METHODS FOR OBTAINING BIODEGRADABLE CONTENTS BASED ON STARCH JELLYZATION WITH CAUSTIC SODA AND CEREAL BRAN

Abstract. The volume and scale of disposable tableware production worldwide is increasing, and polymer materials, which are products of oil refining, are used as the main raw materials. Polymer products are organic materials made on the basis of natural or synthetic high-molecular compounds, and are distinguished by a number of advantages of their materials in industry and production. However, the release of chemical and household toxic substances during the disposal process after use and the fact that their decomposition period is on average more than 500 years is a very serious environmental problem. In order to eliminate such an environmental hazard, as an alternative solution, today, based on the study of the chemical composition and properties of many natural and harmless biocomponents, the possibilities of replacing polymer products with other harmless copolymers and biopolymers are being widely studied and put into practice. This scientific article analyzes the technology for the production of environmentally friendly disposable containers using the bran of some cereal plants, in particular, wheat and corn, which is a secondary product, and using two methods of obtaining biopolymer (ecopolymer) compositions with the participation of caustic soda and starch paste, and based on the processes of natural gelatinization of starch in the composition of cereal bran. It is noteworthy that for the first time in our country, specific ratios and technological conditions have been proposed for the production of biodegradable containers based on local, inexpensive secondary grain resources that decompose under the influence of biological natural resources within a period of 1 to 3 months.

Keywords. Wheat, corn, biomaterial, bran, starch, gelation, caustic soda, hydraulic press, temperature, pressure.

Introduction. It is no secret that today the scale of production of disposable containers and the demand for them is growing all over the world. The main raw materials used in this are polymer materials, which are made on the basis of synthetic high-molecular compounds , and are a product of oil refining, which acquire a variety of functional and colorful colors. According to estimates, in 2020, about 655.5 thousand tons of polymer containers were consumed, which leads to the formation of an average of 180 million m^3 of solid household waste. About 50% of the figures given in these indicators correspond to disposable containers and packaging products for food. It is known that only 3% of these products are recycled after use, and the rest are burned, saturating the Earth's atmosphere with toxic gases [1,2].

Polymer products are organic materials made from natural or synthetic high-molecular compounds. The main types of products used today are based on synthetic polymers: polyvinyl chloride, polypropylene, polyethylene, polystyrene, and polycarbonate. Plastic products for both technical and food products are produced from them, and along with their thermal and physical advantages in industry, they also cause environmental, chemical, and biological harm [3,4].

In order to ensure the implementation of the clause on improving the environmentally safe system of waste management in the Decree of the President of the Republic of Uzbekistan Sh.M. Mirziyoyev No. PF-5863 “On approval of the Concept of Environmental Protection of the Republic of Uzbekistan for the period until 2030”, a number of effective measures are planned to be carried out in our country. Based on the above proposal, it is proposed to replace polymer products with other natural, harmless and inexpensive co-polymers, biopolymers, as well as to use secondary and waste parts of grain crops grown in our country as the main raw materials and their advantages are described [5,6].

Literature analysis. According to an analysis of scientific works available in the Scopus and Web of Science databases, more than 120 thousand scientific research results have been published on “Biopolymer Materials”, and advanced experiments have been conducted in leading countries of the world, such as China (more than 24 thousand), the USA (more than 20 thousand), and India (more than 10 thousand). [7, 8].

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The area under wheat cultivation in the world is about 250 million hectares, which corresponds to an average of more than 360 million tons of grain, which is about 30% of the world's grain production. Today, countries such as Russia, Kazakhstan, China, the USA, India, and Canada occupy leading positions in the production of high-quality wheat. In our country, this indicator is also not small, and an average of 55 centners of wheat are harvested from 1 hectare of land, and in some regions this indicator is 60-77 centners, which is undoubtedly a great achievement of farmers and chemists. This, in turn, has created a basis for fully providing processing enterprises with raw materials and the population with food products, as well as increasing the export potential of agricultural products, and the volume and quantity of secondary products obtained from them prove that the volume and quantity of secondary products are sufficient for cheap and harmless processing products [9,10].

used in the production of various types of flour, cereals, alcohol, starch and other products for the preparation of bread and confectionery products , and the remaining parts are burned as a secondary product as nutritious feed for livestock or as waste. Waste parts of cereal plants are their stalks, straw, roots, chaff and bran parts separated during the processing of grain, which make up 70% of the total plant mass. The stems are used to make paper, cardboard, packaging materials, baskets, hats, the green part is used as fodder for cattle, and the mature part is used as silage [11,12].

