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EFFECT OF USABLE PARTS OF DILL AND OF PRELIMINARY PROCESSING ON THE QUALITY OF FROZEN PRODUCTS DEPENDING ON THE TIME AND TEMPERATURE OF STORAGE

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Abstract. The investigation covered two kinds of the raw material (the leafy part and whole plants of dill 20 cm in height), varied processing before freezing (blanching of the raw material or without blanching), and two different storage temperatures (–20°C and –30°C) during 12-month storage, analyses of frozen products being conducted every 3 months. In comparison with whole dill plants the content of dry matter in leaves was higher by 36%, of total sugars by 45%, starch by 6%, dietary fibre by 35%, polyphenols by 58%, volatile oils by 32%, and total acids by 36%. The activity of peroxidase and catalase in leaves was higher by 59% and 71% respectively. In both usable parts of dill blanching caused significant changes in the level of all chemical components except for dietary fibre. Irrespective of the usable part, preliminary processing and storage temperatures, refrigerated storage caused slight changes in the level of dry matter, total sugars, starch, dietary fibre and total acids. Blanching before freezing and a lower temperature of refrigerated storage resulted in better retention of polyphenols and volatile oils in the two usable parts. At each stage of the investigation frozen leaves were characterized by higher sensory quality. Maintaining high sensory quality of frozen dill for three months did not require blanching and a storage temperature of –20°C was adequate. Storage at –30°C or at –20°C but with blanching before freezing was indispensable for maintaining very good quality for six months. Frozen dill stored for more than six months maintained good quality only when blanched raw material had been used; in addition to this, a lower storage temperature had a favourable effect on maintaining sensory quality, particularly in the case of 12-month storage.

Key words: dill, freezing, storage, chemical composition, sensory quality

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INTRODUCTION

Culinary herbs – including dill – provide main dishes with varied complementary compounds such as vitamins and minerals, and above all compounds affecting the sensory traits of food. The characteristic flavour of dill is due to volatile oils found in all the usable parts of this plant. Dill is classed among species diminishing the risk of cancer [Yang et al. 1996], its consumption decreases the level of cholesterol in the blood [Lansky et al. 1993], and its constituents show antioxidative properties [Kurilich and Juvik 1999]. Growing dill is easy, its growing period is short and by sowing at the appropriate time it is possible to obtain yields during the entire growing season [Kmiecik et al. 2002]. The supply of dill all year round is made possible by freezing it. However, during processing and frozen storage the quality of the raw material deteriorates. Among other things, this is connected with the activity of oxidative enzymes, whose inactivation by blanching before freezing limits the loss of numerous constituents during the storage of frozen vegetables. The lowering of the storage temperature also contributes to the preservation of good quality of frozen products [Kmiecik and Lisiewska 1999, Lisiewska and Kmiecik 1997].

The aim of this work was to compare the level of selected physical and chemical constituents in the leafy part and in whole plants of dill and to determine the level of changes in these compounds during the process of freezing and refrigerated storage of the frozen product. Samples of non-blanched or blanched dill were frozen and stored at –20°C and –30°C and analysed every three months over 12-month period. The sensory evaluation of the frozen products was carried out at the same dates.

MATERIAL AND METHODS

Raw material

The material of the experiment consisted of fresh and frozen dill cultivar Amat harvested in the experimental plot of the Department, which conducted the investigation. The harvest carried out after 37 days, when the plants had reached about 25 cm in height, consisted of cutting plant tops about 5 cm above the soil. The harvested plants were therefore 20 cm in height. The first measure was to separate the leaves from the remaining parts of the plants. It was determined that the leaves constituted 51% of weight of whole plants.

The investigation concerned: (1) two kinds of the raw material: leaves alone and whole dill plants, i.e. leaves with petioles and stems; (2) differentiated treatment before freezing, i.e. non-blanched and blanched samples; (3) differentiated temperatures of refrigerated storage, i.e. at –20°C and –30°C; (4) time of refrigerated storage throughout the year, with analyses chemical composition and sensory quality in the frozen product conducted at 3-month intervals.

