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OBTAINING AND INVESTIGATION OF THE CHEMICAL COMPOSITION OF POWDERED MALT AND POLYMALT EXTRACTS FOR APPLICATION IN THE PRODUCTION OF NON-ALCOHOLIC FUNCTIONAL BEVERAGES

Natavan Gadimova
Corresponding author
Candidate of Technical Sciences, Associate Professor*
E-mail: natavan.qadimova@mail.ru
Hasil Fataliyev
Doctor of Technical Sciences, Professor**
Zulfiyya Allahverdiyeva
Candidate of Agricultural Sciences, Associate Professor**
Teymur Musayev
Candidate of Technical Sciences, Associate Professor
Department of Scientific Research
Institute of Viticulture and Oenology
Absheron r/n, Mehtiabad settlement,
Baku, Azerbaijan, AZ 0118
Nazilya Akhundova
Candidate of Biological Sciences, Associate Professor*
Aynur Babashli
Candidate of Biological Sciences, Associate Professor*
*Department of Engineering and Applied Sciences
Department of Food Engineering
Azerbaijan State University of Economics
Istiglaliyyat str., 6, Baku, Azerbaijan, AZ1001
**Department of Food Engineering and Expertise
Azerbaijan State Agricultural University
Ataturk str., 450, Ganja, Azerbaijan, AZ2000

The group of consumer goods used in regular and daily nutrition, as well as the group of products that have a positive effect on the physiological functions of the body and have a certain chemical composition, should include processed beverages.

It is extremely important to expand the use of malt extracts in the creation of new non-alcoholic beverages, including functional ones. These extracts must come from sources other than typical malt forms, such as food grains and legumes (horse beans, buckwheat, peas, etc.). Buckwheat is a promising raw material for the production of beverages, especially without barley, wheat and rye gluten. To find the optimal parameters of primary mechanical, heat and moisture exchange processes by computer tests, it is required to develop a physical and mathematical method for grinding malt and mixed malt extracts. The aim of the study is to evaluate new malt extracts used in non-alcoholic beverages.

Beverages made from powdered malt and polymalt do not increase the intake of vitamins (B4) and minerals (potassium, calcium and magnesium) in the body, do not cure the deficiency of the nutrient dextrin. They have also not been shown to have a positive effect on physiological processes. The answer to this question lies in increasing the nutritional value of beverages by eliminating gluten, which has a negative effect on some physiological processes in the body. The studied powdered malt and polymalt extracts for functional beverages were evaluated theoretically and practically. The presented results showed that buckwheat extract powder can be used as an ingredient in beverages, as an independent product, and also as a product recommended for people with gluten intolerance

Keywords: buckwheat, peas, barley, corn, non-alcoholic beverages, malt, polymalt, extract, powder, gluten

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1. Introduction

In our nation, there is a low level of consumption of non-alcoholic beverages made from natural grains and fruits, which are a source of biologically active components (flavonoids, phytosterols, etc.). High biological activity and antioxidant protection are both characteristics of flavonoids. One of the critical elements in the creation of functional products is thought to be a high antioxidant content [1]. In turn, beverages are considered the most convenient technological means for creating new types of functional food products. The technology used in beverage production makes it feasible to add newly available components without much difficulty, and the absence of heat treatment allows for preserving all beneficial components.

Therefore, research on the development of new types of non-alcoholic beverages is relevant.

In the development of new non-alcoholic beverages, including functional ones, the demand for increasing the varieties of malt extracts not only from traditional types of malt, but also alternative sources, including those made from food grains and legumes (horse beans, buckwheat, peas, etc.) makes it important to intensify its use.

2. Literature review and problem statement

Grain, as a raw material for the production of non-alcoholic functional beverages, is given much attention, especially for medical reasons – lactose intolerance, allergy to cow's milk [2] and effects on cholesterol levels [3].

The work [4] presents the processing techniques, health properties and characteristics of the product of drinks – cereal grain-based milk alternatives, roasted cereal grain teas, fermented non-alcoholic cereal grain beverages. They are shown to be very beneficial for human health and can be consumed in people's daily lives.

The work [5] conducted studies on obtaining bean milk from germinated horse bean seeds from local raw materials, substantiated the mode and technology of obtaining, as well as its use in the technology of a combined fermented milk kefir drink.

It should be emphasized that sprouted grains are a potential ingredient, as they have a number of positive properties: high nutritional value, low amount of antinutrients, a source of bioactive molecules, sweet taste, etc.

