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 Tamino 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.
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 (Кавиля 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%, хлорофиллиптa 0,75%. Выявлено, что для создания устойчивой к расслаиванию препаративной формы антиоксидантов необходимо 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 другими обработками. Потери массы сокращаются по сравнению с контрольными вариантами в 2,73 ... 3,14 раза и в 1,36 ... 1,86.

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 slow, 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 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 fruit stalk 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 chlorophyllipt 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 Chlorohyphylipt (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

| Treatment Version | Duration of Storage, days | Kavili | | |
|-------------------|--------------------------|--------|---|---|
|                   |                          | 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±0.08 | 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 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 chlorophyllipt 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
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.

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).

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:

\[ y = -5.36x^2 + 33.53x + 41.66, \quad R^2 = 0.99 \]  

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 of 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](image)

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](image)

Dependence is described with a regression model:

\[ y = -4.89x^2 + 30.75x + 42.78, \]

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).

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 shelf life 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 Chlorophyllippt 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).

Бібліографічні посилання

[1] Корниенко С.І. Основні положення галузевої комплексної програми «ОВОЧІ УКРАЇНИ—2020» / С.І. Корниенко, В.П.Рудь // Овочеводство і баштанництво. — 2015. — Вип. 61. — С. 277-288.
[2] Саблюк П. Состояние и перспективы развития агропромышленного комплекса Украины / П.Саблюк // Экономика Украины. — 2008. — № 12. — С.4.
[3] Лищенко М.О. Основні тенденції збуту та формування цін на овочі в Україні / М.О. Лищенко // Економіка і суспільство. — 2016. — Вип. 5. — С. 207-215.
[4] Соломаха І.В. Стан та тенденції розвитку овочевого ринку в Україні / І.В.Соломаха, В. Жабинская // Проблеми і перспективи економіки та управління. — 2015. — № 3 (3). — С. 126–134.
[5] Wang C.Y. Chilling injury of tropical horticultural commodities / C.Y. Wang // HortScience. — 1994. — Vol. 29(9). — P. 986–988.
[6] Postharvest treatments of fresh produce / P.V.Mahajan, O.J. Caleb, Z. Singh, C.B. [et al.] // Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences. — 2014. — Vol. 372, Issue 2017. — P. 20130309–20130309.
[7] Toivonen P.M.A. Benefits of combined treatment approaches to maintaining fruit and vegetable quality / P.M.A. Toivonen // Fresh Produce. — 2009. — Vol. 3. — P. 58–64.
[8] Wang C.Y. Alleviation of chilling injury in tropical and subtropical fruits / C.Y. Wang // Proceedings of the III International symposium on tropical and subtropical fruits. — Fortaleza, Ceara, Brazil, 2010. — P. 267–274.
[9] Wang C.Y. Reducing chilling injury and maintaining quality of horticultural crops with natural products and their derivatives / C.Y. Wang // Acta Hortic. — 2006. — P. 285-290.
[10] Дульев П.Г. Антиоксидантна активність сполуки D-48Н / П.Г. Дульев, Х.І. Васильчина, И.Ю. Високий // Актуальні питання теоретичної та клінічної медицини : збірник тез доповідей V Міжнародної науково-практичної конференції студентів та молодих вчених, Суми : СумДУ, 20-21 квітня 2017 р. — С. 130.
[11] Oxidative Stress Associated with Chilling Injury in Immature Fruit: Postharvest Technological and
Biotechnological Solutions / J. Valenzuela, S.Manzano, F. Palm et al. // International Journal of Molecular Sciences. - 2017. - Vol. 18, Issue 7. - P. 1467.

[12] Laamim M. Treatments to reduce chilling injury in harvested cucumbers // M. Laamim, Z. Lapsker, E.Fallik // Advances in horticultural science. - 1998. - Vol. 12, Issue 4. - P. 175–178.

[13] Balandrán-Quintana R. R. Irreversibility of chilling injury in zucchini squash (Cucurbita pepo L.) could be a programmed event long before the visible symptoms are evident / R.R. Balandrán-Quintana, A.M. Mendoza-Wilson, AA. Gardea-Béjar // Biochemical and biological communications. - 2003. - Vol. 307, No. 3. - P. 553–557.

[14] Development of fruit diseases of microbial origin during storage at treatment with antioxidant compositions / M. Serydük, D. Stepanenko, O. Priss et al. // Vostochno-Európejskij journal periodin shchěroevих technologii. - 2017. - № 3(11). - C. 45–51.

[15] Postharvest treatments of fresh produce / P.V. Mahajan, O.J. Caleb, Z. Sing et al. // Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences. 2017. - Vol. 372. - P. 20–30.

