The color measuring of apple pieces packaged in the edible pectin coating with the addition of hemp flour extract

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Abstract

The aim of this study was color measuring of apple pieces packaged in the coating prepared from pectin and hemp flour water extract (HFE). The apple pieces of Granny Smith apples were packaged in the coating consisted of 1, 3 and 5 % of pectin, which was solved in the 5 % HFE. The color measuring (RGB – red, green, blue; Mean Intensity and Hue Typical) was evaluated on the first day and after 2, 7 and 14 days of storage. The samples were stored in the room temperature (+25ºC) and in the refrigerator (+4ºC). The surface of apple pieces and the inner tissue were analyzed and compared. It was found that the highest impact on color changes of the samples had the packaging of samples in 5 %PHFE. There were not found big differences during storage in the measuring of inner tissue color changes and in measuring color changes of the sample's surface. The principal component analysis (PCA) found that the control and 1 % PHFE (group III) are different from 3%PHFE (group II) and 5%PHFE (group I). The research showed that the packaging of samples in different packaging solution had an impact on the color of packaged apples.

Color parameters, RGB, edible packaging, fruit.

Introduction

The consummation of fresh-cut fruit pieces is gaining popularity because of the high content of beneficial compounds such as vitamins, phenols and other antioxidants (Zambrano-Zagarazo et al. 2014). The edible packaging applied directly on the fruit surface can improve the shelf life of the fruit and can have an impact on the color changes during storage, because the color of the fruit is very important for the consumers (Romani et al. 2018, Zambrano-Zagarazo et al. 2014).

The apples are known for the enzymatic browning when they are in contact with the air. The browning is caused by polyphenol oxidase (PPO). This enzyme can react with oxygen and tannins to create brown pigment (Subhashree et al. 2007).

Pectin is polysaccharide presents in plants (Mohnen 2008). Pectin can be used as the gelling agent during jam preparation (Jancikova et al. 2019).

Usually the hemp seeds are used as feed, but they are gaining more popularity in different forms such as oil, protein powder or flour (Andre et al., 2016). The hemp flour is known for high polyphenols content, essential amino acids and fatty acids and also its anti-allergenic, anti-microbial and anti-cancer properties (Werz et al. 2014; Mikulec et al. 2019). The polyphenols can work as the antioxidants and can affect and improve the shelf life and also the color of packaged food (Wojdyło et al. 2008). These compounds can protect organism against free radicals. They inhibit the lipid oxidation or oxidation of other biomolecules (Chen et al. 2012).

The aim of the research was to package cut apple pieces in the edible packaging consisting of pectin in different concentrations (1, 3, 5 %), with the addition of hemp flour water extract (HFE) and to measure color changes on the surface of apple pieces, same as the color of inner tissue.

Material and methods

Material

The apple samples cultivar was Granny Smith (Italy). The pectin was prepared by Gresik and the hemp flour was bought in the DM drogerie (dmBio).

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Preparation of edible coating

The HFE was prepared as follows: 5 g of hemp flour was weighted and 100 mL of distilled water was added. The extraction was carried out 30 minutes and then the solution was filtered through filter paper Whatman n. 1. The 0.5 (1%PHFE); 1.5 (3%PHFE) or 2.5 g (5%PHFE) of pectin was weighted in the beaker. The 50 mL of hemp flour extract was added. The solution was heated up to 100 °C and then 8 minutes heated.

Preparation of apple samples and edible coating

The 3 apples were peeled and cut into small pieces (1x1x1 cm). The samples were soaked in the solution for 30 seconds and then put on the Petri dishes. The samples were stored under different conditions. The 3 apple pieces (obtained from 3 different apples) from each concentration of pectin and control samples were stored in the room temperature (+25 ºC) and the same samples in the refrigerator (+4 ºC) for 14 days.

Measuring of the color parameters

The color measuring was done by personal camera EOS600D (Canon, JPN). The sample scanning was completed under standard light conditions with 2 lamps Delux L – 1 x 18 W lamps (OSRAM, GER). The shooting was done by the manual: exposure time 1/80, aperture F 5.0, image size L, sensitivity ISO 100. The NIS-Elements BR 4.13.04 image analysis software was used for the evaluation of results. The color changes of the surface and inner tissue of the samples were measured.

