Strawberry Jams: Influence of Different Pectins on Colour and Textural Properties

Mirela KOPJAR, Vlasta PILIŽOTA, Nela Nedić TIBAN, Drago ŠUBARIĆ, Jurislav BABIĆ, Đurđica AČKAR and Maja SAJDL

Faculty of Food Technology, University of J. J. Strossmayer in Osijek, Osijek, Croatia

Abstract

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Colour and texture are very important quality properties of all foods. In this work, the influence was investigated of different types of pectin on colour and textural properties in strawberry jams and low-calorie strawberry jams containing fructose and aspartame or fructose syrup and aspartame. The highest anthocyanin content and total phenol content were detected in strawberry jam samples prepared with low methoxy amidated pectin. During storage, after 4 and 6 weeks at both storage temperatures, room temperature and 4°C, anthocyanin content and total phenol content decreased. Also, free radical scavenging activity decreased during storage. As far as the texture parameters are concerned, namely firmness, consistency and cohesiveness, the highest values were found in strawberry jam samples prepared with high methoxyl pectin.

Keywords: pectin; strawberry jam; low-calorie strawberry jam; anthocyanins; texture

Low-calorie products were originally developed for diabetics and people with specific health problems, and they were considerably expensive. Nowadays, consumers' demand for low-calorie products has significantly risen in an attempt to alleviate the health problems, to reduce or stabilise the body weight, and to work within the frame of a healthier diet. The food industry has been confronted with a new challenge in order to satisfy the consumers; that is the development of low-calorie products with acceptable sensory characteristics and competitive prices, by preferably employing the conventional processing equipment and in agreement with the current strict legislation. The role of sugar substitutes in the successful manufacture of these products is crucial (Sandrou & Arvanitoyannis 2000).

Pectin is primarily used in food industry as a gelling agent for jams, jellies, and other foods (El-Nawawi & Heinkel 1997). The degree of esterification (DE) gives the ratio of esterified galacturonic acid units to total galacturonic acid units in the molecule. This categorises pectins into two broad classes – low methoxyl (LM) with DE < 50%, and high methoxyl (HM) with DE > 50%. The LM pectin is obtained either enzymatically, *in vivo*, or by the controlled de-esterification of HM pectin in either acidic or alkaline conditions. Ammonia is sometimes used in the process, introducing some amide groups into the molecule and yielding 'amidated' pectin (Kratz 1995). The reduction of DE introduces dramatic changes in the functionality of HM and LM pectins. A combination of hydrogen bonding and hydrophobic

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interactions are responsible for the gel formation of HM pectin. The hydrophobicity can be enhanced by sugars which create the conditions of low water activity, thus promoting chain-chain rather than chain-solvent interactions (Morris *et al.* 1980; Oakenfull & Scott 1985). Acidity is also necessary to reduce the negative charges on the carboxyl groups, thus diminishing electrostatic chain repulsion. The gelation theory of HM pectin is not valid for LM pectin. Instead, LM pectin gelation is considered as the formation of a continuous network of ionic cross linkages via calcium bridges. These develop between the carboxyl groups belonging to two different chains in close proximity (Walkinshaw & Arnott 1981; Kasapis 2002).

The effect of the pectin type on the jam colour has not been extensively studied. Although it has been suggested that pectin has a role in the colour degradation of the jam products (Lewis *et al.* 1995), this effect is not yet accurately known.

One of the most important parameters to which consumers are sensitive when selecting foods is the colour. Manufacturing and preservation processes often degrade the colour of food (Gimenez *et al.* 2001). The relatively rapid deterioration of the attractive red colour of freshly made strawberry preserves has been a persistent problem. Colour deterioration is due to at least three factors: the loss of red anthocyanin pigment, formation of brown pigments, and discoloration through factors such as heavy metal contamination (Abers & Wrolstad 1979). Anthocyanins have a crucial role in the colour quality of many fresh and processed fruits. They are a good source of natural antioxidants, however, they are quite unstable during processing and storage. The temperature, pH, oxygen, and water activity are considered to be important factors influencing their stability. During heating, degradation and polymerisation usually lead to their discoloration. It has been proven that some degradation products of anthocyanins have the antioxidant capacity (Tsai & Huang 2004). Maillard reaction products have also been proven to be powerful as antiradical agents (Manzocco *et al.* 2001). The degradation of sucrose and anthocyanins during heating may affect both the colour and antioxidant capacity (Tsai *et al.* 2005).

