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OPTIMUM CONCENTRATION OF EXOGENOUS ANTIOXIDANTS FOR THE STORAGE OF ZUCCHINI FRUIT

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Abstract

The article investigates the influence of exogenous antioxidant substances (chlorophyllipt, ionol and lecithin) on the duration of storage and the quality of zucchini fruit (Kavili F1 and Tarmino F1). It has been established that the use of compositions of the listed antioxidants allows for lengthening of the storage of zucchini for 6 ... 12 days, depending on the type of treatment. It has been shown that in an antioxidant composition, the optimum concentration for ionol is 0.048% and 0.75% for chlorophyllipt. It has been found out that for creating a delamination-resistant preparative form of the antioxidants the required concentration of lecithin amounts to 4%. The joint effect of optimum concentrations of ionol and chlorophyllipt, as well as of the three-component composition, which includes 0.75% chlorophyllipt; 0.048% ionol and 4% lecithin, has been investigated. It has been shown that during the application of the complex antioxidant composition, the average daily weight loss is 2.73 ... 3.14 times reduced as compared with control variants and 1.36 ... 1.86 times reduced as compared with other types of treatment depending on the hybrid of the zucchini. It has been established that the use of such a composition allows for lengthening the storage time of zucchini up to 24 days, which is twice as long as compared with the group of control. Thus the output of standard products of processed zucchini after storage is 91,88 ... 91,95%, taking into account natural mass losses.

Keywords: storage; zucchini; heat treatment; antioxidants; concentration.

ОПТИМАЛЬНІ КОНЦЕНТРАЦІЇ ЕКЗОГЕННИХ АНТИОКСИДАНТІВ ДЛЯ ЗБЕРІГАННЯ ПЛОДІВ КАБАЧКА

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Анотація

Досліджено вплив екзогенних антиоксидантних речовин (хлорофіліпт, іонол та лецитин) на тривалість зберігання та якість плодів кабачка (Кавілі F1 та Таміно F1). Встановлено, що застосування композицій з перелічених антиоксидантів дозволяє подовжити тривалість зберігання кабачків на 6...12 діб залежно від виду обробки. Показано, що в антиоксидантній композиції оптимальна концентрація іонолу становить 0,048 %, хлорофіліпту 0,75 %. Виявлено, що для створення стійкої до розшаровування препаративної форми антиоксидантів необхідна концентрація лецитину складає 4 %. Вивчено сумісний вплив оптимальних концентрацій іонолу та хлорофіліпту, а також трьохкомпонентної композиції, до складу якої входили 0,75% хлорофіліпту; 0,048 % іонолу та 4 % лецитину. Показано, що під час застосування комплексної антиоксиданої композиції, середньодобові втрати маси скорочуються у порівнянні з контрольними варіантами у 2,73...3,14 рази та в 1,36...1,86 порівняно з іншими обробками залежно від гібриду кабачків. Встановлено, що використання такої композиції дозволяє подовжити тривалість зберігання кабачків до 24 діб, що вдвічі довше при порівнянні з контролем. При цьому вихід стандартної продукції оброблених кабачків після зберігання складає 91,88...91,95 % з урахуванням природних втрат маси.

Ключові слова: зберігання; кабачкі; теплова обробка; антиоксиданти; концентрація.

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ОПТИМАЛЬНЫЕ КОНЦЕНТРАЦИИ ЭКЗОГЕННЫХ АНТИОКСИДАНТОВ ДЛЯ ХРАНЕНИЯ ПЛОДОВ КАБАЧКА

