The use of a pectin–cannabis flour coating on freshly cut apple pieces

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Abstract

The aim of the research was to measure the quality properties of cut apple pieces dipped in a pectin–cannabis flour coating during storage. The Granny Smith apple cultivar was used as the material in the research. Cut apple samples were stored in a refrigerator at +4 °C. During 4 days of storage, polyphenol content, antioxidant capacity, and weight loss were measured at three intervals (0 day, 2 days, and 4 days). Apple samples dipped in 1% pectin and 5% cannabis flour had higher polyphenol content, antioxidant capacity, and less weight loss in comparison with other pectin concentrations used. The research showed the utility of a pectin–cannabis flour coating for improving the quality of cut apple during cold (+4 °C) storage.

pectin; cannabis flour; cut apple pieces; Granny Smith.

Introduction

In recent years the popularity of healthy food has been growing, and so the shelf life of fruit and vegetables is becoming increasingly significant in their processing. It is important to prevent fruit and vegetables from spoiling, especially when they are only subjected to minimal treatment. From the point of view of their acceptance by customers, minimally treated fruit and vegetables are also popular as so-called "ready to use" food, i.e. food that can be readily consumed. Freshly cut fruit and vegetables in the form of salads, etc., belong in this category. Besides the shelf life of this kind of food, retaining maximal nutritional value and excellent sensory quality is also important for customers (Yousuf et al., 2018).

For this reason, methods for retaining these qualities are being researched more often, especially methods involving various types of storage, but also involving coating cut pieces of fruit and vegetable with various types of edible coating. To manufacture such coatings, various kinds of polysaccharide bases are used, including pectin, carrageenan, chitosan and the like, as well as various types of proteins or lipids. Other additives, such as plasticizers and netting agents, are added to further improve coating qualities. Additional benefits of edible coatings include the possibility for incorporating components which can further improve the nutritional and sensory qualities of food, e.g. various antioxidant and antimicrobial agents, flavorings, but also probiotics, which are consumed with the food and thus can further contribute to widening the range of the human diet (Santagata et al., 2018; Salgado et al., 2015).

Pectin is found in plant cells and is a poly α-1,4-galacturonic acid, isolated mainly from lemon peel and apple juice, and contains so-called smooth areas – linear and hairy areas – branched. It is used in food processing and the pharmaceutical industry thanks to its favorable properties – it is edible, biocompatible, and also biodegradable (Santagata et al., 2018; Luangtana-anan et al., 2017). The advantage of its biodegradable properties lies in being naturally degradable by microorganisms to carbon dioxide, water, methane and other biomass residues. These properties offer a good solution for environmental problems connected to the increasing amount of waste (Salgado et al., 2015).

Cannabis sativa has been cultivated throughout the world for thousands of years, mainly due to its content of THC (delta-9-tetrahydrocannabinol), which is a psychoactive drug. In recent years, the amount of cannabis cultivation with a lower THC content has also increased. For example, in China roasted cannabis seeds are widely available, and in

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Western Europe cannabis seeds are used for producing alternatives to butter. Cannabis seeds contain 30% of oil, 25% of proteins, edible fiber, vitamins and minerals, and so they are an important source of essential fatty acids. Cannabis seeds can also be used to produce flour, which can afterwards be used as a partial substitute for wheat flour.

This research is focused on incorporating cannabis flour into an edible coating, not only to improve the properties of the coating itself, but also to improve the properties of the coated food, which in this case are cut pieces of apple of the Granny Smith cultivar (Apostol et al., 2015).

Materials and methods

Material

Apples of the Granny Smith cultivar (country of origin Italy, I type quality, caliber 75–80 mm) were bought at a local supermarket and coated immediately after being transported to the laboratory. Individual analyses were performed on day 0, 2 and 4. Apples were chosen that were uniform in size and without visible defects.

Citrus pectin was obtained from Valdemar Grešík – Natura s.r.o., Děčín (CR). Cannabis flour was obtained from the dm-drogerie, Karlsruhe (Germany).

Preparation of the edible coating and apple testing

First, the extraction of cannabis flour was carried out, when a 5% aqueous solution of cannabis flour was prepared. Extraction was carried out for 30 min by mechanical shaker at laboratory temperature. Then, three concentrations of pectin (1, 3, and 5%) were prepared in the cannabis flour extract and solutions were heated at 100 °C and constantly stirred for 8 minutes.