The scientific publications of Potoroko et al. describe the technologies for the production of biodegradable molded eco-containers based on secondary products of cereal plants, and the mechanical properties of using wheat bran as a biopolymer. The recommended samples were developed into plates that can withstand pressure up to 140 T, and an effective method for the production of biodegradable containers based on them was recommended. There are widely used methods of folk medicine from wheat bran, and in addition to watery cereals, preparations prepared with yogurt or milk, honey, beets and fruits such as apricots have been used to treat diabetes, atherosclerosis, constipation, overweight and kidney diseases. The use of bran is not recommended for diarrhea, avitaminosis, inflammation of the gastric mucosa and duodenal diseases, pregnancy and lactation. [13, 18]

Natural ecopolymers can be considered as high-molecular organic compounds of natural origin that are biodegradable in a microbiological environment or in the internal environment of living organisms. At the same time, these materials can be digestible or indigestible, depending on their chemical composition. Studies have noted positive effects of using such materials, such as additional functional properties (antibacterial or flavoring), increasing shelf life and improving product properties (retaining its shape, moisture loss and preventing gas exchange). Cereal bran has a chemical composition that forms this structure, which allows it to be used as a filler or main raw material for biocompositions in the manufacture of biodegradable containers. The suitability of the analyzed wheat bran for storage samples of carbohydrates and starch (21 g per 100 g), proteins (16 g per 100 g), water (15 g per 100 g) and fats (4 g per 100 g) was studied during chemical analysis. [14]

Arabinoxylans in the bran (which constitute 55% of the dietary fiber of the bran and are largely insoluble in water) exhibit gelling properties. Their viscosity and water-binding properties are important in the cooking process of the presented sample, that is, it is theoretically emphasized that they exhibit these properties. Cellulose (which constitutes 9-12% of the bran fiber) together with lignin (also blood fiber) form lignocellulose, which is very resistant to decomposition. β-glucans (which constitute 2.2-2.7% of the bran dry matter) are water-soluble bran polysaccharides with high viscosity [15].

The use of bran as the main filler for the production of biodegradable containers is reflected in a number of patents. One of them mentions the use of bran in combination with water, glycerin, starch and citric acid [11]. Here, water and glycerin, based on their chemical properties, act as plasticizers and partially plasticize due to gelatinization as a result of the exothermic heating of starch in an aqueous environment. Citric acid acts as a catalyst for the above processes, in particular, starch hydrolysis. The subsequent stages of this technical process include the processes of adding raw materials, shaping and drying, boiling the initial composition (except for bran). Another example proposes a method for using a mixture of bran, flour, beet fiber and water for the production of biodegradable containers. The technical requirements of this technology include the processes of preparing the components of the

mixture in the required proportions, dividing them into the required parts, and then preparing this composition at 200 ° C [11, 12]

wheat bran produce natural dishes use in output It was first developed by the Polish farmer and miller E. Wysocki. He discovered that by preparing a slurry of wheat bran and water , which remained during the flour milling process , and heating it under pressure , he could produce biomaterial , which later laid the foundation for the production of biodegradable containers based on waste. The Biotrem company, which is currently operating, also produces biodegradable containers from wheat bran based on this technology [12, 13].

Biotrem (Poland) biodegradable containers currently available on the market in our previous scientific publications. There is a patented method for producing this category of environmentally friendly containers. According to it, bran is mixed with a mixture of absorbents (absorbents) and/or flavoring additives and/or non-fibrous fillers and/or wetting agents and/or natural color additives. The material composition is placed in the first part of a two-part, water-tight, heated mold, after the mold is closed and the mixture is pressed under pressure at a temperature of more than 120 ° C and an average pressure of 1-10 MPa, then the mold is depressurized by creating a gap of no more than 0.5 mm between the edges of the mold, then the mold is closed again if necessary and the depressurization cycles are repeated, and in the last cycle the mold is opened. Samples from Biotrem containers, which were considered an alternative for our scientific research, were selected. [13]

This technology can be used to produce 10,000 plates from one ton of bran , the energy cost of producing 1 kg of which is only 1.3 kg of CO_2 , while the production of single-use plastic containers is 8.5 kg of CO_2 . This proves another advantage of biodegradable containers over plastic containers obtained by refining oil. Considering that currently more than 70% of disposable containers worldwide are made from oil and its processing materials, this value can reduce the energy consumption by several hundred times. [14]

for producing biodegradable containers, recommended by E.P. Kudryakova, a researcher at a higher educational institution in Samara, is as follows: At the first stage of production, raw materials (wheat bran) are received, inspected, and weighed. Before entering production, the bran is ground to pass through a 1.5 mm sieve . For this A hammer mill can be used. The grinder is designed to remove impurities from the paint, as well as to provide lightness and aeration, which helps to better absorb moisture during mixing .