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Аннотация
Исследовано влияние экзогенных антиоксидантных веществ (хлорофиллипт, ионол и лецитин) на продолжительность хранения и качество плодов кабачка (Кавили F1 и Тамино F1). Установлено, что применение композиций из перечисленных антиоксидантов позволяет продлить срок хранения кабачков на 6 … 12 суток в зависимости от вида обработки. Показано, что в антиоксидантной композиции оптимальная концентрация ионола составляет 0,048%, хлорофиллипта 0,75%. Выявлено, что для создания устойчивой к расслаиванию препаративной формы антиоксидантов необходимая концентрация лецитина составляет 4%. Изучено совместное влияние оптимальных концентраций ионола и хлорофиллипта, а также трехкомпонентной композиции, в состав которой входили 0,75% хлорофиллипта; 0,048% ионола и 4% лецитина. Показано, что при использовании комплексной антиоксидантной композиции, среднесуточные потери массы сокращаются по сравнению с контрольными вариантами в 2,73 … 3,14 раза и в 1,36 … 1,86 по сравнению с другими обработками в зависимости от гибрида кабачков. Установлено, что использование такой композиции позволяет продлить срок хранения кабачков до 24 суток, что вдвое дольше при сравнении с контролем. При этом выход стандартной продукции обработанных кабачков после хранения составляет 91,88 … 91,95% с учетом естественной убыли массы.

Ключевые слова: хранение; кабачки; тепловая обработка; антиоксиданты; концентрация.

Introduction

Ukraine has entered the top five vegetable producing countries in the world, since 18% of Europe's vegetables and 33% of the vegetables in the CIS countries are grown here [1]. Today Ukrainian producers supply about 2.15 million tons of tomatoes, 1.88 million tons of cabbage, 0.94 million tons of cucumbers and 0.53 million tons of zucchini to the domestic market [2]. But consumption of vegetables in our country remains low, despite the growing production rate - about 240 kg / one person per year [3]. Taking into account feeding costs (16%), losses in storage (12%), exports (3%), seeding (1%), the consumer receives only 163 kg / one person.

All of these positions require a correction of loss during the storage of products. Potential manufacturers are experiencing an acute need of scientific knowledge. The results of scientific research can reduce the loss of products and increase their shelf life, in particular, of such popular vegetables as zucchini. This will be a convincing rationale for investors.

Problem Statement. At present, Ukraine has 1343 storage facilities with the capacity of 2.4 million tonnes for the storage of vegetable products [4]. But the use of refrigeratory conditions in the storage of fruit of tropical and subtropical cultures proved to have low efficiency due to the damage of subambient temperature and rapid loss of quality [5–8].

The task of improving the livability of zucchini fruit, which represent tropical crops, is still unresolved [9]. The traditional refrigeratory storage results in the coldness stress of zucchini. It is an adaptive response to low temperature conditions.

The damaging influence of excessive free radicals concentration on biological structures is an established fact [10; 11]. Under the influence of extreme factors, oxidative stress provokes an increase in the level of active forms of oxygen, which can damage molecules, suppress the activity of enzymes, and destroy cell membranes. In these pathological conditions, the fruit quickly lose their quality [12; 13].

Analysis of Recent Studies and Publications

Scientists around the world are working on the development and improvement of the products that can prevent the development of the stress state of the fruit on condition of cooling and prolong the storage time [14–17]. It is important to block the processes of free radical oxidation at the initial stages of their development.

Excessive synthesis of active forms of oxygen suppresses the function of endogenous antioxidants, which prompts the development of reliable sources of counteraction. The search for inexpensive, non-toxic antioxidants is under way around the world [18; 19]. But the main attention of scientists is focused on natural oxidation inhibitors, because they play a key role in preventing the oxidation of biological structures [20].

To compensate for the damaging effect of low temperatures, leading world scientists recommend using post-harvest heat treatment of fruit with antioxidants [21; 22].

Statement of the Objectives of the Study. The heat treatment of zucchini fruit with the compositions of natural and synthetic antioxidants will provide the effective support of protective functions of the antioxidant system of fruit only under the condition of proper choice of concentrations. Increased concentrations of some exogenous antioxidant substances can be toxic due to their pro-oxidant effect at high doses [23]. Insufficient level of antioxidants in the agents for heat treatment of zucchini will not provide the desired result. Therefore, the purpose of the work is to choose the optimum concentration of antioxidants for the heat treatment of zucchini before storage.

