

# Research on the Processing of Corn Grain by Steam Pressure and Ultra-High Frequency Drying

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## Abstract

The process of obtaining instant cereals from corn grain is one of the important areas of research aimed at the efficient use of plant resources. From this point of view, research on obtaining special flour and groats from corn not only contributes to increasing the efficiency of its industrial production, but also opens up new prospects in the field of functional nutrition, aimed at organizing special food rations. When processing corn grain, it is important to isolate optimal components for special consumption rations. For this purpose, based on the study and analysis of the chemical composition of corn grain, a number of substances with functional properties were identified. Also, the important properties of the identified substances for human health are scientifically substantiated. Corn stalks and grains are mainly used for fodder purposes for livestock. It should be noted that today, due to unfavorable climatic conditions, the yield of food crops grown on rainfed lands is decreasing or declining, which requires the effective use of available raw materials. For the use of corn grain for food purposes, the autumn varieties "Oqpari" and "Ivola," registered in the state register, were studied.

**Keywords:** Corn groats, early-ripening technology, uhf drying, steam pressure treatment, nutritional value, vitamins and minerals, amino acid composition, functional food, grain processing, porosity and microbiological control.

**Introduction**

Corn grain is widespread in the territory of Uzbekistan, where it is harvested at an average of more than 1.5 million tons per year. The high content of starch, protein, fats, fibers, vitamins, and minerals in grain allows for its assessment as a promising raw material for the functional food industry. In particular, early-ripening cereals made from corn grain can be beneficial for consumers of different ages, which requires new technological approaches in the production of ready-to-consume products.

The relevance of this research lies in the fact that deeply studying and implementing the possibilities of rapid cooking of cereals based on energy-saving technologies while preserving the nutritional, vitamin, mineral, and amino acid composition of corn grain fully meets today's scientific and production needs. In addition, the proposed technology allows for the optimization of production processes by using high-temperature steam treatment and microwave drying methods, achieving results that meet modern safety and quality requirements.

**RESEARCH METHODS AND TECHNIQUES**

Organoleptic indicators of flour were studied based on GOST 26574-85. Its moisture content was determined by GOST 13586.5-93, and the protein content by the Kjeldahl method, in accordance with GOST 10846-91. The oil content was assessed according to GOST 29033-91 using the Soxhlet extraction method, and the water content was assessed according to GOST 9404-88 by drying at 105°C.

The amount of dietary fiber was studied according to GOST 31675-2012. The total nutritional value (caloric value) was determined by calculation method based on 4 kcal per 1 g of protein and carbohydrates, 9 kcal per 1 g of fat.

**RESULTS AND DISCUSSIONS**

For the purpose of using corn grain for food purposes, the autumn corn varieties "Okpari" and "Ivola," registered in the state register, were studied. As a result, an analysis of the functional composition of grain, which is important for the human body, was carried out, and it was substantiated that the "Ivola" variety is the optimal corn variety for drought resistance compared to the "Okpari" variety, and to obtain quick flour and grain, the physicochemical, technological, and biochemical properties of this grain variety were studied.

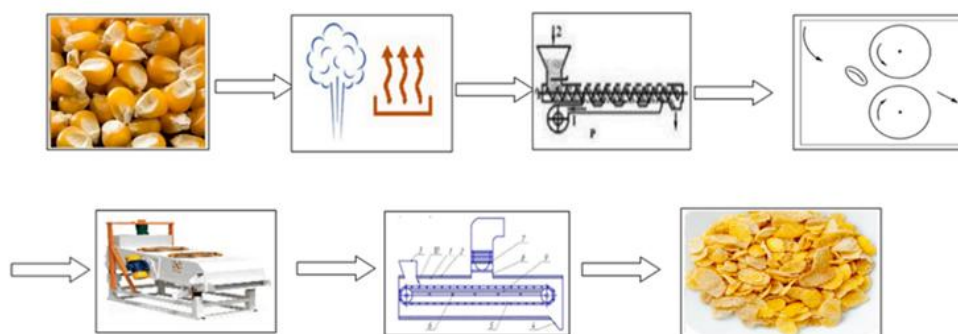
Table 1 Chemical composition and nutritional value of "Okpari" and "Ivola" varieties of corn grain (100 g).

