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Feed and food quality of potato varieties

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Article info

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Potato is an important feed, food and technical crop in the world. The biological value of potatoes as animal feed and a food product is determined by the content of starch and crude protein in the tubers. Starch from tubers is easily absorbed by the human body and is broken down into simple sugars. In addition, potato starch is well absorbed by animals and is characterized by high digestibility. Proteins of potatoes are more biologically complete than proteins of other crops, including winter wheat. They contain all eight essential amino acids. The purpose of the research is to determine the feed and food quality indicators of potato varieties. The relevance of the study lies in the evaluation of potato varieties by biochemical indicators for the use of the best varieties in the food industry, as well as for the use of some varieties in animal feeding. The varieties taken for the study were Aria, Tyras, Skarbnytsia, Shchedryk, Cimmeria, Fotinia, Tradition, Knyahynya, Myroslava, Slavyanka, Strumok, and Sluch. These varieties were created at the Institute of Potato Research of the NAAS, where their food and feed quality were assessed on average for 2021–2023. Biochemical analysis of tubers included determination of dry matter by drying to constant mass. Starch content was determined by polarimetric method. Ascorbic acid content was determined by titration. Carotenoid content was determined by spectrophotometric method. As a result of laboratory analysis of tubers, the Kimmeriya variety had a high content of ascorbic acid and a high content of carotene. The Myroslava variety had high indicators of crude protein content, starch content and carotene content. These varieties are recommended for use in animal feeding. The Sluch variety had the highest dry matter content and a high content of carotene in tubers. This variety has good culinary properties, including taste and smell. Therefore, tubers of the Sluch variety with good economically valuable characteristics can be widely used for food purposes, especially for chips and French fries.

Keywords: potato varieties, dry matter, starch, crude protein, carotenoids, vitamin C.

Кормова і харчова якість сортів картоплі

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Картопля є важливою кормовою, харчовою і технічною культурою в світі. Біологічна цінність картоплі як корму для тварин і продукту харчування визначається вмістом у бульбах крохмалю і сирого протеїну. Крохмаль бульб легко засвоюється в організмі людини і розщеплюється на прості цукри. Також картопляний крохмаль добре засвоюється тваринами і характеризується високою перетравністю. Білки картоплі за біологічною повноцінністю переважають білки інших культур, у тому числі озимої пшениці. Вони містять усі вісім незамінних амінокислот, Метою досліджень є визначення показників кормової і харчової якості сортів картоплі. Актуальність дослідження полягає в оцінці сортів картоплі за біохімічними показниками для використання кращих сортів у харчовій промисловості, а також для використання деяких сортів у годівлі тварин. Для дослідження було взято сорти Арія, Тирас, Скарбниця, Щедрик, Кіммерія, Фотинія, Традиція, Княгиня, Мирослава, Слов'янка, Струмок, Случ. Ці сорти створені в Інституті картоплярства НААН, де й проводилася їх оцінка на харчову і кормову якість у середньому за 2021–2023 роки. Біохімічний аналіз бульб включав визначення сухих речовин шляхом висушування до постійної маси. Вміст крохмалю визначався поляриметричним методом. Вміст аскорбінової кислоти визначався титруванням. Вміст каротиноїдів визначався спектрофотометричним методом. У результаті лабораторного аналізу бульб сорт Кіммерія мав високий вміст аскорбінової кислоти і високий вміст каротину. Сорт Мирослава мав високі показники за вмістом сирого протеїну, вмістом крохмалю і вмістом каротину. Ці сорти рекомендовано використовувати для годівлі тварин. Сорт Случ мав у бульбах найвищій вміст сухої речовини і високий вміст каротину. Цей сорт має гарні кулінарні властивості, включаючи смак і запах. Тому бульби сорту Случ із гарними господарсько цінними ознаками можуть бути широко використаними на харчові цілі, особливо для чіпсів і картоплі фрі.

Ключові слова: сорти картоплі, суха речовина, крохмаль, сирий протеїн, каротиноїди, вітамін С.

