INVESTIGATION OF POTATO STORAGE QUALITY DEPENDING ON VARIETY PECULIARITIES

Ludmila Pusik
Department of technologies of processing of food production[1]
Ludmilap@gmail.com

Vladimir Pusik
Department of Agrotechnology and Ecology[1]
kysmish @ gmail.com

Gennadii Postnov
Department of technologies for processing and food industries[1]
postnov.gennadii@gmail.com

Iryna Safronska
Department of management, statistics and economic analysis
Lugansk National Agrarian University
44 Alchevsky str., Kharkiv, Ukraine, 61002
oblfin@ukr.net

Nina Lyubymova
Department of Forest Management and Life Safety[2]
nina.lioubimova@gmail.com

Galyna Sukhova
Department of Crop Production[2]
syhovagalinaiv@gmail.com

Nataliia Ilina
Department of equipment and engineering of processing and food industries[1]
ilinaana1984@gmail.com

Yana Hrynova
Department of Pedagogy, Psychology and Law[2]
GYG-XNAU@ukr.net

[1]Kharkiv Petro Vasylenko National Technical University of Agriculture
44 Alchevsky str., Kharkiv, Ukraine, 61002
[2]Kharkiv National Agrarian University named after V.V. Dokuchaev
Township Dokuchaevsky, Kharkiv region, Kharkiv district, Ukraine, 62483

Abstract

The aim of the research was to analyze an influence of variety peculiarities, different ripeness groups of potato of Dutch selection on storage quality.

It has been established, that the output of commodity products in early varieties is in average 88.22±1.53 %, in middle-ripening ones – 96.87±1.09. Among the group of early-ripening varieties, there must be separated Kristina with the output of commodity products at the end of storage as 90.15 %. The lowest output of commodity products is in the variety of Tornado – 87.09. The variation coefficient of the commodity products output is 1.9 %, that is the commodity products output varies little. In the group of middle-ripening variety, higher storage quality was observed in varieties Elekta and Setanta. The commodity products output was 92.97 and 92.2 9 % respectively.

Natural mass losses for the period of storage in tubers of all varieties were in average 4.2 %, among them 72.9 % at the expanse of moisture evaporation, and 27.1 % – at the expanse of breathing. In the group of early varieties, mass losses varied from 4.1 %

in the variety Kristina to 5.1 % in the variety Banda. Variation coefficient 7.4 % testifies to the small fluctuation of mass losses in the studied potato varieties.

In the group of middle-ripening potato varieties, mass losses varied with the middle force, variation coefficient 19.5 %. The lower mass loss was observed in the potato variety Elekta as 3.28 %.

Total losses for 6.5 months of storage were 11.78±1.53 in potatoes of the early varieties and 7.91±1.09 in the middle-ripening potato varieties.

Losses were distributed in such a way: in the early varieties 39.6 % are natural losses, 34.4 – technical spoilage and 26 % – absolute spoilage. In the group of middle-ripening potato varieties there was observed the ratio of typical and total losses: natural losses were 47.3 %, technical spoilage 32.0 %, absolute spoilage 20.7 %.

Keywords: potato tubers, storage quality, mass losses, commodity product output, variety peculiarity, ripeness group.

DOI: 10.21303/2504-5695.2020.001524

1. Introduction

Potato is a very old crop. It was known just 14–15 thousand years ago at the territory of Southern America, where the population cultivated it from ancient times [1, 2]. For today potato is the main food, fodder and technical crop. Tubers' food value is determined by high taste qualities and chemical composition, favorable for human health. Tubers contain from 14 to 22 % of starch, 1.5–3 % of proteins, 0.8–1 % of mineral substances, up to 1 % of cellulose. Potato starch is easily assimilated, and the biological value of its proteins is higher than one of other crops. Tubers contain many vitamins of the group B, PP, carotenoids. In winter periods potato is the main variety of vitamin C for humans. It is consumed for food boiled, fried, stewed [3, 4]. 22 countries are considered main world producers of potato; 9 of them are situated in Europe, 5 – in Northern and Southern America, other – in the Asian-Pacific region [5]. The absolute leader is China. The gross harvest of potato exceeded 95 mln tons that were near one fourth of world indices [6].

