UDC 633.44:631.563.9
DOI: 10.15587/1729-4061.2019.155313

PRESERVATION OF PARSNIP ROOT VEGETABLE DEPENDING ON THE DEGREE OF RIPENESS, VARIETAL FEATURES, AND STORAGE TECHNIQUES

L. Pusik
Doctor of Agricultural Sciences, Professor
Department of Technologies of Processing of Food Production named after T. P. Yevsiukova**
E-mail: ludmilap@gmail.com

V. Pusik
Doctor of Agricultural Sciences, Professor*
E-mail: kysmish@gmail.com

N. Lyubymova
Doctor of Technical Sciences, Professor*

V. Bondarenko
PhD, Senior Researcher
Laboratory of Genetics, Biotechnology and Quality
The Plant Production Institute named after V. Y. Yuryev of National Agrarian Academy of Sciences
Moskovsky ave., 142, Kharkiv, Ukraine, 61060

A. Rozhkov
Doctor of Agricultural Sciences, Professor
Department of Crop Production
Kharkiv National Agrarian University named after V. V. Dokuchaev
township Dokuchaevsky, Kharkiv region, Kharkiv district, Ukraine, 62483

O. Sergienko
PhD, Senior Researcher, Head of Laboratory
Laboratory for the Selection of Solanaceous and Cucurbitaceous Cultures
Institute of Vegetables and Melon Growing
National Academy of Agricultural Sciences of Ukraine
township Selektsiyne, Kharkiv region, Kharkiv district, Ukraine, 62478

S. Denisenko
PhD, Associate Professor
Department of Equipment and Engineering of Processing and Food Industries**

L. Kononenko
PhD, Associate Professor
Department of Crop Production
Uman National University of Horticulture
Institutska str., 1, Uman, Ukraine, 20305

*Department of Agrotechnology and Ecology**
**Kharkiv Petro Vasylenko National Technical University of Agriculture
Alchevskykh str., 44, Kharkiv, Ukraine, 61002

Ступінь визрівання овочів, плодів та ягід позначається на їх збереженості. Ступінь стиглості пастернаку не можна визначити і за розміром коренеплоду, оскільки в цьому випадку не останню роль відіграють умови вирощування й агротехніка Смакові якості і консистенцію тканини з періодом вегетації від 120 до 180 днів рослин розрізнити важко. Тому знання впливу ступеня стиглості на лежкість коренеплодів пастернаку має великий практичний інтерес.

Теоретично обґрунтовано та експериментально підтверджено Найменші втрати маси (5,0–6,7 %) та найвища лежкість (93,3–90,3 %) була у пастернаку з вегетаційним періодом – 150 діб. У межах вегетаційного періоду 140–175 діб більший плив на збереженість коренеплодів пастернаку має тривалість вегетаційного періоду – 21,0 %, особливості сорту впливає лише на 1,1 %, взаємодія вивчаємих факторів – 68 %, інші фактори (погодні умови, технологія вирощування) впливають на 9,9 %.

Встановлено, що немиті коренеплоди, що зберігалися у відкритому вигляді в ящиках уражувалися хворобами на 0,7 % більше, ніж миті. Зберігання митих коренеплодів у поліетиленових мішках збільшило їх ураженість майже у 3,5 рази, ніж немитих. У коренеплодах пастернаку накопичувалося сухих речовин від 24,1 (у сорту Петрика) до – 27,7 % (у сорту Студент). Високий вміст сухих речовин відмічено у сорту Борис 25,8 %. У сорту Петрик відмічено вміст моносахаридів 1,2 %, сахарози 3,7 %, загальний вміст цукрів 5,0 %. Загальний вміст цукрів у сорту Борис 5,4 % знаходився на рівні контролю. Найбільшу загальну кількість цукрів накопичили коренеплоди сорту Студент 5,7 %. Встановлено, що вміст вітаміну С у коренеплодах був найменшим у сорту Петрик – 9,9 мг/100 г, у сортів Борис і Студент вміст вітаміну С складав відповідно 10,1 і 10,2 мг/100 г. Вміст нітратів у коренеплодах пастернаку був найменший у сорту Студент 60 мг/кг, а найбільший у сорту Борис 100 мг/кг.

Встановлено, що втрата маси коренеплодів пастернаку на 33 % залежить від умов зберігання, особливість сорту впливає лише на 1 %, вплив взаємодії факторів (умови зберігання, особливості сорту) становить 64 %, інших факторів – 2 %. Застосування поліетиленової плівки для пакування зменщує втрати маси коренеплодів пастернаку сорту Петрик у 2,1–4,7 рази, Студент – у 1,9–3,7, у Борис 2,3–3,1 рази порівняно зі зберіганням коренеплодів у відкритому виді

Ключові слова: коренеплоди пастернаку, ступінь стиглості, тривалість вегетаційного періоду, способи зберігання, збереженість

1. Introduction

Providing people with a product depends not only on the level of production, but also on the efficient organization of storage. At present, the volume of vegetables and fruits losses in this area reaches 40 %. The main reasons are, first of all, the loss of mass during breathing, water evaporation and sprouting. Loss of water and dry substances make up from 10 to 35 % of the total mass loss. The limit value of water loss is different for each type of a raw material. Carrots, beets with leaves lose 3–4 %, roots of carrots, beets, potatoes – 7–8 %. If a product exceeds the maximum level, it becomes unsuitable for sale. Second, the losses that are caused by diseases. Their volume is difficult to forecast, but it can reach 100 % in the case of mass spread. Mechanical damage can cause serious consequences. Third, the loss of mass during storage depends on the degree of ripeness of vegetables and fruits. The degree of ripeness, first of all, depends on duration and conditions of growing, which in turn affects preservation of fruit and vegetable production. Overripe root crops of radish and small radish become woody, with hollows or loose and unsuitable for preservation. Greens become yellow, stems, leaves and petioles become rough and not suitable for consuming. It is possible to judge on the degree of ripeness of vegetables in terms of appearance and consistency almost in all cases [1].