Kopjar *et al.* (2007) investigated the influence of different pectins and their concentration on the colour and texture of raspberry jams and they concluded that different pectins and their concentrations affect the colour and texture. In this work, for the colour and texture investigation the lowest pectin concentration (0.3%) was chosen. Next to customary strawberry jams, low-calorie strawberry jams were prepared by the replacement of sugar with fructose + aspartame and fructose syrup + aspartame. Low-calorie strawberry jams were prepared with low methoxyl pectin and low methoxyl amidated (LMA) pectin since they are used for low-calorie product formulas.

MATERIALS AND METHODS

Materials. Strawberies were bought at a local market and were kept at –20°C before use. Pectins, HM (green ribbon), LM (purple ribbon), and LMA (purple ribbon D-075) were obtained from Obipectin, Switzerland. HM (green ribbon) is high methoxyl, low setting pectin (DE ~ 60%), while the other two pectins (LM and LMA) are low methoxyl pectins (DE < 50%), LMA pectin containing 25% of amidated groups. Potassium chloride, sodium acetate, fructose, hydrochloric acid, methanol, sodium carbonate, and Folin-Ciocalteu reagents were bought from Kemika, Croatia. 2,2-diphenyl-1-picryl-hydrazil (DPPH) was obtained from Fluka, Germany, aspartame from Nutrasweet, Switzerland, and fructose syrup from Baltragro, Russia.

Preparation of strawberry jams. Strawberries (400 g), sucrose (366 g) and pectins (1.8 g) were used for the jams preparation. Citric acid was used for adjusting pH values for proper gelatinisation of pectins. pH necessary for HM was 2.9–3.1, and for LM and LMA 2.8–3.3. Strawberries, larger part of sucrose and citric acid were mixed and cooked at 80°C. Pectin was mixed with part of sucrose and added at the final stage of the jam cooking. For customary jam preparation, all 3 pectins were used. Strawberry jams were cooked until the final product contained 67% of soluble solids (determined by refractometer). The time of cooking was ~ 35 min. Low-calorie strawberry jams were prepared by the replacement of 30% of sucrose with a mixture of fructose and aspartame or a mixture of fructose syrup and aspartame. The ratio of fructose/aspartame and that of fructose syrup/aspartame were 1:1 (mass ratio) the sweetness of fructose, fructose syrup, and aspartame compared to that of sucrose having been taken into account. Pectins, LM and LMA, were used for the preparation of low-calorie jams. These samples were cooked until the final product contained 39% of soluble solids (determined by refractometer). Time of cooking was ~ 20 min at 80°C.

Measurement of monomeric anthocyanins. The extraction of anthocyanins from strawberry jams was carried out with acidified methanol. The samples were held at 4°C over night and centrifuged for 10 min at 4000 rpm. The extracts were used for the determination of monomeric anthocyanins by pH-differential method. Total monomeric anthocyanins were expressed as cyanidin-3-glucoside (Giusti & Wrolstad 2001). The measurements were done in triplicates.

Determination of the total phenol content. After the isolation of the phenolic compounds by the extraction method described in the previous section, the concentration of total phenols was estimated by the Folin-Ciocalteau method, with absorbance monitoring at 765 nm (Ough & Amerine 1988). The spectrophotometric measurement was repeated two times with each extract and the average value was interpolated on the gallic acid calibration curve and expressed as g of gallic acid per kg of the sample.

