Rational use of wheat processing products to create a composite flour mixture

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Abstract. The article presents data on the chemical composition of the powder from sprouted wheat pomace, which determines its high nutritional value: dietary fiber (45%), vitamins, mg / 100g (C - 450, P - active substances 390), minor components, mg / 100g (flavonoids 690, chlorophyll 41, tannins 1310) and minerals, mg / 100g (calcium 60, magnesium 85, phosphorus 300, iron 6.8). The resulting powder is able to provide a daily physiological need for minor components from 41 to 1950%, for micro and macromineral substances from 6 to 48%. It also strengthens the functional significance of the main components in the composition of enriched products due to biologically active substances and dietary fiber. Titrimetric, photometric, and spectrophotometric standardized methods were used in the study of the powder chemical composition and the quality indicators of the composite flour mixture. The composition is justified. A rational ratio of wheat, hemp flour, and powder from sprouted wheat pomace - 70:20:10 respectively is determined, based on the results of organoleptic and physico-chemical indicators. The study revealed increased nutritional value compared to wheat flour. The developed composite flour mixture is able to meet 40 % of physiological norm in terms of nutrients and more than 5000% in selenium; it can be considered as an alternative to wheat flour for the development of enriched food products.

1. Introduction

The annual monitoring of the nutritional status of the population of the Russian Federation indicates the failure to comply with physiological consumption norms for basic nutrients and minor components. In this regard, the direction of designing and developing food products enriched with vitamins, macro- and microelements, and dietary fiber remains relevant [1-4]. The results of studies [5–9] show, the synergistic effect is achieved from the use of multicomponent ingredients, which include products of processing cereals, vegetables, fruit.

The technological process for the production of “Vitgrass” juice from wheat sprouts implies the formation of a secondary product of pomace processing in the amount of up to 35%. As a result of our previous studies [10], the chemical composition of juice production pomace was studied. The technology of complex processing of wheat sprouts to produce powder from pomace was developed. It was found that juice production pomace from wheat sprouts has a high nutritional value, which is due not only to the significant content of dietary fiber, but also to a complex of macro and micronutrients,
minor components of natural origin. In [11], we determined regulated organoleptic, physicochemical, hygienic, microbiological indicators of powder from wheat germ pomace, the technical specifications (TS) were developed and entered into the register of Russian standard FBU "Krasnoyarsk CSM".

The study of the possibility of using powder from pomace in the technology of consumer goods enriched with natural biologically active substances offers practical interest.

2. Results and discussion

The purpose of this study is to substantiate the composition of the composite flour mixture for the enrichment of food products based on powder, hemp and wheat flour. As the objects of study, we selected powder from sprouted wheat pomace TS 10.89.19-005 - 64082567-2019 obtained in the conditions of industrial production of “Prorostki” Ltd., Krasnoyarsk, premium wheat flour according to State Standard (GOST)26574-2017, hemp flour according to TS 9146-107-79036538-2010, samples of composite flour mixtures, consisting of wheat, hemp flour and powder.

Organoleptic indicators, humidity, ash content in accordance with GOST 24027.2-80, the content of pectin, “crude” fiber, lignin, cellulose, hemicellulose, tannins, vitamin P, protein, chlorophyll, reducing sugars — photometric method were determined in powder samples from pomace; chlorophyll - according to the methods described in [12-13]; flavonoids - by spectrophotometric method [14]. The mineral composition was determined using an inductively coupled plasma atomic emission spectrometer iCap 6300 Duo (ThermoScientific, England, 2010) in the analytical laboratory of the Institute of Biophysics of SB RAS, Krasnoyarsk). The calibration of the ISP spectrometer was carried out using multi-element standards (ICP multi-element standards solution IV and XVI, Merck). Sc (5 mg / L, ScandiumStandardfor ICP 92504, Sigma-Aldrich) was used as the internal standard. The elements were detected at the following wavelengths (λ, nm): Ca 317.9, Fe 238.2, K 769.8, Mg 279.0, P 213.6, Zn 213.8. The samples of the composite flour mixture were analyzed according to organoleptic and physicochemical indicators GOST R 50366-92, GOST 15113.4, GOST 15113.2.

The analyzed vegetable, fruit, berry powders - secondary products of processing juice production are characterized by high nutritional value (table 1).

Table 1. The chemical composition of powders.

