journal of cleaner production 140 387-398
[4] Levakhin G, Duskaev G and Dusaeva H 2015 Assessment of chemical composition of grain crops depending on vegetative stage for feeding Asian Journal of Crop Science 7(3) 207-213
[5] Schott A and Andersson T 2015 Food waste minimization from a life-cycle perspective Journal of Environmental Management 147 219-226
[6] Wong M H, Mo W Y, Choi W M, Cheng Z and Man Y B 2016 Recycle food wastes into high quality fish feeds for safe and quality fish production Environmental pollution 219 631-638
[7] Beaton A et al 2019 Waste not, want not: enhancing the ability of yeast to utilise its own leftovers from the brewing industry to fuel the transport industry with ethanol Access Microbiology 1(1A)
[8] Fontan I B, Peterson M and Cechinel M A P 2018 Application of brewing waste as biosorbent for the removal of metallic ions present in groundwater and surface waters from coal regions Journal of environmental chemical engineering 6(1) 660-670
[9] Akbas M Y and Stark B C 2016 Recent trends in bioethanol production from food processing byproducts Journal of industrial microbiology & biotechnology 43(11) 1593-1609
[10] Bykov A V et al 2019 Prospects of applying sunflower sludge after cavitation processing in poultry breeding, IOP Conference Series: Earth and Environmental Science 341 012060