Assay of 2,2-diphenyl-1-picrylhydrazyl radical scavenging activity. Free radical scavenging activity of the strawberry jam samples was measured by 2,2-diphenyl-1-picryl-hydrazil (DPPH). 0.2 ml of the sample extract was diluted with methanol and 1 ml of DPPH solution (0.5mM) was added. After 30 min, the absorbance was measured at 517 nm. The percentage of the DPPH radical scavenging was calculated by the following equation:

$$\text{Scavenging activity (\%)} = (1 - A_1/A_0) \times 100$$

where:

A_0 – absorbance of the blank (methanol replacing the extract)

A_1 – absorbance in the presence of the sample extract

Texture analysis. The texture analysis was performed directly in the jar at the ambient temperature with a Texture analyser TA.XTplus (Stable Mycro System, United Kingdom), using back extrusion procedure. On the basis of the preliminary work, the instrument working parameters were determined with the test mode compression, pre-test speed at 1.0 mm/s, test speed at 1.0 mm/s, post-test speed at 10.0 mm/s, distance 10.0 mm, trigger force at 10.0 g and data acquisition rate at 200 pp. The data were analyzsd using Texture expert Version 1.22 Software (Stable Micro System, United Kingdom) to measure the firmness, consistency, and cohesiveness in the samples. The measurements were done in triplicates.

Storage of strawberry jam. Strawberry jam samples were stored at room temperature and at 4°C, while low-calorie jams were stored at 4°C only. Both types of strawberry jams were analysed after the preparation and after storage. Strawberry jams were analysed after 2, 4, and 6 weeks of storage, while low-calorie strawberry jams were analysed after 2 and 4 weeks due to microbial decay.

RESULTS AND DISCUSSION

Content of anthocyanins

The anthocyanin content was measured in strawberry jam samples and low-calorie strawberry jam samples. The results for anthocyanin content of customary strawberry jams and low-calorie strawberry jams are shown in Tables 1 and 2. Customary jam samples had lower anthocyanin contents than low-calorie jam samples. This difference is due to different recipes and the process conditions that cause the degradation of anthocyanins. Anthocynin pigments are very sensitive to temperature, and a combined time/temperature process can greatly reduce the content of pigments in the final product.

Storage temperature was the main factor that caused the anthocyanins loss. During storage, anthocyanin content decreased in both customary and low-calorie jams. The loss of anthocyanins in strawberry jams was higher when the samples were stored at room temperature than at 4°C.

After the preparation, the highest content of anthocyanins was found in the strawberry jam samples prepared with LMA pectin, while the samples prepared with HM pectin had the lowest content of anthocyanins. Low-calorie strawberry jam samples prepared with LMA pectin had a higher anthocynins content than those prepared with LM pectin. It can be seen in Table 1 that anthocyanin content depended on the degree of pectin esterification. A higher degree of pectin, esterification anthocynin content was lower in both customary and low-calorie jams. This trend remained during the storage of the samples at both storage temperatures.

This can be explained by interactions of anthocyanins and pectin. Mazzaracchio *et al.* (2004)

Table 1. Anthocyanins content (mg/kg) of strawberry jams stored at room temperature and 4°C

Samples	After preparation	After 2 weeks	After 4 weeks	After 6 weeks
Storage at room temperature				
HM+s	140.44 ± 4.21	110.13 ± 4.32	69.29 ± 3.45	61.12 ± 4.12
LM+s	147.78 ± 3.28	119.98 ± 3.24	83.49 ± 3.21	76.40 ± 5.11
LMA+s	175.34 ± 5.31	130.76 ± 4.12	100.19 ± 5.12	89.99 ± 5.62
Storage at 4°C				
HM+s	140.44 ± 4.21	131.50 ± 3.89	118.35 ± 4.87	111.21 ± 3.21
LM+s	147.78 ± 3.28	138.60 ± 4.21	128.12 ± 5.01	123.63 ± 3.89
LMA+s	175.34 ± 5.31	155.93 ± 4.58	139.67 ± 4.21	132.40 ± 4.87

Mean values ± standard deviation
HM – high methoxyl pectin; LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose

Table 2. Anthocyanins content (mg/kg) of low-calorie strawberry jams stored at 4°C

Samples	After preparation	After 2 weeks	After 4 weeks
LM+s+f+a	260.50 ± 3.54	237.92 ± 4.35	179.32 ± 5.41
LMA+s+f+a	277.20 ± 5.21	266.76 ± 5.41	227.94 ± 4.32
LM+s+fs+a	248.81 ± 4.23	236.71 ± 3.28	192.04 ± 3.45
LMA+s+fs+a	265.51 ± 4.89	250.97 ± 4.98	237.12 ± 5.21

