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FOOD AND ENVIRONMENT SAFETY

TECHNOLOGY OF FRESH HERBS STORAGE USING HYDROGEL AND ANTIOXIDANT COMPOSITION

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Abstract: *There is a stable consumer demand for fresh culinary herbs. Also, the greenery contains a large number of valuable phytonutrients. Despite high efficiency and increasing annual production of fresh herbs, the problem of preserving their quality in the post-harvest period remains unresolved. Because of the high specific surface area of evaporation, in the green crops droop quickly, they lose their marketable quality, and, as a result, the level of profitability of greenery production in general is being reduced. It is necessary to use new effective approaches to leafy greens storage in order to reduce product losses during transportation and storage.*
For example, agrarian hydrogel can be used for storage of greenery. Hydrogel is an acrylic potassium polymer that is non-toxic and has a high environmental standard. The hydrogel granules can absorb up to 250 times more moisture than their weight. We propose the following procedure as the method of greenery preservation: the greens are packed in bundles and put in sticks in polyethylene bags with a fastener, pre-filled with hydrogel solutions. The storage temperature is maintained optimally for each species of fresh herbs, the relative humidity is 95 ± 3%. Usage of the proposed method allows obtaining environment-friendly products, preserving their high biological value and increasing the shelf life. The accumulation of peroxide products, which cause physiological disorders, is inhibited as the result of such storage. The use of hydrogel reduces the natural loss of mass by 10% as compared with the control. Duration of greenery storage increases by 30 days.

Keywords: *storage, culinary herbs, leafy greens, hydrogel, antioxidants, marketable quality, ascorbicacid, chlorophylls, carotenoids.*

1. Introduction

Green herbs are rich with phytonutrients [1, 2]. The availability and universalism of leafy greens usage stimulates the high consumer demand all around the year [3, 4]. Widespread commercialization of freshculinary herbs has been restricted due to high perishability and arelatively short shelf-life [5]. However, there is a need for the effective storage of herbs in order to maintain uninterrupted supply of these products to the consumers.
There is a large number of scientific works devoted to the problem of greenery storage due to the complexity of request [6, 7]. The greatest problem in the storage of culinary herbs and leafy greens is the large surface of evaporation, which leads to the rapid loss of mass [6, 8]. Moisture losses in vegetables during storage affect negatively the normal course of metabolic processes. As a result of dehydration, reduction of turgor and texture changes occur [9]. The naturally rapid metabolism of fresh herbs and leafy greens accelerates during the post-harvest period, leading to the quick loss of marketable quality [6].
Most often, the problem of mass loss is solved by packing greenery in polymer materials [9–11]. Perforated film allows reducing weight losses and the intensity of

breathing, also prolonging the shelf life. However, the use of film materials often does not solve the problem of products yellowing.

Approach of storagethat relies on usage of hydrogel-and-antioxidant-based nutrient mediumcontributes positively to the preservation of marketable quality and biological value of green herbs [12]. Method of parsley storage using nutrient medium based on the agrarian hydrogel and antioxidants allows extending shelf life of greens without any significant loss of quality and biological value [13].

2. Materials and methods

The research was conducted in 2013–2016. For storage greens of parsley (Oscar cultivar), dill (Allihator cultivar) and spinach (Matador cultivar) were chosen.

Greenery was grown in the south of the region of Zaporizhzhia in the open ground. Herbs collected in the second decade of September were used for the study. Greens were cut in the morning in dry, clear weather. The parsley and dill greens with stems of at least 10 cm length were harvested for storage. The spinach with at least 2cm long peas was selected for experiment.

The greens were packed in bundles of 120–150g and put in sticks in 80 × 30 mm polyethylene bags pre-filled with nutrient solutions of hydrogel and antioxidants. Hydrogel isa special polymer in granules, which can absorb up to 250 times more moisture than their own weight, and then release it to the plants as the necessity arises. The composition with antioxidant activity was injected to the solution of hydrogel in order to prevent the loss of nutrients in greenery [12]. The antioxidant composition contains butylated hydroxytoluen, a highly active synthetic antioxidant common in food industry, lecithin, a natural antioxidant and emulsifier, and chlorophyllin, an extraction from eucalypt leaves that contains chlorophylls a and b andpossesses antiseptic properties.

Such packed bundles were put into boxes lined with a polyethylene film (thickness of 60 microns). Storage temperature of dill and parsley greens was 1 ± 0.5 °C and 0 ± 0.5 °C for spinach. Relative humidity was held at $95 \pm 3\%$. The herbs that were kept in the refrigerator under the same conditions were taken as control.

The output of marketable product after storage was determined in accordance with the requirements of the state standards of Ukraine and recommendations from researches on the storage and processing of crop production [14].