Interesting work [6] was carried out on the effect of temperature and time of germination of buckwheat variety Bogatyr on changes in the content of vitamins E, C and group B. The results showed that the maximum total content of vitamins B, E and C in germinated buckwheat (4.591 mg/100 g) was observed at a temperature of 21.5 °C and a germination duration of 3 days.

Other studies [7] present the results of obtaining sprouted grains, the possibility of using sprouted wheat in the fermented drink rejuvelac was investigated, a microbiological risk assessment was carried out, and an inoculated alternative preparation with a commercial strain of Lactobacillus acidophilus is developed. Germinated wheat, its use in the preparation of new flour for use in bakery products, as well as the safe production of germinated grains of lactic acid fermentation to create non-alcoholic innovative beverages were investigated.

The work [8] studied the structural and mechanical properties of powdered malt extracts with an assessment of solubility by X-ray diffraction analysis. Scientists have found that the addition of molasses during drying makes it possible to increase the solubility by 1.7 times.

Very little research has been done on the production of powdered malt and polymalt extracts from barley, corn, buckwheat and peas. They are insufficiently studied and require the determination of the general chemical composition, their characteristics and temperature regimes of processing.

There is an urgent need to develop gluten-free products that are nutritionally complete as well as economical. An important requirement in the development of a gluten-free product is to ensure that the development of a gluten-free product does not reduce the nutritional profile of the product to a level that could affect the RDA (recommended dietary allowances) of the individual [9].

Studies have been conducted [10] on the use of husked and non-husked rice of different varieties, as a gluten-free raw material, in the technology of fermented non-alcoholic beverages. Their physical, biological and physicochemical parameters have been investigated, the amino acid and vitamin composition, the content of macro- and microelements have been determined.

Sprouted grain-based non-alcoholic beverages have been little studied, so our research has focused on the use of non-traditional malt extracts in their production.

3. The aim and objectives of the study

The aim of the study is to obtain powdered malt and polymalt extracts from barley, corn, buckwheat, peas. This will make it possible to apply them in the production of functional non-alcoholic beverages.

To achieve the aim, the following objectives are accomplished:

– to conduct a comparative analysis of organoleptic and physicochemical indicators of barley, corn, buckwheat and pea raw materials;

– to conduct an analysis of the dependence of amylolytic (AC) and proteolytic activity of malt on the time of germination, the dynamics of changes in antioxidants and humidity;

– to purchase malt and polymalt extracts in powder form;

– to conduct an analysis of the chemical composition of powdered malt and polymalt extracts;

– to determine the protein fractions of gluten, the amount of amino acids and carbohydrate in powdered malt and polymalt extracts.

4. Materials and methods

Cereals such as barley, corn, buckwheat, peas and malt extracts obtained from them were used as research objects.

Rye, barley, corn and wheat are traditionally used in the production of malt extract, grain distillate and beverages based on them. Buckwheat and peas are considered as alternative sources of raw materials. Buckwheat is considered a promising raw material for beverage development, especially for those who have eliminated barley, wheat and rye gluten from their diet. The main advantage of peas in comparison with other cereals is that the protein substances in them are close to animal proteins in terms of amino acid content. Peas contain essential amino acids (cystine, lysine, arginine, tryptophan, etc.), as well as vitamins. Peas are a promising raw material for the production of malt extracts and beverages.

Our study describes the process of germination of barley, corn, buckwheat, peas. Germination is a complex process involving enzymes such as amylase, invertase, which break down starch and sucrose into mono- and disaccharides. The germination process depends on the duration of germination. After germination of malt, the physicochemical characteristics were determined. The dependence of amylolytic (AC) and proteolytic activity of barley and buckwheat malt on the period of malt ripening was studied. At the next stage of our research, we obtained malt and polymalt extracts in powder form.

We also studied gluten protein fractions in powdered malt and polymalt extracts. For the quantitative determination of gluten, enzyme immunoassay was used [11].

Routine determination of the amount of bioflavonoids in malt and polymalt extracts was carried out by the spectrophotometric method with the help of Spekord M-40 ultraviolet spectrophotometer (Germany).

Analysis of gluten content in powdered malt and polymalt extracts was performed by the standard immunoenzymatic method using R5 antibody according to Codex Alimentarius (Alinorm 08/31/26).

The amount of carbohydrates was calculated by the iodometric method, the amount of bioflavonoids by routine calculation – by the spectrophotometric method with the help of a Spekord M-40 ultraviolet spectrophotometer, the activity of superoxide dismutase – based on the intensity of inhibition by the enzyme source, (based on the recovery of tetvazol-N sky), the activity of catalase – with a garometric device, the activity of the enzyme was calculated in the Catainfo Cat info programs, peroxidase activity was determined by the calorimetric method.

