Bulgarian Journal of Agricultural Science, 23 (No 5) 2017, 860–865
Agricultural Academy

QUALITY AND NUTRITIONAL VALUE OF PASTA PRODUCTS WITH ADDED GROUND CHIA SEEDS

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Abstract

Naumova, N., A. Lukin and V. Erlikh, 2017. Quality and nutritional value of pasta products with added ground chia seeds. *Bulg. J. Agric. Sci.*, 23 (5): 860–865

One of priorities in production of foods with increased nutritional value in different areas of the food industry is a wide use of unconventional plant raw materials. The aim of our research was to study the effect of ground chia seeds on quality and nutritional value of pasta products. It was first established that substitution of 10% of straight durum flour in the home-style noodle formula with the same amount of ground NutraChia Low 8 seeds resulted in the following: the finished product color was changed from “yellow” to “yellowish-gray” retaining acceptable taste properties; amounts of macroelements in the pasta product increased – calcium (by 2.2 times), magnesium (by 3 times), and phosphor (by 1.4 times) – as well as amounts of microelements – copper (by 2 times), zinc (by 1.5 times), and iron (by 3.5%); microstructure of the freshly-cooked product, vitamin value, physicochemical quality indicators of pasta products stored for 15 days in a dark area at the temperature of 20 ± 2°C and relative humidity of 75% max were not affected.

Key words: pasta products; noodle; chia seeds; quality; nutritional value

Introduction

One of priorities in production of foods with increased nutritional value in different areas of the food industry is a wide use of unconventional plant raw materials. For instance, common plant material in Latin America is banana flour, in the Philippines it is desiccated coconut, in India – cassava and potato flour, and in the USA – citrus refuse (Kablikhin, 1992). Food additives also include tomato seeds and powder made of grape refuse and seeds (Reshetnik et al., 2013; Breeson et al., 2009).

In Europe the potential use of chia seeds as a new food ingredient was first considered by the ACNFP (Advisory Committee on Novel Foods and Process, UK) in 2003. In April the Institute of Nutrition of the Russian Academy of Medical Sciences reported the possibility to use chia flour in a diet for children starting from the age of three (Kon et al., 2013; Chillo et al., 2008).

Chia, or Salvia hispanica, is an annual herb in the mint family (Labiatae) growing in Laitin and South America, Mexico, and Argentina (Ixtaina et al., 2011). Chia seeds are a rich source of vitamins C, E, and B vitamins. They also contain 15 to 25% of proteins and 18 to 30% of dietary fibers (Marineli et al., 2014; Sandoval-Oliveros and Paredes-Lopéz, 2012). Chia seeds also contain high amounts of dietary minerals such as calcium (536 mg), magnesium (350 mg), potassium (564 mg), phosphor (751 mg), iron (6.3 mg), copper (1.4 mg), and zinc (4.4 mg) (Kon et al., 2013; Vazques-Ovando et al., 2009).

It is commonly known that most mineral elements are components of biologic catalysts: manganese is used as a cofactor by 12 different enzymes, copper – by 30, iron – by 70, and zinc – by more than 100 enzymes (Segura-Campos et al., 2014). Mineral deficiency decreases enzyme activity, which badly affects the human body because results in functional disorders of individual organs and the immune system and leads to frequent depressions (Efremov et al., 2002).

In this respect, the aim of our research was to study the effect of ground chia seeds on quality and nutritional value of pasta products.

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Materials and Methods

The material for our research included test samples of home-style noodle manufactured according to formula by Zdobnov and Tsyganenko (2006). Basic formula noodle was used as the *control sample* (ingredients: straight durum flour, drinking water, salt, fresh chicken eggs); in experimental samples of noodle various amounts of durum flour were substituted with appropriate amount of ground NutraChia Low 8 seeds (*experimental sample 1* – 5% substitution, *experimental sample 2* –10% substitution, *experimental sample 3* – 15% substitution) (Coates and Ayerza, 1996).

Ground NutraChia Low 8 seeds were partially defatted by supercritical extraction removing 75% of oil and preserving all nutrients. Chia seeds were supplied by "KIMA Limited" (Moscow, Russia), the official representatives of Aromco and Kanegrade (the UK).

The study of noodle test samples was carried out on dried products (over 4 hours at 55°C at constant air drying power). Noodle test samples were stored in a dark area at the temperature of 20 ± 2°C and relative humidity of 75% max.

Shape and color of noodle test samples were assessed visually, and flavor was estimated at tasting.

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 (Skurikhin and Tutelian, 1998).