Research methods and materials

The research was carried on the basis of the Laboratory of Processing and Storage Technology of Agricultural Products at the Research Institute of Agro-Technologies and Ecology of Tavria State Agrotechnological University (Ukraine).

The subject of the study was the fruit of Kavili F1 and Tarmino F1 zucchini. Healthy fruit with a 16-21 cm long fruitstalk were put for storage.

Fruit of zucchini were immersed in the solutions of antioxidant compositions at the temperature of 42 ° C for 10 minutes. They were preserved at 8 ± 0.5 ° C and the relative humidity of 95 ± 1 %. The temperature and duration of heat treatment are based on literary sources [21, 22].

The compositions consisted of the following components [24; 25]:

– chlorophyllipte (Ch) prepared from an alcoholic chlorofilipot solution (PJSC "Halychpharm", Lviv),

– ionol (I) by Sterlitamak Scientific-Production Plant (Russia),

– lecithin (L) 96.55% pure, obtained from sunflower seeds (Sunny Ltd., Dnipro). Untreated fruit were taken for control.

Results and discussion.

Selection of Ionol Concentration. Higher concentrations of ionol (0.036, 0.048, 0.060%) and Chlorophyllipt (0.5%, 0.75%, 1%), which are characterized by minimal antioxidant status, were tested for correction of the antioxidant protection of zucchini tissues. To create a resistant to stratification of antioxidant formulation, the required concentration of lecithin is 4%.

The use of antioxidants extends the shelf life to 18 days, which is 1.5 times more than for the control group (Table 1).

Table 1

Natural Loss of the Mass of Zucchini Due taking into account the action of Antioxidants; X ± SX, n=5

Treatment Version	Duration of Storage, days	Kavili		Tarmino	
		Natural Loss of the Mass,**%**	Average Daily Loss of the Mass,%	Natural Loss of the Mass,%	Average Daily Loss of the Mass,%
Control	12	2.32±0.09	0.19±0.01	3.02±0.05	0.25±0.00
0,036 I+L	18	1.88±0.06	0.10±0.00*	2.43±0.06	0.14±0.00*
0,048 I+L	18	1.81±0.05	0.10±0.00*	2.44±0.06	0.14±0.00*
0,060 I+L	18	1.85±0.06	0.10±0.00*	2.48±0.08	0.14±0.00*
0,50 Ch+L	18	2.26±0.05	0.13±0.00*	2.92±0.07	0.16±0.00*
0,75 Ch+L	18	2.11±0.05	0.12±0.00*	2.59±0.06	0.14±0.00*
1,00 Ch+L	18	2.06±0.06	0.11±0.00*	2.63±0.06	0.15±0.00*
$HIP_{0,95}$	-	0.18	0.01	0.20	0.01
Sx, %	-	3.08	3.41	2.53	2.44

Note. * - difference is likely to be comparable to the control group, p≤0,05.

Antioxidants also reduce the natural loss of the weight of zucchini. The experimental fruit had less natural weight loss for 18 days of storage, than the control group for 12 days. The average daily weight loss in the experimental variants of Kavili hybrid was 1.5 ... 1.9 times less than in the control group. The natural loss of mass for the antioxidant treated Tarmino zucchini is 1,6...1,8 times less than in the control group. The concentrations of ionol and chlorophyllupt probably do not differ according to the effect on the reduction of weight loss. The two-factor analysis to determine the effect of processing and the hybrid on the average daily weight loss confirms the predominant influence

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of the antioxidant processing factor, being 74,2 % (Fig. 1).

