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Effect of pretreatment and conditions and period of storage on some quality indices of frozen chive (*Allium schoenoprasum* L.)

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Abstract

Chive leaves for freezing contained 13.9 g dry matter, 133 mg vitamin C, 4.7 mg β carotene, 121 mg chlorophylls (a + b), 40.4 mg nitrates, and 0.19 mg nitrites in 100 g of edible parts. Blanching of the raw material before freezing reduced the level of dry matter by 22%, vitamin C 29%, β carotene 20%, chlorophylls 21%, and nitrates 26%, while that of nitrites increased three times. Freezing and 12-month storage of frozen material caused further losses in the analysed constituents except dry matter. Losses were distinctly higher on freezing non-blanched chive, a further enhancement of losses being observed with a storage temperature at −20°C. After a 12-month storage of frozen chive, the preserved content of vitamin C ranged from 11 to 66%, β carotene 37 to 65%, chlorophylls 65 to 75%, and nitrates 58 to 81%. If the blanching is omitted and the storage temperature is −20°C, a good preservation of vitamin C is not possible even for a period of 3 months. In contrast, the pretreatment of blanching ensures its good preservation at −20°C and at −30°C, and also yields a very good conservation of all the constituents analysed.

1. Introduction

Among the onion vegetables, the chive has the highest contents of vitamin C and β carotene (Łoś-Kuczera, 1990). It is most frequently obtained in winter and early spring by forced cultivation and, in late spring, is harvested in the field, being used in household cookery as a potherb in a variety of dishes. The development of the catering business and industrial preparation of ready-to-cook food, most frequently pizza and au gratin dishes, has increased the demand for chive throughout the year. This demand can be met by preserving the vegetable as dried or frozen products. The drying of chive considerably reduces its aroma; moreover, before its use, the dried products have to be subjected to rehydration which is usually inadequate if the blast method is used in drying. The use of frozen chive for the above aims, therefore, seems far easier. In general, the literature concerning the chive is limited to agrotechnical problems, there being an almost complete lack of works concerning its chemical composition and numbers of components. Nor are any data available on freezing technology, storage conditions of frozen products, or changes in its chemical composition during storage.

In general, it is known that the pretreatment of blanching, before freezing vegetables for long-term storage, limits the losses of vitamins and deterioration of organoleptic qualities (Duden, 1984; Leino, 1992; Okeibuno-Badifu, 1991). It is also known that the lower the storage temperature the better is the preservation of vitamins and pigments in frozen vegetables (Philippon, Rouet-Mayer, Fontenay, & Duminil, 1986; Poulsen & Nielsen, 1979).

Apart from its cost, the blanching itself causes certain losses in nutrients and may be omitted in the case of some vegetables, especially if frozen for shorter storage periods (Bubicz, Frączek, & Branecka, 1981; Leino, 1992; Niedzielski & Mokrosińska, 1990). Neither is the use of very low storage temperatures necessary for all vegetables (Philippon et al., 1986) as it significantly raises the price of the frozen product. Moreover, only up-to-date storage chambers ensure temperatures approximating −30°C.

The aim of this study was to reveal the effects of blanching and storage temperature on the preservation of vitamin C, β carotene, and chlorophylls, and also changes in the levels of nitrates and nitrites during a 12-month storage of frozen chive.

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2. Materials and methods

2.1. Materials

The investigated material included fresh and frozen chive leaves of the Erfurcki Olbrzymi cultivar, stored under different thermal conditions. The raw material was harvested from a 2-year-old production plantation in the Krakow region. The vegetable was grown on loamy-sandy soil with mineral fertilization adjusted to the requirements of the crop throughout the year, i.e. N-80 kg/ha, P_2O_5—70 kg/ha, and K_2O—110 kg/ha. Of this amount, 30 kg/ha N, 20 kg/ha P_2O_5, and 30 kg/ha K_2O were applied in spring before harvest.

Evaluation of the raw material and preparation of frozen products was carried out on the first harvest of leaves (the first 10 days of May) when they had attained sufficient size and shape. After harvesting, the material was sorted according to the Polish quality norm, shoots with flower bud sets and small yellowing leaves being eliminated. The evaluation of the raw material and freezing were carried out within 12 h of harvesting. Until the time of analyses and pretreatments the chive remained in a cold store.

