EFFECT OF GELLING AGENTS ON COLOR CHARACTERISTICS OF FRUIT JAMS

[1]Jancikova S [1]Dordevic D [1]Javurkova Z

[1]Department of Plant Origin Foodstuffs Hygiene and Technology, Faculty of Veterinary Hygiene and technology, University of Veterinary and Pharmaceutical Sciences Brno, Czech Republic. *e-mail: dani_dordevic@yahoo.com

ABSTRACT

This study was aimedto evaluate the influence of carrageenan and pectin on jam color during 10 days of cold storage (+ 4 ºC). Jam samples were prepared with cherry and apricot fruits and 3 concentrations of gelling agents (0.5 %, 1 % and 2 %). Cherry and apricot jam samples prepared without gelling agent were used as control samples. Pectin, κ-carrageenan and ι-carrageenan were used as gelling agents. The jams were stored in the refrigerator for 10 days. The color of jams was monitored by personal camera, with the usage of image analysis software in three intervals (first day, third day and tenth day). The significant ($p<0.05$) changes of color during 10 days of storage were measured in all prepared jam samples with emphasis that the lowest changes were observed in jams prepared with 1 % pectin, 0.5 % κ-carrageenan and 2 % ι-carrageenan. Otherwise, Principal component analysis (PCA) illustrated that only jam samples prepared with 1 % κ-carrageenan had different RGB parameters in comparison with other laboratory prepared jam samples.

Keywords: cherry, κ-carrageenan, ι-carrageenan, pectin, RGB parameters.

مجلة العلوم الزراعية العراقية -2019 :50(2):675-688 جانسوكفو واخرون

تأثير عوامل التعرق على خصائص اللون لمربى الفاكهة

Jancikova S, Dordevic D, Javurkova

المستخلص

الهدف من الدراسة هو تقييم تأثير الكاراجينان والبكتين على لون المربى خلال 10 أيام من التخزين البارد (+ 4 درجة مئوية). تم تحضير عينات المربى من ثمار الكرز والمشمش و بثلاث تراكيز من عوامل التعرية (0.5٪ ، 1٪ و 2٪). تم استعمال عينات مربى الكرز والمشمش المحضرة بدون عامل التبلور كعينات تحكم. تم استخدام البكتين ، الكاراجينان كعوامل تبليل. تم تخزين المربيات في الثلاجة لمدة 10 أيام. تمت مراقبة لون انحشار الورق بواسطة الكاميرا الشخصية ، باستعمال برنامج تحليل الصور على ثلاث فترات (اليوم الأول واليوم الثالث واليوم العاشر). تم قياس التغيرات الكبيرة في اللون ($p <0.05$) خلال 10 أيام من التخزين في جميع عينات المربى المعدة مع التركيز لوحظت أقل التغييرات في المربى المحضرة بنسبة 1 ٪ البكتين و 0.5 ٪ −κالكاراجينان و 2 ٪ ιالكاراجينان. خلاف ذلك ، أوضح تحليل المكون الرئيسي (PCA) أن عينات المربى فقط المحضرة من 1٪ لها معاملات مختلفة مقارنة مع عينات المربى المعدة الأخرى.

الكلمات المفتاحية: الكرز ، المربى ، الكاراجينان، البكتين ، معلمات ، الكامرة الشخصية

***Received:26/6/2018, Accepted:18/11/2018**

INTRODUCTION

The most fruit species are seasonal growing. It means that the processing of fruits is many times the only option for making certain types of fruits, such as cherries and apricots to be present on the market; especially because their antioxidant potential. Jam production is one of the popular ways for fruit processing which is broadly accepted among consumers (11, 19). Beside consumption in fresh state fruits are very often processed into products such as jams, marmalades, cans, etc. (23). The color of cherries, same the color of other fruits, is highly dependable on fruit ripeness. During fruit ripeness color changes from green to purple red due to the accumulation of polyphenols and anthocyanins and chlorophyll degradation. Certainly that color is also affected by fruit cultivar (6, 8). The color stability of fruit jams depends on pH, oxygen presence, sugar content, ascorbic acid content and used gelling agent type. Cherry jam significantly loses redness after jam preparation, but the color of produced jam usually stayed intact during storage. The loss of color after jam preparation is expectable due to high fruit sensitivity to color loss, even at temperature higher than 18 ºC (1, 16). The importance of jam color can be observed from the observation of the Authors that purple red color of cherries and their product is highly accepted among consumers (8). Basu et al. (3) stated that there is no enough literature information about jam color characteristics during storage and manufacturing, same as the influence of pectin on jam color (15). Pectin is the most often used gelling agents in jam preparation, but carrageenan as hydrocolloids are also very often used in the food industry, especially as stabilizers in chocolate milk drinks. Positive sensory attributes were also connected with jams prepared with carrageenan (7, 12, 20, 21).Carrageenan belong to hydrocolloids that have a wide array of application in the food industry, including thickening, gelling, emulsifying, stabilizing, coating and etc. Hydrocolloids main effect on food is their influence on food textural properties that leads to the changes of food sensory properties. Many food products at the present time would not be possible to produce without hydrocolloids inclusion. Carrageenan provides only fiber with no nutritional value for the human body, meaning that they are not assimilated by the human body, but they are making a unique functional characteristics of food (jell, thicken and stabilize food products). The differences between κ-carrageenan and ι-carrageenan is in the number and position of sulphate groups; κ-carrageenan has one sulphate group and ι-carrageenan has two sulphate groups. They can form a helical conformation due to the monosaccharide structure. In the presence of certain cations (potassium and calcium) carrageenan can form jell. The formed jell is thermally reversible and its texture is from firm and brittle to soft and elastic (4, 17). RGB model of color determination belongs probably to the simplest method for color estimation, but gained results highly correspond with the changes of product color (24). The aim of the research was to monitor the influence of gelling agents on color properties of cherry and apricot jams during 10 days of cold (+ 4 ºC) storage.

MATERIALS AND METHODS

Jams prepared with cherries (*Prunus avium*) and apricots (Prunus armeniaca L.) were used in the research.The whole process of jam preparation was done at the Department of Plant Origin Foodstuffs Hygiene and Technology (Faculty of Veterinary Hygiene and Ecology; University of Veterinary and Pharmaceutical Sciences Brno). Cherries were first washed, rinsed and destoned. The jam preparation was done in four steps: 1) 600 g of fruit (apricot and cherry, separately) was mixed and cooked during 10 min; 2) addition of 480 g of sugar (sugar crystal, producer Korunni, Czech Republic) and gelling agents (pectin, carrageenan kappa and carrageenan iota) in different concentrations (Table 1; 3) the whole mixture (fruit, sugar and gelling agent) was additionally cooked for 5 min; 4) all samples at the end of cooking were poured into glass jars. The sample of cherry jam prepared without a gelling agent served as the control sample. Pectin was produced by Gresik (the Czech Republic) and carrageenans by Raps (Germany). The color analysis was also done by personal camera EOS600D (Canon, JPN). The scanning was done under standard light conditions with 2 lamps Delux L – 1 x 18 W lamps (OSRAM, GER). The shooting mode

was in manual setting: exposure time 1/80, aperture F 5.0, image size L, sensitivity ISO 100. Subsequently, color analysis was processed and analyzed by the NIS-Elements BR 4.13.04 image analysis software. A square area of 2.500 x 2.000 px, in the middle of petri dish, was selected for the evaluation. The homogeneity of variance was determined using Levene's test ($p < 0.05$). For results with a normal distribution and homogenous variance, the significance of difference was determined using one-way ANOVA with Tukey's post-hoc test ($P < 0.05$). For results without a normal distribution and unequal variance, the significance of differences was determined using a non-parametric Games-Howel test ($P < 0.05$). The principal component analysis (PCA) was used for distinguishing different groups among investigated jam samples. Statistical analysis was performed using SPSS, version 20 (IBM Corp., Armonk, NY,USA).