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Introduction

The potato is an important feed, food and technical crop in the world. O. Krupa notes that "in the absence of a significant improvement in the standard of living, a constant increase in the prices of meat, fish and dairy products, potatoes will continue to be the "second bread" for Ukrainians [1]. M. Pysarev, T. Levkivska and H. Bandurenko claim that "potatoes are a relatively cheap raw material, a traditional and favorite culture for the population of Ukraine" [2]. This plant came to Ukraine in the 18th century. At first it was planted in Kharkiv and Poltava provinces, and staring from 1742 it began to be grown in Podilsk, Volyn and Kyiv provinces.

H. Myronova writes that "about 300 varieties of potatoes are grown in agricultural enterprises, farms, gardens, summer cottages. About 200 of them were entered in the State Register of plant varieties suitable for distribution in Ukraine in different years. The vast majority of varieties (50 %) are of Ukrainian selection, and the rest are from the Netherlands, Germany, the Czech Republic and other countries" [3]. V. Semenchuk notes that "growing potatoes in almost all regions of Ukraine contributes to the creation and introduction into production of varieties of domestic breeding, which belong to different groups of ripeness, directions of cultivation and have unequal potential for adaptability to the soil and climatic conditions of our country" [4].

L. Sereda and A. Misiulia note that "annual production of potatoes is 20–23 million tons" [5], and in 2023 potato harvest in Ukraine was 21.2 million tons per area of 1.18 million hectares. In 2024 Ukraine has reduced the production of certified seed potatoes by 40 %. Although A. Artiukh, O. Bezsmertna, D. Melnyk note that "according to the results of the analysis of the volume of production and the area used for potatoes during 2017–2020, it was found that the rate of increase in the volume of potato harvesting exceeds the rate of growth of the area, which means an increase in the level of productivity" [6]. "In terms of production, it ranks fourth among the world's main food crops after rice, wheat and corn and contains all the substances necessary for maintaining human life" [7].

The biological value of potatoes as animal feed and a food product is determined by the content of starch and crude protein in the tubers. The tubers contain dry matter, up to 3% protein, about 1% fiber, 0.2–0.3 % fat, 0.8–1 % ash and vitamins C, B, PP, K and carotenoids. The share of potassium is 568 mg per 100 g of the product. The main component of dry matter is starch that accumulates in tubers in the form of grains of various sizes. The starch content of different varieties ranges from 9 to 24 % of the raw mass. V. Bazalii, O. Zinchenko, Iu. Lavrynenko claim that "potato starch is easily absorbed by the human body, and its proteins are more biologically complete than proteins of other crops, including winter wheat" [8]. The protein contains all eight essential amino acids, and its completeness index ranges from 60 to 92.

In addition, potato starch is well absorbed by animals and is characterized by high digestibility. Increasing the starch content in tubers can make the feed unit cheaper and increase the profitability of using potatoes for feed purposes [9]. Scientists of the Institute for Potato Research of NAAS write that "potatoes have long been used as livestock feed. The nutritional value of 1 kg of tubers is 0.3 feed units and 16 g of digestible protein" [10]. As noted by O. Zinchenko, H. Demydas and A. Sichkar, "the use of potatoes for feed contributes to a significant increase in the productivity of animals, even if the ration includes a minimum amount of concentrates, since it is a high-energy feed. In terms of calories, potatoes are 2.5 times higher than feed beets" [11].

It is indicated in the Holy Scriptures that God "causes the grass to grow for the cattle" [12]. Potato is a herbaceous plant, the tubers of which are valuable feed for dairy cattle and pigs. It is also a valuable feed for poultry. This culture has a high digestibility of organic matter (83–97 %). Potato tubers are widely used for feeding animals in raw and steamed form."The waste from the technical processing of tubers is nutritious feed for cattle and other animals. The tops are used to prepare combined silage. 100 kg of tops correspond to 8.5 feed units" [13]. A. Osypchuk notes that "in terms of the number of feed units and digestible protein that can be obtained from one hectare of sowing, potatoes are second only to corn and sugar beets and far exceed barley, oats, wheat, feed beets and other crops. The average yield of potatoes from one hectare by the number of feed units is equal to the yield of oats harvested from 2.2 hectares, barley from 2 hectares or vetch from 2.3 hectares [14].