As far as this crop is seasonal, the main mass of a newly collected harvest must be stored for a long time. Quality changes and mass losses take place at storage of potato. They depend on many factors, namely: weather conditions of the vegetation period, storage conditions, product quality parameters at the beginning of storage. It is necessary to note, that variety peculiarities and ripeness group are of great importance. We make a great mistake, storing tubers of early-ripening varieties. Even under ideal conditions potato is stored till November-December. Then it begins to sprout fast, losing its quality. It becomes unfit for food needs [7].

The correct choice of a variety mainly determines storage success. It is one of leading techniques in the complex of arrangements for organizing constant provision of the population with the "second bread".

Variety choice is the main factor for getting a high quality product. It has been established, that culinary properties, sensor indicators, flesh condition depend on variety peculiarities. The analysis of quality parameters of three potato varieties, cultivated in India, testifies that the higher quality parameters the less time of tubers boiling. Potato varieties Kufri Djoti and Kufri Badshakh absorb more water at boiling than tubers of the Pukhradj variety. The test for density renovation for boiled potato testifies that the Kufri Djoti and Kufri Badshakh varieties have higher density modules. The viscosity module of Kufri Djoti is higher than one of Kufri Badshakh and Pukhradj [8]. Byelorussian scientists produce chips and dry potato puree of the high quality (8–9 and 7 points respectively) of the varieties Bryansk delicates and Bryansk novinka [9].

The color of chips worsens with a soil temperature decrease: in the Kennback variety – lower 10 °C, seedling – lower 4.4 °C [10].

Russian scientists consider varieties Belosnezhka, Illinsky, Golubizna, Bronnitsky, Osen most fit for producing crackling potato. It is recommended to store tubers at higher temperature (6…8 °C). For transforming tubers into dry puree, it is necessary to store them at temperature 2…4 °C [11].

It has been established, that technological conditions of potato in the period of storage depend on tubers' ripeness degree. Insufficient accumulation of reducing sugars at storage in a refrigerator allows to use potato without preliminary conditioning from September to March [12, 13].

Tubers' storage quality depends on ripeness group. After seven months of storage the output of healthy tubers of early and middle-early varieties was 93.8 and 93.2 % respectively, middle-late and late – 94.3 and 94.6 %.

At storage the content of dry substance, specific moisture, raw cellulose, potassium and phosphorus decreases. Among the studied varieties, the highest content of dry substance, specific moisture was obtained after storage in the Chala variety. The highest content of raw protein was in the Mashenadima variety. The results testify that tubers with high physical-chemical parameters preserve their properties longer [14, 15].

Storage conditions are regulated for minimizing mass losses and ones of reducing sugars, ascorbic acid at a certain level, influencing further tubers' processing [16].

Based on methods and standards of their country, Czech scientists estimated the quality of 760 potato varieties, imported from different world countries. According to estimation criteria, the best were ones, created in France, FGR, Polish and Dutch varieties occupied the middle place. Varieties of the USA, Great Britain and CIS countries occupied the last place, connected with the essential darkening of flesh and mediocre taste [17].

So, a potato variety plays the main role in the total complex of techniques, conditioning the improvement of its storage quality.

At the present moment great attention must be paid to the question of storage quality of nutritive properties of tuber varieties in the storage period and revelation of best ones by the total complex of economic and consumption signs. The presented data demonstrate the necessity to study new potato varieties under storage conditions.

The aim of the research was to analyze an influence of variety peculiarities, different ripeness groups of potato of Dutch selection on storage quality. The research gives a possibility to decrease potato losses, to differentiate and to prolong its storage life.