As for parsnip, it is more complicated, because it is difficult to distinguish plants with a period of vegetation from 120 to 180 days by taste and quality of tissue. It is not possible to determine the degree of ripeness by the size of a root crop, as conditions of cultivation and agrotechnology play important role in this case. Therefore, knowledge of the effect of the degree of ripeness on preservation of root crops parsnips has a great practical interest.

2. Literature review and problem statement

The degree of ripening of vegetables, fruits and berries affects their preservation. We can observe direct connection between the degree of ripeness of bulbs, duration of their state of rest and preservation for an onion. Mature bulbs have a thin, dry neck. However, there are unripe onions sometimes in a batch for prolonged storage – with a thick moist neck. Such onions are very damaged by diseases; they go out of a state of rest quickly. An increase by 5, 10 and 20 % of the content of thick–necked onion reduces the yield of commercial products after prolonged storage by 10.0; 14.4 % and 20.7 %, respectively, comparing with the control version. Loss of mass, waste at the expense of rotten and sick bulbs and total waste increases proportionally. There were particularly high natural losses of mass for seven months of storage in the case with 20 % of bulbs with insufficiently dried neck (7.1 %), with a significant increase in a number of sprouted and diseased bulbs [2]. But an author does not compare ripeness of bulbs by duration of the growing season. Formation of a thin dry neck depends on weather conditions of the growing season. Rainy weather delays ripening of onions and formation of dry scales. Leaves and necks do not have time to dry up before harvesting. Such onions are much worse, it is affected by diseases.

Dry matter loss of the De Bravo and Mobil varieties are 15.09 and 16.33 %, respectively, at storage of tomatoes of the pink degree of ripening, while the Delicate variety is 21.15 % of the original content. The content of dry matter in vegetables of full preserved worse at the same temperatures (0…2 °C) and the storage duration (30 days). Loss of dry matter in ripe vegetables was within the limits of 14.55–30.19 % of the initial content, in blanche ones – 11.90–17.39 %, brown ones – 21.28–26.00 %. In turn, there are greatest losses of acidity in vegetables of blanche degree of ripeness of all varieties during storage, and minimal losses – in pink ones. The content of vitamin C increased in the period of after ripening of blanched fruits, and it decreased with further over-rearing of them. The loss of vitamin C in the storage of ripe vegetables was within the range of 12.79–28.68 % of the original content [3, 4]. We should note that coming of a different degree of ripening of tomatoes depends on a group of ripening. Early-ripening vegetables have shorter duration between the degrees of ripening of tomatoes. Of course, weather conditions of the growing season make their adjustments. Authors established that preservation of zucchini fruits depends on the size of a fruit, that is, the degree of their ripeness. It is possible to store fruits with a diameter of more than 8 cm for 13–18 days under conditions of the raw material area at a daytime temperature of 26…30 °C, fruits with a diameter of 4.5–6.0 cm – 2–6 days. We can store fruits with a diameter of 4.5–6.0 cm at a temperature of 5±1 °C for 5 days, fruits with a diameter of 6.1–8.0 cm – 13–16 days, a mixture in the size of fruits for 10–12 days, and large non-standard fruits (8.1–10.0 cm) – for 18–21 days. Weight loss during depends on their size at storage at a temperature of 5±1 °C by 42 %. The yield of products depends on the size of a fruit by 22 % [5].

Under normal refrigeration conditions, Cucumbers preserve their properties for two days in an open box; we can observe larger natural losses in greenery of the length of 91–110 mm, than in the mixture. It is possible to store cucumbers for almost two weeks with practically no losses at a temperature of 5±1 °C in boxes with polyethylene film or in polyethylene bags of 20 kg capacity. Average daily losses of fruits stored in polyethylene bags did not exceed 0.08–0.10 % [6]. We can note that harvesting of zucchinis, cucumbers, marrows of varying degrees of ripeness will depend on the intended purpose of vegetables. Pickles are for production of extra class canned food, greenery – for current consumption, canning and pickles, large non-standard fruits – for production of paste. Duration of the growing season to the onset of technical ripening of zucchinis was 40–60 days, cucumbers – 40–55 days, so different fruits have different duration of the growing season.

We see the following pattern at the storage of melons of varying degrees of ripeness. The value of natural mass loss, physiological disorders and other diseases of unripe fruit are less than of ripe ones. Deterioration of the taste of ripe fruit is more than less of ripe ones. Preservation of fruits depends on varietal peculiarities, but laying of unripe fruit for the storage contributed to their better preservation in most cases. Weight loss of stored fruits depends on the degree of ripeness by 20.3 % [5]. Instead, there were melon fruits with the first signs of ripeness for the storage collected, when there were a more pronounced grid of cracks and yellowish color on the surface. The melon ripening group determines duration of the growing season. Early-ripening melons have a vegetation period of 55–75 days, and mid-ripening – 90–96 days.