Gelatin can be cooked in a 150-liter D9-41A disintegrator without a mixer. At the next pressing stage, it is recommended to use a hydraulic machine ZDJ-400 , equipped with a hydraulic press, with one workstation, intended mainly for the production of trays and plates from paper raw materials . The machine is used to produce large-sized plates (plates, trays) from harder materials. Using the ZDJ-400 automatic cardboard plate making machine, disposable containers are formed by pressing until they are in the desired shape (Fig. 1). At the final stage of our work, the containers are dried in an industrial drying cabinet. [16]

Figure 1. ZDJ-400 automatic machine for the production of biodegradable containers .

In order to achieve the desired moldability, the prepared biodegradable containers are the manifestation of adhesive properties due to the starch gelatinization of the selected raw materials. The table below shows the main technical requirements, temperature resistance and compatibility for making paste from samples of starchy plants [14].

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Very lengthy literature review.

Summarize and shorten all these details into one small paragraph.

Point out what is necessary for the current study

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Table 1. Gelatinization of different cereal starch samples.

Starch	Gelentinization temperature	Appropriate appearance	Long-term heat resistance	Appearance
Wheat	52-85 ˚C	Smooth	Good	Not transparent
Corn	62-80 ˚C	Smooth	Average	Not transparent
Potatoes	58-65 ˚C	Donley	Bad	Transparent
Tapioca	52-65 ˚C	Donley	Bad	Transparent

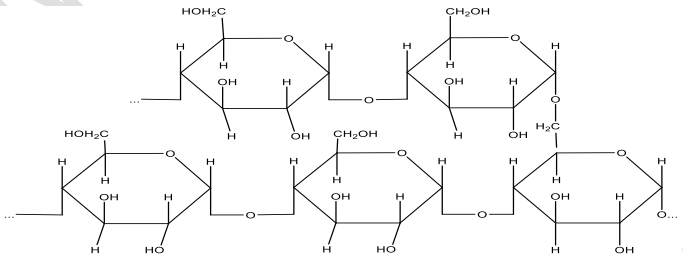
Starch gelatinization is the irreversible gelatinization process (destruction of the starch molecule) of starch suspensions in excess water or other solvents capable of hydrogen bonding (e.g., liquid ammonia, formamide, formic acid, chloroacetic acid, and dimethyl sulfoxide) at elevated temperatures (65 ˚C to 100 ˚C, depending on the type of starch). This process depends on the ratio of starch to solvent and leads to irreversible changes in the starch granules, such as loss of crystallinity, water absorption, and granule swelling.

Research results . In order to ensure that the biodegradable containers we recommend are 100% natural, environmentally friendly, and to increase the quality and durability of the containers, we used natural glue, namely starch glue. During this study, we conducted and analyzed two methods for producing biodegradable containers from wheat bran. The first was the production of 100% natural eco-containers using the starch glue mentioned above, and the second was the laboratory analysis of the container production line as a result of processing under physicochemical effects based on appropriately prepared mixtures of wheat and corn bran with water.

A mixture (gelation) of starch and water in different proportions at a temperature of 50°C to 60°C was accepted for dishes made as starch glue. This glue is commonly used as an auxiliary coagulant in processes such as labeling and packaging of equipment. In our scientific work, the ability to demonstrate the adhesive properties of bran starch, which is manifested by gelation, was analyzed for the possibility of preparing natural dishes with smoothness of the surface and water stability for the prepared compositions.

Preparation of starch glue . It is advisable to use corn starch for this purpose. The gelatinized medium is called the "carrier", and in addition to the carrier and starch, caustic soda can usually be added to the adhesive composition to lower the gelatinization temperature of the starch. To achieve effective results, this component should contain at least 15% of the total solids. However, in practice, significantly more unmodified starch is used than this minimum.

