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Advanced technologies for developing sorghum-based biscuits

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Abstract

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The aim of the present scientific research was to develop innovative approaches for obtaining grain-based foods with the addition of plant raw materials of high biological value. The raw plant materials used for the preparation of the innovative products are rye, which is milled into the flour variety "Bul Millennium", and sorghum, variety "Maxibel". For the preparation of the flour mixtures, Bulgarian varieties of raw materials are used, as well as additional raw materials. The article shows the technological indicators of the products, the mineral composition of the flour and the finished products. When adding whole grain organic rye flour and organic sorghum flour (40:60, 30:70, 20:80 and 10:90) with the addition of 10% apple pectin, pasta products are obtained that are intended for people with specific health needs. From the scientific study it was found that in different ratios (40:60, 30:70, 20:80 and 10:90) with the addition of 10% apple pectin, the rheological properties are significantly different in the different types of mixes, innovative cereal products are obtained basis, in which different values of the macro and micro elements are observed, the flour mixes are rich in iron and have good baking properties. Regarding the iron in the organic flour from rye and sorghum in the different ratios (40:60, 30:70, 20:80 and 10:90), with the addition of 10% apple pectin is as follows: 71.11 mg/kg; 78.80 mg/kg; 83.69 mg/kg; 88.73 mg/kg. The finished products are characterized by high volume and high biological value.

Keywords: bio; wholegrain; rye; sorghum; flour

Introduction

The biscuits are a popular worldwide flour-based confectionery that are usually consumed as dessert or as a light snack between meals. They are most often made from wheat or oat flour, with added sugar, honey or sweeteners, as well as chocolate, nuts, raisins, fruit or other fillings. (Lazova-Borisova et al., 2024).

In Bulgaria, biscuits are a favorite sweet dessert. They are often combined with tea, yogurt, fresh milk or jam. This product can be prepared from whole grain flours (Gentscheva et al., 2022).

Whole grain flours are obtained by grinding the whole grain. Whole grain flour is richer in vegetable fiber than refined flour. (Lazova-Borisova, 2022b).

From a medico-biological point of view, flours from whole grains obtained by so-called simple grinding are more valuable. They are rich in vitamins, minerals, cellulose and proteins (Georgieva et al., 2007).

From a technological point of view, however, they are of low quality, as they are slightly resistant to storage and have poor baking qualities. (Lazova-Borisova, 2022c).

The husks of the grains contain a large amount of minerals, iron, copper, zinc, selenium, magnesium, B vitamins and a high content of ballast substances (plant fibers) (Lazova-Borisova, 2022a).

By grinding the whole grain to obtain whole grain flour, we obtain a product in which all the substances involved in the composition of wheat, corn or rye are preserved (Alexieva et al., 2022).

The mineral composition of the flour depends on the randeman during the milling process (degree of bran extraction).

No matter how refined the flour is, the mineral content is high because they are contained in all parts of the grain and depend mainly on the type of crop (Weigle et al., 2005; Schneider et al., 2015; Wirngo et al., 2016).

Microelements are needed in smaller quantities for the functioning of the human organism and their concentration in wheat is 10-3-10-5%, and in rye the order is the same, but a higher content of Fe, Mg, Zn is found than those published for wheat (Sarker et al., 2015).

Special attention is paid to β-glucans, which are contained in larger quantities in barley and oats.

Numerous studies have been conducted on the influence of β-glucans on human health. β-glucans have been reported to lower low-density lipoprotein cholesterol and thereby protect against cardiovascular disease.

Some studies show that β-glucans act as immunostimulators and have an antitumor effect.

The addition of barley and oat bran to refined flours changes the rheological properties of the dough and the quality parameters of the bread.

In addition, earlier studies have shown that the addition of semolina, duntas and high-fiber semolina products to wheat flour weakens the cellular structure of the medium, which is a consequence of thinning and weakening the reticular structure of the wheat protein. The whole grain sorghum and rye flours used are rich in protein and fiber, making them suitable for use as the main ingredient for bakery products (Sausserde and Kampuss, 2014).

The aim of the present scientific research was to develop a recipe composition and technology for the production and sale of healthy biscuits from rye, sorghum, apple pectin and additional raw materials in different ratios and to investigate their physico-chemical and mineral composition

Materials and Methods

The experiments were conducted in 2024 at the Institute of Cryobiology and Food Technologies in Sofia.

