PROTECTIVE-STIMULATING PROPERTIES OF CHITOSAN IN THE VEGETATION AND STORING TOMATOES

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Abstract

Data for using natural chitosan for plant-induced resistance to diseases and physiological stresses are presented. Provision on the possibility of combining resistance inducer properties not only to diseases, but also to physiological stresses, is postulated.

It is shown that treatment of tomatoes and tomato seeds with chitosan leads to both increased resistance and increased reproductive abilities of tomato plants. The biogenic elicitor chitosan, based on a "Agrohit" ("АгроХит") preparation, induces the resistance of tomatoes to Phytophtora infestan and Alternaria solani. The plants grown from seeds processed by chitosan exhibit less damage from pathogens during the vegetation period. The action of the elicitor influenced a change in terpenoid biogenesis (formation of a phytoalexinari chitin). Beside protection functions, this preparation has stimulating activity and can be used to achieve higher yields of tomatoes, which are tolerant to stress conditions.

The use of elicitors for plant-induced resistance provides ecological safety and an economically significant improvement of the parameters of plant produce and storage.

Keywords: *tomato, tomato seeds, chitosan, induced resistance, phytoalexins, abiotic stress.*

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1. Introduction

The problem of disease resistance of fruits and vegetables to infectious and physiological diseases in the "vegetation-storage" cycle can be solved by using chemical and biological means of protection, termed immunity inducers. A promising direction of research is finding possible plant protection based on inducing mechanisms of their natural stability. Such a protection assumes indirect impacts on pathogens by means of activating natural stability mechanisms of plants. The immune status of plants can be controlled by means of certain immune correctors.

Biogenic elicitors that induce disease resistance in vegetables are chitin and its deacetylated derivate – chitosan. These biopolymers are characterised by safety, biocompatibility, systematicity and duration of a protective action [1].

2. Materials and Methods

There are many various compositions for plant protection on the basis of low molecular chitosan. As an immunity inducer for this purpose, the pollution-free and safe-growth bio-stimulant of melons and gourds – the preparation "Agrohit", made of low-molecular chitosan – was used. The preparation "Agrohit" consists of an active ingredient of chitosan lactatum that contains a 4% solution of chitosan, with a molecular mass of 5–20 kDa, in a 1% solution of a lactic, acetic or hydrochloric acid (Developer: Bioinzheneriya center of RAS, CJSC Bioprogress).

Chitosan for the preparation "Agrohit" was produced from a crust of red king crabs or crawfishes.

The chemical composition of the preparation "Agrohit" is presented in Table 1.

Table 1. Chemical composition of the preparation "Agrohit"

Substance	**Mass fraction (%)**
low-molecular chitosan with a molecular mass of 10–25 kDa	0.5–3
0.5–1.0% aqua solution of lactic acid	10–90
lactoserum	10–90

Tomatoes of the Kuner type were chosen as the research subject for immunity inducer action. Fruits (lactic degree of maturity) and seeds were processed by the composition "Agrohit", applied by the methods of spraying (fruits) and soaking (seeds). The consumption rate of the composition was 1.5 l/t. Seeds and fruits processed by water were used as the reference standard. Green and pink fruits of tomatoes (the first 10 days) were stored at a temperature of 18±2°C, and mature tomatoes (after 10 days) were stored at a temperature of 4±2°C.

The formation of phytoalexins is a de novo local fusion reaction of protective agents of plant cells. The determination of rishitin content in tomatoes was carried out by the technique described in previous work [2].

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3. Results and discussion

The physiological response of plants to any stress includes a huge complex of various biochemical reactions – reactions of oxidising explosion, emergence of free radicals, oxidation of fatty acids, change in membrane transmissivity, synthesis of proteins and other substances participating in the strengthening of a cell-like wall, formation of phytoalexins, activation of different kinds of enzymes, especially oxidoreductases (peroxidases, lipoxygenases, polyphenol-oxidases), phenyl alanine-ammonia-lyase, synthesis of pathogen-induced proteins and inhibitors of proteases, etc. These numerous reactions take place in a particular sequence and characterise the protective response to infection [3]. Among all biochemical indexes available, the ability of plants to form phytoalexins, in some cases, more adequately reflects properties of stability.

