ECRONICON OPEN ACCESS

EC NUTRITION
Review Article

Activation of Oxidizing Processes and Increasing Potato Yield, Ecological Safety and Shelf Life

Sergei V Murashev*

ITMO University, St. Petersburg, Russia

***Corresponding Author:** Sergei V Murashev, ITMO University, St. Petersburg, Russia.

Received: April 24, 2021; **Published:** July 30, 2021

Abstract

Potato the tubers of which acquired high constitutional defense mechanisms during growth (e.g. increasing the strength of cell walls and the Young's modulus of plant tissues in compression) is shown to be the most suitable for long-term storage in cooled condition. Changes in the energy of tubers tissue cells should ensure economical use of nutrients accumulated during the growth and minimum oxygen consumption by respiration during storage. These results at molecular and cellular level can be achieved by pre-sowing treatment of seed potato by amino acid preparation obtained by acidic hydrolysis of collagen. Given that collagen contains glycine amino acid in the highest quantity glycine is the main active component of collagen hydrolysate. Treatment by pure glycine is more effective than collagen preparation treatment. Along with the increasing protection of plants and tubers by constitutional mechanisms a yield increase takes place by 30% on average. Increased yield, accumulation of nutrients and the various energetic processes during vegetation period occurs due to more powerful photosynthetic apparatus in leaves of plants being subjected to glycine treatment. In light harvesting complexes of the photosynthetic apparatus in potato leaves the content of chlorophyll and carotenoids increases. Carotenoids serve not only as an additional light harvesting pigment, but also protect plants from photodamage and oxidative stress.

Keywords: *Potato; Mitochondrial Oxidase; Shelf Life; Breath; Physiological Heat; Nutritional Value*

Introduction

Potatoes are one of the most important plant crops [1], the tubers of which have a high nutritional value [2]. Taking into account the large volumes of potato production in Russia, reducing losses during storage is an important economic and economic task. The processes occurring during storage of plant products and their longevity are influenced by the activity of enzymes, which can change significantly during storage. Among the enzymes, terminal oxidases (cytochrome oxidase, polyphenol oxidase, ascorbate oxidase, etc.), which differ in their properties and specificity of participation in the protective reactions of plant organisms, are of great importance. In this regard, the problem arises of the dependence of the losses of chilled potatoes, associated with both vital activity and microbial damage during storage, on the activity of certain oxidases.

Problem statement based on the foregoing, the task arose to investigate the duration, during the entire period of refrigerated storage and the growing season of plants, the activation of certain terminal oxidases in potato tubers under the influence of biotic or abiotic factors, as well as the effect of this activity on yield losses during storage and formation of tubers during growth. In this case, it is believed that oxidases are activated by biotic or abiotic causes, the elimination of which normalizes the activity of oxidases.

Investigation of the problem: Oxidation products (quinones, etc.), the concentration of which increases in plant tissue with prolonged and active course of processes catalyzed by non-mitochondrial oxidases, disorganize intracellular processes. Disturbances in the functioning of plant cells can be very significant: there is a weakening of immunity, and cell death is possible. The long-term activity of oxidative processes, including during storage of plant products, is associated with two main causes of cell degradation: First, non-mitochondrial oxidative processes are not associated with the synthesis of ATP, while the synthesis of substances that undergo oxidation, for example, phenols, requires constant and significant energy consumption.

Therefore, the role of the polyphenol-polyphenol oxidase system in the normal respiration of plants has long been questioned due to the lack of conjugation with the synthesis of ATP [3]. It is also necessary to bear in mind the darkening that occurs during the active state of this enzyme and worsens the presentation of the product. At the same time, the short-term activity of polyphenol oxidase in extreme situations, for example, when healing wounds received by tubers during harvesting or transportation, undoubtedly has a great protective value.

