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CHANGES IN QUALITY INDICATORS OF MINIMALLY PROCESSED WRINKLED ROSE (*Rosa rugosa* Thunb.) PETALS DURING STORAGE

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ABSTRACT

Rosa rugosa petals, which have long been used in traditional medicine due to their attractive flavor and presence of bioactive components, are also commonly applied to produce minimally processed and non-thermally treated products with the addition of sucrose. Therefore, to ensure safety and high value of such products during storage, it is crucial to investigate changes in quality indicators. The examined material was non-thermally treated and homogenized petals of wrinkled rose with sucrose concentrations of 50%, 60%, and 70%. Products were stored at 6°C and 21°C for 54 weeks in darkness. Throughout the storage, they were analyzed for microbiological contamination and changes in vitamin C content, color and pH stability. Over the storage period, in samples containing 60 and 70% sucrose, a gradual reduction was observed in the total bacteria count and the yeast and mold count. After the storage period, the value of pH decreased very slightly, while very distinct changes were observed in color parameters at 21°C. Vitamin C content decreased sharply during the first 18 days of storage at both temperatures.

Key words: *Rosaceae*, sweetened preserve, color, vitamin C, microbiological contamination

INTRODUCTION

Petals of wrinkled rose (*Rosa rugosa* Thunb.) are used traditionally as dried products as well as to produce jams and minimally processed products with high sugar content. Due to their intense flavor, they are attractive components of teas and confectionery. Sparinska and Rostoks [2015] identified 25 volatile aroma components of petals of different *Rosa rugosa* cultivars, among which phenylethyl alcohol, β-citronellol, cis-geraniol and nerol were predominant. According to these authors, alcohols comprised 89–96% of volatile components in the examined petals, depending on the cultivar. Phenylethylalcohol, due to its good water solubility, does not occur in rose oil; however, it is a component of rose water [Sparinska and Rostoks 2015]. Other studies have also indicated such important aroma components as eugenol and 4-methyleugenol [Hashidoko 1996]. Petals also contain phenolic compounds, such as mono- and oligomeric hydrolysable tannins, including tellimagrandin and rugosin [Hashidoko 1996]. Nowak et al. [2014], who also examined *R. rugosa* petals, detected seven phenolic acids including gallic acid, protocatechuic acid, gentisic acid and p-coumaric acid, as well as nine flavonoid glycosides, for example, rutin, avicularin, quercitrin, isoquercitrin, astragalin and tiliroside.

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Cendrowski et al. [2017] found that ellagitannins comprised 69–74% of total polyphenols in the examined *Rosa rugosa* petals. In the examined raw material, the authors identified four anthocyanins: mainly peonidin 3,5-di-O-glucoside, and three others, i.e. cyanidin 3,5-di-O-glucoside, peonidin 3-O-sophoroside, and peonidin 3-O-glucoside, for which the average sum of the contents from three harvesting seasons was 172 mg·100 g^{-1}. Moreover, the petals also contain β-carotene, fatty oil, bitter substance and wax [Xie and Zhang 2012]. In traditional Chinese medicine, *R. rugosa* is recommended for strengthening the blood circulation and liver function as well as for treating anxiety states, digestive problems and tuberculosis [Zhong et al. 2009, Chen et al. 2015b]. The findings of Xie and Zhang [2012] confirmed its antihypertensive properties resulting from the inhibition of angiotensin I converting enzyme. On the other hand, Kamijo et al. [2008], who cultivated pulverized petals on plates, found that these exhibited a concentration-dependent inhibitory effect on the growth of *Bacteroides vulgatus*, *Escherichia coli*, *Bacillus cereus*, and *Staphylococcus aureus*, whereas they had no effect on bifidobacteria or lactobacilli. According to Olech et al. [2012], who examined tea and tincture prepared from *Rosa rugosa* flowers, both products, to a various extent, showed activity against strains of *Staphylococcus epidermidis*, *S. aureus*, *Bacillus subtilis*, *Micrococcus luteus*, *Escherichia coli* or *Klebsiella pneumonia*. The authors also observed high free radical scavenging activity of tea and tincture made from rose flowers. Chen et al. [2015a] reported that purple-colored *Rosa rugosa* flowers, as one of three of the examined twenty three edible flowers, were characterized by the strongest antioxidant activity before or after digestion. On the other hand, Youwei and Yonghong [2007] found that a product obtained from the closed flower buds with green petals had the highest polyphenolic concentration and best free radical scavenging activities of the crude aqueous extracts from *Rosa rugosa* flowers. Aqueous extracts from more developed flowers contained lower concentrations of polyphenols. This is congruent with findings of Hou et al. [2014], who also investigated changes in the DPPH radical-scavenging activity of different-colored cultivars of *Rosa hybrida* flowers at different stages of flowering. Olech and Nowak [2012] noted that the amount of phenols determined in *Rosa rugosa* petals and antiradical activity of extracts are to a large extent affected by the conditions of extraction and the extractant used.

