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Chemistry

Pseudoprotein-Based Edible Coating for Enhancing the Shelf Life of Banana Fruit

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The present paper deals with the study of biochemical changes that occur during shelf life in covered with edible coating and non-covered bananas. The shelf life of banana fruit largely depends on the storage temperature. Banana is selected as a sample due to its short shelf life. To study the effect of pseudoprotein edible coating on banana shelf life, an experiment was carried out on covered and uncovered (control) samples at different temperatures. The highest shelf life was shown in banana samples stored at 11.5±1.5°C with edible coating and it is important to highlight that under these conditions, the biochemical parameters of the pulp remained almost unchanged and the original texture, stiffness, and quality were preserved. *© 2024 Bull. Georg. Natl. Acad. Sci.*

banana, edible coating, pseudoprotein, preservation, shelf life

Crop storage issues should be resolved at the highest possible level with the aim that agro-products can be stored as long as possible. This process is becoming more and more important because fruits and vegetables are perishable and losses are high. Temperature and humidity of the environment are important factors to be considered for choosing the most favorable method for preservation of agroproducts. Storage temperature or its variation determines the shelf life of fruits and vegetables, biochemical changes, as well as weight loss and product losses. Covering agro-products with edible coating is an alternative to traditional storage methods such as drying and vacuuming, canning, and wax coating. Edible films prevent the colonization of the product surface by microorganisms, prevent a decrease in the content of various useful components, and control the diffusion of water and gases [1]. In recent years, preference has been given to such edible coating, which not only helps to preserve the quality of fruits and vegetables after harvesting but at the same time aims to replace and eliminate non-food (non-biodegradable) packaging materials from this field [2]. Nowadays, most coatings consist of more than one material, together with low molecular weight compounds that work as plasticizers and active agents – bactericides, and antioxidants to provide more complete properties of edible coating [3]; a natural bactericide, for example, tannin [4] – a naturally occurring polyphenol, as well as curcumin, vitamins, rosemary oil, sugars, honey and other food additives may be added to the food coating [5]. Within the framework of the present study, an innovative material created in Georgia – pseudoproteins (biodegradable, biomimetics) are used (as an edible coating) to enhance the shelf life of ბanana fruit. Pseudoproteins are synthetic polymers obtained based on α-amino acids [6,7], the creation and implementation of which was honored with the National Award of Georgia in 2021.

Banana (*Musa sapientum* L.) is one of the important tropical plants [8]. The minimum dietary requirement for fruit in some countries (Bangladesh) is much higher than its availability due to high levels of post-harvest losses. Due to its sweet taste, Cavendish bananas are very popular. The shelf life of banana fruit largely depends on the storage temperature. On average, the shelf life of bananas is 4-5 days [1]. In the previous period through the mathematical planning of the experiments, the optimal conditions for the shelf life of apples and carrots were determined. It has been established that the nutritional value of the products can be effectively maintained under long-term storage conditions with the polymer coating. Pseudoprotein edible coating preserves the external appearance of fruits and vegetables by preserving their biochemical parameters (apples, carrots) [9]. The present study aims to use a pseudo-protein food coating to extend the shelf life of bananas as a perishable fruit.

Materials and Methods

To determine the shelf life of the research banana samples, we selected the following parameters (water-soluble dry matter (BRIX), %, titratable acidity, %, pH, sugar-acid index, weight loss) and factors (temperature °C, concentration of edible coating, %, storage time, week) affecting them. The samples were stored at two different temperatures: 22±2°C (open space) and 11.5±1.5°C (refrigerator, relative humidity 70±18%). We selected bananas of Cavendish variety, which are imported to Georgia.

Three methods are mainly used to cover organic products [10] with a thin polymer layer: dip-coating, spray coating, and electrospun nanofibers coating [11]. With the method of dip-coating bunches of bananas (whole including the stalk) were covered with 7% ethanol solution of pseudoprotein (one of the cheapest copolymeric pseudoprotein composed of amino acid L-leucine, 1,6-hexanediol, sebacic and carbonic acids labeled as 1L6~8L6). The concentration of the pseudoprotein solution 7% was modeled by solving a set of equations and using the rapid ascent method [12]. Alcohol sterilizes the agro-products upon dipping in the solution (duration 5-10 seconds). The test samples were dried at room temperature (up to 20 min). Measurements of the optimization parameters were made every 3rd day in the samples stored at 22±2°C and every 5th day in the samples stored at 11.5±1.5°C.