Vitamin "E" was determined by the spectrophotometric method, vitamin "C" – by the iodometric method, gluten content according to Codex Alimentarius (Alinorm 08/31/26), by the standard immunoenzymatic method using R5 antibody, total antioxidant activity (Photochem analyzer manufactured by Analytik Jena AG (Germany), changes in the amount of antioxidants – by liquid chromatography. The amount of gluten fractions was determined by the immunoenzyme method, gluten immunoenzyme analysis method using antibody R5.

Table 1

Organoleptic and physicochemical indicators of grains to be grown for malting

Name of raw material and organoleptic properties	Indicators						
	Humidity, %	Nature, g/dm^3	Germination capacity, %	Starchiness, %	Extractiveness, % in dry matter	Acidity rate	Protein, %
Barley, light yellow in color, odorless	6.5–7.1	649–653.6	96–97	53–61	71–85.6	2.3–2.7	10.4–11.0
Corn, yellow in color, odorless	7.7–8.5	730–743	90.6–93.0	57–63.6	76–81.6	2.5–3.3	10.0–14.2
Buckwheat, gray-brown in color, odorless	7.9–8.2	500–504.8	91.6–94.4	58–77.8	63.8–72	2.3–2.7	11.0–13.4
Peas, gray-green in color, odorless	7.9–8.05	872–888	94.4–99.8	43.2–51	44.2–60	2.5–3.3	11.5–38.7

5. Results of obtaining powdered malt and polymalt extracts and their application in the production of non-alcoholic beverages

5. 1. Carrying out a comparative analysis of the organoleptic and physicochemical parameters of barley, corn, buckwheat and pea raw materials

In the production of non-alcoholic beverages, cereals and legumes were employed. The above-mentioned types of raw materials grown in our country were subjected to comparative organoleptic and physicochemical analysis and characterization based on the following indicators: amount of impurities, natural grain weight, absolute grain weight, humidity, starchiness, germination capacity, extractiveness, acidity, coating (Table 1).

As can be seen from the table, barley has lower moisture content (6.5–7.1 %) and higher germination capacity (96–97 %). Compared to other raw materials, maximum starch content (58–77.8 %) and low extractability (63.8–72 %) are found in buckwheat. The lowest starch content (43.2–51 %) and extractability (44.2–60 %) are in the pea sample. The degree of acidity of barley and buckwheat, corn and peas is the same, 2.3–2.7 and 2.5–3.3, respectively. The maximum amount of protein (11.5–38.7 %) is observed in peas.

5. 2. Determination of the dependence of the amylolytic and proteolytic activity of malt on the time of germination, the dynamics of changes in antioxidants and humidity

Following malt germination, the following factors were used to assess the primary physicochemical properties: relative humidity, acidity, color, and amylolytic activity of laboratory-obtained juices.

Buckwheat malt processing ideals are as follows: τ=6 days, w=44 %, t=15.6 °C. The enzymatic activity of the amylase complex provided the technological parameters necessary during the preparation of the extract, even though the ideal conditions for buckwheat germination are anticipated.

Tables 2, 3 depict the curves indicating how the optimal malt ripening period affects the amylolytic (AS) and proteolytic activities of barley and buckwheat malts, respectively.

Freshly sprouted buckwheat malt has 264 (w–k) units of amylolytic activity (1.7×the amount of barley). Proteolytic activity was slightly higher than that of newly germinated barley malt.

Table 2

Variation of the amylolytic activity of malt depending on germination time

Name of raw material	Germination period, days							
	in the beginning	1	2	3	4	5	6	7
Barley	57.1	182.8	274.3	377.1	400.0	434.3	457.1	480.0
Buckwheat	45.7	131.4	222.8	257.1	257.1	297.1	297.1	297.1

Table 3

Variation of the proteolytic activity of malt enzymes depending on germination time

Name of raw material	Germination period, days							
	in the beginning	1	2	3	4	5	6	7
Barley	3	11.28	15.7	20.0	22.1	26.0	28.0	29.0
Buckwheat	6	13.8	18.0	21.15	24.3	27.7	28.5	29.5

By using liquid chromatography, changes in the amount of antioxidants were observedduring the production of corn, barley, and buckwheat malt (Table 4).