Despite the production of phytoalexins being well-defined genetic trait, it heavily depends on the physiological condition of a vegetable organism and its environment. The more life-sustaining activities that take place in a cell, the more capable it is of forming phytoalexins, and therefore its stability is higher. In the course of degreening and storage of fruits, their ability to produce phytoalexins decreases, which is in correspondence with the decrease in resistance of fruits to diseases [4, 5] (Fig. 1 and 2).

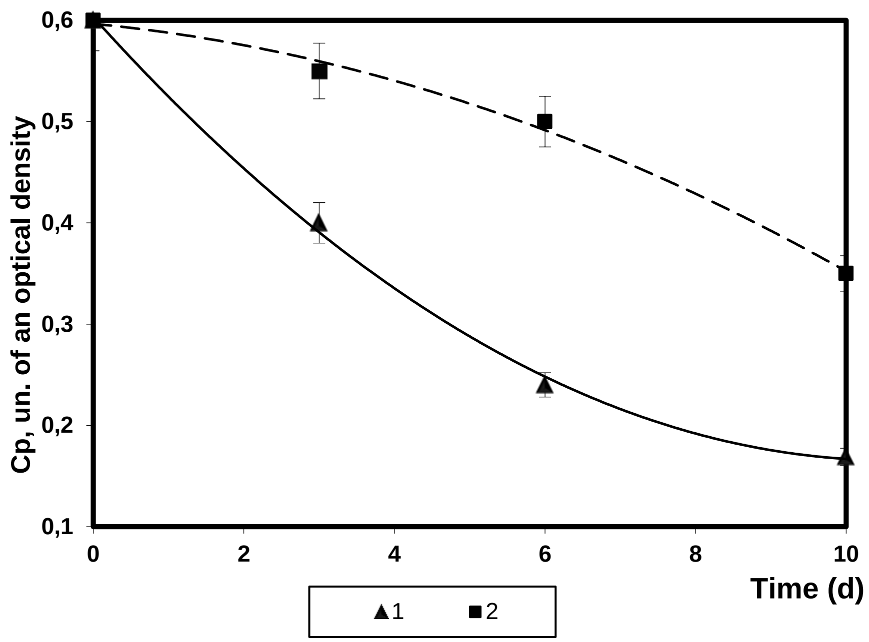

Figure 1. Dependence of optical density of aqueous extract from tomatoes of Kuner type (Cp) on time of degreening of fruits after treatment (t): 1 – monitoring; 2 – treatment by the preparation "Agrohit".