The water-soluble dry matter (BRIX) in bananas was determined by the refractometric method (MA871 Digital Sucrose Refractometer, Milwaukee). The titratable acidity in bananas was determined by the titration method (with 0.01N NaOH solution). For the measuring of pH, we used a portable food pH meter (MW102-FOOD Portable 2-in-1 pH/Temperature Meter, Milwaukee). As for the sugar-acid index, we measure the ratio between water-soluble dry matter (BRIX) and titratable acidity. Weight loss was determined by the weight difference method (Radwag Balance and Scale IMMB-08-01-09-20-EN).

Results and Discussion

The minimum content of water-soluble dry matter/sugars (BRIX) was recorded in the initial samples of bananas and it was 16.5%. In the subsequent period, their value mainly increased, and the maximum result was recorded in uncovered samples at 22±2°C – 27.8%.

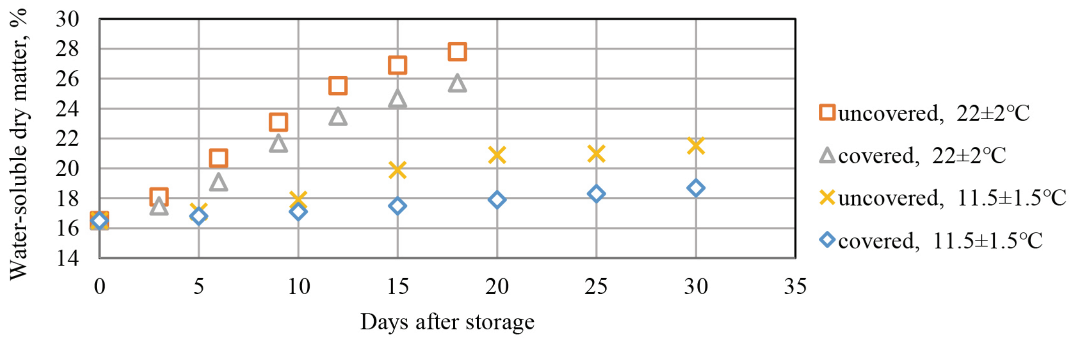

Fig. 1. Changes in dynamics of sugars in banana samples.

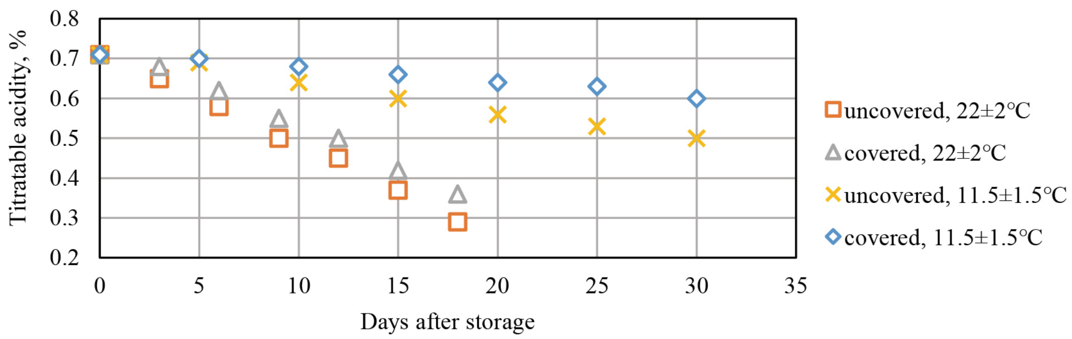

Fig. 2. Changes in dynamics of titratable acidity in banana samples.

The increasing trend was slower in coated samples at 11.5±1.5°C (16.5-18.69%). It should be noted that the increase of sugars in the samples was caused by the hydrolysis of starch and therefore, the accumulation of sugars during the post-harvest ripening process. In an unripe banana, there is about 21% starch, in a fully ripe banana – it decreases to 1%. The starch content of apples is less than 1% and gradually decreases as the apple ripens [8]. The obtained results are given in Fig. 1.

