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Assessment of the physicochemical profile of gluten-free flour and pasta products

Fariza Sagyntay, Auelbek Iztaev, Assel Borankulova, Baltash Tarabayev, Begzada Soltybayeva, Nurbibi Mashanova, Viera Šottníková, Anar Kabylda

ABSTRACT

The production of food products that do not contain gluten is being actively developed since it is not recommended for certain medical reasons, such as celiac disease. Therefore, developing high-quality and highly nutritional gluten-free (GF) pasta products is crucial. A shortage of domestic gluten-free food products characterises the consumer market of Kazakhstan. Buckwheat, rice, and corn flour are widely used to make gluten-free pasta. The results of the study showed that buckwheat flour contains significantly higher amounts of protein (11.9%), ash (1.54%), iron (2.47%), calcium (38.53%), magnesium (56.11%), phosphorus (267.55) and lower carbohydrate content (67.99%) compared to rice and corn flour. Moreover, pasta made from buckwheat flour also showed higher protein 9.39%, Ca (28.80 mg/100g), Mg (48.28 mg/100g), Fe (2.28 mg/100g), Na (5.50 mg/100g), P (196.45 mg/100g) content. Also, amino acids, such as lysine, tyrosine, alanine, valine, etc., were elevated in buckwheat flour-based pasta. Taken together, these data hint that buckwheat has the potential to become a nutrient-rich GF paste ahead of corn and rice. However, further research is needed to determine the cooking qualities and consumer acceptability.

Keywords: gluten-free pasta, flour, celiac, buckwheat, rice, corn

INTRODUCTION

Currently, the production of special foods, including products that do not contain certain ingredients whose presence in food is not recommended for certain medical reasons (allergens, certain types of proteins, oligosaccharides, polysaccharides, etc.). is being actively developed **[1]**. Celiac disease is an immune-mediated enteropathy arising from consuming prolamins of wheat, rye, and barley. A lifelong adherence to a gluten-free diet is known to be the only therapeutic option for individuals with celiac disease **[2]**. The consumer market of Kazakhstan is characterised by a shortage of domestic specialised food products, including gluten-free products, which determines the need to expand their range and develop recipes and innovative production technologies **[3]**, **[4]**. The food engineering of gluten-free flour products is described by two main directions: products based on natural gluten-free raw materials, mainly of plant origin (gluten-free cereals, pseudo-cereals, legumes, nuts, etc.). The biocatalytic direction focused on removing or modifying gluten in gluten-containing raw materials **[5]**. The degree of complexity in the production of gluten-free products is closely related to the role of gluten in the technological system, which is a structure-forming agent. Obtaining high-quality gluten-free products requires the search for ingredients capable of replacing them. Until now, recipes of gluten-free pasta products based on amaranth, corn, rice, chickpea and buckwheat flours are proposed **[6]**, **[7]**, **[8]**. Rice and corn are more popular raw materials in gluten-free pasta production. Meanwhile, buckwheat, amaranth, quinoa, teff and oats are becoming increasingly popular in production as they improve the nutritional content of products **[9]**. The production of pasta products of high quality and high nutritional content is one of the basic conditions for improving nutrition in general. Nevertheless, there is a shortage of established GF paste recipes based on non-conventional raw materials. To improve the nutritional value of GF pasta products, this study investigated the physicochemical composition of corn, rice, and buckwheat flour and pasta products based on them. To the best of our knowledge, this is the first study proposing pasta production from rice-corn or buckwheat flour for the Kazakhstan market. The results of the study showed that there is a significant difference between aforementioned raw materials and pasta products based on them in terms of proximate composition, including amino acid profile.

Scientific Hypothesis

The physicochemical profiles of different GF raw materials differ significantly, and pasta made from GF flour also varies significantly in nutrient content.

MATERIAL AND METHODOLOGY

Samples

The research objects were samples of buckwheat, rice, and corn flour, corn starch derived from local markets. Xanthan gum and egg white are used as additives.

Chemicals

Distilled water (Tandem distribution LPP, Kazakhstan), hydrochloric acid (purity ≥37%), and sulphuric acid (purity ≥94%) were purchased from Topan LLP, Kazakhstan; sodium hydroxide (R&S Alita, Kazakhstan), boric acid (purity ≥99%) (Alchemica, Kazakhstan), rectified ethyl alcohol (purity ≥95%) (Alfa Organic Malt Distillery, LLP, Kazakstan), and lanthanum nitrate 6-aqueous (LabStar LLC, Russia). All chemicals were of analytical grade quality.

Instruments

Laboratory scales M-ETP2 FLAT (Mercury WP Tech Group Co. Ltd, China), electric drying cabinet SESH-ZM (Ukraine), Kjeldahl flasks (100, 250, and 500 cm^3) (Steklopribor Co. Ltd, Kazakhstan), burettes with a capacity of 25 or 50 cm^3 (Steklopribor Co. Ltd, Kazakhstan), droplet eliminator version KO-60 (Ningbo Greetmed Medical Instruments Co., Ltd., China), electric muffle furnace (Nabertherm, Germany), atomic absorption spectrometer (Agilent, China), graphite cuvettes (Spectrolab, USA), hollow cathode lamps (Agilent, China). More information on the different instruments and chemicals used in the various experiments are given in **[10]**, **[11]**, **[12]**, **[13]**, **[14]**, **[15]**, **[16]**, **[18]**, **[19]**, **[20]**, **[21]**, **[22]**, **[23]**.