Despite their pro-health properties and attractive aroma, *Rosa rugosa* petals are an occasional additive, used mainly in confectionery. According to traditional recipes, they are pounded with a lot of sugar and, possibly, acidified and then either stored without previous heat treatment or processed into high-sugar confitures.

The aim of this study was to investigate the effect of sucrose addition as well as temperature and length of storage of minimally processed products obtained from wrinkled rose petals on microbial safety, color and other selected quality indicators.

MATERIAL AND METHODS

Raw material

Rosa rugosa petals were harvested in May from a plantation located in the northwest outskirts of Kraków. Raw material was harvested from five-year-old bushes. Purple-colored flowers were collected after reaching the full size – at stage 6, according to Youwei and Yonghong [2007]. The bushes were grown on luvisol on silt, without chemical sprayings. Harvesting was conducted once. The petals were processed without preliminary washing.

Preparation of minimally processed products. Fresh wrinkled rose petals, on the day of harvesting, were homogenized (Vorwerk, Thermomix 31-1, Germany) with various additions of sucrose (50, 60 and 70 g·100 g^{-1} of product) and a constant amount of citric acid (0.5 g·100 g^{-1} of product). The products obtained were packed in glass jars and stored at two different temperatures, 6°C ±1°C and 21°C ±1°C, for 54 weeks in darkness. The single sample weight was 40 g. Three jars stored at an established temperature were opened every six weeks for analysis. In total, 297 samples were prepared for all analyses.

Methods of analysis

Basic chemical composition of rose petals. The dry matter content was determined by the oven method at 105°C, ash content by burning the samples in a muffle furnace at 550°C [PN-EN 1135:1999], and

saccharide content using high performance liquid chromatography (HPLC) [Ma et al. 2014], in which acetonitrile and water at a volume ratio of 80 : 20 constituted the mobile phase. Separations were carried out on a Purospher Star NH_2 column (Merck-Hitachi) equipped with a refractometer detector (LaChrom RI-Detector L-7490, Merck, Germany) with a mobile phase flow rate of 1 ml·min^{-1}. Total protein content (N × 6.25) was determined according to the Kjeldahl method, applying a K-435 mineralizer and B324 distillers (Buchi Flawil, Switzerland). Vitamin C content was established by means of HPLC, using a chromatograph with UV DAD L-7450 detector [PN-EN 14130:2003]. Separation and identification of vitamin C was conducted on a Lichospher 100 RP 18 column (Merck-Hitachi). The analysis of color was performed in the CIE (L*a*b*) system using a CM-5 Konica Minolta spectrophotometer. Reflectance was measured with reference to the CIE 10° standard observer and illuminant D65, corresponding to daylight with the color temperature of 6504 K. The parameters measured were L* (lightness/darkness), a* (red/green) and b* (yellow/blue).

Analysis of stored and minimally processed products. Baseline pH measurements were performed 15 min after the product's preparation, while the final measurements were made at the end date of the experiment. Water activity was established using the Novasina AG LabMaster-aw system (Lachen, Switzerland). Vitamin C content was established using HPLC according to the procedure described for the raw material. Microbiological analyses were performed every six weeks. Total viable counts of bacteria were determined on plate count agar (PCA) incubated at 30°C ±1°C for 72 h, while counts of yeasts and molds were determined on malt agar (pH 3.5) after 4-day incubation at room temperature [Tournas et al. 2001].

For microbiological analysis, the aseptically collected samples were put into sterile bags and physiological saline with peptone was added. Then, they were homogenized for 2 min (Stomacher 80, Seward, UK) and decimal dilutions were made. Analyses were carried out in three independent replications.

Color measurements were conducted every six weeks by a CM-5 Konica Minolta spectrophotometer, setting L* (lightness/darkness), a* (red/green), and b* (yellow/blue) parameters in the conditions described for the raw material. In addition, chroma (C*) and hue angle (h°) values were calculated according to the following formulas:

$$C^* = \sqrt{a^{*2} + b^{*2}}$$

$$h^o = \tan^{-1}\left(\frac{b^*}{a^*}\right)$$

where 0° or 360° **=** red-purple, 90° **=** yellow, 180° **=** green, 270° **=** blue.

