Testing of the technology of cavitation treatment of sunflower oil sludge to increase the digestibility of feed for calf bulls

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Abstract. The article presents the results of research to assess the effectiveness of the developed technology for processing sunflower oil sludge, using cavitation, to increase the digestibility of feed and metabolism of calf bull. When introduced into the diet of sunflower oil sludge in the native form + 10 % (group II). It was established that the highest indices of digestibility of the majority of nutrients were in cavitated fuse. In particular, fodder enriched with fuse contributed to greater energy consumption and its more productive use. Digestible energy was higher by 7.1 % (P≤0.05) and 9 % (P≤0.05) in groups I and II, respectively. Metabolic energy exceeded the control level by 5.7 and 7.1 MJ. The inclusion of fuse in the compound feed increased nitrogen digestion by 4.5 % (P≤0.05) in group I and by 5.8 % (P≤0.01) in group II. At the same time, higher indicators are achieved when feeding with fuse treated by the cavitation method.

1. Introduction

The nutrients in feed cannot be used immediately by the body. During digestion, they change and then are absorbed. The digestibility of feed can be influenced by a number of factors: diet structure, type of feed, age, physiological state of animals, etc. It is known that its efficiency depends on digestibility of feed, which affects zootechnical and economic indicators. Therefore, further work aimed to improve the efficiency of the livestock industry should involve the development and implementation of high technology innovative solutions. One of such solutions may be the widespread use of various wastes from the food and processing industries.

An important role in animal feeding is assigned to the sunflower fuse, as the cheapest non-food waste of the oil and fat industry. Science has accumulated a sufficient amount of experimental data indicating a high efficiency of fuses in feeding farm animals and birds [1, 2].

The total amount of waste from the processing of vegetable raw materials reaches 1–2 % of its volume, which is capable of producing about 500-800 thousand tons of feed mixtures with a content of 6–10 % crude fat [3, 4].

Meanwhile, the prevailing methods of using fuses in feeding are not rational enough, due to technological difficulties of introducing them into the diet and low efficiency of individual components [5].

It seems relevant to improve efficiency of the use of sunflower fuse in feeding meat bulls.

This study provides an example of the potential of cavitation processing of sunflower fuse to improve the digestibility of nutrients and increase the intensity of metabolic processes in the body of meat bulls.
2. Materials and methods
The Kazakh white-headed bulls aged 13 months were an object of research.

The experimental studies were carried out in accordance with the instructions and recommendations of Russian Regulations, 1987 (Order No.755 on 08/12/1977 the USSR Ministry of Health) and "The Guide for Care and Use of Laboratory Animals (National Academy Press Washington, DC 1996). In carrying out the research, efforts were made to minimize animal suffering and reduce the number of samples used.

The experimental part of the research was carried out at Zhukovo LLC, Orenburg Region. To conduct the physiological experiment, 9 Kazakh white-headed bulls were selected by the method of pair-analogues, general conditions, breed and age. The animals were divided into control and two experimental groups. During the preparatory period, the calves were fed with experimental fodder. The control group (n = 3) was given the main diet, experimental group I (n = 3) – the main diet + 10 % fuse in the native form, experimental group II (n = 3) – the main diet + 10 % fuse subjected to cavitation treatment.

Cavitation processing was carried out using an ultrasonic cavitator at 28 kHz and t = 28 °C, 220 V, 5 W., cavitation threshold of 19 kHz, hydraulic module 1: 2.

During the preparatory period (14 days), the bulls were individually fed. The studies were carried out in accordance with the "Rules for the use of laboratory animals."

The digestibility of nutrients was studied. During the accounting period, when feeds and their residues were accounted, average samples of feces (10 %) and urine (3 %) were collected; studies were carried out using the methods of a zootechnical analysis. The zootechnical analysis was carried out at the Testing Center of the Federal Scientific Center for Biological Systems and Agricultural Technologies of the Russian Academy of Sciences. In stool samples, the mass fraction of dry matter, crude protein (GOST 13496.4-93), crude fat (GOST 13496.15-97), crude fiber (GOST 12396.2-91), and crude ash (GOST 26226-95), calcium (GOST 26570-95), and phosphorus (GOST 26657-97) was determined. The mineral composition of feces was determined according to GOST 30178-96.

In urine samples (3 % of the total), specific gravity, minerals, and nitrogen content were determined. A comparative characteristic of the efficiency of assimilation of nitrogen was studied by calculating the utilization rates of this element. The energy exchange was determined according to the manual by Levakhin V.I. et al. (2016).