Statistical analysis

The statistical analysis was done by the SPSS, version 20 (IBM Corp., Armonk, NY, USA). The homogeneity of variance was determinate by Levene's test ($p < 0.05$). If the results had normal distribution and equal variance the one-way ANOVA with Tukey's post-hoc test ($P < 0.05$) was used. When the results were without normal distribution and unequal variance the significant differences were analyzed using non-parametric Games-Howel test ($P < 0.05$).

The principal component analysis (PCA) was also done by SPSS. It was used for the determination of the differences between all groups of samples. All measurements were done in 10 replicates.

Results and discussion

Color measuring

The results of measuring of red (R), green (G) and blue (B), mean intensity and hue typical of surface of packaged apple pieces are shown in the Table 1. The changes during storage in almost all samples were observed. In previous studies usually L, a, b is measured than R, G, B (Subhashree et al., 2017; Lunadei et al., 2011).

The control sample, stored in refrigerator, showed significant differences ($p < 0.05$) between day 0, day 7 and day 14. In 1%PHFE the RGB decreased also, but the significant differences ($p < 0.05$) occurred more among the results for storage in the refrigerator than in the room temperature. In 3%PHFE and 5%PHFE were found similar results. It is also interesting that in 5%PHFE were found much lower values of RGB than in control samples. In the research by Romani et al. (2018) was also found that the packaged samples had lower color characteristic than unpackaged samples.

Table 2 demonstrates the results of measuring RGB of inner tissue of apple pieces. The Table showed results for packaged samples, which were before imaging cut on half and then the color of inner tissue was analyzed. When we compare the differences between these results and results for the surface of apple pieces during storage, the differences are not so big. The biggest impact occurred on 1%PHFE samples in comparison with control samples. There were also found that the most significant differences ($p < 0.05$) during storage were found in samples stored in refrigerator.

The reason of significant color differences of surface of apple pieces during storage can be caused by PPO, which can react in the presence of oxygen to create brown color. The color differences of inner tissue were not so big as the inner tissue is not so available for oxygen as the surface of apple pieces (Subhashree et al. 2007).

It has to be stressed out that comparison between both types of storage (room temperature and refrigerator temperature) resulted in significant differences ($p < 0.05$) between all analyzed samples. The storage conditions (different temperature regime) had a significant

