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ORIGINAL PAPER

The content of vitamin C in dog rose fruit *Rosa canina* L. depending on the method and duration of storage

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ABSTRACT

The goal of the study was to assess the content of vitamin C in wild rose (dog rose – *Rosa canina* L.) in relation to the storage method and storage duration. The material for the study was collected from three sites in Poland. The first set of samples was collected in Chełmno and the city of Koło (in the region of Wielkopolska). The second set of samples was obtained in Busko Zdrój. The third set of samples was collected near the city of Mielec. 12 samples of fresh rosehips were collected from each of the areas listed above (1 sample = 1 bush). In total, 36 samples were gathered, weighing approximately between 500 g and 600 g. The material for laboratory analysis was divided into fresh fruit, fruit intended for freezing, and fruit intended for drying. Vitamin C content was determined by the use of the Tillmans method. A part of the rosehips was frozen in a freezer at a temperature of about –18°C, and stored for subsequent months. Another batch of rosehips was subjected to drying. Next, the analysis was performed on freshly preserved samples. The dried rosehips were divided into two groups: Group 1 – dried rosehips, stored at room temperature (about 21°C) in a dark room; Group 2 – dried rosehips, stored at a temperature of about 3°C in a refrigerator. Subsequent measurements were made two, three, five and nine months after freezing or drying. As a result of conducted analyses, it was determined that the highest average content of vitamin C in fresh dog rose fruit was found in rosehips from the vicinity of Mielec, followed by those collected from Wielkopolska. The lowest content was found in the rosehips collected in Busko-Zdrój. On average, after preservation, rosehips lost approximately 25% of their vitamin C content (23% loss after drying, and 25% loss after freezing). During storage of rosehips in different conditions, it was found that the content of vitamin C decreased at the slowest rate in frozen fruits, while in dried rosehips this process was much faster. It was also observed that dried rosehips stored at room temperature, after 5 months of storage, lost vitamin C faster than the dried rosehips that were stored in the refrigerator. The test results clearly show that freezing and storing frozen rosehips is the best method of rosehip stabilization as far as the preservation of the highest content of ascorbic acid is concerned. The loss in the amount of vitamin C after a prolonged storage period amounted to about 10% in relation to the amount of the vitamin measured immediately after freezing. It was also noted that after about 5 months of storage, the content of vitamin C in dried rosehips decreased rapidly, and after 9 months, the loss was about 45% for dried rosehips stored in the refrigerator, and about 80% for dried rosehips stored at room temperature.

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KEY WORDS

forest fruit, fruit drying, fruit freezing, non-timber forest products, Tillmans method