Today, the use of computers to analyze the mechanisms of complex chemical processes and the methods of quantum chemical calculations is rapidly developing, which provides an opportunity to theoretically study the chemical reaction of this mechanism and the primary structure of the substance, the product yield, the formed substances, and their spectroscopic parameters. We would like to give the formula of the chemical structure of the starch molecule and the processes that take place using this method. [16 , 19]



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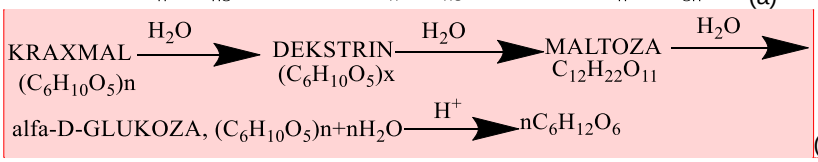

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Figure 2.a) Starch molecule ; b) Starch hydrolysis chemical structure formula.

Starches are known to gel at temperatures of 65.5°C or higher. Since gelation occurs at temperatures above 65°C, the gelation temperature can be artificially lowered to the desired level by adjusting the amount of starch gelling agent such as caustic soda. Another reason we use caustic soda is its effectiveness and low cost. This agent is sufficiently viscous and thick that the resulting adhesive does not penetrate the paper very quickly, but is fluid enough to allow the adhesive to move easily in the circulation system of the storage. We can use the alkaline adhesive composition of corn starch in our processes for obtaining biodegradable containers, to increase the stability of the samples and reduce the permeability of the surface.

The second method of preparing starch glue is the method using animal gelatin, in which gelatin that has undergone the swelling process is poured into the prepared starch paste, mixed and cooked in a water bath at 100-120 ^{0} C for 30 minutes. The prepared glue is stable and forms the basis for the durability of the container surface. The result was proven to be a high level of adhesion, but it was considered inappropriate to use this method because it caused a sharp increase in the cost of the biodegradable containers being produced.

In the second method, due to the fact that wheat and corn bran contains 10-20% starch, a method based on the phenomenon of coagulation and the smooth appearance of the surface of the container was analyzed in the preparation of biodegradable containers based on the processes of starch gelation as a result of certain physical and chemical effects (temperature, pressure, water).

The chemical composition of a mixture of wheat and corn bran in a ratio of 1:1 was analyzed during our previous research and was selected as the optimal ratio. Experiments to evaluate technological and physical parameters of starch glue and wheat and corn bran prepared using the methods we recommended above were conducted in the " Commodity Chemistry and Folk Medicine Scientific Research Center " laboratory at Andijan State University .

from wheat and corn bran in 5 different mass ratios (per 100 g of raw material) for two different methods and their physical and mechanical stability was analyzed. These ratios are given in the table below :

Table 2. Mass ratios of bran and corn bran, respectively (per 100 g of raw material)

Laboratory sample number	Amount of wheat bran (g)	Amount of corn bran (g)
LN 1	90	10
LN 2	80	20
LN 3	70	30
LN 4	60	40
LN 5	50	50

1. Necessary raw materials: -wheat bran; - corn bran, - water.

2. Required equipment and conditions : -temperature 80 -110 ^{0} C; -pressure using a hydraulic press ; - molding in a double-sided mold (diameter 20 cm).

3. Stages of preparation: -Preparation of raw materials; -Heating; - Molding.

When preparing samples, the technologies for manufacturing biodegradable containers were analyzed based on the following parameters. The mechanical strength of the container (load weight 1 kg force = 1 N\ container surface m ^{2} = S), resistance to temperature changes (different temperatures) were determined based on GOST 9147-80, and water resistance was calculated according to the GOST 12605-97 Cobb method , which is based on determining the one-sided swelling of natural materials in water , and the results are presented in Table 3 [16, 17, 18].

Table 3. Physico-mechanical parameters of biodegradable container samples

Sample type	Index name				
	Strength (N \ m ^{2})		To the water endurance %\min		To the temperature endurance ^{0}C \min
	1 kg load (1 N)	2kg load (2 N)	30 min . To be continued	60 min . To be continued	

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1.α-amylase
2. β-amylase (amylopectin)

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Table 2 below.

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LN 1	312.31 stable	624,627 fractures observed	30%	35%	80-100 ^{0}C
LN 2	312.31 stable	624,627 fractures observed	25%	30%	85-110 ^{0}C
LN 3	312.31 stable	624,627 cracks to leave	25%	30%	85-120 ^{0}C
LN 4	312.31 stable	624,627 in the center departure observed	15%	20%	90-150 ^{0}C
LN 5	312.31 stable	624,627 stable	5%	10%	100-160 ^{0}C

It was mentioned above that bran contains up to 20% starch (based on wheat varieties). It is for this reason that in our next samples, the starch contained in the bran content is used as a natural glue due to the irreversible gelatinization process at the expense of active hydrogen bonds in water, and we prepared biodegradable containers under only physical effects, i.e., temperature and pressure.

