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Study of sugar-acid index changes in apple and banana fruits coated with pseudoprotein edible coating

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Abstract

The content and the ratio of soluble sugars and organic acids, the so-called sugar-acid index are significant indicators of fruit quality. The present paper deals with the study of sugar-acid index changes that occurred during shelf life in non-covered and covered (pseudoprotein-based edible coating) apples and bananas. Fruits as vegetables are perishable agro-products. The preservation of products with food coating began in the 80s of the last century, and today it is already an important alternative to traditional methods of preservation of organic products. Edible coating causes a decrease in tissue permeability, thus reducing the rate of water loss which in turn leads to delayed fruit ripening and enhanced shelf life. This study aimed to evaluate the effect of pseudoprotein on extending the shelf life of agro-products (apple and banana). For this purpose, we determine the sugar-acid index in research samples. A 7% pseudoprotein solution in ethanol was used to cover the research samples (apple, banana) with a food coating. The results of the experiment established the nutritional value of the products can be effectively maintained under long-term storage conditions with a pseudoprotein coating.

Keywords: Apple; Banana; Edible coating; Preservation; Pseudoprotein; Shelf life.

1. Introduction

Shelf life extension by edible coating is a significant alternative to traditional ways of preservation. Such films are applied to the surface of the agro-products as a semipermeable barrier that reduces respiration, retards water loss and maintains texture, commodity parameters, as well as stiffness [1]. The idea of covering organic products with polymer films began back in the 80s of the last century, with the use of various materials, including synthetic polymers. In American patent [2] - latexes of methacrylic acid esters (synthetic polymers) were used for this purpose,

which were added up to 45% of water-soluble natural (casein or gelatin) or synthetic polymer (polyvinyl alcohol, polyvinylpyrrolidone or oxyethylated starch). However acrylic latexes, as well as other carbon chain polymers [3] used later, are not subject to biodegradation. Therefore before consumption, it is necessary to remove them from the surface of the product, which is practically impossible to fully implement, and the remaining part of the coating is a health hazard. Thus, currently, superiority is given to edible coating [4]. Polysaccharides, proteins, and lipids are such materials and can form continuous films and coatings [5]. Therefore edible coatings are divided into three types based on the nature of their elements, such as hydrocolloids or natural resins (proteins, polysaccharides, alginates), lipids (fatty acids, acylglycerols, waxes) and their mixtures [3]. Most coatings contain more than one material: low molecular weight compounds are added that work as plasticizers. Plasticizers improve the flexibility of the film. An active agents and food additives (tannin, curcumin, vitamins, rosemary oil, sugars, honey) may be added to the food coating [6]. In the present study, an innovative material created in Georgia - pseudoproteins (Katsarava et al, 2011) was used for the production of food coating. To study the effect of pseudoprotein on increasing the shelf life of apple and banana fruits is the aim of the research. Pseudoprotein is a synthetic biodegradable polymer based on α-amino acids, the so-called biomimetic [7-10]. Most importantly, it will highlight the goal of the study - replacement of the existing multi-component edible coatings with a mono-component, commercially available pseudo-protein, showing high biocompatibility and biodegradability in Medicine. Generally, edible films are made by casting, and the extrusion process and coating of the edible solution are done mainly by dipping and spraying [5].
During preservation of agro-products biochemical changes occur naturally, which lead to changes in the parameters determining the commodity properties of fruits and vegetables. In plant-based foods, the amount of titratable acidity and water-soluble dry matter (BRIX) predominantly decreases, as most of them are hydrolyzed (decomposed). The decrease in titratable acidity during storage can be attributed to the use of organic acids in various biodegradable reactions. Thus, during shelf life, the fetus undergoes many changes in its morphology, anatomy, physiology, and biochemistry. Biochemical changes occurring naturally lead to changes in the parameters determining the commodity properties of fruits.

2. Main Part

2.1. Materials and Methods

Flavor, stiffness, good appearance (color, texture), odor, and freshness can be maintained for a longer time by proper storage conditions of agro-products which increases their shelf life. The sugar-acid index, the content and the ratio of soluble sugars and organic acids are a significant indicator of fruit quality. For organoleptic evaluation, titratable acidity, as well as water-soluble dry matter (BRIX), are important biochemical parameters.