RESUTS AND DISCUSSION

RGB values of analyzed cherry jams, stored in the refrigerator (+ 4 °C) during 10 days, are shown in Table 1 – 10. The Table 1. (cherry jam samples prepared without gelling agent) is indicating statistically significant ($p<0.05$) decrease, during 10 days of storage, in following RGB values: mean intensity, intensity variation, max intensity, mean green, mean blue, mean brightness and bright variation. Oppositely, increase ($p<0.05$) was observed in mean saturation, mean density and density variation. RGB values of apricot jam samples prepared without gelling agent decreased statistically ($p<0.05$) also in hue variation and increased in mean intensity (Table 2). Cherry jams prepared with 0.5 % pectin were associated with decreased ($p<0.05$) RGB values (intensity variation, mean green, mean blue, bright variation and mean density); increased ($p<0.05$) values were measured only in min intensity and mean red (Table 3). In apricot jams decreased values ($p<0.05$) were noticed in mean intensity, hue typical and mean brightness, while only mean blue RGB valued showed significant ($p<0.05$) increase trend (Table 4). Much lesser difference ($p<0.05$) was observed in the samples of cherry jams prepared with 1 % and 2 % pectin; increment only in mean intensity and decrement in mean density (Table 5); increment in hue typical, hue variation and density variation, respectively (Table 7). Fluctuations were more noticeable ($p<0.05$) in apricot jams prepared with 1 % and 2% pectin (Table 6 and 8). Cherry jams prepared with 0.5 % κ-carrageenan did not have so clear increased and decreased trends monitored in RGB values. After ten days of storage (+ 4 °C) decreased values were observed ($p<0.05$ %) only in mean intensity and mean brightness (Table 9), while apricot jams have decreased values also in mean saturation, mean density and density variation (Table 10). RGB values of cherry jams prepared with 1 % κ-carrageenan seemed to be more influenced by higher concentration of gelling agent (κ-carrageenan) than samples prepared with 0.5 % κ-carrageenan. During 10 days of cold storage increased values were measured in following RGB values: mean intensity, sum intensity, mean red and mean brightness; decreased values were following: intensity variation, mean saturation, bright variation, mean density, sum density and density variation (Table 11). Significant ($p<0.05$) decrease in RGB parameters (among samples of cherry jams prepared with 2 % κ-carrageenan) were noticed in the following values: intensity variation and bright variation (Table 13); apricot jams had decreased ($p<0.05$) hue typical value (Table 14). Oppositely from other investigated cherry jam samples, cherry jam samples prepared with 0.5 % of ι-carrageenan had significantly ($p<0.05$) increased (mean intensity, mean red and mean brightness) (Table 15), while apricot jams had decreased following RGB values: intensity variation, mean green, hue variation, bright variation and density variation (Table 16). More changes ($p<0.05$) were observed in jams prepared with 1 % ι-carrageenan (Table 17), while cherry jams prepared with 2 % ι-carrageenan did not have so unambiguously fluctuation of RGB values. The unambiguously trends were noticed only in decrease ($p<0.05$) values of intensity variation and bright variation (Table 19). Oppositely, apricot jams prepared with 1 % and 2 % ι-carrageenan had more significantly ($p<0.05$) decreased RGB values (Table 18 and 20) in comparison with cherry jam samples. Principal

component analysis (PCA) of cherry jam samples' RGB parameters grouped all samples in one group beside jam samples prepared with 1 % κ-carrageenan (Figure 1); apricot jam samples had samples prepared with 1 % pectin as distinguished group (Figure 2), while PCA that included RGB parameters of both (cherry + apricot) tested fruit jams separated in one distinguishable group samples prepared with 0.5 % κ-carrageenan (Figure 3).

Table 1. RGB values of cherry jams prepared without gelling agent

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	34.7±2.3[b]	32.7±3.4[b]	26.2±0.8[a]
Intensity Variation	33.9±3.7[a]	23.8±0.7[c]	21.2±0.9[b]
Min Intensity	3.8±1.4[a]	14.6±3.0[b]	13.0±0.8[b]
Max Intensity	255.0±0.0[a]	254.8±0.4[a]	251.1±0.8[b]
Mean Red	67.8±3.2[a]	79.8±9.8[b]	64.3±2.2[c]
Mean Green	19.5±2.0[a]	9.8±0.3[b]	7.7±0.4[c]
Mean Blue	16.7±1.9[a]	8.4±0.3[b]	6.7±0.4[c]
Hue Typical	53.2±7.6	53.3±17.5	56.3±6.3
Hue Variation	99.5±5.9	99.5±14.8	103.8±4.3
Mean Saturation	175.3±3.6[a]	214.3±4.9[b]	216.1±3.1[b]
Mean Brightness	13.6±0.9[a]	12.8±1.3[a]	10.3±0.3[b]
Bright Variation	13.3±1.4[a]	9.3±0.3[b]	8.3±0.4[c]
Mean Density	1.2±0.1[a]	1.5±0.2[b]	1.7±0.1[b]
Density Variation	0.5±0.1[a]	0.8±0.3[b]	0.9±0.2[b]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 2. RGB of apricot jams prepared without gelling agent

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	85.4±4.5[a]	86.7±3.7[a]	78.1±3.4[b]
Intensity Variation	28.8±4.2[a]	22.3±9.6	19.0±3.0[b]
Min Intensity	25.7±16.5[a]	46.2±13.2[b]	43.3±5.7[b]
Max Intensity	255.0±0.0	253.0±3.3	254.5±0.8
Mean Red	192.1±6.3[a]	199.0±1.1[b]	183.8±5.5[c]
Mean Green	52.1±4.6[a]	51.8±5.9[a]	43.9±3.5[b]
Mean Blue	12.0±3.1[a]	9.3±5.3	6.5±1.5[b]
Hue Typical	10.1±0.5[a]	10.2±2.0[b]	8.7±0.4[c]
Hue Variation	16.0±4.9[a]	14.4±9.8	10.9±2.0[b]
Mean Saturation	233.2±3.9a	237.4±6.4	239.4±2.3b
Mean Brightness	33.5±1.8[a]	34.0±1.5[a]	30.6±1.3[b]
Bright Variation	11.3±1.7[a]	8.7±3.8	7.4±1.2[b]
Mean Density	1.0±0.1	1.0±0.0[a]	1.1±0.1[b]
Density Variation	0.6±0.2	0.5±0.1[a]	0.6±0.1[b]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 3. RGB values of cherry jams prepared with 0.5 % pectin