Introduction

There are 25 species of wild roses growing in Poland. All of them are commonly called 'the wild rose'. Rose bushes are not typical forest species; they can be spotted mainly on the edges of forests, in meadows, and in clearings. Wild roses grow along forest roads, among forest management lines, and in sites where they have a chance of survival, with sufficient sunlight exposure. Very often we can encounter them in roadside and mid-field thickets, and inhabited household farms. Provided that it has the right conditions, a rose bush can survive practically anywhere. We can also often observe it growing in our gardens and in nearby parks, where it is grown as a hedging plant (Popek, 2002; Marszałek and Scelina, 2015). Rosehips of the wild rose – the dog rose *Rosa canina* L. in particular – are highly valued as a food raw material. They are classified as forest fruits, and in terms of the amount of purchased fruit (about 200 tons), rosehips rank third (Statistics Poland, 2022). The fruit of dog rose – known as a rosehip – is a valuable source of vitamin C and mineral salts (iron, calcium, potassium, silicon, magnesium). Due to various factors, such as temperature, light, humidity and carbon dioxide, the amount of ascorbic acid is reduced in favour of dehydroascorbic acid, which is the product of oxidation of the former. In addition to a large amount of vitamin C, rosehips also contain vitamins B1, B2, PP, K, A and E. Furthermore, fresh fruits contain essential oils (0.03%), carotenoids, organic acids (up to 2%), sugars (18%), pectins (up to 4%), folates, and tannins (approx. 2%). The essential oil found in dog rose has regenerating and nourishing properties, beneficial for the skin. In the group of flavonoid compounds, the presence of astragalin, quercetin, rutin, isoquercitrin, as well as flavonoid glycosides has been determined (Cendrowski *et al*., 2012; Kaszuba *et al*., 2019). Dog rose fruit has a wide range of uses. The rosehips are highly beneficial for our body, and our health. They have a nourishing, strengthening and anti-inflammatory properties. Thanks to the chemical compounds contained in rosehips, they also have sedative, diuretic, antitussive, detoxifying, spasmolytic, anti-allergic and antimicrobial properties. Moreover, they improve the general wellbeing, and strengthen our blood vessels. Wild-rose extracts are recommended for pregnant women, nursing mothers, convalescents with stress exhaustion and fatigue, as well as in the cases of hepatitis, infectious diseases, anaemia, rheumatism, and scurvy symptoms. Wild rose flowers, which have an astringent effect, are recommended in the treatment of mild inflammation of the mucous membrane. Rosehips are used in the production of supplements which find application in anticancer therapy, *e.g*., against cervical cancer, breast cancer, and colon cancer. The powdered extract obtained from dog rose can help in the cases of degenerative joint diseases as well as rheumatoid arthritis and osteoporosis. Rosehip extracts have also found their application in the treatment of kidney stones. Furthermore, they have also demonstrated antidiarrheal, antiulcer, and anti-hyperlipidemic effects (Cendrowski *et al*., 2012; Kaszuba *et al*., 2019).

The fruit of wild rose can be processed into juices, syrups, compotes, jams, jellies, vitamin concentrates, and other preserves as well as delicious and aromatic rosehip teas made from ripe, dried, hard fruit. Dog rose fruit, harvested after the first frost in autumn, can also be used to make excellent rose wine and liqueurs or tinctures. For preserves and other products, it is essential to choose fresh, healthy, and undamaged fruit. Before consumption, the seeds should be removed, as they contain a large amount of silica strands, which can cause irritation of the digestive system. It is not advisable to consume whole fruit (Cendrowski *et al*., 2012; Kaszuba *et al*., 2019).

Vitamin C is relatively stable in the dry state, whereas in aqueous solutions it decomposes under the impact of many factors such as higher temperature, a neutral or alkaline environment, the presence of oxygen, iron, and copper. The degree of decomposition in the presence of oxygen depends mainly on the temperature – it increases with the rising temperature – which is why vitamin C is defined as susceptible and sensitive to temperature rise (Janda *et al.*, 2015).

The aim of the study was to assess the content of vitamin C in the dog rose *Rosa canina* in the relation to the storage method and its duration.

Materials and methods

The material for the study was collected from three sites in Poland (Fig. 1). The first set of samples was collected in Chełmno (11 samples) and Koło (1 sample) (in the region of Wielkopolska) (W). In Chełmno, the bushes from which the fruit was harvested were located along field side roads, located along the Ner river. The sites were characterised by very good sunlight exposure. In turn, in the town of Koło, the dog rose bush grew on a green square by a side road. The second set of samples was collected in Busko Zdrój spa (12 samples) (BZ). Dog rose bushes grew along the field roads in the vicinity of the Municipal Park and had full access to the sunlight. The third set of samples was obtained near the city of Mielec (M). Four samples were collected near the village of Książnice Wielkie, from the bushes growing far away from roads, in the vicinity of fields where beehives were located. The remaining 8 samples were collected in the villages of Sarnów, Czajkowa, and Pluty, which are adjacent to each other. Three samples were collected from the embankment along the artificial canal. The remaining samples were harvested in clearings far away from side roads. The fieldwork was carried out at the turn of October and November, after the first frost. Rosehips were harvested by hand. They were picked individually.

Twelve samples of fresh rosehips from dog rose *R. canina* bushes were collected from each of the areas described above (1 sample = 1 bush). Shrubs with wild rose fruit with access to sunlight were selected. The fresh rosehips were then packed in breathable paper bags and subsequently transported to the laboratory. In total, 36 samples weighing approximately 500-600 g were obtained.

