Bread and bakery products are the most common food products that have a significant impact on the biological and energy value of the human diet.

The presence of proteins, fats, vitamins, mineral components, and dietary fiber in them depends on the assortment, recipe, and cooking technology.

The use of dried purslane in powder form as a semi-finished product (raw material and additive) and the development of various technologies with it at the same time can provide the population with a wide range of food products in the diet.

The aim of this work is to determine the quality indicators of the powder from the stems of garden purslane (Portulaca oleracea l.) and its application in the production of functional bakery products. This will make it possible to use them as a protein-carbohydrate-mineral and multicomponent fortifier to obtain functional bakery products.

This paper reports the results of studying in a laboratory the powder from the stalks of garden purslane (PP), growing under the conditions of the Absheron district of Baku, Azerbaijan. Its general chemical and mineral composition, some physical-mechanical and microbiological indicators and safety indicators of PP have been studied, the doses of its introduction into yeast dough have been substantiated. By organoleptic and physical-chemical methods, the technological indicators of the quality of yeast dough and finished products with PP powder for the production of functional bakery products were determined.

Powder from garden purslane stems was used in the production of functional bakery products, and a recipe and technological scheme for the production of "Health" buns using purslane powder were devised

Keywords: garden purslane (Portulaca oleracea L), powder from purslane stems, bakery products

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DETERMINING THE QUALITATIVE PARAMETERS OF POWDER FROM THE STALKS OF GARDEN PURSLANE (PORTULACA OLERACEA L.) AND ITS APPLICATION IN THE PRODUCTION OF FUNCTIONAL BAKERY PRODUCTS

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1. Introduction

Processing of grain crops and subsequent baking of bakery products during production leads to significant losses of biologically active substances, in particular B vitamins and important trace elements. This is especially true for products made of premium and 1st grade flour, which should be fortified in order to improve nutritional value, ensure safety, and increase consumer properties. The development of new varieties of bakery products of high nutritional value using new raw materials of therapeutic and prophylactic orientation requires research [1]. In this aspect, fruit and vegetable raw materials growing without chemicals, as well as in a wild form, and composite mixtures of them in dried form deserve attention. Therefore, these plants in the form of a powder without exaggeration can be called a storing place in terms of the content of essential components, primarily protein, vitamin, carbohydrate, phenolic compounds, organic acids, and other components.

In this regard, crushed dry compositions are currently considered to be the most promising additives from plant raw materials from a technological point of view for the processing and production of enriched functional foods.

Among them, powders from fruit and vegetable raw materials are most suitable for recovery in food systems. Homogenization and mixing them in formulations are convenient for dosing during production, they are economical in consumption and transportation over certain distances [2].

The advantages of using plant compositions in powder form are related to the fact that in terms of the content of

food and bioactive components, they are more concentrated and convenient for various types of technological processing. Vegetable powders in food systems perform the functions of stabilizers, dyes, flavors, and a number of others, often combining several functions simultaneously [3].

The ability to swell and gel in an aqueous environment, sorption, antioxidantness, and high manufacturability allow their wide application in the food industry. Herbal powders are also valuable for cooking, traditional and modern medicine, for pharmaceutical and therapeutic practice [4].

The inclusion of high-nutritional products in the diet is the most effective and recognized worldwide way to solve the problem of good nutrition.

In this aspect, the scientific topic of obtaining and using powdered compositions from fruit and vegetable raw materials, primarily grown without chemicals, including wild form, is relevant.

2. Literature review and problem statement

In the Republic of Azerbaijan, garden purslane (*Portulaca oleracea L.*) has been used for centuries by the local population as a vegetable plant in home cooking in fresh, boiled, and canned forms [5].

To this end, according to many years of experience with traditional medicine plants, garden purslane (Portulaca oleracea L.) is considered to be the most suitable, including its stems; it is widespread under the conditions of Azerbaijan, Uzbekistan, Republic of Kazakhstan, etc. [6].

In the herb, such rare substances, homoisoflavonoids, are isolated as purslanons A-D, feruloil amides [7].

Traditional medicine used purslane in the treatment of diseases of the liver, kidneys, and gallbladders, to reduce high fever, against flatulence, and many other diseases. Purslane is believed to be a genius of traditional medicine. Not only is this plant distinguished by its healing properties, it is successfully used in cooking by many peoples. In cooking, they use mainly purslane herb, which is distinguished by a tart aroma and taste [8].

