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Effect of chitosan/plant oils edible coatings on minimally processed peach quality during storage

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The edible coatings are capable to extend the shelf-life of minimally processed fruits and reduce the synthetic packaging's waste. The used coating materials are obtained from renewable plant sources and byproducts of the food production. In addition, they are functional active ingredients. In this study, low-molecular weight fungal chitosan-based coatings with plant oil emulsions were used for coating of sliced peach. For characterization of the differently coated fruit pieces physical, physicochemical, microbiological and sensorial properties were examined during refrigeration. The used coatings extended the shelf-life time up to 10 days and the coated fruits had acceptable sensory parameters even at the end of the storage.

Keywords: chitosan, plant-oil emulsions, physicochemical characterization, consumer precipitation test, fresh fruit

INTRODUCTION

The edible coating is an alternative possibility to preserve the quality and prolong the shelf-life of minimally processed (e.g. sliced) fruits [1]. The antimicrobial activity [2], and the permeability properties are the key parameters of the coating materials in the shelf-life extension [3], but the retaining of the sensory acceptance may be the biggest mission in this research field [1]. The climacteric peaches are very sensitive fruits for injuries and damages during the storage period [4]. Prolonging the shelf-life using low-molecular weight chitosan-based coatings was already studied in some of the earlier publications of this research team [5-8]. The present paper is dealing with the comparison of chitosan-grapeseed oil and chitosan-clove oil extracts, used as coating solutions [9] on sliced peaches during chilled storage.

MATERIALS AND METHODS

Chemicals

Low-molecular weight, water-soluble, fungal (mushroom origin) chitosan hydrochloride (degree of deacetylation > 85.0%) was purchased from Glentham Life Sciences Ltd, UK. Cold-pressed pure grape seed oil and clove oil were bought from Ikarov LTD, Plovdiv, Bulgaria. Tween 20 emulsifier and glycerol were delivered by Ray-Chem product LTD, Plovdiv, Bulgaria.

Fruits

Fresh peaches (*Prunus persica* L., cv. 'Glohaven') were harvested in full maturation stage at the Fruit Growing Institute – Plovdiv, Agricultural Academy of Bulgaria. The cultivar was chosen based on its ripening time (late July – early August) and resistance to rotting [10]. The intact fruits with 181±41 g average weight were carefully washed and sliced (quartered), before dipping in the coating solutions.

Treatments

Two hundred peach fruits (800 quarters) were used in four experimental series: control (not coated just washed - CONT), coated with low-molecular weight chitosan water solution (1% wt, CH), coated with an emulsion of low-molecular weight chitosan and grape seed oil (0.5% wt, CHG) and coated with an emulsion of low-molecular weight chitosan and clove oil (0.1% wt, CHC). Detailed procedure for emulsion preparation is given in Gechev *et al*. [11]. The fruit quarters were dipped in the coating liquids for 10 minutes and dried for 15 minutes at room temperature before refrigerating. Eight repetition trays (25 fruit pieces/tray) were prepared from each series and stored in a refrigerator at 4±1 °C.

Experimental methods

Visual loss (selected rotted pieces) and weight loss; texture (puncture test, peel side and pulp side);

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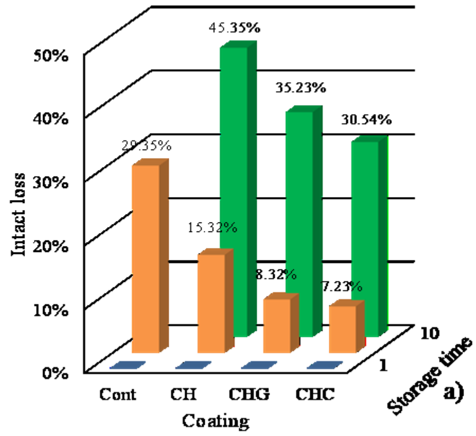
color (CIELab, peel side and pulp side); BRIX; active acidity (pH); water activity, antioxidant content (DPPH method, 96% ethanol extract); microbiological safety, Total Plant Count (TPC) and sensory parameters were examined to follow the shelf-life time during 10 days. Statistical analysis was performed using the software Statistica (TIBCO Software Inc. 2020 version 14). Similar methods were used in the earlier publications [5-8].