Apart from the raw material before and after blanching, the determinations of chemical composition concerned blanched and non-blanched chive, directly after freezing and after its 3-, 6-, 9-, and 12-month storage at −20 and −30°C.

2.2. Methods

Freezing was preceded by pretreatments that included a repeated inspection of the raw material, washing, centrifuging in a centrifuge designed for removing water from leafy vegetables, blanching part of the material, and cutting leaves into fragments 5–7 mm in length.

The blanching in water at 94–96°C, with the weight of the raw material and water at a ratio of 1:5, was conducted for 90 s, this ensuring a decrease in peroxidase activity of 95%. To prevent too great losses of nutrients, the blanching was applied to intact leaves; they were cut after the treatment.

Directly after blanching, the raw material was cooled and centrifuged to remove the remaining water. Since the morphological structure of chive (tubular leaves) suggests that the blanching water may remain inside, possible changes in the weight of the raw material, caused by this treatment, were determined in 4 samples.

Cut leaves of blanched and non-blanched chive were frozen in polystyrene boxes (15 × 11 × 5 cm). In order to eliminate as much as possible of the air remaining between the leaf cuttings, the material was gently pressed under a load of 2.5 kg/dm^2. This allowed the preparation of frozen cubes with a specific gravity of about 240 g/dm^3 for non-blanched samples and 480 g/dm^3 for blanched ones.

Freezing was carried out in a 3101-01 type Feutron blast freezer with forced air circulation. The freezing temperature was −40°C. It took 120–200 min to obtain the temperature appropriate to the method of the experiment.

Analyses of the individual components were carried out in 4 replications, each in two parallel determinations, according to standard methods: dry matter (AOAC, 1984, 32.063), L-ascorbic acid and vitamin C (ISO/6557-2), β carotene (ISO/6558-2), chlorophylls (Wettstein, 1957), nitrates and nitrites (ISO/6635). Moreover, because of scarce literature data concerning the chemical composition of chive the following additional determinations were carried out only in the raw material: simple sugars and total sugars (AOAC, 1984, 32.040, 32.041), total nitrogen (AOAC, 1984, 2.057), total acidity (AOAC, 1984, 22.058), active acidity—pH (AOAC, 1984, 32.010), ash (AOAC, 1984, 32.027), alkalinity of ash (AOAC, 1984, 32.028) and volatile oil (AOAC, 1980, 34.021).

Because of great differences in the dry matter content between the blanched and non-blanched chive, owing to the water retained during blanching, the obtained results were referred to fresh and dry matter, making their proper interpretation feasible and reliable.

The applied method of statistical analysis helped comparison of samples in particular periods of evaluation, between the different periods of evaluation, and all the objects of the experiment with each other. The analysis was carried out according to the Excel 5.0 program, using the Snedecor F test and the Student's t-test, the least significant difference (LSD) being calculated for the probability level $p = 0.01$.

3. Results and discussion

The chive leaves for freezing, in 100 g, contained 13.87 g dry matter, 2.99 g simple sugars, 3.95 g total sugars, 0.37 g total nitrogen, and 1.15 g ash, with ash alkalinity amounting to 8.1 ml 1 N HCl/100 g. Furthermore, they contained a significant amount of vitamin C, β carotene, and chlorophylls, while the content of nitrates was small in relation to other leafy vegetables (Table 1). The total content of acids expressed in ml 1 N NaOH/100 g was 3.6, pH 5.35, and volatile oils 0.17 cm^3/100 g. The level of components given above varies within the ranges reported by Franke (1978); Łoś-Kuczera (1990); and Komosa, Bres, Golcz, Kozik, & Tyksiński (1993). It should be added here that those authors usually did not investigate more than 2–4 components.