The plant in chemical composition is very rich, which is superior to many plants and can not be a competitor to it in this regard. The composition of the plant contains many valuable carbohydrates and is represented from a variety of sugars. Also, the plant contains a lot of carotenoids, which are precursors of vitamin A. They have many substances of anticoagulation action that prevent the formation of blood clots. In addition, purslane is rich in fatty acids, flavonoids, steroids, alkaloids, and other biologically active substances [9].

Purslane is one of the plants of traditional medicine and its properties are the subject of detailed research [10].

An extract from purslane stems after drying was also studied to justify the use of purslane in the production of flour products [11]. The antimicrobial effect of purslane extract on the development of pathogenic microorganisms in the production of dough [12] was shown and its positive effect on the dough formation process was established.

The technological properties of dried purslane for the production of bread products have been studied [13]. By studying the water absorption capacity and turning it into puree, it is recommended for the production of emulsion foods [14].

Using the fresh ground part of this plant, patents have been submitted for the manufacture of salad [15] and mayonnaise. Due to its stabilizing and emulsifying ability in the form of puree, purslane powder is recommended for the production of mayonnaise [16].

The possibility of using purslane for the production of protein paste and for use in therapeutic, prophylactic, and mass nutrition is shown in [17].

All this is primarily due to the diversity of its chemical composition, the presence in it of numerous biologically active components including proteins, carbohydrates, amino acids, phenolic compounds, a variety of vitamins, organic acids, minerals, etc.

Based on the importance and richness of the chemical composition of purslane juice, a technology for obtaining yogurt drinks with additives of purslane juice has been developed [18].

All this is explained by the fact that cultivated wild food and medicinal plants and products of their processing contain in their composition structure-forming, gelling polysaccharides, protein, fat, and biologically active components that have high technological properties. Despite all this, when using them in food technology, to comply with certain technological regimes, additional knowledge and skills about their characteristics with fresh samples was not always possible. The high humidity of the latter prevented this. The use of raw materials in powdered form opens up wide opportunities for their use in food technologies.

In this aspect, the powder from the stems of the garden purslane deserves attention. Due to the concentration of biologically active substances, protein and structuring components in the composition, it can become a drug for multi-purpose food purposes. However, due to these properties, purslane powder has functional properties.

Studies have established that wild purslane contains about 300–400 mg of α-linoleic acid, 12.2 mg, α-tocopherol, 26.6 mg of ascorbic acid, 1.9 mg of β-carotene, and 14.8 mg of glutathione per 100 g of wet leaf weight [19]. It also contains alkaloids, catecholamines, phenolic acids, anthocyanins, avenoids, lignans, terpenoids, betalanins, etc.

In addition, purslane contains about 188.48±6.35 g/100 g of omega-3 fatty acid [20]. Therefore, other authors consider it one of the richest sources of omega-3 fatty acids. In total, 85 metabolites were identified in 3 species of purslane (p.Oleracea, o.rausii, P.granulasollite). The mineral composition of fresh purslane is also very rich [21].

Preliminary study of purslane stalk powder (PP) in the laboratory showed high emulsifying, swelling, water-absorbing, and other abilities in the form of puree. In the initial systems, they allow it to be used as a replacement for part of the flour as an enriching additive for bakery products [22].

In the literature, there are also no studies on the production and characterization of powdered compositions from the stems of garden purslane, primarily for use.

Studies have shown that purslane extract ina certain amount affects gluten, its elasticity and plasticity. The water-absorbing ability of biocomponents in the composition helps improve the structural and mechanical properties of the dough [23]. In addition, the use of garden purslane stems, the production of powder from them separately is justified by the fact that the presence of individual components in the leaves of plants can worsen its technological properties. Thus, the emulsifying, foaming, whipping, and stabilizing properties of puree of whole purslane in food systems can change negatively. This is confirmed in preliminary laboratory experiments.

The need to produce powder from purslane stems is primarily due to the fact that it consists entirely of those stabilizing desirable components that, after soft drying, retain their technological and structural-mechanical properties. They have emulsifying, foaming, and whipping properties. The presence of protein compounds, soluble polysaccharides, including pectin in it confirms what has been said.

PP powder is quite suitable for obtaining beverages separately, in the form of reconstituted puree as an emulsifier and stabilizer for food systems, including minced meat, for jelly products, for the introduction of alcoholic beverages in a blend, etc.