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	28.9±2.6	27.3±5.3	29.4±3.6
Intensity Variation	39.9±6.0[b]	36.1±8.6[b]	25.1±4.5[a]
Min Intensity	8.6±0.8[a]	8.9±0.8[a]	12.8±2.8[b]
Max Intensity	254.8±0.3[a]	254.2±0.4[b]	253.2±2.0
Mean Red	54.2±3.6[a]	54.7±7.1[a]	64.7±8.3[b]
Mean Green	18.2±3.2[a]	15.2±4.8	14.1±1.9[b]
Mean Blue	14.2±2.9[a]	12.1±4.3	9.5±1.3[b]
Hue Typical	19.8±4.9[a]	28.0±5.3[b]	12.4±2.0[c]
Hue Variation	58.8±9.4[a]	72.4±8.2[b]	45.8±5.7[c]
Mean Saturation	196.5±6.5	203.4±5.6	203.4±9.0
Mean Brightness	11.3±1.0	10.7±2.1	11.5±1.4
Bright Variation	15.6±2.3[a]	14.2±3.4[a]	9.9±1.8[b]
Mean Density	1.6±0.1[a]	1.6±0.1[a]	1.4±0.1[b]
Density Variation	0.8±0.1	0.8±0.2	0.6±0.2

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 4. RGB values of apricot jams prepared with 0.5 % pectin

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	87.3±3.3	88.8±2.6[a]	86.0±2.1[b]
Intensity Variation	15.3±3.5	14.9±3.1	14.4±1.3
Min Intensity	57.1±3.3[a]	63.3±7.0[a]	50.5±4.7[b]
Max Intensity	252.8±2.5	251.1±2.2[a]	253.7±0.9[b]
Mean Red	202.9±6.6	205.2±5.6	200.8±3.5
Mean Green	54.8±3.5	57.7±2.5[a]	51.9±2.4[b]
Mean Blue	4.2±1.2[a]	3.5±1.1[a]	5.4±0.5[b]
Hue Typical	10.4±0.3[a]	10.9±0.3[a]	9.5±0.2[b]
Hue Variation	7.7±4.5	6.2±4.3	6.6±1.3
Mean Saturation	246.4±1.4[a]	248.2±1.2[b]	241.3±0.7[c]
Mean Brightness	34.2±1.3	34.8±1.0[a]	33.7±0.8[b]
Bright Variation	6.0±1.4	5.8±1.2	5.6±0.5
Mean Density	1.6±0.3[a]	1.8±0.2[a]	0.9±0.0[b]
Density Variation	1.1±0.2[a]	1.2±0.1[a]	0.4±0.1[b]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 5. RGB values of cherry jams prepared with 1 % pectin

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	31.2±8.1	26.4±3.0	27.3±2.2
Intensity Variation	41.8±13.7	42.9±6.7	36.2±6.5
Min Intensity	7.8±1.4	7.3±0.3[a]	8.8±1.5[b]
Max Intensity	254.9±0.1	254.9±0.1	253.4±1.9
Mean Red	57.2±7.9	51.9±2.5	55.0±3.8
Mean Green	18.6±9.0	13.4±3.4	13.3±3.1
Mean Blue	17.8±8.2	13.9±3.2	13.7±3.0
Hue Typical	140.1±16.4[a]	171.1±8.9[b]	149.7±10.3[a]
Hue Variation	122.3±1.5[a]	115.7±2.3[b]	122.1±1.6[a]
Mean Saturation	187.6±14.5[a]	222.8±3.7[b]	203.0±10.4[c]
Mean Brightness	12.2±3.2	10.4±1.2	10.7±0.9
Bright Variation	16.4±5.4	16.8±2.6	14.2±2.6
Mean Density	1.6±0.2[a]	3.0±0.2[b]	1.9±0.4[c]
Density Variation	0.9±0.3[a]	1.9±0.1[b]	1.2±0.4[a]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 6. RGB values of apricot jams prepared with 1 % pectin

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	92.5±5.4[a]	90.7±5.1[a]	85.1±3.3[b]
Intensity Variation	28.4±10.1[a]	22.2±4.8[a]	15.4±2.0[b]
Min Intensity	49.2±4.3[a]	59.7±2.2[b]	47.6±4.5[a]
Max Intensity	254.0±1.3	254.0±1.1	253.3±1.3
Mean Red	203.3±3.3	204.0±8.2	198.2±5.4
Mean Green	61.8±6.5[a]	60.4±5.5[a]	51.0±3.6[b]
Mean Blue	12.4±6.5[a]	7.8±2.7	6.0±1.0[b]
Hue Typical	11.3±0.6[a]	11.3±0.3[b]	9.4±0.3[b]
Hue Variation	14.0±3.0[a]	9.9±5.5	7.8±2.4[b]
Mean Saturation	235.4±7.8	241.5±3.4	240.3±1.5
Mean Brightness	36.3±2.1[a]	35.6±2.0[a]	33.4±1.3[b]
Bright Variation	11.1±4.0[a]	8.7±1.9[a]	6.0±0.8[b]
Mean Density	1.2±0.1[a]	1.4±0.4[a]	0.9±0.1[b]
Density Variation	0.9±0.1[a]	1.0±0.3[a]	0.4±0.1[b]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 7. RGB values of cherry jam prepared with 2 % pectin

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	36.9±1.8[a]	30.0±1.8[b]	34.9±4.3[a]
Intensity Variation	38.9±1.9	40.8±2.3	36.9±5.1
Min Intensity	8.5±1.5[b]	6.8±0.9[a]	9.4±0.9[b]
Max Intensity	253.4±1.8[a]	254.0±0.3[a]	249.9±3.0[b]
Mean Red	61.0±5.4	52.1±3.1	60.4±4.2
Mean Green	28.4±1.4[a]	20.8±1.5[b]	24.5±4.4
Mean Blue	21.4±1.5[a]	17.0±1.4[b]	19.7±4.2
Hue Typical	16.2±2.4[a]	33.3±3.1[b]	33.0±4.8[b]
Hue Variation	44.6±3.5[a]	76.4±4.9[b]	76.3±4.9[b]
Mean Saturation	158.5±8.0[a]	175.6±2.4[b]	167.5±9.3
Mean Brightness	14.5±0.7[a]	11.8±0.7[b]	13.7±1.7[a]
Bright Variation	15.3±0.8	16.0±0.9	14.5±2.0
Mean Density	1.2±0.0[a]	1.4±0.0[b]	1.3±0.1[c]
Density Variation	0.5±0.1[a]	0.6±0.1[b]	0.6±0.1[b]

