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IMPROVING THE SHELF-LIFE OF THE SWEET CHERRY BY MULTICOMPONENT EDIBLE COATINGS

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Abstract

One of the possibilities in the great challenge to maintain the shelf-life of perishable fruits like the sweet cherry is the application of multicomponent edible coatings. In our study chitosan and grape seed oil multicomponent edible film was applied to protect the quality and delay the microbiological contamination of the fruits. Physical (weight loss, texture, colour), physico-chemical (antioxidant activity, acidity, refractive index and BRIX), sensorial (consumer test) and food-safety (total microbial count, total amount of molds and yeasts, pathogens) parameters were analyzed during 4 weeks of refrigerated storage following the changes of the fruit series. Our results show that the applied coating extended the shelf-life timing of the sweet cherry. The delay in the fruits' decay was different for the samples coated with pure chitosan solution and chitosan-grape seed oil emulsion.

Keywords: Chitosan, Grape seed oil, Sensory evaluation, Physical properties, Antimicrobial effect, Anti-browning effect.

INTRODUCTION

Fresh fruits and vegetables are the most important part of the healthy diet, but they are very perishable (Nair et al., 2020). Transpiration and respiration continue during the postharvest life and hence they lose their quality and safety (Lee & Hwang, 2017). The increasing demand of healthy compounds is a challenge for the food scientist to find a suitable preservation method to keep their fresh values. The sweet cherry is a high-appreciated fruit with a very short season for consummation and low storability. It is rich in ascorbic acid, anthocyanins, and phenolic compounds (Zam, 2019). One of the effective and environmentally friendly possibilities to maintain the nutrition value and the safety of the fruits is the use of biodegradable edible polymers for coating their surface and reduce the level of respiration (Tahir et al., 2019, Sapper & Chiralt, 2018). The edible coatings decrease the quality loss by covering the surface of the fruits with a safety semipermeable barrier. The film forming the properties of these polymers allow the synthesis of membranes (thickness > 30 μm) and coatings (< 30 μm) which are able to protect the food products (Ferreira et al. 2016). The chitosan is a film forming, biodegradable, edible polymer with good antimicrobial properties which can increase the shelf-life of fruits alone or in combination with other components (Kumar et al. 2020). Chitosan is safe (USFDA, 2001) and permitted as a food additive up to 3 gr. daily intake (EU, 2012). Plenty of previous works reported a successful use of chitosan-based coatings to delay the fruit decay (Zam 2019, Zsivanovits et al 2021a, 2021b), preserve the textural, antioxidant or sensorial properties, and delay the microbiological contamination. The literature shows that the grape seed extract is a compound which enhances the antioxidant activity of the edible coatings (Amiri et al., 2021, Avramescu et al., 2020). The emulsified multicomponent coatings can have similar intensified effect like the multilayered ones, but they can be prepared easier with one dipping and drying (Oliveira et al., 2021).

In this study, grape seed oil was incorporated into low molecular weight chitosan coating to investigate the effect of this combination on the shelf-life properties of the sweet cherry variety (Regina). Based on some previous research of the team, the hypothesis of this study is that the emulsified chitosan coating should produce a better quality preservation effect than the pure chitosan coating. It is applied on the fruits with less manipulation than the multilayered coatings, like chitosan-alginate bilayer combination.

MATERIALS AND METHODS

Fruits: the fresh sweet-cherry (*Prunus avium* L., cv. Regina) was harvested in full maturation in the Fruit Growing Institute – Plovdiv, Agricultural Academy of Bulgaria (Malchev & Zhivondov, 2016). The intact fruits with 20±2 mm medium diameter were washed carefully, before dipping to the coating solutions. 630 pieces of sweet cherries were used for three experiment series: ***control*** (not coated just washed), coated with low-molecular weight ***chitosan*** solution and coated with an emulsion from low molecular weight ***chitosan*** and ***grape seed oil extract***. Seven repetitions tray (30 fruits/trays) were prepared from each series and stored in a refrigerator at 4±1 °C.

Chemicals: Low molecular weight fungal (mushroom origin) chitosan hydrochloride (degree of deacetylation > 85.0%) was purchased from Glentham Life Sciences Ltd, UK. Cold pressed pure grape seed oil extract was bought from Ikarov EOOD, Plovdiv, Bulgaria. The tween 20 emulsifier was delivered from Sigma Aldrich and the glycerol was sold by Ray-Chem product EOOD, Plovdiv, Bulgaria.

Preparing of the experimental series:

- Control fruits [C]: carefully washed with tap water and dried at room temperature onto a paper with good water absorbance properties.
- Chitosan coated fruits [CH]: After washing and drying, the fruits were dipped to 1 % water-soluble chitosan solution for 10 minutes to assure the uniformity of the coating and were left to dry at room temperature for 10 minutes.
- Chitosan-Grape-seed oil emulsion coated fruits [CH-GSO]: The dipping emulsion was prepared from 1% water soluble chitosan solution and 0.5 % GSO, 0.5 % Tween 20 and 0.15 % glycerol. The dipping and drying time was 10 minutes like above.

After drying, the fruits were picked to place-numbered trays (30 pieces, 7 trays) and stored in a refrigerator to the day of the experiments.