Total color difference (ΔE), indicating the color difference from the standard plate, was calculated as:

$$\Delta E = \sqrt{\Delta a^{*2} + \Delta b^{*2} + \Delta L^{*2}}$$ [Pathare et al. 2013]

Color differences can be classified as very distinct (ΔE > 3), distinct (1.5 < ΔE < 3) or small (1.5 < ΔE) [Adekunte et al. 2010]. In this study, ΔE for every sample was calculated between initial and final values of L*, a*and b* parameters. Color analyses were performed in 6 replications.

RESULTS AND DISCUSSION

The contents of selected basic chemical components in fresh wrinkled rose petals are presented in Tab. 1. The content of dry matter and ash in the examined material was smaller than that determined in the *Rosa damascena* petals [Sengul et al. 2017], but higher than that reported by Rop et al. [2012] for *Rosa odorata* flowers (10.09%). Protein content in the *Rosa rugosa* petals was lower than that found by mentioned authors in the *Rosa odorata* flowers. The levels of proteins and ash determined by Pires et al. [2017] in rose petals were 7.58, and 4.29 g·100 g^{-1} DW, respectively. In this study, the content of glucose and fructose was 3.51 g·100 g^{-1} FW, while the sum of soluble sugars determined by Pires et al.

Table 1. Basic chemical components of fresh wrinkled rose petals

Dry matter (%)	15.8 ±1.4
Ash (%)	0.46 ±0.04
Protein (%)	1.52 ±0.10
Glucose (g·100 g^{-1})	1.63 ±0.01
Fructose (g·100 g^{-1})	1.88 ±0.04
Vitamin C (mg·100 g^{-1})	75.7 ±3.4
L*	32.42 ±2.62
a*	29.32 ±2.11
b*	–10.7 ±0.988

± standard deviation (n = 12 for L* a* b* and n = 3 for other components)

Table 2. pH values of minimally processed wrinkled rose petals with varying sucrose addition

Sucrose addition (%)	pH		
	initial values	final values	
		6°C	21°C
50	3.76	3.58	–*
60	3.68	3.28	3.42
70	3.65	3.34	3.41

* Samples were perceived visually as fermented and were not subsequently examined

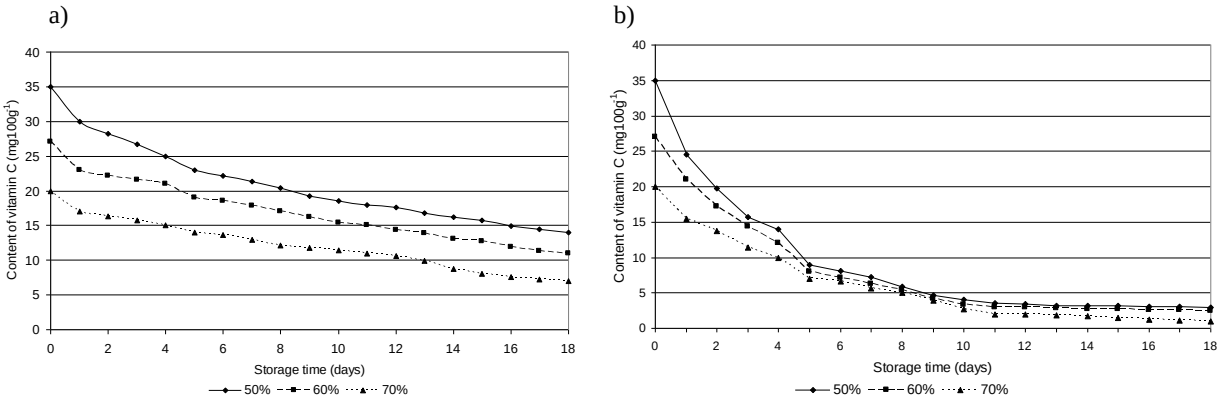

Fig. 1. Changes in the content of vitamin C in minimally processed wrinkled rose petals with the addition of various concentrations of sucrose during storage at 6°C (a) and 21°C (b)

