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Change of chemical and biochemical indicators of Phuc Trach pomelo in the preservation process with chitosan-based coating with tannin and vinegar

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Abstract

The objective of this study was to determine the change in physicochemical and biochemical parameters of Phuc Trach pomelo during preservation by coating. From there, it forms the basis for building a preservation process. Preservative coating preparations are formed by mixing ingredients according to the ratio: 1.92% chitosan, 0.24% tannin, 1.92% vinegar, and 95.92% water. One kg of this preparation will be enough to cover about 19 kg of pomelo. Set up four experimental formulas to preserve Phuc Trach pomelo: CT1: preserved in the natural environment, no preservative coating is used, the content of coating-forming preparations is 0%; CT2, CT3, CT4 used coating-forming preparations with the content of 1.0%, 1.5% and 2.0%, respectively. The results showed that Phuc Trach pomelo preserved in formula CT3 with the composition of 1.5% was effective in limiting the change of physico-chemical and biochemical indicators more effectively than other experimental formulas. After 7 weeks of storage, the colour changed from 0.96 to 8.16, hardness changed from 15.16 to 10.23 (kg/cm^2); respiratory intensity from 35.68 to 18.95 (mL CO_2/kg.h); soluble solids content from 10.04 to 11.46^{o}Bx; total sugar content from 8.99 to 5.06%; vitamin C content from 0.84 to 0.42mg/g; total protein content from 0.79 to 0.38%; total organic acid content from 0.62 to 0.17%. Meanwhile, Phuc Trach pomelos preserved in other recipes until the 5th and 6th week were completely rotten. Therefore, the formula CT3 was selected with a preservative composition of 1.5% to develop the process of preserving Phuc Trach pomelo.

1. Introduction

Pomelo is a fruit with high nutritional and economic value. In 100 g of edible portion contains 91.4 g water, 0.2 g protein, 7.3 g carbohydrate, 0.7 g cellulose, 23 mg calcium, 0.5 mg iron, 6 g magnesium, 18 mg phosphorus, 159 mg potassium, 3 mg sodium, 0.16 mg zinc, 95 mg vitamin C, 0.04 mg vitamin B_1, 0.02 mg vitamin B_2, 0.3 mg vitamin PP (Tran *et al*., 2020; Tran *et al*., 2021). Pomelos will be spongy, and reduced in quality if not harvested in time. The tree still had to provide nutrients to grow fruit, so it affected the next fruiting cycle (Nguyen, 2019; Kahramanog˘lu *et al.*, 2020). Especially, at the end of autumn and early winter, the weather in the central part of Vietnam often has heavy rain for a long time. This causes Phuc Trach pomelo to fall prematurely. Meanwhile, as Phuc Trach pomelo is in the ripening period, so long-term heavy rain reduces the economic efficiency of pomelo growers.

In Vietnam, there are many methods of preserving pomelos, such as cold preservation, chemical preservation (lime applied to the stem), preservation by covering coating, biocoating (Nguyen and Nguyen, 2019). The preservation method by bio-coating has many advantages: ensuring food safety and hygiene, low cost, simplicity, and ease of implementation and application at many scales. Therefore, it is necessary to apply chitosan-based coating in combination with tannin and vinegar in the process of preserving Phuc Trach pomelo.

Chitosan is an animal polymer extracted from the shells of shrimps, crabs, and sentinel crabs. They are of natural origin, are biodegradable, non-toxic, easy to form coatings, and safe for human use in food, pharmaceuticals, and cosmetics. Chitosan has many diverse biological effects can absorb water, retain moisture, and has strong antifungal and antibacterial properties with many different strains. Tannin is a polyphenol compound found in many plants that has the ability to create stable bonds with proteins and other

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macromolecular organic compounds such as amino acids and alkaloids. Tannins often create an acrid taste, have antibacterial, antifungal, and antioxidant effects. Vinegar is a food acid produced on an industrial or manual scale. Vinegar is used widely in food processing and preservation. It has a strong antiseptic effect and inhibits the growth of mold. Combining three ingredients chitosan, tannin, and vinegar with water will form a yellow viscous liquid to form a coating to preserve citrus fruits (Nguyen and Nguyen, 2019). This coating has a characteristic yellow colour, a homogeneous viscous liquid. The coating ensures food safety and hygiene and does not pollute the environment. In this study, the change in physicochemical and biochemical parameters of Phuc Trach pomelo during preservation by biocoating was determined, thereby serving as the basis for building a preservation process for this fruit.