The main and additional raw materials used to produce biscuits are a mix of whole grain rye flour, stevia, egg mélange, cow butter, yogurt, apple pectin, vanilla, baking powder, bicarbonate of soda, lecithin and sorghum flour, and the flours are ground on a stone mill with a size of flour particles 900 μm. The rye flour was delivered by the Milling Plant in the village of Medovo, Pomorie municipality. The raw material sorghum was delivered by the Agricultural Institute in Shumen.

Test baking in laboratory conditions are by the single-phase method (Karajov, 2007).

Macro and microelements in organic whole grain flours were determined on an atomic emission photometer – AES-ICP "Varian-Liberty II" in the Central Laboratory of the Bulgarian Food Safety Agency.

Determination of total protein content (BDS EN ISO 16634-2:2016).

Determination of fat content (BDS EN ISO 11085:2010).

Determination of total ash content (ISO 1762:2019).

Determination of fiber content (BDS EN ISO 12009:2017).

Beta glucans were determined by the enzymatic method of McCleary (McCleary and Glennie, 1985).

Sensory evaluation was conducted by 10 trained tasters on a 9-point hedonic scale 0–9 (Lim et al, 2009).

Energy value of 100g product kJ/ kcal/- calculation based on chemical composition.

Ten percent (10%) apple pectin has been added to the basic organic whole grain rye flour and organic whole grain sorghum flour.

Statistical analysis was performed with Microsoft Excel 2016.

The aim of the present scientific research was to develop innovative approaches for obtaining grain-based foods with the addition of Bulgarian varieties of plant raw materials with high biological value. The raw plant materials used for the preparation of the innovative products are rye, from which the flour variety "Bul Millennium" is obtained and sorghum variety "Maxibel". For the preparation of the flour mixtures, Bulgarian varieties of raw materials were used, as well as additional raw materials.

Results and Discussion

According to Sausserde and Kampuss (2014), the whole grain sorghum and rye flours used are rich in protein and fiber, making them suitable for use as the main ingredient for bakery products.

The table 1 shows chemical composition of the flours. The β-glucans in rye flour is 1.65%, in sorghum has 2.15% β-glucans. The ash in rye flour is 1.87%, in the sorghum flour is 1.70%.They have no significant difference.

The macro element composition of the whole grain flours used is extremely rich. The calcium content of sorghum flour is significantly increased compared to rye flour. Regarding the phosphorus content, the highest values are observed in

Table 1. Chemical composition of the flours (n = 10)

Type of sample	β-glucans %	Ash %	Proteins %	Fiber %	Fat %	Carbohydrates %	Energy value kcal/100 g product
Rye Flour	1.65	1.87	11.70	7.27	3.48	32.84	229
Sorghum flour	2.15	1.70	12.30	8.90	3.59	33.59	230

$p < 0.002$

Source: Authors' own elaboration

sorghum flour, followed by rye. Magnesium as a macronutrient is higher in sorghum flour compared to rye. As a summary, it can be said that of the flours used, sorghum flour is richer in the macro nutrients sodium, calcium and phosphorus, compared to rye flour.

From the point of view of the micro element composition, the flours used to make the biscuits have a rich composition of copper, zinc, manganese, iron, cobalt, selenium and iodine. The content of zinc, cobalt and selenium also in the whole grain flours used has negligible differences in values and can be said to be almost equivalent. More than twice as much copper and zinc is found in sorghum flour than in rye flour.

The macro element composition of the biscuits is extremely important for the healthy qualities of the product. As can be seen from the table, high calcium and sodium contents are observed. The amounts of magnesium and sulfur are low values in the mineral composition of the biscuits.