Recommended daily intake of mineral elements for an adult was taken from existing regulations (Tutelian, 2009).

Microstructure of noodle test samples was assessed with the help of JSM – 6460LV scanning electron microscope (JEOL, Japan) supplemented with energy dispersive spectrometer for X-ray microanalysis (OXFORD INSTRUMENTS, England) (Munoz et al., 2012).

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.

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

Tiamine, riboflavin and tocopherol contents in noodle test samples were counted using the method of high performance liquid chromatography (Skurikhin and Tutelian, 1998).

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.

The content of Salmonella bacteria in noodle test samples was determined by inoculating the product in a selective liquid and then into a selective agar nutrient medium incubating the inoculations at 37 ± 1° C for 24 ± 3 hours, followed by identification of all visible colonies using biochemical and serological tests.

The content of Escherichia coli bacteria was determined by inoculating the product in a selective diagnostic nutrient medium, incubating the inoculations at 37 ± 1° C for 24 ± 3 hours, counting typical and atypical colonies and determining whether the bacteria from these colonies are able to ferment lactose to form gas.

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).

Results and Discussion

Quality of freshly-cooked noodle test samples

The first stage of our research focused on the effect of different amounts of added ground NutraChia Low 8 seeds on organoleptic properties of home-style noodle test samples. The results of studies are presented in Table 1.

The results of organoleptic assessment of home-style noodle test samples indicated changes of consumptive qualities of the product depending on the introduced amount of ground chia seeds. For instance, 5% of NutraChia Low 8 added to durum flour only slightly changed the past color from "yellow"

Table 1
Organoleptic properties of noodle test samples

Parameter	Results of studies			
	Control sample	*Sample 1*	*Sample 2*	*Sample 3*
Shape	slant-cut rectangles			
Color	yellow, uniform throughout	yellow-gray, uniform throughout	yellowish-gray, uniform throughout	dark gray, uniform throughout
Flavor	usual the product, no off-flavor			unusual for the product, grass taste

Table 2

Concentration of mineral elements and protein in noodle test samples

Parameter	Test results, mg/kg (% of recommended daily intake)	
	Control	*Sample 2*
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)
Protein content, %	13.5 ± 0.7	14.8 ± 0.7

to "yellow-gray". 10% NutraChia Low 8 content changed the finished product color to "yellowish-gray", but taste properties were still acceptable. Amount of chia seeds increased by 15% changed flavor at tasting of experimental sample making it "unusual for the product" due to grass taste. *Sample 3* color was also unacceptable for visual perception of the product.

Based on the obtained results, for further studies we chose the test sample with 10% substitution of durum flour with appropriate amount of NutraChia Low 8 (*Sample 2*) as at maximum percentage of unconventional plant material it still preserved acceptable consumptive properties.

Considering widely known high nutritional value of chia seeds (Kon et al., 2013) we further analyzed mineral composition (Table 2) and microstructure (Figure 1) of past products.