Table 4

Changes in antioxidants and humidity steeping and malting

Name of raw material		Germination period, days							
		in the beginning	1	2	3	4	5	6	7
Barley	W, %	5	30.0	40.1	44.0	46.2	47.9	47.8	
	AO, mg/100 g	4	2.1	1.4	1.8	2.3	3.9	6.0	
Corn	W, %	9.0	32.5	44.2	44.8	46.0	48.1	48.5	
	AO, mg/100 g	3.8	1.9	1.5	1.7	2.25	3.8	3.9	
Buckwheat	W, %	15.5	35.0	42.0	45.1	46.2	47.1	49.2	
	AO, mg/100 g	8.0	4.25	4.0	4.2	4.4	6.0	10.25	

Antioxidants are present in more significant quantities than in buckwheat, barley, and corn (more than 2 times). Due to the amplification of oxidation processes during soaking and the influence of physical and biochemical elements for the nourishment of the embryo, the level of antioxidants in the investigated grains drastically drops. The highest humidity (42, 45, 44 %) and the least quantity of antioxidants are correlated with each other by a factor of 3.

5. 3. Obtaining powdered malt and polymalt extracts

The presence of active enzymes, particularly amylase, in freshly germinated malts is the primary quality requirement in the production of powdered malt and polymalt. The level of amylolytic activity serves as proof of this. Various malts made from different grains have different levels of amylolytic activity. When selecting a sensible regime for the crushing of malts, this should be taken into consideration (Table 5).

The goal of crushing is to dissolve as many biopolymers from grain raw materials as possible. In accordance with the prevailing crushing process principles, different leavened dough preparation techniques have been developed (juice extraction, brewing).

The advantages of the juice extraction method in crushing include the following: short crushing time, minimal contact of the crushed material with air. Juice extraction has the drawback of producing a minimal amount of extract.

The employment of enzymes in the raw material effectively is a benefit of the brewing process. As a result, more extractives are present, inferior malt is processed, and enzymes with little amylolytic activity are produced. The longer process time and increased energy usage of the brewing method are its drawbacks.

Different malt compositions were chosen in the following ratios to broaden the variety of malt and polymalt extracts: sample 1 (three-component powdered polymalt extract TDE-1) – buckwheat: corn: barley – 1:1:1; sample 2 (three-component TPE-2) – buckwheat: peas: barley – 1:1:1; sample 3 (powdered buckwheat malt extract TQSE); sample 4 (powdered peas malt extract TNSE).

A ratio of 1:1:1 was used to compare freshly germinated malt to pulverized water, while a ratio of 1:5 was used to compare the hydro module to water. It has an acidity of 3–5.5. For the hydrolysis of starch-free polysaccharides to gexor and pentose, as well as the hydrolysis of proteins to amino acids and low-molecular compounds, the pulp was heated to 42–45 °C and held for 40–45 minutes. After that, the crushing temperature was raised to 52–55 °C and maintained for 40–45 minutes. To minimize sugars, the pulp was held at 63 °C for an additional 60 minutes. The dense cotton cloth was filtered and heated to a temperature of 70–72 °C.

The juice obtained with an initial dry matter concentration of 15–16 % was evaporated in a vacuum drying cabinet (SPT-200) at a concentration of 0.025–0.030 MDa air and at a temperature of 50–60 °C to a dry matter concentration of 35–40 °C. The material was then spray-dried in optimal modes. Malt extract obtained in the form of dry powder (with a dry matter content of 97.0–97.5 %) was tightly packaged.

According to studies, barley malt has higher quantities of the amylolytic complex enzymes than freshly sprouted buckwheat and pea malts. As a result, the crushed samples No. 3 and 4 were prepared using the infusion technique. This technique involved exposing a portion of the pulp to high temperatures in order to stratify the starch, which accelerates the hydrolysis process.

The malts were crushed, mixed with tap water using a hydro module at a ratio of 1:4.5 between 40–42 °C, and then acidified with lactic acid to a pH of 5.0 to 5.5 while being held for 12 to 15 minutes. Stirring continuously, let stand for 30–35 minutes. The stagnant part of the juice is collected in a special container. The solid fraction was stirred constantly and heated to the sticky temperature of starch (67 °C for buckwheat, 63 °C for peas) and kept for 30–35 minutes. The mass was combined with the juice, cooled to 45 °C at 45 V, and then held at 45 °C for 15 minutes, followed by 50 °C, 63 °C, 72 °C, and 75 °C, respectively. The extract was filtered after these operations for hydrolytic reactions. Dry materials that were 12–13 % at the beginning of the process were evaporated and dried.

