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ON THE POTENTIAL FOR USING GROUND CHIA SEEDS IN PRODUCING MACARONI PRODUCTS WITH HIGH MINERAL VALUE

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Abstract: *The aim of this research is to study the potential use of ground chia seeds in producing macaroni products with high mineral value. The materials used include: top-grade durum flour for use in macaroni products, ground NutraChia Low 8 chia seeds; macaroni products — home style noodles. It has been determined that ground NutraChia Low 8 chia seeds contain more calcium (8.7 times), magnesium (4 times), sulfur (3.6 times), potassium (2.3 times), and phosphorus (2.3 times) than top-grade durum flour. Replacing 10 % of top-grade durum flour in the home style noodle recipe with the same amount of ground NutraChia Low 8 chia seeds leads to an increase in the following macronutrients in macaroni products: calcium (2.2 times), magnesium (2 times), phosphorus (1.4 times); and the following micronutrients: copper (2 times), zinc (1.5 times), iron (3.5 %). Adding ground chia seeds to the noodle recipe does not have a negative effect on the vitamin value, physico-chemical parameters and the product's safety at the microbiological level. We have discovered the potential to use the studied amount of ground NutraChia Low 8 chia seeds in the production of macaroni products with high mineral value.*

Keywords: *macaroni products, noodles, chia seeds, mineral content, quality.*

1. Introduction

One of the most important government projects the Russian Federation and in most economically developed countries (USA, United Kingdom, Germany, Italy, Belgium etc.), as well as in many developing countries in Africa, Asia and Latin America, is the improvement of the quality of life of their citizens by preserving health and productivity [1, 2], [7, 8], [12]. It has been determined that fighting mineral deficiency in individual dietary intake lowers the duration of diseases 2-3 times, and the total sickness rate by 20-30 % [17], [22].

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An important trend in high nutritional value macaroni production is the increased use of untraditional plant raw materials [14], [20]: soybean, pea, lentil flour [10], oat flour, separately or combined with rice flour [21], triticale [13], buckwheat, barley, corn flour [15], lupin flour, sunflower seed flour etc. [5].

To date, there have been positive results in using chia seed flour as an untraditional plant ingredient in the making of baked goods [6], instant porridge [4], mixed rhy-wheat and wheat bread [11], [24].

Chia (*Salvia hispanica*) is an annual herb in the Labiatae family native to Latin and South America, Mexico and Argentina. Chia seeds have a rich mineral content and contain calcium (536 mg), magnesium (350 mg), potassium (564 mg), phosphorus (751 mg), iron (6.3 mg), copper (1.4 mg) and zinc (4.4 mg). Chia seeds are rich in vitamins C, E and B. Protein content in the seeds is between 15 and 25 %, fiber content is between 18 and 30 % [9].

In Europe the potential for using chia seeds as a new food ingredient was first explored by ACNFP (United Kingdom) in 2003. Taking into account the safe use of chia seeds in the diets of the US, Australian, Canadian and European populations, in January 2013 the EFSA made a decision to allow the use of 5 to 10 % chia seeds in mass consumed food products, including bread and baked goods, breakfast cereals, fruit, nut and cereal mixes etc. In April 2013 the Institute of Nutrition of the Russian Academy of Medical Sciences presented a report on using chia seed flour in food for children over the age of three [9].

In light of this, the goal of this research is to study the use of ground chia seeds in the production of high mineral value macaroni products.

2. Material and Methods

The materials used in our study include:

- Top-grade flour (semolina) made from durum wheat for the purpose of producing macaroni products. Manufactured by Garnec LLC (Vladimir Oblast, Russia);
- Ground NutraChia Low 8 chia seeds (the seeds are partially deoiled using SFE, removing 75 % of the oil and preserving all the nutrients). Supplied by KIMA Limited (Moscow, Russia), an authorized agent of Aromco Ltd. and Kanegrade (United Kingdom);
- Test samples of home-style noodles made using the recipe by Zdobnov and Tsyganenko [23]. As a control sample we used noodles made using a basic recipe (contents: top-grade durum flour, drinking water, sodium chloride, fresh chicken eggs); for the experiment – adding 10 % ground NutraChia Low 8 chia seeds by replacing an equivalent amount of durum flour used for making noodles.

The study of noodle test samples was carried out on dried products (over 4 hours at 55 °C at constant air drying power).

The elemental composition of wheat flour and ground NutraChia Low 8 chia seeds was studied on JSM – 6460LV, a scanning electron microscope (JEOL, Japan), equipped with an electromagnetic dispersion spectrometer for electron probe microanalysis made by OXFORD INSTRUMENTS (England).