The material for laboratory analyses was divided into fresh fruit, fruit intended for freezing, and fruit intended for drying. The material was randomly selected from various locations of fruit batches from individual areas and individual bushes, in accordance with the recommenda-

Fig. 1.
Location of research areas

tions of the standard (PKN, 1969). The measurement of fresh material samples took place shortly after harvesting, and after the fruit had been cleaned of stalks, stems and seeds. The remaining samples, intended for freezing and drying, were also cleaned.

Determination of vitamin C content was performed by the use of the Tillmans method which is recommended by the current standard for the determination of vitamin C content in food products (PKN, 1998). This method consists in the reduction of the dye to a colourless leuco-compound, while the oxidation of vitamin C takes place.

The content of L-ascorbic acid in mg per 100 g of product was calculated according to the following formula, with the accuracy down to 0.01 mg%:

$$X = \frac{a \cdot d}{m \cdot c \cdot n} \cdot 100$$

where:

X – content of L-ascorbic acid in mg per 100g of product [mg%],
a – the amount of dye [ml] used for titration [ml],
d – total volume of the measuring cylinder [ml],
m – titre of 2.6-dichlorophenolindophenol dye,
c – amount of tested filtrate taken for titration [ml],
n – weight of raw material [g].

Some of the rosehips were frozen in a freezer at approximately –18°C and stored for a number of subsequent months. It is assumed that this is the optimal temperature in the freezer. In such conditions, bacteria do not develop and food does not lose its properties. The first frozen dog rose fruits were analysed several days after freezing. Subsequent determinations were made two, three, five, and nine months after freezing.

Another batch of fruit was intended for drying. The samples with the material were evenly distributed on Petri dishes and placed in the dryer. Initially, the fruit was dried at the temperature 50-60°C for 30 minutes. Then, in order to dry the fruits completely, they were subjected to the temperature of 40-45°C, until the moisture content was reduced down to the range of 7-12% (Grochowski, 1990).

After drying, the analysis was performed on freshly dried samples. The dried fruits were divided into two groups: Group 1 – dried rosehips, stored at room temperature (about 21°C) in a dark room; Group 2 – dried rosehips, stored at a temperature of about 3°C in a refrigerator. Subsequent determinations were made two, three, five, and nine months after drying.

The obtained data were compiled in the form of tables and figures in the Excel software, and the statistical significance of differences and correlations were examined in Statistica 12 programme (StatSoft, 2016). The Shapiro-Wilk test was used to test the normality of the data distribution; then, the *t*-test, the Kruskal-Wallis test, and the test of multiple comparisons of *post-hoc* means (testing the statistical significance of differences) were used for further analyses, whereas Spearman's rank correlation test was used to test the correlation (Kot *et al.*, 2007). In statistical analyses, a significance level of p=0.05 had been adopted.

Results

It was determined that the highest content of vitamin C in rosehips of *R. canina* was found in samples from the area of Mielec, followed by those originating from Wielkopolska, whereas the lowest vitamin C content was found in samples taken from Busko-Zdrój (Fig. 2, Table 1). After the preservation of rosehips, a significant change in the content of vitamin C in dog rose after drying and freezing was observed, with the greatest change in the content of vitamin C deter-

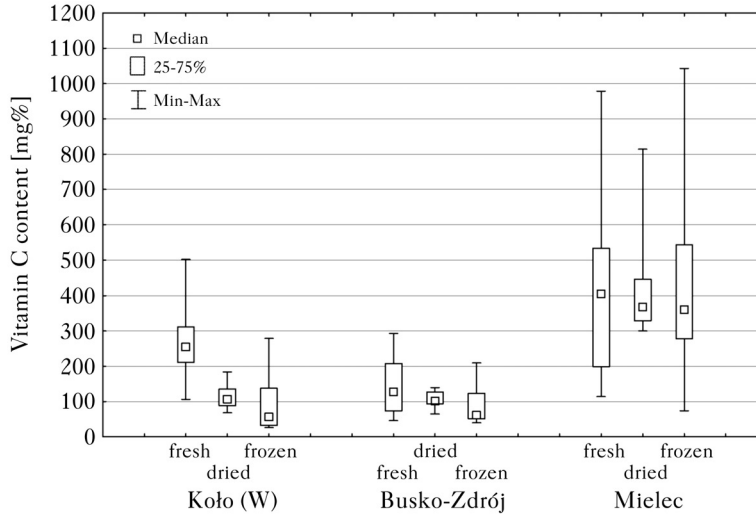

Fig. 2.