Table 5

The main physicochemical indicators of malts

Name of raw material	Indicators						
	Mass share of the extract (per malt dry matter, %)	Mass share of protein substances (per dry matter of malt, %)	Juice obtained in the laboratory			Sugaring time, minutes	Amylolytic activity, (w–k) unit
			transparency (visual)	color, color unit	acidity, acidity unit		
Barley	77.5–82.7	9.5–12.5	A little bitter	0.15–0.21	0.52–0.84	14.2–14.7	433–451
Corn	77.5–84.7	7.2–15	A little bitter	0.19–0.25	0.22–0.54	It is not sugared	127–137
Buckwheat	64.2–70.8	10.7–12.3	A little bitter	0.21–0.45	0.38–0.44	It is not sugared	257–217
Peas	46.6–52	18.2–27.4	A little bitter	0.18–0.24	0.61–0.77	It is not sugared	155–185

5. 4. Chemical composition of powdered malt and polymalt extracts

The extracts of powdered malt and powdered polymalt contain vitamin B_1 in amounts of 0.55–4.39 mg/100 g, B_2 in amounts of 0.2–1.68 mg/100 g, B_4 in doses of 3.39–44.0 mg/100 g, vitamin C in doses of 0.16–1.17 mg/100 g, and vitamin E in amounts of 0.45–0.78 mg/100 g, respectively. It appears that some ascorbic acid is broken down and some is oxidized during technical processing to produce dehydroascorbic acid (Table 6).

The efficiency of the spray-drying process to create malt and polymalt extracts in powder form by catalyzing the fundamental enzymatic system of cereals, particularly the release or combination of hydrogen: catalase, peroxidase, and the significance of oxidoreductases is evaluated.

In the aforementioned enzymatic malted barley, it is particularly tiny. Their activity increases by 40–70 times during germination. It is reduced three times more after being wet and dried. When dried at 60 °C, oxidoreductases are largely inactivated.

The biological activity of the extract's components can be preserved during spray drying in the best mode by the presence of active superoxide dismutase (highest pea extract) and catalase (most frequently found in buckwheat extract).

Bioflavonoids, a large class of plant phenolic chemicals, exhibit capillary-strengthening (vitamin P activity) effects. Rutin, quercetin, and kaempferol are only a few of the flavanol groups, flavanones, and brown-colored complexes that are abundant in these substances. Powdered buckwheat extract was shown to contain the most bioflavonoids on a regular basis. Its significant biological activity suggests that it is used in functional drink technology. The recommended daily intakes of the components under study are displayed in the final columns of Tables 3–5 for comparison with the normative input.

Table 7 shows the extract component concentrations as a percentage of the recommended daily norm.

Table 7 provides the percentage of crushed polymalt extracts and powdered malt according to the daily intake guideline.

The amount of vitamin B_4 (thiamine) is more than 30 % of the daily intake.

Malt and polymalt extract powders were found to include calcium, phosphorus, sodium, and potassium. Calcium, phosphorus, sodium, and potassium were observed in powdered malt and polymalt extracts. The maximum amount of calcium, sodium and phosphorus can be found in powdered polymalt extract of barley, buckwheat, and corn (1*), potassium in powdered pea malt extract (4*), and the maximum amount of copper in polymalt extract of barley, buckwheat, and pea (2*) (Table 8).

Table 9 provides the percentage of each macro- and micronutrient's daily intake.

Powdered buckwheat malt extract contains more than 100 % of the recommended daily intake of calcium, up to 80 % of the recommended daily intake of phosphorus, up to 50 % of the recommended daily intake of potassium, and more than 50 % of the recommended daily intake of magnesium. Powdered pea malt contains up to 80 % of the recommended daily intake of potassium.

Table 6

Biological properties of extract components

Extract components	Vitamins, %					Oxyreductase activity			Bioflavonoids (routinely, mg/100 g)
	B_1	B_2	B_4	C	E	Superoxide dismutase	Peroxidase	Catalase	
Powdered polymalt – buckwheat, corn, barley	0.55–0.63	1.32–0.8	5.035–10.53	0.52–0.28	0.45–0.75	1,765–1,835	342–360	24–32	218–262
Powdered polymalt – buckwheat, peas, barley	0.81–0.91	0.20–0.32	8.9–12.1	0.16–0.24	0.6–0.68	1,112–1,138	336–350	33.7–38.3	494–526
Powdered buckwheat malt extract	0.91–0.95	0.71–0.84	3.39–3.61	0.60–0.72	0.62–0.78	695–805	271–307	36–44	483–597
Powdered peas malt extract	4.27–4.39	1.68–1.36	38–44	1.03–1.17	0.66–0.78	1,199–1,351	213–481	13–27	22–38
Daily production rate	3.25	2.5	750	75	11.5	–	–	–	400