The blanching treatment induced a significant decrease in the levels of the analysed indices. As concerns fresh matter (Table 1) the losses reached 22% of dry matter, 29% of vitamin C, 20% of β carotene, 21% of chlorophylls, and 26% of nitrates, while the content

Table 1
Content of selected ingredients in fresh and frozen chive, in fresh matter[a]

Ingredient	Pre-freezing treatment	Before freezing	Storage temperature (°C)	Storage time in months					LSD ($p=0.01$)
				0	3	6	9	12	
Dry matter (g/100 g)	Non-blanched	13.87	−20	13.88	13.84	13.90	14.13	14.13	$F_{emp} < F_t$
		13.87	−30	13.95	13.93	13.85	14.03	14.01	$F_{emp} < F_t$
	Blanched	10.81	−20	10.87	10.89	10.98	11.01	11.02	$F_{emp} < F_t$
		10.81	−30	10.92	10.98	10.97	11.00	10.99	$F_{emp} < F_t$
LSD ($p=0.01$)		0.419		0.312	0.441	0.417	0.368	0.245	
LSD ($p=0.01$)					0.323				
Vitamin C (mg/100)	Non-blanched	133	−20	63	40	31	23	14	4.0
		133	−30	61	61	56	52	48	4.0
	Blanched	94	−20	91	80	77	67	60	5.1
		94	−30	90	90	88	86	88	5.0
LSD ($p=0.01$)		3.5		5.8	4.7	4.5	5.6	4.6	
LSD ($p=0.01$)					4.2				
β-Carotene (mg/100 g)	Non-blanched	4.74	−20	3.93	2.40	2.24	2.27	1.74	0.312
		4.74	−30	3.94	3.34	3.41	3.18	2.67	0.289
	Blanched	3.78	−20	3.41	3.26	3.28	3.30	3.09	0.354
		3.78	−30	3.29	3.17	3.32	3.29	3.04	0.318
LSD ($p=0.01$)		0.380		0.444	0.299	0.251	0.262	0.354	
LSD ($p=0.01$)					0.293				
Chlorophyll (a + b) (mg/100 g)	Non-blanched	121	−20	106	107	80	80	79	9.3
		121	−30	107	109	89	92	91	10.7
	Blanched	95	−20	88	89	84	86	86	4.6
		95	−30	90	91	88	91	91	$F_{emp} < F_t$
LSD ($p=0.01$)		11.5		6.9	12.0	$F_{emp} < F_t$	7.6	5.3	
LSD ($p=0.01$)					7.8				
Nitrates (mg/1000 g)	Non-blanched	409	−20	400	408	317	325	330	38.5
		409	−30	402	336	271	283	292	32.6
	Blanched	301	−20	299	303	277	271	278	$F_{emp} < F_t$
		301	−30	294	267	272	233	236	33.8
LSD ($p=0.01$)		35.4		41.2	35.3	37.7	37.0	36.2	
LSD ($p=0.01$)					32.2				
Nitrites (mg/1000 g)	Non-blanched	0.19	−20	0.08	0.02	0.05	0.00	0.00	
		0.19	−30	0.05	0.03	0.02	0.00	0.00	
	Blanched	0.61	−20	0.17	0.13	0.04	0.00	0.00	
		0.61	−30	0.17	0.14	0.00	0.00	0.00	
LSD ($p=0.01$)		0.091		0.042	$F_{emp} < F_t$	–	–	–	
LSD ($p=0.01$)					–				

[a] From four determinations.

of nitrites increased 3 times, though their amount never exceeded 1 mg/1000 g of the product and is negligible from the practical point of view. It should be stressed that the actual losses due to this treatment were distinctly smaller, since blanched chive increased its weight by 16–19% (18% on average). The increased weight being taken into consideration, actual losses were 8, 17, 6, 7 and 13%, respectively. Analysis of the losses on a dry matter basis (Fig. 1) showed that, statistically, the only significant losses caused by blanching concerned vitamin C.