2. Materials and methods

2.1 Materials

Phuc Trach pomelo fruit reaches technical maturity in about 260 - 280 days after fruiting. The average fruit weight is 1285±100.35 g. The pods are pale yellow; fruit flesh has a pinkish colour, aroma, and characteristic sweetness; pomelo cloves are succulent and elastic. These pomelos are collected in the garden of pomelo growing members of Phuc Trach Pomelo Cooperative and Phat Loc General Service, Phuc Trach Commune, Huong Khe District, Ha Tinh Province.

Preservative materials and chemicals include chitosan, tannin, vinegar, clean water, and quicklime, ensuring quality standards, originating in Vietnam. Tannin used in this study was provided by Nguyen Phuc Trading Materials Joint Stock Company. Chitosan is manufactured at Chitosan Vietnam Co., Ltd. In addition, in this study, cooking vinegar provided by Ajinomoto Vietnam Company was also used. Besides the above-mentioned ingredients, clean water is also used as a solvent to dissolve tannin, dilute chitosan solution, and vinegar.

2.2 Sampling method

Phuc Trach pomelos were sampled according to Vietnamese National Standards TCVN 9017:2011 (Vietnamese National Standards, 2011). Fresh fruits - Sampling method on the field.

2.3 Experimental set-up method

Based on the results of exploratory research, the experiment on preserving Phuc Trach pomelos by chitosan-based coating combined with tannin and edible vinegar was carried out with the ratio of 1.92% chitosan, 0.24% tannin, 1.92% vinegar, and 95.92% water. One kg of this preparation will be enough to cover about 19 kg of pomelo. The experiment was carried out according to four formulas as follows (Vietnamese National Standards, 1988b; Nguyen, 2019; Nguyen and Nguyen, 2019; Tran *et al*., 2020).

CT1: the content of coating-forming preparations is 0%

CT2: the content of coating-forming preparations is 1.0%

CT3: the content of coating-forming preparations is 1.5%

CT4: the content of coating-forming preparations is 2.0%

Each experimental recipe is 40 kg of Phuc Trach pomelo and is repeated 3 times. Before being put into storage, Phuc Trach pomelos are treated with 0.1% Na_2SO_3 solution to kill fungi, with a dipping time of 1-2 minutes, and then drained. After that, these pomelos are dipped into tannin biocoating preparations combined with chitosan and vinegar for 1-2 minutes to preserve.

2.4 Determining the physical and chemical criteria

2.4.1 Color variation

The colour change of Phuc Trach pomelo rind over each period was determined using a hand-held colorimeter Nippon Denshoku NR 300 (Japan). The machine works on the principle of light analysis. For each measurement sample, the meter will display the measurement results of 3 L, a, and b readings. The colour variation of the fruit was determined by the formula: $\Delta E = [(L_i-L_o)^2 + (a_i-a_o)^2 + (b_i-b_o)^2]^{1/2}$. In which: L_i, a_i, b_i: Colorimetric results at the i-th analysis, L_o, pond, b_o: Colorimetric results of input materials (Nguyen, 2019; Nguyen and Nguyen, 2019).

2.4.2 Hardness of Phuc Trach pomelo

To determine the hardness of Phuc Trach pomelo using the Absolute hardness tester. The deeper the durometer's penetration into the flesh, the smaller the hardness of the fruit. (Nguyen, 2019; Nguyen and Nguyen, 2019).

2.4.3 Respiratory intensity

The respiratory intensity of Phuc Trach pomelo was determined by the ICA15 DUAL ANALYSER respiratory intensity meter. Respiration intensity is calculated as the amount of CO_2 produced per 1 kg of product in a unit of time. The respiratory intensity was calculated according to the following formula:

$$X = \frac{A.V}{1000.m.t.100}$$

Where X: respiratory intensity (mL CO_2/kg.h), A: measured CO_2 concentration (%), m: weight of sample put into the test (kg), t: time (hrs), 1000: conversion factor from g to kg, V: volume of free air in the

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respirometer (mL) (Nguyen, 2019; Nguyen and Nguyen, 2019).