[2017] was 10.24 g·100 g^{-1} DW, which is about twice as low as the level observed in this study. According to these authors, the content of total available carbohydrates, including fiber, was 86.12 g·100 g^{-1} DW, while the amount of organic acids was 4.26 g·100 g^{-1} DW. Color parameters (L*, a*, b*) of fresh wrinkled rose petals are shown in Tab. 1. Color parameters of two pink roses determined by Cunja et al. [2014] were 55.7 (L*), 35.8 (a*) and –6.6 (b*) for *R. rubiginosa* and 36.6 (L*), 49.3 (b*) and –11.2 (b*) for *R. glauca*. On the other hand, vitamin C content in fresh *Rosa rugosa* petals is more than two times higher than Ibrahim et al. [2014] reported for fresh calyces of roselle (*Hibiscus sabdariffa* L.). As reported by Sengul et al. [2017], the content of vitamin C in *Rosa damascena* petals is 45 mg·100 g^{-1} of fresh weight. In nature, one of the richest sources of this vitamin is rose fruits, which may contain from 840 to 3500 mg·100 g^{-1}, depending on the species or variety [Cendrowski et al. 2012a]. According to Babis and Kucharska [2004], the fruits of *Rosa hybrida* have 2425 mg of this vitamin, while those of *Rosa spinosissima* have 668 mg·100 g^{-1}. The contents of vitamin C in the fruits of *Rosa rugosa*, determined by Oszmiański and Urbański [1993] and Skręty et al. [2013], were respectively 444 mg·100 g^{-1} and 712.3 mg·100 g^{-1}. Initial vitamin C concentrations in minimally processed wrinkled rose petals were different; the highest were in the product with 50% addition of sucrose, the lowest in that with 70% sugar content. Throughout storage, the content of this vitamin in products decreased; larger and faster reduction was observed in samples stored at 21°C than at 6°C (Figs. 1a and b). After 18 days, the amount of vitamin C

Table 3. Changes in the number of microorganisms in minimally processed wrinkled rose petals with varying sucrose addition during storage

Storage time (weeks)	Sucrose addition (%)	Storage temperature			
		6°C		21°C	
		total bacteria count (cfu·g^{-1})	yeasts and molds (cfu·g^{-1})	total bacteria count (cfu·g^{-1})	yeasts and molds (cfu·g^{-1})
1	50	$1{\cdot}10^3$	$21{\cdot}0^3$	$1{\cdot}10^2$	$1{\cdot}10^2$
	60	$1{\cdot}10^4$	$4{\cdot}10^3$	$1{\cdot}10^4$	$41{\cdot}0^3$
	70	$1.2{\cdot}10^4$	$11{\cdot}0^3$	$1.21{\cdot}0^4$	$11{\cdot}0^3$
6	50	$7{\cdot}10^2$	$1{\cdot}10^3$	<10	40
	60	$1{\cdot}10^3$	$1.5{\cdot}10^3$	<10	<10
	70	$1{\cdot}10^2$	$2.5{\cdot}10^3$	<10	10
12	50	$1{\cdot}\times10^2$	$1{\cdot}10^2$	<10	<10
	60	$1{\cdot}10^3$	$1{\cdot}10^3$	<10	<10
	70	$1{\cdot}10^2$	$1.8{\cdot}10^3$	<10	10
18	50	<100	<100	<10	<10
	60	<100	<100	<10	<10
	70	$1{\cdot}10^2$	$3{\times}10^2$	<10	<10
24	50	<100	$2.5{\cdot}10^3$	$>10^4$	$>10^4$
	60	<100	$1.5{\cdot}10^2$	<10	<10
	70	<100	$3.5{\cdot}10^2$	<10	<10
30	50	<100	$2{\cdot}10^2$	–*	–*
	60	<100	$1{\cdot}10^2$	<10	<10
	70	<100	$6{\cdot}10^2$	<10	<10
36	50	<10	$2{\cdot}10^2$	–	–
	60	<10	<100	<10	<10
	70	<10	$1{\cdot}10^2$	<10	<10
42	50	<10	$2{\cdot}10^2$	–	–
	60	<10	<10	<10	<10
	70	<10	<100	<10	<10
48	50	<10	$1{\cdot}10^2$	–	–
	60	<10	<10	<10	<10
	70	<10	<100	<10	<10
54	50	<10	$1{\cdot}10^2$	–	–
	60	<10	<10	<10	<10
	70	<10	<100	<10	<10