Preparation of the material for analyses and freezing

Non-blanched leaves were cut into 5-7 mm sections. A sample representative of whole non-blanched plants was prepared by mixing leaves (previously cut into 5-7 mm sections) with the stem and petioles strained through a sieve of 2 mm sieve mesh. The preparation of blanched samples consisted of blanching in water at 94-96°C. The ratio of the blanched material to water was 1:5. The time of blanching was 30 s in leaves and 3 min in stems with petioles. After cooling in water and removing the remaining water by centrifugation to the weight equal to that before blanching, the leaves were cut into sections of 5-7 mm while petioles and stems were granulated as in the case of the non-blanched dill. In blanched and non-blanched samples the same proportion as in the raw material was maintained between the leaves and the stems with petioles.

Freezing and storage of frozen dill

Packing the dill in polythene bags 0.08 mm thick preceded its freezing. The content of a bag was 650 g of the raw material. The bags were pressed tightly to remove as much air as possible, then welded closely. Directly after closing, the product was frozen at –40°C in a 3626-51 Feutron blast freezer with forced air circulation to a temperature of storage i.e. –20°C and –30°C. After freezing the bags were placed in storage chambers at –20°C and –30°C respectively, and kept there until the time of evaluation.

ANALYSES

In chemical analyses all the samples cited in "Material and Methods" were taken into consideration. In each object investigated the average evaluated sample contained 650 g of the material and the manner of sampling ensured its being representative of the entire lot of the dill. Analyses of the raw material were begun within 2 hours of the harvest and of frozen products after the storage period appropriate to the method of the investigation. The frozen samples for analysis were defrosted at 2-4°C during 17-18 hours. An average laboratory sample representing a given combination of the experiment was granulated in a laboratory food mixer in a weight ratio of 1 part dill and 1 part water.

The components were determined using methods given in AOAC [1984]: the level of dry matter (32.019), total sugars (32.041) and total acids (32.043). The content of starch was determined using the Lintner method [Nowotny 1969]; and that of dietary fibre using the Hellendoorn method [Hellendoorn et al. 1975]. Polyphenols were extracted with an 80% methanol solution and spectrophotometrically determined using the Folin-Ciocalteau reagent [Swain and Hillis 1959], the results being expressed as mg of catechin. Volatile oils were measured using the ISO 6571 [1984] method; peroxidase activity using the spectrophotometrical method given by Bergmeyer [Bergmeyer 1974]; and catalase using the method given by Ciszewska [Ciszewska et al. 1997].

In the sensory evaluation all the research combinations given in the chapter "Material and methods" with frozen and defrosted dill were taken into consideration. The frozen product was defrosted at 2-4°C and then left to reach the ambient temperature. In sensory evaluation a scale of 1 to 5 was used, the general appearance, colour, consistency and flavour being taken into consideration in frozen samples, while in defrosted products apart from the above traits the taste was also assessed. The evaluation was conducted by a team of five people meeting the basic requirements with respect to sensory sensitivity according to ISO 3972 [1991].

All the determinations of the chemical composition were conducted in four replications. Statistical analysis was carried out using the Statistica 6.1 Pl program. On the basis of the Snedecor F test and the Student t test the least significant difference (LSD) was computed for the level of error probability $\alpha = 0.01$ for chemical composition and $\alpha = 0.05$ for sensory traits. For chemical components which during the storage period showed changes not exceeding 20% compared with the raw material before freezing, the data given in the tables concern only the content in the raw material and after 12 months.

RESULTS AND DISCUSSION

In 100 g of dill leaves the content of dry matter was 12.89 g and in whole plants 9.49 g (Table 1). Kmiecik et al. [2002] found a slightly higher level of dry matter depending on the analysed part of the plant and the growing period. After blanching the level of dry matter was reduced by 18% in leaves and 10% in whole plants. According to Kmiecik and Lisiewska [1999] and Lisiewska and Kmiecik [1997] decreases in dry matter content in blanched chive and parsley leaves were 22% and 16%, respectively. Freezing and refrigerated storage did not change the level of this constituent.