Laboratory Methods

The tests of proximate chemical composition were conducted for flour as well as for different GF pasta. The protein, fat, total ash, starch, and testable acidity were analysed according to the GOST 10846-91 **[10]**, GOST 29033-91 **[11]**, GOST P 51411-99 **[12]**, GOST 10845-98 **[13]**, GOST 27493-87 **[14]**, respectively. In addition, the mass fraction of carbohydrates was detected using the permanganatometric method. The GOST 13496.3-92 **[15]** was used to determine the moisture content and pH. Mineral contents were analysed according to the GOST 32343-2013 (ISO 6869-2000) **[16, 17]** by the atomic absorption spectroscopy (AAS) method, which is the quantitative analysis based on the properties of atoms to absorb light at a certain wavelength (resonance absorption). Vitamin A content was examined based on GOST P54635-2011 **[18]**. Besides, the hydro-soluble vitamins were determined using GOST P 50929-96 (M-04-41-2005) **[19]**. The energy value of pasta products was calculated based on the actual content of proteins, fats, and carbohydrates.

Determination of total arsenic (Ars) was conducted by atomic absorption spectrometry with hydride generation with preliminary mineralisation of the sample under pressure using the GOST 30178-96 **[20]**. Inversion-voltamperometric methods were used for determining the content of cadmium (Cd), lead (Pb), and mercury (Hg) according to GOST EN 14083-2013 **[21]**. This method is based on the ability of elements to electrochemically precipitate on the indicator electrode from the analysed solution at a given potential of the limiting diffusion current, and then dissolve in the process of anodic polarisation at a certain potential characteristic of each element.

The amino acid profile of developed formulations was analysed to maximize the biological value of pasta products. The amino acid profile of raw materials was studied under GOST 31480-2012 (M-04-38-2011) **[22]**. The amino acid composition of pasta was determined in accordance with GOST P 55569-2013 (M-04-38-2009) **[23]**.

Description of the Experiment

Sample preparation: The flour samples were obtained from the local market. Subsequently, 50 g were extracted from each sample manually. Then, samples were dried in air or a desiccator. The thoroughly mixed material was placed in a clean and dry test tube for further experiments.

Number of samples analyzed: 5 samples (3 samples of flour, 2 samples of pasta).

Number of experiment replication: 3.

Design of the experiment: In the first phase, we obtained non-conventional GF raw materials and determined the proximal composition of rice, corn, and buckwheat flour. In the next phase, we generated two different GF pasta using rice, corn, and buckwheat flour as raw materials. The recipe of the developed pasta samples is given in Table 1. The dough was made with room temperature water (cold mixing, 30 °C). After kneading, all the samples were rounded, placed in polythene bags, and kept at room temperature for 1 hour. Then, the samples were rolled using a regular rolling pin to form pasta straws 1 mm wide and 50 mm long. After, the samples were photographed, labelled, described, and placed in a drying cabinet at 40 °C for 4 hours so that the final moisture content was not lower than 13%. Finally, the proximal composition of developed GF pasta samples was detected.

Statistical Analysis

All data were computed on one-way analysis of variance (ANOVA) or independent sample t-test, followed by the least significant difference (LSD) test to calculate significant differences between the samples ($p \leq 0.05$) using SPSS software (version 25.0, IBM Corporation, New York, USA). Outcomes were expressed as triplicate analyses' mean ± standard deviation (SD) values.

Table 1 Recipe of pasta samples based on GF flour.

Recipe No.1	Buckwheat flour	70%
	Corn starch	30%
	Egg white	9.4%
	Xanthan gum	5%
	Salt	1%
	Water	100%
Recipe No.2	Corn flour	60%
	Rice flour	40%
	Xanthan gum	5%
	Salt	1%
	Water	70%

RESULTS AND DISCUSSION

Study of the chemical composition of rice, maise, buckwheat flour

The quality of food products, including gluten-free pasta, is largely determined by the quality of raw materials. As can be seen in Table 2.

Table 2 Physicochemical composition of rice, maise, buckwheat flour.

Physicochemical parameters	Rice	Corn	Buckwheat
Protein, %	^{B}7.77 ±0.01	^{B}8.0 ±0.00	^{A}11.9 ±0.05
Fat, %	^{A}1.16 ±0.03	^{B}1.71 ±0.003	^{A}1.12 ±0.005
Carbonhydrates, %	^{A}76.62 ±0.18	^{B}71.91 ±0.04	^{C}67.99 ±0.4
Ash, %	^{A}0.92 ±0.005	^{B}0.85 ±0.00	^{C}1.54 ±0.01
Starch, %	^{A}74.38 ±0.01	^{B}70.23 ±0.08	^{C}67.1 ±0.05
Titratable acidity, °T	^{A}1.5 ±0.006	^{B}6.31 ±0.008	^{C}8.4 ±0.06
Energy, kcal	^{A}329.18 ±0.4	^{B}316.95 ±0.03	^{C}314.45 ±0.2
Vitamin A, mg/100mg	ND	0.03 ±0.006	ND
Iron, mg/100g	^{A}0.27 ±0.005	^{C}1.70 ±0.008	^{B}2.47 ±0.005
Calcium, mg/100g	^{A}8.12 ±0.01	^{B}19.65 ±0.07	^{C}38.53 ±0.01
Magnesium, mg/100g	^{A}41.52 ±0.01	^{B}26.99 ±0,005	^{C}56.11 ±0.05
Copper, mg/100g	^{A}0.111 ±0.006	^{B}0.044 ±0.003	ND
Sodium, mg/100g	ND	8.50 ±0.2	ND
Phosphorus, mg/100g	^{A}87.6 ±0.1	^{B}96.74.±0.1	^{C}267.5 ±1.2
Pb	0.001 ±0.0003	0.0016 ±0.0002	0.002 ±0.0006
Cd	0.0007 ±0.0003	0.0033 ±0.0006	ND
As	ND	ND	ND
Hg	ND	ND	ND