The powder of garden purslane obtained by drying in a chamber at a temperature of 30–40 °C is a two-phase system of the "solid phase - gas" type and its properties are due to the size of the dispersed particles with the following indicators and chemical composition.

Since the dispersion of particles depends on the structure and chemical phase of the powder, it determines its certain qualities. The flowability, packaging, storage, and dosage of the powder during the production depend on the dispersion.

Therefore, the determination of moisture content, diameters (in μm), and powder density after grinding dried stems and sieving is very important. However, these indicators for PP powder have not yet been conclusively studied.

In this regard, for many new, not industrially produced, but promising for use in food technology powders from wild and cultivated vegetable raw materials, such as purslane, this is very important. Many of the recommended powders in this regard have not yet been fully studied granulometrically and have not received reliable estimates for chemical and mineral composition, especially since they are absent from local raw materials.

Based on these prerequisites the timeliness of the creation of PP powder is justified.

The technological properties of dried purslane (powder) for enrichment of products with dietary fiber have been studied. The possibilities of using purslane powder for the production of bread products, and the quantitative composition of dietary fiber in bakery products with purslane powder additives were also studied.

Using the ground part of this miracle plant, Azerbaijan's patents for salads and mayonnaise have been submitted, materials have been published on the prospects of its use for obtaining protein paste and for use in therapeutic, prophylactic, and mass nutrition. All this, first of all, is explained by the richness of its chemical composition, the presence in it of numerous biologically active components including proteins, carbohydrates, amino acids, phenolic compounds, a variety of vitamins, organic acids, minerals, etc.

It should be noted that cultivated and wild food and medicinal plants and products of their processing are rich in structure-forming, gelling polysaccharides, protein, fat, and biologically active components. When used in food technology, they require compliance with certain technological regimes, additional knowledge of their characteristics, especially in powdered form.

To date, except for previous studies in the scientific literature [9–15, 17], there are no, or limited, materials on the use of purslane whole in powder form for the needs of the food industry (with the exception of cooking), or for food technology.

Based on the above, the task of the study was to study the chemical and elemental composition, microbiological and mineral safety indicators. As well as the study of physical and mechanical, including granulometric indicators of PP powder (from convective drying of purslane) for use in the development of technologies for bakery products for functional purposes.

Despite all this, there is no single methodology and technology for assessing the manufacturability of powders. It is absent due to the multiplicity and difference in sources of raw materials, methods and production, the difference in structural-mechanical, rheological, and thermophysical properties, etc. In this regard, for many new, industrially unproduced, but promising for use in food technology powders from wild and cultivated vegetable raw materials such as purslane, this is very important. Many of the recommended powders in this regard have not yet been fully studied granulometrically and have not received reliable estimates for chemical and mineral composition, especially since they are absent from local raw materials.

Usually, depending on the grinding of vegetables, the average particle size in them ranges from 120 to 140 μm, which is important for use in a system of flour mixtures, where the degree of grinding is from 90 to 140 μm.

In addition to studies in the literature, there is almost no obtaining and characterization of powdered compositions from the stems of garden purslane for use in the technology of bakery products as a multicomponent food additive. Studies have shown that purslane extract in a certain amount has a strengthening effect on the gluten of flour [24]. It increases its elasticity and plasticity, and the high water-absorbing capacity of biocomponents in its composition contribute to the improvement of structurally mechanical properties of the dough. At the same time, the chemical composition, and physical-mechanical, and other indicators of purslane powder for use in food production, including in the technology of bakery products, have not been finally studied.

Thus, the given scientific data [11–13, 15, 17] predetermine purslane, dried under a gentle regime, from stems, especially in powder form. There are concentrated numerous food substances as a raw material, and a multicomponent food additive for functional purposes.

However, all this in scientific research was carried out by the authors spontaneously, without a single generalized methodology, they did not take into account all the necessary points for the use of powders in food systems. In addition, in all studies concerning vegetable powders, the physicochemical, mineral, and vitamin composition is not fully defined, granulometric indicators, including physical ones, such as particle size and density related specifically to their field of application, are not taken into account.

Thus, numerous studies are being conducted, both on the development of additives of increased nutritional value, and on the use of powders in food products. However, studies on the use of dried purslane stalks in powder form in bakery products are not conducted. In this regard, it is advisable to study the issue of including in bakery products powder from dried stems of garden purslane (Portulaca oleracea), having emulsifying, foaming, and whipping properties.