Table 7

Vitamin content of malt and polymalt extracts

Extracts	Vitamins		
	B_1 (thiamine) according to the daily requirement, %	B_2 (riboflavin) according to the daily requirement, %	B_4 (choline) according to the daily requirement, %
Powdered polymalt – barley, buckwheat, corn	40.25	36.35	3.04
Powdered polymalt – barley, buckwheat, peas	48.65	38.9	3.07
Powdered buckwheat malt	53.1	27.1	1.42
Powdered pea malt	77.45	41.85	1.6
Daily production rate, mg/100 g	2.5	2.0	750

Table 8

Amount of macro and micronutrients in powdered malt and polymalt extracts

Content indicators	Extracts, mg/100 g			
	1*	2*	3*	4*
Macroelements				
Calcium	4,850	437	300	680
Phosphorus	420	262	280	70
Sodium	480	409	240	420
Potassium	270	655	340	4,430
Microelements				
Zinc	0.013	0.032	0.039	0.037
Copper	0.008	0.024	0.004	0.007
Iron	0.047	0.041	0.029	0.047

Note: 1 – powdered polymalt – buckwheat, corn, barley; 2* – powdered polymalt –buckwheat, peas, barley; 3* – powdered buckwheat malt extract; 4* – powdered peas malt extract*

Table 9

Amount of macro and micronutrients in % of powdered malt and polymalt extracts according to the daily consumption norm

Content indicators	Extracts, mg/100 g				
	1* in % of daily demand	2* in % of daily demand	3* in % of daily demand	4* in % of daily demand	Daily intake rate
Mass fraction of macronutrients – mg/100 g					
Calcium	56.3–45	64.6–48.7	412.5–90.0	85–68	800–1,000
Phosphorus	15–8	62.6–17.6	31.3–16.7	8.8–4.7	800–1,500
Sodium	3.3–2.2	2.7–1.8	6.0–4.0	3.0–2.0	4,000–5,000
Potassium	13.5.8	32.8–16.4	17.0–8.5	56.5–28.8	2,000–4,000
Magnesium	53.3–4.2	145.7–109.3	80–67.5	53.3–47.5	800–400
Amount of microelements, mg %					
Zinc	0.26–0.085	0.64–0.16	0.78–0.2	0.74–0.19	5–20
Copper	0.2–0.07	2.4–8.8	0.4–0.13	0.7–0.13	1–3
Iron	0.31	0.073	0.153	0.343	15

Note: 1 – powdered polymalt – buckwheat, corn, barley; 2* – powdered polymalt –buckwheat, peas, barley; 3* – powdered buckwheat malt extract; 4* – powdered peas malt extract*

5. 5. Gluten protein fraction, amino acid and carbohydrate content in powdered malt and polymalt extracts

Enzyme-linked immunosorbent assay was used for the first time in the analysis of extracts to quantify the amount of gluten fractions (Table 10).

Table 10

Protein fraction of gluten in polymalts with powdered malt

Numbering and name of components	Example description	Detection limit, mg/kg (ppm) quantification limit, mg/kg (ppm)	Result, mg/kg (ppm)	Uncertainty *
Powdered polymalt extract (barley, buckwheat, corn)	Powdered polymalt extract	5.0; 10.0	More than 270	0.8
Powdered polymalt extract (barley, buckwheat, peas)	Powdered polymalt extract	5.0; 10.0	More than 270	0.8
Powdered buckwheat malt extract	Powdered malt extract	5.0; 10.0	20.4	0.8
Powdered pea and malt extract	Powdered malt extract	5.0; 10.0	More than 270	0.8

The Table 10 findings lead to the conclusion that buckwheat malt extract can be marketed as food for persons with gluten intolerance, as well as an ingredient for beverages and a stand-alone product.

The presence of absorbed nitrogen should be a sign of good raw material if it is intended to employ powdered malt and powdered polymalt in beverages and there is a fermentation stage. Amino acid nitrogen content in powdered extracts was kept under control. The following is the mass fraction of amine nitrogen: powdered polymalt (from barley, buckwheat, and corn) extract contains 430 mg/100 g; powdered polymalt (from barley, buckwheat, and peas) extract contains 760 mg/100 g; powdered buckwheat malt extract contains 530 mg/100 g; and powdered pea malt extract contains 1,170 mg/100 g.

Below is information on the content of amino acids in the extracts and the percentage of daily intake (Table 11).

Modern theories hold that the amino acid content of protein constituents is the first and most crucial factor in determining the biological value of dietary proteins. According to

Table 11, buckwheat malt extract has the same amount of the most deficient amino acid, methionine, as buckwheat grain (270 mg/100 g). Tryptophan is up to 1/3, and lysine is twice less.