It is possible to present duration of storage of fruits and berries as a function, which depends on environmental factors [7]. If conditions are unfavorable, it leads to a rapid decrease in the content of accumulated fruit substances, changes in the direction of metabolism, and accordingly – to aging and self-destruction.

Common standards for assessment of the quality of berries are the content of dry soluble substances and organic acids in them. And the main factor in determination of the quality of berries is the ratio of sugars and organic acids, because this indicator characterizes the harmony of taste. Surveys show that consumers do not have enough information about the color, size and weight of berries, but they want to know more about fruits they consume [8].

In order to keep fruits longer and with the least losses, it is necessary to collect them in a period preceding full physiological ripeness. Fruit, which we put into storage in the collecting stage of ripeness, continues to ripen gradually. Thus, the decisive factor for high preservation of fruits is a state of their ripeness during the putting them for the storage. This is the main factor, which determines the success of long–term storage of fruits and berries, and it is possible to regulate intensity of this process by conditions of storage itself [7].

The main factor that determines a level of components of the chemical composition of berries is variety characteristics, and therefore we consider nutritional properties as a hereditary sign of strawberries. However, the dependence of their content on a stage of development, a degree of ripening, a region of cultivation, meteorological conditions, ecological and agrotechnological factors is known.

After ripening is a highly effective, coordinated process determined by genetic programs. The research found that ripening of straw berries depends on temperature changes. So, high temperatures stimulate consumer ripeness of berries, and low temperatures – on the contrary – delay it. The level of expression of genes associated with early ripening decreases at an increase in temperature.

Changes occur in shape and size, consistency, color, taste and aroma formation of berries in the process of development and ripening of berries in the mother plant [9]. The content of main pigments, sugars, the proportion of organic acids, softening of consistency decreases gradually during the ripening berries [10]. So, we know that glucose and fructose content in berries increases gradually during development of the fetus, while the sucrose content grows in the process of ripening. The starch found in young strawberry berries disappears until reaching consumer ripeness [9].

It is necessary to collect berries of black currant in 4–6 days before consumer ripeness for processing, when almost 70 % of them correspond to the technical condition, and 2–3 % is unripe. Fruits in this phase have dense pulp and contain 8–12 % less dry soluble substances, 5–13 less sugars and 13–28 % more acids. The share of technical defective products increases to 6–7 % during three–day storage of fruits at the temperature of 0...+2 °C (with a loss of 0.9–1.1 % by weight), the content of dry soluble substances decreases by 6–13 %, sugar – by 4–19 % and acids – up to 16–17 %. The level of ascorbic acid in fruits decreases because of the delay in harvesting – by 30–50 % [11]. In the above studies, authors determined the degree of ripeness visually and by the content of components of the chemical composition.

The quality of strawberries and the duration of their storage depend on the degree of ripeness entirely. If we collect berries before the optimal ripeness, its storage life becomes longer, but the quality and nutritional value decrease. On the other hand, fully ripe strawberries have a high nutritional value with a limited storage life [12].

It is necessary to collect berries in a stage of consumer ripeness for achievement of optimal color characteristics and fully formed taste and aroma. According to data [13], it is necessary to collect strawberries when> 2/3 of a berry has pink or red color.

Consequently, each individual variety has its own indicators of optimal degree of ripeness, which provide possibility of the most prolonged storage of fruits with the slightest decrease in their quality. These are indicators such as duration of the vegetative period for vegetables and a number of days from flowering to a fruit, a size of a fruit, main and cover color of a fetus, density of skin and a pulp, certain shades of taste and aroma of a fruit. The sum of active temperatures of the growing season, a hydrothermal coefficient plays a great role. At the last stage of promotion of products to the consumer – methods of storage, intensity of respiration of a fruit, a change in a chemical composition. They are subject to fluctuations depending on environmental factors within the same variety.

It is recommended to collect the varieties of parsnips collected in the stage of technical maturity, which comes after 84–150 days after shoots. We should note that preservation of juicy products depends on conditions and methods of storage. There are investigations of preservation of roots of carrots and beets in paper [14], radishes – in work [15], mother roots – in work [16] and carrots – in study [17]. Authors of paper [18] recommend collecting roots, cabbage considering a size of the product body or as needed. The content of components of the chemical composition, especially sugars, influences duration of storage of root crops. Formation of components of the chemical composition of root crops depends on varietal characteristics and duration of the growing season, but there were no above-mentioned studies with root crops of parsnip conducted.

The experience of world vegetable growing shows that, losses make up 35 %, that is, one third of a harvest of fresh vegetables due to shortcomings during harvesting and without its improvement in the process of advancement of products by the logistic chain. Here we take into consideration a variety of factors – from the quality of a product itself to various ways of processing (sorting, washing, and packaging). It is possible to achieve high marketability of vegetable products during sorting only after cleaning and washing [19]. We should note that there is not enough scientific information on storage of parsnip root crops. Therefore, it is important to investigate an effect of the degree of ripening, post-harvest improvement of root crops of parsnip and the way of storage on their preservation.

3. The aim and objectives of the study

The objective of the study was the scientific substantiation of an influence of the degree of ripening of root crops of parsnip on their preservation to determine storage duration in dependence on varietal characteristics, duration of the growing season, post harvest improvement and a storage method.