2.4.4 Soluble solids content

The content of soluble solids was determined by a Japanese ATAGO N-1α refractometer, the unit of measure is "°Bx" at 20°C. When light passes through a solution of different dissolved solids, the light is refracted at different angles of refraction. From this, it is possible to deduce the solids concentration of the analyte (Nguyen, 2019; Nguyen and Nguyen, 2019).

2.4.5 Total sugar content

The total sugar content of Phuc Trach pomelo was determined according to Vietnamese National Standard TCVN 4594:1988 (Vietnamese National Standards, 1988b). This method is carried out on the principle of extracting total sugar from the sample with hot water, using hydrochloric acid to produce glucose. The amount of glucose was determined by reacting with Fehling solution, $Fe_2(SO_4)_3$, $KMnO_4$.

2.4.6 Vitamin C content

The vitamin C content of Phuc Trach Pomelo was determined according to the standard TCVN 6427-2:1998 (Vietnamese National Standards, 1998). This method is performed according to the principle of extracting ascorbic acid from Phuc Trach pomelo by oxalic acid solution or metaphosphoric acid/acetic acid solution. Titrate with 2.6 dichlorophenolindophenol until a faint pink colour appears.

2.4.7 Total protein content

The protein content of Phuc Trach pomelo fruit was determined according to the Vietnamese National standard TCVN 9936:2013 (Vietnamese National Standards, 2013). Decompose organic matter with sulfuric acid, alkalinize the reaction products, distillate liberated ammonium, and collect boric acid solution. The mixture was then titrated with a standard sulfuric acid solution.

2.4.8 Total organic acids

The total organic acid content of Phuc Trach pomelo fruit was determined according to Vietnamese National Standard TCVN 4589:1988 (Vietnamese National Standards, 1988a). This method is carried out on the principle of direct titration of the acids present in the sample with sodium hydroxide solution with phenolphthalein indicator.

3. Results and discussion

3.1 Biochemical and microbiological parameters of fresh Phuc Trach pomelo before being stored

Biochemistry is an important criterion to evaluate the quality of fresh Pomelo. To serve as a basis for determining the quality change of Phuc Trach pomelos during storage, some biochemical parameters of fresh Phuc Trach pomelos were analyzed before being put into storage. The results are shown in Table 1.

Table 1. Biochemical parameters of fresh Phuc Trach pomelo before putting into storage

No.	Analytical parameters	Units	Results
1	Soluble solids and dry matter content	°Bx	10.02±0.02
2	Total sugar content	%	9.87±0.13
3	Vitamin C content	mg/g	0.95±0.47
4	Total protein content	%	0.91±0.12
5	Total organic acid content	%	0.72±0.31

Table 1 shows that fresh Phuc Trach pomelos before being put into storage have a high content of nutritional components. The soluble dry matter content is 10.02°Bx, the total sugar content is 9.87%, the vitamin C content is 0.95%, the total protein content is 0.91% and the total organic acid content is 0.72%.

3.2 Colour change of Phuc Trach Pomelo during storage

The colour of Phuc Trach pomelo changed from green to yellow due to the physiological and biochemical activities of the fruit not only during the pre-harvest process but also during the storage process. The preservation coating has the effect of preventing water loss, limiting the respiratory process and inhibiting the aging of the fruit. Therefore, the preservation coating somewhat limits the colour change of the fruit. The results of determining the colour change of Phuc Trach pomelo during storage are shown in Table 2.

The preservation coating is made up of chitosan biocoating combined with tannin and vinegar. Phuc Trach pomelo in formula CT1 without coating has the fastest colour change rate. By the end of the 5th week of storage, all Phuc Trach pomelos in formula CT1 were completely rotten. The peel of Phuc Trach pomelo in formulas CT2, CT3 and CT4 still retains its yellow-green colour and has a high gloss. This is explained that Phuc Trach pomelo in formulas CT2, CT3, and CT4 is covered with a coating, which prevents water evaporation and creates a high gloss on the surface of the fruit. Comparing the preservation formulas, the results showed that Phuc Trach pomelos preserved in the formula CT3 (with the content of biological

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Table 2. Colour change of Phuc Trach pomelo during storage