This culture has high food and taste properties, and ability for long-term storage. "Potato dishes are on the tables of the population of Ukraine every day, year-round, because potatoes have many nutritional, mineral, biologically active substances and medicinal properties" [15]. Potatoes are widely used as raw materials for the production of various food products, namely potato flakes, crackers, chips, starch, glucose, alcohol. The content of dry matter in the tubers determines nutritional qualities of potatoes, namely nutrition, taste, how fast it becomes soft after boiling and, in some varieties, the darkening of the pulp after cooking.

Morpho-physiological and technological features of cultivation of commercial and garden potatoes were studied by S. Kalenska, N. Knap and I. Fedosii [16]. The chemical composition and feed value of tubers depends on soils, fertilizers, variety and environmental factors. R. Vozhehova, H. Balashova, L. Boiarkina in the Institute of Irrigated Agriculture of NAAS conducted an experiment, "the purpose of which was to determine the influence of the level of planting density and mineral nutrition with local application of complex fertilizer on the productivity of the early-ripening Kobza potato variety during summer planting" [17].

N. Pysarenko, V. Sydorchuk and N. Zakharchuk investigated potentially drought-resistant varieties of potatoes of different groups of maturity according to yield and evaluated them according to their consumer qualities at early accounting periods [18]. In 2018–2020, the IInstitute for Potato Research of NAAS studied the influence of different rates of application of mineral fertilizers in combination with chelated fertilizers on yield, biometric indicators of potatoes, and nutritional qualities of tubers [9].

In 2018–2019, P. Zaviriuha in Ternopil region evaluated foreign varieties according to the yield of tubers

and biometric indicators. The scientist showed the importance of varietal characteristics regarding the accumulation of starch in tubers and its release from a unit of area [20]. O. Barabolia, D. Vakuliuk and T. Prudkyi studied the nutritional qualities of the early Povin variety, the medium-ripening Slovianka variety of Ukrainian selection and the late-ripening Pikasso variety of Dutch selection at different storage temperatures [21].

The relevance of the research topic is in the detection of promising varieties of potatoes for the content of dry matter, starch, crude protein and vitamins for use both for feed purposes and food needs.

The aim of the study

The purpose of the research is to determine the feed and food quality indicators of potato varieties.

To achieve the set goal, the following tasks had to be solved:

1) to carry out laboratory analysis of average samples of different varieties of potatoes;

2) to evaluate potato varieties according to the main biochemical indicators of feed and food quality.

Materials and methods

The research was conducted at the Institute for Potato Research of NAAS in 2021–2023 in laboratory conditions on average samples of tubers of various potato varieties. uch varieties as Ariia, Tyras, Skarbnytsia, Shchedryk, Kimmeriia, Fotyniia, Tradytsiia, Kniahynia, Myroslava, Slovianka, Strumok, Sluch were taken. These varieties were created at the Institute for Potato Research of NAAS of Ukraine. The content of dry matter in the tubers was determined by drying to a constant weight. The content of starch was determined by the polarimetric method. The content of ascorbic acid was determined by titration of the sample solution with 0.001 N of KI solution. The content of carotenoids was determined by the spectrophotometric method at a wavelength of 450 nm [22].

Results and discussion

The agricultural production puts forward reasonable demands on new varieties that form the national potato varietal diversity. The varieties require a comprehensive combination of high productivity with resistance to diseases, pests and environmental stress factors. New varieties must have high product quality, as well as good transportability, suitability for long-term storage and processing.

However, one of the important indicators that is paid attention to when growing potatoes for sale both fresh and for processing is the dry matter content. The biochemical composition can differ significantly even in tubers grown under the same bush. For example, a tuber that was formed earlier usually has a higher starch content than one formed later. Therefore, the influence of various factors on the biochemical composition of tubers studies in the modern scientific research.