Mean values ± standard deviation
LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose; f – fructose; fs – fructose syrup; a – aspartame

observed that apple pectin with a high number of methoxyl groups did not seem to interact with anthocyanins or to have bathochromic or hypsochromic effects. Pectin could also induce a slight increase in flavilium cation that is in equilibrium with the pseudobase at the same pH. In addition, a weak hydrophobic interaction effect between methoxyl groups of the B ring of these aglycones and the methoxyl groups of pectin could occur, these would be expelled and a weak co-pigmentation effect would be induced (Mazzaracchio *et al.* 2004). Pectins esterified to a lower DE probably interact with anthocyanins more easily because they have fewer methoxyl groups. Hubbermann *et al.* (2006) detected that most of their tested hydrocolloids resulted in only small changes in colour stability, except for sodium alginate which had a significantly stabilising influence on the redness of elderberry concentrate colour. However, during storage a tendency towards the stabilisation of redness was observed for pectin, corn starch, and sodium alginate in those samples. Since alginate and pectin are polyuronic acids, their colour stabilising effect may be based on electrostatic interactions between the anthocyanin flavilium cation and the dissociated carboxylic groups of the colloids, in a similar manner as calcium ions are bound in pectin and alginate gels (Belitz & Grosch 1999). Due to this association, anthocyanins may be prevented from water attack, which leads in turn to colour stabilisation (Hubbermann *et al.* 2006).

The influence of different sugar replacements was also monitored. At the beginning and after two weeks of storage, the strawberry jam samples prepared with the mixture of fructose + aspartame had a higher anthocyanins content than the samples prepared with the mixture of fructose syrup + aspartame. After 4 weeks of storage, the situation was reversed, the samples prepared with the mixture of fructose syrup + aspartame had a higher anthocyanins content. It is known that a high concentration of sugar in fruit preserves stabilises anthocyanins (Wrolstad *et al.* 1990). This effect could be explained by the fact that sugar addition reduces water activity a_w. Even low changes of the sugar concentration and water activity can affect the pigment stability. Rubinskiene *et al.* (2005) studied the influence of sucrose, fructose, and aspartame on the stability of the anthocyanins in black currant. The impacts of aspartame and sucrose were similar; thermostability was reduced when their concentration increased from 0% to 20%, while further increase of the concentration to 40% had a positive effect on the pigments stability. With the increase of the fructose concentration, the thermostability of pigments decreased linearly (Rubinskiene *et al.* 2005). The results reported earlier also showed that fructose, arabinose, lactose, and sorbose had greater effects on the anthocyanins degradation as compared with those obtained with additions of glucose, sucrose, and maltose (Elbe & Schwartz 1996). Since aspartame was present in a very low concentration, its positive effect on the degradation of anthocynins could not be noticed in this case. The addition of fructose and fructose syrup had a greater effect.

Total phenol content

Total phenol content was also determined in all samples (Tables 3 and 4). It can be noted that total phenol content of all strawberry jam samples followed the trend observed with anthocyanins content. Total phenol content was higher in the jam samples prepared with LMA pectins than in those prepared with HM pectin (Table 3). During storage, total phenol content decreased at both temperatures.

Free radical scavenging activity

During storage of the customary strawberry jam and low-calorie jam samples free radical scavenging activity decreased due to the decrease of total phenol and anthocynin contents (Tables 5 and 6). The values for free radical scavenging activity of the customary strawberry jam samples stored at room temperature and at 4°C were similar. That can be explained by the fact that at 4°C the jam samples had a higher anthocyanin content while at

Table 3. Total phenols content (g/kg) of strawberry jams stored at room temperature and 4°C