RESULTS AND DISCUSSION

Visual loss and weight loss: The biggest losses ccould be detected in fruits without coatings. The chitosan-emulsion-based coatings reduced the intact and weight loss. The smallest losses were seen with chitosan-clove essential oil coating (Fig. 1), because it has the highest water retention ability [12].



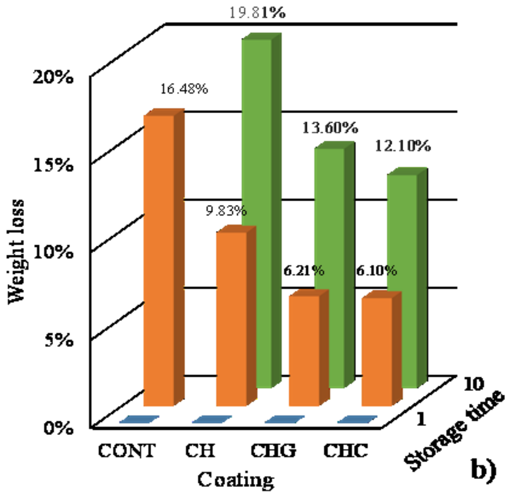


Figure 1. Visual (a) and weight loss (b) of the fruit pieces

Color changes during the shelf-life period

The coating changes the color parameters in a different range [12]. Color indicators (L – brightness; a – red-green; b – yellow-blue) depend on the packaging and change strongly during the storage (Figure 2). The water loss during the storage can be a factor affecting fruit brightness [13]. CONT samples become lighter (L*), but packaging can delay (CH and CHG) or prevent (CHC) this process. The pulp side of the samples becomes darker during the storage, this process can also be delayed by the packaging (CH and CHC). A similar process was observed by Pizato *et al*. [14].

Color indicators a and b on the peel side show a loss of reddish color (a*). The pulp side of the peaches also becomes greener and yellower (b*). The inhibitory effect of the packages is visible; it is strongest with CHC packaging, followed by CH packaging and weakest with CHG packaging.

All of the changes are noticeable or clearly visible based on the ΔE parameter (Fig. 3a) which is defined as:

$$\Delta E = \sqrt{(L_0 - L_i)^2 + (a_0 - a_i)^2 + (b_0 - b_i)^2} \qquad (1)$$

where $(L_0;\ a_0;\ b_0)$ and $(L_i;\ a_i;\ b_i)$ are the color parameters of the two compared samples [15].

The hairy skin and the fresh injured slice surfaces showed significant differences, because of the possibility for the deep diffusion of the coating solution. During the storage the differences were growing, but on the cut surface these did not depend on the coating (Fig. 3b). During the 10 days of storage, the color changes for samples coated with CH were significantly bigger than those of emulsion-coated samples (Fig. 3b) [15, 16].

Texture parameters of the fruit pieces

The coated samples showed higher firmness than the uncoated. The highest firmness was shown in case of CHC coating at the beginning, but during the storage, these fruit pieces softened faster. The firmness changes of the CHG coated fruit pieces were smaller than with the other coatings (Fig. 4) [17].

Physico-chemical changes

During short storage, as a consequence of drying, the soluble solid content (°Brix, Table 5) increases. Uncoated fruits dry out faster than the rest [18]. Emulsion packages better retain water and slow down losses. Similar results were obtained in our previous studies with other fruits [5-8]. CHG-coated slices also showed desiccation, but the process was slower [19]. Clove essential oil helps to retain the water content of the fruit slices. Packaged samples lose their freshness more slowly than unpackaged ones. During the storage, cell walls break down and intracellular water leaks out [20].

The drying and the pH changes depend on the water retention capability of the coating [21] (Table 1). The application of a coating containing hydrophobic substances (oils, fats, emulsifiers, essential oils, etc.) can be used to isolate or maintain the separation of components that differ in terms of water activity in a compound food [22]. Reduction of water activity (a_w) and protection with moisture-resistant packaging are common methods used to prevent food spoilage [23]. Based on our results, CHC packaging has a suppressive effect on the water activity.

