Instant grains in sports nutrition: effect of microwave processing on moisture content and moisture-binding capacity

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Abstract. The article discusses the effect of microwave processing on the moisture content and moisture-binding capacity of grains. The samples of grains that underwent technological processing were analyzed.

Two types of grains common in sports nutrition were studied: pearl barley and buckwheat.

The effect of microwave processing on the moisture and moisture-binding capacity of grains was evaluated. The optimal modes of microwave processing of grains were established.

Keywords - sports nutrition, pearl barley, buckwheat

I. INTRODUCTION

Nutrition plays an important role in ensuring optimal growth and development of the human body. It helps to adapt to the effects of various environmental agents and affects both health and life expectancy.

In the diet of people involved in sports, grains play an important role. They are a source of slow carbohydrates and are used by athletes, both during weight gain and fat burning.

Currently, consumers consider as important not only the taste and quality of food but also the time taken to prepare the meal. Therefore, in recent years, much attention has been paid to instant products.

The introduction of grain products in the diet will significantly reduce the time spent on recovery processes.

The proposed technology for instant products significantly reduces cooking time. This is especially true during the preparation for competitions with 2 or 3 daily training sessions.

One of the varieties of such products is grain food concentrates, which include grains and instant grains. They are used to prepare the first and second dishes and are valuable for humans, as grains contain a large number of essential amino acids, carbohydrates, including dietary fiber, vegetable fats, vitamins and minerals.

II. LITERATURE REVIEW

Currently, microwave energy is widely used in food production. Important advantages of its application are selectivity and uniformity of heating. These properties of the microwave field can reduce energy consumption, increase productivity and preserve the nutritional value of raw materials compared to traditional methods.

In [1], information is given on improving the properties of crispy potato snacks prepared without oil and using multiple microwave drying to heat the product.

In [2], the positive effect of using microwave extraction to extract pectin from the peel and cup of eggplant is indicated.

Microwave radiation is used for the pasteurization of raw materials [3].

Of particular interest is the work [4], which studied changes in the structure and properties of high amylose corn starch under short-term microwave irradiation (1–4 min). It was established that, compared to untreated corn starch, with a short microwave exposure time (1 min), the content of resistant starch increased and viscosity decreased. With an increase in exposure time (2–4 min), the opposite effect was observed — viscosity increased and the content of resistant starch decreased.

This study provides a deeper understanding of the effect of microwave irradiation on starch and is important for the production of grains with new functionality and high nutritional value.

Thus, the principle of production of instant food concentrates consists of irreversible changes occurring in grains after certain processing, which lead to the destruction of starch granules, their gelatinization, protein denaturation and, in general, to a better cooking quality and significant reduction of cooking time.

The traditional method for the production of instant grains is the method of additional hydrothermal treatment of cooked-dried grains with subsequent dry-rolling. [5] The main disadvantages of this method include relatively low productivity, high energy consumption and the cost of production.

In the production of grain flakes, an extrusion method is used [6]. When it comes to the speed, the extrusion method is the most productive. Extrusion products do not require cooking and are ready for use.

Recently, the method of thermal micronization has become increasingly widespread in the production of instant food concentrates. It is based on grain swelling with moisture vapor inside the grain under intense infrared (IR) heating [7]. As a result of this treatment, starch softens and passes into easily digestible sugars, while fiber acquires a more uniform structure. As a rule, expanded grain obtained by micronization is subjected to dry-rolling to destroy the integrity of the core and reduce cooking time.

Instant grains obtained by extrusion and thermal IR micronization are mainly used for viscous and liquid grains as a result of the destruction of the core. Moreover, during the
destruction and separation of the grain shell with dry-rolling and extrusion, its initial nutritional value is substantially lost.

One of the important tasks is to increase the nutritional value of grains and reduce energy and resource costs in their production.

This research is aimed at developing technology for the production of instant grains using microwave processing for thermal micronization.

A method for the production of instant grains based on micronization through microwave processing has been proposed [8,9]. Due to the volumetric heating in the microwave field, this technology allows not only to reduce the time of hydrothermal processing, but also to exclude the dry-rolling operation. As a result, the efficiency of instant grains production is increased, energy and resource consumption are reduced, and nutritional value is increased.

The purpose of this work is to study the effect of microwave processing on moisture and moisture-binding capacity in the production of instant grains.