In fresh matter of leaves the content of total sugars was 1.19 g $\times 100$ g^{-1}, being by 45% higher than in whole plants of dill (Table 1). Depending on cultivar and the period of growth, Kmiecik et al. [2002] found a higher content of sugars in leaf blades than in leaf blades with petioles, though only by 13% on average. Spinach leaves compared with petioles also showed a higher content of sugars [Oguchi et al. 1996], while the leaves of leaf beet contained less sugars than the petioles [Gębczyński 1998, 1999]. After blanching the total content of sugars was reduced by 46% in leaves and by 39% in whole plants. The considerable loss of these and other water soluble constituents can be explained by the very large surface area of dill in relation to its weight. In spite of this unfavourable ratio, the recorded decrease in the level of total sugars did not significantly differ from losses quoted for New Zealand spinach [Jaworska and Słupski 2001] and leaf beet [Gębczyński 1999, 1998]. During the refrigerated storage of frozen dill the recorded slight variation did not exceed 20% in the level of total sugars (column A in Table 1). Similar changes of sugars were reported by Jaworska and Kmiecik [2000], Jaworska and Budnik [1996] and Gębczyński [1999] during the refrigerated storage of other leafy vegetables.

Leaves and whole dill plants contained similar amounts of starch: 0.75 g and 0.71 g in 100 g fresh matter respectively (Table 1). After blanching the level of starch in dill was lower by 12% on average in comparison with the raw material. According to Jaworska and Kmiecik [2000] similar losses of starch were found in fresh matter of common spinach and New Zealand spinach. After freezing and during storage of frozen products changes in the level of this constituent were small, not exceeding a 10% variation.

The content of dietary fibre was 2.52 in 100 g of leaves, i.e. 35% more than in whole plants. Kmiecik et al. [2002] determined 1.74-3.99 g of dietary fibre in 100 g fresh matter of dill leaves, depending on the cultivar and the harvest time. Ishida et al. [2000] showed that the leaves of two sweet potato cultivars contained 33-59% more dietary fibre than the stems. The leaf blades of leaf beet also showed a greater content of this constituent than did the petioles [Gębczyński 1998, 1999]. In blanched dill the content

Table 1. Content of dry matter and selected chemical constituents in raw and frozen dill
Tabela 1. Zawartość suchej masy i wybranych wyróżników chemicznych w świeżym i mrożonym koprze