The research aims to study the biochemical changes and the effect of pseudoprotein biodegradable edible coating on the extension of the shelf life of fruits. To determine the shelf life of the apple and banana samples, the following parameters were selected: water-soluble dry matter (%) (BRIX), and titratable acidity (%). The factors affecting these parameters are temperature (℃), concentration of edible coating, (%), storage time, (day). The apple variety "Banana" and the banana variety "Cavendish" (which are imported to Georgia) were selected as research objects due to their short shelf life.

From the three known mainly used methods to cover organic products with a thin polymer layer [1, 4, 11] we choose dip-coating. With the method of dip-coating apples and bunches of bananas (whole including the stalk) were covered with 7% ethanol solution of pseudoprotein (one of the cheapest copolymeric pseudo-protein 1L6~8L6). The concentration of the pseudoprotein solution 7% was modeled by solving a set of equations and using the rapid ascent method [12]. During 5-10 seconds, alcohol sterilizes the agro-products upon dipping in the solution. The test samples were dried at room temperature for up to 20 minutes (Figure 1). Measurements of the research parameters were made every 5th day. Apple samples were stored at 1.5±1.5℃ and banana samples at 11.5±1.5℃ (appropriate storage temperature).

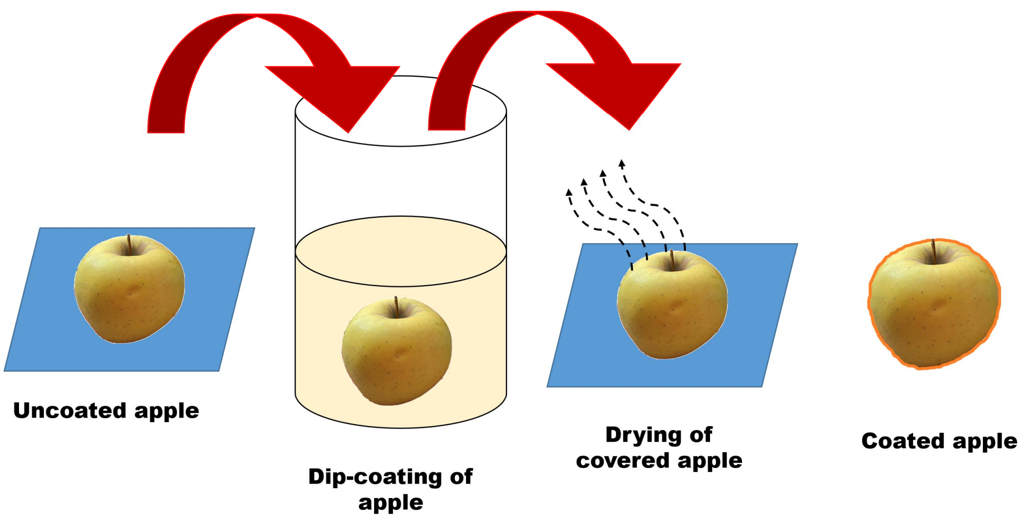


Figure 1. Scheme of preparation of covered samples on the example of apples

To determine the sugar-acid index, we measure the ratio between water-soluble dry matter (BRIX) and titratable acidity. The water-soluble dry matter (BRIX) in apples and 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).

2.2. Results and Discasing

In fruit, soluble sugars mainly contain glucose, fructose, and sucrose. Organic acids in fruit predominantly include malate, citrate, and tartaric acid. Sourness and sweetness (two major components for consumers' preferences) are predictable by two acidity parameters: pH and titratable acidity. pH represents the activity of free hydrogen ions, while titratable acidity is the amount of weakly bound hydrogen ions that can be released from the acids [13]. As known, the sourness of the fruit is not determined only by the presence of organic acids, like the sweetness is not determined only by the content of sugars. The feeling of taste of the fruit (sour, sweet, low sour, low sweet) depends on the ratio of sugar and acid, the sugar-acid index. The sugar-acid ratio is the primary index for the evaluation of fruit quality, specifically of flavor and fruit ripening. The values of the sugar acid index are established: if it varies between 20-30, acidity is not felt; 10-20 - are weak acids; 5-10 - are acids; and less than 5 – are strong acids [14]. The obtained results for apples are given in Table 1 and for bananas in Table 2.