The Ukrainian scientists obtained results on the dynamics of biochemical indicators in potato varieties of different maturity groups. They studied the influence of mineral fertilizers as the main nutrition and additional fertilizing with micronutrients on the biochemical composition of tubers. The experiments were carried out on different areas in the soil and climatic conditions of the Carpathian region. In particular, plants of the early-ripening potato variety Ariia prevailed in the accumulation of dry matter and, accordingly, starch. The highest dry matter content of 23.3 % and starch of 17.1 % in the mid-early variety Aria was in the variant with the application of the recommended dose of fertilizers $N_{90}P_{90}K_{120}$ and with treatment with microfertilizers on the feeding area of 70 × 20 cm. In the mid-ripening variety Gurman, the highest dry matter indicators were on the feeding area of 70 × 20 cm – 22.0 %, and the starch content on the feeding areas of 70 × 20 cm and 70 × 30 cm – 16.3 %. The accumulation of vitamin C did not depend on the ripeness group of the variety, the feeding area and the dose of mineral fertilizer in combination with foliar feeding and was in the early-ripening variety Ariia at the level of 23.2 mg% and in the mid-ripening variety Gurman – 23.1 mg% [23]. By the way, the varieties Ariia and Gurman were created at the Institute for Potato Research of NAAS of Ukraine.

As a result of the research, varieties characterized by an increased content of dry matter, crude protein, and vitamins were selected. As shown in ***Table 1***, the content of dry matter during the years of the research ranged from 16.6 % to 22.5 %. Sluch varieties were characterized by the highest dry matter content – 22.5 %; Skarbnytsia – 21.6 %; Kimmeriia – 19.4 % and Tyras – 19.1 %. The lowest percentage of dry matter in the tubers was found in such varieties as Kniahynia – 16.6 %, Slovianka – 16.8 % and Strumok – 17 %.

Table 1

Biochemical indicators of potato varieties on average for the years 2021–2023

Variety	Content				
	dry matter, %	crude protein, %	starch, %	vitamin C, mcg/mg	carotene, mcg/mg
Ariia	18.1	1.6	14.8	0.14	0.17
Tyras	19.1	1.8	12.9	0.15	0.07
Skarbnytsia	21.6	2.0	15.0	0.14	0.21
Shchedryk	18.7	1.8	13.5	0.15	0.04
Kimmeriia	19.4	1.9	15.0	0.15	0.23
Fotyniia	18.4	1.8	15.4	0.15	0.04
Tradytsiia	17.3	2.1	16.5	0.15	0.09
Kniahynia	16.6	2.2	13.1	0.13	0.20
Myroslava	18.8	2,2	16.9	0.13	0.20
Slovianka	16.8	1.7	10.8	0.13	0.22
Strumok	17.0	2.1	16.0	0.14	0.06
Sluch	22.5	2.5	18.5	0.14	0.20

According to the research results, the crude protein content ranged from 1.6 % to 2.5 %. Thus, the average late Sluch variety had the highest content of crude protein – 2.5 % by raw weight, and the early Ariia variety had the lowest content of crude protein – 1.6 %. Kniahynia and Myroslava varieties also had a high content of crude protein in the tubers – 2. 2%.

The content of starch in tubers refers to the nutritional characteristics of tubers. The starch of the tubers is easily digested and broken down into simple sugars. V. Gaviy and S. Priplavko note that storage of potatoes for nine

months caused changes in the starch content of tubers. The greatest starch losses were observed in the group of medium-late varieties (Koroleva Anna) and amounted to 9.7 %. The lowest starch losses after 9 months of storage were characterized by the varieties Granada and Bella Rossa. During storage, a varietal dependence of changes in the starch content in potato tubers of varieties of different ripeness is observed. The highest content of monosaccharides in potato tubers is characterized by the variety Koroleva Anna. Tubers of the Bella Rossa and Granada varieties both at the beginning and at the end of the study were distinguished by the lowest amount of monosaccharides [24].