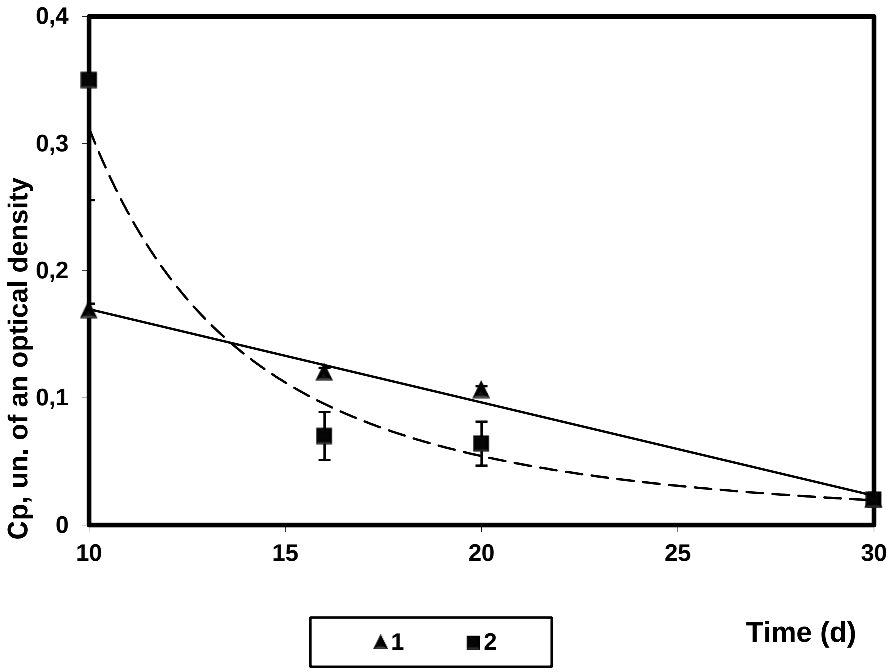

Figure 2. Dependence of optical density of aqueous extract from tomatoes of Kuner sort (Cp) on storage time of fruits after treatment (t): 1 – monitoring; 2 – processing by the preparation "Agrohit".

However, pre-processing tomato fruits by a preparation based on chitosan changes the nature of metabolism of rishitin in their tissues. It is supposed that the induction of phytoalexin formation caused by chitosan gives the prolonged protective reactions of vegetable tissue.

Due to there being a directly proportional dependence [3] between the concentration of rishitin phytoalexin in tomatoes and the amount of optical density of aqueous extract from it, the influence of the preparation based on chitosan on rishitin concentration and, consequently, the protective characteristics of tomatoes, was estimated by the alteration of the amount of optical density. Dynamic characteristics of protective reactions in tomatoes were exhibited within the first 2–3 days (Fig. 1). According to Tyuterev [3], the duration of signal transmission and mechanisms of induction of protective reactions take place on 1–4 days after the influence of a biotic or abiotic stress. As phytoalexins are phytotoxic, they must be metabolised rapidly so as not to remain in plant cells for a long time.

The reduced temperature of the storage of tomatoes fruits was an additional abiotic stress in the present study. It is known that plant cells actively react to any change in the environment, reconstructing the metabolism and metabolic reactions needed to maintain normal functioning of an organism in the changed conditions and to create protective responses of the immunising action. Hypothermia affects phytoalexin activity of vegetable tissues, which may be a reason for the change in enzyme activity and physiological state during the post-climacteric period. The functionally active state of rishitin in comparison with monitoring testifies for the long-term tension of metabolic processes in the cells of a vegetable object caused by adaptation to low temperatures of storage (4±2°C) (Fig. 2).

Under the influence of pre-plant treatment of tomato seeds by the preparation "Agrohit", pathogen resistance was induced. Inspection of experimental and reference planting spots of plants of tomato showed that in planting spots made on a natural infection background, there were plants with signs of phytophthora withering; this was in the form of yellowish-brown spots on the ends and on the edges of foliage. From the results of the phytopathologic analysis of an average sample of the selected exemplars, which were grown with the application of immunisation of seeds among pathogens, the main agents of Alternaria blight and phytophthora rot were revealed. The extension of plant diseases at vegetation in the experimental sample was minimal: the first signs of infection by phytophthora rot appeared only at the end of vegetation.

Processing of the seed material by chitosan not only suppressed development of phytopathologic diseases, but also induced systemic stability of a plant against the influence of pathogens, making its endogenous immunity active. The biological resistance against a complex of diseases was 43%.

Recently in the literature, the question about the adaptation of plants to stressful environmental factors, such as predators, diseases, pesticides and rapidly changing climatic conditions, is widely discussed. Therefore, it is important to note the beneficial impact of processing the seeds with a chitosan preparation on the growth and development of the protected plants. Their ability to cope with the influence of adverse factors affects their ability to develop and on the productivity and quality of vegetable production.

Soaking seeds in the preparation "Agrohit" boosted the acceleration of viability and accumulation of biomass, i.e. a thickening of stalks. Moreover, this treatment significantly increased the leaf area, which demonstrates an increase in the energy available at germination and the dynamic growth of the tomato plants.

Thus, this study showed the ability of chitosan, as part of the preparation "Agrohit", to cause an intensification of protective reactions in the plants and fruits of tomato, with the formation of stress metabolites, to increase the total level of phytophysiological activity.

4. References

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