Note: ND, not detected; $^{A, B, C}$ mean $p < 0.01$.

The buckwheat flour contains a significantly higher amount of protein (11.9%), ash (1.54%), TA (8.4 °T), iron (2.47%), calcium (38.53%), magnesium (56.11%), phosphorus (267.55) and lower carbohydrate content (67.99%) compared to rice and corn flour (p <0.01). A recent study reported that the flour from Fagopyrum esculentum and *Fagopyrum tataricum* buckwheat varieties also exhibited higher protein content (11.81-14.90%), ash (2.58-2.85%) and lower total carbohydrate (61.69-67.83%) compared to hard wheat flour **[24]**. It was shown that protein and ash content in buckwheat flour fractions increased in the order from internal to external fractions **[25]**. Rice flour differs significantly from others in carbohydrate content (76.62%). Similar amounts of total carbohydrates were found in Thai rice varieties, although this may depend on variety and processing **[26]**. It is reported that the longer the hydrolysis lasts, the higher the carbohydrate content of white rice flour **[27]**. The presented values indicate that a higher fat content is found in corn flour (1.71%). The lipid content of treated and untreated white and yellow maise varieties differed significantly **[28]**.

Table 3 Amino acid profile analysis of different GF flour.

Amino acids	Rice	Corn	Buckwheat
Arginine	^{A}0.945 ±0.002	^{B}0.873 ±0.004	^{C}1.346 ±0.00
Lysine	^{A}0.250 ±0.008	^{B}0.392 ±0.005	^{C}1.686 ±0.005
Tyrosine	^{A}0.288 ±0.005	^{B}0.285 ±0.002	^{C}0.303 ±0.002
Phenylalanine	^{A}0.620 ±0.01	^{A}0.602 ±0.001	^{B}0.646 ±0.001
Histidine	^{A}0.290 ±0.00	^{B}0.288 ±0.001	^{C}0.478 ±0.001
Leucine+Isoleucine	^{A}0.629 ±0.00	^{B}0.787 ±0.005	^{C}1.117 ±0.002
Methionine	^{A}0.260 ±0.01	^{B}0.252 ±0.005	^{C}0.538 ±0.001
Valine	^{A}0.502 ±0.003	^{B}0.602 ±0.005	^{C}0.999 ±0.001
Proline	^{A}1.677 ±0.005	^{B}1.362 ±0.00	^{C}0.704 ±0.005
Threonine	^{A}0.419 ±0.05	^{B}0.472 ±0.005	^{C}0.750 ±0.05
Serine	^{A}0.603 ±0.1	^{B}0.708 ±0.03	^{C}0.675 ±0.06
Alanine	^{A}0.394 ±0.08	^{B}0.522 ±0.001	^{C}1.150 ±0.2
Glycine	^{A}0.419 ±0.8	^{B}0.446 ±0.05	^{C}0.750 ±0.05

Note: ND, not detected; $^{A, B, C}$ mean p <0.01.

It is well known that starch provides unique functionality in GF pasta processing. The starch content was the lowest in buckwheat flour, consistent with the previous study **[29]**. The starch content of buckwheat grain varies between 60-70% **[30]**. Vitali et al. (2010) reported that the total starch content of buckwheat, corn, and rice flour was 54.15%, 60.25%, and 64.84%, respectively **[31]**. Rice has been shown to contain higher amounts of amylose, a constituent of starch **[32]**.

Moreover, rice and corn flour lagged behind buckwheat flour in iron, calcium, and magnesium content. In a previous study, enhanced Ca and Mg were found in white buckwheat flour **[33]**. Another paper emphasizes that buckwheat is used as a "smart food" because it is high in nutrients and minerals such as Ca (110 mg/100g), Mg (231-390 mg/100g), and P (330-347 mg/100g) **[34]**.

Safety is a crucial aspect of the food products industry. Metals are widespread and at certain concentrations, including some heavy metals, lead to health issues. Regarding toxic trace elements, Pb (lead) and Cd (cadmium) were detected in rice and corn flour, while As (arsenic) and Hg (mercury) were not identified in all GF flour samples. Mercury is particularly dangerous because of its highly toxic effect and its ability to accumulate in the body **[35]**. Analysis of the results showed their safety and compliance with TR TS 021/2011 requirements. Of interest is that rice-based foods have been shown to contain significantly more toxic elements **[36]**, which may be due to contaminated soil.