Samples	After preparation	After 2 weeks	After 4 weeks	After 6 weeks
Storage at room temperature				
HM+s	3.39 ± 0.17	1.99 ± 0.34	1.33 ± 0.39	0.79 ± 0.04
LM+s	3.96 ± 0.28	2.46 ± 0.04	1.50 ± 0.05	0.98 ± 0.06
LMA+s	4.24 ± 0.08	2.59 ± 0.08	1.59 ± 0.17	1.07 ± 0.05
Storage at 4°C				
HM+s	3.39 ± 0.28	2.06 ± 0.38	1.08 ± 0.06	0.73 ± 0.02
LM+s	3.96 ± 0.15	2.26 ± 0.08	1.12 ± 0.09	0.97 ± 0.08
LMA+s	4.24 ± 0.31	2.56 ± 0.05	1.26 ± 0.37	1.02 ± 0.12

Mean values ± standard deviation

HM – high methoxyl pectin; LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose

Table 4. Total phenol content (g/kg) of low-calorie strawberry jams stored at 4°C

Samples	After preparation	After 2 weeks	After 4 weeks
LM+s+f+a	5.21 ± 0.54	2.31 ± 0.04	1.53 ± 0.25
LMA+s+f+a	5.47 ± 0.62	2.42 ± 0.01	1.75 ± 0.28
LM+s+fs+a	4.21 ± 0.17	1.84 ± 0.16	1.71 ± 0.16
LMA+s+fs+a	4.89 ± 0.40	2.29 ± 0.02	2.06 ± 0.23

Mean values ± standard deviation

LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose; f – fructose; fs – fructose syrup; a – aspartame room temperature the formation occurred of Maillard reaction products possessing the antioxidant activity. It has been proven that some degradation products of anthocyanins have the antioxidant capacity (Tsai & Huang 2004). Maillard reaction products were also proven to be powerful as antiradical agents (Manzocco *et al.* 2001).

Texture analysis

Texture parameters, namely firmness, consistency, and cohesiveness, were different between all the treatments (Tables 7–9). After the production, the strawberry jam samples prepared with HM pectin had significantly higher values for all texture parameters investigated than those prepared with LM and LMA pectins. Also, the samples prepared with LM pectin had higher values of all texture parameters than did the samples with LMA pectin.

Both formulas (with of fructose + aspartame mixture and with fructose syrup + aspartame mixture) for the low-calorie strawberry jams with the addition of LM pectin had significantly higher values, of the texture parameters investigated. Also, low-calorie strawberry jams with the mixture of fructose + aspartame had significantly higher values of firmness, consistency, and cohesiveness than, the jams prepared with the mixture of fructose syrup + aspartame using both pectin formulas.

The type of pectin that was used exhibited a significant influence on all parameters investigated, i.e. firmness, consistency, and cohesiveness. With an increase of the degree of esterification of the pectins used, a significant increase occurred of firmness, consistency, and cohesiveness in all strawberry jam samples.

During the storage at room temperature, the values of the texture parameters significantly increased in all samples investigated. In the samples stored at 4°C different trends occurred. After two weeks of storage, strawberry jams revealed a significant decrease in the values of firmness and consistency. After four and six weeks an increase of these values was observed as compared to the values found after two weeks of storage. The values

Table 5. Free radical scavenging activity (%) of strawberry jams stored at room temperature and 4°C

Samples	After preparation	After 2 weeks	After 4 weeks	After 6 weeks
Storage at room temperature				
HM+s	90.94 ± 0.22	62.51 ± 0.31	43.56 ± 0.34	37.96 ± 0.26
LM+s	90.94 ± 0.04	61.13 ± 0.93	42.79 ± 0.11	38.02 ± 0.06
LMA+s	90.37 ± 0.40	62.16 ± 0.04	43.54 ± 0.54	38.42 ± 0.40
Storage at 4°C				
HM+s	90.94 ± 0.22	57.5 ± 0.31	42.9 ± 0.17	37.02 ± 0.54
LM+s	90.94 ± 0.04	58.9 ± 0.05	42.9 ± 0.17	36.72 ± 0.02
LMA+s	90.37 ± 0.40	59.85 ± 1.02	40.69 ± 0.06	36.62 ± 0.31

Mean values ± standard deviation

HM – high methoxyl pectin; LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose

Table 6. Free radical scavenging activity (%) of low-calorie strawberry jams stored at 4°C