*lowercase letters indicate statistical significant difference (p<0.05) between colums

Table 8. RGB values of apricot jam prepared with 2 % pectin

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	95.8±4.9[a]	88.7±4.1[b]	80.7±2.3[c]
Intensity Variation	34.9±7.1[a]	24.9±4.5[b]	25.9±4.6[b]
Min Intensity	37.8±5.5	36.3±5.0	39.7±2.9
Max Intensity	254.9±0.2	254.6±0.4	254.7±0.3
Mean Red	201.7±2.5[a]	197.1±4.8[b]	180.9±1.6[c]
Mean Green	67.7±5.8[a]	59.6±4.4[b]	50.8±2.8[c]
Mean Blue	18.1±6.4[a]	9.4±3.3[b]	10.3±2.9[b]
Hue Typical	12.6±0.9[a]	11.5±0.3[b]	10.7±1.1[a]
Hue Variation	18.2±5.6	13.0±3.4	16.2±5.3
Mean Saturation	226.6±7.3[a]	238.3±4.4[b]	234.2±3.7[b]
Mean Brightness	37.6±1.9[a]	34.8±1.6[b]	31.6±0.9[c]
Bright Variation	13.7±2.8[a]	9.8±1.8[b]	10.2±1.8[b]
Mean Density	1.0±0.1[a]	1.3±0.2[b]	1.0±0.0[a]
Density Variation	0.7±0.1[a]	1.0±0.1[b]	0.6±0.1[a]

*lowercase letters indicate statistical significant difference (p<0.05) between colums

Table 9. RGB values of cherry jam prepared with 0.5 % κ-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	23.2±5.8	23.9±5.0[a]	18.6±1.3[b]
Intensity Variation	32.9±14.2	30.6±9.0	25.8±3.2
Min Intensity	5.0±0.3[a]	7.7±1.9[b]	5.9±0.5[c]
Max Intensity	253.4±2.0	254.6±0.5	252.5±2.3
Mean Red	45.3±4.3[a]	53.6±8.4[b]	39.5±2.9[c]
Mean Green	12.7±7.2	8.8±3.6	8.0±1.1
Mean Blue	11.7±6.4	9.1±3.3	8.2±1.1
Hue Typical	88.8±20.7[a]	144.6±17.5[b]	131.7±3.6[b]
Hue Variation	116.3±9.6[a]	122.8±2.4[a]	125.0±0.3[b]
Mean Saturation	195.9±15.2[a]	222.7±5.5[b]	203.2±9.9[a]
Mean Brightness	9.1±2.3	9.4±2.0[a]	7.3±0.5[b]
Bright Variation	12.9±5.6	12.0±3.5	10.1±1.2
Mean Density	1.7±0.2[a]	2.7±0.6[b]	1.9±0.3[a]
Density Variation	0.9±0.3[a]	1.7±0.4[b]	1.0±0.4[a]

*lowercase letters indicate statistical significant difference (p<0.05) between colums