The initial titratable acidity of the banana sample was recorded at 0.71% (the highest value), which decreased differently at 22±2°C and 11.5±1.5°C in uncovered and covered samples. The titratable acidity gradually decreased during the storage period of bananas at both research temperatures. On the 21st day after the storage of the samples at 22±2°C, titratable acidity decreased to 0.29% (the lowest value), and at 11.5±1.5°C - to 0.6%. The obtained results are given in Fig. 2.

Titratable acidity and pH are important biochemical parameters for the organoleptic evaluation of bananas. Banana fruit has the peculiarity of ripening on the tree, and during post-harvest ripening, the titratable acidity and pH of the pulp continue to change before consumption. The content of organic acids in bananas includes citrate, malate, oxalate, and phosphate [13]. The decrease in titratable acidity during storage was related to the utilization of organic acids in various biodegradable reactions. It was revealed that the pseudo-protein edible coating maintained a higher titratable acidity and therefore, slowed down the reduction of organic acids in the fruits during their storage. The maximum pulp pH (5.72) was recorded in the uncoated sample at the end of the storage (21 days) at 22+2°C and the minimum pH (3.92) in the initial samples. All samples showed an increasing trend in pH, which is due to a decrease in acidity during ripening. The obtained results are given in Fig. 3.

Increasing of pH in banana samples observed in the present investigation was in agreement with S. A. Zhomo and S. M. Ismail (2014, Dhaka, Bangladesh, Krishi Foundation Scientific Journal) [8].

The sense of taste of the fruit (sour, sweet) depends on the ratio of sugar and acid, the so-called sugar-acid index. The obtained results are given in Fig. 4.

In the coated samples stored at 11.5±1.5°C, the sugar acid index changed from 23 to 31, indicating no sour taste, which is also typical for the taste properties of bananas. In the rest of the samples, the sugar acid index values go beyond the typical scale (>30), and the high sugar content in them (Fig. 1) is not directly proportional to the sweet taste, because the titratable acidity (Fig. 2) is low. This circumstance indicates the low taste quality of the banana samples.

As a result of an experiment, it was determined that the weight loss is relatively high in uncoated samples, which is 3.4% (22±2°C) during 21 days and 2.1% (11.5±1.5°C) during 32 days. The weight losses in covered samples are relatively low and are 1.8% (22±2°C) and 1.7% (11.5±1.5°C). The obtained results are given in Fig. 5.

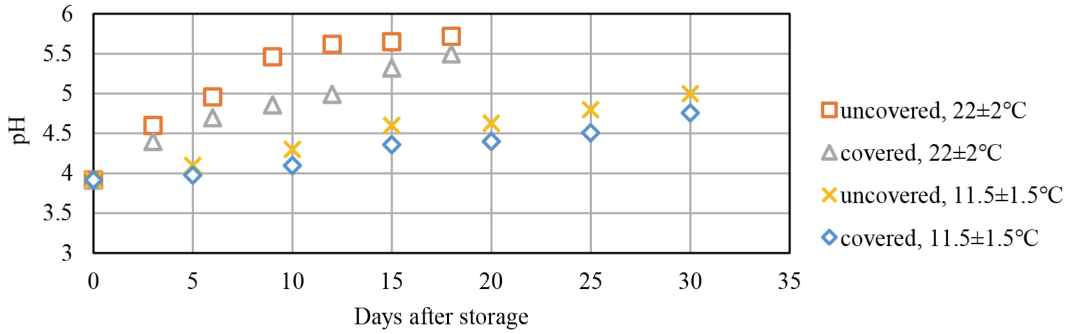

Fig. 3. Changes in dynamics of pH in banana samples.

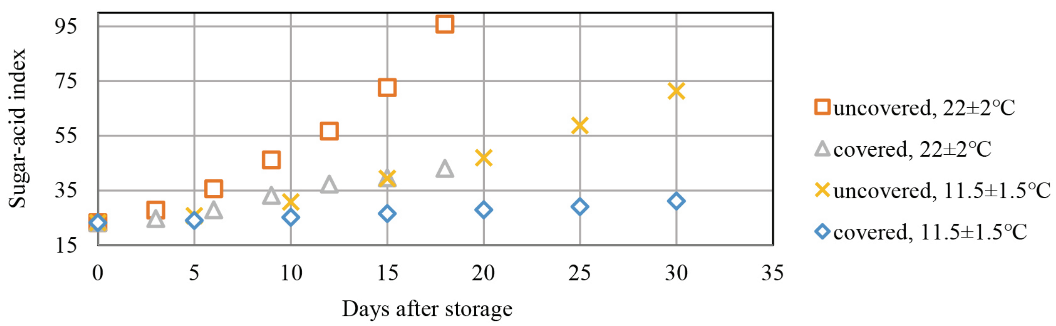

Fig. 4. Changes in dynamics of sugar-acid index in banana samples.