Storage time (weeks)	The colour change of Phuc Trach pomelo according to the content of coating-forming preparations			
	CT1 (0%)	CT2 (1.0%)	CT3 (1.5%)	CT4 (2.0%)
1	0.95^{ab}	0.95^{ab}	0.96^{c}	0.94^{d}
2	1.86^{a}	1.75^{b}	1.73^{c}	1.78^{d}
3	2.88^{a}	2.82^{b}	2.76^{c}	2.81^{d}
4	3.46^{a}	3.18^{b}	3.13^{c}	4.13^{d}
5	5.76^{a}	5.54^{b}	4.38^{c}	5.67^{d}
6	-	7.86^{b}	7.43^{c}	7.67^{d}
7	-	-	8.16^{c}	-

Values with different superscripts within the same row are statistically significant different (P<0.05).

products forming a preservative coating of 1.5%) had the slowest change, specifically: From week 1 to week 7, colour varies from 0.96 to 8.16.

3.3 The change in hardness of Phuc Trach pomelo fruit during storage

The hardness of Phuc Trach pomelo gradually decreases during storage due to dehydration and changes in biochemical composition. The higher the hardness, the better the fruit quality is, and the better the preservation process has been. The results of determining the effect of preservation coating on the change of hardness of Phuc Trach pomelo are presented in Table 3.

The results in Table 3 show that the decrease in hardness of Phuc Trach pomelo in the CT1 treatment decreased from 15.18 (kg/cm^2) to 11.28 (kg/cm^2) after 3 weeks of storage. Phuc Trach pomelo preserved in the formula CT2 the hardness decreased from 15.13 (kg/cm^2) to 11.57 (kg/cm^2), the formula CT3 hardness decreased from 15.16 (kg/cm^2) to 12.73 (kg/cm^2) and the formula CT4 hardness decreased from 15.15 (kg/cm^2) to 11.69 (kg/cm^2). By the end of the 5th week of storage, all Phuc Trach pomelos preserved in formula CT1 were completely rotten and by week 6, all Phuc Trach pomelos preserved in formula CT2, CT4 are completely rotten. Comparing the change in hardness of Phuc Trach pomelo preserved in the experimental formulas CT2, CT3, and CT4, the results showed that Phuc Trach pomelo preserved in the formula CT3 had the slowest change. Thus, it shows that with the content of probiotics forming a preservative coating of 1.5% in the formula CT3, it has the best effect on limiting the change in the hardness of Phuc Trach pomelos.

3.4 Change in respiratory intensity of Phuc Trach pomelo during storage

Respiration is a complex physiological and biochemical process that changes the organic substances present in the fruit. This process consumes nutrients to form compounds that nourish, maintain the vital activities of the fruit, and partially release heat to the environment. The results of determining the effect of the preservation coating on the respiratory intensity change of Phuc Trach pomelo are presented in Table 4.

After one week of storage, the maximum respiratory intensity of Phuc Trach pomelo was in the formula CT1, then the formula CT2, CT4, and the lowest was in the formula CT3, with a respiratory rate is 35.68 (mL CO_2/kg.h). By the third week of storage, the respiratory intensity of Phuc Trach pomelo in the formula CT1 was 38.79 (mL CO_2/kg.h). Meanwhile, Phuc Trach pomelo in the CT2, CT3, and CT4 formulas had a slower respiratory rate. Therefore, the role of the preservation coating is to reduce gas exchange leading to a reduction in the respiratory process and reducing the loss of natural mass of Phuc Trach pomelo. Comparing preservation formulas, the results showed that Phuc Trach pomelos preserved in formula CT3 (the content of 1.5% probiotics to form preservative coating) after 7 weeks of storage had a change. respiratory rate slower than other

Table 3. The change in hardness of Phuc Trach pomelo fruit during storage

Storage time (weeks)	Hardness variation of Phuc Trach pomelo (kg/cm^2) according to the content of coating-forming preparations			
	CT1 (0%)	CT2 (1.0%)	CT3 (1.5%)	CT4 (2.0%)
1	15.18^{a}	15.13^{b}	15.16^{cd}	15.15c^{d}
2	12.67^{a}	12.91^{b}	13.83^{e}	12.91^{d}
3	11.28^{a}	11.57^{b}	12.73^{e}	11.69^{d}
4	10.22^{a}	11.13^{b}	11.96^{e}	11.71^{d}
5	9.25^{a}	10.79^{b}	11.52^{e}	10.87^{d}
6	-	10.43^{b}	11.26^{e}	10.64^{d}
7	-	-	10.23^{e}	-

Values with different superscripts within the same row are statistically significant different (P<0.05).