3. The aim and objectives of the study

The aim of this work is to identify the qualitative indicators of powder from the stems of garden purslane (Portulaca oleracea l.) (chemical, mineral composition) and its use in the

production of bakery products. This will make it possible to use it as a protein-carbohydrate-mineral and a polycomponent enricher for the production of bakery products for functional purposes.

To accomplish the aim, the following tasks have been set:

– to determine the qualitative indicators of powder from the stems of garden purslane;

– to use powder from the stems of garden purslane in the production of bakery products for functional purposes;

– to make a recipe and technological scheme for the production of the bun "Health" using purslane powder.

4. Materials and methods of research

4. 1. The object and hypothesis of the study

The objects of the study were laboratory samples of dry powder from the stems of garden purslane, made under gentle conditions in the laboratory, which were purchased fresh in the Baku supermarket "Safastore" from the harvest of Absheron villages in 2020.

Dry stems were obtained by drying the ground healthy part of the entire purslane according to the following scheme: washing→slicing and drying→separation of dry leaves→grinding of dry stems in a microshredder→sieving to a single-phase state with a wheat flour size of 100 μm (Fig. 1).

Fig. 1. The sequence of obtaining dry stems from garden purslane: *a* — fresh purslane; *b* — fresh stalks of purslane before drying; *c* — dried stems crushed at a temperature of 30–40 °C; *d* — drying at a temperature of 60 °C

The stalks of purslane were dried at a temperature of 30–40 °C in the chamber as a result of convective drying. After that, by mechanical grinding and sifting, the crushed samples were transferred to a powder with the size of wheat flour of the first and highest grades with a diameter of 100 μm (Fig. 2).

The resulting powder from dried stems of garden purslane (Portulaca oleracea) was used in determining its quality indicators.

Fig. 2. Powder from dried stalks of garden purslane (Portulaca oleracea)

The hypothesis of the study was as follows. Having determined the qualitative indicators (chemical and mineral composition) of PP powder, one can establish the possibility of its use in bakery products, having previously developed the recipe and technological scheme of bakery products with purslane powder.

4. 2. Research methods

When performing experimental work, the following research methods were used:

– the general chemical composition of PP powder was characterized by well-known methods for biochemical study of plants [25] (Table 1);

– at the same time, the acidity of PP was determined by a well-known method, which was 2.5 g/100 g, which shows the presence of a significant amount of organic acids in its composition, as described in the literature [25];

– the results of the determination of microbiological parameters and safety indicators of the studied powder – Density (ρ, kg/m^2) and the average equivalent particle diameter (*d*eq, μm) were determined according to the methe odology described in [26];

– at the same time, humidity (*W*, %), the average equivalent particle diameter (*d*eq), and density (ρ, kg/m^2), were established, which were 4.5 %, 110 μm, and 485 kg/m, respectively [27];

– the concentration of mesophilic aerobic and facultative-anaerobic microorganisms in powder (QMAFAnM) was determined according to GOST 10444.15-94, the amount of molds and yeast – according to GOST 10444.12-88, the presence of bacteria of the Escherichia coli group (BGKP) – according to GOST R 52816-07, pathogenic microorganisms, including salmonella – according to GOST R 52814-07, S.aureus – GOST R 52815-07.

As the main raw material of the dough for bakery products, baking flour of the first grade was used, which had a humidity of 13.5 % and an acidity of 3.2 degrees. Pressed yeast was used in accordance with the requirements of GOST 171-81.

The dough for bakery products with purslane powder was prepared as sponge dough and straight dough according to traditional technology. The control was samples of dough and products without the addition of PP powder. Analyzes were carried out with 5 repetitions.

The powder, recovered in advance in water at 20–25 °C in a ratio of 1:5, was introduced for 15 minutes at the stage of kneading the dough. The powder is restored so that lumps do not form during kneading, the proteins in it are swelled, the water is absorbed, etc. When using vegetable oil, the recovered powder was homogenized with a formulation amount of oil within 1 minute. 4 hours after baking, the specific volume and yield in them were determined. The organoleptic product indicators were evaluated on a point scale (Tables 5, 6).

The quality of bakery products was assessed by organoleptic and physical-chemical indicators, depending on the amount of PP in % to the total amount of flour in the recipe of products, within 3–12 %. Products with a traditional recipe according to the collection of recipes served as controls [28].