The following equipment was used: cupboard drier ShS-80 -01 СИУ (Russia), electric furnace SNOL1.6.2.5.1 / 9-IZ (Russia), laboratory balance VLT-150П (Russia), a machine for determining protein, nitrogen model UDK 139 UDK 139 (Italy).

The laboratory analysis of biosubstrates was carried out at the Center for Collective Use of the Federal Scientific Center for Biological Systems and Agricultural Technologies of the Russian Academy of Sciences.

Statistical processing. Data are expressed as mean values ± standard error of the mean. Statistical analysis was performed using Statistica 10.0 (StatSoft Inc., USA) and Microsoft Excel (Microsoft, USA). Significance of the group differences was estimated using Student’s t-test with p≤0.05 considered as significant.

3. Results
Digestibility of nutrients in experimental animals. Studies of the effect of sludge fuse on the digestibility of nutrients have revealed a number of differences. The digestibility of dry matter increased in experimental group I by 2.3 % (P≤0.05), in experimental group II – by 2.8 % (P≤0.05).

An increase in the digestibility coefficient of organic matter was 2.38 % (P≤0.05) and 3.1 % (P≤0.01) (Table 1).

In experimental groups I and II, the digestibility of crude protein increased by 0.7 % and 1.47 % (P≤0.05), respectively. The digestibility of raw fat increased by 1 % and by 3.1 % (P≤0.05). The
digestibility coefficient of nitrogen-free extractive substances increased by 2.3 % and 4.8 % (P≤0.05). In terms of fiber digestibility, young experimental groups were inferior to the control one by 1.37-1.41 %.

**Table 1. The digestibility ratios of nutrients from diets of experimental animals, %**

| Indicator                        | Group                     | M   | m       | M   | m       | M   | m       |
|----------------------------------|---------------------------|-----|---------|-----|---------|-----|---------|
| Dry matter                       | control                   | 65.45 | 0.36 | 67.73 | 0.38* | 68.24 | 0.51*   |
| Organic matter                   | I experimental            | 68.23 | 0.38 | 70.61 | 0.42* | 71.37 | 0.56**  |
| Crude protein                    | II experimental           | 64.10 | 0.39 | 64.76 | 0.43 | 65.57 | 0.35*   |
| Crude fat                        |                           | 68.75 | 0.87 | 69.73 | 0.92 | 71.85 | 0.71*   |
| Crude fiber                      |                           | 56.86 | 0.44 | 55.45 | 0.21 | 55.49 | 1.62    |
| Nitrogen-free extractive substances |                           | 71.49 | 1.50 | 73.78 | 0.92 | 76.24 | 0.87*   |

Significant difference in relation to control: * – P≤0.05; ** – P≤0.01

Thus, for the majority of nutrients, the highest digestibility indices were found in bulls that received ultrasound-treated fuse.

*Energy exchange and nitrogen in the body of experimental animals.* An analysis of the energy exchange in the body of experimental animals revealed changes in the efficiency of processes at the stage of digestion and interstitial metabolism. The fuse had improved efficiency of the conversion of feed energy in the body of experimental animals.

It was established that bulls that received fuse consumed 4.4-5.2 % more gross energy (P≤0.05). Moreover, this indicator was higher in animals of experimental group II by 0.7 %.

Regarding the consumption of digestible and metabolic energy, this advantage was preserved. The metabolic energy of consumed feed is used to ensure physiological functions, maintain biosynthesis processes in. Bulls of the experimental groups spent more energy on maintaining life (P≤0.05), supermaintaining life (P≤0.05), production (P≤0.05) by 3.6 – 4.7 %, 11.3 – 14 %, and 12.4 – 16 %, respectively (Table 2).

**Table 2. Nutrient intake and energy use of experimental animals**

| Indicator                        | Group                     | M   | m       | M   | m       | M   | m       |
|----------------------------------|---------------------------|-----|---------|-----|---------|-----|---------|
| Gross energy, MJ                 | control                   | 134.6 | 1.53 | 140.6 | 1.13* | 141.6 | 1.26*   |
| Digestible energy, MJ            | I experimental            | 88.3 | 1.40 | 94.6  | 0.81* | 96.3  | 1.18*   |
| Exchange energy, MJ              | II experimental           | 72.9 | 1.24 | 78.6  | 0.99* | 80.0  | 1.02*   |
| Gross energy exchange, % to maintain life |               | 54.2  | 55.9  | 56.5  |       |       |         |
| Exchange energy, MJ: to superexcision |                     | 33.4  | 0.35 | 34.6  | 0.55 | 35.0  | 0.29*   |
| growth                           |                           | 39.5  | 0.79 | 44.0  | 0.73* | 45.0  | 0.92*   |
| KPI VE, %                        |                           | 13.7  | 0.33 | 15.4  | 0.32* | 15.9  | 0.36*   |
| KPI OE, %                        |                           | 10.2  | 10.9  | 11.3  |       |       |         |

Significant difference in relation to control: * – P≤0.05

The inclusion of fuse contributed to an increase in the productive use of gross energy by 0.7–1.1 %, and exchange energy by 0.3–0.7 %.