* Samples were perceived visually as fermented and were not subsequently examined

in samples stored at 6°C and at 21°C was lower than 15 mg·100 g^{-1} and 5 mg·100 g^{-1}, respectively. For vitamin C degradation, besides enzyme activity, the presence of oxygen is also significant. Oxygen solubility in water solutions depends on the type of solutes (e.g., sugars and electrolytes), their molecular weight, concentration and temperature of the solution. Value of this parameter decreases with an increase in sugar concentration and rise of temperature [Ji et al. 2007; Eya et al. 1994; Whitcombe et al. 2005., Mishima 1996]. However, measurement of this parameter in more complex systems than aqueous solutions presents some difficulties [Pénicaud 2012 et al.]. In this study, greater changes in vitamin C content were observed at higher temperature of product storage, which agrees with the Van't Hoff rule. Differences in losses of vitamin C observed in the products with various sucrose additions, stored at the same temperature, were not very high. Products stored at 6°C for 18 days lost 60–65% of the initial vitamin concentration. Over storage, changes observed were smaller in the products containing more sucrose. Recorded differences were probably due to lower water activity and thus lower predicted oxygen solubility.

Measurements of pH values of minimally processed wrinkled rose petals were carried out at the beginning and the end of the experiment. During the whole storage period, there was a slight decrease in pH values of tested samples, from 0.09 to 0.35 (Tab. 2), although slightly larger changes occurred in samples stored at 6°C. This is probably due to the transformation of chemical compounds, resulting in the release of hydronium ions and an increase in acidity during the product storage. Similar changes in pH values were observed by Pavlova et al. [2013] when analyzing peach and raspberry jams during storage.

As the analyzed low-processed wrinkled rose petals were not subjected to high-temperature thermal treatment, they were contaminated by microorganisms originating mainly from the raw material. Aerobic mesophiles from the genus *Bacillus*, including. *B. subtilis*, *B. licheniformis*, *B. pumilus* and *B. cereus*, are the bacteria very often contaminating the spices. Thermophiles and psychrotrophs occur much less frequently in this plant material, while occasionally there can also be found pathogens of the genus *Clostridium* (*C. perfringens*) [Farkas 2000]. Molds frequently present on spices include *Aspergillus*, *Penicillium*, *Fusarium*, *Rhizopus* and *Mucor*; however, yeasts of the genera *Saccharomyces* and *Candida* have also been found [Farkas 2000, Halt and Klapec 2005]. According to Kneifel et al. [2002], total aerobic mesophilic counts of various types of flowers belonging to medicinal plants range from 10^3 to 10^7 cfu·g^{-1}, and yeast and mold counts range from 10^2 to 10^5 cfu·g^{-1}. On the other hand, analyses of fresh chamomile flowers, which were obtained from three French growers, revealed significant differences in the aerobic plate count contamination level, which was respectively $2.5 \cdot 10^5$ g^{-1}, $2.9 \cdot 10^6$ g^{-1}, and $1.0 \cdot 10^8$ g^{-1} [Michels 2000].

In this study, initial contamination of the total bacteria count did not exceed $1 \cdot 10^4$ cfu·g^{-1}, while for yeast and molds, it was $4 \cdot 10^3$ cfu·g^{-1} (Tab. 3). The level of contamination decreased with the passage of time, but its dynamics was much higher in the products stored at 21°C than at 6°C. Similar tendencies were observed in all samples.

Herbert and Sutherland [2000] noted in the example of pathogenic bacteria that although low storage temperatures inhibit the development of some microorganisms, they also facilitate the survival of pathogens that cannot proliferate at such low temperatures. As an example, the authors point to *Escherichia coli*, which in acidic environments survived longer at 5–7°C than at 25°C. In this study, the contributing factors for the microbial reduction in the examined products were probably the lowering of pH by the addition of citric acid, the reduction in water activity (a_w) caused by the addition of sucrose and citric acid, and antimicrobial properties of the pulverized rose petals alone. The antimicrobial properties of rose petals with respect to Gram-positive and Gram-negative bacteria and fungi were investigated, among others, by Kurhade et al. [2011], Khan and Tewari [2011], Zhang et al. [2011] and Kamijo et al. [2008]. The authors found that the examined extracts from petals of various rose species were effective against various strains including *E. coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus cereus*,

B. subtilis, and *Salmonella sp*. Zhang et al. [2011], who investigated the antimicrobial activity of petals of red, yellow and white roses (*Rosa damascene* Mill.) in five species of Gram-negative bacteria, Gram-positive bacteria and fungi, found that, among the studied microorganisms, *Micrococcus luteus* was characterized by the highest susceptibility, while *Saccharomyces cerevisiae* demonstrated the lowest one.