Vitamin C content in dog rose originating from different locations and subjected to various methods of preservation

Table 1.

Mean (M), Minimum (Min), Maximum (Max), standard deviation (SD) and coefficient of variation (CV [%]) of vitamin C content in dog rose originating from different locations and subjected to various methods of preservation

Location	Methods of preservation	M [mg%]	Min [mg%]	Max [mg%]	SD [mg%]	CV [%]
Wielkopolska	fresh	267.81	106.32	501.94	100.97	37.70
	dried	116.40	68.15	183.88	33.22	28.54
	frozen	93.97	26.14	278.61	78.82	83.88
Busko	fresh	149.19	46.06	292.84	84.34	56.54
	dried	106.58	64.94	139.66	23.13	21.70
	frozen	90.12	39.60	209.33	55.85	61.98
Mielec	fresh	415.89	114.03	978.44	249.78	60.06
	dried	413.39	300.20	813.94	139.32	33.70
	frozen	403.72	74.15	942.90	264.32	65.47
Average	fresh	277.63	46.06	978.44	196.14	70.65
	dried	213.46	64.94	813.94	166.81	78.15
	frozen	207.27	26.14	942.90	230.12	111.02

mined in frozen fruit. In the samples originating from Wielkopolska, the content of vitamin C decreased more than twice, and the decrease was also noticeable in the samples from Busko-Zdrój. By contrast, samples from the vicinity of Mielec showed insignificant differences. On average, after preservation, dog rosehips lost about 25% of the initial amount of vitamin C (23% decrease after drying, and 25% decrease after freezing). The *t*-test was used to assess the statistical significance of differences compared to the content of vitamin C in fresh fruit. This test showed statistically significant differences in the content of vitamin C in fruits from Wielkopolska and Busko-Zdrój (t=2.991, p=0.007), as well as Busko-Zdrój and Mielec (t=–3.355, p=0.003). There were no significant differences between the content of vitamin C in fruits from Wielkopolska and Mielec (t=–1.823, p=0.082). After preservation, the *t*-test showed statistically significant dif-

ferences in the content of vitamin C only in fruits from Wielkopolska (fresh versus dried: t=4.724, p=0.000; and fresh versus frozen: t=4.501, p=0.000). Rosehips from other locations, when subjected to drying or freezing, did not show statistically significant differences in the content of vitamin C in comparison to fresh fruit.

In the next stage of the research, changes in the content of vitamin C in frozen and dried fruits were analysed in relation to the storage duration, with dried fruits stored in a refrigerator (temperature of about 3°C), and in a cupboard at room temperature (about 21°C). The results of the conducted analyses show that the smallest reduction in the content of vitamin C was found in frozen fruits stored in the freezer (Fig. 3, Table 2). In turn, the dried fruit, in the initial period, showed a significant decrease in the content of vitamin C, after which the content of vitamin C stabilized, and started to decrease again after 5 months of storage. The decrease in the content