Table 11

Amount of amino acids in powdered malt and polymalt extracts

Amino acids	Extracts, mg/100 g				
	1* in% of daily demand	2* in% of daily demand	3* in% of daily demand	4* in% of daily demand	Daily intake rate
Arginine	6.3	18.1	10.3	29.8	600
Serine	13.7	18.7	18.0	45.0	2,000
Tyrosine	8.0	19.8	8.5	20.0	4,000
Ascorbic acid	9.8	36.8	13.7	59.2	8,000
Histidine	9.05	54.5	14.0	26.0	2,000
Alanine	15.0	41.3	16.7	34.3	3,000
Glycine	18.7	20.0	19.0	33.0	3,000
Cysteine	4.8	7.3	4.3	8.0	3,000
Glutamic acid	18.1	30.4	13.1	34	13,600
Proline	13.4	25.8	9.4	22.8	5,000
Threonine	12.7	34.3	12.3	61.7	3,000
Leysin	13.8	24.8	45.6	34.0	5,000
Isoleucine	7.3	17.0	10.5	19.08	4,000
Methionine	7.0	19.7	9.0	9.0	3,000
Valine	10.0	34.0	12.3	24.5	4,000
Tryptophan	6.0	28.0	11.0	16.0	1.000
Lysine	4.8	18.3	9.5	38.3	4,000
Phenylalanine	16.0	38.0	20.3	41.3	3,000

Note: 1 – powdered polymalt – buckwheat, corn, barley; 2* – powdered polymalt –buckwheat, peas, barley; 3* – powdered buckwheat malt extract; 4* – powdered peas malt extract*

Reporting was used to determine the biological value of proteins in the polysaccharide and powdered malt extracts. These extracts can be used in the therapeutic-prophylactic and rehabilitative diet since the proteins have a maximum biological value. Lysine, tryptophan, and isoleucine are the amino acids most scarce in polymalt (barley, buckwheat, and corn) extract's protein.

Phenylalanine, tyrosine, lysine in the extract of barley, buckwheat, peas, and tryptophan in the extract of pea malt (barley, buckwheat, peas) and tryptophan in the extract of pea malt (barley, buckwheat, peas) methionine+cysteine) were studied.

The carbohydrate content of powdered malt and polymalt extracts was studied and the results are given in the table below (Table 12). The quality and quantity of the extracts' carbohydrate content, as well as the way how they will be used in the diet and whether they will contain glucose, sucrose, or maltose, are crucial considerations for their use (the main carbohydrate of malt and polymalt).

The maximum amount of carbohydrates was observed in samples 1* and 3*, and the minimum amount of mono- and disaccharides was observed in pea malt extract (4*). Maltodextrins were found in the extracts to the extent that they did not change the color of iodine.

Table 12

Carbohydrate content of powdered malt and polymalt extracts

Components	Extracts, mg/100 g			
	1*	2*	3*	4*
Mass fraction of carbohydrates	79.8	74.3	79.4	35.1
Maltose, in% of total carbohydrate	27.8	27.0	27.3	18.9
Glucose, in% of total carbohydrate	21.0	19.4	19.6	18.1
Sucrose, in% of total carbohydrate	1.8	1.0	0.8	0.9
Dextrins:	–	–	–	–
Erythrodextrins	–	–	–	–
Achrodextrins	–	–	–	–
Maltodextrins	–	–	–	–

Note: 1 – powdered polymalt – buckwheat, corn, barley; 2* – powdered polymalt –buckwheat, peas, barley; 3* – powdered buckwheat malt extract; 4* – powdered peas malt extract*

6. Discussion of the results of using grains and legumes in the production of non-alcoholic beverages

Thus, studies on the use of malt extracts from barley, corn, buckwheat and peas in the production of non-alcoholic beverages revealed the following features.

The organoleptic and physicochemical analysis of raw materials – barley, corn, buckwheat and peas, (Table 1) shows that the germination rate of barley is higher (96–97 %), and the moisture content of barley is lower than that of corn, buckwheat, and peas (Table 1). The amylolytic activity of freshly germinated buckwheat malt is 1.7 times lower than that of barley. The proteolytic activity was slightly higher than that of freshly germinated barley malt. This is due to the characteristics of the enzymatic complex and the physicochemical composition of the cereal plant.

During soaking, due to the intensification of the oxidation process and the influence of physico-biochemical factors on the nutrition of the embryo, the amount of antioxidants decreases. Due to oxidative interaction with environmental oxygen, the amount of natural antioxidants in grain also decreases. Starting from the second day of malt germination, a continuous increase of antioxidants is observed. On the sixth day, as a result of the biochemical synthesis of antioxidants inherent in germinating grain, their amount increases: in buckwheat – 31%, in barley – 46 %, in corn – 49 %.