The moisture content of grains is one of the most important indicators of its quality, which is determined immediately after taking the grains for storage. Water has a strong effect on the grains themselves and microorganisms on their surface. On wet grains, microbes develop faster, the number of ticks and insects increases, other changes occur.

Humidity is a factor showing the proportion of grain nutrients and the duration of its storage. The moisture content of grains affects its nutritional value and is a determining factor during storage. For different types of grains, the maximum allowable humidity ranges from 12 to 17%. At the same time, products intended for long-term storage or shipment to remote areas should have 1–1.5% less moisture than those used for current consumption. Excessive moisture leads to the activation of physiological and physico-chemical processes. Grains begin to swell, germinate, high molecular weight biopolymers break down, and enzymes are activated. Grain flowability decreases, it becomes vulnerable to mechanical damage. If the wet grain remains for a long period, its storage and processing become impossible. In any case, product quality when using moist raw materials worsens.

Moisture-binding capacity shows how much water can bind raw materials as a percentage of their own weight. Knowledge of the moisture-binding capacity of raw materials allows controlling the process of food production and predicting the consistency of the final product. For instant grains, this indicator is a key one, since it not only affects moisture containment during storage, but also helps to increase the volume and accelerate cooking.

To achieve the purpose of the study, the following tasks were set:
- to identify the dependence of the change in moisture in the grain from the power of the microwave processing;
- to identify the dependence of the moisture in the grain on the duration of the microwave processing;
- to identify the dependence of moisture-binding capacity on the mode of microwave processing.

III. MATERIALS AND METHODS

The types of grains common in Russia were selected as research materials:
- pearl barley of the 1st grade, without shell, characterized by passage through a sieve with 4 mm meshes (GOST 5784-60, as amended on 01.07.1997).
- buckwheat of the 1st grade, produced from cooked grains, not passing through a sieve with 1.6 × 2.0 mm meshes (GOST 5550–74 as amended on 01.01.1996).

The moisture content of grains was determined in accordance with GOST 26312.7-88 Grains. Moisture determination method (with changes to N1).

The grains were crushed in a laboratory mill for 30 s, mixed, laid out with a mass of m = 5 g in boxes and dried in an oven for 40 minutes at a temperature of t = 130 °C. After drying, the boxes were removed from the dryer, closed and placed in a desiccator for cooling.

The moisture content of grains was determined by the formula

\[ H = \frac{100 \cdot (M1-M2)}{M1}, \quad (1) \]

where \( H \) - humidity, %
M1 - weight of the sample before drying, g
M2 - weight of the sample after drying, g.

The choice of these particular grains is due to the fact that they are one of the most popular in sports nutrition.

Buckwheat and porridge from it is considered one of the most vitamin-rich, especially when it comes to vitamins B1, PP, as well as silicon (almost a daily norm). Buckwheat contains almost 6 grams of protein per 100 grams, which is especially appreciated by athletes. In addition, buckwheat is rich in iron (2.2 milligrams per 100 grams), making it so popular among bodybuilders.

Pearl barley is rich in B vitamins: B1, B2, B5, B6, B9, ranging from 4 to 16% of the daily need for potassium, phosphorus, magnesium, iron, zinc, copper, manganese, selenium. It contains 2.3 grams of protein and 28 grams of carbohydrates, a small amount of healthy fats (1.1 g.) and proteins (9.3 g.), saturated with amino acids, which play a particularly important role for the formation of new cells, especially in strength sports. Moreover, pearl barley is not characterized by low calorie content (350 kcal) and low glycemic index (20–30).

To ensure uniform microwave processing, the grains were moistened before experiments.

Moistening the grains with water allows increasing the amount of free moisture in the capillaries of the near-surface shells and in the central layers, creating optimal conditions for the absorption and transmission of microwave radiation, increasing the specific surface of vaporization in the capillary-porous structure of the grain, and reducing the specific energy consumption for vaporization during microwave processing.

Microwave processing was performed using a Samsung microwave oven. To ensure uniform heating and to prevent sticking, the grains were periodically mixed.

The experiments were carried out at various modes of microwave processing.