Moisture content in noodle test samples was counted using the method of drying the regrounded sample weight of the product over 4 hours at 100 °C until it

reached a fixed mass, followed by cooling the sample and processing the results.

Ash content was calculated by burning a sample weight of regrounded product until the organic substance was completely burned, followed by measuring the residue.

Acidity was calculated through titration of the suspension of a sample weight of regrounded product in a 0.1 N solution of sodium hydrate with the addition of 5 drops of 1 % phenolphthalein solution until it turned pink and remained pink for 1 minute.

Cooking loss of the noodles was determined by testing residue in the cooking water dried over 4 hours at 100 °C until it reached a fixed mass followed by cooling and processing the results.

Protein content was determined through the nitrogen content using the Kjeldahl method; phosphorus, copper, iron, zinc, magnesium and potassium in noodle test samples were determined using atomic absorption spectrophotometry [16].

The recommended daily intake of mineral elements for an adult was taken from the existing regulations [18].

Tiamine, riboflavin and tocopherol content in noodle test samples was counted using the method of high performance liquid chromatography [16].

Mesophilic aerobic and facultative anaerobic microorganisms in noodle test samples were counted by inoculating the product in agar, incubating the inoculations at 30 ± 1 °C for 72 ± 3 hours in aerobic conditions and counting all visible colonies. Yeast and mold count was determined by inoculating the product in Sabouraud dextrose agar, incubating the inoculated product at 24 ± 1 °C for 5 days, and counting all visible colonies.

All measurements were repeated three times. The statistical analysis was performed using the following software packages: Microsoft Excel XP, Statistica 8.0. Statistical error did not exceed 5 % (with a 95 % confidence level).

3. Results and Discussion

3.1. Elemental Composition of Plant Raw Materials

The first stage of the study was devoted to evaluating the elemental composition of plant raw materials. The elemental composition test results for top-grade durum flour and ground NutraChia Low 8 chia seeds is presented in Table 1.

Elemental composition of raw materials Table 1

Parameter name	**Test results, weight %**	
	Top-grade durum flour	***NutraChia Low 8 chia***
Carbon content	69.8 ± 2.3	70.1 ± 2.5
Oxygen content	25.8 ± 0.9	16.4 ± 0.7
Phosphorus content	1.70 ± 0.02	4.00 ± 0.05
Calcium content	0.30 ± 0.01	2.60 ± 0.02
Potassium content	1.60 ± 0.03	3.70 ± 0.04
Magnesium content	0.30 ± 0.01	1.20 ± 0.02
Sulfur content	0.50 ± 0.01	1.80 ± 0.02
Iron content	–	0.20 ± 0.01

With regard to the oxygen content in the studied plant raw material samples certain particularities have been noted. Wheat flour contains 57 % more oxygen, which can be explained by its fineness degree. NutraChia Low 8 is an agglomeration of separate ground Salvia hispanica herb seeds mixed with wheat grains that were more finely ground when made into graded flour, with the final powdered product (flour) sifted multiple times in the process of production, resulting in oxygen enrichment.

Nonetheless, among the macronutrients in NutraChia Low 8 chia samples there is more calcium (8.7 times), magnesium (4 times), potassium (2.3 times), phosphorus (2.3 times) than in the traditional plant raw materials, which matches known data 19. Among the macronutrients the presence of iron was determined. The sulfur content has also increased (by 3.6 times), which is likely caused by the heightened protein content in chia seeds [9], as it is known that proteins contain sulfur due to its presence in certain amino acids: cysteine, cystine, methionine.

3.2. The Nutritional Value of Macaroni Products

The second stage of the study focused on mineral and vitamin content in macaroni products. The content of specific mineral elements in noodle test samples corresponds to the previous results of testing the elementary composition of wheat flour and ground chia seeds (Table 2).