Table 4 Water-soluble vitamin contents of different GF flour.

Contents	Rice	Corn	Buckwheat
B1 (thiamine chloride)	^{A}0.16±0.003	^{B}0.11±0.003	^{C}0.14±0.008
B2 (riboflavin)	^{A}0.13±0.003	^{B}0.07±0.004	^{C}0.19±0.005
B6 (pyridoxine)	^{A}0.08±0.02	^{B}0.07±0.003	-
B3 (nicotinic acid)	^{A}0.23±0.003	^{B}0.57±0.008	^{C}0.29±0.008
B5 (pantothenic acid)	0.03±0.002	0.04±0.003	0.03±0.001

Note: ND, not detected; $^{A, B, C}$ mean p <0.01.

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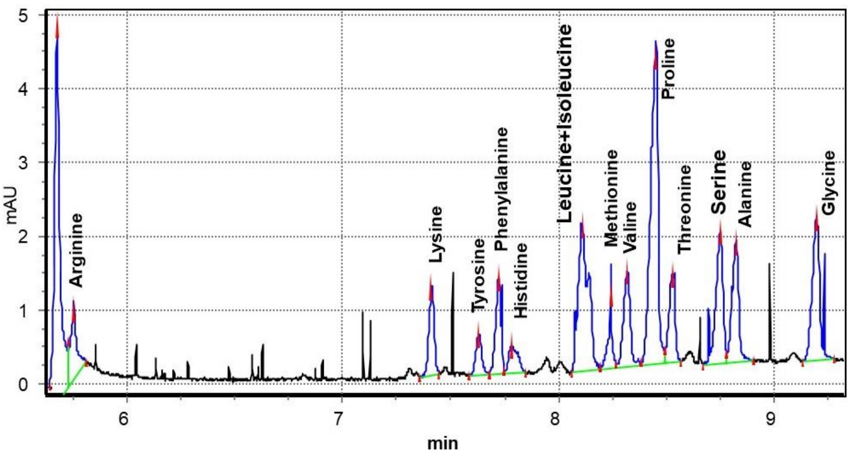

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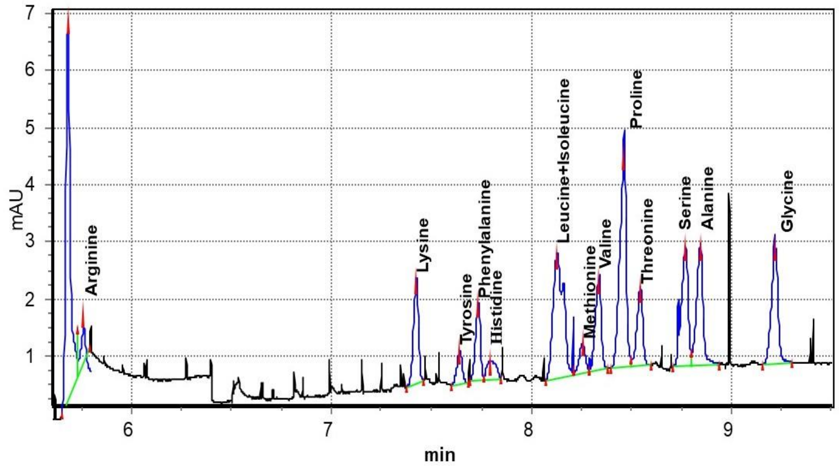

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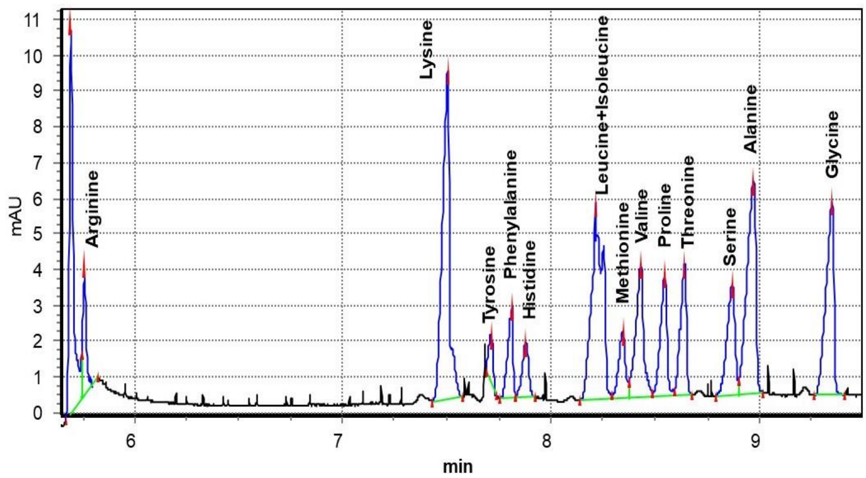
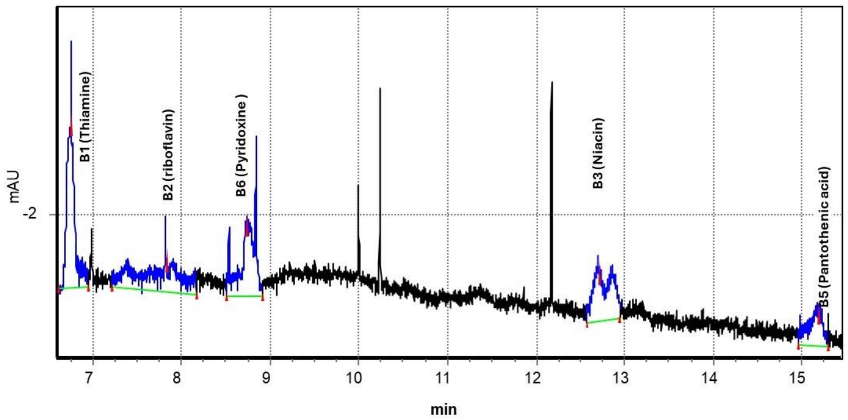


