CHARACTERISATION OF EDIBLE-COATED MINIMAL PROCESSED PEACH

Running title: Characterization of edible-coated Peach

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Abstract Chitosan is a preferred polysaccharide for the production of edible films and coatings, because of its biocompatibility, nontoxicity and antibacterial activity. Minimal processed (peeled, pitted and sliced) peach fruits were treated with chitosan-Ca-lactate and chitosan-alginate solutions and refrigerated (at 4°C) for eight days. Three replicates (30 probes) were inspected (based on healthy appearance) and characterized on the first, fourth and eighth days. Physical (weight-loss and texture of the slices, colour CIELab of the mashed flesh), physicochemical (refractometrical dry content, antioxidant activity, pH, water-activity), and microbiological properties (total number of microorganisms, *E. coli*, fungi and yeasts) were investigated. At the beginning of the experiments, and after the fourth day, the control series had better appearance then the treated series. It can be explained with the less manipulations. Based on the received data, the safety shelf-life time of coated peach-flesh slices is eight days. The results show that the chitosan-alginate treatment is able to preserve better the probes than the chitosan-Ca treatment. Based on this study, the edible coating is a promising application in preparation of ready-to-eat fruit salads or in fruit decoration of confectionery products.

Key words: Shelf life time, Physical properties, Chitosan treatment,

Introduction. Peach is one of the most important fruit species in Bulgaria with rapid return of the investments due to early fruiting and relatively low phytosanitary problems (Kutinkova et al. 2018; Zhivondov, 2009). Production and distribution of fresh-cut fruits has been limited due to their short shelf life. Furthermore, processing operations such as washing, sanitizing, peeling, cutting, slicing, dicing or shredding and packaging (Corbo et al., 2010) can alter the integrity, safety, and decrease the quality and shelf life of the product, thus, limiting their marketing. Nevertheless, fresh-cut peaches shelf life is short (5–7 days at 4 °C), because processing operations damage the cell membrane (Russo et al., 2014; Gabri et al., 2014), increase metabolic activities (respiration rate, enzyme activity and ethylene production) and cause deterioration (tissue softening, browning, off-

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flavor among others) (Azarakhsh et al., 2014). Besides, the fresh-cut fruit is susceptible to microbial spoilage because of the absence of protective peel that facilitates the microbial adhesion to tissue, which contains nutrients (vitamins, minerals, sugars and other) and pH suitable for microbial growth (Corbo et al., 2010; Gabri et al., 2014; Russo et al., 2014). Edible coatings are traditionally used to improve food appearance and conservation due to their environmentally friendly nature (Khwaldia et al., 2004). An edible coating is a thin layer of edible material (proteins, lipids and polysaccharides) applied on the food surface, usually by immersion in liquid solutions (Falguera et al., 2011). Through their effects, these coatings play an important role in preservation and some of their functions are to protect from mechanical, physicochemical (water loss, deterioration in texture, changes in the content of soluble solids and acids, enzymatic browning and loss of vitamin C, among others) and microbiological (helps to minimize microbial growth) damage (Oms-Oliu et al., 2008; Falguera et al., 2011).

Chitosan has been found to be nontoxic, biofunctional, biodegradable and biocompatible polysaccharide, with bactericidal and fungicidal properties (Li et al., 2006; Chung and Chen, 2008). Chitosan based coatings have been reported like inhibitors against *E. coli* and *S. cerevisiae*. The functional properties of chitosan-based films can be improved by combining them with other hydrocolloids and film-forming materials (Tamer & Çopur, 2009).

The alginate is also a polysaccharide, extracted from brawn algae. It is used like gelation agent in coatings and give transparent, flexible films. Alginate-based coatings have been used to coat garlic (Maftoonazad et al. 2008). Extension of the treatments with salts (Ca or Zn ions) have strengthener effect and restrict of the water solubility of the coatings (Maftoonazad et al. 2008).

In this study, minimal processed (peeled, pitted and sliced) peach fruits were treated by chitosan-Ca-lactate and chitosan-alginate solutions and refrigerated (at 4°C) for nine days.

Material and Methods

Peach (*Prunus persica* L. cultivar 'Glohaven') fruits were delivered from the Fruit Growing Institute, Plovdiv, Bulgaria and selected based on size, color, without signs of damage or decay. The cultivar was chosen based on its resistance for rotting (Byrne et al. 2012). The fruits were washed with water, peeled and cut of slices. The sliced of peach were treated with 1% solution of Chitosan-Ca-lactate (multicomponent) and chitosan-alginate (bi-layer). The technological time for immersing and drying between and after was 10 minutes, at room temperature. Fruits were stored in refrigerator at 4°C for nine days in open trays.

The samples were analyzed before treatments (0^{th} day, peeled, sliced peaches – texture), after treatment and during the storage time (1^{st}, 4^{th} and 8^{th} days, control and coated samples, for visual quality loss, weight, texture, physicochemical and microbiological analysis). The probes were scrapped out on the 9^{th} day based on their *visual quality* however, the weight-loss and the texture of the probes was determined again.

