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IDENTIFICATION OF PROMISING CHICKPEA VARIETIES FOR ENRICHMENT WITH SELEN

Забезпечення населення екологічно чистими білковими харчовими продуктами рослинного походження є важливою проблемою, але нативне використання бобів нуту обмежується наявністю в них антипоживних речовин. У результаті ферментативних процесів, які протікають під час пророщення зерен нуту, вміст антипоживних речовин суттєво зменшується. Рослинний білок зерна нуту має здатність до акумуляції неорганічних мікроелементів, трансформуючи їх в органічні форми, під час замочування у процесі пророщення. Беручи до уваги розповсюдженість йод-дефіцитних станів, автори вважали за доцільне в якості збагачуючих мікроелементів використовувати селен, а саме $NaHSeO_3$ (1 г – 0,52 мкг/г селену), який є синергістом йоду та в органічноз'язаному стані здатен досить продуктивно боротись із йод дефіцитним захворюванням. Науковцями, селікціонерами та технологами не визначені сорти нуту із показниками якості, що є найбільш оптимальними для процесу пророщення та фортифікації. Тому об'єктом проведеного дослідження були зерна нуту різного вегетаційного періоду ранньостиглі та середньостиглі (95…115 та 115…125 діб визрівання, відповідно), за період вирощування 2014…2018 роки. Досліджено загальний вміст білків жирів та вуглеводів, математично опрацьовано та оптимізовано за такими критеріями, як max кількість білка, min період вирощування, середній вміст жирів та вуглеводів, не менше як 100 експериментальних зразків зерен нуту. Встановлено, що ранньостиглі сорти нуту мають оптимальний вміст білка – 19,55 %, жирів – 15,95 % вуглеводів – 64,5 %. Середньостиглі сорти нуту мають – 18,7 % білка, 15,95 % жирів та 64,75 % вуглеводів. З проведеного експерименту встановлено, що найбільш перспективними для збагачення селеном є ранньостиглі сорти нуту, оскільки за вмістом білка перевищують середньостиглі сорти на 0,85 %, а за вегетаційним періодом дозрівають на 20…25 діб раніше.

Ключові слова: *нутове борошно, зерна нуту, варіабельність поживних речовин, збагачення селеном, йод-дефіцитні стани.*

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1. Introduction

Modern science of nutrition shows that for the growth, development, preservation of health, maintaining high efficiency, the body's ability to withstand infectious disease and other environmental factors, physiologically sound nutrition is necessary. Particular attention is required to a deficiency of trace elements, which are the most important catalysts for biochemical processes and participate in the synthesis and metabolism of hormones, in particular, this applies to selenium, an essential trace mineral essential for human nutrition. It acts as an agent that promotes the detoxification of reactive oxygen derivatives; trace element is involved in the formation of macrophages, red blood cells play the role of an antitumor factor [1, 2]. Selenium deficiency is observed in 17 % of the world's population. One way to overcome the deficiency of selenium is development of culinary dishes and diets enriched with organic forms of selenium, which can be introduced in sanatoriums and restaurant establishments. One of the favorite recipe ingredients of the Slavic peoples is flour [3]. Flour enriches 30 % of the countries of the world, including the USA, Canada, Belgium. Bill No. 9117, registered in the Verkhovna Rada of Ukraine in 2019, states that Ukrainian flour producers in 2020 will be required to add vitamins and minerals to their products.

It is rational to use legumes, namely chickpeas, as the raw material for developing enriched flour technology [4, 5]. Plant protein, which is a part of chickpea grains, is able to accumulate and biotransform inorganic forms of selenium, forming its organic forms during soaking during germination. Biological synthesis of organic forms of selenium, in comparison with other methods, requires little energy and economic costs, is environmentally friendly and eliminates the possibility of the formation of harmful by-products [6, 7]. To develop the technology of flour from germinated grain, enriched with trace elements in the metabolized form, it is necessary to transport the maximum possible number of trace elements into the grain [8]. This can be achieved through the use of solutions of mineral salts, namely sodium hydroselenite ($NaHSeO_3$), which is a carrier of 0.52 μg of selenium per 1 g of substance [9, 10]. Today, the development of new technologies enriched with selenium that can be implemented in sanatoriums and restaurant establishments is an important task. This will solve an important social problem – maintaining the health of the nation, maintaining high efficiency, the body's ability to withstand infectious disease and other

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environmental factors [11]. Studies conducted by various health authorities and nutrition institutes of Ukraine and the world [12, 13] indicates the relevance of this problem – the low intake level of microelement selenium in the human body with food.

Analysis of published data [14, 15] indicates the relevance of developing new sources of organic trace elements. A promising biotechnological way of obtaining such sources of selenium is to use the process of chickpea germination as objects for its biotechnological accumulation.