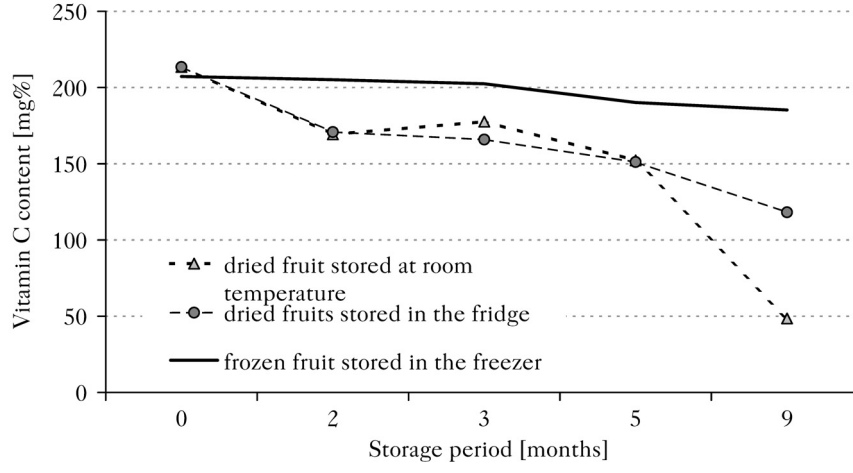

Fig. 3.
The content of vitamin C in dog rose depending on the storage method and duration

Table 2.
Minimum (Min), maximum (Max), standard deviation (SD) and coefficient of variation (CV [%]) of vitamin C content in dog rose depending on the storage method and duration

Methods of preservation	Storage period [months]	Min [mg%]	Max [mg%]	SD [mg%]	CV [%]
Dried fruit stored at room temperature	0	64.94	813.94	166.81	78.15
	2	57.05	607.04	132.76	78.42
	3	71.27	726.10	147.63	83.12
	5	37.45	898.25	170.04	111.73
	9	13.31	215.19	48.27	99.54
Dried fruits stored in the fridge	2	52.55	809.33	154.45	90.42
	3	61.96	639.06	131.33	79.16
	5	33.51	580.86	136.52	90.31
	9	35.06	367.43	92.65	78.40
Frozen fruit stored in the freezer	0	26.14	942.90	230.12	111.02
	2	35.95	954.59	224.14	109.25
	3	31.08	937.21	232.80	114.97
	5	12.36	736.81	184.16	96.83
	9	15.43	973.52	223.70	120.73

of vitamin C was much more rapid in dried fruit stored at room temperature than in fruit stored in the refrigerator.

The correlation between the content of vitamin C in dog rosehips and the storage period was examined. The Spearman's rank correlation test showed statistically significant correlations for dried fruit only. For dried rosehips stored at room temperature, a moderate negative correlation (r=–0.503) was found, and for dried fruit stored in a refrigerator a weak negative correlation (r=–0.282) was determined. No statistically significant correlation was found for frozen fruit.

Discussion

Research on *Rosa canina* rosehips has been conducted for many years. Numerous studies have demonstrated a very high utility value of dog rose, such as the high content of vitamin C. Grochowski (1990) demonstrated the average content of vitamin C in dog rose growing in the territory of Poland to be about 475 mg%. Furthermore, the variability of the vitamin C content in relation to the year of research and the origin of the fruit was concluded to be very high, ranging from 52 mg% to 1575 mg%. The impact of the fruit origin on vitamin C content was also demonstrated by Halásová and Jičínská (1988), who found that the content of vitamin C in dog rose from Slovakia and Hungary ranged from 630 to 976 mg%, and that from the Czech Republic, 1853 mg%. During numerous studies conducted for roses alone, it was found that the content of vitamin C in different types of rose, may range from 130 mg% up to 12000 mg%. These upper values are unprecedented, and they may include cultivated and meticulously tended rose species. Ascorbic acid is a highly variable ingredient. Such substantial changes in the content of vitamin C and such differences as described above depend, among others, on the degradation of this compound, which is due to the passage of time, water content, temperature, and amount of CO_2 during storage, drying, and processing of the raw material (Buchwald *et al.*, 2007; Cendrowski *et al.*, 2012). The content of vitamin C in dog rose also depends on the season, prevailing climate, and on the method of its processing. Nevertheless, it has been demonstrated (Skręty *et al.*, 2013) that properly stored dog rose can become an excellent source of vitamin C all year long. The conducted research shows that fresh dog rosehips reached vitamin C content values in the range of about 700 mg%. When subjected to freezing, the rosehips did not lose too much ascorbic acid (up to about 5%), whereas drying them resulted in a decrease in the content of vitamin C by almost a half (Skręty *et al.*, 2013; Kaszuba *et al.*, 2019). A similar correlation was also noted by Nojavan *et al.* (2008), who found the content of vitamin C at the level of 417.5 mg% in frozen dog rose, and only 211 mg% in dried fruits. An even lower content of vitamin C in dried dog rose was reported in the study by Bozan *et al.* (1998). Depending on the place of origin of the fruit, the authors found a vitamin C content of 48 to 114 mg%. Similar findings were recorded in our research. Dog rose fruit showed a high variability in the content of vitamin C, both in the fresh state, and after preservation. However, a greater decrease in vitamin C content was observed after freezing than after drying. On average, after preservation, dog rose fruit lost about 25% of the amount of vitamin C (23% decrease after drying, and 25% decrease after freezing). However, during storage, the content of vitamin C in frozen fruit decreased much slower than in dried fruit. As a result, after 9 months of storage, it was found that the content of vitamin C in frozen fruit decreased by only about 10% compared to the content of vitamin C measured immediately after fruit processing. In turn, in dried fruit stored in the refrigerator, this content decreased by about 45%, whereas the most vitamin C was lost in dried fruit stored at room temperature: as much as about 80%. Similar correlations were demonstrated in the studies by Gałązka-Czarnecka and Krala (2007), in which they established that dog rose fruit stored in refrigerated