Organoleptic parameters were assessed using a 20-point scale for appearance, taste, crumb condition, structure, porosity, and aroma by tasting the products after baking.

The physicochemical indicators of the dough and finished products with PP additives were characterized by specific volume (cm^3/g), porosity (in %), acidity (degree), fermentation duration (hour), and humidity (%) [29].

At the same time, the effect of purslane powder on other indicators of manufactured bakery products was studied.

5. Results of the study of powder from the stems of garden purslane (Portulaca oleracea L.) and bakery products with them

5. 1. Determination of quality indicators of powder from the stems of garden purslane (Portulaca oleracea L.)

Table 1 gives the comparative average chemical composition of fresh, dried, and power of purslane.

Table 1

Comparative average chemical composition of fresh, dried purslane powder (% per purslane stalk dry matter)

Name of defined components	Fresh purslane stalks from literature, including [8, 14–16, 18]	Dried purslane stalks, experiment	Powder from dry purslane stalks, experiment
Dry substances, %, including	11.5	92.0	95.5
Total sugar	3.5	34.4	35.0
incl. glucose	1.7	13.0	13.2
Fructose	1.8	13.7	13.9
Nitrogen substances	2.4	18.4	18.7
Phenolic substances	1.56	9.5	10.1
Organic acids	0.31	2.4	2.5
Pectin substances:	0.50	4.1	4.2
incl. pectin	0.25	2.2	2.3
Protopectin	0.25	1.9	1.9
Cellulose	1.15	7.6	8.0
Lignine	0.21	1.3	1.4
Hemicelluloses	0.24	1.4	1.5
Ash	2.1	18.2	18.7
Vitamin C, mg %	0.14	1.23	1.25
Carotene, mg %	0.04	0.35	0.36

The results of determining the microbiological indicators are given in Table 2.

Safety indicators of powder from the stems of dry purslane are given in Table 3.

The mineral composition of the powder from the stems of purslane is given in Table 4.

Table 2

Microbiological parameters of powder from the stems of garden purslane (PP)

Identified indicators	Concentration of microorganisms in purslane powder	Requirements for the norm of microbiological parameters for powdered products
QMAFAnM, CFU/g, not more than	1.2×10^2	5×10^3
Weight of product, g, not permitted: Coliforms	Not detected	OST (industry standard) in 1 g
S.aureus	Not detected	OST in 1 g
Pathogenic including salmonella	Not detected	OST in 25 g
Mold	Not detected	1×10^2

Table 3

Safety indicators of powder from dry purslane stalks

Permissible level of content, μg/kg, not more than			
Indicators	Standards according to GOST	Dry stems	Purslane powder
Toxic elements:	1.0	0.36	0.38
Lead	1.0	0.12	0.12
Arsenic	0.1	0.04	0.04
Cadmium	0.01	<0.005	0.005
Mercury	15.0	1.9	1.95
Zinc	30	6.3	6.4
Nitrates	200	<36.0	<36.0
Radionuclides, Bq/kg	80	17.5	17.4
Cesium-187			
Strontium-90	100	<15	<15
Pesticides: Hexachlorocyclohexane (α, β, γ-isomers)	0.005	<0.001	<0.001
DDT and its metabolites	0.005	<0.001	<0.001

Table 4

Mineral composition of purslane stalk powder

Name of indicators	Concentration in the composition of the powder	Marginal error
Ash, % dry weight	18.7	±0.25
Calcium, mg/100 g	140.5	±1.88
Zinc, mg/100 g	5.88	±0.08
Iron, mg/100 g	85.24	±1.14
Magnesium, mg/100 g	55.6	±0.74
Sodium, mg/100 g	65.35	±0.87
Potassium, mg/100 g	1830	±24.47
Manganese, mg/100 g	10.8	±0.14
Phosphorus, mg/100 g	285	±3.05

It was necessary to determine how the properties of the dough from the mixture of wheat flour of the 1st grade and PP will change, as well as to outline ways to eliminate the negative impact of PP on the quality of products.

5. 2. Applying powder from the stems of garden purslane in the production of bakery products for functional purposes

The organoleptic parameters of bakery products, depending on the concentration of the applied PP powder after baking, are given in Table 5.