Composition	Cost of nutrients	
	Ivola	Oqpari
Proteins. gr	9,43	8,42
Fats. gr	4,74	4,0
Carbohydrates. gr	74,25	73,2
Water gr.	10,4	12,6
Food fibers. gr	1,2	1,7
Nutritional value. Kcal	393,6	378,7

According to the analysis of Table 1, the "Ivola" corn variety, which has high nutritional value, was selected as the optimal variety for the research object and its nutritional composition was substantiated.

Recently, the demand for early-ripening grains is constantly increasing. In these products, it is possible to balance the amino acid composition of protein and thereby increase its biological value. Corn is one of the most high-yielding crops grown in the territory of Uzbekistan, and according to the Ministry of Agriculture, the Inspection for Control of Grain and Seed Production, the gross harvest of corn in 2024 will be 1640 million tons, which is 5420 thousand tons more than in 2023. Corn grain contains the essential amino acid leucine, which surpasses wheat grain in this indicator. Corn groats are a difficult-to-shake and brittle product, and steam-pressure treatment is considered effective. The upper shell of corn grain becomes soft and elastic under steam pressure and does not crumble when pressed on smooth rollers.

Using steam directly in the groat production processes in the proposed technology is advisable for optimizing energy-intensive stages such as bleaching, shell separation, and grinding. To obtain early-ripening grain from corn grain, it is processed under a pressure of 0.10 MPa for 3-5 minutes. Obtaining early-ripening grain from corn grain from bleached corn is not advisable, as it leads to the formation of a large number of embryos, grain fragments, and flour, which negatively affects the quality and cost of the finished product. For the processing of corn grain grown in local conditions, we set ourselves the goal of carrying out the processes according to the sequence shown in Figure 1.



**Figure 1. Block diagram of the proposed corn grain processing process**

In the technology of obtaining rapidly cooked cotton grain from corn, the corn grain is conditioned, its moisture content is increased to 20-24% before subsequent heat treatment. This is done to soften the grain, improve its elasticity, and ensure a uniform gelatinizing structure of the grains. After this, it was standardized to obtain grains with the following parameters. In this case, the corn grain was given a moisture content of 24% and simmered for 4 hours.

Then, they were treated at a steam pressure of 0.5 MPa for 10-55 minutes. The corn grain emerging from the evaporation chamber was dried to a moisture content of 10-12%.

The husk is loosened, the kernel has not lost its strength, and its brittleness is reduced (plasticized). After separating the corn husks up to 14%, the mixture was directed for crushing on smooth rollers with a rotational speed ratio of 1:1 and an interval of 0.2 mm.

The resulting grain was dried using the microwave drying method to a moisture content of 7-8% and standardized by sorting in a control separator.

The quality indicators of the early-ripening corn grain obtained using the proposed new method were determined.

In the composition of the obtained product, the proportion of coarse, early-ripening grains was 85, fine-grained grains - 7.0%, and shells formed during bleaching - 8%.

When conducting experiments, the total amount of electricity consumed to obtain 1 kg of early grain was 1.2 kW/h. This indicator shows the energy efficiency of the technological process and confirms the optimality of the modern UHF drying method compared to traditional methods, the results are presented in Table 2.

**Table 2. Selected modes and parameters for the proposed new method of rapid cooking of Ivola corn grain (cotton).**

Grain name	Given humidity in GTI %	Steam pressure and processing time, MPa/min.	UHF 600 W/kg/min drying GHz/min	Amount of separated shell, %	Quantity of early grain, %	Amount of received defective grain, %	Energy consumption for obtaining 1 kg of grain, kW/h
Corn	24	0,5/15	2,45/3	8.0	85.0	7.0	1.2

According to the analysis of Table 3.2.1, the proposed new method for obtaining early grain from corn grain was compared with the traditional method in terms of grain yield, production stages, and time spent, and is presented in Table 3.