Table 1. Color characteristic of the surface of apple pieces

	control				1%PHFE			
	Day 0	Day 2	Day 7	Day 14	Day 0	Day 2	Day 7	Day 14
Mean Intensity$_{RT}$	204.83 ± 4.90^{A}	208.28 ± 6.91^{aA}	201.28 ± 8,37^{A}	197.48 ± 10.88^{bA}	205.01 ± 4.03^{aA}	208.03 ± 11.58^{aA}	202.27 ±13.68^{A}	191.60 ± 8.99^{bA}
Mean Intensity$_{R}$	217.66 ± 5.02^{aB}	213.29 ± 6.15^{aB}	179.16 ± 13.96^{bB}	175.94 ± 16.50^{bB}	223.56 ± 2.42^{aB}	215.37 ± 6.32^{bB}	198.78 ± 8.80^{cB}	196.45 ± 11.17^{cB}
Mean red$_{RT}$	238.82 ± 2,82^{aA}	248.77 ± 2.26^{bA}	243,42 ± 5.19^{aA}	242,28 ± 4.56^{aA}	235.60 ± 2.61^{aA}	247.32 ± 3.99^{bA}	240.65 ± 6.64^{A}	236.36 ± 4.91^{aA}
Mean red$_{R}$	246.98 ± 1.73^{aB}	249.34 ± 1.67^{bB}	231.59 ± 7.86^{cB}	229.97 ± 12.48^{cB}	245.91 ± 1.48^{aB}	247.77 ± 2.60^{aB}	239.50 ± 4.26^{bB}	236.01 ± 5.70^{bB}
Mean green$_{RT}$	218.87 ± 4.63^{acA}	221.79 ± 6.77^{cA}	210.70 ± 8.56^{abA}	206.23 ± 11.20^{bA}	218.54 ± 3.45^{aA}	220.19 ± 11.41^{aA}	210.71 ± 13.37^{A}	199.73 ± 9.13^{bA}
Mean green$_{R}$	230.67 ± 4.05^{aB}	227.70 ± 6.27^{aB}	189.81 ± 16.77^{bB}	185.81 ± 19.37^{bB}	236.15 ± 2.15^{aB}	229.44 ± 6.44^{bB}	211.79 ± 10.22^{cB}	209.25 ± 12.44^{cB}
Mean blue$_{RT}$	156.81 ± 9.56^{A}	154.27 ± 12.57^{A}	149.72 ± 12.83^{A}	143.91 ± 17.42^{A}	160.87 ± 7.09^{aA}	156.57 ± 20.04^{A}	155.46 ± 21.66^{A}	138.72 ± 13.16^{bA}
Mean blue$_{R}$	175.32 ± 9.99^{aB}	162.82 ± 10.88^{aB}	116.07 ± 17.73^{bB}	112.03 ± 17.93^{bB}	188.61 ± 5.13^{aB}	168.91 ± 10.98^{bB}	145.05 ± 12.91^{cB}	144.09 ± 16.27^{cB}
Hue Typical$_{RT}$	33.05 ± 1.18^{aA}	31.56 ± 1.41^{bA}	28.56 ± 0.92^{cA}	27.63 ± 1.15^{cA}	33.43 ± 0.46^{aA}	31.03 ± 1.74^{bA}	28.47 ± 1.27^{cA}	27.20 ± 0.67^{cA}
Hue Typical$_{R}$	33.54 ± 0.80^{aB}	32.86 ± 1.38^{aB}	27.89 ± 2.21^{bB}	27.19 ± 1.95^{bB}	36.08 ± 1.32^{aB}	33.58 ± 1.44^{bB}	31.03 ± 2.05^{cB}	31.23 ± 2.02^{cB}
	3%PHFE				5%PHFE			
	Day 0	Day 2	Day 7	Day 14	Day 0	Day 2	Day 7	Day 14
Mean Intensity$_{RT}$	200.04 ± 7.37^{a}	183.07 ± 12.89^{b}	169.18 ± 7.97^{c}	169.06 ± 9.98^{c}	175.36 ± 10.48^{a}	154.61 ± 22.97	148.60 ± 16.43^{b}	157.63 ± 16.25^{b}
Mean Intensity$_{R}$	199.38 ± 8.11^{a}	195.29 ± 9.65^{a}	168.35 ± 11.39^{b}	173.16 ± 15.82^{b}	190.07 ± 8.58^{a}	184.51 ± 7.93^{a}	154.13 ± 11.33^{b}	154.69 ± 9.91^{b}
Mean red$_{RT}$	234.09 ± 3.98^{a}	231.27 ± 9.69^{a}	219.35 ± 5.96^{b}	217.18 ± 7.51^{b}	219.88 ± 9.49^{a}	208.75 ± 19.00	202.90 ± 11.70^{b}	209.26 ± 11.57
Mean red$_{R}$	233.78 ± 4.94^{a}	237.81 ± 5.63^{a}	218.19 ± 9.15^{b}	221.20 ± 12.35^{b}	230.29 ± 4.78^{a}	229.11 ± 6.05^{a}	207.59 ± 9.85^{b}	206.70 ± 8.13^{b}
Mean green$_{RT}$	211.42 ± 6.32^{a}	194.50 ± 14.02^{b}	177.79 ± 8.26^{c}	178.41 ± 9.96^{c}	186.75 ± 11.66^{a}	161.29 ± 26.46^{b}	154.85 ± 17.30^{b}	164.71 ± 16.74
Mean green$_{R}$	211.64 ± 7.46^{a}	206.11 ± 10.71^{a}	178.74 ± 12.40^{b}	185.58 ± 18.17^{b}	201.96 ± 8.09^{a}	193.07 ± 8.84^{a}	163.03 ± 13.74^{b}	162.97 ± 11.54^{b}
Mean blue$_{RT}$	154.61 ± 12.31^{a}	123.43 ± 15.45^{b}	110.39 ± 10.56^{b}	111.60 ± 12.99^{b}	119.44 ± 11.73^{a}	93.78 ± 24.09^{b}	88.06 ± 20.70^{b}	98.91 ± 20.80
Mean blue$_{R}$	152.72 ± 12.46^{a}	141.93 ± 13.52^{a}	108.13 ± 13.00^{b}	112.69 ± 17.10^{b}	137.96 ± 13.23^{a}	131.36 ± 9.52^{a}	91.77 ± 10.73^{b}	94.41 ± 11.51^{b}
Hue Typical$_{RT}$	31.05 ± 0.65^{a}	28.66 ± 1.30^{b}	26.79 ± 0.91^{c}	27.36 ± 0.54^{c}	29.11 ± 1.02^{a}	25.43 ± 2.36^{b}	25.08 ± 1.20^{b}	25.68 ± 1.18^{b}
Hue Typical$_{R}$	31.67 ± 0.61^{a}	29.08 ± 1.54^{b}	27.78 ± 1.13^{b}	29.23 ± 2.03^{b}	30.18 ± 0.88^{a}	27.21 ± 0.94^{b}	26.59 ± 1.55^{b}	26.26 ±