Item Wskaźnik	Kind of raw material Rodzaj surowca	Method of pretreatment Rodzaj obróbki wstępnej	Raw material before freezing Surowiec przed mrożeniem	After 12-month storage Mrożonka po 12 miesiącach składowania w temperaturze		A
				–20°C	–30°C	
Dry matter Sucha masa g×100 g^{-1}	leaves liście	NB	12.89 ± 0.17	13.08 ± 0.17	13.01 ± 0.17	0 ÷ +1
		B	10.51 ± 0.23	10.77 ± 0.10	10.65 ± 0.10	–1 ÷ +3
	whole plants całe rośliny	NB	9.49 ± 0.19	9.73 ± 0.14	9.65 ± 0.15	–1 ÷ +3
		B	8.59 ± 0.15	8.74 ± 0.12	8.64 ± 0.12	–2 ÷ +2
			LSD (α = 0.01) – 0.298			
Total sugars Cukry ogółem g×100 g^{-1}	leaves liście	NB	1.19 ± 0.06	0.96 ± 0.06	1.01 ± 0.04	–19 ÷ –5
		B	0.64 ± 0.04	0.56 ± 0.03	0.59 ± 0.04	–13 ÷ +2
	whole plants całe rośliny	NB	0.82 ± 0.05	0.67 ± 0.04	0.72 ± 0.03	–18 ÷ –1
		B	0.50 ± 0.03	0.40 ± 0.03	0.43 ± 0.02	–20 ÷ +4
			LSD (α = 0.01) – 0.080			
Starch Skrobia g×100 g^{-1}	leaves liście	NB	0.75 ± 0.02	0.72 ± 0.03	0.74 ± 0.03	–4÷ +3
		B	0.65 ± 0.03	0.64 ± 0.04	0.64 ± 0.02	–5 ÷ +2
	whole plants całe rośliny	NB	0.71± 0.03	0.66 ± 0.03	0.67 ± 0.03	–7 ÷ –3
		B	0.63 ± 0.02	0.63 ± 0.03	0.64 ± 0.03	0 ÷ +5
			LSD (α = 0.01) – 0.057			
Dietary fibre Błonnik pokarmowy g×100 g^{-1}	leaves liście	NB	2.52 ± 0.18	2.72 ± 0.11	2.66 ± 0.09	+1 ÷ +8
		B	2.45 ± 0.11	2.52 ± 0.08	2.55 ± 0.08	0 ÷ +4
	whole plants całe rośliny	NB	1.86 ± 0.13	1.91 ± 0.06	1.90 ± 0.08	0 ÷ +5
		B	1.84 ± 0.09	1.91 ± 0.11	1.90 ± 0.09	–1 ÷ +4
			LSD (α = 0.01) – 0.204			
Total acidity Kwasowość ogólna cm^3 0,1 M NaOH×100 g^{-1}	leaves liście	NB	16.0 ± 0.06	19.7 ± 0.06	18.0 ± 0.04	+5 ÷ +20
		B	8.2 ± 0.04	8.9 ± 0.03	8.6 ± 0.04	0 ÷ +9
	whole plants całe rośliny	NB	12.0 ± 0.05	14.4 ± 0.04	13.5 ± 0.03	+8 ÷ +20
		B	7.1 ± 0.03	8.1 ± 0.03	7.7 ± 0.02	+1 ÷ +14
			LSD (α = 0.01) – 1.107			

A – extreme percentage deviation from content before freezing revealed during the frozen storage (analyzed after 0, 3, 6, 9 and 12 months).
NB – non-blanched.
B – blanched.
x ± SD – mean value of four samples and standard deviation.
A – skrajne procentowe odchylenia od zawartości przed zamrożeniem wykazane w trakcie zamrażalniczego składowania (analizy wykonano po 0, 3, 6, 9 i 12 miesiącach).
NB – nieblanszowane.
B – blanszowane.
x ± SD – średnia z czterech oznaczeń i odchylenie standardowe.

of dietary fibre did not significantly change. Similarly in blanched petioles of leaf beet and in New Zealand spinach no changes were found in the content of dietary fibre [Gębczyński 1998, Jaworska and Słupski 2001]. Refrigerated storage caused a slight increase in the content of dietary fibre (column A in Table 1).

In the leafy part of dill the content of acids corresponded to 16.0 cm^3 0.1 M NaOH in 100 g fresh matter, while in whole plants the level of this constituent was lower by 26% (Table 1). These values approximate to the results given by Kmiecik et al. [2001] for this species. Blanching reduced the content of acids by half in dill leaves and by 40% in whole plants. In New Zealand spinach and common spinach blanching also resulted in a considerable decrease in the content of acids [Jaworska and Kmiecik 2000]. Jaworska and Kmiecik [2000] reported that during refrigerated storage the content of total acids in common spinach and New Zealand spinach remained at a constant level. In stored frozen dill a variation in total acidity was observed, however it did not exceed 20% of the value determined in dill before freezing. Greater changes in the level of this component occurred in frozen non-blanched dill and in frozen products stored at the higher temperature.