Samples	After preparation	After 2 weeks	After 4 weeks
LM+s+f+a	88.02 ± 0.22	61.57 ± 1.26	39.74 ± 0.26
LMA+s+f+a	88.18 ± 0.72	59.23 ± 0.04	40.02 ± 0.03
LM+s+fs+a	88.56 ± 0.02	58.69 ± 0.48	40.06 ± 0.37
LMA+s+fs+a	88.68 ± 0.36	58.23 ± 0.56	39.55 ± 0.02

Mean values ± standard deviation

LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose; f – fructose; fs – fructose syrup; a – aspartame

Table 7. Texture parameters of strawberry jams stored at room temperature

Samples	Firmness (g)	Consistency (g s)	Cohesiveness (g)
HM+s 0	206.54 ± 15.05	1951.69 ± 94.71	180.81 ± 15.54
HM+s 2	228.90 ± 8.12	2016.24 ± 94.86	338.25 ± 12.59
HM+s 4	240.84 ± 9.45	2177.34 ± 85.12	392.26 ± 11.45
HM+s 6	251.93 ± 10.21	2349.68 ± 74.16	500.33 ± 12.65
LM+s 0	113.11 ± 10.12	735.38 ± 90.2	169.52 ± 12.59
LM+s 2	121.29 ± 10.45	869.95 ± 82.54	200.05 ± 15.12
LM+s 4	170.06 ± 12.15	916.17 ± 75.28	343.22 ± 13.41
LM+s 6	184.09 ± 11.45	958.46 ± 58.99	366.52 ± 12.12
LMA+s 0	109.19 ± 11.21	720.32 ± 71.64	136.32 ± 16.41
LMA+s 2	115.60 ± 12.58	816.42 ± 63.21	180.83 ± 14.54
LMA+s 4	125.77 ± 9.12	914.13 ± 56.41	215.77 ± 12.53
LMA+s 6	145.15 ± 9.47	1038.22 ± 54.23	236.82 ± 13.12

Mean values ± standard deviation
HM – high methoxyl pectin; LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose; 0 – after preparation; 2 – after 2 weeks of storage; 4 – after 4 weeks of storage; 6 – after 6 weeks of storage

Table 8. Texture parameters of strawberry jams stored at 4 °C

Samples	Firmness (g)	Consistency (g s)	Cohesiveness (g)
HM+s 0	206.54 ± 15.05	1951.69 ± 94.71	180.81 ± 15.54
HM+s 2	128.98 ± 10.14	859.44 ± 85.12	205.82 ± 14.21
HM+s 4	143.90 ± 12.18	1030.46 ± 64.23	290.08 ± 11.52
HM+s 6	175.76 ± 11.21	1329.05 ± 73.12	306.79 ± 12.34
LM+s 0	113.11 ± 10.12	735.38 ± 90.2	169.52 ± 12.59
LM+s 2	78.33 ± 8.78	542.76 ± 89.12	211.52 ± 12.32
LM+s 4	109.87 ± 9.45	664.99 ± 54.25	284.55 ± 14.24
LM+s 6	134.49 ± 12.14	828.27 ± 45.45	292.56 ± 11.25
LMA+s 0	109.19 ± 11.21	720.32 ± 71.64	136.32 ± 16.41
LMA+s 2	80.39 ± 9.41	541.89 ± 78.12	170.82 ± 14.21
LMA+s 4	94.82 ± 10.54	554.57 ± 85.12	187.62 ± 13.12
LMA+s 6	103.54 ± 12.54	647.53 ± 56.12	236.77 ± 12.45

Mean values ± standard deviation
HM – high methoxyl pectin; LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose; 0 – after preparation; 2 – after 2 weeks of storage; 4 – after 4 weeks of storage; 6 – after 6 weeks of storage

of cohesiveness increased in all samples stored at 4°C. In low-calorie strawberry jams, such a trend was not observed. Those samples showed an increase in the values of all texture parameters.

The difference between the values of the texture parameters in strawberry jams is due to different mechanisms of the gel formation.