Table 5

Organoleptic parameters of bakery products depending on the concentration of the applied PP powder after baking

Indicators control	The amount of applied PP powder, % of the formulation amount of flour									
	3	4	5	6	7	8	9	10	11	12
Shape	Proper, characteristic of bakery products									
Crust condition	Smooth, without bubbles and cracks, traces of detonation								Slightly rough	
Color of the crust	Dark golden									
Crumb condition	Very soft, gentle elastic						Soft		Dense, soft	
Structure of porosity	Large and uneven pores						Large and small pores		Small uniform	
Baked	Baked through									
Mixture	No lumps, no traces of poor mixture									
Crumb color	White								Slightly greyish	
Taste	Characteristic of bakery products									
Smell	Characteristic of bakery products								Less tangible wheat	

The physical and chemical indicators of the quality of bakery products with the addition of PP powder in the amount of 10 % in comparison with control samples are given in Table 6.

Table 6

Quality indicators of bakery products depending on the introduced PP additive

Identified indicators	Control (no additives)	Marginal error	With the addition of 10 % PP	Marginal error
Specific volume, cm^3/g	2.71	±0.21	2.86	±0.22
Increase in specific volume, %	–	–	5.5	±0.48
Porosity, %	66	±1.01	69	±1.06
Increase in porosity of bread (bakery products), %	–	–	4.5	±0.05
Acidity, degree	3	± 0.21	3.3	±0.32
Humidity, %	45	±2.01	48	±2.1

As can be seen from Table 6, in a sample of products with a 10 % additive instead of flour, the specific volume of the products increases, which is associated with an increase in the water absorption capacity of the PP powder when it is introduced into the dough.

Studies have shown that the introduction of PP into the dough in an amount of 10 % provides an increase in the humidity of the finished products by 3 %, while the porosity of the products increases by 4.5 %.

The results showed that the organoleptic characteristics of the products were identical to the control.

5. 3. Preparation of the recipe and technological scheme for the production of the bun "Health" using purslane powder

Based on these data, the recommended recipe and technological mode of preparation of products by sponge-dough and straight-dough techniques were developed, as a result of which bakery products for functional and prophylactic purposes were obtained (Table 7).

Table 7

Recipes and modes of preparation of bakery products by sponge-dough and straight-dough techniques

No.	Formulation	Sponge-dough technique		Straight-dough technique
		sponge dough	dough	dough
1	Wheat flour, g	50	42	92
2	Purslane powder (PP), g	–	10	10
3	Water, l	as calculated		as calculated
4	Baker's yeast, g	1	–	2
5	Initial temperature for dough kneading, °C	30–32	32–33	32–33
6	Duration of dough fermentation, per hour	4–4.3	1–1.5	1–1.5
7	Resulting acidity at the stage of dough production, degree	3–4	2,5–3.1	3–3.3

The organoleptic parameters of bakery products, obtained by the straight-dough technique with additives of PP powder in the amount of 10 %, are given in Table 8.

Table 8

Organoleptic characteristics of bakery products with additives of PP powder in the amount of 10 %

Quality indicators	Estimate
Shape	Proper, characteristic of bakery products
Crust condition	Smooth, no bubbles or cracks
Crust color	Dark golden
Porosity structure	Large uniform pores
Bakedness	Baked, soft crumb, well chewed
Mixture	Without lumps and traces of unmixed
Taste	Pronounced, characteristic of rolls
Smell	Pronounced, corresponding to rolls

Fig. 3 shows the proposed technological scheme for the manufacture of bakery products (straight-dough technique) for functional purposes.

Bakery products were baked according to traditional technology, which is used at enterprises.

According to the above technological regime, bakery products were prepared for functional and preventive purposes.