Directly after harvest the content of polyphenols in dill leaves was 175 mg in 100 g fresh matter, 58% more than in whole plants. As given by Kmiecik et al. [2001] the content of polyphenols for three cultivars and five growing periods was 167-288 mg in 100 g fresh matter of dill leaves and 115-233 mg in leaves with petioles. In blanched dill the content of polyphenols was found to increase by 39% in fresh matter of leaves and by 43% in whole plants (Table 2). Talcott et al. [2000] recorded an increase in the level of polyphenols in carrots after thermal processing. Diverging from the present results, Price et al. [1998] and Puupponen-Pimia et al. [2003] showed a considerable reduction in the content of these compounds during the cooking of spinach and leaves of leaf beet. Freezing did not significantly influence the level of polyphenols in blanched dill; however, in non-blanched samples their content significantly decreased by 13-19% depending on the usable part. The storage of frozen dill for 12 months caused fluctuation in the content of polyphenols, with a tendency toward decrease. The reduction was 7-31% in non-blanched and 2-9% in blanched samples. In non-blanched samples the favourable effects of the lower storage temperature were also observed.

In fresh leaves of dill the content of volatile oils was 58 mg^3 in 100 g fresh matter, exceeding that in whole plants by 32%. These results were within the limits given by other authors [Lisiewska et al. 2001, Huopalahti and Linko 1983]. After blanching the content of volatile oils was reduced by 19% in leaves and by 23% in whole plants. This was due to the great volatility of compounds in the composition of volatile oils [Aharoni et al. 1993]. After the freezing of non-blanched samples decreases in the content of volatile oils were fairly similar in the two usable parts, amounting to 11-14%. In samples of blanched dill their content practically did not change. After 12-month storage of frozen non-blanched dill the losses were 67-78% compared with the content in the raw material after freezing, and 10-33% in frozen blanched products. The preservation of aromatic substances did not depend on the usable part of dill, while the lower storage temperature favourably affected the level of these compounds. The obtained results confirm the opinion of Sankat and Maharaj [1996] that low storage temperatures limit the loss of volatile oils.

The activity of peroxidase and catalase was higher in the leaves of dill than in whole plants by 59% and 71% respectively (the results are not given in the tables). Blanching

Table 2. Content of polyphenols and volatile oils in raw and frozen dill
Tabela 2. Zawartość polifenoli i olejków eterycznych w świeżym i mrożonym koprze

Item Wskaźnik	Usable part Część użytko-wa	Method of pretreat-ment Rodzaj obróbki wstępnej	Raw material before freezing Surowiec przed mroże-niem	Tempera-ture of storage Tempera-tura skład-owania	Frozen product (storage time in months) Mrożonka (czas składowania w miesiącach)				
					0	3	6	9	12
Polyphe-nols Polifenole mg×100 g^{-1}	leaves liście	NB	175 ± 6	–20°C	145 ± 7	134 ± 10	149 ± 11	155 ± 7	100 ± 5
			175 ± 6	–30°C	150 ± 6	132 ± 9	126 ± 5	133 ± 5	124 ± 5
		B	243 ± 11	–20°C	237 ± 11	232 ± 10	244 ± 11	226 ± 11	216 ± 10
			243 ± 11	–30°C	250 ± 12	243 ± 13	246 ± 10	237 ± 11	229 ± 7
	whole plants całe rośliny	NB	111 ± 8	–20°C	97 ± 2	100 ± 4	82 ± 3	85 ± 5	67 ± 3
			111 ± 8	–30°C	90 ± 4	83 ± 3	92 ± 5	101 ± 5	84 ± 3
		B	159 ± 9	–20°C	150 ± 7	142 ± 6	163 ± 7	154 ± 5	147 ± 8
			159 ± 9	–30°C	164 ± 6	172 ± 6	170 ± 6	163 ± 8	151 ± 8
		LSD (α = 0.01)			factor I – czynnik I factor II – czynnik II interaction I×II – współdzia-łanie I×II			5.7 5.0 14.1	
Volatile oils Olejki eteryczne mm^3×100 g^{-1}	leaves liście	NB	58 ± 2	–20°C	50 ± 2	43 ± 2	30 ± 2	19 ± 2	11 ± 2
			58 ± 2	–30°C	51 ± 2	43 ± 3	36 ± 2	25 ± 2	16 ± 2
		B	47 ± 2	–20°C	45 ± 2	42 ± 2	40 ± 2	36 ± 2	30 ± 2
			47 ± 2	–30°C	45 ± 2	43 ± 3	42 ± 2	40 ± 2	40 ± 2
	whole plants całe rośliny	NB	44 ± 2	–20°C	38 ± 2	30 ± 1	21 ± 2	15 ± 2	9 ± 1
			44 ± 2	–30°C	39 ± 2	30 ± 2	25 ± 1	20 ± 1	13 ± 1
		B	34 ± 2	–20°C	32 ± 2	29 ± 2	28 ± 1	25 ± 2	22 ± 1
			34 ± 2	–30°C	31 ± 2	29 ± 2	29 ± 2	29 ± 2	28 ± 2
		LSD (α = 0.01)			factor I – czynnik I factor II – czynnik II interaction I×II – współdzia-łanie I×II			1.4 1.2 3.4	