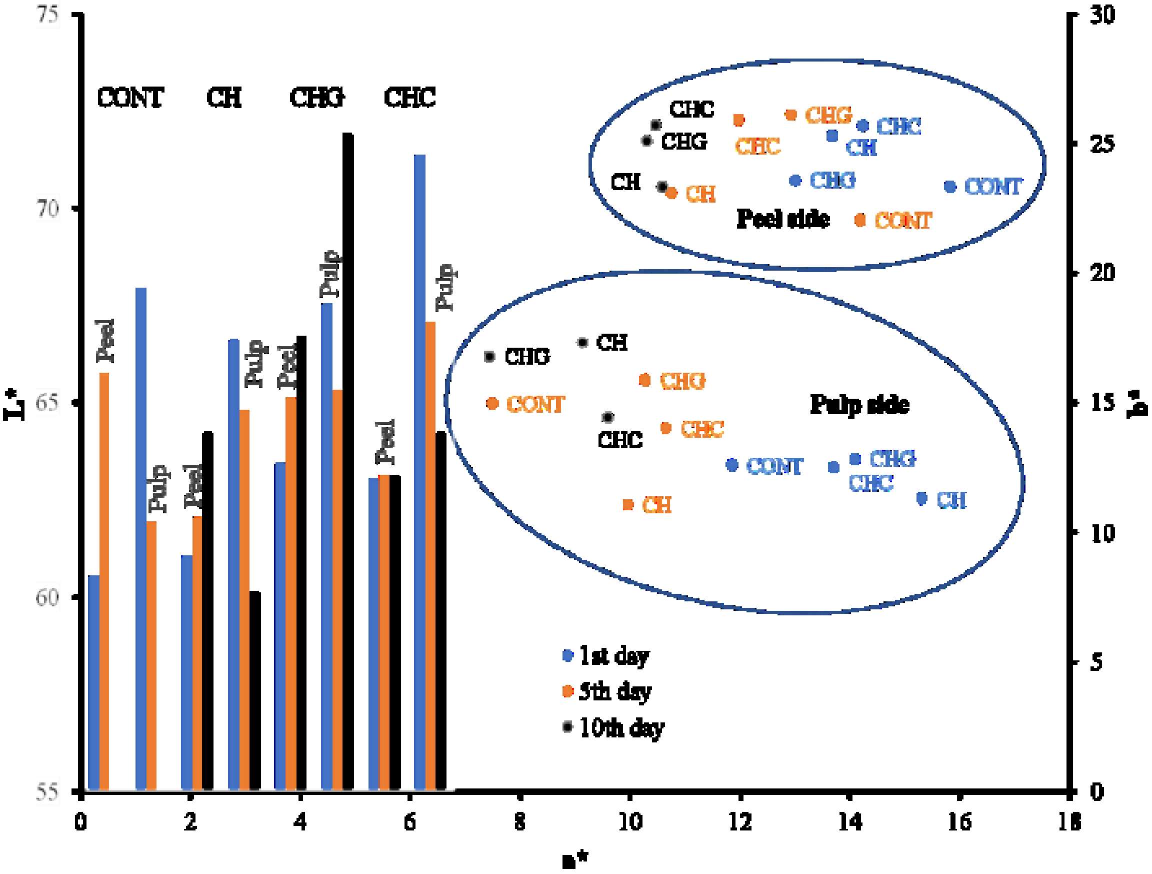
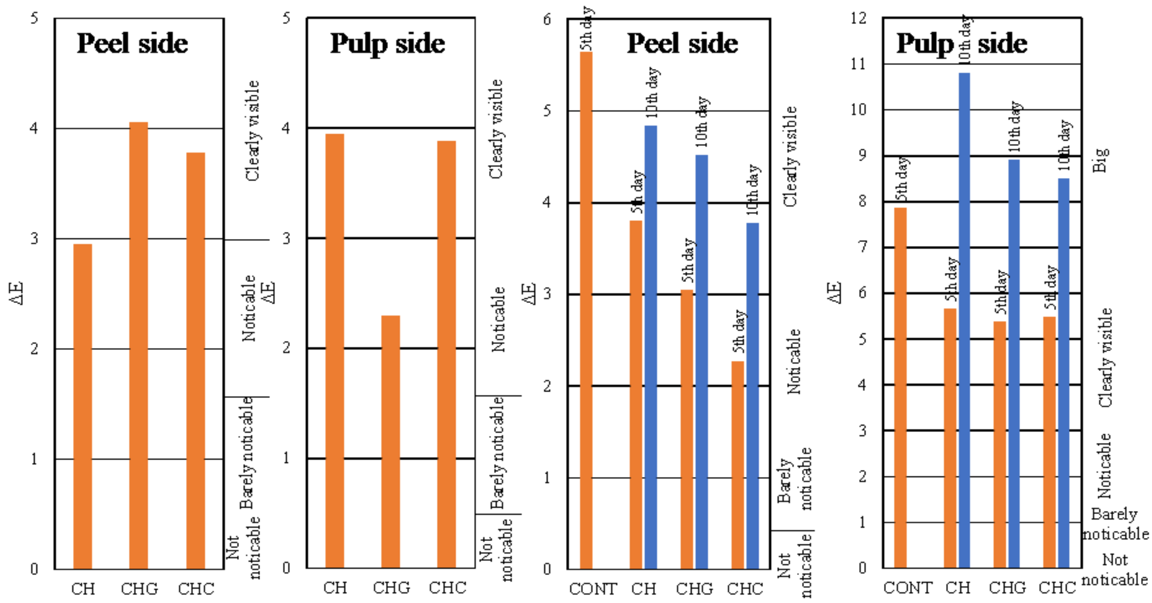