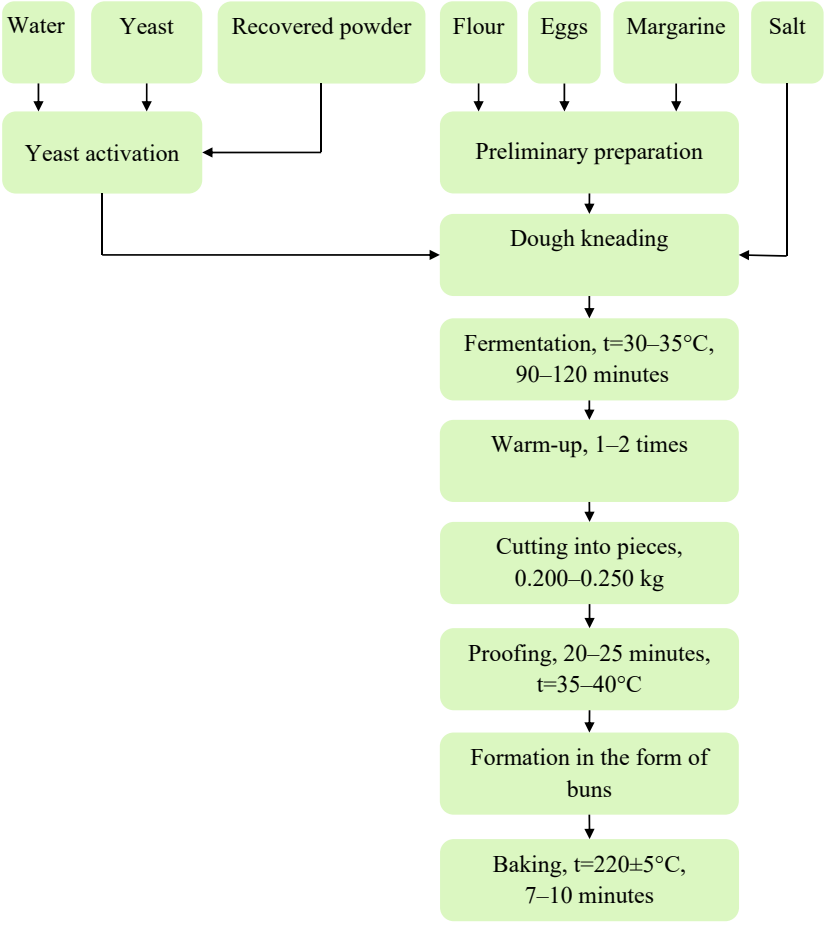

Fig. 3. Technological scheme of production of the bun "Health" by a straight-dough technique using purslane powde

6. Discussion of the results of determining the quality indicators of powder from the stems of garden purslane (Portulaca oleracea l.)

Analyzes have shown that the resulting powder from purslane stems has a rich chemical composition: proteins (16–19.0 %), fiber (6.5–8.0 %), sugars (35.0 %), pectin substances (4.1–4.2) %. The content of vitamins in it is in mg %: B_1 (0.45–0.6), B_2 (0.4–0.55), PP (6.1–6.6), C (2.4–2.6), E (3.1–4.8), carotenoids in the powder – (0.18–0.28). The content of organic acids in it is (2.4–2.5 %), minerals (18.5 %), phenolic compounds (9.5–10.1 %), etc. (Table 1). The results indicate that, at low temperature drying, the data on the composition were close to the vacuum data obtained earlier [6].

Comparative results in Table 1 show that the nitrogen content and ash content of fresh purslane in terms of edible part (dry weight) are approximately the same. This suggests that the amount of proteins and minerals in PP powder will be close to those confirmed in works [19–21]. The same applies to phenolic substances.

The data in Table 2 show that according to microbiological indicators, the powder from purslane stems fully complies with the requirements of TR TC 021/2011 and can be used in the formulation both as an additive and as an acidifying mixture. Verification of the microbiological parameters of the PP powder showed that 1 g of powder contained 1.2×10^2 CFU spore-forming bacteria, but there were no mold fungi in it.

When determining the microbial contamination of finished bakery products immediately after baking, it was found that yeast and mold were absent in it both on the surface and in the crumb. Spore-forming bacteria were found in the crumb of the control product and in those prepared using 10 % PP powder, the amount of CFU was 1.1×10^3 and 0.5×10^3, respectively. In samples containing 5 %; 8.0; 9, and 10.0 % of the experimental mixture, spore-forming bacteria were not detected.

Thus, the study proposed for the test confirmed the positive effect of PP powder on the microbiological safety of bakery products. The best results are observed when increasing the dosage of PP to 10.0 %.

The data in Table 3 demonstrate that PP powder complies with sanitary and hygienic standards for use, which gives grounds to use it as an additive instead of part of the flour and acidifying mixture as an additive in the production of bakery products.

In addition, the specified mineral composition (Table 4) is well consistent with the results obtained by various authors that purslane, including its stems, is a rich source of mineral components. Obtaining samples from purslane, including from its stems, after drying ensures their concentration in the composition of the powder, which is especially useful when used in small concentrations in food systems to enrich and increase the functionality of products.

The data in Table 5 show that in the recipes of bakery products from flour of the 1st grade, it is possible to intro-

duce PP in an amount of 10 %, which does not affect the deterioration of the quality of finished products. Increased concentration of the introduced PP into the dough of more than 10 % partially worsens the organoleptic qualities (appearance and some other) of the products.