NB – non-blanched.
B – blanched.
x±SD – mean value of four samples and standard deviation.
NB – nieblanszowane.
B – blanszowane.
x±SD – średnia z czterech oznaczeń i odchylenie standardowe.

decreased the activity of peroxidase to zero and of catalase to 4-6% of the activity determined in the raw material. In blanched samples no regeneration of the enzymes was observed during the period of storage contrary to the opinion of Barrett and Theerakulkait [1995], who stressed a pronounced regeneration capacity of enzymes. The freezing of non-blanched samples effected a decrease in the activity of peroxidase by 40-60% and of catalase by 56-69%, a greater decrease in the activity of these enzymes occurring in

Table 3. Result of sensory evaluation of frozen dill
Tabela 3. Wyniki oceny sensorycznej mrożonek z kopru

	Usable part Część użytkowa	Method of pretreatment Rodzaj obróbki wstępnej	Temperature of storage Temperatura składowania	Frozen product (storage time in months) Mrożonka (czas składowania w miesiącach)				
				0	3	6	9	12
Before defrost	leaves liście	NB	–20°C	4.84	4.76	4.63	4.38	4.10
			–30°C	4.84	4.84	4.72	4.59	4.45
		B	–20°C	4.72	4.71	4.70	4.57	4.45
			–30°C	4.72	4.72	4.71	4.69	4.67
	whole plants całe rośliny	NB	–20°C	4.71	4.67	4.67	4.46	4.27
			–30°C	4.71	4.71	4.70	4.59	4.48
		B	–20°C	4.50	4.50	4.50	4.41	4.19
			–30°C	4.50	4.50	4.50	4.48	4.39
			LSD (α = 0.05)	factor I – czynnik I factor II – czynnik II interaction I×II – współdziałanie I×II				0.027 0.021 0.067
After defrost	leaves liście	NB	–20°C	4.58	4.33	4.23	3.63	2.71
			–30°C	4.58	4.37	4.32	3.93	3.09
		B	–20°C	4.93	4.93	4.93	4.66	4.40
			–30°C	4.93	4.93	4.93	4.91	4.88
	whole plants całe rośliny	NB	–20°C	4.30	3.98	3.89	3.54	2.54
			–30°C	4.30	4.00	3.98	3.77	2.88
		B	–20°C	4.66	4.65	4.64	4.36	4.03
			–30°C	4.66	4.66	4.66	4.57	4.54
			LSD (α = 0.05)	factor I – czynnik I factor II – czynnik II interaction I×II – współdziałanie I×II				0.026 0.021 0.059

NB – non-blanched.
B – blanched.
NB – nieblanszowane.
B – blanszowane.

the case of freezing to the lower temperature. With the passage of storage time enzymatic activity in frozen non-blanched dill decreased. However, no unequivocal effect of storage temperature on enzymatic activity was observed in spite of Leino's [1992] opinion that activity was lower at lower temperatures. After 12-month storage the activity of enzymes in non-blanched dill was still greater than that recommended for vegetables earmarked for refrigerated storage [Williams et al. 1986].