Apples were peeled, cut to pieces about 1x1x1 cm and then submerged into each solution for 30 seconds. Then they were moved to petri dishes and stored at 4 °C for 4 days. Analyses were carried out on days 0, 2 and 4.

The coding of samples was as follows: K (control samples without a pectin coating), 1% PKM (samples coated in 1% pectin in the cannabis flour extract solution), 3% PKM (samples coated in 3% pectin in the cannabis flour extract solution) and 5% PKM (samples coated in 5% pectin in the cannabis flour extract solution).

Determining the total content of polyphenols

1 g of each sample was weighed and homogenized, followed by extraction, which was performed in 10 ml of distilled H_2O for 10 minutes on a mechanical shaker at laboratory temperature. Then an FC solution (diluted 1:10) and a 7.5% Na_2CO_3 solution were added to filtered extract. Samples were incubated at laboratory temperature for 30 minutes, and then absorbance at 765 nm was measured. The results are given as the amount of gallic acid contained in 1 g of the sample. The gallic acid standard was used for measuring the calibration curve (Tomadoni et al., 2016).

Antioxidant activity

The antioxidant activity of samples was determined by the FRAP (ferric reducing antioxidant power) method adapted by Behbahani. 0.1 g of the sample was weighed and then extraction was carried out in 75% methanol in an ultrasonic bath for 30 minutes. Then, a 180 µl filtered sample, 300 µl water and 3.6 ml working solution (50 ml of acetate buffer, 5 ml of TPTZ solution, and 5 ml of $FeCl_3 \cdot 5\ H_2O$ solution) was taken. Next, incubation was carried out for 8 minutes at laboratory temperature and in the dark. Absorbance was measured against a blank (960 µl of H_2O + 7.2 ml of working solution) at the wave length 593 nm. Antioxidant activity is expressed as the Trolox content in 1 g sample. Trolox was used for establishing the calibration curve (Behbahani et al., 2017).

Weight loss

Weight loss was determined gravimetrically as the difference between the initial weight and final weight of each experimental group, each time on day 0, 2 and 4. The results were converted to percentages.

Statistics

The statistically significant difference ($p<0.05$) between groups was determined using one-way ANOVA, the parametric Tukey post hoc test (in cases when Levene's test showed $p>0.05$), and the non-parametric Games-Howel post hoc test (in cases when Levene's test showed $p<0.05$). Total differences between the particular samples of tested apple cuts were checked by principal component analysis (PCA). Statistics software SPSS 20 (IBM Corporation, Armonk, USA) was used for the statistical evaluation of data.

Results and discussion

Content of polyphenols

During the storage period, a gradual increase in polyphenol content was observed for individual samples (Table 1). At the same time, statistically significant differences were identified for all samples when individual days of storage were compared. For values converted to gram of fresh sample, a gradual increase in polyphenol content was also observed with some samples (1% PKM and 3% PKM). This could be caused by the activation of the phenylpropanoid metabolism due to stress caused by plant tissue injury during preparation of the apple sample (Salinas, Roca et al., 2018). An increase in polyphenol content during the storage period was also observed in 2004 by Napolitano et al. For both obtained results, the highest values at the end of the storage period were observed at 1% PKM (0.84 ± 0.00; 0.50 ± 0.00), then at 3% PKM, followed by 5% PKM, while the control had the lowest content of polyphenols.

It can be seen that the change in the polyphenol content for individual samples was different during the storage period, thus we can conclude that presence of the pectin coating with the addition of cannabis flour influences the change in the polyphenolic qualities of individual samples (Alarcón-Flores et al., 2014), (Plate XXI. Graph 1a, 1b).