We solved the following tasks to achieve the objective:

– determination of natural losses of root crops mass during storage;

– investigation of proneness of root crops to diseases;

– investigation of a change in components of the chemical composition of parsnip root crops during their storage;

– conduction of a comparative assessment of preservation of parsnips root crops depending on a type of packaging and post-harvest treatment.

4. Materials and methods to study the formation of nutritional value of cauliflower, chemical and organoleptic parameters

We conducted field experiments on the experimental field in the eastern part of the Left Bank Forest – steppe of

Ukraine at the territory of Kharkiv oblast using drip irrigation. We carried out laboratory experiments at the Department of Fruit and Vegetables and Storage at Kharkov National Agrarian University named after V. V. Dokuchaev (Ukraine).

We carried out field experiments in accordance with generally accepted methods for Petrik, Student, and Boris parsnip varieties. We harvested parsnips by a general method with a vegetative period of 140, 150 and 175 days. We stored standard root crops. We stored root crops in the Polair refrigerating chamber (manufactured in Russia) at a temperature of 0±0.5 °C and a relative humidity of 85–90 %.

Paper [26] presents more detailed materials and methods for investigation of preservation of the quality of broccoli cabbage, chemical and organoleptic parameters.

5. Results of studies on preservation of parsnip root crops

5. 1. Preservation of parsnip root crops depending on duration of the growing season and varietal characteristics

Studies on the effect of terms of duration of the growing season on preservation of parsnip root crops under irrigation showed that the highest preservation (91.5–90.3 %) was in parsnips with a vegetation period of 150 days (Table 1). Extension of the growing season to 175 days or its reduction to 140 leads to increased losses during storage. Younger root crops lose mass more due to water evaporation primarily and due to increased proneness to diseases a little, and roots with a period of vegetation 175 days – due to pathogens affection. Preservation depends on characteristics of the variety. The yield of marketable root crops of the Petrik variety was 83.7–90.3 %, whereas it was 82.8–91.5 % for the Student variety. The yield of marketable roots in the Boris variety was 85.9–90.4 %.

The conducted dispersion analysis shows that duration of the vegetation period (factor B) has the greater effect to preservation of root crops of parsnips in the period of vegetation of 140–175 days – 21.0 %, the variety (factor A) affects only 1.1 %, the AB interaction of factors – 68 %, other factors (weather conditions, technology of cultivation) affect 9.9 %.

Mass loss of root crops occurs unevenly during storage. It is quite high and ranges from 1.6–2.0 % for duration of the growing period of 140 days depending on the variety at the beginning of storage, when the healing period has not yet expired. Mass loss of root crops with duration of the growing period of 175 days (1.3–1.8 %) is less and they are the smallest in root crops with a vegetative period of 150 days. Further, mass losses decrease gradually to 0.5–0.7 % and increase again to 1.2–2.1 % (Fig. 1) at the end of storage.

As for sprouting, there are less sprouted root crops in young root crops than in more ripe ones. Unripe root crops are less resistant to diseases, especially to fomosa [20].

Table 1

Preservation of root crops of parsnip depending on duration of the growing season, % (t=0±0.5 °C)

Period from sowing to harvesting, days	Losses during storage, %				Yield of healthy root crops, %
	Mass	Sprouts	Absolute wastage	Root crops affected by diseases	
Petrik					
140	9.8	0.5	0.8	5.2	83.7
150	6.7	0.7	0.3	2.0	90.3
175	8.8	0.8	0.2	1.6	88.6
Student					
140	10.2	0.9	1.1	4.4	82.8
150	6.2	0.5	0	1.8	91.5
175	9.5	1.2	0.7	2.6	86.6
Boris					
140	8.4	0.5	0.7	4.5	85.9
150	5.8	0.5	0.1	3.2	90.4
175	7.9	0.7	0.2	1.4	89.8
$HIP_{05\ A\ factor}$	0.71	–			
$HIP_{05\ B\ factor}$	0.87	–			