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Table 4. The change in respiratory intensity of Phuc Trach Pomelo during storage

Storage time (weeks)	Change in respiratory intensity of Phuc Trach Pomelo (mL CO_2/kg.h) according to the content of coating-forming preparations			
	CT1 (0%)	CT2 (1.0%)	CT3 (1.5%)	CT4 (2.0%)
1	47.31[a]	39.74[b]	35.68[c]	36.72[d]
2	43.73[a]	36.87[b]	31.85[c]	31.94[d]
3	38.79[a]	32.69[b]	29.98[c]	30.62[d]
4	32.72[a]	29.75[b]	27.93[c]	27.98[d]
5	30.81[a]	24.65[b]	22.69[c]	24.79[d]
6	-	21.53[b]	19.97[c]	20.84[d]
7	-	-	18.95[c]	-

Values with different superscripts within the same row are statistically significant different (P<0.05).

experimental formulas.

3.5 Change of soluble dry matter content of Phuc Trach pomelo during storage

Depending on different storage conditions, the soluble dry matter content in Phuc Trach pomelo changes quickly or slowly. This variation of Phuc Trach pomelo is shown in Table 5.

Table 5 shows that the soluble dry matter content of Phuc Trach pomelo increases gradually during storage. Phuc Trach pomelo in formula CT1 increased more rapidly than Phuc Trach pomelo in formula CT2, formula CT3, and formula CT4. By the third week of storage, the soluble dry matter content of Phuc Trach pomelo preserved in the formula CT1 increased from 10.16°Bx to 10.62°Bx, the formula CT2 increased from 10.08°Bx to 10.54°Bx, the formula CT4 formula increased from 10.09°Bx to 10.58°Bx and the slowest increase was in formula CT3 increased from 10.04°Bx to 10.45°Bx. This change tended to increase gradually in the following weeks of storage and after 5 weeks of storage, Phuc Trach pomelos in the CT1 formula were completely rotten. The reason for this phenomenon is due to the hydrolysis of the cell wall by various enzymes such as pectinase, cellulose, hemicellulose, and pectinesterase, which convert insoluble substances into solutes. Compared with fresh Phuc Trach pomelo before being put into storage, this change is not much. It shows that, with a preservative product content of 1.5%, it has effectively limited the change in the soluble dry matter content of Phuc Trach pomelo.

3.6 Change in total sugar content of Phuc Trach pomelo fruit during storage

Total sugar is an important indicator to evaluate the quality of Phuc Trach pomelo during storage, the total sugar content has a decreasing trend. The results of the determination of the total sugar content of Phuc Trach pomelo during storage are presented in Table 6.

Research results in Table 6 show that after one week of storage, the total sugar content of Phuc Trach pomelo in the formulas CT1, CT2, and CT4 has the same variation and more compared with Phuc Trach pomelo preserved in formula CT3. By the 5th week of storage, the total sugar content of Phuc Trach pomelo preserved in the formula CT1 changed more than the other formulas, specifically the remaining total sugar content was 2.17%. Phuc Trach pomelo fruit in CT1 formula is not covered by a preservative coating, leading to the activity of enzymes and microorganisms, the impact of environmental factors is strong, causing the fruit to change rapidly and cause damage to the fruit. reduce total sugar content. Comparing the preservation formulas of CT2, CT3, and CT4, the results showed that Phuc Trach pomelos preserved in the formula CT3 had a slower change in total sugar content. By the end of the 5th week of storage, all Phuc Trach pomelos were preserved in the formula CT1 and

Table 5. Variation of the soluble dry matter content of Phuc Trach pomelo during storage

Storage time (weeks)	Variation of the soluble dry matter content of Phuc Trach pomelo (°Bx) according to the content of coating-forming preparations			
	CT1 (0%)	CT2 (1.0%)	CT3 (1.5%)	CT4 (2.0%)
1	10.16[a]	10.08[b]	10.04[c]	10.09[d]
2	10.47[a]	10.41[b]	10.32[c]	10.43[d]
3	10.62[a]	10.54[b]	10.45[c]	10.58[d]
4	11.34[a]	11.28[b]	11.06[c]	11.31[d]
5	11.51[a]	11.43[b]	11.27[c]	11.39[d]
6	-	11.52[b]	11.38[c]	11.54[d]
7	-	-	11.46[c]	-

Values with different superscripts within the same row are statistically significant different (P<0.05).