Visual quality loss: the healthy, intact fruit pieces were chosen for the experiments, and it is given in % for the actual 30 pieces on tray.

Weight-loss analysis: On each measuring days all of the samples were weighed by laboratory balance (up to 0.001 resolution). The changing of the weight is expressed in the weight changing of identified pieces (%) and statistically evaluated for each day and both coating type or control.

The *texture parameters* of the control and coated probes were examined with a TAXT2i Texture Analyzer (Stable Micro Systems Ltd, Godalming, UK). The yield and rupture parameters of the samples were evaluated using a puncture test with a cylindrical probe (d = 5 mm; deformation speed = 1 mms^{-1}; relative deformation up to 75%).

For the purpose of the physicochemical properties, equalized fruit-pulp was prepared from 1/3 of the selected fruits.

Soluble solid content was expected by ABBE (Carl Zeiss Jena, Germany) type refractometer at 20 °C in five repetitions. The results are presented as percentage (°Brix).

The *water activity* was detected by hygrometric method, using a thermostatic Novasina (model EEJA-3, Novasina AG, Zurich, Switzerland) instrument, calibrated with saturated KCl (84.3% r.h.) on samples equilibrated for 4 h at 25°C in 2 repetitions.

Antioxidant activity: Total antioxidant activity (TAA) was quantified by the method based on the capacity of different components to scavenge the ABTS radical cation compared to the standard antioxidants (ascorbic acid and Trolox) in a dose response curve. TAA due to both hydrophilic and lipophilic compounds in the same extraction. The absorbance of the extract was measured by spectrophotometer (UVVIS EVOLUTION 201 Thermo Scientific USA) The results are expressed as mg of Trolox equivalent 100 g^{-1} (Arnao et al. 2001).

Active acidity (pH) of the pulp was measured by an INOLAB pH 7110 type (RADELKIS, Hungary) pH meter at 20°C in five repetitions. The instrument was calibrated at pH 4.0 and 7.0.

The *colour parameters* of the samples were investigated by a COLOR COLORGARD SYSTEM/05 (Gardner USA) type colorimeter and expressed in CIE system in terms of L* (lightness), a* (redness and greenness) and b* (yellowness and blueness).

The *total number of microorganisms* (TNM – EN ISO 4833-2:2013), the *total coliform bacteria* (ISO 16649-2:2001) and the *total yeasts and molds* (TYM – EN ISO 21527-2:2011) were detected based on the horizontal method for enumeration. The results were expressed as a logarithm of colony forming units (log cfu/g) for TNM and TYM.

Results and discussions

Visual quality loss: During the shelf-life period, the number of healthy pieces are decreased. For the 4th day 70%, 80 and 90% of healthy pieces remind from the control, the treated with Chitosan-Ca-lactate and the treated with Chitosan-Alginate respectively. For the 7th days 60 % of the control, 70% of the Chitosan-Ca-lactate treated and 90 % of the Chitosan-Alginate treated samples were still usable for further experiments. However, for the 9th day already 40% of the control, 50 % of the Chitosan-Ca-lactate and 60 % of the Chitosan-Alginate treated probes were capable for experiments only. It means the end of the shelf-life time, because there is not enough pieces for further distribution among the physicochemical and microbiological methods.

The *weight-loss* of the fruit pieces means probably water-loss (drying – Zhu et al. 2008). Furthermore, the aim of the coating is the preservation of the actual water content. During the refrigerated storage, there is a condensed water on the surface of fruits as well. The decreasing of the equilibrium water content is the fastest in the control samples, and the weight-loss is around 10%, 15% and 23% at the 4th, 7th and 9th day respectively. For the chitosan-Ca-lactate coated samples, it is a bit smaller, around 9%, 14% and 19%. The slowest decreasing was seen on the chitosan-alginate coated samples, with around 7.5%, 10.5% and at the end about 15%. The better preservation of the water quantity is probably the result of the received strong ionic complex (barrier effect) on the surface of the fruit pieces. There are some similar results in the literature for the reducing of water-loss with chitosan and alginate coatings on different fruits (chitosan coating on peaches – Maftoonazad et al., 2008; on litchi – Dong et al., 2004).

The changes of the *texture* are a complex result, because shows the drying and the disintegration of the cells (braking of the cell-wall from the higher turgor) also. The received parameters – reduced hardness and increasing of the deformation needs for rupture of the pieces – demonstrate the softening. The used coating can delay this process, but for the 9th day their advantage is reduced or

eliminated. The best way to demonstrate the effect of coatings is investigation of the rupture force by rupture test (fig. 1).