The highest starch content among the studied varieties had Sluch – 18.5 %, Myroslava – 16.9 % and Tradytsiia – 16.5 % (***Table 1***). The lowest rate of starch content was found in Slovianka variety – 10.8 %. When determining this indicator, almost the same values were established in such varieties as Skarbnytsia, Kimmeriia and Fotyniia, that is, 15.0 %; 15.0 % and 15.4 %, respectively.

The potato tubers are a source of vitamins. The consumption of 300 g of potatoes provides almost 50 % of the daily human need for vitamin C. The content of vitamins also determines the feed and nutritional qualities of potatoes. The content of ascorbic acid is distributed unevenly in tubers. On average, 21 % is found in the top, 17.2 % in the umbilical cord, 16.9 % in the peel, 17.7 % in the cambial part, and 16.1 % in the core. The highest content of vitamin C is during the period of intensive growth of tubers. The main loss of vitamin C occurs during the storage period - from December to February (60 %). However, losses largely depend on storage conditions. For example, at low temperatures (about 0 °C), vitamin C is almost completely destroyed. The content of ascorbic acid also depends on the variety, technology and especially on soil and climatic conditions. As a rule, on light soils it is higher than on heavy ones. Thr excess nitrogen and potassium leads to a decrease in the content of vitamin C, and the excess phosphorus leads to an increase. The dry weather contributes to its accumulation, while wet and cold weather has the opposite effect. During the growing season, fluctuations in the content of ascorbic acid are observed. The significant precipitation, a decrease in air temperature and cloudy weather cause a decrease in vitamin activity in leaves and young tubers. With the onset of warm, clear and moderately humid weather, a repeated increase in the content of vitamin C in tubers is observed, especially in late-ripening varieties.

As shown in Table 1, the content of vitamin C in the tubers of the studied varieties ranged from 0.13 to 0.15 mcg/mg. The highest content of ascorbic acid was characterized by such varieties as Tyras, Shchedryk, Kimmeriia, Fotyniia, Tradytsiia. The value of the index in these varieties was 0.15 mcg/mg.

The color of the pulp also refers to the edible features of the tubers. It is known that varieties with yellow pulp are superior to varieties with white pulp in terms of carotenoid content. The latter are antioxidants that bind free radicals in the human body, an excess of which accelerates the aging process. Involvement in the breeding work of the source material of potatoes with yellow pulp of tubers ensures an increase in the content of carotenoids in newly created varieties. Among 12 studied varieties, the carotene content ranged from 0.04 to 0.23 mcg/mg. Such varieties as Kimmeriia – 0.23 mcg/mg, Slovianka – 0.22 mcg/mg, Skarbnytsia – 0.21 mcg/mg and Kniahynia, Myroslava and Sluch – 0.20 mcg/mg had a high content of carotenoids. Such varieties as Fotyniia, Shchedryk, Tyras, Tradytsiia had the lowest content of carotenoids, respectively 0.04, 0.04, 0.07 and 0.09 mcg/mg.

Conclusions

As a result of the research, the feed and food quality of potatoes was studied. Laboratory analysis of average samples of 12 potato varieties was carried out. Varieties characterized by a high content of dry matter, crude protein, and vitamins were also selected.

Therefore, such varieties as Kimmeriia, Myroslava and Sluch stood out for the complex of high biochemical indicators. Kimmeriia variety had a high content of vitamin C (0.15 mcg/mg) and a high content of carotene (0.23 mcg/mg). Myroslava variety had good indicators for crude protein content in tubers (2.2 %), starch content (16.9 %) and carotene content (0.20 mcg/mg).

A high content of dry matter ensures an increased yield of finished products in production. Sluch variety had 22.5 % dry matter and 0.20 mcg/mg carotene in tubers. Therefore, this variety is recommended for the production of potato products, namely chips and French fries.

Conflict of interest

The authors state that there is no conflict of interest.

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