| Name of the indicator                        | Powders   | [15] Carrot | [15] Beet | [15] Apple | [15] Hawthorn |
|----------------------------------------------|-----------|-------------|-----------|------------|--------------|
| Moisture, %                                  | 8.00±0.40 | 6.5         | 5.1       | 6.8        | 4.4          |
| Protein, g/100 g                             | 5.14±0.12 | 9.2         | 10.0      | 6.7        | 6.1          |
| Lipids, g/100 g                              | 13.98 ± 0.29 | 0.5     | 0.5       | 6.8        | 4.9          |
| Watersoluble substances, %                   | 6.81 ± 0.34 | -         | -         | -          | -            |
| among them there are soluble carbohydrates, %| 1.56 ± 0.08 | 20.8     | 3.0       | 40.9       | 12.6         |
| including reducing sugars, %                | 3.28 ± 0.16 | absent  | absent    | 5.0        | 1.5          |
| Organic acids, g/100 g                       | 450.54 ± 4.2 | 32.7     | 93.2      | 81.3       | 22.6         |
| Vitamin C, mg/100 g                          | 45,24±1.21 | 10.1       | 7.0       | 13.4       | 28.3         |
| Dietary fibres, %                            | 1.03±0.05  | 8.8        | 8.3       | 12.4       | 12.2         |
| Among them there are                        |            |            |           |            |              |
| Pectin substances, %                         |            |            |           |            |              |
Compared with the presented powders (carrot, beet, apple, hawthorn), which are sources of reducing sugars, pectin substances, the evaluated powder from juice production pomace of wheat sprouts has a higher amount of lipids, a significant content of vitamin C, dietary fiber, according to table 1. A comparative analysis of the chemical composition of the powders revealed that the developed powder is 2 times higher than the apple sample in lipid content, and 27 times higher than carrot and beetroot samples. The powder from sprouted wheat pomace is of particular value due to the significant amount of vitamin C, which is 5.5 and 4.8 times higher than the content in beet and apple samples, respectively, and 13 and more times higher than in carrot and hawthorn powders. The presence of a functional ingredient - dietary fiber in large quantities, exceeding the analyzed fruit, berry, vegetable powders from 1.6 to 6.4 times is the competitive advantage of the powder from squeezed wheat germ. A fine-dispersed structure and a large surface area were revealed in the powder from the sprouted wheat pomace due to the small bulk density, which allows predicting properties such as neutralization and elimination of metabolic products, toxins, bacteria, toxic elements from the body, acting as a biosorbent due to its complexing abilities.

The quantitative content of flavonoids, chlorophyll, tannins, and P-active substances was determined in the composition of minor components of the powder from the wheatgrass pomace (table 2).

### Table 2. The content of minor components in the powder from wheatgrass pomace.

| Name of the indicator       | Powder from sprouted wheat pomace | The satisfaction degree from the physiological consumption norm of FNR*% |
|----------------------------|-----------------------------------|---------------------------------------------------------------------|
| Flavonoids, mg/100 g       | 690, 48 ± 5,08                    | 81                                                                  |
| Chlorophyll, mg/100 g      | 41, 27 ± 1,36                     | 41                                                                  |
| Tannins, mg/100 g          | 1310,82 ± 6,27                    | 655                                                                |
| P-active substances, mg/100 g | 390,10 ± 3,64                    | 1950                                                               |

* FNR - Federal Norms and Regulations

The research results presented in table 2, indicate a high nutritional value of the powder from the sprouted wheat pomace due to the high content of natural minor components, meeting the physiological norm of consumption from 41% in terms of tannins and up to 1950% in P-active substances. The results of the study of macro- and microelements in powder from squeezed wheatgrass pomace are presented in table 3.

### Table 3. The results of the analysis of macro- and micronutrients in powder from squeezed wheat.

| Name of indicator | Content in 100 g of powder from sprouted wheat pomace, mg / 100 g | Physiological rate of consumption, mg (TP TC 022/2011) | The Satisfaction degree from the physiological consumption norm *% |
|-------------------|---------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------|
| Calcium (Ca)      | 60,01                                                               | 1000                                                 | 6,00                                                             |
| Phosphorus (P)    | 300,44                                                              | 800                                                  | 37,56                                                            |
| Iron (Fe)         | 6,82                                                                | 14                                                   | 48,71                                                            |
| Magnesium (Mg)    | 85,12                                                               | 400                                                  | 21,28                                                            |

Data analysis of table. 3, allows us to conclude that, in accordance with the requirements of TR TS 022/2011 “Food products in terms of their labeling”, the powder from sprouted wheat pomace has a high content of phosphorus and iron, and is also a source of magnesiu. The basic raw material in flour confectionery is wheat flour, which has good organoleptic, physico-chemical and technological properties, while it has a low nutritional value. Premium wheat flour contains a small amount of protein and dietary fiber compared with other types of flour. The composite flour mixtures are getting more popular now in order to enrich flour confectionery. Their advantage over premium wheat flour is a reduced amount of carbohydrates, an increased amount of protein, vitamins and minerals.
The obtained experimental data on the chemical composition of the powder from sprouted wheat pomace suggests that combining it with wheat flour will enrich the flour mixture and confectionery based on it not only in the content of dietary fiber, but also in the composition of other macro- and micronutrients - vitamins and mineral components. Hemp flour was used as a source of protein and minerals for the developed composite flour mixture. According to the published data, the protein content in hemp flour is 30g / 100g, fat 8g / 100g, carbohydrates 25g / 100g, magnesium 4.5 mg, iron 0.33 mg, selenium 3.7 mg [16].