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For this, we used a mold heated at 100 - 105 ^{0}C in laboratory conditions and a hydraulic press with a load of 32 tons and a mold with a diameter of 18 and 22. We prepared a mixture of wheat bran and water as a biomaterial for making biodegradable containers. The proportions of the samples were prepared based on the ratio of 100 g of biomaterial and are presented in the table below.

The above mass ratios were carried out several times in order to record the optimal performance of the water bran mixture. It is the mixing of the amount of water in the right proportion that is considered the main factor in the process of starch hydrolysis at high temperature. From the prepared samples, we took out a total of 80 grams for a mold with a diameter of 16 cm, and 190 grams for a mold with a diameter of 22 (the depth of the molds is different).

The process includes the following steps:

- Sampling ;
- Placing on two-sided iron molds ;
- pressing with a 32-ton hydraulic press ;
- Heating the pressed sample for 4-5 minutes at 100-105 0 ^{C} ;

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The dishes removed from the mold undergo the final drying stage in the drying apparatus at 140 ^{0} C, which helps our prepared dishes to be molded in an optimal shape. Ready-made biodegradable containers are presented in Figure 3 .

Figure 3. Samples of biodegradable containers made by pressing on the basis of wheat bran.

The optimal ratio of prepared containers is 70 to 30, and the sample retains its shape in the mold for the time indicated above due to gelatinization of the starch in it.

Despite being made from bran, the resulting containers are very strong and are suitable for hot or cold, liquid or solid food. The disposable containers produced have been shown to

decompose without any disposal problems after use, within 30-31 days at a temperature of 55-70 C and a humidity of 45-60%. [15] Similarly, disposable plastic containers take more than 500 years to do this. In fact, a more efficient way to dispose of biodegradable containers is to use them as local livestock feed. The 100% natural composition and nutritional value of organic waste not only make them harmless containers, but also provide a high-quality and nutritious source of feed for local livestock [20, 21, 22].

Conclusion: 100% natural, fully biodegradable, disposable containers made from wheat bran The production method is based on the technology of pressing the shell at high temperatures (above 150 ° C) and under high pressure, without the use of adhesives and preservatives. Based on this technology, biodegradable containers (or eco-containers) are adapted to withstand temperature shocks compared to plastic containers that currently occupy a leading position in the market, that is, they allow food to be served in a container both hot and cold .

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As a general conclusion for our study, we recommend environmentally friendly container models that are 100% harmless to plastic disposable containers. Such biodegradable containers based on bran and corn starch and based on bran and animal gelatin were recommended. The grain samples grown in our country are soft grains and have a high amount of separated bran, which is also economically effective. Our non-degradable containers based on wheat bran and water, which can be recommended for production on automatic lines, have both economic and environmental benefits. Such biodegradable containers, which are completely environmentally friendly, can also be a very valuable addition to animal feed.

scientific research, we presented the Biotrem company's biodegradable container production line, which is recommended as an alternative to our biodegradable containers. In conclusion, we would like to conclude by listing the advantages of our biodegradable containers, which were prepared in laboratory conditions during our research and are recommended for production:

- Completely harmless based on chemical composition;
- due to the fact that it consists of natural fiber complexes that provide vitamins and nutrients, by using it for animal feed, after use, it is possible to dispose it not only harmlessly, but also usefully;
- It completely decomposes in soil resources from 30 to 70 days and does not harm soil components;
- The cost of Biotrem biodegradable containers is 32,000 soums for a set of 20 cm plates (the price of 1 plate is 3,200 soums), during our study, 100 grams of bran and technical conditions were spent on a 20 cm diameter plate, and the average cost was estimated at 13,000 (the price of 1 plate is 1,300 soums). As a result, an economic efficiency of 19,000 soums was calculated compared to an imported product sample of the same category.

On the basis of the above conclusions, we would like to recommend the creation of lines for the creation of biodegradable containers from the bran obtained as a result of the large-scale cultivation of grain products in our country, several times cheaper than samples made abroad, of high quality, without disposal problems, completely harmless and environmentally friendly.

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