To activate polyphenol oxidase, an increased oxygen content in the tissues is required. Its influx into damaged tissues occurs through wounds received by potato tubers. After their healing, the flow of oxygen slows down, and the activity of polyphenol oxidase decreases. The prolonged course of oxidative processes deprives the necessary resources of various energy-dependent vital processes in cells. The most important of them include, for example, the creation and maintenance of membrane potential, the presence of which is directly related to the living state of cells.

Energy-dependent processes also include renewal processes in cells. So, enzyme molecules, including polyphenol oxidase, have a certain time of active state, after which the molecules lose their activity and must be replaced by new, active molecules. There is no doubt that any renewal processes in cells require energy expenditure. Another group of extremely necessary energy-dependent processes in cells constitutes the transport of substances inside cells and the maintenance of the required concentrations of compounds in the intracellular compartments. Secondly, an increase in the concentration of oxidized compounds will change the redox potential of the cell, which will affect the conditions for the functioning of all processes occurring in it.

The activity of enzymes will change, including those involved in the production of energy in cells. As a result, the transport flows and concentration gradients of substances characteristic of the homeostatic state between the cell compartments will change. It is easy to see that two groups of causes that cause cell degradation during prolonged activity of oxidative processes not associated with the formation of ATP are closely interrelated.

The question arises, how, in order to preserve their vital activity, cells must respond to prolonged activation of such oxidative processes with prolonged external biotic or abiotic action? Of course, there can be only one cellular response - an increase in the synthesis of ATP in cells. For this, in turn, the intensity of respiration must increase, which will lead to an accelerated loss of substances consumed in this process, primarily carbohydrates.

However, as a result of intensive evaporation of water, a deceptive effect of increasing the dry matter content and nutritional value of potatoes can arise. The indicated cellular response can be effective only if the conjugation of respiration and oxidative phosphorylation is maintained, as well as in the absence of intensification of anaerobic processes in plant cells. But even with the most favorable outcome with the preservation of the conjugation of respiration and oxidative phosphorylation, an increase in the intensity of respiration will necessarily cause an increased release of carbon dioxide and physiological heat. The latter will negatively affect the storage of potatoes and their presentation.

Physiological heat release stimulates the evaporation of water from plant products. It accounts for about 80% of the mass loss of plant products associated with life activity. Respiration intensification due to external biotic or abiotic effects leads to an increase in water evaporation, which increases the set of components that form dry matter, and this despite an increase in carbohydrate losses associated with an increase in respiration intensity. In such a situation, it is of particular importance to determine the natural loss of potato mass and accompanying measurements.

Due to the evaporation of water in potatoes, the content of starch, ascorbic acid, protopectin and other components increases. As a result, there will be a deceptive impression of an increase in the biological (increase in the content of vitamin C), food (increase in the content of starch) value of potatoes and an improvement in its preservation, and, consequently, an increase in the resistance of tubers to the action of microorganisms (an increase in the content of protopectin).

Turgor and an increase in the humidity of the air environment inside the layer of potato tubers, which can lead to sweating of the tubers. Due to an increase in the humidity of the environment in the potato layer, the probability of condensation of water increases, the drops of which on the surface of the tubers create the environment necessary for the development of phytopathogenic microorganisms.

In turn, an increase in temperature in the thickness of a stack of potatoes due to self-heating creates favorable conditions for the development of phytopathogenic microorganisms, a loss of turgor reduces the resistance of potato tubers to their action. Loss of turgor will also worsen the external presentation of plant products. At the same time, it is well known that on the dry and turgid surface of the tuber, the emergence of a focus of infection is practically not observed, drying is especially important, which hinders or prevents the introduction of microorganisms [4].

Potatoes, in comparison with other types of plant products, are distinguished by the highest sensitivity to increased CO_2 concentration in the ambient air, the level of which should not exceed 1% [4]. With an increase in the maximum permissible concentration of very sensitive to the action of CO_2 species of plant products, resistance to damage by phytopathogenic microorganisms decreases, and when water condensate falls on the surface of the tubers, specific acid burns and other damage are formed.