Characterizing protein metabolism at the stage of digestion and absorption of components, one should analyze the balance of nitrogen in the body. Based on the experiment, it was found that in all experimental groups the nitrogen balance was positive, and the efficiency was different (Table 3).

The results of the studies showed that the introduction of fuse in experimental feed increased the consumption of feed nitrogen by 3.4 %.
Due to the fact that irrespective of differences in the compound feed, the content of nitrogen in feces was similar in all groups, the general pattern in the digested amount remained the same. Young animals of experimental groups I and II digested 4.5 % (P ≤ 0.05) and 5.8 % (P ≤ 0.01) of nitrogen more than their peers in the control group.

Table 3. The average daily nitrogen balance of experimental animals, g

| Indices                                |control |Experimental I | Experimental II |
|----------------------------------------|--------|---------------|-----------------|
| Received                               |154.34  |159.65         |159.66           |
| Excreted with feces                    |55.41   |56.26          |54.97            |
| Excreted with urine                    |72.07   |74.32          |75.06            |
| Digested                               |98.93   |103.39         |104.69           |
| Deposited per a head                   |26.66   |29.07          |29.63            |
| Deposited per 100 kg of live weight    |9.11    |9.38           |9.41             |
| Utilization coefficient from the received, % |17.40 |18.21          |18.58            |
| Utilization coefficient from the digested, % |27.15 |28.12          |28.30            |

| Group | M | m |
|-------|---|---|
| control | | |
| Experimental I | | |
| Experimental II | | |

Significant difference in relation to control: * – P ≤ 0.05; ** – P ≤ 0.01

In urine of animals fed with fuse, the amount of nitrogen was 3.1–4.1 % more.

The greatest amount of nitrogen was assimilated by animals of the experimental groups. In them, this indicator was 8.3–10.0 % higher (P ≤ 0.05). Higher nitrogen uptake was observed in calves of experimental group II. It was higher by 1.9 %.

4. Discussion

It has been proven that the introduction of by-products of the fat and oil industry into the diet of farm animals favorably affects their growth indices, digestibility of energy and protein content [6]. The highest digestibility indices were found in bulls that received fuse after cavitation treatment. Perhaps the factor determining the digestibility is a change in the diversity and functional activity of the rumen microbiota. Being included in the process of cicatricial digestion, microorganisms closely interact with plant materials; as a result, cicatrical microorganisms can affect the metabolism of other nutrients [7, 8].

Energy is spent on the growth and maintenance of life; therefore, animals need it. The energy efficiency of fodder products is determined by two main factors: the nature of chemical compounds and the degree of assimilation of these compounds [9]. Fodder enriched with fuse contributed to greater energy consumption and its more productive use. Moreover, the best indicators are achieved when fuse treated with cavitation is included in the compound feed.

An important indicator of the effectiveness of fuse is the deposition of nitrogen in animals. The degree of nitrogen utilization is determined by the age and productivity, as well as feeding conditions. The nitrogen balance characterizes the biological usefulness of diets and is an indicator of the ability of animals to use the nitrogenous part of the feed.

Analyzing the metabolism of nitrogen in experimental animals, it should be noted that its balance was positive in all groups, which indicates the dominance of assimilation over dissimilation. This is quite natural for healthy young animals, in whom muscle tissue develops intensively at an early age, and protein is its basis. Moreover, the bulls of the experimental groups absorbed feed nitrogen by 9.0–11.1 % more than the control peers. It is possible that cavitation activates protein metabolism, enhances the supply of amino acids to organs and tissues and accelerates the formation of muscle tissue, which is consistent with previous studies [10-13], which demonstrate the potential of cavitated fuse for feeding farm animals.

5. Conclusion

Feeding calves with cavitated fuse improves the digestibility of dry matter by 2.8 % (P ≤ 0.05), raw fat – by 3.1 % (P ≤ 0.01), nitrogen-free extractive substances – by 4.8 % (P ≤ 0.05). The gross energy
exchange increases by 2.3 % (P≤0.05) and the coefficient of productive energy use increases by 0.7 %, while the productive use of feed nitrogen increases by 1.2 %.

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