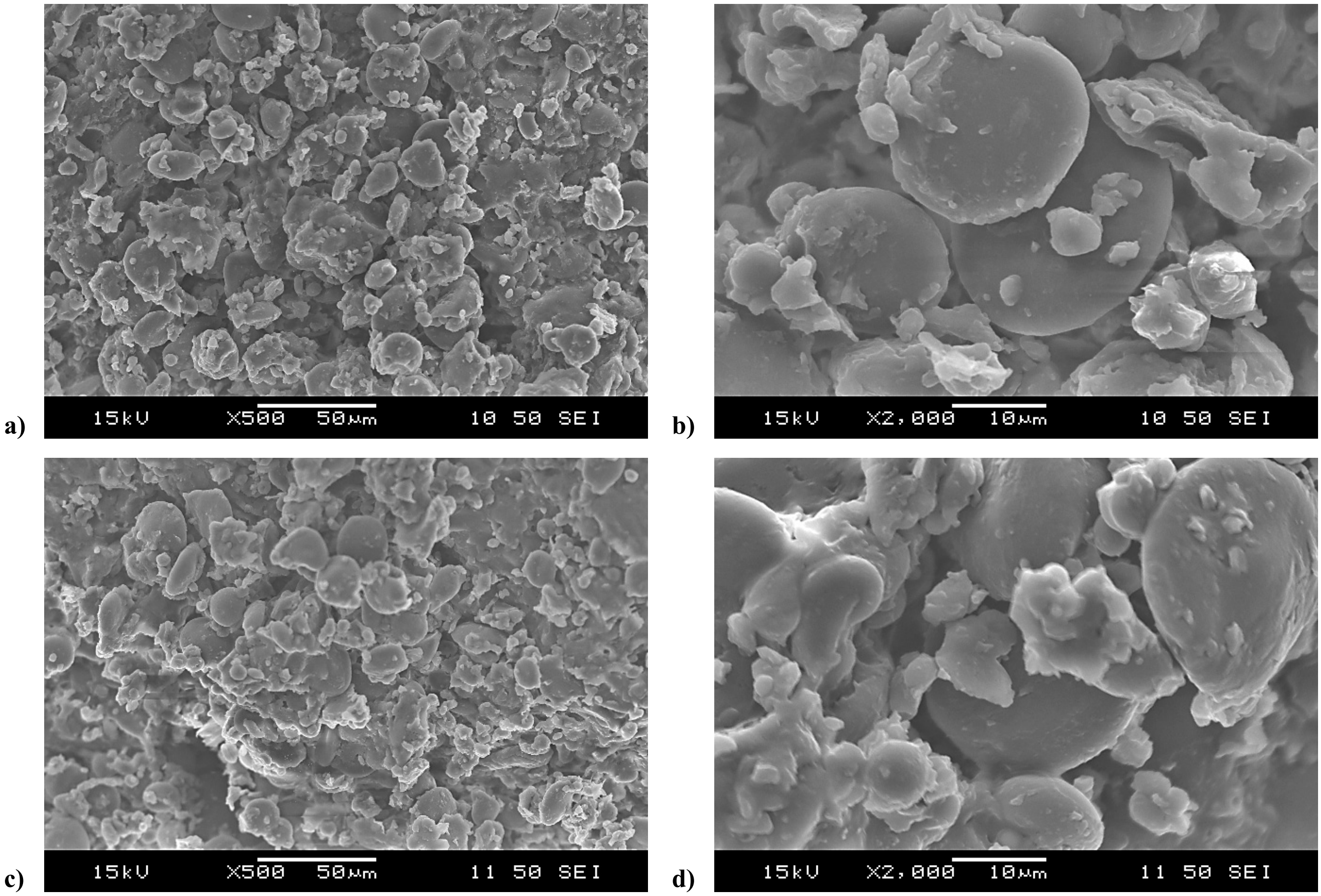

Fig. 1. Microstructure of noodle test samples, different magnification

a), *b*) control (magnified x 500 and 2000); *c*), *d*) sample 2 (magnified x 500 and 2000)

It was first established that plant additive NutraChia Low 8 in amount under consideration had a positive influence on the replenishment of mineral value of home-style noodle samples. Test sample of pasta products had increased concentration of macroelements – calcium (by 2.2 times), magnesium (by 2 times), and phosphor (by 1.4 times) – and of microelements – copper (by 2 times), zinc (by 1.5 times), and iron (by 3.5%).

According to our calculations, supplementing the noodle formula with NutraChia Low 8 makes it possible to meet a significantly higher demand of an adult for mineral elements, which allows the optimization of diet based on individual microelements and the prevention of some nutritional diseases.

We revealed a tendency to increased protein content (by 1.3%) in noodle test samples. It could be explained by the commonly known data: durum flour consists of inner layers of endosperm and contains 8 to 22% of protein (Vassiltchouk et al., 2009; Iskakova et al., 2010), while chia seeds contain 15 to 25% of protein. In addition, the plant material under consideration is gluten-free (Kon et al., 2013). Gluten is a globular protein forming the network determining physicochemical properties of pressed raw products and influencing the finished product quality (Vassiltchouk et al., 2009; Medvedev, 2005; Khromchenkova et al., 2014). However, despite the benefits, gluten does serious harm to the human body. It destroys the internal walls of the digestive system, preventing the intestine from normal operation. It is hard for people in their forties and older to digest gluten, which affects their overall well-being (Ayerza and Coates, 2011; Capitani et al., 2012). In this respect, we studied the microstructure of noodle test samples shown in Figure 1.

Microscopic investigation of pasta products magnified by different extents showed that the control and experimental samples contained globular proteins in the concentration sufficient for formation of required structural-rheological dough properties and finished product quality, which corresponded to the results of organoleptic assessment, namely maintaining the shape of home-style noodle irrespective of introduced NutraChia Low 8 amount. Noodle test samples did not have significant differences of structure, size, number, and position of protein molecules.

Changes in quality of noodle test samples during storage

The final stage of the research focused on estimation of storage quality of pasta products. Physicochemical studies of freshly-cooked noodle test samples revealed that supplementing the noodle formula with ground NutraChia Low 8 seeds did not have a negative effect of product quality parameters, but introduced some specific features (Table 3).