1.37^{b}*lowercase letters indicate statistically significant differences ($p<0.05$) between columns (storage length)
*uppercase letters indicate statistically significant differences ($p<0.05$) between different storage conditions (room temperature x refrigerator)

Table 2. The color characteristic of inner tissue of cut apple pieces

	control				1%PHFE			
	Day 0	Day 2	Day 7	Day 14	Day 0	Day 2	Day 7	Day 14
Mean Intensity$_{RT}$	220.39 ± 1.97^{aA}	226.05 ± 3.88^{A}	230.88 ± 1.26^{bA}	228.19 ± 3.08^{bA}	220.55 ± 2.24^{aA}	228.38 ± 1.96^{bA}	231.31 ± 1.08^{bA}	227.59 ± 3.33^{bA}
Mean Intensity$_{R}$	228.42 ± 2.88^{aB}	226.60 ± 3.02^{aB}	205.16 ± 5.55^{bB}	223.28 ± 2.66^{aB}	227.53 ± 6.38^{B}	231.15 ± 1.57^{aB}	215.52 ± 9.73^{B}	222.24 ± 3.76^{bB}
Mean red$_{RT}$	243.01 ± 1.37^{aA}	252.12 ± 1.31^{bA}	249.73 ± 1.05^{bA}	249.46 ± 1.82^{bA}	244.22 ± 1.70^{aA}	252.41 ± 1.25^{bA}	250.45 ± 1.23^{bA}	249.66 ± 1.56^{bA}
Mean red$_{R}$	248.75 ± 1.99^{aB}	250.81 ± 2.11^{aB}	243.09 ± 2.10^{bB}	247.76 ± 1.39^{aB}	248.05 ± 1.49^{aB}	252.01 ± 1.13^{bB}	245.22 ± 5.31^{B}	245.13 ± 2.41^{aB}
Mean green$_{RT}$	233.63 ± 2.48^{aA}	241.62 ± 3.52^{cA}	239.52 ± 0.89^{bcA}	235.69 ± 2.69^{abA}	233.85 ± 1.50^{aA}	242.93 ± 1.63^{bA}	239.32 ± 0.64^{bA}	234.91 ± 2.86^{aA}
Mean green$_{R}$	242.71 ± 2.73^{aB}	241.26 ± 3.47^{aB}	224.74 ± 6.72^{bB}	237.60 ± 1.78^{aB}	242.27 ± 4.51^{B}	244.48 ± 1.63^{aB}	234.34 ± 6.18^{B}	237.60 ± 2.15^{bB}
Mean blue$_{RT}$	184.53 ± 3.18^{aA}	184.41 ± 7.36^{aA}	203.40 ± 3.85^{bA}	199.42 ± 5.34^{bA}	183.59 ± 4.79^{aA}	189.90 ± 4.10^{acA}	204.17 ± 1.99^{bdA}	198.19 ± 5.65^{cdA}
Mean blue$_{R}$	193.80 ± 4.18^{aB}	187.74 ± 6.91^{aB}	147.64 ± 8.79^{bB}	184.49 ± 4.99^{aB}	192.29 ± 14.69^{B}	196.97 ± 2.33^{B}	166.99 ± 17.85^{B}	184.01 ± 6.96^{B}
Hue Typical$_{RT}$	36.32 ± 1.34^{acA}	36.83 ± 0.84^{aA}	33.92 ± 0.22^{cA}	31.62 ± 0.36^{bA}	35.99 ± 0.33^{aA}	36.80 ± 0.55^{aA}	33.14 ± 0.51^{bA}	31.15 ± 0.26^{cA}