conditions of 3°C after 2 weeks of storage lost about 50% of the vitamin C content compared to fresh fruit. After 6 months of storage in such conditions, the decrease in vitamin C content was as much as 98%. By contrast, in the case of freezing, the changes occurred much more slowly, and the pace of change depended on the freezing temperature applied. For the temperature of –18°C, after 6 months of storage, a decrease in the content of vitamin C by about 51% was noted, while at the temperatures of –25°C and –50°C a comparable level of vitamin C loss was observed only after 9 months.

The results obtained in the research confirm previous studies by other authors and show that the best way of storing rose fruit is freezing. However, it should be remembered that fruit should not be stored in such a way for longer than 9 months, because after such a period the content of vitamin C significantly decreases. The high variability in the content of vitamin C in rose hips from the same location should also be taken into account. This makes such research difficult because different fruits with different levels of vitamin C are taken for each vitamin C analysis.

Conclusions

As a result of the conducted analyses, the following conclusions can be drawn:

- The highest average content of vitamin C in fresh dog rose *Rosa canina* was found in fruits from the vicinity of Mielec, followed by those originating from Wielkopolska, and the lowest, from Busko-Zdrój. There was also a very high variability in the content of vitamin C within each of the studied populations. This makes this type of analysis difficult because other fruits, in which the content of vitamin C may be different, are taken for subsequent analyses.
- After fruit preservation, a significant change in the content of vitamin C in dog rose was observed after drying and freezing of the rosehips, with the greatest change in the content of vitamin C observed in frozen fruit. On average, after preservation, dog rose lost about 25% of the amount of vitamin C (23% decrease after drying, and 25% decrease after freezing).
- When fruit was stored in different conditions, it was found that the slowest decrease of vitamin C content was observed in frozen fruit, while in dried fruit this process was much faster; whereas dried fruit stored at room temperature, after 5 months of storage, lost vitamin C faster than dried fruits stored in the refrigerator.
- The conducted research clearly indicates that the best of the discussed methods of rosehip stabilization as far as the preservation of the highest content of ascorbic acid is concerned, was the method of freezing and storing the frozen fruits. The loss in the amount of vitamin C after a prolonged storage period amounted to about 10% compared to the amount of the vitamin measured immediately after freezing.
- It can also be conducted analyses, it can also be concluded that after about 5 months of storage, the content of vitamin C in dried fruit decreased rapidly, and that after 9 months, the loss amounted to about 45% for dried fruit stored in a refrigerator, and to about 80% for dried fruit stored at room temperature.

Autors' contributions

K.M. – conceptualization, methodology, formal analysis, material collection, statistical analyses, investigation, writing – original draft preparation; R.W. – conceptualization, methodology, material collection, manuscript review and editing; M.B.G. – conceptualization, methodology, material collection, manuscript review and editing.