2. Materials and methods for studying the intensity of natural mass losses of potato at storage

The storage was conducted with the early ripening potato varieties of Dutch selection: Banda, Kristina, Tornado, with middle-ripening: Setanta, Elekta, Savanna (**Table 1**). The studies were conducted at PE "Potato of Poltava region" (v. Stavkove, Zinkivsky district) of the Forest-steppe of Ukraine.

The Dutch potato variety Kristina **(Fig. 1**) has the skin of an unusual dark-red color and cream flesh. It looks perfectly at shop shelves. It provides great interest and high popularity and also great success in final buyers. It also has high taste qualities. Due to the high content of starch and other nutritive substances, it is used for frying and salads [18].

Fig. 1. Kristina variety [18]

The potato variety Savanna (**Fig. 2**) of Dutch selection has the perfect outlook and even skin, color of tubers is cream-white. It differs by even, massive tubers. It is one of best representatives of middle-ripening potato, provides high harvests [19].

The potato variety Tornado (**Fig. 3**) has the bright-engrained skin of bright-raspberry color. The flesh color is white. It provides great interest and high popularity and also great success in final buyers. The potato has a peasant taste. It is used for many dishes [20].

Fig. 2. Savanna variety [19]

Fig. 3. Tornado variety [20]

The Banba variety (**Fig. 4**) is a middle-ripening potato variety. Oval-oblong tubers with the dark-yellow skin. The flesh is light-yellow. The skin is even with fine eyes. It is a perfect variety for retail in super-markets. It has a pleasant taste. It is suitable for many dishes [21].

Fig. 4. Banba variety [21]

The Setanta variety (**Fig. 5**) is a middle-ripening potato variety. Tubers are even, of the oval form. The skin is even, of red color. The flesh is yellow. It differs by the high content of starch and dry substances. It is used for producing starch, chips, fried potato [22].

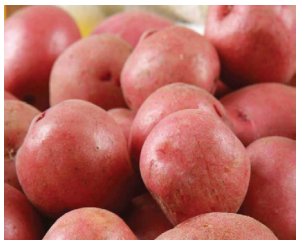

Fig. 5. Setanta variety [22]

The potato variety Elekta (**Fig. 6**) of Dutch selection has tubers with a perfect outlook. The skin and flesh are of light-yellow coloration, even. The eyes' depth is small. Well-stored. It is used for many dishes [23].

Harvested potato was put in temporary storehouses with tidal-exhaust ventilation, covered with straw for a healing period at temperature 15…18 °C. In 2 weeks it was examined, sorted by hand, cleaned from soil, vegetable residues, fine, mechanically damaged, old tubers, injured by pests, ill were eliminated. Then potato was loaded in boxes and laid for storage in a stationary

depository, equipped with mandatory ventilation. At the main storage period the temperature was kept within 3…5 °C and relative air humidity 90–95 %.

Fig. 6. Elekta variety

Table 1

Potato variety characteristic

Quality parameters	Varieties					
	Banba	**Tornado**	**Kristina**	**Savanna**	**Setanta**	**Elekta**
Form of tubers	oval	oval	oval	oval	oval	oval
size	big	big	big	big	big	big
Content of dry substances, %	18	18	19	20	23	18
Color of tubers	Dark-yellow	Bright-raspberry	Dark-red	Creamy-white	red	yellow
Color of flesh	Light-yellow	white	creamy	white	yellow	Light-yellow
Depth of eyes	fine	fine	fine	fine	fine	fine
Skin condition	even	even	even	even	even	even
Storage quality	Very good	good	very good	good	Very good	Very good

The experiments on potato storage were conducted according to "Methodical instructions for scientific-research works on vegetable storage" [24, 25]

Natural losses were determined by the formula $P=(P_1–P_2)\times100/P_1$, where P_1 – mass at the beginning of storage, kg; P_2 – mass after storage, kg.

Together with natural losses, there was determined technical spoilage, absolute spoilage, divided in losses at the expanse of sprouts and rotten.

The content of dry substances (dry mass) was determined by drying a potato batch to the constant mass at temperature 105 °C in a drying chamber according to [26].