Hue Typical$_{R}$	38.40 ± 0.45^{aB}	36.85 ± 1.50^{B}	35.20 ± 1.59^{bB}	36.39 ± 0.59^{B}	38.67 ± 2.00^{B}	37.34 ± 0.36^{B}	37.24 ± 0.63^{B}	37.91 ± 0.64^{B}
	3%PHFE				5%PHFE			
	Day 0	Day 2	Day 7	Day 14	Day 0	Day 2	Day 7	Day 14
Mean Intensity$_{RT}$	213.40 ± 7.91^{A}	214.53 ± 5.82^{A}	220.82 ± 2.05^{A}	212.97 ± 4.96^{A}	212.52 ± 5.68^{A}	215.37 ± 6.85^{A}	212.00 ± 5.30^{A}	218.53 ± 2.66^{A}
Mean Intensity$_{R}$	218.11 ± 1.93^{aB}	228.13 ± 3.17^{bB}	215.60 ± 6.00^{aB}	217.14 ± 3.07^{aB}	210.22 ± 4.13^{aB}	228.53 ± 1.77^{bB}	222.41 ± 1.63^{cB}	220.88 ± 2.02^{cB}
Mean red$_{RT}$	238.32 ± 4.06^{aA}	247.15 ± 4.30^{bA}	249.13 ± 1.61^{bA}	244.33 ± 2.11^{A}	237.68 ± 4.59^{A}	244.57 ± 6.65^{A}	239.63 ± 4.14^{A}	246.44 ± 5.56^{A}
Mean red$_{R}$	241.56 ± 1.11^{aB}	250.25 ± 1.65^{bB}	240.35 ± 3.65^{aB}	243.32 ± 1.63^{aB}	234.63 ± 4.67^{aB}	250.00 ± 1.44^{bB}	244.12 ± 1.73^{cB}	243.81 ± 0.58^{cB}
Mean green$_{RT}$	225.43 ± 7.48^{A}	232.04 ± 5.95^{A}	227.23 ± 1.94^{A}	224.93 ± 3.41^{A}	224.60 ± 6.49^{A}	230.58 ± 8.78^{A}	220.78 ± 5.70^{A}	227.64 ± 4.28^{A}
Mean green$_{R}$	230.51 ± 2.09^{aB}	240.46 ± 3.25^{bB}	230.27 ± 4.41^{aB}	234.56 ± 1.33^{B}	221.51 ± 4.08^{aB}	241.78 ± 1.21^{bB}	235.66 ± 1.06^{cB}	234.77 ± 0.67^{cB}
Mean blue$_{RT}$	176.46 ± 12.48^{A}	164.40 ± 8.19^{aA}	186.09 ± 5.06^{bA}	169.63 ± 10.32^{A}	175.28 ± 7.15^{A}	170.97 ± 5.35^{A}	175.59 ± 6.06^{A}	181.52 ± 1.19^{A}
Mean blue$_{R}$	182.26 ± 2.83^{B}	193.68 ± 4.76^{aB}	176.16 ± 11.03^{bB}	173.52 ± 6.53^{bB}	174.52 ± 3.98^{aB}	193.82 ± 3.07^{bB}	187.56 ± 2.88^{bcB}	184.06 ± 5.02^{cB}
Hue Typical$_{RT}$	34.52 ± 1.66^{acA}	35.51 ± 0.62^{aA}	28.51 ± 0.86^{bA}	32.20 ± 1.91^{cA}	34.45 ± 2.29^{A}	35.14 ± 1.41^{aA}	30.91 ± 0.62^{bA}	31.08 ± 4.08^{A}
Hue Typical$_{R}$	35.35 ± 0.60^{aB}	35.92 ± 0.92^{aB}	36.54 ± 0.21^{aB}	37.82 ± 0.47^{bB}	33.99 ± 0.95^{aB}	36.88 ± 0.71^{bB}	36.75 ± 0.64^{bB}	36.72 ± 0.33^{bB}