[16] Priss O. Investigation of the respiration rate during storage of fruit vegetables under the influence of abiotic factors / O.P. Priss, V.V. Kamytsa // Progress in the technical and technological harvesting processes of agro-industrial enterprises. - 2014. - Вип. 1. - С. 209–221.

[17] Priss O. Effect of heat treatment with antioxidants on oxygen radical scavenging during storage of zucchini squash // O.P. Priss, V.V. Kamytsa // Eastern-European Journal of Enterprise Technologies. - 2015. - № 6(10). - С. 47-53.

[18] Kovalyev Yu. Plants antioxidative system: participation in cell signaling and adaptation to influence of stressors / Y.Y. Kovalyev, Y.V. Karpets, O.I. Obozny // The Bulletin of Kharkiv National Agrarian University. Series Biology. - 2011. - Vol 1 (22). - P. 6–34.

[19] Wang C.Y. Combined treatment of heat shock and low temperature conditioning reduces chilling injury in zucchini squash / C.Y. Wang // Postharvest Biology and Technology. - 1994. - № 4. - P. 65–73.

[20] Lurie S. Fundamental aspects of postharvest heat treatments / S. Lurie, R. Pedreschi // Horticulture Research. - 2014. - Vol. 30. - P. 1–7.

[21] Bouyed J. Exogenous antioxidants - double-edged swords in cellular redox state: health beneficial effects at physiologic doses versus deleterious effects at high doses / J. Bouyed, T. Bohn // Oxid Med Cell Longev. - 2010. - № 3(4). - P. 228–237.

[22] Pat. 41177 UA, A23B 7/00, A23L 3/34. Речовина для обробки плодових овочів перед зберіганням / O.П.Прись, Т.Ф. Прохудіна, В.Ф. Жукова. - у 2008 13962; заявл. 04.12.2008; опубл. 12.05.09; Бюл.№ 9.

[23] Pat. 31851 Україна. МПК А 23 В 7/14. Речовина для обробки яєць і плодових овочів перед зберіганням / О. П. Прись, М. Є. Сердюк, В. В. Коляденко, Т. Ф. Прохудіна, В. Ф. Жукова; заявник та власник охоронного документа Таврійський державний агротехнологічний університет. - № у 2007 13781; заявл. 10.12.07 ; опубл. 25.04.08. Бюл. № 8.

References

[1] Kornienko, S.L., Rud, V.P. (2015). Osnovni polozhennia haluzevoi kompleksnoi pryhmary «OVOCHI UKRAINY–2020». Ovochynyvstvo i bashtannytstvo, 61, 277–288.

[2] Sabluk, P. (2008). Sostoyanie i perspektivy razvitiya agropromyshlennogo kompleksa Ukrainy. Ekonomika Ukrainy, 12, 4.

[3] Lyshenko, M.O. (2016). Osnovni tendentsii zbutu ta formuvannia tsin na ovochi v Ukraini. Ekonomika i susiptstvo, 5, 207–215.

[4] Solomakha, I.V., Zhabynskaia, V. (2015). Stan ta tendentsii rozvytku ovochovoego rynku v Ukraini. Problemy i perspektivy ekonomiky ta upravlinnia, 3/3, 126–134.

[5] Wang C.Y. (1994). Chilling injury of tropical horticultural commodities. HortScience. 29(9), 986–988.

[6] Mahajan, P.V., Caleb, O.J., Singh, Z., Watkins, C.B., Geyer, M. (2014). Postharvest treatments of fresh produce. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences. 372/2017, 20130309–20130309. https://doi.org/10.1098/rsta.2013.0309.

[7] Toivonen, P.M.A. (2009). Benefits of combined treatment approaches to maintaining fruit and vegetable quality. Fresh Produce, 3, 58–64.

[8] Wang C.Y. (2010). Alleviation of chilling injury in tropical and subtropical fruits. Proceedings of the III International symposium on tropical and subtropical fruits. – Fortaleza, Ceara, Brazil. 267–274. https://doi.org/10.17660/actahiric.2010.864.35.

[9] Wang C.Y. (2006). Chilling injury and maintaining quality of horticultural crops with natural products and their derivatives. Acta Hortic. 712, 285–290. https://doi.org/10.17660/ActaHortic.2006.712.31.

[10] Valenzuela, J., Manzano, S., Palma, F., Carvajal, F., Garrido, D., Jamilena, M. (2017). Oxidative Stress Associated with Chilling Injury in Immature Fruit: Postharvest Technological and Biotechnological Solutions. International Journal of Molecular Sciences. 18/7, 1467. https://doi.org/10.3390/ijms18071467.