The copper content in the final realized product is low, at the expense of the other micro elements. Zinc, cobalt, man-

Table 2. Macro element composition of the used whole grain flours (n = 10)

Sample type	Ca mg/kg (x±sx)	P g/kg (x±sx)	Na g/kg (x±sx)	K g/kg (x±sx)	Mg g/kg (x±sx)	S g/kg (x±sx)
Rye flour/ flour sorghum 40:60+10% apple pectin	97.57±0.01	7.45±0.01	13.31±0.01	8.72±0.01	4.71±0.01	4.25±0.01
Rye flour/ flour sorghum 30:70+10% apple pectin	123.14±0.01	8.94±0.01	14.45±0.02	5.77±0.01	3.79±0.01	1.37±0.01
Rye flour/ flour sorghum 20:80+10% apple pectin	99.57±0.01	9.67±0.01	17.57±0.01	9.78±0.01	9.59±0.01	7.57±0.01
Rye flour/ flour sorghum 10:90+10% apple pectin	117.45±0.01	10.57±0.01	19.17±0.01	8.57±0.01	6.34±0.01	6.45±0.01

$p < 0.002$

Source: Authors' own elaboration

Table 3. Micro element composition of the used whole grain flours (n = 10)

Sample type	Cu mg/kg (x±sx)	Zn mg/kg (x±sx)	Mn mg/kg (x±sx)	Fe mg/kg (x±sx)	Co µg/kg (x±sx)	Se µg/kg (x±sx)	I µg/kg (x±sx)
Rye flour/ flour sorghum 40:60+10% apple pectin	6.57±0.01	30.45±0.01	48.21±0.01	71.11±0.01	49.71±0.01	49.25±0.01	72.18±0.01
Rye flour/ flour sorghum 30:70+10% apple pectin	8.58±0.01	36.77±0.01	56.23±0.01	78.80±0.01	46.59±0.01	46.57±0.01	76.17±0.01
Rye flour/ flour sorghum 20:80+10% apple pectin	6.54±0.01	56.23±0.01	65.27±0.01	83.69±0.01	34.57±0.01	36.65±0.01	66.49±0.01
Rye flour/ flour sorghum 10:90+10% apple pectin	10.74±0.01	66.55±0.01	75.64±0.01	87.84±0.01	46.54±0.01	26.54±0.01	65.54±0.01

$p < 0.002$

Source: Authors' own elaboration

Table 4. Macro element composition of biscuits (n = 10)

Sample type	Ca mg/kg (x±sx)	P g/kg (x±sx)	Na g/kg (x±sx)	K g/kg (x±sx)	Mg g/kg (x±sx)	S g/kg (x±sx)
Biscuits 20:80+10% apple pectin	245.78±0.01	7.78±0.01	23.45±0.01	8.98±0.01	5.18±0.01	6.27±0.01
Biscuits 10:90+10% apple pectin	289.92±0.01	5.88±0.01	24.78±0.01	5.72±0.01	2.98±0.01	5.73±0.01

$p < 0.005$

Source: Authors' own elaboration

Table 5. Micro element composition of biscuits (n=10)

Sample type	Cu mg/kg (x±sx)	Zn mg/kg (x±sx)	Mn mg/kg (x±sx)	Fe mg/kg (x±sx)	Co µg/kg (x±sx)	Se µg/kg (x±sx)	I µg/kg (x±sx)
Biscuits 20:80+10% apple pectin	6.37±0.01	45.45±0.01	54.07±0.01	82.91±0.01	44.26±0.01	47.25±0.01	86.51±0.01
Biscuits 10:90+10% apple pectin	8.89±0.01	46.37±0.01	56.22±0.01	86.37±0.01	68.44±0.01	61.39±0.01	91.31±0.01

$p < 0.005$

Source: Authors' own elaboration

Table 6. Chemical composition of the biscuits (n=10)

Type of sample	β-glucans %	Ash %	Proteins %	Fiber %	Fat %	Carbohydrates %	Energy value kcal/100g product
Biscuits	2.15	1.70	12.30	8.90	3.59	33.59	230

$p < 0.002$

Source: Authors' own elaboration

ganese and selenium are approximately equal in the biscuits. The highest values of micro elements in the biscuits are iron and iodine.

The table 6 shows chemical composition of the biscuits. The β-glucans in biscuits has 2.15 %. The ash is 1.70%.The biscuits are with high fiber and proteins.

A preliminary preparation was made by adding baking powder to the flour mixture of rye and sorghum, and then a dough was mixed according to the single-phase mixing method with the remaining raw materials. The preliminary baking was done at 180°C for 30 minutes.