* lowercase letters indicate statistically significant differences ($p<0.05$) between columns (storage length)
* uppercase letters indicate statistically significant differences ($p<0.05$) between different storage conditions (room temperature x refrigerator)

impact on samples' color. Also, the mean intensity comparison showed that samples were not different in intensity but in color changes.

In the research conducted by Lunadei et al. (2011) there was found that during 9 days of storage of apple pieces the R value increased, and B value decreased. The comparison of surface color changes, there was determined that in control sample the R value increased during storage in room temperature. The comparison of other samples showed decreasing in B value and in R value too, but these changes can be impacted by the color of the coating used for packaging of apple pieces. When the color changes in inner tissue of apples were compared, there can be described, that the unpacked samples and 1%PHFE had the color changes of inner tissue similar to finding by Lunadei et al. (2011) during storage at room temperature. In other cases (3%PHFE and 5%PHFE) the R and B value increased during storage, so the coating had the impact on these samples.

Principle component analyses

The Fig. 1 presents differences between all examined samples. The control and PHFE1 are close together and created group III. The PHFE3 (created group II) and the PHFE5 (group I), and they are distant from group III. It shows that the packaged samples with the higher amount of pectin has different properties/different color than the control and samples with hemp flour extract and 1 % of pectin. It can be said that the packaging of cut apple pieces in the solutions of 5% and 3% pectin with hemp flour extract had an impact on the packaged samples.

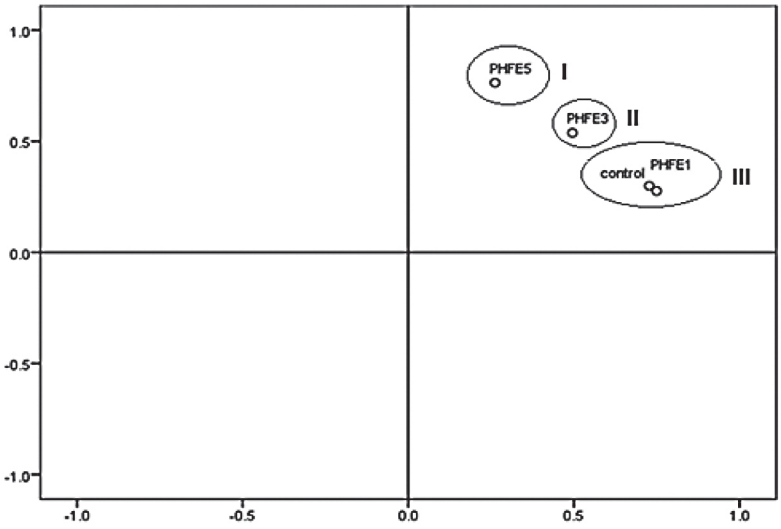

Fig. 1. The principle component analyses for cut apple pieces
Legend: control - samples without packaging, PHFE1 – 1%pectin with HFE, PHFE3 – 3%pectin with HFE, PHFE5 – 5%pectin with HFE

Conclusion

The results revealed that the highest impact on samples color changes had PHEF5 coating. Coating had lower impact on the inner tissue than on surfaces. The principal component analysis (PCA) showed significant ($p<0.05$) differences, forming separate groups: group III (CONTROL and PHFE1), group II (PHFE3) and group I (PHFE5). It can be concluded that 3 % and 5 % pectin with hemp flour extract had an impact on the color changes. The

simple edible coatings used in the study had impact on packaged samples. Also, it has to be emphasized that color measuring can be influenced by the color of coatings due to the presence of the hemp seed extract.

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