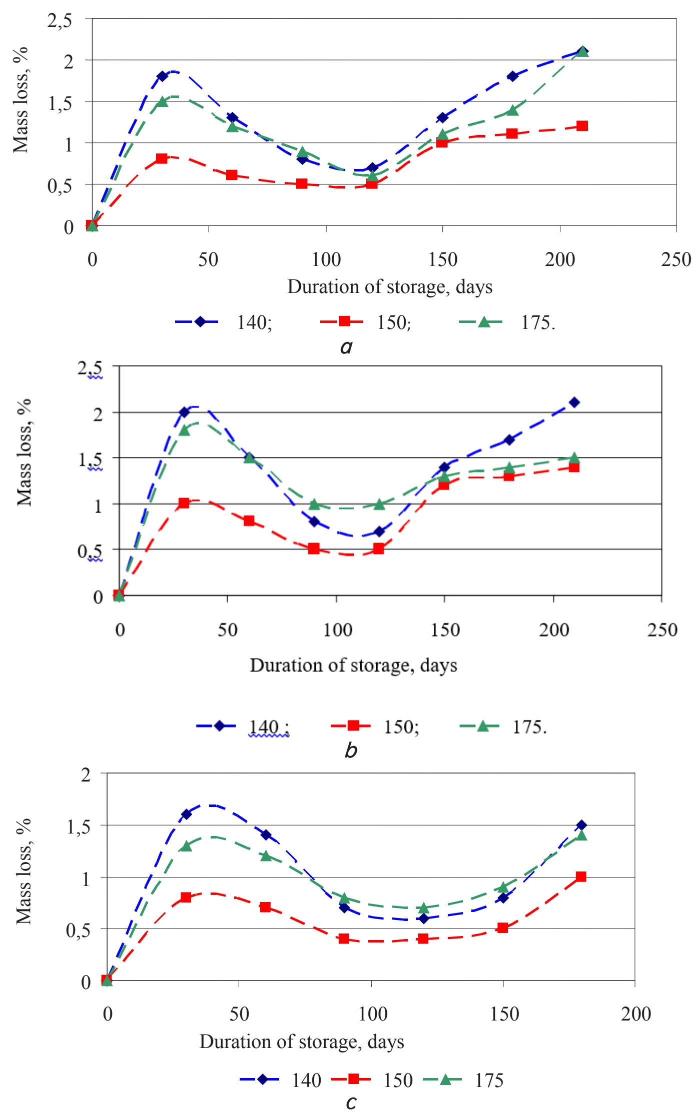

Fig. 1. Dynamics of mass loss of parsnip root crops depending on duration of the growing season, % (t=0±0.5 °C): *a* — Petrik variety; *b* — Student variety, *c* — Boris variety

Absolute wastage (0.7–1.1 %) was higher in roots with a vegetative period of 140 days, apparently, due to the fact that they retain moisture worse; they fade and lose resistance to effects of environmental factors and microorganisms.

The results of research shown in Fig. 1 do not go disagree with the results of research conducted on preservation of carrots and red beet [21].

But along with the high yield of marketable products at the end of storage, we are also interested in its overall consumer qualities. Therefore, we conducted studies to define preservation of the main nutrients during storage of root crops in various ways in order to evaluate one or another method of storage comprehensively.

5. 2. Content of components of the chemical composition of parsnip root crops depending on duration of the growing season

We determine the nutritional value of root crops by the high content of carbohydrates and presence of well-digestible substances, vitamins, enzymes and mineral salts of calcium and phosphorus. Parsnip takes one of the first places among root crops as to the content of easily digestible carbohydrates [22].

We analyzed the content of the main biochemical substances in root crops of parsnip and should note that root crops accumulated dry substances from – 24.1 (in Petrik) to – 27.7 % (in Student) on average over the years of research in root crops of the studied varieties. We also can note the high content of dry matter in Boris – 25.8 %. The content of monosaccharides was 1.2 % in the Petrik variety (control), sucrose 3.7 %, the total content of sugars was 5.0 %. The total content of sugar was at the control level in the Boris variety (5.4 %). The largest total number of sugars accumulated root crops of the Student variety – 5.7 %. We found that the content of vitamin C was the smallest in the Petrik (control) variety – 9.9 mg/100 g. Thus, the content of vitamin C was 10.1 and 10.2 mg/100 g, respectively, in the Boris and Student variety, which were significantly less than control. We paid special attention to the content of nitrates in fresh vegetable products.

However, the presence of nitrates in a plant and storing of them in product organs is a biological necessity for nutrition of plants and photosynthetic activity [23]. The years of research defined that the nitrate content in root crops of parsnip was the smallest in Student (60 mg/kg) variety and the highest in Boris (100 mg/kg) variety. In general, we should note that the content of nitrates was lower than the maximum allowable level (MAL 250 mg/kg). The Student variety was the best among the studied assortment as for organoleptic parameters. It received the highest rating of 4.8 points during the tasting. The Petrik (control) and Boris varieties also received high tasting scores of 4.2 and 4.5 points, respectively.

There was a decrease in dry matter by 6.2–11.4 % in the root crops from the beginning of storage, a decrease in the total content of sugars – 16.8–25.8, sucrose – by 20.0–36.5, vitamin C – by 9.8–30.0 %. The content of monosaccharides, on the contrary, increased by 8.0–30 %, depending on the way of storage. Losses of sugars depended on duration of storage of root crops. In recent months of storage, that is April and May, there were the largest losses of sugars, despite maintenance for the optimum temperature mode.

5. 3. Preservation of parsnip root crops in dependence on the storage method of storage post-harvesting improvement

The researches of many scientists proved that preservation of root crops depends on the method of their storage. The results of our research do not go against them. We established that the mass loss of root crops of parsnip depends on storage conditions by 33 %, the characteristic of the variety affects only 1 %, and the influence of factors interaction (storage conditions, features of the variety) is 64 %, other factors affect 2 % (Table 2).

Our research found that the use of a polyethylene film reduces losses of root mass of parsnip: for the Petrik variety – by 1.9–3.7 times, for the Student variety – by 2.1–4.7 times, for the Boris variety – by 2.3–3.1 times comparing with storage in open boxes. This is due to the fact that storage inhibits intensity of respiration of root crops under such conditions; the anaerobic type of respiration prevails, which leads to a decrease in consumption of dry matter for respiration. In addition, root crops retained turgor and had a good appearance at the end of storage (Table 2).