Table 10. RGB values of apricot jam prepared with 0.5 % κ-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	78.9±5.8[a]	91.3±0.5[b]	81.0±2.2[a]
Intensity Variation	14.9±4.3	16.6±2.5[a]	12.3±4.1[b]
Min Intensity	50.8±5.2[a]	59.3±3.9[b]	45.3±2.2[c]
Max Intensity	251.0±2.2	251.4±2.0	251.8±3.5
Mean Red	184.2±8.7[a]	205.4±1.0[b]	188.6±1.8[a]
Mean Green	48.4±7.1[a]	63.7±0.5[b]	49.0±4.3[a]
Mean Blue	4.1±2.1	4.9±0.9	5.4±1.2
Hue Typical	9.9±1.1	12.0±0.2	9.4±0.7
Hue Variation	6.5±3.2	7.1±4.0	4.8±1.3
Mean Saturation	246.0±3.3[a]	245.2±1.0[a]	239.7±1.9[b]
Mean Brightness	30.9±2.3[a]	35.8±0.2[b]	31.8±0.9[a]
Bright Variation	5.9±1.7	6.5±1.0[a]	4.8±1.6[b]
Mean Density	1.8±0.3[a]	1.4±0.1[b]	0.9±0.0[c]
Density Variation	1.2±0.1[a]	1.1±0.1[b]	0.3±0.1[c]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 11. RGB values of cherry jam prepared with 1 % κ-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	29.6±1.3[a]	33.1±1.9[b]	35.5±4.1[b]
Intensity Variation	41.9±3.0[b]	40.8±1.4[b]	32.5±2.2[a]
Min Intensity	4.2±0.3[b]	2.8±2.5[b]	8.9±1.6[a]
Max Intensity	252.2±1.6[a]	255.0±0.0[b]	246.3±5.2[c]
Mean Red	47.5±0.9[a]	51.3±2.9[b]	60.3±5.7[c]
Mean Green	21.8±1.6[a]	25.6±1.6[b]	24.5±3.9
Mean Blue	19.6±1.5[a]	22.3±1.5[b]	21.8±3.7
Hue Typical	70.0±2.3[a]	37.9±8.3[b]	66.2±12.2[a]
Hue Variation	105.9±2.5[a]	80.1±9.2[b]	105.4±7.5[a]
Mean Saturation	169.2±2.9[a]	135.7±5.8[b]	147.7±13.8[b]
Mean Brightness	11.6±0.5[a]	13.0±0.8[b]	13.9±1.6[b]
Bright Variation	16.4±1.2[a]	16.0±0.5[a]	12.8±0.8[b]
Mean Density	1.5±0.1[a]	1.2±0.0[b]	1.2±0.1[b]
Density Variation	0.9±0.1[a]	0.4±0.0[b]	0.5±0.2[b]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 12. RGB values of apricot jam prepared with 1 % κ-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	88.3±2.5[a]	96.4±3.0[b]	86.6±4.9[a]
Intensity Variation	31.8±3.3	32.7±2.1	31.4±1.4
Min Intensity	37.6±3.3[a]	53.7±3.8[b]	36.2±5.1[a]
Max Intensity	253.3±1.2	253.6±1.0	254.3±0.8
Mean Red	186.8±4.0[a]	202.7±4.4[b]	185.0±8.5[a]
Mean Green	60.8±2.9[a]	68.5±4.3[b]	58.2±4.0[a]
Mean Blue	17.5±3.7	18.2±1.7	16.7±2.4
Hue Typical	13.4±3.5	13.9±1.9[a]	12.2±1.4[b]
Hue Variation	22.5±15.4	22.5±12.5	22.5±7.3
Mean Saturation	222.7±4.9	225.5±2.6	223.9±3.7
Mean Brightness	34.6±1.0[a]	37.8±1.2[b]	34.0±1.9[a]
Bright Variation	12.5±1.3	12.8±0.8	12.3±0.6
Mean Density	0.9±0.1[a]	1.4±0.2[b]	1.0±0.1[a]
Density Variation	0.6±0.1[a]	1.1±0.2[b]	0.6±0.1[a]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 13. RGB values of cherry jam prepared with 2 % κ-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	40.5±1.7[a]	33.4±2.6[b]	37.8±2.2[c]
Intensity Variation	32.9±1.5[a]	29.8±2.0[b]	24.6±2.6[c]
Min Intensity	7.5±0.7[a]	4.3±1.2[b]	6.5±0.9[a]
Max Intensity	250.1±3.3[a]	253.5±1.3[b]	218.5±15.6[c]
Mean Red	64.2±2.1[a]	54.6±2.5[b]	59.3±2.5[c]
Mean Green	30.5±1.6[a]	24.1±2.6[b]	28.5±2.3[a]
Mean Blue	26.8±1.4[a]	21.6±2.6[b]	25.6±2.1[a]
Hue Typical	61.2±9.9[a]	44.9±5.6[b]	54.9±9.9[a]
Hue Variation	101.5±7.7[a]	91.1±4.1[b]	98.7±8.4
Mean Saturation	122.0±3.1[a]	129.5±10.4[a]	105.9±4.1[b]
Mean Brightness	15.9±0.7[a]	13.1±1.0[b]	14.8±0.9[c]
Bright Variation	12.9±0.6[a]	11.7±0.8[b]	9.6±1.0[c]
Mean Density	1.0±0.0[a]	1.1±0.1[b]	1.0±0.0[a]
Density Variation	0.3±0.0[a]	0.4±0.1[b]	0.3±0.0[c]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 14. RGB values of apricot jam prepared with 2 % κ-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	91.7±5.1[a]	100.6±4.4[b]	87.6±1.7[a]
Intensity Variation	30.7±1.5[a]	32.0±0.9[b]	29.6±0.9[a]
Min Intensity	34.4±5.2[a]	48.0±4.4[b]	37.5±1.5[a]
Max Intensity	250.6±0.7[a]	246.8±2.7[b]	250.3±1.5[a]
Mean Red	187.0±7.9[a]	196.0±5.0[b]	180.5±1.7[a]
Mean Green	68.3±5.2[a]	78.2±5.5[b]	63.6±2.2[a]
Mean Blue	19.9±2.4[a]	27.5±2.9[b]	18.8±1.5[a]
Hue Typical	12.6±0.8[a]	13.5±0.8[b]	12.1±1.0[c]
Hue Variation	13.8±9.1	14.9±10.7	14.0±8.4
Mean Saturation	216.3±3.2[a]	203.3±5.6[b]	216.5±2.9[a]
Mean Brightness	36.0±2.0[a]	39.4±1.7[b]	34.4±0.7[a]
Bright Variation	12.0±0.6[a]	12.5±0.4[b]	11.6±0.3[a]
Mean Density	1.1±0.2	1.4±0.3	1.1±0.1
Density Variation	1.0±0.2[a]	1.3±0.2[b]	1.0±0.1[a]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 15. RGB values of cherry jam prepared with 0.5 % ι-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	20.9±1.8[a]	23.3±2.8	25.0±2.0[b]
Intensity Variation	38.7±3.9	42.3±4.7[a]	36.2±3.6[b]
Min Intensity	3.8±0.4[a]	2.5±1.6[a]	6.2±0.3[b]
Max Intensity	255.0±0.0[a]	255.0±0.0[a]	253.5±1.4[b]
Mean Red	36.1±2.0[a]	40.4±2.8[b]	46.1±2.4[c]
Mean Green	14.0±2.1	16.0±3.0	15.4±2.0
Mean Blue	12.7±2.1	13.6±2.7	13.6±1.9
Hue Typical	42.2±6.8[a]	37.7±3.8[a]	49.0±2.9[b]
Hue Variation	87.5±7.5[a]	82.7±3.5[a]	95.2±2.1[b]
Mean Saturation	189.4±5.5[a]	202.3±4.4[b]	194.0±2.4[a]
Mean Brightness	8.2±0.7[a]	9.1±1.1	9.8±0.8[b]
Bright Variation	15.2±1.5	16.6±1.8[a]	14.2±1.4[b]
Mean Density	1.9±0.1[a]	2.2±0.1[b]	1.8±0.1[a]
Density Variation	1.0±0.1[a]	1.4±0.1[b]	1.1±0.1[a]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 16. RGB values of apricot jam prepared with 0.5 % ι-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	89.7±2.9	92.5±4.4[a]	84.9±6.0[b]
Intensity Variation	20.1±5.6[a]	17.8±3.0	14.7±3.3[b]
Min Intensity	49.8±4.6	55.8±10.3	52.1±3.4
Max Intensity	254.1±1.0[a]	252.4±1.4[b]	245.6±18.7
Mean Red	199.9±3.2	205.1±7.7[a]	194.3±9.7[b]
Mean Green	61.3±3.3[a]	66.5±5.1[b]	54.5±6.3[c]
Mean Blue	7.9±2.8	5.9±1.0	5.8±1.9
Hue Typical	11.5±0.4	12.5±0.4	10.2±0.7
Hue Variation	9.0±3.7[a]	7.6±4.4	4.0±0.6[b]
Mean Saturation	238.7±3.4[a]	243.2±1.4[b]	240.4±2.6[a]
Mean Brightness	35.2±1.1	36.3±1.7[a]	33.3±2.3[b]
Bright Variation	7.9±2.2[a]	7.0±1.2	5.8±1.3[b]
Mean Density	1.0±0.1[a]	1.4±0.3[b]	0.9±0.1[a]
Density Variation	0.6±0.1[a]	1.0±0.3[b]	0.4±0.1[c]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 17. RGB values of cherry jam prepared with 1 % ι-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	24.6±1.6[a]	26.7±1.6[b]	35.5±1.2[c]
Intensity Variation	36.8±1.4[a]	35.4±2.1	34.2±1.3[b]
Min Intensity	2.7±0.4[a]	1.7±1.6[a]	5.5±1.4[b]
Max Intensity	253.9±1.1[a]	255.0±0.0[b]	249.9±1.7[c]
Mean Red	38.5±2.3[a]	42.6±1.8[b]	54.5±1.7[c]
Mean Green	17.8±1.3[a]	19.4±1.7[b]	26.7±1.2[c]
Mean Blue	17.5±1.4[a]	18.0±1.4[a]	25.2±1.2[b]
Hue Typical	105.7±13.9[a]	79.3±7.7[b]	107.3±13.6[a]
Hue Variation	118.8±3.7[a]	112.0±4.2[b]	119.3±3.4[a]
Mean Saturation	150.2±6.9[a]	146.2±4.3[a]	118.0±2.9[b]
Mean Brightness	9.6±0.6[a]	10.5±0.6[b]	13.9±0.5[c]
Bright Variation	14.4±0.5[a]	13.9±0.8	13.4±0.5[b]
Mean Density	1.5±0.1[a]	1.4±0.0[b]	1.1±0.0[c]
Density Variation	0.7±0.1[a]	0.6±0.0[a]	0.4±0.0[b]