A short period of the storage of zucchini (12 days in control group) is due to their rapid yellowing and development of microbiological diseases. Changes in the coloring of Tarmino zucchini is less noticeable. So, Tarmino has a higher yield of standard fruit, both in the group of control and in the experimental one due to its intense dark green color.

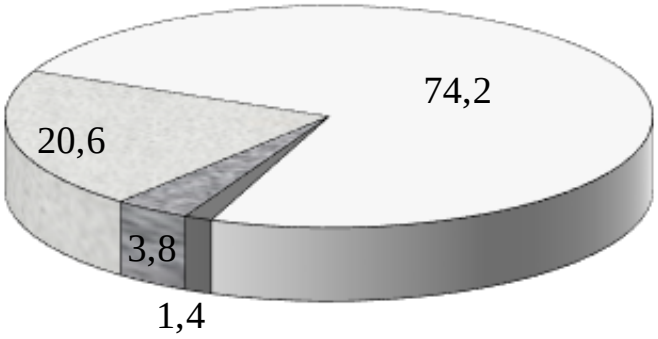

Fig. 1. Share of the Influence of the Factors on the Average Daily Weight Loss: – antioxidant treatment; – zucchini hybrid; – interaction of factors; – residual

In treated fruit, the yield of standard products after storage for 18 days varied from 87.11 to 92.99%, depending on the hybrid of zucchini and the variant, taking into account natural mass losses (Fig. 2).

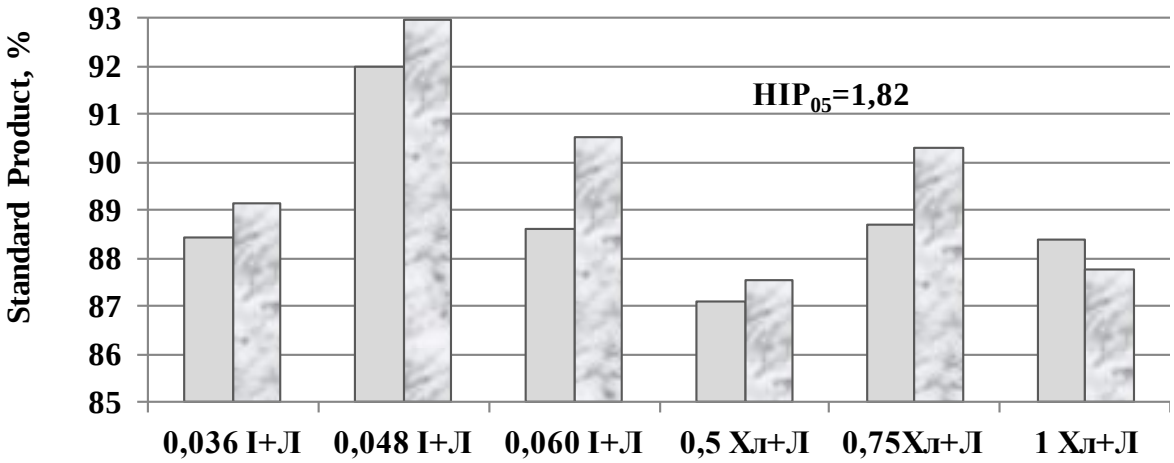

Fig. 2. Output of standard production of zucchini after storage under the action of antioxidants: – Kavili, – Tarmino

For experimental data, control and experimental fruit were stored for 18 days. The regression model was constructed using averaged data output of the standard production of both hybrids of zucchini for the effects of various concentrations of ionol. The dependence of the output of standard products on the concentration of ionol is described by the following model:

$$y = -5{,}36x^2 + 33{,}53x + 41{,}66,\ R^2=0{,}99 \qquad (1)$$

where y shall mean the output of standard production of zucchini,%; x shall mean the concentration of ionol,%.

Graphical representation of the predictive theoretical curve is shown in Fig. 4.

Thus, the optimum concentration of ionol to increase the yield of standard products after storage shall be 0.048 %.