The results obtained (Table 6) indicate that increasing the dose of the powder to 10 % led to an acceleration of the onset of the maximum fermentation value from 90 to 110 minutes. In short, the higher the concentration of powder in the dough (from 5 % to 10 %,) the faster the fermentation process in it. However, the further introduction of additives into the dough worsened the organoleptic characteristics of the finished products. Therefore, the maximum dose of powder injection into the dough was taken to 10 %. These results are consistent with the results of previous studies concerning the study of the process of gas formation in the dough. The results showed that the organoleptic parameters of the products were identical to the control.

As can be seen from the data in Table 8, the introduction of PP powder in an amount of 10 % intensifies the process of activation of yeast, thereby affecting the duration of fermentation, as a result of which the duration of the process is reduced by 2.5–3 times. The powder is introduced in order to enrich the products with functional biologically active components to obtain a new range. The nutritional and biological value of bakery products is improved. The components of the PP powder activate yeast, accelerate the process of dough maturation, and this improves the porosity of the products. The mixture is without lumps and traces of non-kneading. The condition of the crust of the finished bakery products is smooth, without bubbles and cracks, and its color is dark golden. The taste and smell are pronounced. In the formulation, part of the wheat flour 10 % is replaced with PP powder, and this is more cost-effective.

This confirms the results of earlier studies where it is indicated that the extract from the stems of the garden purslane favorably affects the structure of dough formation during the preparation of yeast dough [11].

From the technological scheme, it can be seen (Table 7) that according to the recipe, the reduced purslane powder (PP) is added to activate the yeast. Then, eggs, margarine, salt, and activated yeast with powder are added to wheat flour. Knead the dough and leave it to ferment for 90–120 minutes at a temperature of 30–35 °C. After fermentation, a wash is carried out 1–2 times. Then the dough is cut into pieces of 200–250th and left for proofing for 20–25 minutes at a temperature of 30–35 °C. After proofing, it is formed in the form of buns and baked for 7–10 minutes at a temperature of 220 °C.

It should be noted that the use of dried purslane in powder form as an additive and the development of various technologies with it at the same time can provide the population with a wide range of food products in the diet.

The use of purslane in a dry state (in powder form) can eliminate even more reasons for seasonality to provide raw materials for the entire period of the year.

The use of purslane powder (PP) will serve as an incentive for the development of industrial technologies in order to use it not only for food but also for pharmaceutical and medical purposes.

The results of the research can be recommended in the preparation of bakery products in the production of powdered compositions, namely from the stems of garden purslane for use in the technology of bakery products, as a multicomponent food additive. This will expand the range of products and diversify the nutrition of consumers.

The limitation of the study is due to the fact that it is necessary to take into account the thermoanalytical parameters of PP depending on the heating temperature. This will improve their quality indicators for use in the food industry, for the selection of equipment and the mode of technological processing.

Prospects for further research are drawing up a plan for the analysis of risks and critical control points (HACCP) for an enterprise for the production of new types of powdered compositions; studying the storage process and establishing guaranteed shelf life for new types of food additives.

7. Conclusions

1. Qualitative indicators of powder from the stems of garden purslane have been determined. Analyzes have shown that the resulting powder from purslane stems has a rich chemical composition. According to microbiological indicators, the powder from purslane stems fully complies with the requirements of TR TC 021/2011 and can be used in the formulation both as a preservative and as an acidifying mixture. The specified mineral composition agrees well with the results obtained with various authors that purslane, including its stems, is a rich source of mineral components. At the same time, the presence of a high content of proteins and phenolic compounds in the composition of powder from the stems of garden purslane has been experimentally confirmed.

2. A boundary has been established – the optimal amount of introduction of PP powder for the production of bakery products, which is 10 % of the formulation amount of flour. That is, in the recipes of bakery products from flour of the 1st grade, it is possible to introduce PP in an amount of 10 %, which does not affect the deterioration of the quality of the finished products. An increased concentration of the introduced PP into the dough of more than 10 % partially worsens the organoleptic qualities (appearance, volume, consistency) of the products.

3. The organoleptic characteristics of bakery products, obtained by using a straight-dough technique with addition of PP powder in the amount of 10 %, provide an improvement in the quality of bakery products “Health”.

Conflicts of interes

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

All data are available in the main text of the manuscript.

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