Figure 1 Chromatograms of amino acid composition of a) rice flour, b) corn flour, and c) buckwheat flour; the x-axis is a retention time (min), and the y-axis represents abundance.

A)



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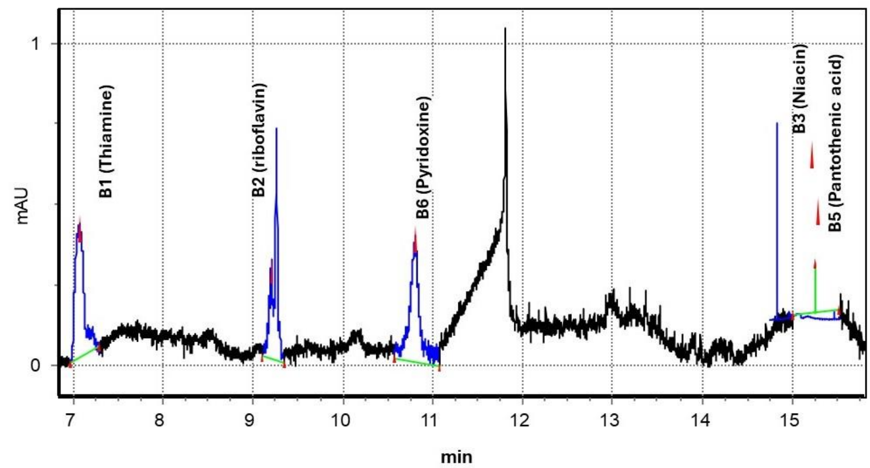

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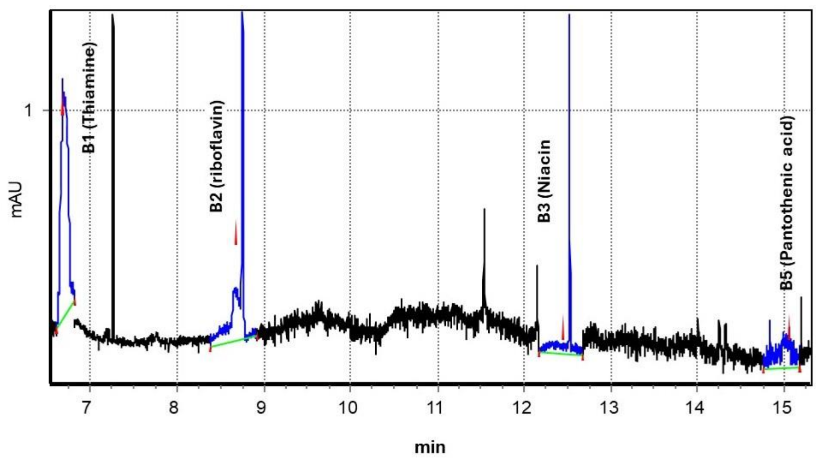


Figure 2 Chromatograms of water-soluble vitamin composition of a) rice flour, b) corn flour, and c) buckwheat flour; the x-axis is a retention time (min), and the y-axis represents abundance.

In terms of amino acid composition, the buckwheat flour was rich in indispensable amino acids, including lysine, histidine, leucine+isoleucine, phenylalanine, methionine, threonine, valine compared to other flour (p <0.01) (Table 3, Figure 1). The results suggest that buckwheat significantly exceeds other cereal crops' nutritional value and protein content. Saeed et al. revealed that lysine (1.03-11 g/kg), isoleucine (0.88-1.19 g/kg) and leucine (1.01-1.05 g/kg) in buckwheat cultivars flour [37]. Notably, it has been demonstrated that egg-white protein-fortified pasta increases nutritional quality **[38]**. It should be noted that amino acid profiles may vary according to soil, cultivar, and climate.

Furthermore, it has been observed that patients with celiac disease are deficient in vitamins **[39]**. Our research outcomes also demonstrated that rice flout contains greater content of B1 (0.16 mg/100g) and B6 (0.008 mg/100g), while corn flour was rich in B3 (0.57 mg/100 g) and buckwheat in B2 (0.19 mg/100g) (Table 4, Figure 2). In the previous study, buckwheat, rice, and corn flour did not significantly differ in B1 content, while buckwheat was rich in B2 (0.22 mg/100 g) **[40]**.