Selection of Chlorophyllipt Concentration. Studying the influence of different concentrations of Chlorophyllipt on the output of the standard product showed that for the Kavili hybrid of zucchini, unlike Tarmino, the increase of the

standard product output on condition of the use 0.75 Ch is misleading with respect to 0.5 Ch (see. Fig. 3).

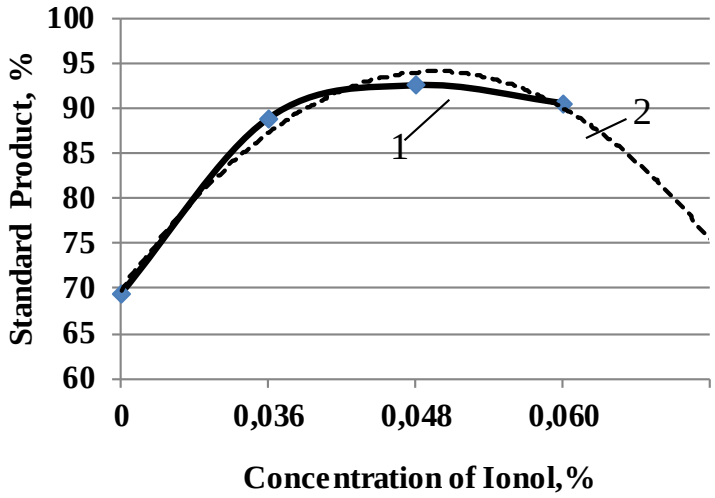

Fig. 3. Dependence of the Output of Standard Zucchini Production on the Concentration of Ionol: 1 – experimental curve; 2 – expectation parabola

The results of studies built very accurate (R2=0,98) dependence of the yield of standard zucchini product from concentration of Chlorophyllipt (Fig. 4).

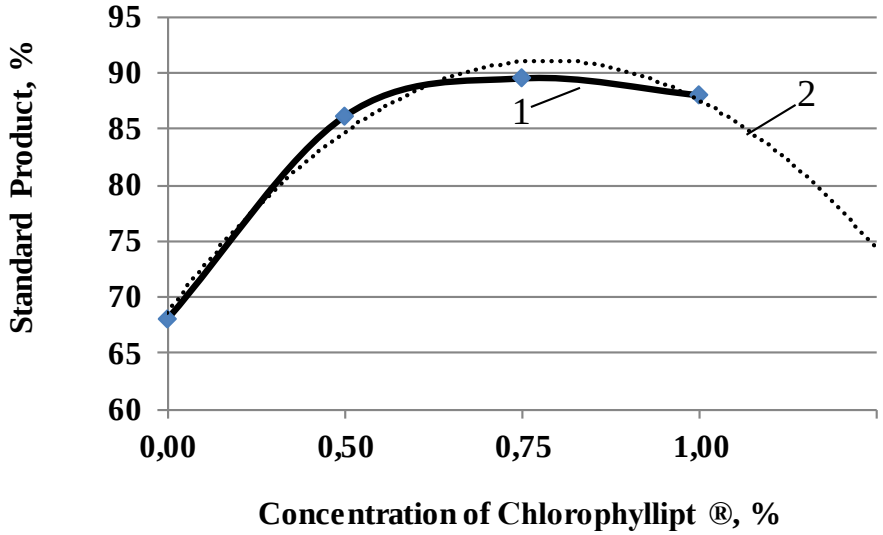

Fig. 4. Dependence of the Output of Standard Zucchini Production on the Concentration of Chlorophyllipt: 1– experimental curve; 2 – expectation parabola

Dependence is described with a regression model:

$$y = -4{,}89x^2 + 30{,}75x + 42{,}78, \quad (2)$$

where y shall mean the output of standard product after storage,%; x – shall mean the concentration of Chlorophyllipt, %.

Thus, 0,75% of Chlorophyllipt shall be the optimum concentration to increase the yield of standard zucchini after storage.