Physical methods for periodical control:

Weight loss, loss of intact fruits, color parameters of whole fruits and fruit flesh, texture parameters, refractive index, Brix and water activity were investigated at the beginning and after that once a week, up to the 4 week storage period. Before the tests, the fruits were tempered at room temperature for one hour.

Color parameters were determined using a colorimeter (PCE-CSM 5 portable colorimeter). The CIELAB color parameters L, a, b, and c were measured (Measuring geometry 8°/d, Ø 8 mm, light source D65) and ISO yellowness indexes were calculated by the Color Quality Controller System 3 software. A white control plate (L* = 94.3; a* = -0.92; b* = -0.67) was used as a calibration plate. One tray (30 pieces) whole fruits and 15 halved fruits were measured weekly.

Texture parameters of 15 fruit were examined by a slowly puncture test with a TA.XT2 Texture Analyser (Stable Micro Systems, Surrey, UK). A 5 mm cylindrical probe was used to measure the firmness, Young's modulus, deformation work, rupture stress and crunchiness every week. Before the tests, 3 diameters of fruits were recorded by a digital caliper.

The *refractive index, Brix and water activity* were investigated on a meshed pulp from 15 fruits with portable digital instruments, Kern ORF3SM and Rotronic HP23-AW-SET-40 respectively.

Physicochemical methods

Titratable acidity (TA) was investigated by titration of the fruit juice with NaOH (0.1 N) in triplicate and expressed as g of malic acid equivalent per 100 g fresh weight (Gonçalves et al. 2021). The *pH* of the juice was obtained in triplicate by a Milwaukee MW1 02-FOOD digital pH meter.

The *total antioxidant capacity* was determined by the free radical scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP) assay. The *total polyphenol content* (TTP) was detected by spectrophotometric method. The methods were described in details by Petrova et al. (2016). These parameters were analyzed 3 times during the shelf-life period.

Sensory evaluation

Fresh cherries non-coated, coated with chitosan (1%) and coated with chitosan (1%) & grape seed's oil (0.5%), were used for sensory analysis. The whole cherry fruits belonging to the variety "Regina" prepared the day before the test and stored at 5 °C for three weeks were evaluated by thirty volunteers aged between 20–50 years, who like and eat cherries frequently. Twelve samples, labeled with 3-digit numbers were randomly provided together with a glass containing potable water and pieces of non-salted cracker served to panelists for eliminating the residual taste between the samples. Appearance, shape & size, color, fruit taste, aroma, firmness and browning around the stone were the evaluated attributes. Each was scored for a quality evaluation on a structured 9-point scale labeled from "absolutely no quality" (1) to "extremely good quality" (9) (Coklar et al. 2018, Yang et al. 2019). The analysis of the sensory parameters was stopped after the 3rd week (best before date).

Methods for microbiological safety analysis:

The analytical methods for safety analysis were selected based on the Commission Regulation (EC) № 2073/2005 of 15 November 2005 on the microbiological criteria for foodstuffs:

- Total plate counts (TPC) (BS EN ISO 4833-1: 2013): Microbiology of the food chain. Horizontal method for enumeration of microorganisms. Part 1: Counting of colonies at 30 °C by a crop flooding technique (ISO 4833-1: 2013)
- Escherichia coli (BS ISO 16649-2: 2014): Microbiology of food and feed. Horizontal method for the enumeration of β-glucuronidase- positive Escherichia coli. Part 2: Colony-counting technique at 44°C using 5-bromo-4-chloro-3-indolyl β-D-glucuronide.
- Moulds and yeasts (BS ISO 21527-2: 2011): Microbiology of food and feed. Horizontal method for counting yeasts and moulds. Part 2: Colony-count technique in products with a water activity less than or equal to 0.95.
- Salmonella (BDS EN ISO 6579-1:2017/Amd 1:2020): Microbiology of the food chain — Horizontal method for the detection, enumeration and stereotyping of Salmonella — Part 1: Detection of Salmonella spp. — Amendment 1: Broader range of incubation temperatures, amendment to the status of Annex D, and a correction of the composition of MSRV and SC.

Microbiological parameters were determined 3 times during the storage period in the laboratory of the Institute of Food Preservation and Quality – Plovdiv.

Statistical analysis

Statistical analysis was performed using the statistical package Statistica. A multifactor ANOVA with posterior Multiple Range Test was used to find significant differences ($p<0.05$) between the storage time and the edible coating on the sensory evaluation profile.

RESULTS AND DISCUSSION

Physical methods:

The loss of intact fruits (fig. 1): During the first and the second week of the storage the chitosan coated samples show the smallest loss, 7.14% and 20.95% respectively. After 3 weeks of storage (best before time) the loss is the smallest for Ch-GSO coated samples, 41.43% and at the end of the storage (used before time) the loss is the smallest again for the Ch-GSO coated samples, 68.1%.

The *weight loss* (fig. 2) was the highest for the control samples (up to 29%) during the full storage period and the smallest for the pure chitosan coated sweet cherry samples (up to 21%).