Table 2

Mineral and vitamin content in noodle samples

Parameter name	Test results, mg/kg (% of recommended daily intake)	
	Noodles made with a basic recipe	***Noodles made with NutraChia Low 8***
Copper content	2.38 ± 0.02 (238)	5.12 ± 0.02 (512)
Iron content	11.73 ± 0.30 (117 for men, 65 for women)	12.15 ± 0.30 (121 for men, 67 for women)
Zinc content	7.76 ± 0.05 (64)	11.47 ± 0.05 (95)
Magnesium content	199.95 ± 23.00 (49)	392.38 ± 31.00 (98)
Calcium content	70.56 ± 4.40 (7)	157.13 ± 5.20 (15)
Phosphorus content, mg/100 g	160 ± 34 (20)	230 ± 49 (28)
Thiamine content, mg/100 g	0.27 ± 0.03 (18)	0.29 ± 0.03 (19)
Riboflavin content, mg/100 g	0.12 ± 0.02 (6)	0.14 ± 0.02 (8)
Tocopherol content	Less than 25	Less than 25

A positive effect of adding the NutraChia Low 8 herbal supplement on enriching the mineral value of noodles has been proven for the first time. The macaroni product test samples contained more macronutrients, including calcium (2.2 times), magnesium (2 times), phosphorus (1.4 times), and micronutrients: copper (2 times), zinc (1.5 times), iron (3.5 %).

The tiamine, riboflavin and tocopherol

content in macaroni product test samples had a tendency to increase, but was within the range identical to control samples, therefore, it is not possible to note vitaminization in home style noodles caused by replacing 10 % of durum flour with NutraChia Low 8.

Calculations show that adding the studied quantity of NutraChia Low 8 the recipe of home style noodles makes it possible to fulfill an adult's daily mineral intake requirements more efficiently, which helps optimize the diet based on the selection of certain micronutrients and prevent many diet-dependent diseases.

3.3. Evaluating the Quality and Safety of Macaroni Products

The final stage of the study focused on evaluating the quality and safety of macaroni products. The results of the physiochemical testing of macaroni product test samples were the first to show that adding ground NutraChia Low 8 chia seeds to the noodle recipe did not have negative effects on the quality parameters, but it did bring in changes. For example, a tendency for an increase in protein content (by 1.3 %) in noodle test samples was found (Table 3). This can be explained with publicly available data: Semolina made from durum wheat consists of the internal layers of endosperm and contains 8 to 22 % protein [3], [19], whereas chia seeds contain 15 to 25 % protein combined with the absence of gluten [9].

Table 3

Quality and safety parameters of the noodle test samples

Parameter name	**Research outcome**	
	Noodles made with a basic recipe	***Noodles made with NutraChia Low 8***
Water content, %	12.7 ± 0.3	13.1 ± 0.3
Loss of mass during the drying process, %	19.3 ± 0.5	17.7 ± 0.5
Protein content, %	13.5 ± 0.7	14.8 ± 0.7
Ash content, %	2.9 ± 0.1	3.1 ± 0.1
Acidity, degrees	3.2 ± 0.3	4.0 ± 0.3
Cooking loss, %	6.3 ± 0.5	5.6 ± 0.5
Mesophilic aerobic and facultative anaerobic microorganisms, CFU/g	980	560
yeast and mold count, CFU/g	Less than 10	Less than 10

Ash content in noodle samples was increased only slightly (by 0.2%), which is connected to the previously discovered heightened mineral content in NutraChia Low 8.

According to the existing regulations, the water content in home-style noodles should not exceed 13 %. An increase (by 0.4 %) in moisture in the lab noodle samples is caused by the known ability of chia seeds to absorb a large amount of water — 12 times of their weight and more, which supposedly caused the decrease (by 1.6 %) in the mass of

macaroni products after drying and a decrease (by 0.7 %) in concentration of the dry solids in the water after cooking. However, the discovered tendency in moisture increase in home-style noodles made with the addition of untraditional plant raw materials has not had a stimulating effect on the increase in undesired microorganisms, which supports the safety of test samples of the product for the consumer.

The acidity in both control and test samples of the macaroni products were within normal range (did not exceed 5 degrees).

4. Conclusions

Ground chia seeds by NutriaChia Low 8 contain more minerals such as calcium (8.7 times), magnesium (4 times), sulfur (3.6 times), potassium (2.3 times) and phosphorus (2.3 times) than top grade durum wheat flour.

Replacing 10 % of top-grade durum flour in the home style noodle recipe with the same amount of ground NutraChia Low 8 chia seeds leads to an increase in the following macronutrients in macaroni products: calcium (2.2 times), magnesium (2 times), phosphorus (1.4 times); and the following micronutrients: copper (2 times), zinc (1.5 times), iron (3.5%). This allows us to optimize the diet using separate mineral components and prevent an array of diet-dependent diseases.

Adding ground NutraChia Low 8 chia seeds to the noodle recipe does not have a negative effect on vitamin value, the physico-chemical quality parameters and the product's microbiological safety.

For the first time, the potential of using up to 10 % ground NutraChia Low 8 chia seeds in high mineral value macaroni products has been proven.

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