Table 1. Total content of polyphenols in mg/g of apple pieces

Sample	Day 0	Day 2	Day 4
K	0.26 ± 0.00^{aA}	0.34 ± 0.00^{bA}	0.55 ± 0.00^{cA}
1% PKM	0.28 ± 0.00^{aB}	0.47 ± 0.00^{bB}	0.84 ± 0.00^{cB}
3% PKM	0.16 ± 0.00^{aC}	0.48 ± 0.00^{bC}	0.68 ± 0.00^{cC}
5% PKM	0.27 ± 0.00^{aAB}	0.41 ± 0.00^{bD}	0.53 ± 0.00^{cD}

* Superscript with a lower case letter shows statistically significant differences (p≤0.05) between data in the row
* Superscript with an upper case letter shows statistically significant differences (p≤0.05) between data in the column

Table 2. Total content of polyphenols converted to mg/gram of fresh sample of apple pieces

Sample	Day 0	Day 2	Day 4
K	0.26 ± 0.00^{aA}	0.23 ± 0.00^{bA}	0.32 ± 0.00^{cA}
1% PKM	0.28 ± 0.00^{aB}	0.33 ± 0.00^{bB}	0.50 ± 0.00^{cB}
3% PKM	0.16 ± 0.00^{aC}	0.31 ± 0.00^{bC}	0.39 ± 0.00^{cC}
5% PKM	0.27 ± 0.00^{aAB}	0.26 ± 0.00^{aD}	0.30 ± 0.00^{bD}

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Antioxidant activity

Antioxidant activity represents the full antioxidant potential of food, which is affected mainly by phenolic acids, further by flavonoids, carotenoids and also by vitamin C (Ranjitha et al., 2017).

As in polyphenols, a gradual increase was also observed for antioxidant activity with individual samples, which could also have been caused by tissue stress when cutting the samples. This stress may have activated the metabolism of antioxidative compounds (Salinas Roca et al., 2018).

In the case of antioxidant activity, the highest values at the end of storage period were observed for the control (20.25 ± 0.21 μmol/g; 11.88 ± 0.13 μmol/g), but only slightly lower values were observed at 1% PKM, next at 5% PKM and lastly at 3% PKM. (Plate XXI. Graph 2a, 2b)

Table 3. Antioxidant activity of apple pieces

Sample		Day 0	Day 2	Day 4
	K	6.16 ± 0.07^{aA}	6.94 ± 0.11^{bA}	20.25 ± 0.21^{cA}
1%	PKM	5.69 ± 0.06^{aB}	11.72 ± 0.12^{bB}	18.15 ± 0.14^{cB}
3%	PKM	5.15 ± 0.08^{aC}	9.01 ± 0.18^{bC}	10.19 ± 0.11^{cC}
5%	PKM	4.52 ± 0.05^{aD}	11.74 ± 0.12^{bB}	16.77 ± 0.21^{cD}

* Superscript with a lower case letter shows statistically significant differences ($p \leq 0.05$) between data in the row
* Superscript with an upper case letter shows statistically significant differences ($p \leq 0.05$) between data in the column

Table 4. Antioxidant activity converted to gram of fresh sample of apple pieces

Sample		Day 0	Day 2	Day 4
	K	6.16 ± 0.07^{aA}	4.56 ± 0.07^{bA}	11.88 ± 0.13^{cA}
1%	PKM	5.69 ± 0.06^{aB}	8.34 ± 0.08^{bB}	10.92 ± 0.09^{cB}
3%	PKM	5.15 ± 0.08^{aC}	5.77 ± 0.12^{bC}	5.80 ± 0.06^{bC}
5%	PKM	4.52 ± 0.05^{aD}	7.44 ± 0.08^{bD}	9.44 ± 0.12^{cD}

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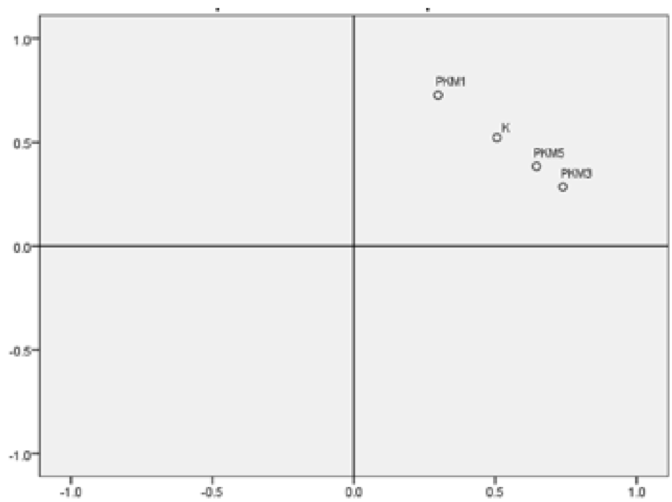
Weight loss

Weight loss is connected mainly with water evaporating from the surface of the fruit/vegetable pieces. Statistically significant differences were observed in weight loss when comparing Day 2 and Day 4. No statistically significant differences were observed when comparing Day 2 samples, although statistically significant differences were observed when comparing Day 4 samples with samples of 1% PKM and 5% PKM. As can be seen, weight loss in individual samples grew with longer storage time (Radi et al., 2018).