Conflict of interest

The authors declare no conflict of interest.

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STRESZCZENIE

Zawartość witaminy C w owocach dzikiej róży *Rosa canina* L. w zależności od sposobu i okresu przechowywania

Owoce dzikiej róży są bardzo cenione jako surowiec spożywczy. Zaliczane są one do owoców leśnych i zajmują trzecie miejsce pod względem ilości skupowanych owoców (około 200 ton) (GUS 2022). Celem przedstawionej pracy była ocena zawartości witaminy C w owocach dzikiej róży *Rosa canina* L. w zależności od sposobu i czasu przechowywania.

Materiał do badań pobrano z trzech stanowisk w Polsce (ryc. 1). Pierwszy zestaw próbek zebrano w miejscowości Chełmno (11 próbek) oraz w mieście Koło (Wielkopolska) (1 próbka).

Drugi zestaw zebrano na terenie uzdrowisk sanatoryjnych w Busku-Zdroju (12 próbek). Trzeci zestaw próbek pozyskano w okolicach Mielca. Z każdego stanowiska zebrano po 12 prób świeżych owoców dzikiej róży (1 próba = 1 krzew). Łącznie zebrano 36 próbek o wadze około 500-600 g. Materiał do analiz laboratoryjnych podzielono na owoce świeże, do mrożenia i do suszenia. Oznaczanie zawartości witaminy C wykonano metodą Tillmansa (Polska Norma 1998), polegającą na redukcji barwnika do bezbarwnego leukozwiązku przy jednoczesnym utlenianiu witaminy C. Część owoców dzikiej róży zamrożono w temperaturze około –18°C i przechowywano przez kolejne miesiące. Inną partię owoców przeznaczono do wysuszenia. Po zamrożeniu lub wysuszeniu przeprowadzono analizę świeżo utrwalonych próbek. Owoce suszone podzielono na dwie grupy: 1 grupa – przechowywane w temperaturze pokojowej (około 21°C) w ciemnym pomieszczeniu; 2 grupa – przechowywane w temperaturze około 3°C w lodówce. Kolejne oznaczenia wykonano po 2, 3, 5 i 9 miesiącach od zamrożenia lub wysuszenia. Na podstawie analiz stwierdzono, że największą średnią zawartość witaminy C w świeżych owocach miały owoce dzikiej róży z okolic Mielca, następnie z Wielkopolski, a najmniejszą z Buska-Zdroju (ryc. 2, tab. 1). Po utrwaleniu owoców zaobserwowano znaczącą zmianę w zawartości witaminy C, przy czym największą zmianę wykazały owoce mrożone. Po utrwaleniu owoce róży utraciły średnio około 25% ilości witaminy C (po suszeniu 23%, po mrożeniu 25%). Badając owoce przechowywane w różnych warunkach, stwierdzono, że najwolniej zmniejszała się zawartość witaminy C w owocach mrożonych, natomiast w owocach suszonych proces ten przebiegał o wiele szybciej, przy czym owoce suszone przechowywane w temperaturze pokojowej po 5 miesiącach traciły witaminę C szybciej niż owoce suszone przechowywane w lodówce (ryc. 3, tab. 2). Na podstawie wykonanych badań można stwierdzić, że najkorzystniejszym z omawianych sposobów stabilizacji owoców dzikiej róży, ze względu na zachowanie największej zawartości kwasu askorbinowego, była metoda mrożenia i przechowywania owoców zamrożonych. Straty zawartości witaminy C po długim okresie przechowywania wynosiły około 10% w stosunku do jej ilości tuż po zamrożeniu. W wyniku przeprowadzonych analiz można również stwierdzić, że po około 5 miesiącach przechowywania zawartość witaminy C w owocach suszonych gwałtownie spadała: po 9 miesiącach straty wynosiły około 45% dla owoców suszonych przechowywanych w lodówce i około 80% dla owoców suszonych przechowywanych w temperaturze pokojowej.