***lowercase letters indicate statistical significant difference (p<0.05) between colums**

Table 18. RGB values of apricot jam prepared with 1 % ι-carrageenan

RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	94.4±3.7[a]	94.5±3.9[a]	85.6±2.6[b]
Intensity Variation	35.3±3.6	33.1±1.6	32.2±2.1
Min Intensity	47.4±4.5[a]	50.9±7.7[a]	34.4±1.9[b]
Max Intensity	254.8±0.2[a]	254.8±0.2[b]	255.0±0.1
Mean Red	198.3±6.0[a]	201.0±7.1[a]	183.3±3.2[b]
Mean Green	66.9±3.4[a]	66.1±4.0[a]	56.7±2.9[b]
Mean Blue	18.0±3.6	16.5±1.2	16.8±2.2
Hue Typical	13.3±2.0	13.5±1.6	12.7±1.4
Hue Variation	20.7±9.6	22.6±9.5	25.5±6.1
Mean Saturation	227.2±4.7	228.4±2.0a	222.8±3.5b
Mean Brightness	37.0±1.5[a]	37.1±1.5[a]	33.6±1.0[b]
Bright Variation	13.8±1.4	13.0±0.6	12.6±0.8
Mean Density	1.4±0.3[a]	1.1±0.2[b]	0.9±0.0[c]
Density Variation	1.2±0.2[a]	0.9±0.2[b]	0.4±0.1[c]

***lowercase letters indicate statistical significant difference (p<0.05) between colum**

Table 19. RGB values of cherry jam prepared with 2 % ι-carrageenan

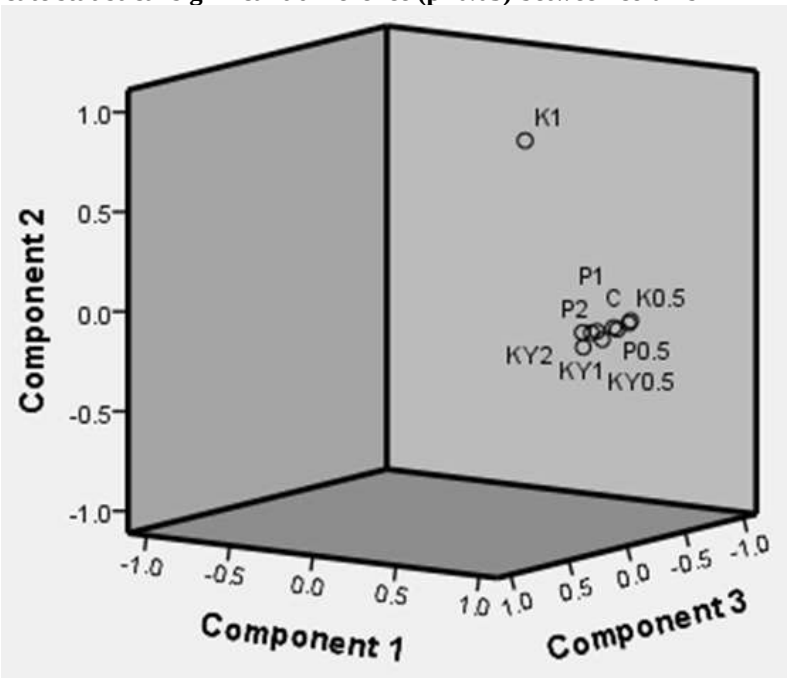
RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	32.6±1.2[a]	25.6±1.1[b]	29.9±0.6[c]
Intensity Variation	32.7±1.7[b]	31.4±1.3[b]	25.5±2.7[a]
Min Intensity	3.0±0.5[a]	0.7±0.6[b]	3.1±0.5[a]
Max Intensity	250.3±1.1[a]	254.8±0.5[b]	219.0±7.9[c]
Mean Red	47.7±1.5[a]	37.8±0.8[b]	43.7±1.1[c]
Mean Green	27.8±1.3[a]	21.5±1.3[b]	25.4±0.8[c]
Mean Blue	22.3±0.9[a]	17.6±1.3[b]	20.6±0.9[c]
Hue Typical	35.8±3.3[a]	24.0±7.4[b]	28.1±3.0[b]
Hue Variation	72.7±1.7[a]	55.2±9.4[b]	65.2±3.8[c]
Mean Saturation	116.0±4.9[a]	125.4±1.7[b]	104.8±1.7[c]
Mean Brightness	12.8±0.5[a]	10.1±0.4[b]	11.7±0.2[c]
Bright Variation	12.8±0.7[a]	12.3±0.5[a]	10.0±1.1[b]
Mean Density	1.1±0.0[a]	1.2±0.0[b]	1.1±0.0[a]
Density Variation	0.4±0.1	0.4±0.0[a]	0.4±0.0[b]

*lowercase letters indicate statistical significant difference (p<0.05) between colums

Table 20. RGB values of apricot jam prepared with 2 % ι-carrageenan

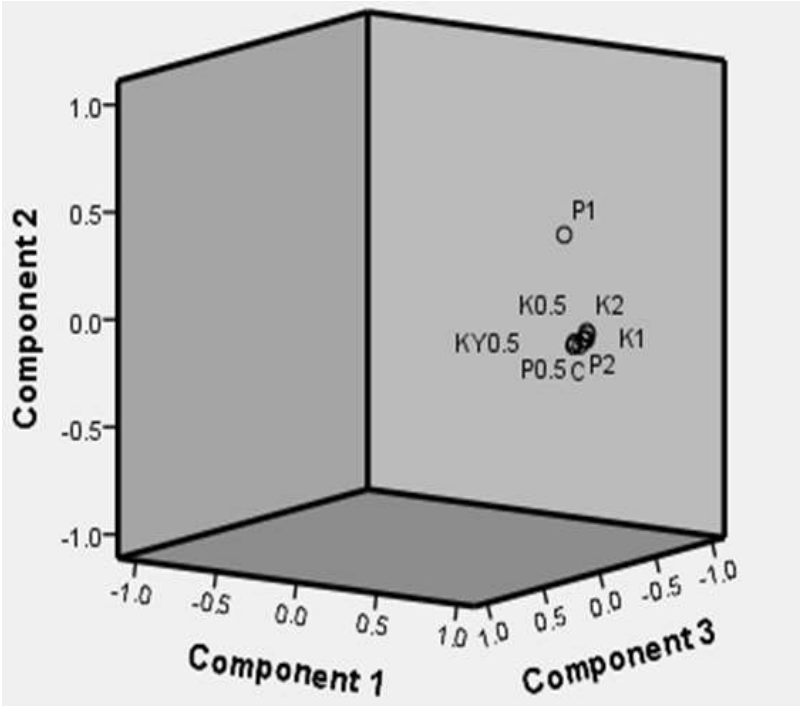
RGB	1st measuring 1st day	2nd measuring 3rd day	3rd measuring 10th day
Mean Intensity	95.3±1.3[a]	98.8±2.0[b]	87.8±3.4[c]
Intensity Variation	35.7±0.9[a]	34.4±0.7[b]	33.1±2.2[b]
Min Intensity	42.1±2.2[a]	47.6±2.0[b]	35.2±1.8[c]
Max Intensity	253.2±0.7	253.3±1.0	254.6±0.6
Mean Red	192.4±2.8[a]	200.0±2.6[b]	182.1±1.4[c]
Mean Green	70.3±1.1[a]	72.6±1.7[b]	60.9±4.5[c]
Mean Blue	23.2±0.6	23.7±1.8	20.3±4.6
Hue Typical	13.5±2.2	14.3±2.9	12.9±1.5
Hue Variation	20.2±12.2	24.0±12.8	24.8±7.2
Mean Saturation	215.0±0.8	214.1±3.5	216.3±8.7
Mean Brightness	37.4±0.5[a]	38.7±0.8[b]	34.4±1.3[c]
Bright Variation	14.0±0.4[a]	13.5±0.3[b]	13.0±0.9[b]
Mean Density	1.6±0.2[a]	1.3±0.2[b]	0.9±0.1[c]
Density Variation	1.4±0.1[a]	1.2±0.2[b]	0.6±0.1[c]