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Table 6. The change in total sugar content of Phuc Trach pomelo during storage

Storage time (weeks)	Change in total sugar content of Phuc Trach pomelo (%) according to the content of coating-forming preparations			
	CT1 (0%)	CT2 (1.0%)	CT3 (1.5%)	CT4 (2.0%)
1	4.21[a]	8.07[b]	8.99[c]	8.13[d]
2	4.58[a]	7.08[b]	7.74[c]	3.71[d]
3	3.41[a]	5.21[b]	7.36[c]	5.39[d]
4	3.19[a]	3.04[b]	6.27[c]	5.15[d]
5	2.17[a]	3.02[b]	6.08[c]	5.11[d]
6	-	2.86[b]	5.74[c]	4.93[d]
7	-	-	5.06[c]	-

Values with different superscripts within the same row are statistically significant different (P<0.05).

Table 7. Variation of vitamin C content of Phuc Trach Pomelo during storage

Storage time (weeks)	Variation of vitamin C content of Phuc Trach Pomelo (mg/g) according to the content of coating-forming preparations			
	CT1 (0%)	CT2 (1.0%)	CT3 (1.5%)	CT4 (2.0%)
1	0.75[a]	0.65[b]	0.84[c]	0.81[d]
2	0.73[ad]	0.85[b]	0.78[c]	0.72[ad]
3	0.61[a]	0.57[b]	0.72[c]	0.65[d]
4	0.55[a]	0.52[b]	0.68[c]	0.57[d]
5	0.32[a]	0.35[b]	0.53[c]	0.52[d]
6	-	0.27[b]	0.49[c]	0.36[d]
7	-	-	0.42[c]	-

Values with different superscripts within the same row are statistically significant different (P<0.05).

by the 6th week of storage, all Phuc Trach pomelos were preserved in the formula CT2, and CT4 were rotten. completely broken. It shows that with a preservative product content of 1.5% in the formula CT3, the effect of limiting the change in total sugar content is greater than in the formula CT2 with a preservative content of 1% and formula CT4 with 2% composition. Because formula CT2 with low content of preservatives, it is not able to limit the loss of total sugar content. But when used with too large a concentration of preservatives in the formula CT4, Phuc Trach pomelos are covered with a thick coating, causing water to accumulate on the surface of the peel, causing the fruit to rot quickly, and reducing the content of the fruit.

3.7 Changes in vitamin C content of Phuc Trach pomelo during storage

Vitamin C is an important micronutrient in Phuc Trach Pomelo. The vitamin C content in the fruit tends to decrease during storage. The results of determining the change in vitamin C content of Phuc Trach Pomelo during storage are shown in Table 7.

Table 7 shows that during the preservation process, the vitamin C content of Phuc Trach pomelos decreased gradually in all recipes. By the 5th week of storage, the vitamin C content of Phuc Trach Pomelo in the formula CT1, CT2, and CT4 remained 0.32 mg/g, 0.35 mg/g, and 0.52 mg/g. Comparing the 4 experimental formulas, by the 5th week, the vitamin C content of Phuc Trach pomelo decreased the lowest and the remaining was 0.53 mg/g. By the 7th week of storage, only Phuc Trach pomelos preserved in the formula CT3 were not completely rotten and the remaining vitamin C content of Phuc Trach pomelos was determined to be 0.42 mg/g. If compared with fresh Phuc Trach pomelo before being put into storage, this change is not much. Thus, with a preservative composition of 1.5% in the formula CT3, it was effective to limit the loss of vitamin C content of Phuc Trach pomelo fruit more effectively than other experimental formulas.

3.8 Changes in total protein content of Phuc Trach pomelo during storage

The total protein content is also an important indicator to evaluate the quality of vegetables in general and Phuc Trach pomelo in particular. During the preservation process, the total protein content tends to decrease gradually due to the degradation process by enzymes. The change in total protein content of Phuc Trach pomelo is presented in Table 8.