Table 2

Preservation of parsnip depending on the storage method (t=0±0.5 °C)

Method of storage	Natural mass loss, %	Root crops affected by diseases, sprouting, wastage, %	Yield of healthy root crops, %
Petrik			
Poured to boxes (control)	6.7	3.0	90.3
In boxes, interlayered with wet sand	6.4	1.2	92.4
In boxes, with polyethylene tabs	3.5	3.9	92.6
In polyethylene bags	1.8	3.2	95.0
Student			
Poured to boxes (control)	6.2	2.3	91,5
In boxes, interlayered with wet sand	5.9	0.8	93,3
In boxes, with polyethylene tabs	2.9	2.5	94,6
In polyethylene bags	1.3	2.7	96,0
Boris			
Poured to boxes (control)	5.8	3.8	90,4
In boxes, interlayered with wet sand	5.4	1.2	93,4
In boxes, with polyethylene tabs	2.7	3.3	94,0
In polyethylene bags	1.6	3.0	95,4
HIP_{05} A factor	0.51		
HIP_{05} B factor	0.80		

It is possible to achieve high marketability of vegetable products at sorting after cleaning and washing only. We found that unwashed root crops stored in open boxes were affected by diseases by 0.7 % more than washed ones (Table 3).

Storing of washed root crops in polyethylene bags increased damage to them almost in 3.5 times than unwashed ones. We can explain the highest preservation of unwashed parsnip root crops by the fact that there are both pathogens of putrefactive diseases and their antagonists in the soil. Very thin roots broke off during washing of roots and gave way to microorganisms.

Table 3

Preservation of parsnip root crops of the Petrik variety depending on the method of packaging and washing

Method of the study	Mass loss, %	Affection by diseases, %	Yield of standard product, %
Unwashed in boxes	6.2	2.3	91.5
Washed in boxes	6.9	0.6	92.5
Unwashed in polyethylene bags	3.5	3.9	92.6
Washed in polyethylene bags	3.9	14.0	82.1

6. Discussion of results of studying the preservation of parsnip root crops depending on the degree of ripeness and storage methods

All root crops, except for radishes, were two-year crops. Their general biological feature – possibility to be in a state of rest at a lowered temperature. The state of rest is not deep in root crops and it is forced. The growth restores under satisfactory conditions. Biological function of the state of rest is differentiation of the cone of growth of buds of root crops preparing them for reproductive development [24]. The period while buds complete this preparation determines duration of rest and, consequently, preservation of a product.

There is dependence between the degree of ripening on the time of collection and the rate of differentiation of buds during storage, that is, preservation of root crops. In turn, ripening depends on many factors and, above all, on conditions of a year, terms of sowing and harvesting, etc. [1].

We can determine the degree of ripening of carrots by the ratio of sucrose/monosaccharides, that is, the ratio of the simplest polymer and sugar monomers. If this ratio is significantly higher than one, which means the prevalence of polymerized forms of sugars over simple ones, then ripening and preservation of products are good. If the ratio of sucrose/monosaccharide is less than one, simple forms of sugar prevail, ripening is insufficient, and preservation will be short. We observed the high content of dry matter and carotene in ripe root crops. Synthesis of carotene and vitamin C continues in the first months of storage if carrots have a vegetative period of 120–130 days. They reached a peak of accumulation and begin to hydrolyze. The content of all biologically active substances begins to decrease from the beginning of storage in overripe root crops [14].

We observed the highest yield of marketable products (98.3 %) at the storage of root crops of carrots in a box pallet with a polyethylene tab, where root crops were topped with wet sand. Polyethylene tabs and sand slowed down evaporation of moisture from root crops. Mass loss decreased in 6.2–7.6 times in comparison with control, the number of ill products – in 7.0–7.9 times, and there was no wastage at all.

Studies showed that there is high relative humidity of air (96–97 %) and a concentration of CO_2 (about 2 %) in the inter-root space at storing of parsnips in boxes with polyethylene tabs of a film with a thickness of 150–200 microns with an open top. Such environment conditions contribute to reducing of loss of root crops, that is, increased CO_2 concentration and low storage temperature reduce intensity of respiration of parsnips and improve its preservation. Condensate forms on walls of polyethylene tabs and on the raw material in the first days of storage, when root crops arrive in a storage room where the air temperature is low. It evaporates after. This "infectious droplet" stimulates development of microbiological processes, because it is enriched with organic matter and salts that penetrate from surface cells of plant tissue. It is the initial stage of plant damage by fungal diseases, which leads to germination of spores that are on the surface of a droplet in a weighed state under satisfactory conditions of feeding them with oxygen. The storage of parsnip in boxes with polyethylene tabs reduces mass loss significantly, but it can cause disease due to condensation, which is formed as a result of activation of vital processes of root crops, under conditions of high storage temperature (3–5 °C) (which sometimes happens in the storage).

We noted the similar trend during storage of red beet by the above methods. We observe the worst preservation of root crops (77.7–79.2 %) at storage in boxes in bulk without tabs. In this case, there are large natural losses of mass, a large number of diseased products and wastage. Application of polyethylene tabs increased the preservation of root crops by 13.5–14.0 %, however, there were quite a lot of diseased products at the end of the storage (3.5–4.2 %). The lowest total losses (3.1–3.8 %) were at storage of beets in a container with polyethylene tabs topped with a layer of wet sand [14].