**Table 3. Existing regimes and production parameters for the rapid preparation of corn grain cereals using traditional methods.**

Grain name	Given humidity in GTI %	Steam pressure and processing time, MPa/min.	UHF 600 W/kg/min drying GHz/min	Amount of separated shell, %	Quantity of early grain, %	Amount of received defective grain, %	Energy consumption for obtaining 1 kg of grain, kW/h
Corn	18	0,10/5	3/14	12	63.0	7.0	1.2

According to the analysis of Table 3, in the technological process of obtaining early-ripening grain from corn grain using the traditional method, the grain was pre-moistened to a moisture content of 18% and processed at a steam pressure of 0.10 MPa for 5 minutes, and the grain was obtained by pressing on a two-roller machine to a thickness of 2.5 mm. After this, an infrared drying of 2.5  $\mu$ m in 3 kV/h was carried out, drying to a moisture content of 13-14% for 14 minutes. In the composition of the obtained product, the share of coarse, early-ripening oilcake was 63.0%, fine-grained grain - 25%, and shells formed during bleaching - 12%.

When conducting experiments, the total amount of electricity consumed to obtain 1 kg of early grain was 4 kW/h. This indicator justifies the suitability of microwave drying compared to traditional methods due to the high energy consumption of the technological process.




According to the analysis of Table 4, the optimal frequency of ultra-high frequency drying was determined, and it was established that at a drying rate of 2.45 GHz per 180 seconds, the optimal electrical energy voltage is 600 watts per 1 kg of product.

In this case, the influence of the established parameters of microwave drying on nutrients and the microbiological activity of the product was taken into account.

At the same time, during the steaming process at a pressure of 0.5 MPa, the temperature in the chamber reached 140-145°C, which, in turn, leads to the almost complete disinfection of the finished product.

The thermal temperature of the steam supplied over a short period of time does not significantly affect the nutrients, as it is carried out in a humid environment. Optimal parameters of microwave drying are also based on practical experiments based on the above-mentioned theoretical data.

**Table 4 Research on the selection of optimal parameters of the microwave drying method in the production of instant cereals.**

Parameters	Example 1	Example 2	Example 3
Microwave frequency. GHz	3,0	2.65	2.45
Power density. W/g	1.5-6	1.5-6	1.5-6
Validity period. sec.	60-180	60-180	60-180
Temperature range. °C	80-120	80-120	80-120
Initial humidity (%)	24	24	24
Actual humidity (%)	5-6	6-7	7-8
Degree of reduction of microbes. 105 times, that is, a decrease of 100,000 times, survived by 0.001%.	> 10 <sup>5</sup>	> 10 <sup>5</sup>	> 10 <sup>5</sup>
Optimal porosity capacity (W/kg)	800	700	600
Porosity of early-ripening barley (g/cm3)	600-700 	550-720 	600-650 

The chosen microwave drying method for rapidly cooking grains, unlike other drying methods, also effectively affects the porous texture and microbiological activity of the product.

The following table shows the indicators of microbiological activity.