The world is actively developing a category of products of special dietary consumption, characterized by a change in quality, by adjusting their composition, taking into account orientation to modern theories of nutrition. The method of enriching chickpea flour is known, according to which chickpea grains are germinated in a solution of sea food salt. According to this production method, at the first stage of obtaining a salt solution, sea food salt is dissolved in distilled water (t=20...23 °C) in a ratio of 2:1. The resulting 2 % solution is used for germination of legumes. Then the grains are washed, sorted, left in solution at a temperature of 20...24 °C until sprouts form 1...2 mm long. Germinated grains are dried at a temperature of 65...70 °C for 11...13 hours to moisture content of 12...14 %, crushed to a particle size of 1 mm [16]. Flour made according to the developed technology has a high content of macro- and microelements, but researchers have not found how the chemical composition of grain affects, namely, the protein content on the degree of microelement accumulation.

Currently, there are scientific works on the development of technology for the enrichment of flour with selenium, which consist of chickpea grains germinated in an aqueous extract, hydromechanical processing and grinding to particles with a size of 280–850 microns, and drying [17]. The proposed method allows the manufacture of flour with high nutritional value and high consumer properties. But the developers studied only the aforementioned variety, which makes it impossible to establish the most promising varieties for enrichment with selenium, the exact content of the trace element has not been established, only a range of values has been determined.

All of the above technological approaches were used by inventors to develop technology for chickpea flour enriched with selenium, and have a number of disadvantages, including studies of only one vegetative variety. Scientists have not investigated the nutrient content in chickpea grains of various vegetative varieties and promising varieties for enrichment with selenium have not been determined. Therefore, *the object of the study* was the chickpea grains of various vegetation periods, early ripe and mid-ripening (95...115 and 115...125 days of ripening, respectively), for the growing period of 2014...2018. Namely, the varieties of the Agrotek collection nursery. Early ripening varieties: Krasnokutskyi 195, Sovkhoznyi, Yubileinyi, Brown, Lokhvytsia, Major, Turetskyi, Chornomorka, Gigant, Jupiter (ripening period 95...115 days). Mid-ripening varieties Vector, Boiarynia, Budzhak, Anatolii, Yevropeiskyi, Pivdenno-Skhid, Tsyhanochka, Juvileinyi-2405, Bashkirka, Kvitka (ripening period 115...125 days). And *the purpose of the work* is identification of promising varieties of chickpeas for enrichment with selenium.

2. Methods of research

The research on nutrient content of sprouted grains is performed by ion exchange and liquid chromatography on a Shimadzu LC-20 liquid chromatograph (Japan). Mathematical optimization was performed using MATLAB. The mathematical model is based on all data on varieties of different vegetation periods for 5 years, 400 indicators were mathematically processed.

The criteria for evaluating the most promising varieties for enrichment were: max protein content, min growing time, average fat and carbohydrate content.

3. Research results and discussion

Tables 1, 2 show the research results of the variability of nutrients in early ripening and mid-ripening chickpea grains of the Agrotek collection nursery for the period 2014...2018.

Table 1

Study of nutrient variability of early ripening chickpea grains of Agrotek collection nursery for the period 2014...2018

Early ripening varieties of chickpeas	Year														
	2014			2015			2016			2017			2018		
	The total content of proteins, fats and carbohydrates in the studied varieties of chickpea grains														
	P., %	F., %	C., %	P., %	F., %	C., %	P., %	F., %	C., %	P., %	F., %	C., %	P., %	F., %	C., %
Krasnokutskyi 195	23.9	16.8	59.3	22.1	16.0	61.9	22.9	16.5	60.6	22.3	16.7	61.0	23.4	16.0	609
Sovkhoznyi	27.3	15.4	60.9	22.6	15.8	61.6	22.9	15.3	61.8	23.6	15.6	60.8	23.0	15.2	618
Yubileinyi	24.1	16.1	59.8	23.7	15.9	60.4	24.7	15.4	59.9	23.4	15.8	60.8	23.5	16.0	605
Brown	22.4	15.9	61.7	16.1	62.6	22.1	22.1	16.6	61.3	22.0	16.9	61.1	22.2	16.5	613
Lokhvytsia	19.9	14.9	65.2	21.6	15.3	63.1	21.4	15.8	62.8	21.2	15.7	63.1	19.9	15.5	646
Major	19.0	17.1	63.9	21.0	17.9	61.1	21.1	17.2	61.7	19.9	17.6	62.5	19.8	17.7	632
Turetskyi	21.7	15.2	63.1	22.0	15.6	62.4	22.6	15.8	61.6	22.0	15.7	62.3	21.9	16.2	61.9
Chernomorka	20.3	15.6	64.1	21.7	16.3	62.0	20.7	16.7	62.6	21.2	16.9	61.9	20.8	16.9	62.3
Gigant	21.6	17.3	61.1	20.1	16.2	63.7	21.3	16.9	61.8	20.3	16.4	63.3	21.7	17.0	61.3
Jupiter	21.2	14.7	64.1	21.4	15.2	63.4	21.6	15.5	26.9	21.9	15.9	62.2	21.5	16.0	62.5

Note: P. – protein content; F. – fat content; C. – carbohydrate content

Table 2

Study of nutrient variability of mid-ripening chickpea grains of Agrotek collection nursery for the period 2014...2018