Quality and sensory evaluation of the finished biscuits:

Fig. 2. Incision on the biscuits
Source: Authors' own elaboration

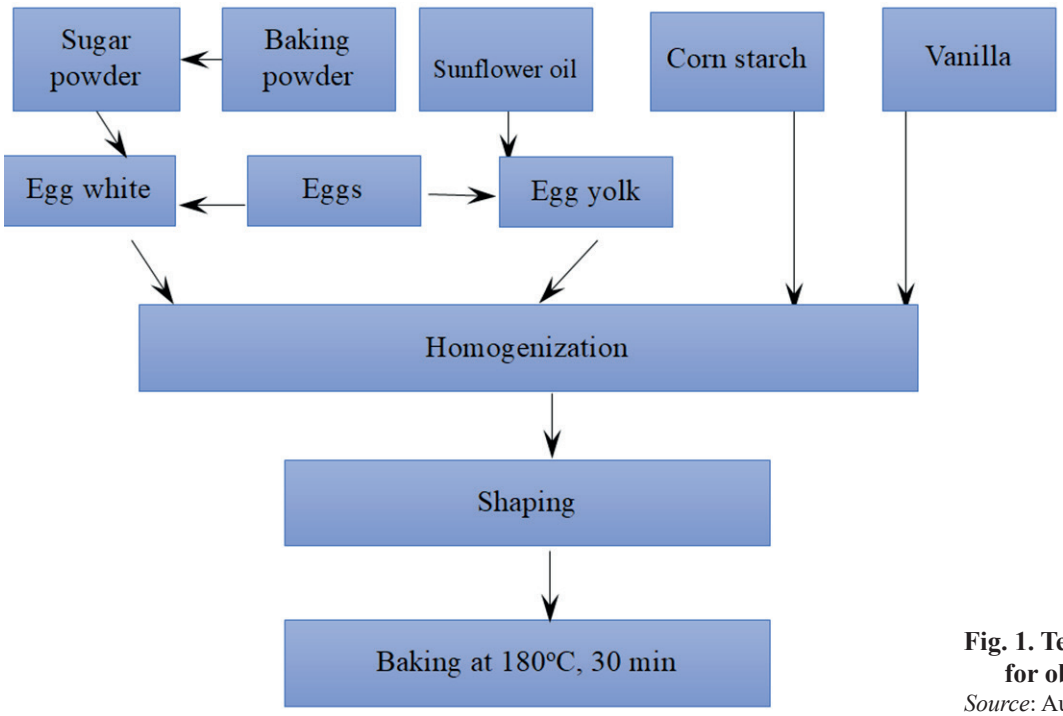

Fig. 1. Technological scheme for obtaining biscuits
Source: Authors' own elaboration