In the course of studies, the combined effect of optimum concentrations of ionol and Chlorophyllipt have been studied, as well as a three-component composition consisting of 0.75% Ch; 0.048 % I and 4 % L. The use of this composition for processing the zucchini fruit allows to extend storage to 24 days (2 times longer in comparison with the control group). When using the composition Ch + I + L, the output of standard products after storage is 91.88 ... 91.95% depending on the hybrid of zucchini, taking into account natural mass losses. Average

daily natural mass losses are reduced 2.73 ... 3.14 times in comparison with the control group and 1.36 ... 1.86 times compared to other treatments depending on the hybrid of zucchini (Fig. 5).

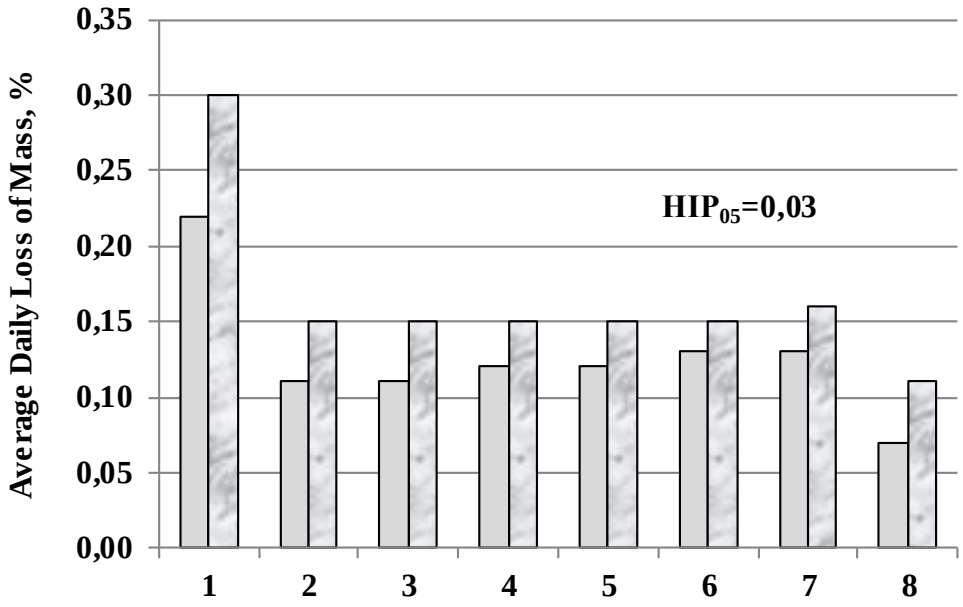

Fig. 5. Average Daily Loss of Mass During the Period of Zucchini Storage Under the Influence of Antioxidants: – Kavili, – Tarmino; 1 – control, 2 – 0,048 I +L; 3 – 0,060 I +L; 4 – 0,50 Ch +L; 5 – 0,75 Ch +L; 6 – 1 Ch +L; 7 – 0,75Ch +0,048I; 8 –Ch +I+L

Conclusions

The use of biologically active substances (I (0.036, 0.048, 0.060%), Ch (0.5%, 0.75%, 1%), L (4%)) allows to extend the shelflife of zucchini (Kavili F1 and Tarmino F1) for 6 ... 12 days depending on the treatment. Average daily weight loss due to antioxidant activity is reduced by 1.5 ... 1.9 times.

Optimum concentration of ionol shall be 0.048%, concentration of Chlorophyllipt shall be 0.75 %.

The developed three-component composition Ch + I + L (0.75% Ch; 0.048 % I and 4 % L) allows to reduce the average daily weight loss of fruit by 2.73 ... 3.14 times, depending on the zucchini variety. The use of such a composition allows you to store zucchini for 24 days with a yield by weight after storage, 91.88 ... 91.95% (taking into account the natural weight loss).

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