At determining the chemical composition of tubers at the end to the determined storage term, the content of chemical substances was recalculated for the initial mass by the formula:

$$x=a\cdot(100–b)/100,$$

where x – content of substances taking into account natural mass losses, %; a – content of substances at the end of storage, %; b – mass losses for the storage period, %.

The data, presented in the work, are the mean value of three measurements. The statistical analysis was conducted using Microsoft Excel 2007. Differences were considered statistically significant at the significance level $\alpha=0.05$.

3. Results of studying the intensity of potato mass losses at storage

Storage as one of stages of commodity movement from a producer to a consumer provides quality and quantity preservation of a commodity with minimal losses, and also direct supply of a product to the population. Storage quality parameters are: standard product output, loss volume and storage term.

The potato mass at storage decreases. Natural losses take place at the expanse of dry substance decrease and water evaporation. Natural mass losses for the period of storage in tubers of all varieties were in average 4.2 %. At the expanse of dry substances – 27.1 % .

In the group of early varieties, mass losses varied from 4.1 % in the Kristina variety to 5.1 % in the Banda one. There is the essential difference $HIP_{05}=0.31$ % between the varieties by the mass

loss. Variation coefficient 7.4 % testifies to the small variation of mass loss in the studied potato varieties. The force of variety influence is 73 %.

In the group of middle-ripening varieties the mass loss varied with the middle force, variation coefficient – 19.5 %. The lowest mass loss was observed in the potato variety Elekta as 3.28 % (HIP_{05}=0.55) % (**Fig. 7**).

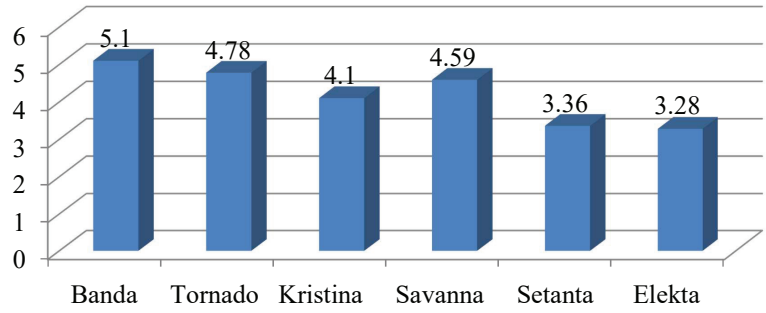

Fig. 7. Potato mass losses after seven months of storage, %

The standard product output and losses are reversely proportional that is the more losses the less output of standard products. Both storage quality parameters depend on conditions and terms of storage, variety peculiarities.

In average the commodity product output for all varieties for the storage period was 92.54 % of the initial mass (**Table 2**).

Table 2

Storage quality of potato depending on variety, %

Variety	Natural losses	Technical spoilage	Absolute spoilage	Total losses	Commodity product output
Early varieties					
Banda	5.10	4.29	3.20	12.59	87.41
Tornado	4.78	5.00	3.03	12.91	87.09
Kristina	4.10	2.80	2.95	9.85	90.15
HIP_{05}	0.31	0.68	0.48	0.27	1.78
In average for varieties	4.66±0.5	4.03±1.1	3.06±0.12	11.78±1.53	88.22±1.53
Variation coefficient	7.4	27.9	4.6	8.0	1.9
Influence force of the factor (variety)	73.0	93.0	78.0	99.0	96.0
Middle-ripening varieties					
Savanna	4.59	3.10	1.52	9.21	90.79
Setanta	3.36	2.30	1.85	7.51	92.79
Elekta	3.28	2.20	1.55	7.03	92.97
HIP_{05}	0.55	0.48	0.29	0.49	0.72
In average for varieties	3.74±0.66	2.53±0.45	1.64±0.17	7.91±1.09	96.87±1.09
Variation coefficient	19.5	19.3	10.6	15.5	6.0
Influence force of the factor	93.0	86.0	78.0	98.0	95.0