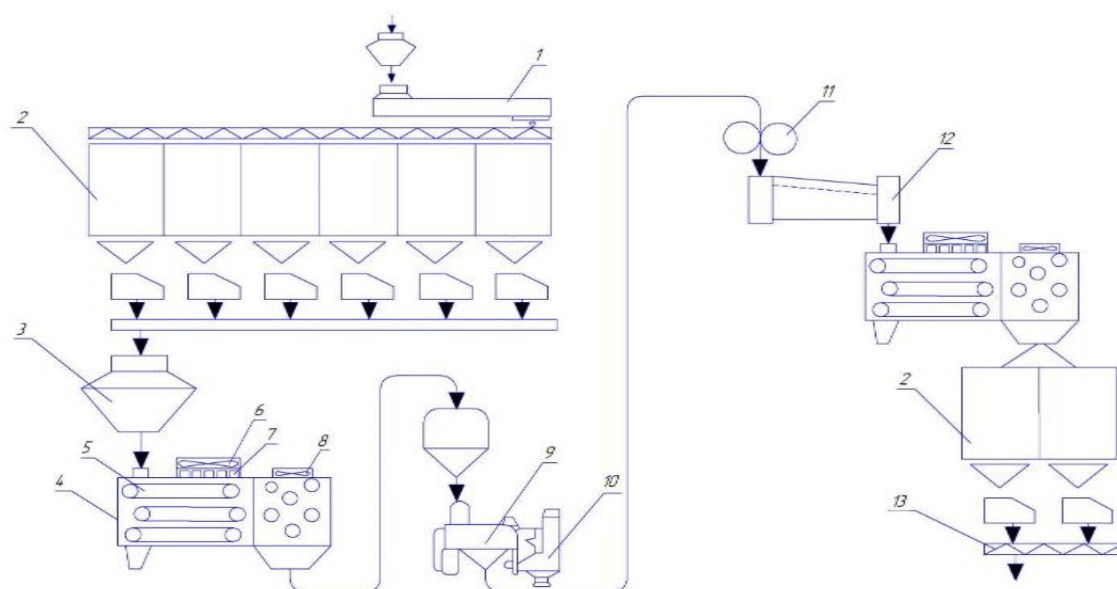
**Table 5. Microbiological indicators of early cereals obtained during the drying process**

Sample	Microbiological indicators					
	Determined forms of microorganisms					
	KMAFANM (Mesophilic aerobic and facultative anaerobic microorganisms) COE/gram		coliform bacteria group COE/gram		Yeast and mold fungi COE/gram	
	Fact.	Norm	Fact.	Norm	Fact.	Norm
Grain moisture content, up to 7-8%	Not detected	1×10 <sup>4</sup>	in 1 gram of product nothing found	in 1 gram of product not allowed	in 1 gram of product nothing found	Yeast 10. Mold 50.



Analysis of Table 5 shows that KMAFanM food products lack common mesophilic aerobic and facultative anaerobic microorganisms. This indicator is important when assessing the degree of microbiological contamination of the product. COE/g (colony-forming unit/gram) is taken as the unit of measurement. CFU/g indicates how many colonies of living microorganisms are present in each gram of the product.

These indicators are the main criteria for determining the safety, quality, and shelf life of products. When corn grain was processed at a steam pressure of 0.5 MPa for 15 minutes and dried at an ultra-high frequency (600 W/2.45 GHz), the highest quality grains were obtained. Based on the obtained effective results, a new technology for obtaining early-ripening corn grain has been developed.



**Figure 2. Technological scheme for obtaining quick-prepared cereals from corn grain.**

1- moistening apparatus, 2- storage facilities, 3- evaporator, 4- first-stage microwave drying unit, 5- kapron mesh conveyor, 6- ventilator, 7- magneton, 8- cooler, 9- bleaching equipment, 10- running separator, roller machine, 12- separator, 13- finished product conveyor.

## CONCLUSION

The conducted research shows that the "Ivola" corn variety grain is the most optimal raw material for the production of early-ripening cereals in terms of nutritional value, functional composition, vitamin and mineral content. During the research, the composition of protein, carbohydrates, fat, fiber, B vitamins, and trace elements in the grain of this variety was thoroughly studied, and it was established that it is an important source of amino acids for the human body.

The proposed new technological method - a combination of steam-pressure treatment and microwave drying - allowed for the preservation of nutrients and biologically active components of the product at a high level. In particular, it has been proven that microwave drying at a frequency of 2.45 GHz and a power of 600 W/kg for 3 minutes maintains optimal product moisture content and fully meets microbiological safety requirements.

New technological solution compared to traditional methods: increasing grain yield by 22%; improving quality; reducing energy consumption; improving organoleptic indicators of the product.

Also, based on the technological map (block diagram of the process) developed on the basis of the proposed method, the stages of production are simplified and efficiency is increased.

Based on the research results, early-ripening grains prepared from the "Ivola" variety of corn grain can be widely used to enrich the daily diet of the population, produce functional food products, and implement environmentally friendly, energy-saving technologies.

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