Table 8 shows the end of the first week, the total protein content of Phuc Trach pomelos preserved in the formula CT1 decreased the most compared to the formulas CT2, CT3, and CT4. This phenomenon occurs because Phuc Trach pomelo in formula CT1 is not covered by a preservative coating, leading to the activity of enzymes, microorganisms, and the impact of environmental factors; resulting in the rapid change of

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fruit and a decrease in total protein content. By the fifth week of storage, the total protein content of Phuc Trach pomelos decreased the most in the formula CT1, then in the formula CT2 and formula CT4, and the lowest decrease was in the formula CT3. Meanwhile, by the 7th week of storage, only pomelos preserved in the formula CT3 were not completely rotten and the total protein content of Phuc Trach pomelos was determined to be 0.38%. It shows that, with the preservative product content of 1.5% in the formula CT3, it has the effect of limiting the loss of total protein content of Phuc Trach pomelo fruit more effectively than the experimental formulas CT1, CT2, and CT4.

3.9 Change in the total organic acid content of Phuc Trach pomelo during storage

The total organic acid content has the effect of creating the characteristic flavor of Phuc Trach pomelo. Therefore, it is necessary to limit the reduction of total organic acid content during storage. The results of determining the change in the total organic acid content of Phuc Trach pomelo are shown in Table 9.

After one week of storage, the total organic acid content of Phuc Trach pomelo in the formula CT1 decreased to 0.31%, the formula CT2 reduced the remaining 0.38%, and the formula CT4 the remaining reduction is 0.39% and the lowest reduction in the formula CT3, the remaining reduction is 0.62%. In the following weeks of storage, the total organic acid content of Phuc Trach pomelo in all treatments decreased, the greatest reduction was still in the formula CT1 and the lowest was still in the formula CT- C. It shows that Phuc Trach pomelo in formula CT1 does not use preservative coating, leading to the activity of enzymes and microorganisms, the impact of environmental factors is strong, causing the fruit to be changed. rapidly and reduce the total organic acid content. In the formula CT3, the preserved fruit with 1.5% inoculant content was more effective than other formulas in limiting the change in the total organic acid content of Phuc Trach pomelo in the preservation process.

4. Conclusion

The comparison between 4 experimental formulas to preserve Phuc Trach pomelo fruit is formula CT1, formula CT2, formula CT3, and formula CT4. The results showed that Phuc Trach pomelo preserved in formula CT3 with 1.5% inoculant content was effective in limiting the change of physico-chemical and biochemical indicators more effectively than other experimental formulas. After 7 weeks of storage, the colour changed from 0.96 to 8.16, hardness changed from 15.16 to 10.23 (kg/cm^2), respiratory intensity from 35.68 to 18.95 (mL CO_2/kg.h), soluble dry matter content from 10.04 to 11.46^{o}Bx, total sugar content from 8.99 to 5.06%, vitamin C content from 0.84 to 0.42 mg/g, total protein content from 0.79 to 0.38% and total organic acid content from 0.62 to 0.17%. Meanwhile, Phuc Trach pomelos preserved in other recipes until the

Table 8. Variation of the total protein content of Phuc Trach pomelo during storage

Storage time (weeks)	Variation of the total protein content of Phuc Trach pomelo (%) according to the content of coating-forming preparations			
	CT1 (0%)	CT2 (1.0%)	CT3 (1.5%)	CT4 (2.0%)
1	0.08^{ab}	0.08^{ab}	0.79^{c}	0.69^{d}
2	0.65^{a}	0.66^{b}	0.75^{c}	0.63^{d}
3	0.57^{ad}	0.46^{b}	0.69^{c}	0.56^{d}
4	0.45^{a}	0.38^{b}	0.65^{c}	0.49^{d}
5	0.26^{ab}	0.27^{ab}	0.59^{c}	0.38^{d}
6	-	0.22^{b}	0.42^{c}	0.34^{d}
7	-	-	0.38^{c}	-

Values with different superscripts within the same row are statistically significant different (P<0.05).