As already noted, physiological heat release causes self-heating of potatoes, activating the tuber process. The keeping quality of potatoes is determined by the depth and duration of the dormant period, during which the intensity of respiration and the activity of redox enzymes are low [5]. Therefore, if, under an external biotic or abiotic effect, the intensity of respiration and the activity of oxidative enzymes (peroxidase, polyphenol oxidase, etc.) during the dormant period in potatoes remain at a higher level in comparison with the control variant, this indicates that the depth of dormancy decreases, and its the duration is shrinking.

Naturally, a reduction in the duration of a biologically determined dormant period will reduce the persistence of potatoes. Thus, intensification of respiration stimulates a whole complex of negative changes in potatoes, as a result of which the likelihood of its damage by phytopathogenic microorganisms increases, view. As a result, the duration of storage and the possibility of subsequent sale of potatoes are reduced. The ongoing changes create additional difficulties in organizing storage. To prevent them, it is necessary to ensure that excess carbon dioxide, moisture and heat are removed from the potato stack. This can be achieved by increasing ventilation.

The intensification of respiration makes the removal of heat, carbon dioxide and regulation of air humidity during ventilation more difficult and time consuming. Increasing active ventilation inevitably leads to increased storage costs. At the same time, active ventilation allows the supply of exogenous growth-regulating substances to the layer of stored products [4], which eliminates the need to develop, create and use any additional mechanisms for processing potatoes.

Activity of oxidative enzymes (peroxidase, polyphenol oxidase, etc.). The tissues in which it is observed are characterized as tumor in comparison with normal tissues [6]. Consequently, if the activation of the combination of the above enzymes is characteristic of tumor tissues, then the external influence providing such activation, in essence, transfers normal tissue by biochemical properties to the category of tumor ones. It should be emphasized that the continuous activity of polyphenol oxidase is an anomaly leading to the energy depletion of plant organisms.

This enzyme is characterized by activation during aging of tissues. Thus, prolonged activity of oxidative non-mitochondrial enzymes, increased respiration and energy metabolism negatively affect the keeping quality and preservation of potatoes. It is possible to prevent external influences that cause such reactions in potatoes by strengthening constitutional defense mechanisms, including the formation of certain morphological features in tubers and the synthesis of antibiotic substances (phenols, etc.) [7]. Phenols also belong to antibiotic substances, however, polyphenol oxidase is not activated, except for the period when tubers may be injured.

Solution to the problem: The formation of constitutional defense mechanisms occurs during the growth of tubers. The activation of polyphenol oxidase during this period interferes with the formation of the potato crop. It is known that the ability to tuberize in potatoes is associated with a weak activity of polyphenol oxidase [8]. A similar situation is observed in root crops.

For example, in carrots, the increase in the crude substance in normal tissue occurs with a decreased activity of polyphenol oxidase more intensively than in tissue with an increased activity of this enzyme [6]. Consequently, this is a universal and not a specific feature of the effect of polyphenol oxidase. Its activity, due to the lack of conjugation with the synthesis of ATP and other previously indicated reasons, cannot contribute to the formation of the crop.

Unless we take into account a special group of nitrogen-fixing microorganisms, plants assimilate nitrates by roots and leaves. The absorption of nitrates is a regenerative process. The reactions catalyzed by oxidases are essentially a reverse oxidation process. Therefore, in a situation where polyphenol oxidase and other oxidative enzymes are activated, it is difficult to expect the reduction of nitrates and a decrease in their content in the storage organs of plants.

Detoxification of heavy metals in plant tissues occurs as a result of their binding into stable chelate complexes. Reduced glutathione has the ability to form stable complexes. As in the case of nitrates, the activation of oxidative enzymes and the maintenance of glutathione in a reduced state are opposite processes. It is obvious that the binding of heavy metals into complex compounds under conditions of activation of oxidative processes is difficult. For example, when polyphenol oxidase is activated, the formation of quinones, which are capable of oxidizing glutathione, increases.