The losses in vitamin C content may be regarded as small since Ajayi, Oderinde, and Osibanjo (1980) found decreases in vitamin C content in the order of 52–81% for 6 species of leafy vegetables subjected to blanching. Moreover, the above authors revealed the occurrence of dehydroascorbic acid, 3–24% of the vitamin, in the blanched material, while its zero content was assessed in the raw material. Lisiewska and Kmiecik (1997) reported 47–51% losses of vitamin C in parsley leaves affected by blanching. The effect of blanching on β carotene is not clear, since both losses (Lisiewska & Kmiecik, 1997) and increases (Nutting, Neumann, & Wagner, 1970) were reported, the deviations from the content in the raw material being insubstantial, as was the case in the present study. Smaller losses of chlorophylls were found in parsley leaves (Lisiewska & Kmiecik, 1997) than in chive, while Jaworska and Budnik (1996) observed an even greater content of this component in New Zealand spinach after its blanching than before such treatment. Losses in nitrate content during blanching are reported in all the studies concerning this problem (Kmiecik & Lisiewska, 1994).

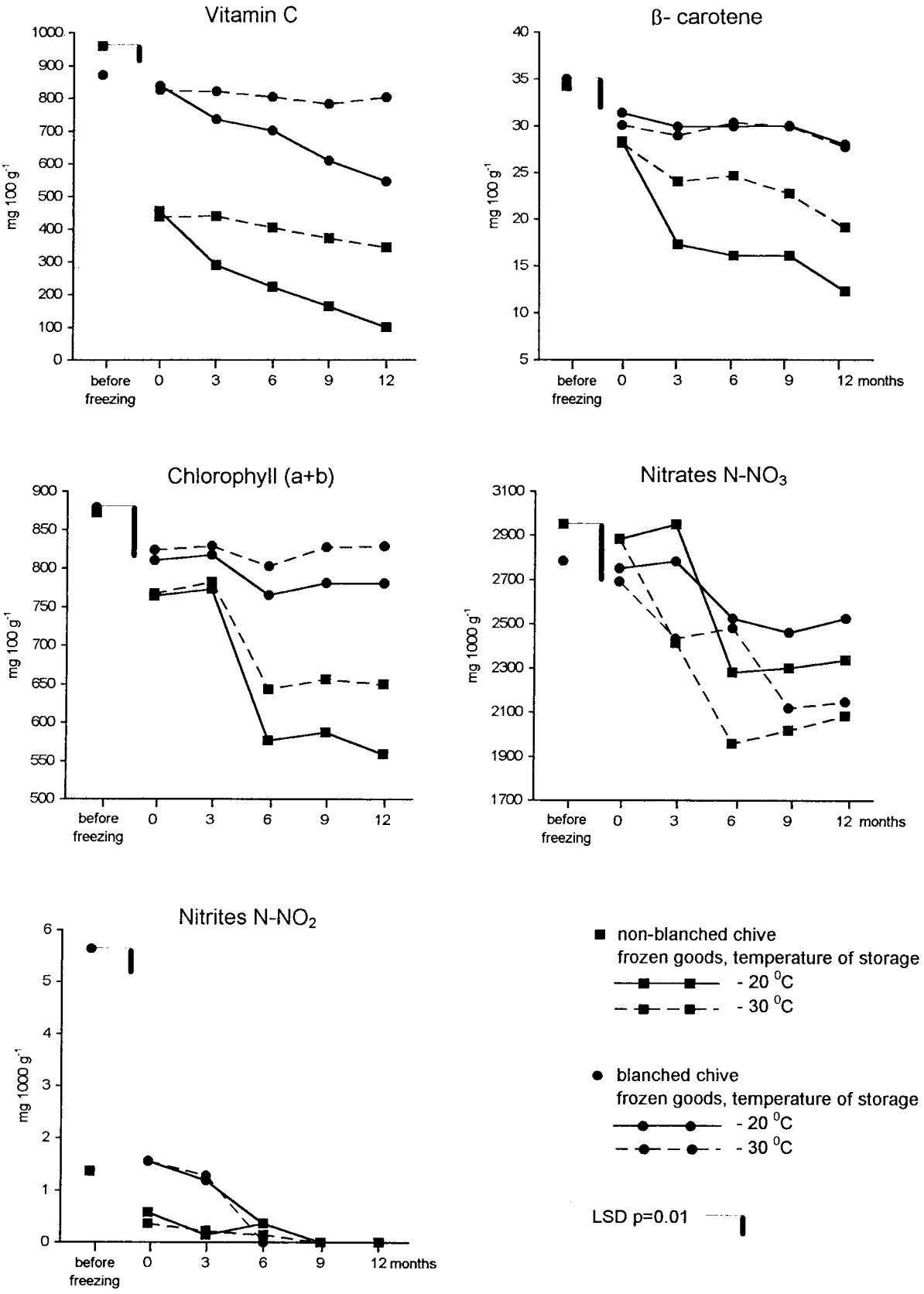

Fig. 1. Content of selected ingredients in fresh and frozen chive, in dry matter.