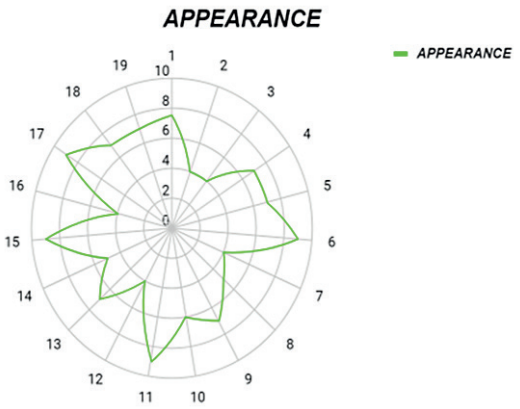

Fig. 3. Sensory indicator "Appearance"
Source: Authors' own elaboration

Fig. 4. Sensory indicator "Taste"
Source: Authors' own elaboration

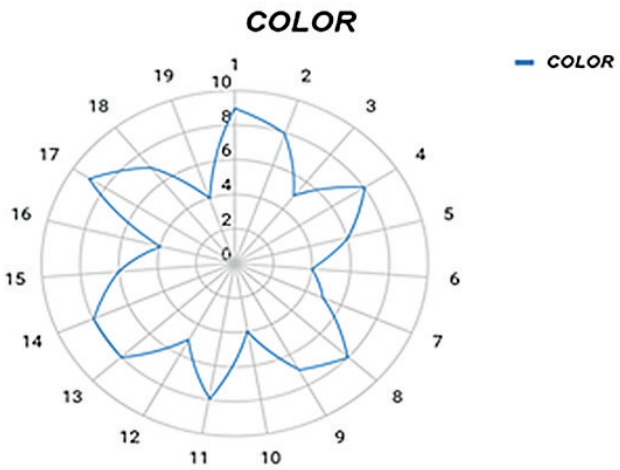

Fig. 5. Sensor indicator "Color"
Source: Authors' own elaboration

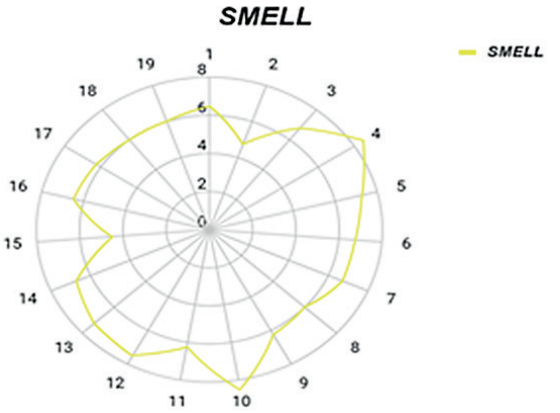

Fig. 6. Sensory indicator "Smell"
Source: Authors' own elaboration

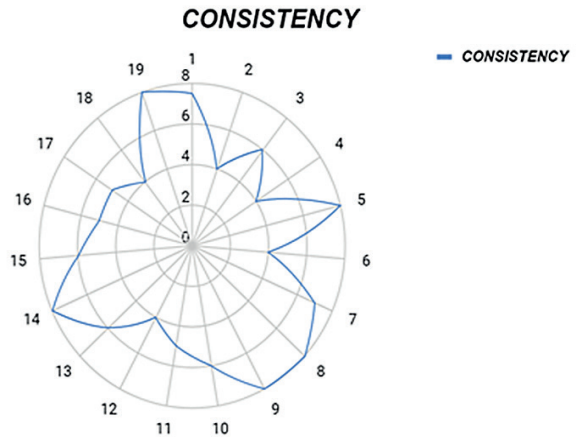

Fig. 7. Sensory indicator "Consistency"
Source: Authors' own elaboration

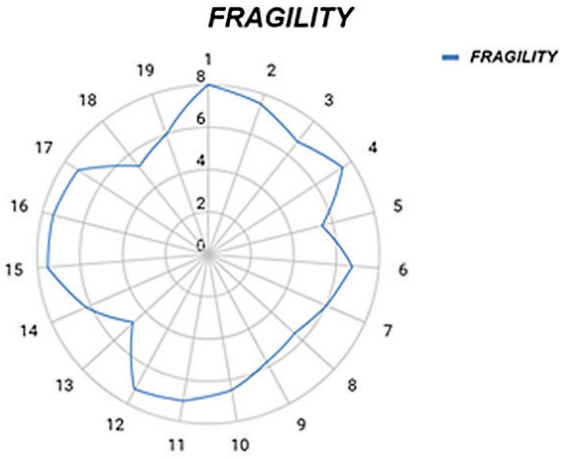

Fig. 8. Sensory indicator "Fragility"
Source: Authors' own elaboration

They are rectangular biscuits with the correct shape. The upper crust has a golden to reddish tinge, normal thickness and characteristic cracking. The taste is characteristic and slightly sweet. It has a pleasant aroma, typical for this type of biscuits (Lim et al. 2009).

The data from the organoleptic evaluation according to the indicators – appearance, taste, color, smell, consistency, fragility, are presented in Figures 3-8. Therefore, the created new biscuit products were positively received by the tasters and defined with a sweet taste.

The consistency of the biscuits is normal, as is the brittleness. The color of the biscuits is pale brown, typical of the raw materials used.

The biscuits had a taste, smell and color typical of the raw materials used, and the consistency and brittleness were typical of biscuits.

Conclusions

Innovative methods for obtaining grain-based foods with added raw plant material with high biological activities were applied. The raw plant materials used for the preparation of the innovative products are from Bulgarian varieties of rye from which the flour variety "Bul Millennium" and sorghum variety "Maxibel" was obtained, as well as additional raw materials.

The resulting products have high levels of microelements in iron and iodine biscuits. The appropriate parameters for the technological process for obtaining biscuits have been found. The product has a utility model №5170U1 from the Patent Office of the Republic of Bulgaria /16.07.2025 till 16.07.2029/. The authors of the article are inventors of the product.

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