[11] Laamim, M., Lapsker, Z., Fallik E. (1998). Treatments to reduce chilling injury in harvested cucumbers. Advances in Horticultural science. 12/4, 175–178.

[12] Balandrán-Quintana, R. R., Mendoza-Wilson, A.M., Gardea-Béjar, A.A. (2003). Irreversibility of chilling injury in zucchini squash (Cucurbita pepo L.) could be a programmed event long before the visible symptoms are evident. Biochemical and biophysical research communications,307/3, 553–557.

[13] Serydük, M.E., Stepanenko, D., Priss, О., Kopylova, T., Garginashvili, N., Kulik, A., Atanasova, V., Kashkano, M., Kozonova J. (2017). Development of fruit diseases
of microbial origin during storage at treatment with antioxidant compositions. *Eastern-European Journal of Enterprise Technologies*, 3/1, 45–51. https://doi.org/10.15587/1729-4061.2017.103858

[14] Mahajan, P.V., Caleb, O.J., Sing, Z., Watkins, C.B., Geyer M. (2017). Postharvest treatments of fresh produce. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 372, 20–30. https://doi.org/10.1098/rsta.2013.0309

[15] Priss, O.P., Kalytka, V.V. (2014). Skorochenina vtrat pid chas zberihannia ovoch chutlyvykh do nyzkykh temperatur. *Prohresyvi tekhnika ta tekhnolohii kharchovykh vyrobnytstv restoranoho hospodarstva i torhivli*, 1, 209–221.

[16] Priss, O., Yevlash, V., Zhukova, V., Kuchev, S., Verkholantsева, V., Kalugina I. (2017). Investigation of the respiration rate during storage of fruit vegetables under the influence of abiotic factors. *EUREKA: Life Sciences*, 6, 10–15. https://doi.org/10.21303/2504-5695.2017.00494

[17] Simakhina, H.O. (2014). Perspektyvy stvorenia koncentrativ antyoksydantnoi dii z likarskykh trav. *Likarske roslynnytstvo: vid dosvidu mynuhoho do novitnikh tekhnolohii : materialy III Mizhnarodnoi naukovo-praktychnoi Internet-konferentsii*, Poltava, 15-16 travnya 2014 r. Poltava, 149–153.

[18] Priss, O.P., Kalytka, V.V. (2015). Effect of heat treatment with antioxidants on oxygen radical scavenging during storage of zucchini squash. *Eastern-European Journal of Enterprise Technologies*, 6/10, 47–53.

[19] Kolupaev, Y.Y. Karpets, Y.V., Obozniy, O.I. (2011). Plants antioxidative system: participation in cell signaling and adaptation to influence of stressors. *The Bulletin of Kharkiv National Agrarian University. Series Biology*, 1 (22), 6–34.

[20] Wang, C.Y. (1994). Combined treatment of heat shock and low temperature conditioning reduces chilling injury in zucchini squash. *Postharvest Biology and Technology*, № 4, pp. 65–73.

[21] Wang, C.Y. (1994). Combined treatment of heat shock and low temperature conditioning reduces chilling injury in zucchini squash. *Postharvest Biology and Technology*, 4, 65–73.

[22] Lurie, S., Pedreschi, R. (2014). Fundamental aspects of postharvest heat treatments. *Horticulture Research*. – Vol. 30. – P. 1–7.

[23] Bouayed, J., Bohn, T. (2010). Exogenous antioxidants - double-edged swords in cellular redox state: health beneficial effects at physiologic doses versus deleterious effects at high doses. *Oxid Med Cell Longev*, 3 (4), 228–237.

[24] Pat. 41177 UA, A23V 7/00, A23L 3/34. Rechovyna dlia obrobky plodovykh ovochiv pered zberihanniam / O. P. Priss, T. F. Prokudina, V. F. Zhukova. – u 2008 13962; zaialvl. 04.12.2008; opubl. 12.05.09; Biul. № 9.

[25] Pat. 31851 Ukrainy, MPK A 23 V 7/14. Rechovyna dlia obrobky yahid i plodovykh ovochiv pered zberihanniam /O.P. Priss, M.Ye. Serdiuk, V.V. Koliadenko, T.F. Prokudina, V.F. Zhukova; zaialvyk ta vlasnyk okhoronnoho dokumenta Tavriyskiy derzhawnyi ahrotehnolohichnyi universtet. – № u 2007 13781; zaialvl. 10.12.07 ; opubl. 25.04.08, Biul. № 8.