According to current standards, moisture content of home-style noodle should not exceed 13%.

The increase of moisture content of freshly-cooked noodle test samples (by 3.1%) and the preservation of this tendency during storage is explained by the well-known ability of chia seeds to absorb a large amount of water – 12 times or more than its own weight (Zettel et al., 2015; Capitani et al., 2012; Munoz et al., 2012). However, this did not stimulate the growth of sanitary-indicatory (*E.coli*) and pathogenic (Salmonella) microorganisms, which proves the safety of the product test samples for consumers' health.

Acidity of freshly-cooked pasta products was by 25% higher than in basic formula noodles, but did not exceed normal limits (5 degrees max). Thiamin, riboflavin, and tocopherol contents in noodle test samples tended to increase, but was within the limits typical of the control sample; thus, it

Table 3
Quality parameters of noodle test samples

Parameter	Storage period					
	0 days		15 days		30 days	
	Control	*Sample 2*	*Control*	*Sample 2*	*Control*	*Sample 2*
Water content, %	12.7 ± 0.3	13.1 ± 0.3	12.5 ± 0.3	12.9 ± 0.3	12.2 ± 0.3	12.7 ± 0.3
Acidity, degrees	3.2 ± 0.3	4.0 ± 0.3	3.6 ± 0.3	4.7 ± 0.3	4.3 ± 0.3	6.0 ± 0.3
Thiamine content, mg/100 g	0.27 ± 0.03	0.29 ± 0.03	0.21 ± 0.03	0.22 ± 0.03	0.16 ± 0.03	0.12 ± 0.03
Riboflavin content, mg/100 g	0.12 ± 0.02	0.14 ± 0.02	0.12 ± 0.02	0.12 ± 0.02	0.10 ± 0.02	0.10 ± 0.02
Tocopherol content, mg/kg	< 25	< 25	< 25	< 25	< 25	< 25
Mesophilic aerobic and facultative anaerobic microorganisms, CFU/g	980	560	750	470	110	230
Yeast and mold count, CFU/g	< 10	< 10	< 20	57	< 40	130
Pathogenic microorganisms, including salmonella in 25 g of products	not found	not found	not found	not found	not found	not found
E.coli bacteria (coliform) in 0.1 g of product	not found	not found	not found	not found	not found	not found

was not possible to state vitamin enrichment of home-style noodle thanks to substitution of 10% of durum flower with NutraChia Low 8.

During all the period of studies, moisture content, vitamin value, and concentration of mesophilic microorganisms were decreasing. This process was accompanied by the growth of noodle acidity and concentration of yeast and mold. In addition, chia-containing samples had higher levels of acids and unfavorable microorganisms. On the 15th day of storage, the acidity of the noodle test samples still complied with the regulated requirements, but after 30 days of storage the acidity of the samples exceeded the norm (6 degrees instead of the regulated 5 degrees). Control of the content of spoilage microorganisms – mesophilic microflora, as well as the amount of yeast and mold is provided only for instant pasta (including products with vegetable based additives). Thus, the content of these microorganisms should not exceed 50 000 and 100 CFU/g respectively. The research showed that the amount of yeast and mold in the noodle test samples complied with the current standard only during 15 days of storage. Collectively, the results obtained marked the completion of the experiment and determined the shelf life of the products being developed – not more than 15 days.

Moreover, within two-week storage there was a minimal percent of thiamin breakdown (compared to the initial content): in *the control sample* – 22%, in *experimental sample 2* – 24%.

Thus, for the first time our research studied storage changes of quality, vitamin value of home-style noodle, and justified and determined useful shelf life of pasta products containing 10% of NutraChia Low 8.

Conclusions

10% substitution of durum flour with appropriate amount of ground NutraChia Low 6 seeds in home-style noodle provides:

– change of the finished product color from "yellow" to "yellowish-gray" preserving acceptable taste properties;

– increase of concentration of macroelements – calcium (by 2.2 times), magnesium (by 2 times), and phosphor (by 1.4 times) – and of microelements – copper (by 2 times), zinc (by 1.5 times), and iron (by 3.5%).

Introduction of ground NutraChia Low 8 seeds into noodle formula does not affect microstructure of freshly-cooked product, vitamin value, physicochemical indicators of quality of pasta products stored for 15 days in a dark area at the temperature of 20 ± 2°C and relative humidity of 75% max.

Acknowledgements

The work was supported by Act 211 of the Government of the Russian Federation, contract № 02.A03.21.0011.

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Received March, 3, 2017; accepted for printing September, 14, 2017