Table 9. Change in the total organic acid content of Phuc Trach pomelo during storage

Storage time (weeks)	Variation of the total organic acid content of Phuc Trach pomelo (%) according to the content of coating-forming preparations			
	CT1 (0%)	CT2 (1.0%)	CT3 (1.5%)	CT4 (2.0%)
1	0.31^{a}	0.38^{bd}	0.62^{c}	0.39^{bd}
2	0.54^{a}	0.27^{b}	0.59^{c}	0.33^{d}
3	0.27^{a}	0.31^{b}	0.47^{c}	0.29^{d}
4	0.29^{a}	0.25^{ad}	0.32^{c}	0.25^{ad}
5	0.16^{ab}	0.17^{ab}	0.26^{c}	0.24^{d}
6	-	0.16^{b}	0.21^{c}	0.18^{d}
7	-	-	0.17^{c}	-

Values with different superscripts within the same row are statistically significant different (P<0.05).

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5th and 6th week were completely rotten. Therefore, the formula CT3 was selected with a preservative composition of 1.5% to develop the process of preserving Phuc Trach pomelo.

Conflict of interest

The author declares the research results in this article to be completely honest. The data has never been used or rotated from other research projects in any form.

References

Kahramanog˘lu, K., Chen, C., Gan, Z., Chen, J. and Wan, C. (2020). The Effects of Edible Coatings on the Postharvest Quality of Citrus Fruits as Affected by Granulation. *Journal of Food Quality*, 2020, 8819233, 1-8. https://doi.org/10.1155/2020/8819233.

Nguyen, V.L. (2019). Determining the effect of saponin preservation coating combined with chitosan and acetic acid on quality change of Cao Bang mandarin. *Journal of Science- Hanoi National University of Education*, 64(3), 97-107. https://doi.org/10.18173/2354-1059.2019-0012

Nguyen, V.L. and Nguyen, Q.T. (2019). Choose the method to create the suitable biocoating to preserve Cao Phong orange (*Citrus sinensi*s Osbeck). *Journal of Science and Technology*, 55, 103-107.

Tran, T.M., Tran, T.T., Nguyen, V.M. and To, N.P.M. (2020). Morphological characteristics and physicochemical properties of 4 pomelo varieties in the Mekong Delta. *Industry and Trade Magazine*, 24, 57-64.

Tran, T.T., Mai, T.T., Mai, D.T. and Nguyen, T.T. (2021). Research on herbal tea bags processing technology for pomelo peel of Nam Roi cultivar (*Citrus grandis* (L.) Osbeck). *Science Journal of Can Tho University*, 57, 10-20. https://doi.org/10.22144/ctu.jsi.2021.002

Vietnamese National Standards. (1988a). Canned goods - Method for the determination of total organic acids and volatile acids, 1-3. (TCVN 4589-1988). Retrieved from http://tieuchuan.mard.gov.vn/ViewDetails.aspx?id=5343&lv=5&cap=1

Vietnamese National Standards. (1988b). Canned foods - Determination of total sugar, reducing sugar and starch content, 1-4. By field 67.040. Equivalent to ST SEV 3450-81, IDT (TCVN 4594:1988). Retrieved from https://tieuchuan.vsqi.gov.vn/tieuchuan/view?sohieu=TCVN+4594%3A1988

Vietnamese National Standards. (1998). Fruit, vegetables and derived products - Determination of ascorbic acid content - Part 2: Routine methods, 1-10. By field 67.080.01. Equivalent to ISO 6557/2:1984, IDT. (TCVN 6427-2:1998). Retrieved from https://tieuchuan.vsqi.gov.vn/tieuchuan/view?sohieu=TCVN+6427-2%3A1998

Vietnamese National Standards. (2011). Fresh fruits - Sampling method on the field, 1-5. By field 67.080.10. Normative references TCVN 5102:1990 (ISO 874:1980) (TCVN 9017:2011). Retrieved from https://tieuchuan.vsqi.gov.vn/tieuchuan/view?sohieu=TCVN+9017%3A2011

Vietnamese National Standards. (2013). Starches and derived products - Determination of nitrogen content by the Kjeldahl method - Titrimetric method, 1-6. By field 67.180.20. Equivalent to ISO 3188:1978, IDT. (TCVN 9936:2013). Retrieved from https://tieuchuan.vsqi.gov.vn/tieuchuan/view?sohieu=TCVN+9936%3A2013

https://doi.org/10.26656/fr.2017.7(2).167