In general, reduction of microbial counts was slightly irregular, especially at 6°C, but in spite of that, the products were characterized by good microbiological quality throughout the storage period. The only exception was the sample with 50% sucrose addition stored at 21°C, in which the total viable count, as well as the yeast and mold count, exceeded 10^4 cfu·g^{-1} in the 24th week of storage. Because of visible fermentation, those samples were not analyzed in consecutive weeks. In very high concentrations of sugar, only yeasts and filamentous fungi can reproduce [Christian 2000]. In a new environment, microbial growth starts with the lag phase, in which microbial cells do not divide, but adapt to the environment, which is followed by the phase of logarithmic growth. Christian [2000] claims that with the decrease in water activity, duration of the lag phase rises towards infinity. Therefore, according to the mentioned author, descriptions of experiments in which minimal a_w for the microbial growth had been set, should be supplemented with information about the duration of such an experiment. The phenomenon of prolonging the lag phase duration under conditions of reduced a_w and lowered pH probably explains the observed deterioration in samples with 50% sugar content, in which no growth of microorganisms was observed until the 24th week of storage. According to Kręgiel and Stobińska [2000], sugar concentration of 25–35% inhibits the growth of majority of bacteria; to inhibit yeast and mold development, sugar concentrations in the medium should be respectively more than 65% and about 80%. In general, yeasts and molds are also more resistant to reduced pH than bacteria. In this study, as a result of homogenization of rose petals with sucrose and citric acid, a new environment was created that could interact in a variety of ways with the microorganisms present in the products. These products were characterized by lowered water activity, which was the result of added sucrose and citric acid. Water activity of products containing 50%, 60% and 70% sucrose were 0.69, 0.63 and 0.59, respectively. Moreover, a fairly low pH (3.28–3.76) and limited oxygen conditions were established. Reduced water activity and low pH may promote the development of osmotolerant molds and yeasts [Rawat 2015]. There are known yeast species such as *Zygosaccharomyces rouxii*, the growth of which is not inhibited by up to 60–70% sucrose concentrations and that are resistant to different preservatives [Rojo et al. 2015]. The microbiological deterioration that occurred in the product with 50% sucrose addition stored at 21°C was probably due to the proliferation of yeasts.

The results of color analysis are presented in Figs. 2–5. Throughout storage of minimally processed wrinkled rose petals, the values of parameter L* were increasing irregularly, indicating brightening of the products (Fig. 2). This phenomenon was probably caused by transformations of pigments during storage. Changes in values of the parameter a* (Fig. 3), that indicates the proportion of red color and, to some extent, the content of anthocyanins [Zawiślak and Michalczyk 2015], were much more visible at higher storage temperature. Generally, a decrease in the values of a* was observed, which was probably caused by degradation of anthocyanins. Similar observations were reported by Kadivec et al. [2016] with regard to strawberry spreads during storage. Cunja et al. [2014], who examined selected rose species and cultivars, found a strong correlation between the parameter a* and total anthocyanin content. Cendrowski et al. [2012b] observed an increase in the value of L* in confitures from *Rosa rugosa* petals produced by single boiling, during their storage at 6°C and 22°C. As for confitures obtained by the multiple-boiling method, the value of L* decreased after 180 days of storage in comparison to the initial value. There was an increase in a* in a single-boiling confiture throughout the storage period and in multiple-boiling ones at the first stage of storage at 6°C, which was explained by the authors by anthocyanin polymerization.