3.1. Preparing grains for the experiment.

The preparation of grains was carried out as follows: sorted, low-quality grains were removed, then washing was carried out at a water temperature of 14-18 °C for 4-5 minutes with constant stirring to reduce the contamination of grains and remove excess starch. Then, soaking was carried out, followed by softening to achieve a moisture content of 28-30%. This is necessary to increase the amount of free moisture in the capillaries of the surface shells and in the central layers and to create optimal conditions for microwave processing by increasing the specific surface of vaporization in the capillary-porous structure of the grain and reducing the specific energy consumption for vaporization.

3.2. Method for determining the moisture content of grains.

The moisture content of grains was determined in accordance with GOST 26312.7-88 Grains. Moisture determination method (with changes to N1).

The grains were crushed in a laboratory mill for 30 s, mixed, laid out with a mass of m = 5 g in boxes and dried in an oven for 40 minutes at a temperature of t = 130 °C. After drying, the boxes were removed from the dryer, closed and placed in a desiccator for cooling.

The moisture content of grains was determined by the formula

\[ H = \frac{100 \cdot (M1-M2)}{M1}, \quad (1) \]

where \( H \) - humidity, %
M1 - weight of the sample before drying, g
M2 - weight of the sample after drying, g.
3.3. Method for determining the moisture-binding capacity of grains.

The moisture-binding capacity of grains was determined by centrifugation.

A weighed portion of grinded grains weighing 1 g was placed in a weighed centrifuge tube, 10 cm³ of distilled water was added and mixed for 1 min at a speed of 1000 min⁻¹. The mixture was left for 30 min, and then it was centrifuged for 15 min at a speed of 4000 min⁻¹. Non-adsorbed water was drained, the tube was weighed and the moisture-binding capacity was calculated by the formula:

\[ BCC = \left( \frac{m_{\text{w.a.}}^2 - m_{\text{w.a.}}^1}{m_{\text{w}}^2} \right) \times 100\% \]  

(2)

where BCC - moisture-binding capacity, %;

\( m_{\text{w.a.}}^1 \) - the mass of the centrifuge tube with grains before adding water, g;

\( m_{\text{w.a.}}^2 \) - the mass of the centrifuge tube with grains after draining the water, g;

\( m_{\text{w}} \) - mass of sample, g.

IV. RESULTS

Figures 1 and 2 show the results of a study of the effect of microwave processing on the relative humidity of pearl barley and buckwheat.

Figures show that with increasing power and processing time, the moisture content of grains decreased. Moreover, the longer the duration and power of the microwave processing, the higher the gradient of change in the moisture content of the grain.

For long-term storage of starchy grains, their moisture content should not exceed 15%. The lower the humidity, the longer the shelf life. From this point of view, according to the results of the experiment, the optimal microwave processing power under these conditions is 500 W, the processing time is 5-6 minutes. Under these conditions, the moisture content of buckwheat was 7.2 - 6.6%, pearl-barley - 10.5 – 13.7 %. Such humidity guarantees long-term storage of grains.

The effect of microwave processing on the moisture-binding capacity of grains is shown in Figures 3-4.

V. CONCLUSION

The experiments performed allow us to conclude the following:

1. The necessity of moistening grains before microwave processing was experimentally established. Under the effect of
microwave processing the moisture heats up, transfers heat to the grains and / or passes into a vapor state. This leads to the increase in volume, the membranes and cell walls soften with subsequent destruction under the effect of excessive steam pressure. Thus, microwave processing of moistened grain results in thermal micronization.

2. With increasing power and processing time, the moisture content of grains decreased. Moreover, the longer the duration and power of the microwave processing, the higher the gradient of change in the moisture content of the grain. The minimum humidity required for long-term storage of instant grains was provided at a microwave processing power of 500 W and exposure duration of -5-6 min. Exceeding these values led to the deterioration of the organoleptic properties.

3. The moisture-binding capacity of buckwheat and pearl barley increases with increasing power and exposure time of microwave processing. Optimal microwave processing power of 500 W and exposure duration of 5 minutes improves the moisture-binding capacity of pearl barley by 20% and buckwheat by 8%. The increase in moisture-binding capacity provides an increase in volume and a decrease in the cooking time.

4. The studies have confirmed the possibility of using microwave processing for instant cereals for athletes during intense physical exertion in conditions of training camp or during competitions. This will simplify the planning of the athlete’s diet and uniform intake of essential nutrients.

REFERENCES