In the section of ripeness groups, the commodity product output in early varieties is in average 88.22±1.53 % (HIP_{05}=1.78 %), in middle-ripening – 96.87±1.09 (HIP_{05}=0.72 %.) Each ripeness group contains varieties that demonstrated better output of commodity products. Among the group of early-ripening varieties, there must be separated Kristina with the output of commodity products at the end of storage as 90.15 %. The lowest output of commodity products is in the variety of Tornado – 87.09. The variation coefficient of the commodity products output is 1.9 %, that is the commodity products output varies little. In the group of middle-ripening varieties, higher storage quality was observed in varieties Elekta and Setanta. The commodity products output was 92.97 and 92.29 % respectively.

It has been established, that the commodity product output in early-ripening varieties of potato depends by 96 % on variety peculiarities, in middle-ripening ones – by 95 %.

Natural mass losses for the period of storage in tubers of all varieties were in average 4.2 %, among them 72.9 % at the expanse of moisture evaporation, and 27.1 % – at the expanse of breathing. In the group of early varieties, mass losses varied from 4.1 % in the variety Kristina to 5.1 % in the variety Banda. Variation coefficient 7.4 % testifies to the small fluctuation of mass losses in the studied potato varieties.

In the group of middle-ripening potato varieties, mass losses varied with the middle force, variation coefficient 19.5 %. The lower mass loss was observed in the potato variety Elekta as 3.28 %.

Total losses for 6,5 months of storage were 11.78±1,.53 in potatoes of the early varieties (HIP_{05}=0.27 %), and 7.91±1.09 in the middle-ripening potato varieties (HIP_{05}=0.49 %).

Losses were distributed in such a way: in the early varieties 39.6 % are natural losses, 34.4 – technical spoilage and 26 % – absolute spoilage **(Fig. 8)**. In the group of middle-ripening potato varieties, there was observed the ratio of typical and total losses: natural losses were 47.3 %, technical spoilage 32.0 %, absolute spoilage 20.7 % (**Fig. 9**).

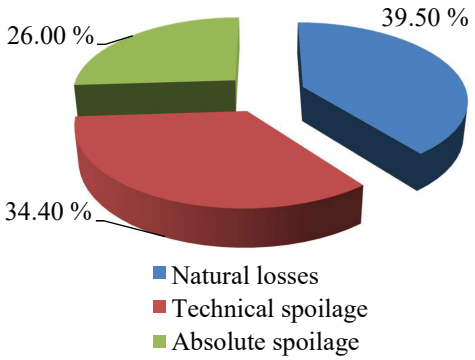

Fig. 8. Structure of total losses of early potato varieties at storage, %

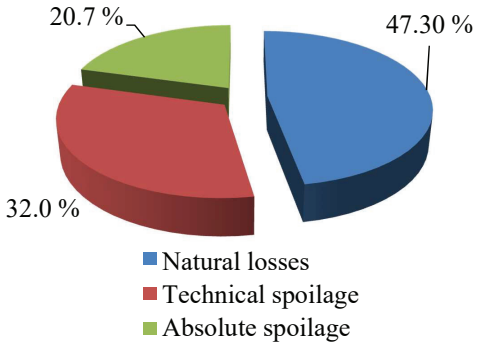

Fig. 9. Structure of total losses of middle-ripening potato varieties at storage, %

So, biological peculiarities of a variety influence tubers' storage quality.

It has been established, that natural losses of the potato mass at storage in the structure of total ones prevail over other types of losses (39.6 and 47.3 %). In average 27–30 % of natural losses take place at the expanse of dry substance. The studies have established that dry substance losses decrease in varieties of the early group in average by 13.8 %, in ones of the middle-ripening group – by 3.7 % of the initial content (**Table 3**).

The least losses of dry substances among the studied varieties were in the variety Setanta – 3.7 % comparing with the initial content.