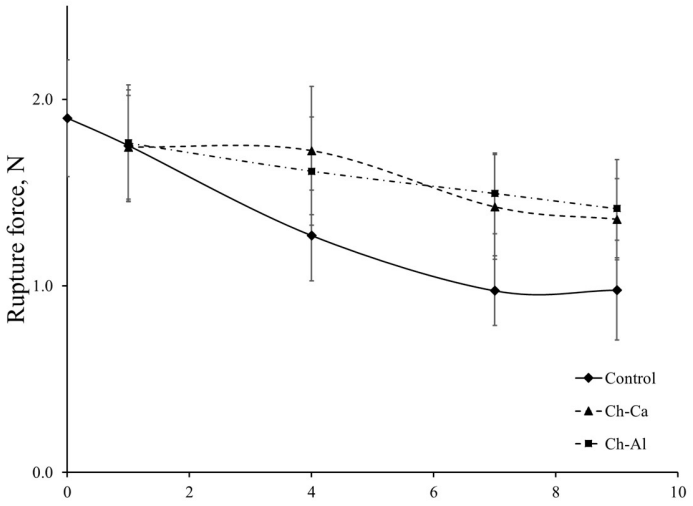

Figure 1 Hardness of the samples

On the 0th day the texture is measured on the fresh pilled and sliced samples. On the 1st day (the treated samples with coating) the samples were already softer, but without differences in the hardness. Up to the 4th day the samples coated with chitosan-Ca-lactate are harder, but later they lost this advantage, and the chitosan-alginate coated samples preserved better their hardness, but without significant differences which is very similar with the results of Maftoonazad et al. (2008).

Soluble solid content. The non-treated fruits lost their water content (freshness). The result is dry, crusted, inside soft, but tough fruit pieces. The chitosan-alginate coated probes are dried up also, but much smaller than the control. The chitosan-Ca-lactate coated probes not changed, because they have strong water barrier.

The *water activity* of all of our samples, with and without coatings, during the full storage time, was around A_w = 0.81, which is lower than the critical value (A_w=0.85). Based on the received results the coatings and the storage time did not had significant effect on the water activity.

The *active acidity* (pH) of the probes is stable, around 4. May be, it is the result of microbiological safety and stability.

The *antioxidant activity* is decreasing during the storage. The used treatments at the beginning delay the decreasing, but to the end of the shelf-life they are already not effectives (table 1).

Enzymatic browning is one of the effective factors in *colour change* of fruits and vegetables during storage (Akbarian et al 2014).

The vectorsum of a* and b* *colour parameters* describe may be in the best way the yellow-brown colour of the fresh samples.

$$c^* = \sqrt{(a^2 + b^2)} \quad (1)$$

The changing of the colour (*enzymatic browning*) can be describing by the changing of c* in time:

$$\Delta c^* = c_1^* - c_8^* \quad (2)$$

where: $c_1^* = c^*$ average on the first day and $c_8^* = c^*$ average on the 8th day.

Based on our experiments $\Delta c^*$was the biggest for the control samples (11.67), the next was for the chitosan-Ca-lactate coated samples (7.35) and the smallest was for the chitosan-alginate coated samples (5.96). That result means that the chitosan-alginate coating saved better the colour of the samples than the chitosan-Ca-lactate, because the stronger ionic coating complex was better barrier for the oxygen and delayed the progression of the enzymatic browning (Akbarian et al 2014).

Table 1 Result of physicochemical and microbiological properties

		Brix	pH	a_w	Antioxidants	TNM	TYM
1st day	Control	9.5±0.17b	3.93±0.03a	0.806±0.009	1213.11±0.30b	4.633	3.373
	Ch-Al	7.5±0.21a	4.03±0.02b	0.809±0.005	1106.50±0.57a	4.471	3.04
	Ch-Ca	10±0.16c	4.18±0.02c	0.805±0.003	1209.60±0.50b	4.639	3.217
4th day	Control	10.8±0.21c	4.02±0.02a	0.815±0.003	1159.44±0.30b		
	Ch-Al	7.7±0.21a	4.07±0.02b	0.809±0.002	1099.41±1.01a		
	Ch-Ca	9.9±0.16b	4.08±0.02b	0.816±0.009	1167.3±0.75b		
8th day	Control	11.4±0.14c	3.93±0.01a	0.812±0.001	1114.57±0.04b	7.487	5.875
	Ch-Al	8.3±0.19a	3.92±0.01a	0.816±0.001	1022.76±0.03a	5.974	5.162
	Ch-Ca	10.2±0.16b	4.00±0.02b	0.808±0.005	1111.53±0.08b	6.462	5.478

The results of the *microbiological evaluations* show that, all of the samples are safe, without harmful disease contaminations (*total coliform bacteria)*. The *TNM* and the *TYM* were analysed at the beginning and at the end of the shelf-life time. Based on the results the chitosan-based coatings could delay the accumulation of bacteria and fungi. The limitation effect of chitosan-alginate combination was higher than the chitosan-Ca-lactates. This effect could be explained with the better barrier properties of the stronger ionic complex (Table 1).

Conclusions. The chitosan-alginate treatment is better in preservation of the freshness, because that complex is a stronger barrier. The results obtained in this study demonstrate the antimicrobial activity of the chitosan.

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