Study of the chemical composition of rice, maise, buckwheat flour-based pasta

The obtained results of experiments on the determination of proximal chemical content in the selected pasta samples indicate that the protein content in the buckwheat and corn starch-based pasta demonstrated significantly greater (p <0.05) protein content 9.39%, Ca (28.80 mg/100g), Mg (48.28 mg/100g), iron (2.28 mg/100g), Na (5.50 mg/100g), P (196.45 mg/100g) compared to rice and corn flour-based GF pasta (Table 5, Figure 5). Besides, the recipe No. 2 exhibited lower starch (1.63%) and higher moisture content (6,47%). The pasta made of buckwheat flour also showed similar protein content in a previous study (9.9%) **[41]**. In addition, noodles prepared with buckwheat, corn, and potato starches contained more potassium, phosphorus, and magnesium, while mineral content decreased with increasing amounts of starch **[42]**. The pasta made of rice and corn flour showed higher total starch (69.2%) in our study. A previously published study also reported that rice-based GF pasta exhibited greater total starch (89.3%) content **[41]**. Arcangelis et al. reported that gelatinization of buckwheat, rice, and corn flours using 0.1% propylene glycol alginate and 0.5% fatty acid monoglycerides proved to be the best combination to produce a gluten-free paste with good nutritional and culinary properties **[41]**.

Therefore, it was suggested that other pseud o-grain-based flours, such as amaranth, can be added to the rice-corn pasta to increase its protein content. For example, rice-based GF pasta enriched with amaranth flour or soybean flour showed increased protein content **[43]**, **[44]**. Also, the corn pasta prepared with 70% corn flour and 30% broad bean flour resulted in increased protein content **[45]**.

Table 5 Physicochemical composition of the two different manufactured GF pasta.

Physicochemical parameters	Recipe No.1 (rice +corn flour)	Recipe No.2 (buckwheat+corn strach)
Protein, %	^{B}7.91 ±0.1	^{A}9.39 ±0.3
Fat, %	^{A}1.62 ±0.09	^{B}1.07 ±0.1
Carbonhydrates, %	^{A}73.80 ±0.2	^{B}68.61 ±0.3
Ash, %	^{B}1.40 ±0.01	^{A}1.63 ±0.07
Starch, %	^{A}69.2 ±0.6	^{B}66.5 ±0.5
Titratable acidity, °T	^{A}4.31 ±0.08	^{B}3.13 ±0.1
pH	^{B}5.17 ±0.04	^{A}5.67 ±0.02
Moisture, %	-	6.47 ±0.005
Energy	^{A}321.06 ±0.2	^{B}308.24 ±0.05
Vitamin A, mg/100mg	^{A}0.018 ±0.001	^{B}0.026 ±0.001
Iron, mg/100g	^{B}1.18 ±0.09	^{A}2.28 ±0.02
Calcium, mg/100g	^{B}13.72 ±0.1	^{A}28.80 ±0.3
Magnesium, mg/100g	^{B}30.3 ±0.1	^{A}48.25 ±0.05
Copper, mg/100g	^{A}0.08 ±0.001	^{B}0.02 ±0.003
Sodium, mg/100g	^{B}4.07 ±0.06	^{A}5.50 ±0.09
Phosphorus, mg/100g	^{B}90.98 ±0.3	^{A}196.48 ±0.2

Note: ND, not detected; *A, B, C* mean p <0.05.

The presence of essential amino acids may determine the biological value of proteins, and the amino acid content of GF pasta may depend on different raw materials. Our results indicate that pasta products based on buckwheat flour and corn starch showed elevated levels of almost all amino acids except histidine, methionine, and proline (Table 6). The essential amino acids, including phenylalanine (6.93-7.27%), leucine (7.23-8.52%), and lysine (5.83-6.03%) were detected in buckwheat noodles **[46]**. A previous study on buckwheat cookies showed a predominance of alanine, lysine, isoleucine, leucine, glutamic acid, glycine, cysteine content **[37]**. Essential amino acids are of particular importance, among which lysine is significant. Lysine is an essential amino acid for cellular growth and repair **[47]**. Phenylalanine and tyrosine are precursors of monoamine neurotransmitters in the brain **[48]**. Messia et al. showed that pasta made from 100% buckwheat had higher levels of His, Lys, Met than other GF pasta, while the maize-based pasta showed higher levels of Leu **[49]**.

Table 6 Amino acid profile analysis of different recipe-base pasta.

Amino acids	Recipe No.1	Recipe No.2
Arginine	^{B}1.139 ±0.001	^{A}2.037 ±0.001
Lysine	^{B}0.235 ±0.005	^{A}0.354 ±0.006
Tyrosine	^{B}0.339 ±0.001	^{A}0.349 ±0.001
Phenylalanine	^{B}0.632 ±0.002	^{A}0.644 ±0.003
Histidine	^{A}0.265 ±0.001	^{B}0.238 ±0.002
Leucine+Isoleucine	^{B}0.606 ±0.005	^{A}0.671 ±0.002
Methionine	^{A}0.262 ±0.005	^{B}0.231 ±0.002
Valine	^{B}0.486 ±0.001	^{A}0.571 ±0.001
Proline	^{A}1.624 ±0.100	^{B}1.441 ±0.2
Threonine	^{B}0.413 ±0.001	^{A}0.424 ±0.001
Serine	^{B}0.535 ±0.002	^{A}0.572 ±0.002
Alanine	^{B}0.340 ±0.001	^{A}0.465 ±0.03
Glycine	^{B}0.388 ±0.001	^{A}0.498 ±0.001

Note: ND, not detected; $^{A, B, C}$ mean p <0.01.