Most labile components of tubers at storage are sugars, vitamin C and starch. The continuous process of sugars transformation in starch and vise versa takes place in tubers. Under conditions of optimal storage temperatures there is observed a certain predominance of starch transformation in

sugars over starch synthesis of them, influencing their ratio, decreasing in average by 8.8 % of the initial level in the group of early-ripening potato varieties and by 5 % in the middle-ripening ones.

Table 3

Decrease of the dry substance content from the initial content in potato tubers at storage, %

Variety	Content of dry substances, %		Relative decrease of dry substance content, %
	Beginning of storage	End of storage	
Early varieties			
Banba	26.1	25.8	3.9
Tornado	17.9	13.3	25.6
Kristina	19.5	17.2	11.8
Average for varieties	21.1	18.7	13.8
Middle-ripening varieties			
Savanna	20.7	19.8	5.1
Setanta	24.1	23.2	3.7
Elekta	20.1	19.3	3.9
Average for varieties	21.6	20.8	3.7

4. Conclusions

It has been established, that the variety peculiarities and ripeness group of potato of Dutch selection influence storage quality. The output of commodity products in early varieties is in average– 88.22±1.53 %, in middle-ripening ones – 96.87±1.09. Among the group of early-ripening varieties, there must be separated Kristina with the output of commodity products at the end of storage as 90.15 %. The lowest output of commodity products is in the variety of Tornado – 87.09.

In the group of middle-ripening variety, higher storage quality was observed in varieties Elekta and Setanta.

The commodity products output was 92.97 and 92.2 9 % respectively.

In the group of early varieties, mass losses varied from 4.1 % in the variety Kristina to 5.1 % in the variety Banda. In the group of middle-ripening potato varieties, mass losses varied with the middle force, variation coefficient 19.5 %. The lowest mass loss was observed in the potato variety Elekta as 3.28 %.

References

[1] Fedorchenko, M. O., Bielova, T. O. (2014). Istoriya kultury kartopli. Materialy II nauk.-prakt. internet-konf. Poltava, 80–83.

[2] Istoriya kartopli. Available at: http://www.agro.franko-terminal.com/content/view/5034/184/lang,ua/

[3] Korinchevska, D. V. (2009). Biokhimichnyi sklad ta fiziolohichnyi stan pry zberihanni bulb kartopli prodovolchoho pryznachennia. NNI Roslynnytstva ta gruntoznavstva, 115.

[4] Andre, C. M., Ghislain, M., Bertin, P., Oufir, M., del Rosario Herrera, M., Hoffmann, L. et. al. (2007). Andean Potato Cultivars (Solanum tuberosumL.) as a Source of Antioxidant and Mineral Micronutrients. Journal of Agricultural and Food Chemistry, 55 (2), 366–378. doi: https://doi.org/10.1021/jf062740i

[5] Cabluk, P. T., Kaliev, H. A. (2008). Svitove i rehionalne vyrobnytstvo ahrarnoi produktsiyi. Kyiv: NNTs IAE, 210.

[6] Svitovyi rynok kartopli. Available at: https://www.profihort.com/2019/08/svitovij-rinok-kartopli-3/

[7] 5 oshibok pri hranenii kartofelya. Available at: https://7dach.ru/Exspert/5-oshibok-pri-hranenii-kartofelya-3860.html

[8] Kaur, L., Singh, N., Singh Sodhi, N., Singh Gujral, H. (2002). Some properties of potatoes and their starches I. Cooking, textural and rheological properties of potatoes. Food Chemistry, 79 (2), 177–181. doi: https://doi.org/10.1016/s0308-8146(02)00129-2

[9] Pshechenkov, K. A., Sidyakina, I. I., Zeyruk, V. N., Davydenkova, O. N. (2001). Trebovaniya k syr'yu dlya pererabotki kartofelya. Kartofel' i ovoshchi, 2, 16–17.