Figure 2. Changing of the CIELab parameters of the fruit pieces



a) b)

Figure 3. Total color differences (ΔE) between the control and the coated pieces on the peel and on the pulp side, after the coating (1st day, a) and between the 1st day and 5th or 10th days on the peel side and pulp side (b).

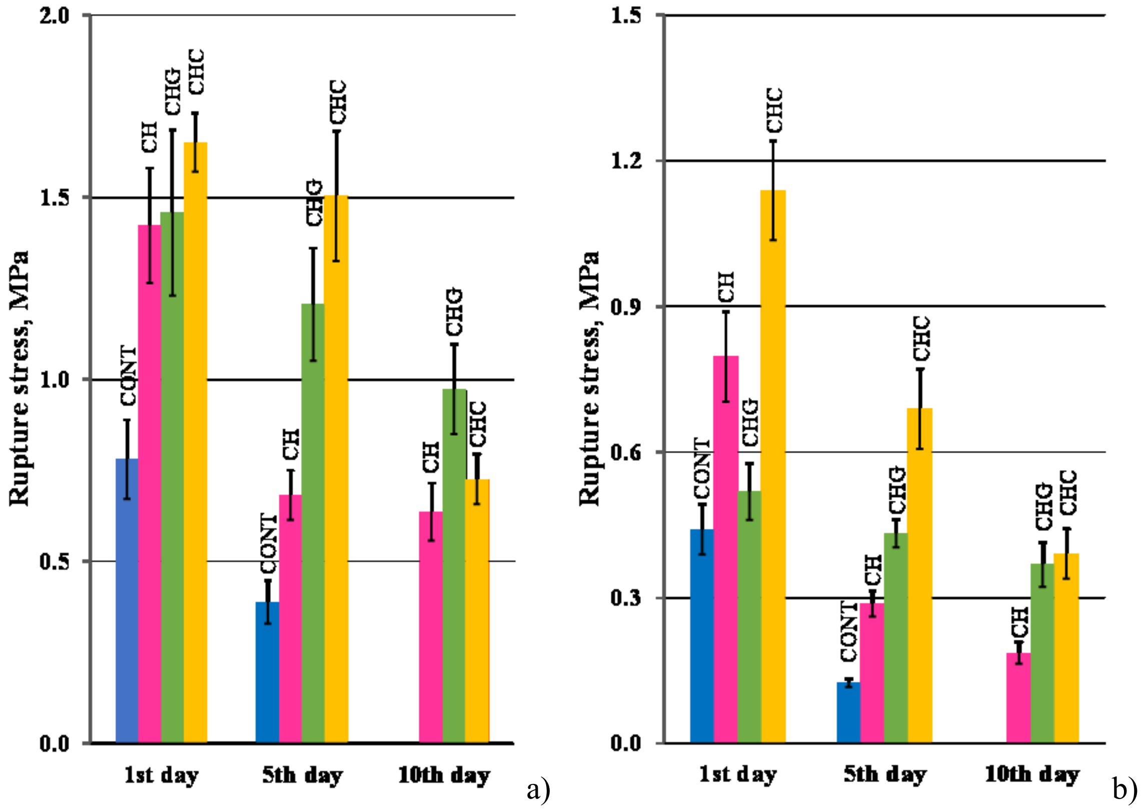


Figure 4. Firmness of the fruit pieces on the peel side (a) and on the pulp side (b)

Table 1. Physico-chemical parameters and microbiological status of the fruit pieces

	Day	°Brix	pH	aw	AOA (DPPH), µmolTE/100g dw	TPC, cfu/g	Molds & Yeasts, cfu/g
CONT	1st	15.67 ± 0.93	3.62	0.94	240.58±12.29	< 10	< 10
	5th	17.90 ± 0.52	3.86	0.94	223.37±11.18	$4.3*10^4$	$2.4*10^3$
CH	1st	13.83 ± 0.32	3.48	0.94	248.17±12.48	< 10	< 10
	5th	15.50 ± 2.20	3.74	0.93	233.44±11.67	< 10	< 10
	10th	14.90 ± 1.04	3.97	0.89	211.25±10.52	$4*10^1$	$2*10^1$
CHG	1st	13.50 ± 0.92	3.60	0.94	254.13±12.76	< 10	< 10
	5th	15.27 ± 0.87	3.76	0.93	248.16±12.48	< 10	< 10
	10th	15.70 ± 0.90	3.81	0.88	225.50±11.27	$1.9*10^2$	$1.1*10^2$
CHC	1st	16.95 ± 1.07	3.78	0.87	258.21±13.56	< 10	< 10
	5th	15.93 ± 0.92	3.84	0.88	254.62±10.84	< 10	< 10
	10th	14.34 ± 0.83	3.81	0.89	232.05±10.75	$1.5*10^2$	$8*10^1$

It is well known that oxidation is one of the main factors causing spoilage of fruits and vegetables [24]. The increase in pH is a consequence of enzymatic reactions during respiration. Different acidity and pH changes in fruits with chitosan-based coatings have also been reported in the literature [18, 25]. In this work, to investigate the antioxidant activity of grape seed oil and clove oil, free