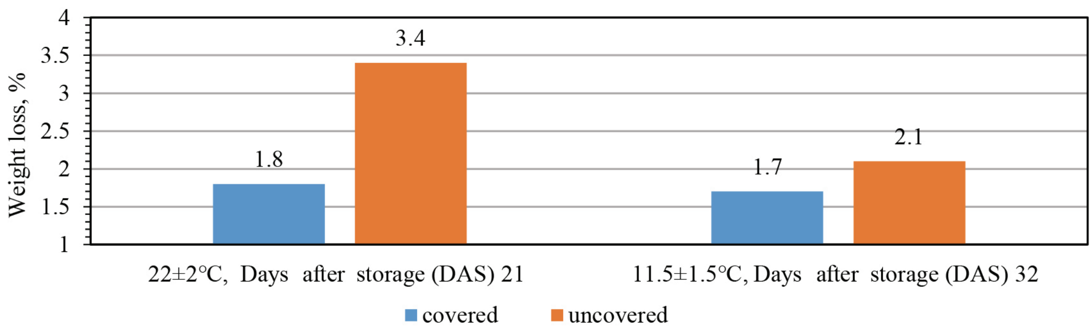

Fig. 5. Weight loss changes in banana samples.

Fig. 6. Samples stored at 22±2°C.

Fig. 7. Samples stored at 11.5±1.5°C.

Fig. 8. Peeled samples stored at 11.5±1.5°C.

Highly significant results were obtained for the shelf life in covered and uncovered banana samples at different temperatures. In covered banana samples at 22±2°C maximum shelf life was 21 days and at 11.5±1.5°C – 32 days. It is obvious, that the pseudoprotein edible coating improved the shelf life of bananas. This coating causes a decrease in tissue permeability, thus reducing the rate of water loss which in turn leads to delayed fruit ripening. This finding also agrees with the studies of S. A. Zhomo and S. M. Ismail (2014) [8].

Conclusion

Through the conducted studies, it has been established that the nutritional value of bananas can be effectively preserved with the pseudoprotein edible coating under long-term storage conditions. The biochemical properties of bananas were greatly influenced by treatment with pseudoprotein edible coating during storage. The application of pseudo-protein-based edible coating showed that the treatment improved the firmness, color, and texture, and reduced the weight loss of the fruit during the long-term storage than in their control samples. Water-soluble dry matter (BRIX), fruit pulp pH, and sugar-acid index increased during shelf life. The growth trend in the coated samples was slower than in their control samples. Also, there was a slow decrease in titratable acidity in the coated samples compared to the uncoated ones. The shelf life was higher in samples covered with pseudoprotein edible coating and was 32 days at 11.5±1.5°C and 21 days at 22±2°C.

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ქიმია

ფსევდოპროტეინული საკვები საფარის გამოყენება ბანანის შენახვის ვადის გასაზრდელად

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ნაშრომში წარმოდგენილია საკვები საფარით დაფარული და დაუფარავი ბანანის ნიმუშებში მიმდინარე ბიოქიმიური ცვლილებები. ბანანის ნაყოფის შენახვისუნარიანობა დიდწილად დამოკიდებულია შენახვის ტემპერატურაზე. ფსევდოპროტეინული საკვები საფარით ბანანის შენახვისუნარიანობაზე მოქმედების შესასწავლად ჩატარდა ექსპერიმენტი დაფარულ და დაუფარავ ნიმუშებში განსხვავებულ ტემპერატურებზე. ყველაზე მაღალი შენახვის ვადა ნაჩვენებია 11.5±1.5°C შენახული საკვები საფარით დაფარული ბანანის ნიმუშებში. აღსანიშნავია, რომ ამ პირობებში რბილობის ბიოქიმიური პარამეტრები თითქმის უცვლელი დარჩა და შეუნარჩუნდა პირვანდელი ტექსტურა, სიმტკიცე და ხარისხი.

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