[10] Davies, H. V., Jefferies, R. A., Scobie, L. (1989). Hexose Accumulation in Cold-stored Tubers of Potato (*Solanum tuberosum L.*): The Effects of Water Stress. Journal of Plant Physiology, 134 (4), 471–475. doi: https://doi.org/10.1016/s0176-1617(89)80012-4

[11] Pshechenkov, K. A., Sidyakina, I. I., Zeyruk, V. N., Davydenkova, O. N. (2000). Syr'evaya baza dlya pererabotki kartofelya (proizvodstvo obzharennyah kartofeleproduktov). Pishchevaya promyshlennost', 6, 14–15.

[12] Blenkinsop, R. W., Copp, L. J., Yada, R. Y., Marangoni, A. G. (2002). Changes in Compositional Parameters of Tubers of Potato (Solanum tuberosum) during Low-Temperature Storage and Their Relationship to Chip Processing Quality. Journal of Agricultural and Food Chemistry, 50 (16), 4545–4553. doi: https://doi.org/10.1021/jf0255984

[13] Putz, B. (1990). Kartoffeln: Züchtung – Anbau – Verwertung. Hamburg: Behr'sVerlag.

[14] Chemeda, A., Bultosa, G., Dechassa, N. (2014). Effect of Variety and Storage on the Tuber Quality of Potatoes Cultivated in the Eastern Highlands of Ethiopia. Science, Technology and Arts Research Journal, 3 (1), 84. doi: https://doi.org/10.4314/star.v3i1.14

[15] Yang, Y., Achaerandio, I., Pujolà, M. (2016). Effect of the intensity of cooking methods on the nutritional and physical properties of potato tubers. Food Chemistry, 197, 1301–1310. doi: https://doi.org/10.1016/j.foodchem.2015.11.028

[16] Valencia Flórez, L. F., Trejo Escobar, D. M., Latorre Vásquez, L. I., Hurtado Benavides, A. M., Mejía España, D. F. (2019). Influence of storage conditions on the quality of two varieties of native potato (Solanum Tuberosum group phureja). DYNA, 86 (209), 49–55. doi: https://doi.org/10.15446/dyna.v86n209.72958

[17] Koltunov, V. A., Voitseshyna, N. I., Furdyha, M. M. (2014). Resursnyi potentsial sortymentu kartopli. Kyiv, 323.

[18] Kartofel' Kristina (Gollandiya). Available at: https://ipmpotato.com.ua/srednerannie/kristina.html

[19] Kartofel' Savanna (Gollandiya). Available at: https://ipmpotato.com.ua/rannie/savanna.html

[20] Sort kartofelya Tornado (Gollandiya). Available at: https://ipmpotato.com.ua/rannie/tornado.html

[21] Irlandskiy kartofel' «Banba»: opisanie sorta i pravila kul'tivirovaniya. Available at: https://dachadecor.ru/ogorod/irlandskiy-kartofel-banba-opisanie-sorta-i-pravila-kultivirovaniya

[22] Kartofel' Setanta (Gollandiya). Available at: https://ipmpotato.com.ua/srednerannie/setanta.html#

[23] Elektra (Electra). Available at: https://kartofan.org/xarakteristika-sorta-kartofelya-elektra.html

[24] Dzheneev, S. Yu. et. al.; Dzheneev, S. Yu., Ivanchenko, V. I. (Eds.) (1998). Metodicheskie rekomendatsii po hraneniyu plodov, ovoschey i vinograda (organizatsiya i provedenie issledovaniy). Yalta: Institut vinograda i vina "Magarach".

[25] Metodyka derzhavnoho sortovyprobuvannia silskohospodarskykh kultur. Vyp. 4 (kartoplia, ovochevi ta bashtanni kultury) (2001). Kyiv, 4–11.

[26] DSTU ISO 751:2004. Fruit and vegetable products. Determination of water-insoluble solids (control test) (2005). Kyiv.

[27] Metodychni rekomendatsiyi shchodo provedennia doslidzhen z kartopleiu (2002). Nemishaieva: UAAN, Instytut kartopliarstva, 182.

Received date 04.09.2020
Accepted date 12.11.2020
Published date 30.11.2020