Irrespective of the applied pretreatments, the freezing did not induce any practical or statistically significant changes in dry matter or nitrates, the observed losses relating only to the contents of vitamin C, β carotene, chlorophylls, and nitrates (Table 1). The level of losses depended upon the components analysed and upon the application or omission of blanching.

In non-blanched frozen chive the content of vitamin C was reduced 53–54% in relation to raw material, in blanched frozen chive 3–4% in relation to the blanched product, and 32% in relation to the raw material. Already, at this stage of frozen chive production from blanched material, the content of vitamin C in fresh weight of the product exceeded that in the product from the non-blanched vegetable by 46% on average. It should also be stressed that, in the remaining amount of vitamin C, the content of L-ascorbic acid in non-blanched samples was half that in blanched ones (Table 2). Directly after freezing, the content of β carotene was significantly lower in all of the samples than in the material before freezing. During freezing, the losses reached 17% in frozen samples of non-blanched chive and 10–13% in those of the blanched raw material. Frozen products of non-blanched chive contained, by 17%, more β carotene, on average than those of blanched leaves. In general, in the course of freezing chive, the levels of chlorophylls were significantly reduced. Their losses were 12% in frozen non-blanched leaves and 5–7% in blanched ones. After freezing, the products of non-blanched chive contained about 20% more chlorophylls than the blanched samples.

During freezing, the decreases in nitrite content were particularly significant. In non-blanched frozen chive leaves, the content of nitrites was reduced 2–3 times and in blanched ones more than 3 times, reaching values below those determined in the raw material. Blanched samples contained 2.5 times more nitrites than the non-blanched ones, though in general these were trace amounts.

Changes in the contents of some components that were investigated in chive, during freezing, were also studied in New Zealand spinach by Jaworska and Budnik (1996), in parsley leaves by Lisiewska and Kmiecik (1997) and Nutting et al. (1970), and in Brussels sprouts by Niedzielski and Mokrosińska (1990). Losses in vitamin C in New Zealand spinach were negligible, both in blanched and non-blanched samples. In parsley leaves, freezing caused much greater losses of vitamin C in non-blanched samples than in blanched ones. During freezing, losses of β carotene in parsley reached 27% in non-blanched samples, showing trace values in blanched variants. In all the vegetables, the losses of chlorophylls were significantly greater in non-blanched samples.

Table 2
Percentage L-ascorbic acid in vitamin C of fresh and frozen chive

Pre-freezing treatment	Before freezing	Storage temperature (°C)	After freezing and storage time in months				
			0	3	6	9	12
Non-blanched	96	−20	46	30	29	26	32
	96	−30	47	43	32	21	19
Blanched	95	−20	96	95	92	64	58
	95	−30	95	90	90	70	68

During storage of frozen chive, the level of the analysed components depended upon the period and temperature of storage and upon the blanching of the raw material. The content of dry matter changed to a non-significant degree; chlorophylls and nitrates underwent a fairly slow rate of changes but vitamin C and β carotene a relatively rapid one. It should be stressed that these observations chiefly concern non-blanched frozen products (Table 1, Fig. 1).

During storage of frozen chive, the content of vitamin C gradually decreased as was also observed in the case of other species of leafy vegetables (Jaworska & Budnik, 1996; Niedzielski & Mokrosińska, 1990). After 12 months, the level of vitamin C was reduced by 2–78% in relation to the value found directly after freezing. Greater losses occurred in non-blanched samples, increasing during storage in conditions of a higher temperature. After the storage period, the content of vitamin C/100 g of the product ranged from 14 to 88 mg, corresponding to 11–66% of the amount assessed in fresh chive leaves. The content of vitamin C in blanched samples exceeds that in non-blanched ones on average by 139%. After storage at −30°C, vitamin C content was by 243% greater than that assessed after storage at −20°C in the case of non-blanched samples and by 47% in that of blanched chive leaves. Also, Lisiewska and Kmiecik (1997) observed a better preservation of vitamin C in blanched parsley leaves during storage of the frozen product and in leaves stored at the lower temperature. There is a distinct decrease in the proportion of L-ascorbic acid in vitamin C of non-blanched products (Table 2).