Color parameters:

One of the requirements of the edible packaging is not to change the color of the packaged product. The packaging of cherries with edible coatings almost did not change the color characteristics - this can be seen from the small, insignificant differences in the values of color characteristics on the first day. During the storage, the color of the cherries changed from dark red to brown. This is shown by a decrease in the indicators a* (red-green) and b* (blue-yellow) and an increase in h* (color angle – Table 1).

Table 1 Color characteristics of the cherries packed with edible coatings of chitosan + GSO.

Day	L*	a*	b*	c*	h*	□E*
Control						
1	27.92±1.80d	12.36±0.71e	4.43±0.20d	13.14±0.74d	17.64±1.17a	70.38±1.33a
7	27.14±1.66c	10.40±0.75d	3.59±0.31c	11.02±0.86c	18.42±1.6b	70.72±0.71ab
14	26.67±1.17bc	8.75±0.57c	2.93±0.25b	9.24±0.60b	19.34±1.34c	70.77±1.37b
21	26.56±1.46b	7.15±0.41b	2.91±0.17ab	7.78±0.57b	20.87±1.57d	70.99±1.09bc
28	25.74±0.95a	5.18±0.26a	2.08±0.14a	5.58±0.44a	22.13±1.88d	71.38±0.78c
Chitosan						
1	28.89±1.53c	12.48±0.77c	4.46±0.37c	13.26±0.99c	18.38±1.32a	69.49±0.78a
7	28.11±1.80b	10.91±0.79b	3.87±0.27b	11.6±0.95b	18.92±1.59ab	69.95±1.08b
14	27.57±0.90ab	10.52±0.68b	3.59±0.28b	11.13±0.85b	19.05±1.40b	70.84±1.56d
21	26.98±1.81a	9.62±0.72b	3.69±0.30b	10.30±0.89b	19.22±1.70b	70.12±0.48bc
28	26.97±1.23a	7.59±0.59a	2.69±0.19a	8.05±0.58a	20.85±1.31c	70.47±0.72cd
Chitosan+GSO						
1	28.38±1.22d	12.65±0.79c	4.41±0.39b	13.4±0.94c	17.49±1.29a	69.95±0.71a
7	27.36±1.10c	9.99±0.87b	3.31±0.29a	11.27±0.77b	17.96±1.27ab	70.44±0.74bc
14	27.31±0.92bc	9.56±0.81ab	3.16±0.27a	10.09±0.62ab	18.88±1.45c	70.92±1.01d
21	26.75±1.44a	8.63±0.70a	3.04±0.29a	9.16±0.58a	18.98±1.66cd	70.22±0.56ab
28	26.82±0.77ab	8.50±0.67a	3.11±0.27a	9.05±0.59a	20.04±1.50d	70.65±0.58cd

The changes in these parameters were the greatest for the control samples (<50%) and the smallest for the samples packed with chitosan + GSO (about 30%) and intermediate for the fruits packed with chitosan (about 40%). The reported changes are close to the literature data (Tsaniklidis et al. 2017).

The saturation (C * value) indicates a brighter color of the fruit peel and a higher market value. Covered fruits show a slower decrease in saturation compared to the control. Better preservation of the saturation value is observed for the samples, packaged with pure chitosan coating, but at the end of the storage time samples with the chitosan + GSO coating are more stable (Fig. 3).

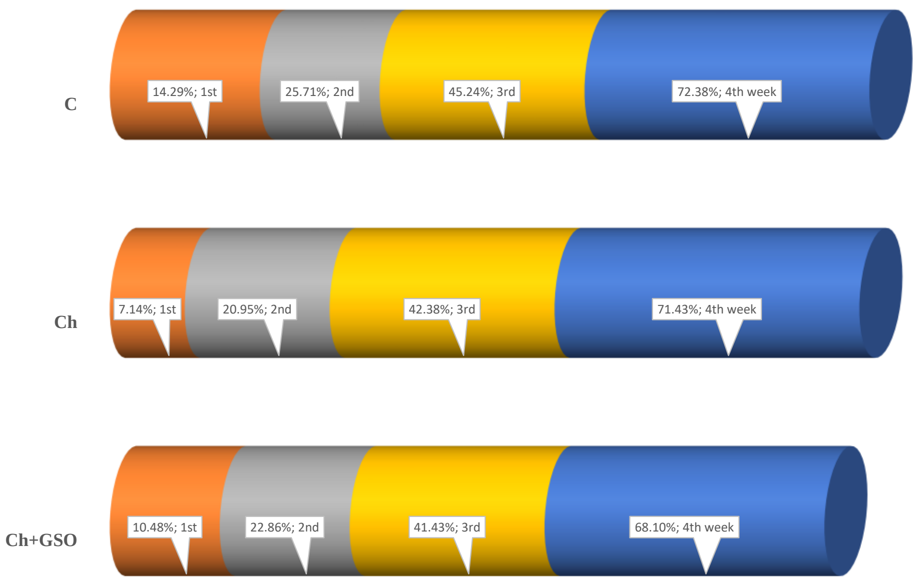


Fig 1 Result for the loss of intact fruits for the sweet cherry coated with chitosan + GSO emulsion.