CONCLUSIONS

Since anthocyanins are highly unstable pigments, the effect was followed of different pectins on the retention of these pigments in customary strawberry jams and low-calorie strawberry jams. The results obtained with the jams stored at different

Table 9. Texture parameters of low-calorie strawberry jams stored at 4 °C

Samples	Firmness (g)	Consistency (g s)	Cohesiveness (g)
LM+s+f+a 0	175.67 ± 8.53	1031.41 ± 54.21	55.53 ± 8.45
LM+s+f+a 2	242.14 ± 9.12	1354.52 ± 52.12	78.66 ± 9.45
LM+s+f+a 4	253.52 ± 10.23	1438.08 ± 60.14	109.39 ± 8.39
LMA+s+f+a 0	161.62 ± 10.21	737.60 ± 54.39	35.51 ± 7.87
LMA+s+f+a 2	177.86 ± 9.45	766.74 ± 60.41	69.58 ± 8.54
LMA+s+f+a 4	181.77 ± 9.23	826.63 ± 58.21	103.14 ± 9.65
LM+s+fs+a 0	124.10 ± 11.24	616.21 ± 68.21	40.32 ± 7.21
LM+s+fs+a 2	194.23 ± 10.21	988.46 ± 61.21	70.98 ± 8.45
LM+s+fs+a 4	317.05 ± 11.21	1023.77 ± 81.45	130.87 ± 8.74
LMA+s+fs+a 0	113.60 ± 10.12	640.62 ± 54.21	34.98 ± 6.54
LMA+s+fs+a 2	123.07 ± 9.54	697.34 ± 59.45	66.55 ± 8.87
LMA+s+fs+a 4	144.09 ± 9.63	742.16 ± 69.24	100.73 ± 9.46

Mean values ± standard deviation

LM – low methoxyl pectin; LMA – low methoxyl amidated pectin; s – sucrose; f – fructose; fs – fructose syrup; a – aspartame; 0 – after preparation; 2 – after 2 weeks of storage; 4 – after 4 weeks of storage

temperatures are in accordance with the previous reports on other food products (Spayd & Morris 1981; Withy *et al.* 1993; García-Viguera *et al.* 1998; Manzocco *et al.* 2001). During the storage of strawberry jam samples, the degradation of anthocynins occurred. The degradation was higher in the samples stored at room temperature. The types of pectin had different influence on the retention of anthocyanins. The higher was the degree of pectin esterification, the higher loss of anthocyanins was observed.

Total phenol content followed the values of anthocyanin content. During storage at both temperatures, the room temperature and 4°C, a loss of total phenols was observed. Also, free radical scavenging activity decreased during the storage at both temperatures. The values of total phenol content and free radical scavenging activity in customary strawberry jam were similar at both storage temperatures probably due to the formation of Maillard reaction products with antioxidant activity at the room temperature. At 4°C, the contribution to these similar values is probably due to as higher anthocyanin content in the samples.

The highest values of all textural parameters showed the samples prepared with HM pectin. During storage of strawberry jam samples at the room temperature, the firmness and consistency values increased while in the samples stored at 4°C decrease occurred of those parameters. However after two further weeks of storage, an increase occurred of those values in comparison to the values found after two weeks of storage. Cohesiveness in strawberry jam samples at both temperatures increased during the storage time. Low-calorie jam samples did not show this trend. The values of the texture parameters increased in low-calorie jam samples during storage at 4°C. Low-calorie strawberry jams with LM pectin had higher values of the texture parameters than the samples prepared with LMA pectin.

The formulation of jams, as of any other food products, is very important since the composition of the matrix strongly influence the quality properties of the foods due to the interactions between the matrix constituents, as was shown in our work. Small modifications (addition of different pectins or partial replacement of sugar) of the food matrix composition greatly affect the quality of strawberry jams, probably due to changes in the interactions between the food matrix ingredients.

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Corresponding author:

Dr. Sc. Mirela Kopjar, Faculty of Food Technology, Franje Kuhača 18, P.O. Box 709, 31 000 Osijek, Croatia
tel.: + 385 31 224 300, fax: + 385 31 207 115, e-mail: mirela.kopjar@ptfos.hr