Table 1. Changes in dynamics of the sugar-acid index in apple samples stored at 1.5±1.5℃ (the table shows the average values of the results of the conducted tests)

Time, days	Water-soluble dry matter (BRIX), %		Titratable acidity, %		Sugar-acid index	
	Uncovered	covered	uncovered	covered	uncovered	covered
0	13.3	13.3	0.56	0.56	23.87	23.88
5	12.9	13.1	0.51	0.54	25.54	24.39
10	12.5	12.9	0.48	0.53	26.21	24.48
15	12.0	12.7	0.42	0.51	28.80	25.05
20	11.5	12.5	0.38	0.49	30.53	25.67
25	10.1	12.3	0.33	0.45	30.92	27.22
30	9.8	12.1	0.27	0.41	36.11	29.41
35	9.6	11.9	0.24	0.40	40.64	30.01

Table 2. Changes in dynamics of the sugar-acid index in banana samples stored at 11.5±1.5℃ (the table shows the average values of the results of the conducted tests)

Time, days	Water-soluble dry matter (BRIX), %		Titratable acidity, %		Sugar-acid index	
	uncovered	covered	uncovered	covered	uncovered	covered
0	16.0	16.0	0.69	0.69	23.28	23.28
5	16.5	16.4	0.67	0.68	24.81	24.04
10	17.6	16.6	0.63	0.66	28.16	25.15
15	19.4	17.1	0.57	0.65	34.04	26.43
20	20.1	17.5	0.54	0.63	37.22	27.92
25	21.0	17.9	0.50	0.61	42.42	29.26
30	21.4	18.2	0.47	0.59	45.43	30.76

Data analysis showed that titratable acidity decreased in apples and bananas, while water-soluble dry matter decreased in apples and increased in bananas. It is known from the literature that the water-soluble dry matter in bananas first increases and finally decreases. This is explained by starch hydrolysis. 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 [15].

The kinetics of the process of sugar-acid index changes in coated and uncoated samples during storage are presented in Figure 2 for apple samples and Figure 3 for banana samples.

Figure 2. Changes in dynamics of the sugar-acid index in apple samples (Kinetics of the shelf life)