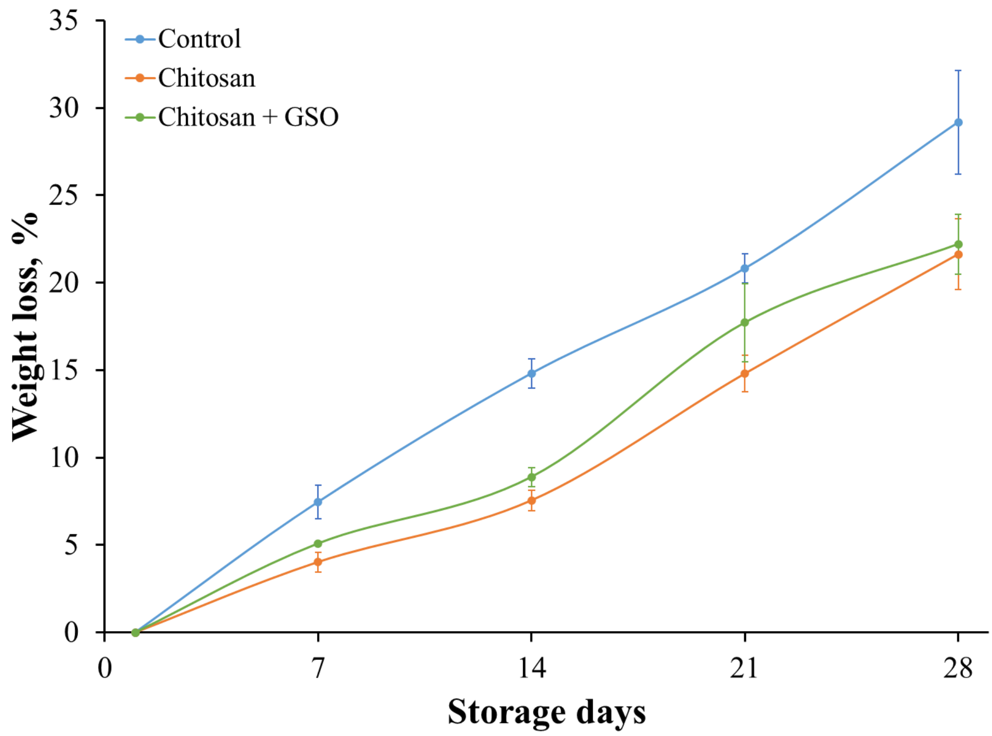


Fig. 2 Results for the weight loss for the sweet cherry coated with chitosan + GSO emulsion.

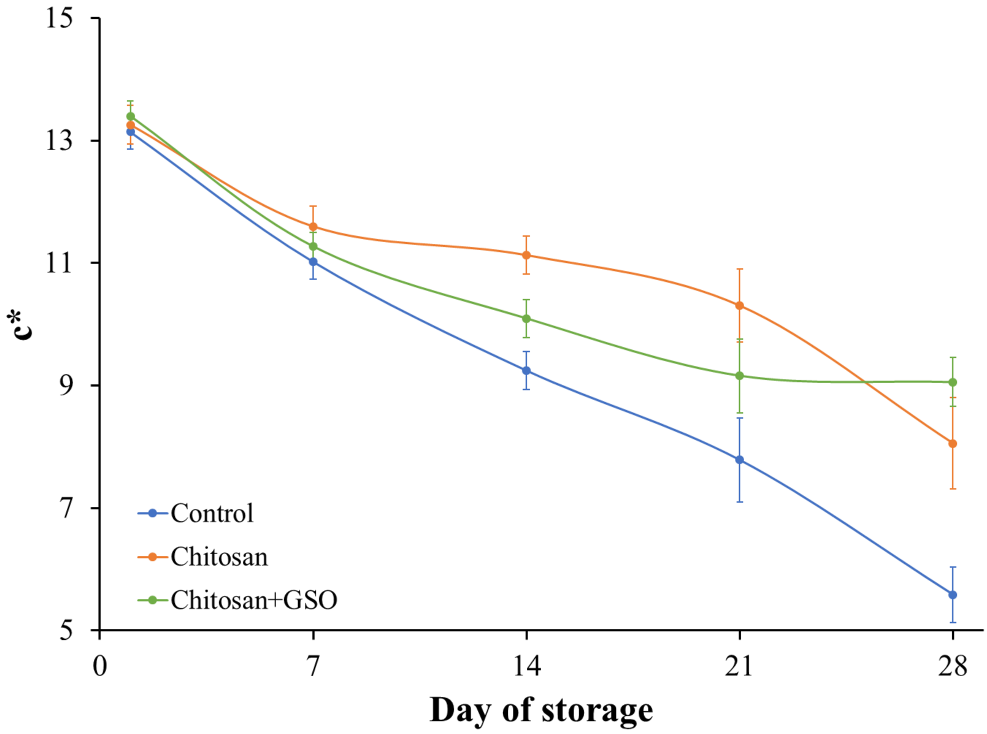


Fig. 3 Change in the saturation of the whole, packaged cherries.