radical scavenging rate assays of the four systems, CONT, CH, CHG and CHC, were performed. Based on the DPPH assay, the differences in the antioxidant activity of the samples were small and not significant [26]. Storage time changes were greatest for uncoated samples. The CHC-coated series best preserved their antioxidant activity [27]. By the end of the storage, the reason for the larger changes in antioxidant activity is most likely the volatility of these components [28].

Microbiological status of the fruit pieces

The applied coatings saved the fruit pieces from microbiological contamination (Table 1). The growing of the Total Plant Count (TPC) shows the end of the shelf-life period. The uncoated samples wasted their safety during 5 days. The emulsion coatings have a lower inhibitor effect than the pure chitosan. The CHC coating shows smaller microbiological contamination than the CHG [11, 29].

Consumer perception of samples with different packaging during storage

Storage time significantly affected the assessed sensory characteristics, as statistically significant differences ($p = 0.05$) were found in appearance, color and aroma; days of storage did not affect the juiciness and consistency of the fruit. The evaluated sensory characteristics were significantly affected by the type of coating during storage ($p = 0.05$). On the 1st day and the 5th day, significant differences with respect to the control and other samples were observed, on the 10th day there were bigger changes in the appearance and color of the samples coated with chitosan and clove oil (Fig. 5) [28, 29].