Thus, an obstacle arises for the manifestation of the properties of the ligand by glutathione. Thus, not only the production of ecologically safe plant products with a reduced content of nitrates and other toxic components, but also the production of the plant products itself when the enzyme polyphenol oxidase is activated, which is not conjugated with ATP synthesis, is a difficult problem to solve.

Strengthening constitutional defense mechanisms in potato tubers, which is an energy-consuming process (for example, the synthesis of lipid components of integumentary tissues), when oxidative processes are activated, also seems unlikely. Their enhancement can be provided by changes in cellular metabolism, which can be carried out by pre-sowing treatment of potato tubers with glycine.

Glycine is capable of stimulating the growth and development of plants, the formation of their storage organs. An action similar to glycine can also be exerted by a product obtained by acid hydrolysis of collagen [9]. This is due to the fact that the share of glycine in collagen accounts for the largest part of the amino acid composition, and also due to the fact that glycine, during acid hydrolysis of collagen, is least exposed to the destructive effects of high temperature and acidic environment of all its constituent amino acids.

There are also other reasons. In terms of efficiency, pure glycine significantly surpasses acidic collagen hydrolyzate. Strengthening of permanently acting protective mechanisms [10], an increase in productivity, stress resistance and adaptive capabilities under the action of glycine or a glycine-containing product of acid hydrolysis of collagen occurs with plants that have aboveground fruiting parts [11] and with underground fruiting organs [12]. Autumn processing with glycine increases the resistance of perennial plants in winter to low negative temperatures [13]. A deeper dormant state of plants during the long period [14] increases productivity, and the harvested crop is better safety.

The depth of dormancy of plants in winter directly affects the formation of storage organs during the growth of protective mechanisms that minimize yield losses during storage. Under the action of glycine, productivity increases, stress resistance increases and the adaptive capacity of potatoes is enhanced [9], including the formation of wound periderm of tubers [15].

The stimulating effect of glycine has been confirmed by tests on potato varieties with different ripening periods. The mechanism of the stimulating action is realized through the breakdown of excess exogenous glycine in plant cells, as a result of which energy and metabolic flows in them change, which determine both the formation of generative organs and subsequent refrigerated storage after separation from the parent plant As a result of an increase in the synthetic capabilities of plant organisms, constantly acting protective mechanisms are enhanced, due to the creation of conditions for the energy-intensive synthesis of substances that perform protective functions, including membrane lipids, lipid components of the epidermis, phenolic compounds and others.

Under the influence of exogenous glycine, metabolic processes in cells change in such a way that the synthesis of endogenous auxin is stimulated, which affects the defense mechanisms. Long-term storage becomes possible due to the economical consumption of nutrients and minimal oxygen consumption. The active state of cytochrome oxidase and the reduction of electron leaks from the electron transport chain of mitochondria ensure the flow of energy-dependent processes in cells and prevent the formation of free radicals, which together creates conditions for long-term and normal vital activity of cells of plant storage organs during storage.

Conclusion

The analysis made it possible to establish that in the course of formation in potato tubers, constitutional defense mechanisms should be strengthened, ensuring the long-term storage and cooling and minimization of losses from microbial damage. The optimal ratio between dichotomous pentose phosphate pathways of respiration arises under the influence of the effective concentration of glycine, which creates conditions for the formation of all the necessary metabolites used in the synthetic processes of plant tissues. Under the influence of glycine, changes also occur in the energetics of cells, consisting in an increase in their energy potential. The growth of the energy potential between the cytokine in favor of the latter, and in reducing the leakage of electrons from the electron transport chain of mitochondria due to the reduction in the content of oxidized forms of compounds that are potential acceptors of electrons. Activation of cytochrome oxidase is caused by microstress occurring under the action of exogenous glycine. This approach to solving the most important problem will allow to establish long-term storage of potatoes, and with minimal losses you will be different high quality and environmental safety.

Bibliography

1. Marchenko VI., *et al*. "Est' li budushchee u rossiiskoi plodoovoshchnoi produktsii [Is there a future Russian fruit and vegetable products]". Proceedings of the St. Petersburg State Agrarian University 35 (2014): 26-31.