At the first stage of the development of the ingredient composition of the composite flour mixture, a certain amount of wheat flour was replaced by hemp. For the study, 5 samples were used, the ratio of wheat and hemp flour: No. 1 - 90:10, sample No. 2 - 80:20, sample No. 3 - 70:30, sample No. 4 - 60:40, sample No. 5 - 50:5. The judicious mix of different types of flour in the composition of the composite mixture was determined on the basis of regulated physical, chemical and organoleptic indicators in accordance with GOST R 50366-92, the results are presented in figure 1.

![Figure 1](image1.png)

**Figure 1.** The results of organoleptic evaluation of samples with different ratio of wheat and hemp flour in the mixture.

According to the results of organoleptic evaluation, the highest score was obtained by sample No. 2 with a ratio of wheat and hemp flour 80:20. As a result of studying physical and chemical parameters, such as mass fraction of moisture, mass fraction of metal impurities, foreign impurities and pest infestation in bread stocks, it was revealed that with an increase in the amount of hemp flour in the composition of the composite mixture, the mass fraction of moisture in the samples increases. At a dosage of 30% and higher hemp flour in the mixture, the moisture indicator does not correspond to the regulated value. Considering the results obtained in terms of organoleptic and physico-chemical parameters, a rational ratio of 80:20 wheat and hemp flour in the composite mixture was revealed.

At the second stage of the development of the ingredient composition of the composite flour mixture, part of the wheat flour was replaced by the powder from sprouted wheat pomace. To determine the rational ratio of wheat, hemp flour and powder from wheat pomace, 4 samples were developed: the ratio of wheat flour to hemp flour and powder in sample No. 1 - 75: 20: 5, sample No. 2 - 70:20:10, sample No. 3 - 65:20:15, sample No. 4 - 60: 20: 20. The results of the organoleptic characteristics of the composite mixture are presented in figure 2.

![Figure 2](image2.png)

Analysis of the data presented in figure 2 showed that the highest number of points was received by two samples No. 1 (75:20:05) and No. 2 (70:20:10) with a balance of wheat, hemp flour and powder.
To select one of the samples, the amount of dietary fiber was determined, it was found that the content in sample No. 1 was 9.4 g, in mixture No. 2 it was 12 g. As a result sample No. 2 was selected. The comparative analysis of food values of wheat flour and developed composite flour was carried out after that (table 4).

Table 4. The comparative analysis of nutritional value of wheat flour and developed composite flour mixture.

| Name of the indicator       | Physiological rate of consumption, mg (TPTC 022/2011) | Wheat flour | Composite flour mixture | Satisfaction degree from the physiological consumption norm % | Wheat flour | Composite flour mixture |
|-----------------------------|-------------------------------------------------------|-------------|-------------------------|-------------------------------------------------------------|-------------|------------------------|
| Protein g/100 g             | 75                                                   | 11          | 14                      | 15                                                          | 19          |                        |
| Fat g/100 g                 | 83                                                   | 1           | 4                       | 1                                                           | 5           |                        |
| Carbohydrates,g/100 g       | 365                                                  | 70          | 55                      | 19                                                          | 15          |                        |
| Dietary fiber g/100 g       | 30                                                   | 3.5         | 12                      | 11                                                          | 40          |                        |
| Ferrum g/100g               | 14                                                   | 1.2         | 1.6                     | 8.6                                                         | 11.4        |                        |
| Magnesium,g/100g            | 400                                                  | 16,         | 10,0                    | 4                                                           | 2.5         |                        |
| Zinc,g/100g                 | 15                                                   | 0.7         | 1.0                     | 4.7                                                         | 6.7         |                        |
| Selenium, g/100g            | 0,07                                                 | -           | 3.7                     | 0                                                           | 5285.7      |                        |
| Nutritional value, kcal     | 2500                                                 | 340         | 310                     | 14                                                          | 12          |                        |

Based on the data obtained in table 4, we can conclude that, in accordance with the requirements of TP TC 022/2011, a flour mixture with a ratio of wheat, hemp flour and powder from sprouted wheat pomace 70:20:10 is characterized by a high content of dietary fiber - 12 g per 100 g. This amount allows you to meet 40% of the physiological norm and more than 5000% of the daily norm of selenium.

The developed composite flour mixture contains 15 g. less carbohydrates and 3 g. more protein. Ferrum content increased by 0.4 mg., zinc – by 0.3 mg., selenium - by 3.7 mg., dietary fiber – by 9 g. The energy value decreased by 30 calories compared with wheat flour.

3. Conclusions
The high nutritional value of the powder from the sprouted wheat pomace has been established, due to the significant content of dietary fiber, vitamin C, minor components, macro and micronutrients. The composition of a composite flour mixture consisting of wheat, hemp flour and powder from sprouted wheat pomace has been developed based on the results of organoleptic and physico-chemical indicators. The comparative analysis of the nutritional value of wheat flour and composite mixture has been carried...
out, indicating its significant excess in the developed flour mixture based on powder. The satisfaction degree of the physiological norm of consumption for individual food substances is from 40 to 5000%. It can be concluded that a flour mixture of wheat, hemp flour and powder from sprouted wheat pomace can be used to enrich food products.

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