It is also evident that for both days of storage, at the time of measurement the smallest percentage loss was discovered at 1% PKM, which should thus be the best of all coating types examined for coating apple pieces.



Graph 3: PCA analysis of cut apple pieces coated in different coatings comprising of pectin and cannabis flour extract (PKM1 – 1% PKM; PKM3 – 3% PKM; PKM5 – 5% PKM, K – control)

Table 5. Weight loss of apple pieces during storage

Sample	Day 2	Day 4
K	52.12 ± 1.41^{a}	70.46 ± 2.35^{b}
1% PKM	40.54 ± 10.83^{a}	66.25 ± 1.67^{bA}
3% PKM	56.14 ± 3.69^{a}	75.68 ± 0.59^{b}
5% PKM	57.76 ± 2.29^{a}	77.56 ± 1.21^{bB}

* Superscript with a lower case letter shows statistically significant differences ($p \leq 0.05$) between data in the row
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On the basis of the PCA analysis, 1% PKM was found to differ from the other samples tested. We can therefore conclude that a coating comprising 1% pectin with cannabis flour extract can work very well as a food preservative compared to the other coatings tested (3% PKM, 5% PKM, K).

Conclusion

The research has ascertained that the best results were obtained by 1% PKM, which showed the best values for polyphenol content and also for antioxidant activity. Moreover, it was also discovered that at 1% PKM, there was a lower percentage of weight loss and thus the sample retained more of the qualities of the fresh sample. This opens the way for further research in preserving apples or other fruit in an edible pectin coating with the addition of cannabis flour, so that fruit can retain qualities that are as close as possible to those of fresh fruit.

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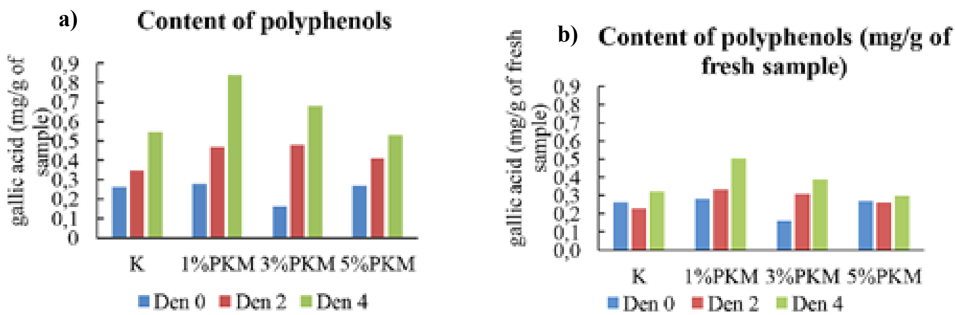
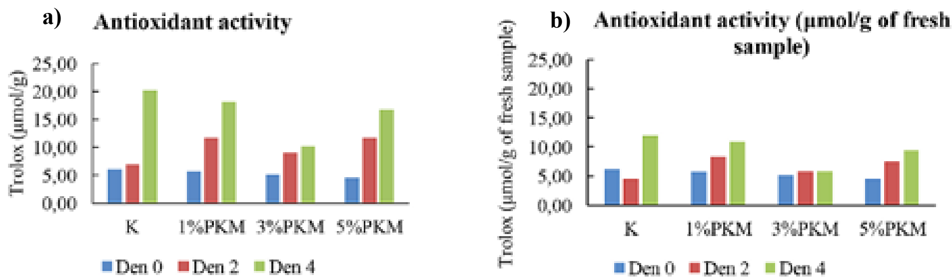


*Den – Day

Graph 1: a) Content of polyphenols – gallic acid (mg/g of sample) of apple pieces; b) Content of polyphenols – gallic acid (mg/g of fresh sample) of apple pieces



*Den - Day

Graph 2: a) Antioxidant activity – Trolox (µmol/g) of apple pieces; b) Antioxidant activity – Trolox (µmol/g of fresh sample) of apple pieces