According to Baardseth and Slinde [1987] unfavourable sensory changes of frozen vegetables during refrigerated storage are associated with enzymatic activity to a great degree. However, according to Lisiewska and Kmiecik [1997] blanching can be dispensed with in the case of strongly flavoured vegetables and also when the storage time of products is short or at temperatures of around –30°C. Maintaining high sensory quality of all the investigated dill samples for three months did not necessitate their blanching and a temperature of –20°C was sufficient (Table 3). However, maintaining such quality for a further three months was only possible at a storage temperature of –30°C or at –20°C, if the raw material had been blanched before freezing. Frozen products stored for longer than six months preserved good quality but only if blanched raw material had been used for freezing. The lower the storage temperature the better the preservation of sensory quality, particularly in the case of 12-month storage. The most important considerations in the appraised of sensory quality were the colour and flavour of frozen products and the taste and consistency of defrosted samples.

CONCLUSIONS

Compared with the whole plant, dill leaves were distinguished by having a higher content of the analysed chemical constituents as well as higher peroxidase and catalase activity, both as fresh material and after freezing. Blanching before freezing and a lower storage temperature of the two usable parts effected better preservation of polyphenols and volatile oils during 12 months of storage. At every stage of the investigation frozen leaves showed higher sensory traits. The preservation of high sensory quality of frozen dill for six months required a storage temperature of –30°C or of –20°C if the raw material was blanched before freezing. Frozen products stored for a period exceeding six months showed good quality only if the raw material had been blanched; furthermore, a lower storage temperature had a favourable effect on maintaining sensory quality, particularly in the case of 12-month storage.

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WPŁYW CZĘŚCI UŻYTKOWEJ I OBRÓBKI WSTĘPNEJ NA JAKOŚĆ MROŻONEGO KOPRU W ZALEŻNOŚCI OD CZASU I TEMPERATURY SKŁADOWANIA

Streszczenie. W badaniach uwzględniono dwa rodzaje surowca (część liściową i całe rośliny o wysokości 20 cm), zróżnicowaną obróbkę przed mrożeniem (pominięcie blanszowania oraz blanszowanie surowca), zróżnicowaną temperaturę składowania mrożonki (–20°C i –30°C) oraz okres przechowywania przez 12 miesięcy, analizując mrożonki co 3 miesiące. Liście kopru w porównaniu z całymi roślinami miały więcej suchej masy o 36%, cukrów ogółem o 45%, skrobi o 6%, błonnika pokarmowego o 35%, polifenoli o 58%, olejków eterycznych o 32%, i kwasów ogółem o 36% oraz większą aktywność peroksydazy i katalazy odpowiednio o 59% i 71%. Blanszowanie spowodowało istotne zmiany w obu częściach użytkowych w poziomie wszystkich wskaźników chemicznych z wyjątkiem błonnika pokarmowego. Zamrażalnicze składowanie, niezależnie od rodzaju części użytkowej, obróbki wstępnej przed mrożeniem i temperatury składowania, spowodowało niewielkie zmiany w poziomie suchej masy, cukrów ogółem, skrobi, błonnika pokarmowego i kwasów ogółem. Blanszowanie przed mrożeniem i niższa temperatura zamrażalniczego składowania, obu części użytkowych, wpłynęły na lepsze zachowanie polifenoli i olejków eterycznych. Mrożonki z liści na każdym etapie badań charakteryzowały się lepszymi cechami sensorycznymi. Zachowanie wysokiej jakości sensorycznej mrożonego kopru, przez 3 miesiące, nie wymagało jego blanszowania i wystarczającą temperaturą składowania była temperatura –20°C. Zachowanie wysokiej jakości przez 6 miesięcy wymagało składowania w temperaturze –30°C lub w –20°C i blanszowania surowca przed zamrożeniem. Mrożonki przechowywane powyżej 6 miesięcy miały dobrą jakość, ale tylko wtedy, gdy były wykonane z surowca blanszowanego, przy czym niższa temperatura składowania, szczególnie przy przechowywaniu przez 12 miesięcy, wpłynęła na lepsze zachowanie jakości sensorycznej.

Słowa kluczowe: koper, mrożenie, przechowywanie, skład chemiczny, jakość sensoryczna

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