Cherry flesh color

The color characteristics of the cherry flesh on the first day are presented as averages (Table 2). During the storage, the change in brightness is greater for the fruits packed in chitosan coating, which means a loss of color. This is the disadvantage of this packaging. For cherries packed with chitosan + GSO, these values are constant during the first 3 weeks (quality shelf life), as the oil content keeps the fruit from discoloration, but then suddenly exceeds the values of the samples with the other coating. The reduction of red color, a* is the largest and continuous for the control samples. During the first 3 weeks, this change is slower for the samples with chitosan packaging and is the slowest for the samples with chitosan + GSO packaging. In the 4th week, the value decreases very quickly and becomes close to that of the control. The values of the yellow color index (b*) are very similar for the control and the packaged chitosan-coated fruits. Fruits packed with chitosan + GSO show higher values with an increasing trend which may be due to the diffusion of oil into the flesh.

Saturation (value C*) indicates browning of the flesh under the stone. This is an important sensory feature of the stored cherries. The flesh of the covered fruit shows a slower browning than the control. The chromium value was stable in the fruits with chitosan + GSO coating until the end of the quality (Fig. 4).

According to the literature, the color changes are due to enzymatic reactions that are related to the intensity of respiration (Tsaniklidis et al. 2017). The study of these enzymatic changes, their dependence on packaging components requires a more in-depth study in the future, in the framework of a new project proposal.

Table 2 Color characteristics of the packaged cherry flesh.

Day	L*	a*	b*	c*	h*	ΔE*
			Control			
1	20.64±4.10a	16.24±1.38b	7.09±0.54a	17.73±3.36b	23.38±2.04a	79.15±6.00b
7	19.58±3.39a	14.97±1.40ab	6.59±1.67a	16.35±7.24ab	22.95±2.07a	67.13±5.81a
14	22.01±5.14a	13.43±1.05a	6.52±3.51a	14.99±2.85ab	22.50±1.94a	65.57±4.77a
21	22.69±3.10a	12.48±0.98a	5.63±1.68a	13.73±2.36a	21.92±1.60a	64.36±5.20a
28	22.87±4.57a	11.32±0.98a	5.45±3.02a	12.71±2.58a	21.89±1.78a	55.05±5.24a
			Chitosan			
1	20.64±1.9a	16.24±1.38bc	7.09±0.54a	17.73±1.36b	23.38±2.05b	79.15±6.00b
7	20.55±1.79a	15.35±1.19b	6.58±0.53ab	16.82±1.16a	23.37±1.9b	80.82±5.88b
14	22.15±1.59ab	14.61±1.26ab	6.55±0.51ab	15.88±1.09a	23.35±1.83b	76.55±6.52b
21	22.95±1.45ab	14.42±1.39ab	6.15±0.57b	15.61±1.26a	22.61±1.59a	70.64±5.43a
28	24.70±2.21b	14.13±1.25a	5.48±0.46c	14.95±1.16a	22.61±1.74a	62.66±5.22a
			Chitosan+GSO			
1	20.64±1.80a	16.24±1.38b	7.09±0.54a	17.73±1.36b	23.38±2.05a	79.15±6.00b
7	18.51±1.59a	16.44±1.29b	7.62±1.72a	18.11±1.54b	20.50±1.82a	80.43±6.23b
14	19.36±1.66a	15.71±1.12b	8.47±2.07b	17.86±1.49b	27.59±2.12b	80.83±6.26b
21	20.90±1.68a	14.85±1.07b	9.00±2.01c	17.37±1.48b	28.36±2.42b	79.03±6.87b
28	26.66±1.95b	12.05±0.96a	10.07±1.83c	15.70±1.02a	34.55±2.54c	67.41±5.53a

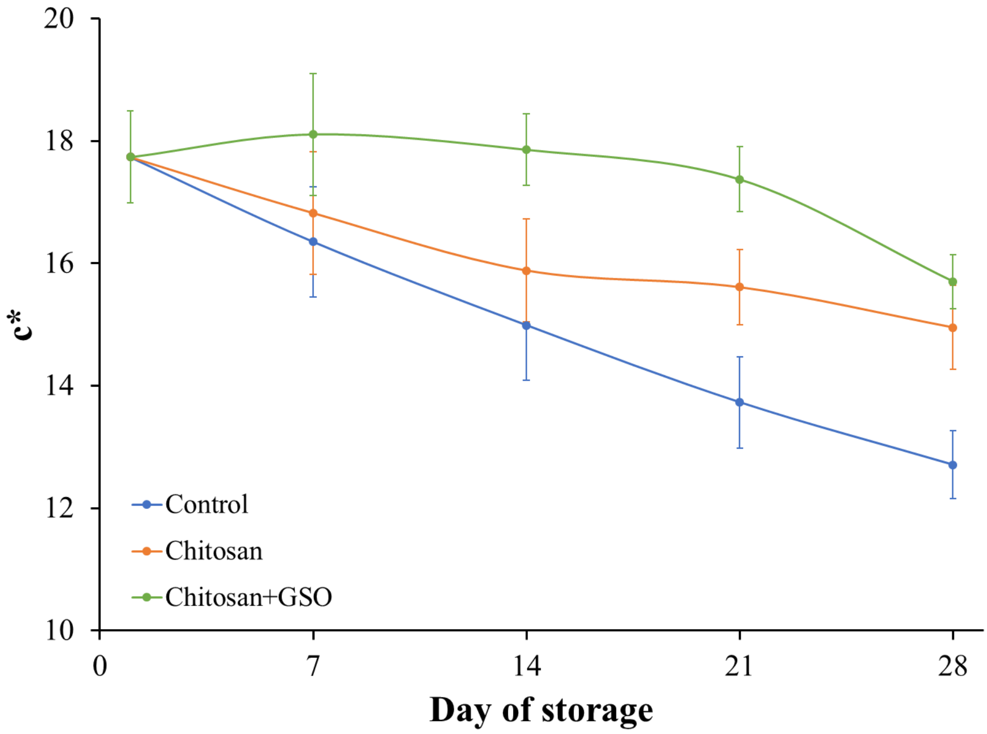


Fig. 4 Saturation changes of the halves of the coated cherries.