During the 12-month storage of frozen chive, losses in β carotene were particularly great in non-blanched samples stored at −20°C, reaching 56% in relation to the product directly after freezing. A significantly lower level of losses (32%) was found in non-blanched chive stored at −30°C. In blanched samples, stored both at −20 and −30°C, no significant decrease in β carotene was found, the losses reaching 9 and 8%, respectively. In experiments with frozen dill after 21-days' storage, Chladek (1972) observed double the losses of β carotene in non-blanched samples as in blanched ones, after 7 months its preservation in non-blanched products reaching 58%. After 12-month's storage of frozen chive, β carotene content ranged from 1.74–3.09 mg/100 g of the product, depending on the factor analysed, the preservation of β carotene reaching 37–65% in relation to the raw material. Differences between blanched samples stored at −20 and −30°C were statistically non-significant with regard to both fresh and dry matter (Table 1, Fig.1).

The rate of decreases in chlorophyll content, during storage of frozen chive, depended decidedly on the blanching treatment and, in the case of non-blanched chive leaves, on the temperature of storage. Directly after freezing, the non-blanched samples contained 20% more chlorophyll than the blanched ones. After 6-month's storage the content of this component was the same in all the samples, being maintained at a similar level for the following 6 months in two blanched samples and in the non-blanched one at −30°C. After 12 months, the content of chlorophylls was 79–91 mg in 100 g of the frozen product, their preservation reaching 65–75% in relation to fresh chive leaves. In blanched chive leaves, and in a one non-blanched sample stored at −30°C, the content of chlorophylls was 13% greater than in a non-blanched sample stored at −20°C. It should be pointed out that, after 12-month's storage, the ratio of chlorophylls a and b was similar, ranging from 2.7 to 2.8, while in the raw material it reached 2.5. Also Bubicz et al. (1981) observed a greater stability of chlorophyll a than that of b in frozen leaf blades of celery. In general, chlorophylls were fairly stable constituents of frozen chive. Bubicz et al. (1981) did not find great losses of chlorophylls during storage of celery leaf blades. Nor did Lisiewska and Kmiecik (1997) or Philippon et al. (1986) in frozen parsley leaves, though, in the case of parsley, the losses increased with increasing storage temperature, as did those in frozen chive.

In the period of storage of frozen chive, the content of nitrates varied slightly, a distinct decreasing tendency being observed, which confirms data given in the literature concerning the freezing of various vegetable species (Kmiecik & Lisiewska, 1994). After the 12-month storage of frozen samples, a content of 236–330 mg NO_3/1000 g of the product was determined, corresponding to 58–81% of the amount recorded in raw chive. In samples blanched before freezing, the content of nitrates was on average 17% smaller than in non-blanched ones, though the difference was not statistically verified among all the samples investigated. Moreover, this content was 13% smaller in samples stored at −30°C than in those at −20°C. The applied analytical methods displayed the occurrence of nitrites, whose level, as given above, was very low, only to the 6th month of storage.

4. Conclusions

If the quality criterion of frozen chive is the level and preservation of vitamin C, even a 3-month storage of non-blanched frozen products practically cannot be used should the temperature maintained in the store be only −20°C. A lowering of the temperature to −30°C allows storage of frozen products for at least 6 months. If the quality criterion is the colour of frozen chive, expressed by the content of chlorophylls, this period may be considerably lengthened. The blanching pre-treatment of chive leaves permits a good preservation of vitamin C, β carotene, and chlorophylls at −20°C even for 12 months. The blanching of the raw material and a lowering of the storage temperature to −30°C ensure a very good preservation of vitamin C in frozen chive. Moreover, the freezing of blanched leaves distinctly helps the formation of blocks of a greater bulk density, thus decreasing the costs of storage of frozen products.

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