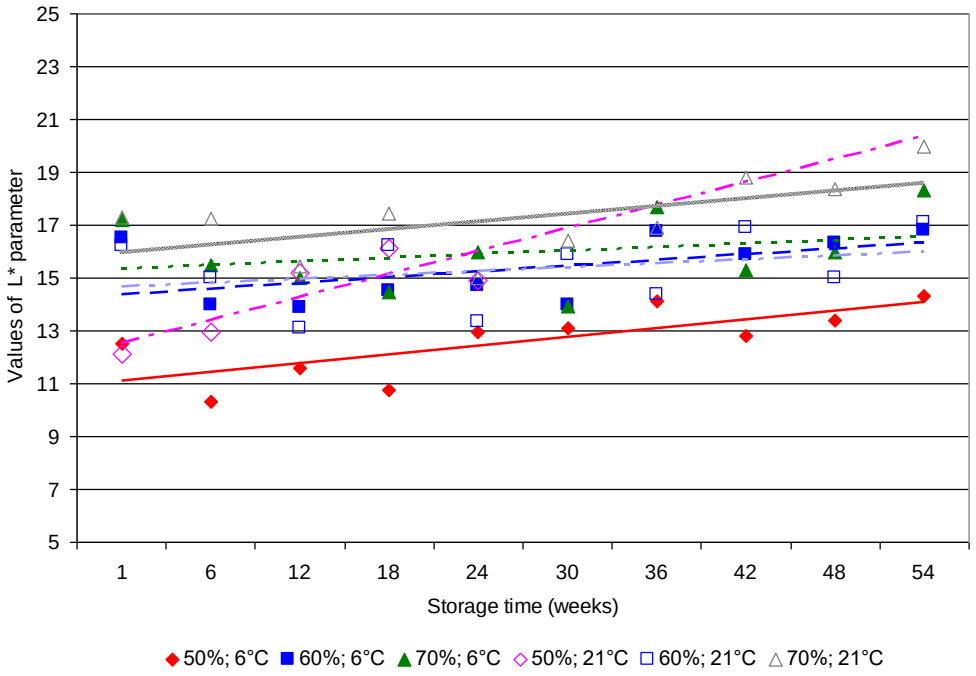

Fig. 2. Changes in parameter L* of minimally processed wrinkled rose petals with varying sucrose addition

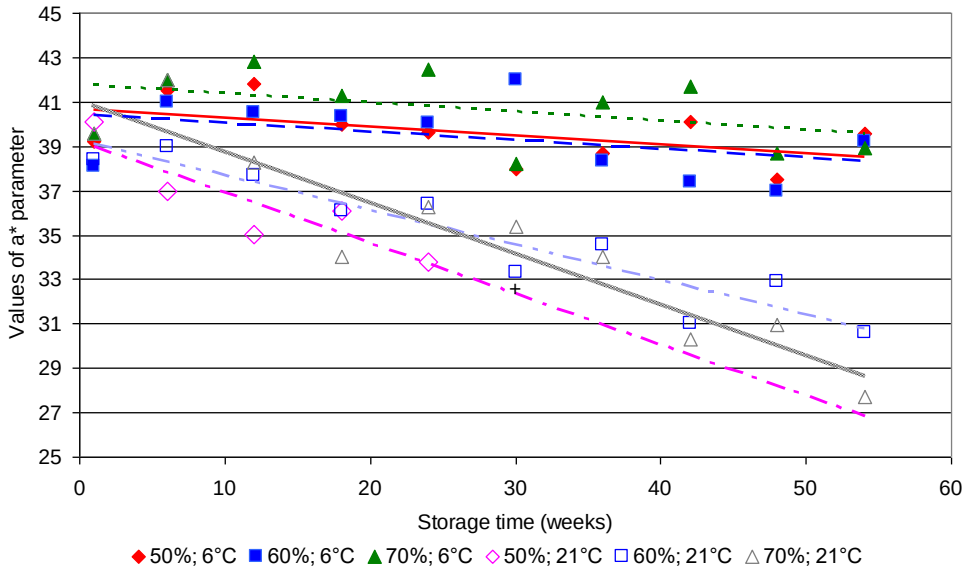

Fig. 3. Changes in parameter a* of minimally processed wrinkled rose petals with varying sucrose addition

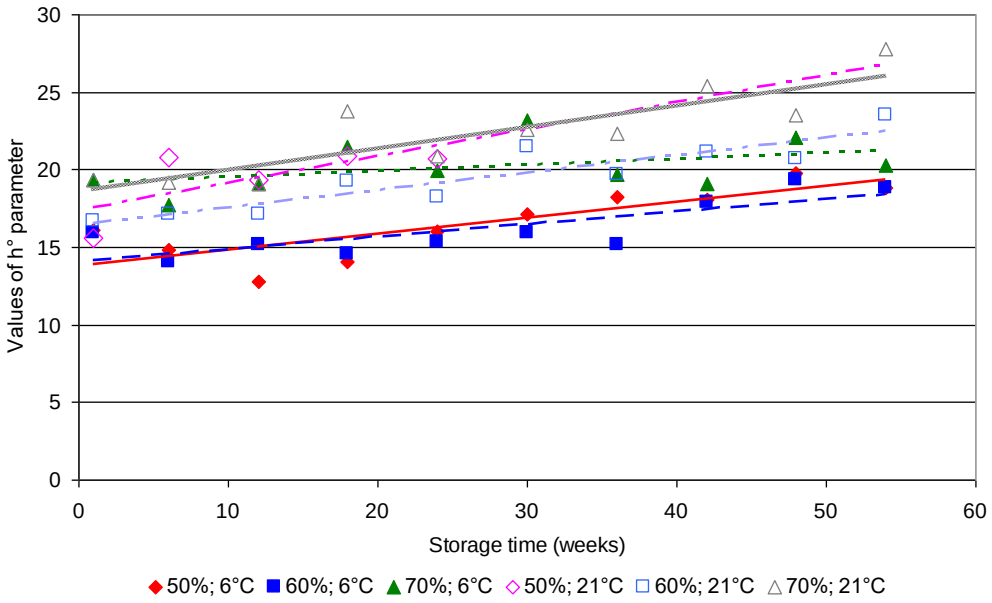

Fig. 4. Changes in parameter h° of minimally processed wrinkled rose petals with varying sucrose addition