Textural characteristics of coated cherries

The yield point of the control fruits increased until the 3rd week, and then decreased, reaching values close to the initial ones (Table 3). The increase is due to the drying of the cells, and the decrease at the end of the period is due to the rupture of the cell structure (Rojas-Graü et al., 2007). Immediately after coating, the fruit shows lower brittleness, most likely because when immersed part of the water in the solution diffuses inside the fruit. After the first week, they show the highest values due to the film. Later, the values begin to decrease and remain constant until the end of the storage.

Table 3 *Textural characteristics of coated cherries.*

Day	Yield point, kPa	Deformation work, kPa	Young's modulus, kPa	Hardness, kPa	Crispness
Control					
1	72.69± 9.80a	2.80±0.48a	830.75±125.96a	181.83±24.63a	0.38±0.06a
7	90.49±16.85bc	3.90±0.76b	750.15± 97.68a	238.95±41.87ab	0.42±0.05a
14	105.59±16.77cd	5.64±0.91c	625.76± 85.93b	254.54±40.16bc	0.47±0.04b
21	112.76±21.23d	5.84±0.75c	515.88± 69.33bc	291.65±53.06c	0.51±0.02bc
28	79.36±11.77ab	6.13±1.30c	458.79± 87.62c	198.51±29.61d	0.54±0.07c
Chitosan					
1	67.78± 9.44a	2.50±0.46a	845.02±147.35c	169.3±23.78a	0.39±0.03a
7	99.70±16.48b	4.79±0.90b	841.26±124.98c	249.39±41.13c	0.41±0.04ab
14	93.09±16.15b	4.99±0.70bc	759.75±127.97b	226.1±25.3bc	0.46±0.03bc
21	86.87±15.59b	5.44±1.02c	628.82±102.85ab	214.17±39.13b	0.47±0.05c
28	87.60±13.77b	5.78±0.96c	546.32± 85.11a	215.68±37.63b	0.49±0.09c
Chitosan+GSO					
1	69.64±13.10a	2.90±0.51a	863.55±171.40c	177.97±30.58a	0.37±0.03a
7	108.78±20.52c	4.91±0.96b	843.29±167.80b	272.04±50.94c	0.45±0.05b
14	90.56±15.01b	5.40±0.82bc	804.16±153.00bc	277.15±46.36c	0.47±0.06bc
21	92.77±17.48b	6.04±0.64cd	675.05±121.42ab	232.11±35.92b	0.47±0.03bc
28	92.94±16.20b	6.54±1.31d	605.53±83.190a	224.53±40.59b	0.50±0.05c

The deformation work, regardless of the coating, is constantly increasing during the storage, which is a consequence of drying and loss of fruit volume. The Young's modulus is one of the indicators of elasticity. Covered fruits retain their crunchy texture better during the first 2 weeks. During the 3rd week, all samples lose their elasticity to varying degrees. The best preservation of the crispness' value is observed in the coating with chitosan + GSO (Fig. 5). The change in the hardness is similar to the brittleness. The results obtained are in line with those reported by Khin et al., (2007), and Najafi Marghmaleki et al., (2021). The crisp values are constantly increasing, which means that the difference between brittleness and hardness decreases. The change is slower for coated fruits with the differences between the coatings being insignificant (Diaz-Mula et al., 2012).

Physicochemical methods

Chitosan-based coatings lower pH which increases slightly during the shelf life (Table 4). During the storage, the titratable acidity of the samples increases, which is a result of drying (the reduction of water content). The increase in acidity, similar to exhalation, varies depending on the type of packaging. Various changes in acidity and pH in fruits with chitosan-based coatings have also been reported in the literature (strawberries, guavas and lychees by Dong et al., 2004; Hernandez-Munoz et al., 2008; Hong et al., 2012).

The cherries are good sources of natural antioxidants (Ferretti et al., 2010). The minimal processing reduces and makes unstable the antioxidant activity of the cherries without packaging and with chitosan coating. Packaging components add their antioxidant activity, but cannot control the decrease in values. The amount of polyphenols increases relatively, but this is the result of drying the samples.