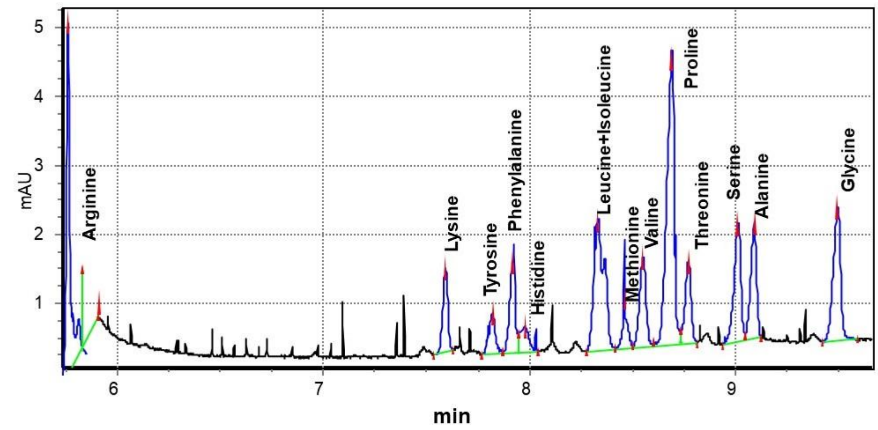
GF products have been shown to contain lower amounts of riboflavin, thiamine, and niacin compared to their wheat counterparts **[50]**. Regarding vitamins, the buckwheat-corn starch pasta demonstrated higher B2, B6, and B3, while B1 and B5 were detected only in rice-corn-based samples (Table 7). It is well known that B vitamins turn food into energy and are essential for the body's metabolism. For instance, vitamin B1 plays a critical role in energy metabolism and muscle contraction, while the role of both B1 and B6 vitamins in the transmission of nerve signals is well-documented **[51]**. B5 is involved in acetyl-CoA, fat, and protein synthesis, whereas B3 regulates intracellular calcium release **[52]**. Therefore, vitamin content is the most important issue in developing gluten-free pasta.

Table 7 Water-soluble vitamin contents of different recipe-based pasta.

Contents	Recipe No.1	Recipe No.2
B1 (thiamine chloride)	0.14 ±0.005	-
B2 (riboflavin)	^{B}0.14 ±0.01	^{A}0.35 ±0.1
B6 (pyridoxine)	^{B}0.047 ±0.001	^{A}0.072 ±0.001
B3 (pantothenic acid)	^{B}0.15 ±0.005	^{A}0.18 ±0.01
B5 (nicotinic acid)	0.031 ±0.005	-

Note: ND, not detected; $^{A, B, C}$ mean p <0.01.

A)



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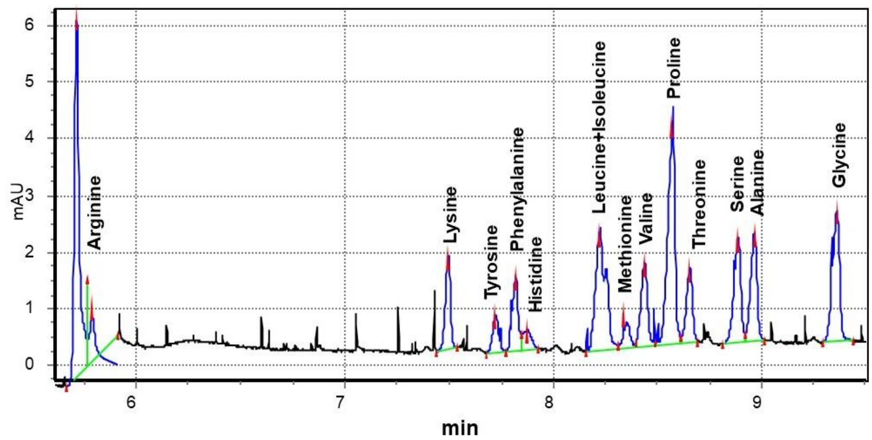
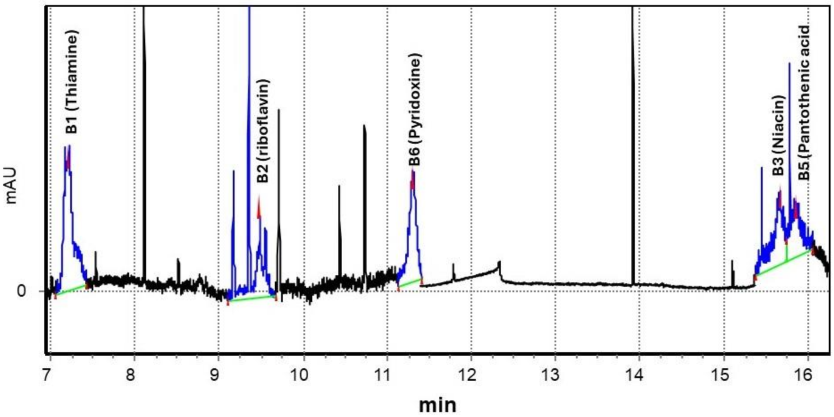


Figure 3 Chromatograms of amino acid composition of pasta A) No.1 recipe; B) No.2 recipe.