When obtaining powdered malt and polymalt extracts, the technology of juice extraction was also investigated. Raw materials are ground with 100 % acidity with ground lactic acid at a pH of 0.06–0.09 % to enhance the effect of grinding, stabilize enzyme activity, increase the production of extracts, and remove bitter and aromatic compounds from the skin.

It should be mentioned that vitamin B_1 levels in powdered buckwheat malt extract are almost three times higher than in the original substance. This rise was 39 % in powdered pea malt extract, which is comparable to the quantity of vitamin B_1 in buckwheat. The vitamin B_2 content in buckwheat malt was 5 times greater than in pea malt extract and 8 times higher in peas. This demonstrates the efficacy of extract powdering and spray drying. Vitamin B_4 in powdered pea malt extract was 10 times less abundant (200 mg/100 g) than in peas (Table 6).

Compared to other forms of extracts, the levels of vitamins C and E in pea malt powder and buckwheat malt powder are higher (Table 7).

The total bioflavonoids of powdered malt extract of buckwheat as a result of regular use increased 10 times and amounted to 540 mg/100 g (in buckwheat – 2.4 mg/100 g).

The selection of biosources with the necessary enzyme complex and biologically active components is scientifically substantiated: bioflavonoids, vitamins, macro- and microelements, carbohydrates, amino acids, gluten fractions. The possibilities of their application in the development of technologies for non-alcoholic functional drinks are also substantiated.

Drinks based on powdered malt and polymalt do not work to improve the supply of the body with vitamins (B_4) and minerals (potassium, calcium, magnesium), that is, to eliminate the existing deficit of nutrients. The solution to this problem is to increase the nutritional value of drinks due to the addition of vitamins and essential minerals, probiotic microorganisms: lacto- and bifidobacteria (enriched drinks), and also due to the removal of gluten, which negatively affects some physiological functions of the body.

Buckwheat is considered a promising raw material in the development of beverages, especially for those who have removed barley, wheat and rye gluten from their diet.

7. Conclusions

1. All samples of barley, corn, buckwheat and peas had a natural color and no foreign odor. Barley samples have less moisture than other samples (6.5–7.1 %). Barley and peas samples have high germination capacity (96–97 %/94.4–99.8 %), while corn and buckwheat samples have low germination capacity (90.6–93.0 %/91.6–94.4 %). Starchiness (43.2–51.0 %) and extractiveness (44.2–60.0 %) are least observed in peas. At the same time, the amount of protein was found to be high in the pea samples, and the least in the barley sample.

2. The optimal germination values of buckwheat malt are as follows: τ=6 days, w=44 %, t=15.6 °C. The amylolytic activity of buckwheat malt was 1.7 times lower than that of barley, 264 (w–k). Proteolytic activity was slightly higher compared to barley malt. The amount of antioxidants is 2 times higher than in buckwheat, barley and corn.

3. When preparing powdered malt and polymalt extracts, the brewing method was chosen to prepare the crushed samples. In this method, enzymes of raw materials are effectively used. At this time, extractive substances pass at a higher level, it becomes possible to process low-quality malt and enzymes with low amylolytic activity.

4. A higher amount of vitamin B_1 (0.91–0.95/4.27–4.39 mg/100 g, respectively) was determined in powdered buckwheat and powdered pea malt extracts compared to other samples. Vitamin B_2 was found the least in powdered polymalt (buckwheat, peas, barley) extract – 0.20–0.32 mg/100 g, and the most in powdered peas malt extract – 1.68–1.36 mg/100 g. The lowest amount of vitamin B_4 – 3.39–3.61 mg/100 g was observed in powdered buckwheat malt extract, and the highest amount was observed in powdered peas malt extract – 38–44 mg/100 g.

Total bioflavonoids in powdered buckwheat malt extract increased ten times and amounted to 483–597 mg/100 g (in buckwheat – 2.4 mg/100 g). The lowest amount of bioflavonoids was found in powdered pea malt extract (22–38 mg/100 g).

5. The mass fraction of carbohydrates was higher in samples 1* and 3* of powdered malt and polymalt extracts, 79.8 %–79.4 %, respectively. Maltose was found least in sample 4* at 18.9 % and most at 27.8 % in sample 1*. Sucrose was found more (1.8%) in sample 1*. Buckwheat malt extract in powder form can be offered as an ingredient for non-alcoholic beverages and as an independent product, as a recommended food for people with gluten intolerance.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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