The overall score (the area of the sensory diagram) was calculated based on all sensory indicators. On the first day, the unpackaged samples received the highest overall score, followed by samples with CHG, CH and the lowest score was with CHC. By the 5th day, the loss of sensory quality was very rapid. Uncoated samples lost the most from their overall score. Retention of the overall score of CH and CHG values up to day 5 was very decent, and it was the best for CHC-coated samples. By the 10th day, the loss of sensory quality became slower. Uncoated samples were no longer tested because they lost their safety. Samples with CH packaging showed the lowest score, followed by those with CHC and CHG coatings, without significant differences. This result indicates that emulsion coatings best preserve the sensory evaluation of sliced peaches.

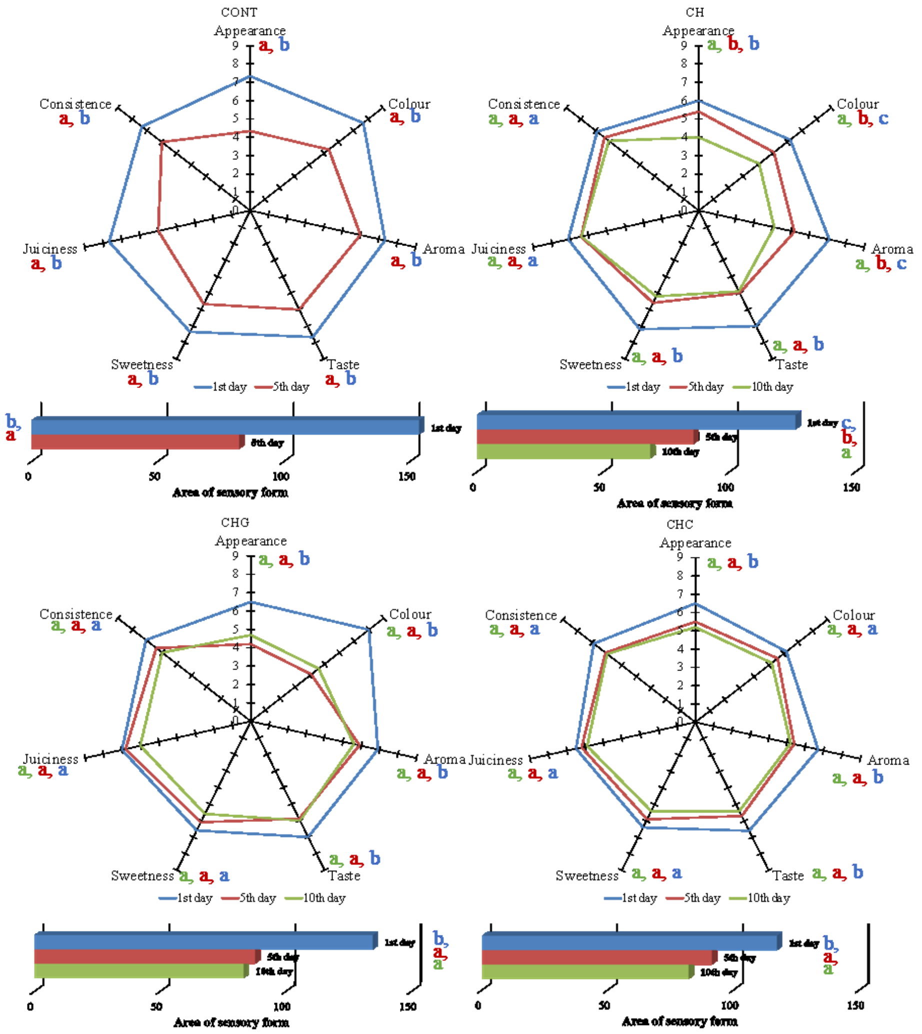


Figure 4. Consumer perception during the storage with different coatings

CONCLUSIONS

The applied multicomponent emulsion coatings saved the safety and quality of the coated pieces of peach. The observed prolonged shelf-life of the sliced peaches was 10 days. Based on the analyzed results, the clove essential oil emulsion solution was the best from the applied coatings.

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