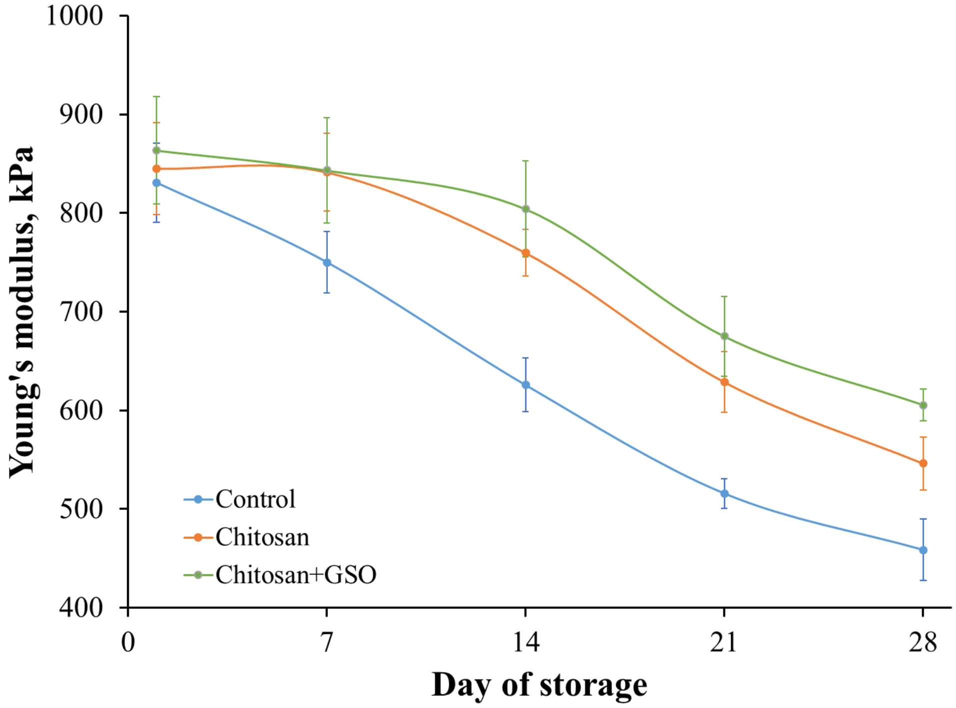


Fig. 5 Young's modulus changes of the coated cherries.

Table 4 Result of the physicochemical analysis for the sweet cherry coated with chitosan + GSO emulsion.

Treatment	Storage day	pH	AOA µmolTE/100g	TPP mgGAE/100g	FRAP µmolTE/100g
Control	1st	3.72+0.07b	2008+5a	220+2a	2048+8c
	14th	3.70+0.01a	1982+3b	273+5c	2026+9ab
	28th	3.72+0.01b	1972+3bc	247+5b	2018+6a
Chitosan	1st	3.53+0.01a	2021+11a	228+4a	2077+18ab
	14th	3.56+0.01b	1986+7b	263+5b	2057+17a
	28th	3.64+0.01c	1971+11bc	243+8bc	2040+12a
Chitosan +GSO	1st	3.69+0.10a	2727+15c	332+9a	2922+15bc
	14th	3.77+0.01a	2640+26a	382+9c	2902+ 5b
	28th	3.78+0.01ab	2680+12b	362+11bc	2879+14a

The soluble dry content of the cherries (Table 5) depends on the type of packaging (Rößle et al., 2010). Packaged samples dry more slowly than the controls. The slowest is the drying of cherries with chitosan packaging, in which Brix has minor changes until the end of the storage (Alandes et al., 2006). Most likely, the reason for these changes is the strong chemical bonding of the water at the beginning of the storage, as later the cell walls break down and the intracellular water leaks out (Ghasemnezhad et al., 2011). The hardness of these samples also began to decrease (Comabella and Lara, 2013).

The refractive index shows a similar trend as the soluble dry matter content, as it is measured by the same instrumental principle. The water activity of the samples changes very little during the storage. The minimum amount of active water is after the second week, and then, because of the breakdown of the cellular structure, the release of bound water begins (Petriccione et al., 2015).

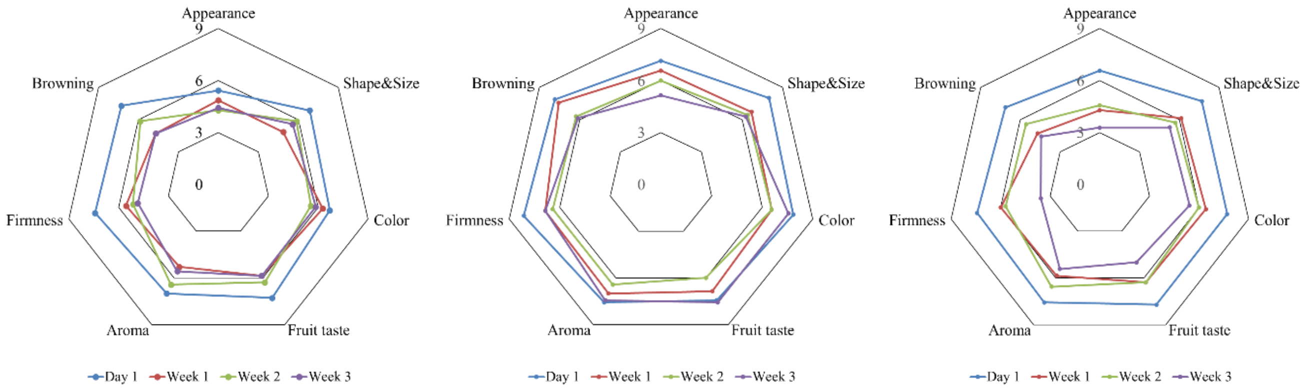
Table 5 Refractometry and water activity results of cherries packed with edible coatings of chitosan and GSO.