Mid-ripening varieties of chickpeas	Year														
	2014			2015			2016			2017			2018		
	The total content of proteins, fats and carbohydrates in the studied varieties of chickpea grains														
	P., %	F., %	C., %	P., %	F., %	C., %	P., %	F., %	C., %	P., %	F., %	C., %	P., %	F., %	C., %
Vector	19.7	15.5	64.8	19.5	15.9	64.6	19.3	15.1	65.6	19.8	15.0	65.2	19.3	15.7	650
Boiarynia	20.6	14.7	64.7	19.9	14.0	66.1	20.2	15.0	64.8	20.7	14.6	64.7	20.9	14.3	648
Budzhak	19.7	16.0	64.3	20.0	16.2	63.8	20.2	15.9	63.9	19.6	16.4	64.0	19.1	16.2	647
Anatolii	17.3	13.9	68.8	17.0	14.1	68.9	17.9	14.0	68.1	17.4	13.4	69.2	17.8	13.6	686
Yevropeiskyi	15.9	19.9	64.2	16.0	20.0	64.0	15.2	19.2	65.6	15.7	19.5	64.8	15.9	19.7	644
Pivdenno-Skhid	15.7	16.1	68.2	15.1	16.4	68.5	15.6	16.7	67.7	15.4	16.2	68.4	15.9	16.8	673
Tsyhanochka	16.1	17.2	66.7	15.9	17.0	67.1	16.5	17.6	65.9	15.2	16.9	67.9	16.4	17.8	658
Juvileinyi-2405	14.7	15.3	70.0	14.1	15.9	70.0	14.5	15.4	70.1	14.8	15.2	70.0	14.3	14.9	699
Bashkirka	19.4	16.3	64.3	19.0	16.7	64.3	19.9	16.8	63.3	19.3	16.6	64.1	19.2	16.1	647
Kvitka	20.2	15.4	64.4	20.2	15.0	64.8	20.2	15.6	64.2	20.2	15.9	63.9	20.2	16.0	638

Note: P. – protein content; F. – fat content; C. – carbohydrate

Fig. 1, 2 depict the optimization of nutrients in chickpea grains of various vegetation periods and different varieties.

As experimental studies show, the optimal protein content in early ripening varieties of chickpeas is 19.5 %, fats 15.95 %, carbohydrates 64.5 %. Mid-ripening – 18.7 % protein, 16.55 % fat, 64.55 % carbohydrates.

This discrepancy between the chemical composition of soybean grains is explained, in addition to a different ripening period, by climatic factors (the number of hot and rainy days), which significantly affect the chemical composition of legumes.

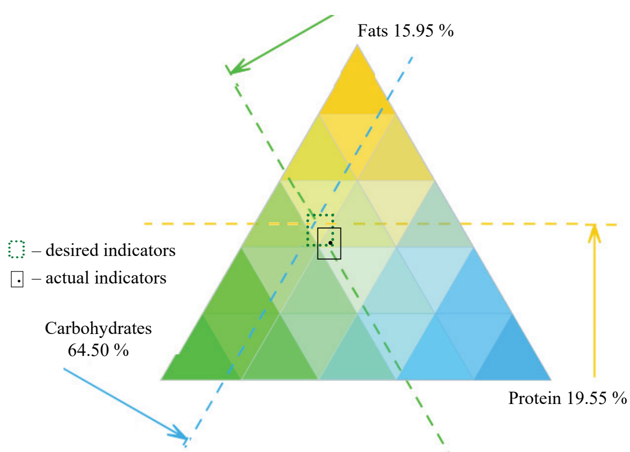

Fig. 1. Nutrient optimization of early ripening chickpea varieties

The conducted studies show the values of indicators that are as close as possible to the desired values. The best result is obtained by early ripe varieties of chickpeas, which have a high protein content of 19.55 %. As well as a short growing season, up to 95...105 days.

This is economically advantageous for the «manufacturing enterprise», since it does not overlap with sown winter crops and, as a result, does not lead to downtime of sown areas.

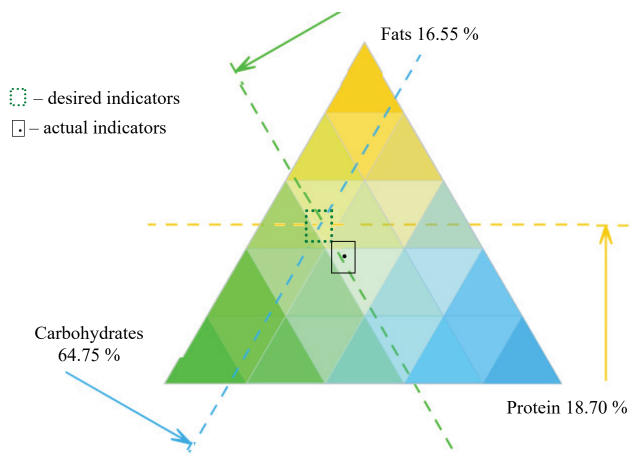

Fig. 2. Nutrient optimization of mid-ripening chickpea varieties

4. Conclusions

The experiment conducted in the work can establish that the most promising for enrichment with selenium is early ripe varieties of chickpeas, since protein content exceeds mid-ripening varieties by 0.85 %, and ripen 20–25 days earlier in the growing season.

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