Parsnip, especially slightly withered one, absorbs moisture very quickly during washing. The root surface becomes dry after washing, but there is free water in a root, which evaporates and precipitates on walls of polyethylene bags and root crops in the first hours of storage. These drops on root crops with dissolved nutrients in them are a good environment for microorganisms. Condensation on walls of bags, retarded aeration, somewhat elevated temperature in the first days of storage – these factors contributed to development of putrid microorganisms and caused an increased of diseases (3.9–14.0 %). Therefore, parsnip root crops stored in polyethylene bags should be washed before realization. Washed roots are more often affected at growth points, that is, where it is difficult to wash off dirt and where moisture remains. But, if a polyethylene bag forms condensation and deteriorates aeration, then there is always an increased loss due to evaporation in wooden vegetable boxes. The comparative estimation of storage of freshly washed root crops in polyethylene bags and vegetable wooden boxes (Table 3) indicates that root crops preserve well for 6 months in vegetable boxes, because they dry up there gradually and evaporate excess of moisture. In addition, it is difficult to dry a large washed batch quickly, and wet root crops that fall into polyethylene bags, that is, under conditions of constant high humidity, are quickly affected by rot and it is not possible to store them for a long time.

There were similar studies carried out with carrots. The average weight loss was equal at comparison of preservation of washed carrots and unwashed carrots, but unwashed root crops were less affected by diseases and they were more sprouting during storage. Unwashed carrots sprout more intensively. The land stuck to root crops contains vitamins, growth and other substances, which possibly stimulate sprouting [25].

The qualitative composition of parsnip root crops sugars is connected to their preservation. Persistent at storage varieties of parsnip are different from poorly preserved one by higher content of sucrose and less monosaccharide. The Student variety with sugar content of 5.7 % has a yield of standard fruits of 91.5 %. The Petrik variety with sugar content of 5.0 % has a yield of standard products of 90.3 %. This feature of the composition of sugar parsnips of varying preservation does not change in the process of prolonged storage.

Probably, we should consider the complex mechanism, which underlies sucrose transformations as the factor for good preservation of root crops, because the metabolism includes not only the sucrose that was found in vegetables at the beginning of storage, but also that sucrose, which was formed as a result of interconversions of carbohydrates. Therefore, it is almost impossible to determine the period of sales of products by the level of sucrose, since the level of its content varies widely in certain periods of storage as a result of ongoing hydrolysis of the carbohydrate complex, and therefore it does not always reflect the state of stored objects objectively.

Some authors state that proneness of carrot varieties to diseases is in direct dependence on the content of monozes in root crops – the more they are, the more they rot. [18] Studies conducted confirmed this opinion.

7. Conclusions

1. The smallest mass losses (5.0–6.7 %) and the highest level of stability (91.5–90.3 %) were in parsnips with a vegetative period of 150 days.

In the range of the growing period from 140 to 175 days, the growing period influences preservation of parsnip root crops the most – by 21.0 %, characteristics of a variety affect only 1.1 %, the interaction of the studied factors (AB) – 68 %, other factors (weather conditions, technology of growing) affect 9.9 %.

2. We found that unwashed root crops stored in open boxes are affected by diseases by 0.7 % more than washed ones. Storing of washed root crops in polyethylene bags increased damage to them almost in 3.5 times comparing with unwashed ones.

3. On average, the years of research showed that dry matter accumulated in root crops of the varieties under investigation from – 24.1 (for the Petrik variety) to – 27.7 % (for the Student variety). The high content of dry matter was for the Boris variety – 25.8 %. The content of monosaccharides was 1.2 %, sucrose – 3.7 %, and the total sugar content (5.0 %) for the Petrik (control) variety. The total content of sugar in the Boris variety (5.4 %) was at the control level. The largest total number of sugars were accumulated by root crops of the Student variety – 5.7 %. We found that the content of vitamin C in root crops was the lowest in the Petrik (control) variety – 9.9 mg/100 g, the Boris and Student varieties content of vitamin C was 10.1 and 10.2 mg/100 g, respectively, and it was less than control.

There was a decrease in dry matter by 6.2–11.4 % in root crops at the beginning of storage, the total content of sugars by – 16.8–25.8, sucrose by 20.0–36.5, vitamin C by 9.8– 30.0 %. The content of monosaccharides, on the contrary, increased by 8.0–30 %, depending on the method of storage.

4. We established that the mass loss of parsnip root crops depends on storage conditions by 33 %, characteristics of the variety affects only 1 %, the influence of factors interaction (storage conditions, features of the variety) is 64 %, and other factors – 2 %. The application of polyethylene film for packaging reduces loss of root masses of parsnip in 1.9–3.7 times for the Petrik variety, in 2.1–4.7 times for the Student variety and in 2.3–3.1 for the Boris variety comparing with storage of root crops in open boxes.