Determination of pigment content. The contents of chlorophyll and carotenoids were determined spectrophotometrically – at 644 and 662 nm for chlorophyll, and additionally at 440.5 nm for determination of carotenoids – from an extract in acetone [15]. For this study, samples of 150–200 mg were rubbed with $MgCO_3$ and 5 cm^3 of 100% acetone.The extract was poured through a glass pore filter into a Bunsen flask, quantitatively transferred to a volumetric flask of 25 cm^3 and adjusted to the mark with pure acetone. The obtained acetone extract contained the mixture of green and yellow pigments. The optical density (D) of the mixture was quantified at three wavelengths –662, 644 and 440.5 nm –with the spectrophotometer.

The concentration of pigments derived from the measurements with following equations:

$$X_{(Chla)} = 9.784\ D_{662} - 0.990\ D_{644};$$
$$X_{(Chlb)} = 21.426\ D_{644} - 4.650\ D_{662};$$
$$X_{(Chla+Chlb)} = 5.134\ D_{662} + 20.436\ D_{644};$$
$$X_{(Carotenoids)} = 4.695\ D_{440.5} - 0.268\ X_{(Chla+Chlb)}.$$

The content of pigments (A) in the plant material was calculated by the formula:

$A = X \cdot v/H \cdot 100$,

where X is the pigments concentration, $mg \cdot dm^{-3}$; v – the volume of extract, ml (25 cm^3); H – the sample of plant material, g (0.1–0.2 g).

Determination of vitamin C. The iodometric method was used to determine the vitamin C content [16]. The method is based on the measurement of reducing ability of ascorbic acid. Specifically, ascorbic acid reduces the potassium iodide to free iodine while oxidation. This iodine concentration is then determined by the colour reactionwith starch.

The samples (2.0–10.0 g) were weighed and levigated with a small amount of water in a porcelain mortar. The substance then was quantitatively transferred to a volumetric flask of 100 cm^3, adjusted to full volume and filtered. For titration 1 cm^3 of 2% HCl, 0.5 cm^3 of 1% potassium iodine solution, 2 cm^3 of 0.5% starch solution and 6–7 cm^3 of distilled water were added to 10 cm^3 of the extract. Titration with 0.01 N solution of potassium iodide was conducted until the stable blue colour appeared. A control titration containing 10 cm^3 of water instead of the extract was conducted simultaneously. Vitamin C content was quantified basing on the volume of 0.01 N potassium iodide added, with a conversion factor of 0.8806 mg/cm^3. All determinations were executed three times and then the mean values of all results were calculated.

3. Results and Discussion

Duration of green herbs storage fluctuated slightly throughout years of research and reached 20…40 days in average depending on the species (Table 1). Using a nutrient medium with antioxidants allows extending the shelf life of the greenery for more than twice (to prolong it at least for 30 days). Such results can be achieved first of all due to the absence of fading. In studied variants of greens the reduction of mass losses down to 4...4.5-fold in dill and spinach, and to 40-foldin parsley is observed (Table 2).

The quality of products stored with the use of hydrogel and antioxidants remained fairly high while the shelf life was extended. Thus, at the end of storage period, the output of standard production reached 88.67...93.65% depending on the type of herb (natural loss of mass was taken into account (Table 3).

Table1

Green herbs storage duration, days

Herb	Control	With nutrients
parsley	40	80
dill	18	48
spinach	22	55

Table2

Natural weight loss(n=5)

Herb	Experiment	Lossofmass, %, M ± m
Parsleyafter40 days	Control	15.98±1.49
	Withnutrients	0.35±0.21
Dill after18 days	Control	25.32±2.09
	With nutrients	6.33±0.76
Spinach after 22 days	Control	16.44±1.28
	With nutrients	3.59±0.46

Table 3

Quantity of standard products (n=5)

Herb	Experiment	Marketable quality, %, M ± m
Parsley	Control	80.84±1.06
	With nutrients	93.65±0.44
Dill	Control	69.30±1.10
	With nutrients	88.67±1.05
Spinach	Control	79.98±1.07
	With nutrients	90.65±1.01

Such a high yield of standard production is provided not only by the reduction of mass losses, but also by the reduction of the amount of yellowed herbs. Transformation of pigment singreenery is one of the markers of metabolic processes during its storage –amount of chlorophylls and carotenoids decreases during storage. Decomposition of chlorophylls and carotenoids was slower in leafy greens, which were stored with a nutrient medium based on hydrogel and antioxidants. The content of chlorophylls in the control groups in the end of storage decreased by15...40% of the initial amount. In contrast, the content of chlorophylls in greenery, which was stored using hydrogel and antioxidants, was 15...52% higher than in control group (Fig. 1, 2, 3).

The proposed method allows maintaining a higher content of vitamin C (Fig. 4-6).

Content of vitamin C was gradually decreasing during storage. In samples that were stored without usage of hydrogel ascorbic acid was decomposing more intensively and at the end of storage its content dropped to 17...72 % from the initial amount depending on the variety.