*lowercase letters indicate statistical significant difference (p<0.05) between colums



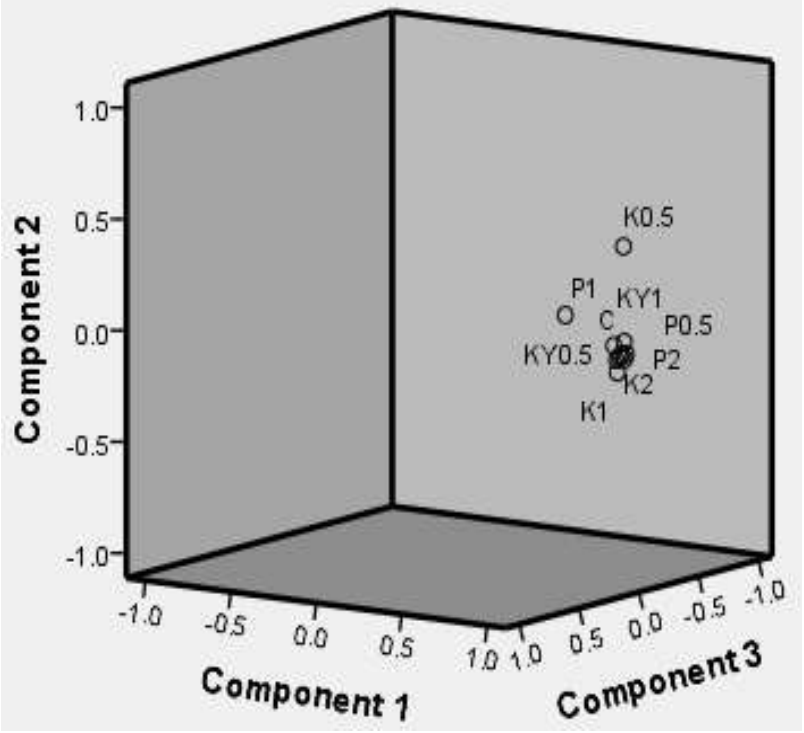
*C: control; P0.5: 0.5 % pectin; P1: 1 % pectin; P2: 2 % pectin; K0.5: 0.5 % κ-carrageenan; K1: 1 % κ-carrageenan; K2: 2 % κ-carrageenan; Y0.5: 0.5 % ι-carrageenan; Y1: 1 % ι-carrageenan; Y2: 2 % ι-carrageenan

Figure 1. Principal component analysis (PCA) of cherry jams' RGB parameters



***C: control; P0.5: 0.5 % pectin; P1: 1 % pectin; P2: 2 % pectin; K0.5: 0.5 % κ-carrageenan; K1: 1 % κ-carrageenan; K2: 2 % κ-carrageenan; Y0.5: 0.5 % ι-carrageenan; Y1: 1 % ι-carrageenan; Y2: 2 % ι-carrageenan**

Figure 1. Principal component analysis (PCA) of apricot jams' RGB parameters



***C: control; P0.5: 0.5 % pectin; P1: 1 % pectin; P2: 2 % pectin; K0.5: 0.5 % κ-carrageenan; K1: 1 % κ-carrageenan; K2: 2 % κ-carrageenan; Y0.5: 0.5 % ι-carrageenan; Y1: 1 % ι-carrageenan; Y2: 2 % ι-carrageenan**

Figure 1. Principal component analysis (PCA) of cherry and apricot jams' RGB parameters

The redness of fruit jams is mainly affected by heat not stabile anthocyanin content and enzymes, meaning that they are mainly decomposed in fruit products such as jam since high temperatures are applied during the production. Food processing and preservation processes almost always affect the changes/degradation of food color. Pectin represents also a factor in the formation of fruit jam color due to its property to act as co-

pigment (2, 8, 1). Authors Kopjar et al. (15) stated that the influence of pectin was not enough investigated, but it had been noticed its influence on jam color by Lewis et al. (16). Certainly that color acceptability of fruit jams highly depends and is in correlations with fruit type, same as with the type of processed fruit product. Higher pectin concentration (1.5 %) was found to result in negative sensory properties (color acceptability) of pineapple leathers; discoloration of strawberry jams during storage with increase concentrations of pectin was found too. It has to be stressed out the jam color is one of the most important jam attribute for consumers. The selection of food product by consumers are many times done according food color, and for an example, purple red color of cherries and their products is highly accepted by consumers (8, 9, 14, 15, 18). Rababah et al. (19) in their research with cherry jams observed significant loss of redness after jam preparation, but no significant loss of cherry jam redness was observed during 15 days of storage at 25 °C, 35 °C, 45 ° C and 55 °C. Carrageenan as hydrocolloids can be used in fruit jam preparation and the information from other researchers are indicating their positive properties such as positive affection on jam mouthfeel taste. The advantage of carrageenan is that they can be used in small quantities such as a few parts per million oppositely from acacia gum that has to be used in high quantities (12, 17, 20). In comparison with pectin carrageenan are found to possess better binding properties, though in some cases the best option is the combination of pectin (especially low molecular) with carrageenan (12). In the presence of salts (particularly K+ ions) carrageenan (ionic polymer) forms helical gels. Helix formation and gelation is especially supported by certain cations such as K+, Rb+, Cs+ and NH4+. The gelation of carrageenan goes from the transition of disordered random coil to the ordered helical state (7). RGB model of color determination is simple, but it is the method that highly corresponds with the changes of color. Each RGB image is represented as 3D arrays that correspond with three different 2D; (R) red, (G) green and (B) blue (24). The ordinary jam production means application of high temperatures (> 80 °C) that highly influence the color of the final product since it was found that the critical temperature for fruit color changing (the loss of red color and the formation of a brown color) is only 18 °C. Anthocyanin are sensitive to higher temperature, but discoloration can also occur due to the presence of heavy metal. The loss of red color for many fruit products represents an immediate loss in attractiveness for potential consumers. Certain fruit species are more resistible for color changing. The amount of amino acids in fruits affects Maillard reaction and consequently leads to the browning process which can be also affected by factors such as heavy metal contamination (1, 15). The changes/decrease of color during storage of fruit jams can be due to copolymerization, phenolic and protein interactions and cation complexes formation with pectin (21). The influence of ι-carrageenan on the digital image analysis was confirmed in the study of Dias et al. (10). Their study confirmed that the influence is in dependence on applied products. It was noticed that usage of k and y carrageenans do not effect differently the color of low fat frankfurters, both external and internal color. Oppositely, the mixtures of k+I carrageenan used in different concentrations statistically significant ($p<0.05$) influenced external yellowness of low fat frankfurters. It was also observed that the usage of carrageenans improved color and overall acceptability of low fat frakfurters. The color improvement of products with carrageenans was evaluated better by panelists in comparison with products prepared with potato starch. Frankfurters with i-carrageenan had the highest redness. The added mixtures of finely grounded toasted bread and i-carrageenan gave the best color marks of low fat frankfurters (12). The research certainly showed the influence of gelling agents on color parameters of cherry and apricot jams, though the influence is not unambiguous. Lesser changes in RGB parameters during 10 days of cold storage (+ 4 ºC) were observed in jams prepared with 1 % pectin and 0.5 % κ-carrageenan. The use of lesser amount of carrageenan seems to have the same effect on cherry and apricot jam color as the standard amount use of pectin (1 %). Though, the