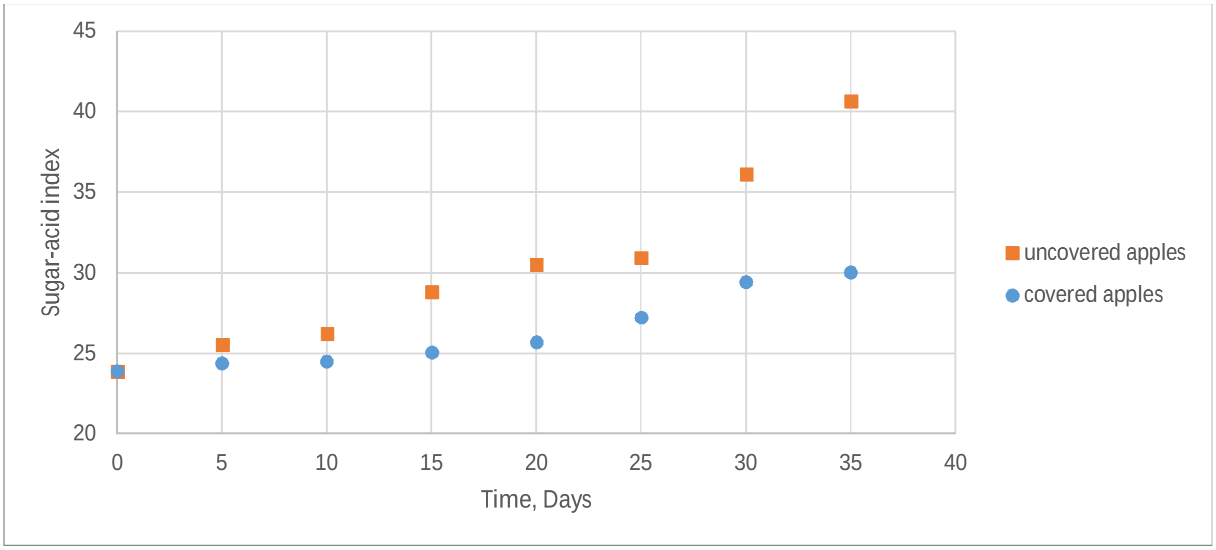
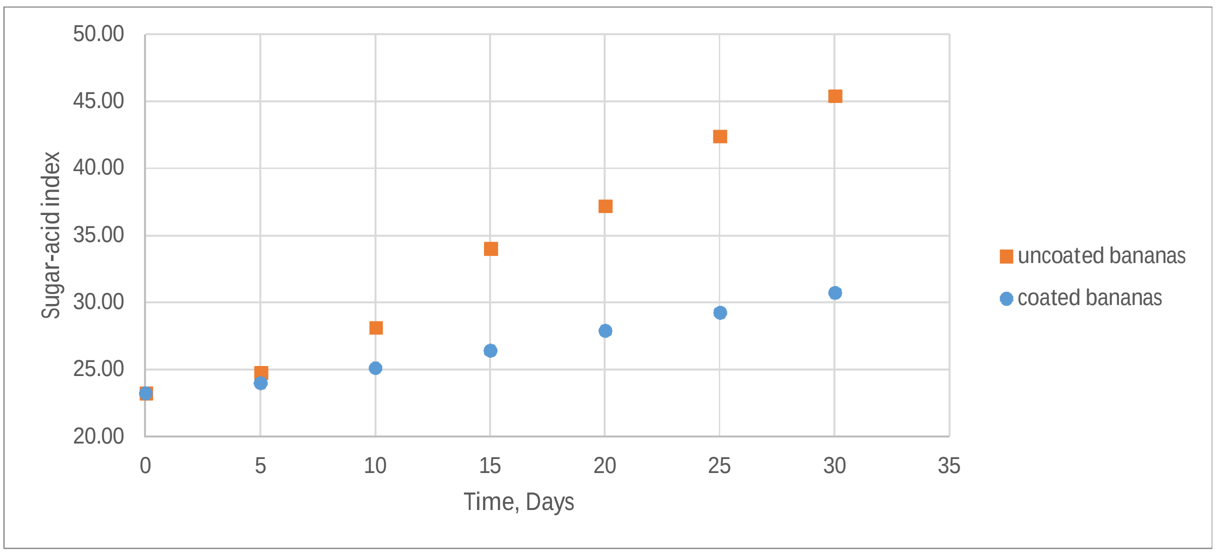


Figure 3. Changes in dynamics of the sugar-acid index in banana samples (Kinetics of the sshelf life)



In the coated samples stored at 1.5±1.5℃ (Table 1, Figure 2), the sugar-acid index change ranged from 23.88 to 30.01 (duration 35 days), indicating no sourness, which is typical for the taste properties of the apple variety “Banana”. Similarly, in the coated samples stored at 11.5±1.5℃ (Table 2, Figure 3), the sugar-acid index change ranged from 23.28 to 30.78, indicating also no sour taste, which is typical for the taste properties of bananas. In the rest of the samples (apple, banana) the sugar acid index values go beyond the typical scale. This circumstance indicates the low taste quality of the apple and banana samples. On the 20th day, the uncoated sample's sugar-acid index is 30, while coated samples have the same meaning on the 35th day. It is obvious, that the pseudoprotein edible coating improved the quality and shelf life of fruits. 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 Jomo and Ismail (2014) [15].