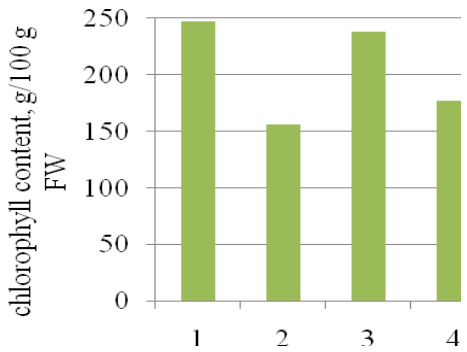

Fig. 1. Changes of chlorophylls content inparsley during storage: 1 - before storage; 2 - control group after 40 days; 3 - greenery in nutrition medium after 40 days; 4 - greenery in nutrition medium after 80 days.

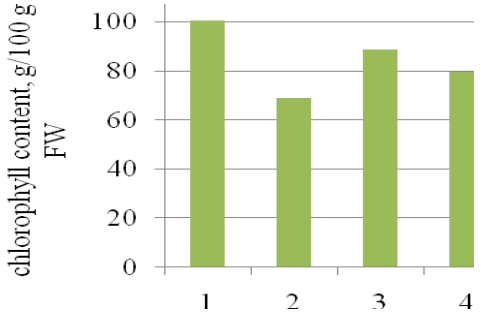

Fig. 2. Changes of chlorophylls content indill during storage: 1 - before storage; 2 - control group after 18 days; 3 - greenery in nutrition medium after 18 days; 4 - greenery in nutrition medium after 48 days.

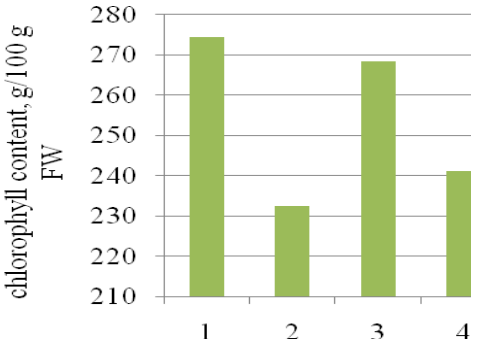

Fig. 3. Changes of chlorophylls contentinspinach during storage: 1 -beforestorage; 2 - control group after 22 days; 3 - greeneryin nutritionmedium after 22 days; 4 - greeneryin nutritionmedium after 55 days.

The vitamin C amount was 13.7...40.1% higher in the experimental specimen with the addition of antioxidant compositions than in control.

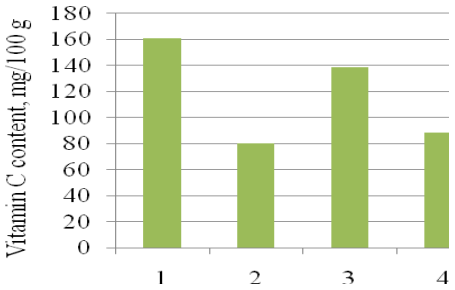

Fig. 4. Changes ofvitamin C content in parsley during storage: 1 - before storage; 2 - control group after 40 days; 3 - greenery in nutrition medium after 40 days; 4 - greenery in nutrition medium after 80 days.

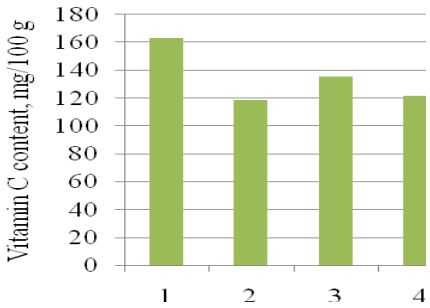

Fig. 5. Changes ofvitamin C contentindill during storage: 1 - before storage; 2 - control group after 18 days; 3 - greenery in nutrition medium after 18 days; 4 - greenery in nutrition medium after 48 days.

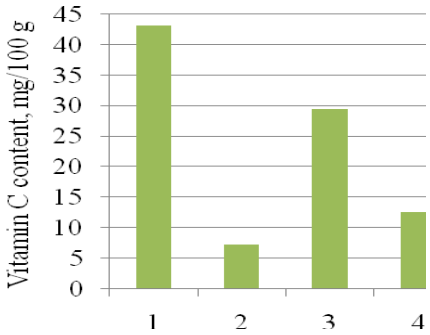

Fig. 6. Changes of vitamin C contentinspinach during storage: 1 - before storage; 2 - control group after 22 days; 3 - greenery in nutrition medium after 22 days; 4 - greenery in nutrition medium after 55 days.

4. Conclusions

Hydrogel and antioxidants used in storage procedure can extend the shelf life of greenery for 48-80 days, and allow increasing the yield of marketable production to 80...90% after greenery storage. This method of storage allows stabilization of the biological value of greenery. Level of preservation in experimental variants at the end of storage is higher than that in control groups for 2.2...70.7 % for vitamin C and for3.7... 15.5% for chlorophylls.

5. References

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