Storage day	TA g(MA)/100g	Soluble solid content, °Brix	SSC/TA	Refractive index	Water activity aW
Control					
1	0.537+0.006a	13.67±0.58a	25.47±1.23a	1.3537	0.942
14	0.563+0.006b	17.03±0.45b	30.24±0.88b	1.3589	0.921
28	0.573+0.006bc	21.67±2.12c	37.78±3.62c	1.3667	0.942
Chitosan					
1	0.687+0.006a	13.80±0.34a	20.10±0.34a	1.3540	0.954
14	0.717+0.006b	14.27±0.32a	19.91±0.56a	1.3558	0.927
28	0.723+0.012bc	17.33±0.30b	23.97±0.68b	1.3597	0.942
Chitosan+GSO					
1	0.517+0.006a	13.67±1.15a	26.44±2.09a	1.3536	0.944
14	0.533+0.006a	17.25±0.66b	32.34±0.89b	1.3593	0.929
28	0.553+0.006a	20.90±3.10bc	37.74±5.26bc	1.3660	0.935

Sensory evaluation

Storage time and edible coating of the cherries did show an important effect on the evaluated sensory characteristics since statistically significant differences ($p = 0.05$) were found between the treatment, days of storage and the “appearance”, “firmness” and “browning around the stone”; days of storage solely affected the “size & shape of the fruit” and the “fruit taste”. Color and aroma were affected neither by the storage nor by the coating. The treatment with chitosan (1%) was rated the highest for overall keeping quality for the whole period of storage (77 % of the quality of the fruit in the 3rd week) although the treatment with chitosan (1%) & grape seed’s oil (0.5%) was rated the lowest with 54% of the keeping quality preserved at the end of the storage. Overall, the samples evaluated showed high degree of keeping quality during the storage. It ranged from 85.7 to 54.3% for the coated samples and from 75.7 to 64.3% for the control (fig. 6).

Similarly to the effects of chitosan and Grapefruit seed extract (GSE) - Won et al. (2017) study chitosan coatings on the sensory attributes of cherry tomatoes. Glossiness, color, taste, and overall acceptability of uncoated, chitosan coated, and GSE-chitosan-coated samples at day 0 did not show statistically significant differences ($P > 0.05$). All samples stored at 10 and 25 °C for 7 d showed no statistically significant difference in terms of glossiness, color, flavor, taste, and overall acceptability (P > 0.05). Sensory evaluation of color did not reveal any significant difference, corroborating the colorimetric measurement. For chitosan-coated samples stored for 7 d at 10 and 25 °C, flavor seemed not to differ. Yang et al. (2014) tested the effect of the chitosan-based coatings with different concentrations of fruit and leaf extracts on the quality of fresh blueberry fruits in different postharvest storage conditions for 35 days; at room conditions for 3 days. The results regarding the use of the chitosan-based coatings and fruit and leaf extracts are promising for extension of the shelf life in the conditions of maintaining the nutritional quality of fresh blueberries during the postharvest storage. The 2% chitosan coating with 8% or 12% fruit and leaf extracts showed a shelf-life extension compared with the control, and the coating with fruit and leaf extracts had a more effective control of fruit decay (Miteluț et al. 2021).



Control Chitosan Chitosan + GSO

Fig. 6 The result of the sensory analysis for the sweet cherry coated with chitosan + GSO emulsion.

Microbiological safety analysis

The samples were kept in a safe statement without pathogens, but at the end of the last week there was microbiological contamination already on the control and on the emulsion coated samples. The grape seed oil at the beginning saved the fruits, but to the end maybe it is already perished or the emulsion layer is not intact on the surface of the fruits. The pure chitosan coating showed the longest safety preservation (Table 6).

Table 6 The result of the safety analysis for the sweet cherry coated with chitosan + GSO emulsion.

Treatment	Day of storage	Total plate counts	Molds and yeasts	Escherichia coli	Coliforms	Salmonella
Control	1^{st}	<10	<10	<10	<10	Not det.
	14^{th}	<10	<10	<10	<10	Not det.
	28^{th}	$1.4*10^3$	10^5	<10	<10	Not det.
Chitosan	1^{st}	<10	<10	<10	<10	Not det.
	14^{th}	<10	<10	<10	<10	Not det.
	28^{th}	<10	<10	<10	<10	Not det.
Chitosan + GSO	1^{st}	<10	<10	<10	<10	Not det.
	14^{th}	<10	<10	<10	<10	Not det.
	28^{th}	$3.7*10^2$	$4.2*10^3$	<10	<10	Not det.

CONCLUSION

The edible coating is a useful technology since it is environmentally friendly and helps preserve the freshness and nutritional value of the fruit. Based on all the studied parameters, our experimental series provides information on the shelf life of the coated sweet cherry: "Best before time" is no more than 21 days, about 3 weeks and "Use before" is 28 days, about 4 weeks. The treatment with chitosan was rated the highest for keeping overall sensory quality for the storage period.

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