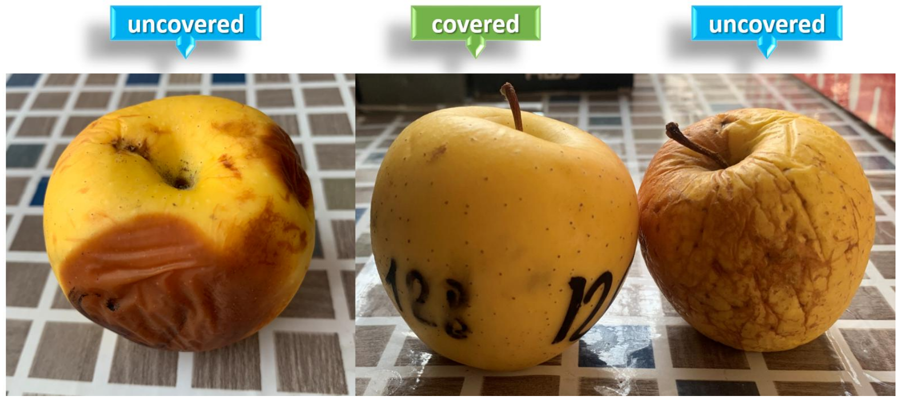


Figure 2. Apple samples stored at 1.5±1.5℃ after 35 days.

Figure 3. Banana samples stored at 11.5±1.5℃ after 32 days.

Figure 4. Peeled banana samples stored at 11.5±1.5℃ after 32 days.

3. Conclusion

Through the conducted studies, It has been established that the nutritional value of apple and banana fruits can be effectively preserved with the pseudoprotein edible coating under long-term storage conditions. Changes in biochemical parameters occurred naturally in the uncovered and covered apples and bananas. However, a slow rate of changes in the sugar-acid index (low speed) was shown by the samples coated with edible coating. Visual evaluation of coated and uncoated samples with thin film clearly shows that the pseudo-protein-based edible coating maintains its appearance and quality such as firmness, color, and texture. The nutritional value of apples and bananas can be effectively preserved with the pseudoprotein edible coating under long-term storage conditions.

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ფსევდოპროტეინული საკვები საფარით დაფარულ ვაშლსა და ბანანში შაქარმჟავა ინდექსის ცვლილებების შესწავლა

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აბსტრაქტი

შაქარმჟავას ინდექსი გამოითვლება შაქრებისა და სატიტრავი მჟავიანობის თანაფარდობით და აგროპროდუქტების საგემოვნო თვისების მნიშვნელოვანი მაჩვენებელია. კვლევაში შესწავლილია საკვები ფსევდოპროტეინული საფარით დაფარულ ვაშლსა და ბანანში შაქარმჟავა ინდექსის ცვლილებები. საკვები საფარით პროდუქტების შენახვა გასული საუკუნის 80-იან წლებში დაიწყო და დღეს უკვე იგი საკვები პროდუქტების შენახვის ტრადიციული მეთოდების მნიშვნელოვან ალტერნატივას წარმოადგენს. საკვები საფარით დაფარულ აგროპროდუქტებში ნელდება მომწიფების პროცესი, რაც ახანგრძლივებს შენახვის ვადას. კვლევაში შესწავლილია საკვები საფარით დაფარულ ხილში მიმდინარე შაქრებისა და ორგანული მჟავების ცვლილებები, კერძოდ, მათი საგემოვნო თვისებების განმსაზღვრელი პარამეტრი შაქარმჟავას ინდექსი. უკანასკნელ წლებში საკვებ საფარებად გამოყენებისას უპირატესობა ენიჭება ბიოდეგრადირებად მასალებს. კვლევაში გამოყენებულია ბიოდეგრადირებადი ფსევდოპროტეინების საფუძველზე დამზადებული საკვები საფარის 7%-იანი კონცენტრაციის სპირტხსნარი (ეთანოლი), რომლითაც დაფარულია ხილის ნიმუშები (ვაშლი, ბანანი). ჩატარებული კვლევით დადგინდა, რომ ფსევდოპროტეინული საფარით შესაძლებელია პროდუქტების კვებითი ღირსების ეფექტური შენარჩუნება ხანგრძლივი შენახვის პირობებში.

საკვანძო სიტყვები: ბანანი; ვაშლი; საკვები საფარი; ფსევდოპროტეინი; შენახვის ვადა.

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