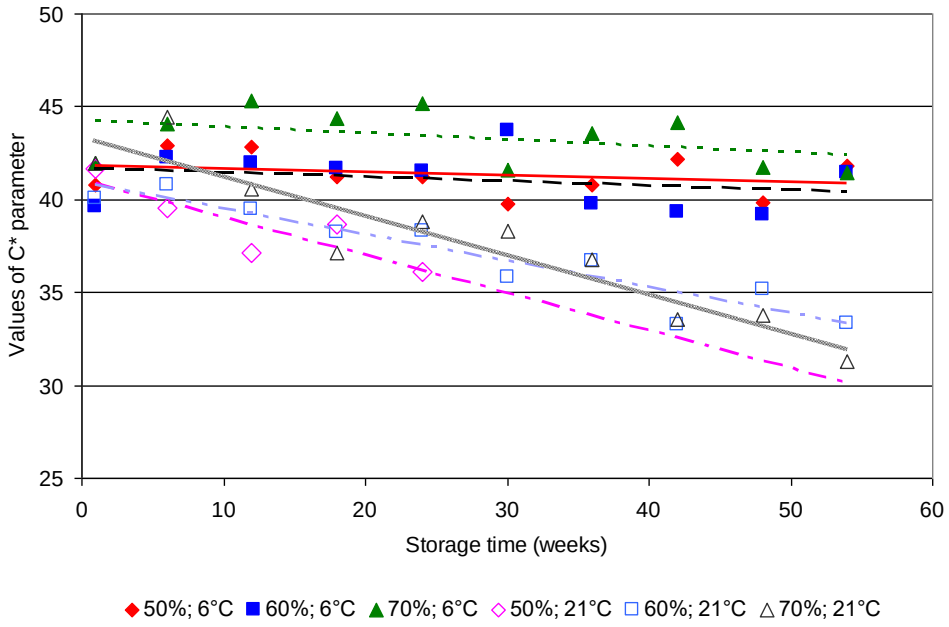

Fig. 5. Changes in parameter C* of minimally processed wrinkled rose petals with varying sucrose addition

Values of hue angle (parameter h°) were growing unevenly during the storage, with changes in color from red-purple to yellow; however, the changes observed were still quite slow (Fig. 4). At higher temperature, this trend was more distinct. This phenomenon was probably caused by degradation of pigments during storage, the extent of which was larger in warmer conditions. The same was observed by Cendrowski et al. [2012b] for the storage temperature of 22°C. The authors noted an increase in value of the parameter h° for both single- and multiple-boiled confitures. Chroma (C*) is a measure of color intensity or saturation. In the analyzed products, chroma values were decreasing during storage, reflecting a decrease in the color intensity, much more pronounced in the samples stored at 21°C (Fig. 5). Ścibisz et al. [2011] observed the same tendency in berry jams kept at 6°C and 22°C. It was also found that as a result of lower storage temperature (6°C), the total color differences were not very distinct; values of the parameter ΔE in the products with 50%, 60% and 70% sucrose addition were 2.87, 2.74 and 1.39, respectively. Storing products at higher temperature (21°C) led to very distinct differences in ΔE, which in the products with 50%, 60% and 70% sucrose addition were 7.07, 8.05 and 12.22, respectively.

CONCLUSIONS

Minimally processed wrinkled rose petals with 60% and 70% sucrose addition were microbiologically stable during the storage at both temperatures. In these products, throughout storage, there was observed a gradual reduction of the total viable count as well as a decrease in the yeast and mold counts. Such a trend was observed mainly at 21°C.

Color of the products stored at 6°C for 54 weeks was quite stable, with ΔE values not exceeding 2.9, whereas in the products kept at 21°C, changes in color were much more distinct and the values of ΔE reached 12.2.

In the analyzed products, vitamin C content declined very sharply during the first 18 days of storage. Products stored at 6°C lost 60–65% of the initial vitamin concentration, whereas in those kept at 21°C, the losses were much higher (87–95%). Sucrose concentration influenced vitamin C content, however differences were not substantial.

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