2. Marchenko VI and Stepanova NYu. "Khimicheskii sostav plodov i ovoshchei [The chemical composition of the fruit and vegetables]". Nauchnoe obespechenie razvitiya APK v usloviyakh reformirovaniya. Proceedings of the conference. St. Petersburg (2014): 414-417.

3. Kretovich VL. "Osnovy biokhimii rastenii [Fundamentals of biochemistry of plants]". Moscow, Vysshaya shkola Publ (1971): 464.

4. Shirokov EP. "Tekhnologiya khraneniya i pererabotki plodov i ovoshchei s osnovami standartizatsii [Technology of storage and processing of fruits and vegetables with standardization bases]. Moscow, Agropromizdat Publ (1988): 319.

5. Shirokov EP and Polegaev PI. "Khranenie i pererabotka produktsii rastenievodstva s osnovami standartizatsii isertifikatsii [Storage and processing of crop production with the basics of standardization and certification]. Part1. Kartofel', plody, ovoshchi. Moscow, Kolos (1999): 254.

6. Polishchuk VL and Kalinin FL. "Oksidazy v tkanyakh morkovi s normal'nym rostom i pri indutsirovanii opukholi [Oxidases in carrots fabrics with normal growth and at induction of a tumor]. Growth and stability of plants. Kiev, Naukova dumka Publ (1967): 272.

7. Tret'yakov NN., *et al*. "Fiziologiya i biokhimiya sel'skokhozyaistvennykh rastenii [Physiology and biochemistry of agricultural plants]. Moscow, KolosS Publ (2005): 656.

8. Kuznetsov VV and Dmitrieva GA. "Fiziologiya rastenii [Vegetable physiology]. Moscow, Vysshaya shkola Publ (2005): 736.

9. Bol'shakov OV., *et al*. "Preparaty «Biostim A» i «Biostim M» -novye regulyatory rosta i razvitiya rastenii [The preparations Biostim A and Biosty M -new regulators of growth and development of plants]. Storage and processingof agricultural 6 (1999): 29-31.

10. Murashev SV and Verzhuk VG. "Sovremennaya tekhnologiya polucheniya plodovo-yagodnoi produktsii susilennymi postoyanno deistvuyushchimi zashchitnymi mekhanizmami [Modern technology of production of fruits and berries with reinforced constantly acting defense mechanisms]. Fruit and berry-culture of Russia 22.2 (2009): 153-158.

11. Murashev SV., *et al*. "Sposob podgotovki plodov semechkovykh kul'tur kkholodil'nomu khraneniyu [The method of preparation of pome fruit crops in cold storage]. Patent RF (2004): 2283576.

12. Sapronov NM., *et al*. "Sposob stimulyatsii rosta i razvitiya korneplodov sakharnoi svekly [A method of stimulating the growth and development of sugar beet]. Patent RF, no (2007): 2337544.

13. Murashev SV., *et al*. "Sposob obrabotki plodovo-yagodnykh kultur (varianty) [The method of processing fruit and berry crops (versions)]. Patent RF (2012): 2485764.

14. Kolomicheva EA and Murashev SV. "Deistvie aminokislotnoi obrabotki na sostoyanie pokoya rastenii, formirovanie plodov i ikh kholodil'noe khranenie (teoreticheskie polozheniya) [Action amino acid processing plant in the state of rest, the formation of fruits and cold storage (theoretical position)]. Scientific journal NRUITMO. Series: Processes and equipment for food production 2.16 (2013).

15. Murashev SV. "Stimuli ruyushchee deistvie glitsina na formirovanie ranevoi peridermy v klubnyakh kartofelya [The stimulating effect of glycine on the formation of wound peridermin potato tubers]. Proceedings of the St. Petersburg State Agrarian University Izvestiya 40 (2015): 33-37.

Volume 16 Issue 8 August 2021