A)



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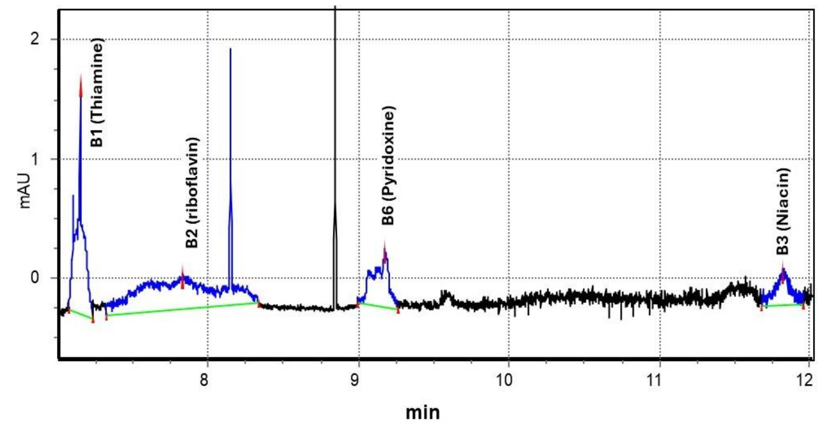

Figure 4 Chromatograms of water-soluble vitamin composition of a) No.1 recipe; b) No.2 recipe pasta.

Figure 5 Ready pasta made from rice-corn flour (left) and from buckwheat flour (right).

CONCLUSION

The results of the study showed that buckwheat flour contains significantly higher amounts of protein (11.9%), ash (1.54%), iron (2.47%), calcium (38.53%), magnesium (56.11%), phosphorus (267.55) and lower carbohydrate content (67.99%) compared to rice and corn flour. Moreover, pasta made from buckwheat flour also showed higher protein 9.39%, Ca (28.80 mg/100g), Mg (48.28 mg/100g), Fe (2.28 mg/100g. Regarding amino acid composition, higher contents of arginine, threonine, lysine, leucine-isoleucine, methionine, phenylalanine, were observed in buckwheat flour. Meanwhile, ready gluten free pasta made from buckwheat flour also showed higher contents of protein, ash, iron, calcium, magnesium, vitamin A, vitamins B2, B3, B6, and essential amino acids including leucine+isoleucine, lysine, phenylalanine, threonine, and valine. Taken together, these data hint that buckwheat has the potential to become a nutrient-rich gluten free paste, surpassing corn and rice. However, further research is needed to determine culinary quality and consumer acceptability.

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Contact Address:

*Fariza Sagyntay, Almaty Technological University, Faculty of Food Technology, Tole bi 100, 050012, Almaty, Kazakhstan,
Tel.: +7 707 271 97 00
E-mail: farizasagintaeva@gmail.com
ORCID: https://orcid.org/0000-0002-6805-8888

Auelbek Iztaev, Almaty Technological University, Faculty of Food Technology, Tole bi 100, 050012, Almaty, Kazakhstan,
Tel.: +7 700 216 225
E-mail: auelbekking@mail.ru
ORCID: https://orcid.org/0000-0002-7385--482X

Assel Borankulova, Taraz Regional University named after M.Kh.Dulaty, Suleimanova 7, 080000, Taraz, Kazakhstan,
Tel.: +7 702 817 9253
E-mail: aselboor@mail.ru
ORCID: https://orcid.org/0000-0002-9696-5303

Baltash Tarabayev, S.Seifullin Kazakh Agro-Technical Research University, Department of Technology of Food and Processing Production, Zhenis Ave. 62, Astana 010011, Kazakhstan,
Tel.: +7 771 255 70 96
E-mail:tarabaev5009@gmail.com
ORCID: https://orcid.org/0000-0002-5783-3973

Begzada Soltybayeva, Taraz Regional University named after M.Kh.Dulaty, Suleimanova 7, 080000, Taraz, Kazakhstan,
Tel.: +7 705519 21 75
E-mail: soltibaeva@mail.ru
ORCID: https://orcid.org/0000-0002-3260-4429

Nurbibi Mashanova, S.Seifullin Kazakh Agro-Technical Research University, Department of Technology of Food and Processing Production, Zhenis Ave. 62, Astana 010011, Kazakhstan,
Tel.: +7 705 739 81 03
E-mail: nurmashanova@gmail.com
ORCID: https://orcid.org/0000-0001-8664-5173

Viera Šottníková, Mendel University in Brno, Faculty of Agronomy, Department of Food Technology, Zemědělská 1, 613 00, Brno, Czech Republic,
Tel.: +420545133068
E-mail: viera.sottnikova@mendelu.cz
ORCID: https://orcid.org/0000-0002-5963-7116

Anar Kabylda, AF LPP "Kazakh Research Institute of Processing and Food Industry", Al-Farabi 47, 010000, Astana, Kazakhstan,
Tel.: +7 775 900 15 07
E-mail: anara121579@gmail.com
ORCID: https://orcid.org/0000-0002-7876-9368

Corresponding author: *