research clearly showed high correlation between used fruits and influence on gelling agents on jam color. Gelling agents among other factors, have impact on fruit jams color which is an important factor in the acceptance of product due to consumers' perceptions.

REFERENCES

1.Abers JE, Wrolstad RE. Causative factors of color deterioration in strawberry preserves during processing and storage. Journal of Food Science 1979; 44: 75-81

2.Abid M, Yaich H, Hidouri H, Attia H, Ayadi MA. Effect of substituted gelling agents from pomegranate peel on colour, textural and sensory properties of pomegranate jam. Food chemistry 2018; 239: 1047-1054

3.Banerjee S, Bhattacharya S. Food gels: gelling process and new applications. Critical reviews in food science and nutrition, 2012; 52: 334-346

4.Basu S, Shivhare US, Singh TV. Effect of substitution of stevioside and sucralose on rheological, spectral, color and microstructural characteristics of mango jam. Journal of Food Engineering 2013; 114: 465-476

5.Bednarova M, Pospiech M, Jandasek J, Tremlova B. Carrageenans in the meat industry: detection using microscopic methods. Maso International Journal of Food Science and Technology 2014; 1: 11-14

6.Bloukas JG, Paneras ED, Papadima S. Effect of carrageenan on processing and quality characteristics of low-fat frankfurters. Journal of Muscle Foods 1997; 8: 63-83

7.Budak NH. Bioactive components of Prunus avium L. black gold (red cherry) and Prunus avium L. stark gold (white cherry) juices, wines and vinegars. Journal of food science and technology 2017; 54: 62-70

8.Caplan I, Lamureanu G, Alexe C. Suitability for Processing of Some Sweet Cherry Varieties. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca-Food Science and Technology 2016; 73: 7-13

9.CE, Walker JRL, Lancaster JE. Effect of polysaccharides on the colour of anthocyanins. Food Chemistry 1995; 54: 315–319

10.Dervisi P, Lamb J, Zabetakis I. High pressure processing in jam manufacture: effects on textural and colour properties. Food Chemistry 2001; 73: 85-91

11.Dias J, Alvarenga N, Sousa I. Shelf-life of reduced-fat white chocolate fillings using iota-carrageenan. Emirates Journal of Food and Agriculture 2017; 29: 893-898.

12.Dóka O, Bicanic D, Stéger-Máté M, Végvári G. Application of Photothermal Methods for Quantification of Carotenoids in Apricot Jams. International Journal of Thermophysics 2015; 36: 2370-2379

13.Gajar AM, Badrie N. Processing and Quality Evaluation of a Low-Calorie Christophene Jam (Sechium edule (Jacq.) Swartz. Journal of food science 2002; 67: 341-346

14.Gimenez J, Kajda P, Margomenou L, Piggott JR, Zabetakis I. A study on the colour and sensory attributes of high-hydrostatic-pressure jams as compared with traditional jams. Journal of the Science of Food and Agriculture, 2001; 81: 1228–1234

15.Hmar BZ, Mishra S, Pradhan RC. Physico-chemical and sensory analysis of Kendu (Diospyros melaxoxylon Roxb.) jam using fuzzy logic. Journal of Food Measurement and Characterization 2017; 11: 1928-1935

16.Kopjar M, Pilizota V, Tiban NN, Subaric D, Babic J, Ackar D, Sajdl M. Strawberry jams: influence of different pectins on colour and textural properties. Czech J Food Sci 2009; 27: 20-28

17.Milani J, Maleki G. Hydrocolloids in food industry. In Food Industrial Processes-Methods and Equipment. InTech. 2012

18.Phimpharian C, Jangchud A, Jangchud K, Therdthai N, Prinyawiwatkul W, No HK. Physicochemical characteristics and sensory optimisation of pineapple leather snack as affected by glucose syrup and pectin concentrations. International Journal of Food Science & Technology 2011; 46: 972-981

19.Rababah TM, Al-U'Datt M, Al-Mahasneh M, Yang W, Feng H, Ereifej K, Kilani I, Ishmais MA. Effect of jam processing and storage on phytochemicals and physiochemical properties of cherry at different temperatures. Journal of food processing and preservation 2014; 38: 247-254

20.Ramirez-Sucre MO, Velez-Ruiz JF. The physicochemical and rheological properties of a milk drink flavoured with cajeta, a Mexican caramel jam. International journal of dairy technology 2011; 64: 294-304

21.Selvamuthukumaran M, Khanum F. Processing seabuckthorn fruit for antioxidant rich jam development and shelf stability assessment. Indian Journal of Traditional Knowledge 2014; 13: 335-346

22.Thakur R, Pristijono P, Golding JB, Stathopoulos CE, Scarlett C, Bowyer M, Singh SP, Vuong QV. Effect of starch physiology, gelatinization, and retrogradation on the attributes of rice starch-ι-carrageenan film. Starch-Stärke 2018; 70: 1700099

23.Toker R, Gölgharr M, Tokgöza H, Teppe S. Organic acids and sugar compositions of some loquat cultivars (*Eriobotrya japonica L.*) grown in Turkey. Journal of Agricultural sciences 2013; 19: 121-122.

24.Witjaksono G, Hussin NHFBM, Rabih AAS, Alfa S. Real time chromametry measurement for food quality detection using mobile device. In IOP Conference Series: Materials Science and Engineering 2017; 237: 12-24