References

1. Koltunov V. A. Upravlinnia yakistiu ovochevykh koreneplodiv. Kyiv: KNTEU, 2007. 252 p.
2. Sharma K., Lee Y. R. Effect of different storage temperature on chemical composition of onion (Allium cepa L.) and its enzymes // Journal of Food Science and Technology. 2015. Vol. 53, Issue 2. P. 1620–1632. doi: https://doi.org/10.1007/s13197-015-2076-9
3. Sargent S. A., Moretti C. L. Tomato / K. C. Gross, C. Y. Wang, M. Saltveit (Eds.) // Agricultural handbook number 66: The commercial storage of fruits, vegetables, and florist and nursery stocks. Washington, 2007.
4. A review of recent research on tomato nutrition, breeding and post-harvest technology with reference to fruit quality / Passam H. C., Karapanos I. C., Bebeli P. J., Savvas D. // The European journal of plant science and biotechnology. 2007. Vol. 1. P. 1–21.
5. Koltunov V. A., Puzik L. M. Porivnialna otsinka sposobiv zberihannia plodiv kabachka // Ovochivnytstvo i bashtannytstvo. 2007. Issue 53. P. 354.
6. Koltunov V. A., Puzik L. M., Vakulenko L. M. Vplyv rozmiru ploda na zberezhenist kabachkiv, dyni, ohirkiv // Sbornik nauchnyh rabot Krymskogo gosudarstvennogo agrarnogo universiteta. 2006. Issue 93. P. 56–60.
7. Metabolic profiling of strawberry (Fragaria×ananassa Duch.) during fruit development and maturation / Zhang J., Wang X., Yu O., Tang J., Gu X., Wan X., Fang C. // Journal of Experimental Botany. 2010. Vol. 62, Issue 3. P. 1103–1118. doi: https://doi.org/10.1093/jxb/erq343
8. Fruit Quality of New Early Ripening Strawberry Cultivars in Croatia / Voča S., Dobričević N., Dragović-Uzelac V. et. al. // Food Technology & Biotechnology. 2008. Vol. 46, Issue 3. P. 292–298.
9. Biochemical changes during fruit development of four strawberry cultivars / Moing A., Renaud C., Gaudillère M. et. al. // Journal of the American Society for Horticultural Science. 2001. Vol. 126, Issue 4. P. 394–403.
10. Berry composition and climate: responses and empirical models / Barnuud N. N., Zerihun A., Gibberd M., Bates B. // International Journal of Biometeorology. 2013. Vol. 58, Issue 6. P. 1207–1223. doi: https://doi.org/10.1007/s00484-013-0715-2
11. Osokina N. M., Kostetska K. V. Vtraty plodovykh ovochiv pry zberihanni // Materialy tez mizhnarodnoi naukovo-praktychnoi konferentsiyi "Innovatsiyni ahrotekhnolohiyi v umovakh hlobalnoho poteplinnia". Melitopol, 2009. P. 177–179.

12. Maturity stages affect the postharvest quality and shelf-life of fruits of strawberry genotypes growing in subtropical regions / Rahman M. M., Moniruzzaman M., Ahmad M. R., Sarker B. C., Khurshid Alam M. // Journal of the Saudi Society of Agricultural Sciences. 2016. Vol. 15, Issue 1. P. 28–37. doi: https://doi.org/10.1016/j.jssas.2014.05.002
13. Kader A. A. Future research needs in postharvest biology and technology of fruits // Acta Horticulturae. 1999. Issue 485. P. 209–214. doi: https://doi.org/10.17660/actahortic.1999.485.28
14. Koltunov V. A. Yakist plodoovochevoi produktsiyi ta tekhnolohiya yii zberihannia. Ch. I. Yakist i zberezhenist kartopli ta ovochiv. Kyiv, 2004. 583 p.
15. Koltunov V., Bielinska Ye. Obhruntuvannia efektyvnosti zberezhenosti redysu metodom Kharrinhtona // Tovary i rynky. 2010. Issue 2. P. 62–68. URL: http://tr.knteu.kiev.ua/files/2010/10/12.pdf
16. Zherdetskyi I. K. Osoblyvosti zberihannia matochnykh koreneplodiv // Propozytsiya. 2010. Issue 11. P. 82–84.
17. Zavadska O. V., Bobos I. M., Diadenko T. V. Prydatnist koreneplodiv morkvy (Daucus carota L.) riznykh sortiv dlia pererobky // Sortovyvchennia ta sortoznavstvo. 2013. Issue 1. P. 51–54. URL: https://www.researchgate.net
18. Albert S. Vegetable harvest times. URL: https://harvesttotable.com/vegetable_harvest_times/
19. Sych Z. D., Fedosiy I. O., Podpriatov H. I. Pisliazbyralni tekhnolohiyi dorobky ovochiv dlia lohistyky i marketynhu: navch. pos. Kyiv, 2010. 440 p.
20. Ahatov A. K. Bolezni i vrediteli ovoshchnyh kul'tur i kartofelya. Moscow, 2013. 463 p.
21. Koltunov V. A. Tekhnolohiya zberihannia prodovolchykh tovariv: laboratornyi praktykum. Kyiv, 2002. 340 p.
22. Castro A., Bergenståhl B., Tornberg E. Parsnip (Pastinaca sativa L.): Dietary fibre composition and physicochemical characterization of its homogenized suspensions // Food Research International. 2012. Vol. 48, Issue 2. P. 598–608. doi: https://doi.org/10.1016/j.foodres.2012.05.023
23. Manosa N. A. Influence of temperature on Yied and Guality of carrots (Daucus carota var. sativa). URL: http://scholar.ufs.ac.za:8080/xmlui/bitstream/handle/11660/1299/ManosaNA.pdf;sequence=1
24. Rubatzky V. E., Quiros C. F., Simon P. W. Carrots and related vegetable umbelliferae. USDA-ARS, University of Wisconsin, USA. CABI, 1999. 294 p.
25. Sovremennye metody hraneniya i posleuborochnoy dorabotki plodoovoshchnoy produkcii: prakt. pos. / Andryushko A. et. al. Kyiv, 2006. 90 p.