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THE EFFECT OF FREEZING CONDITIONS OF LEEK STORAGE ON THE LEVEL OF THAWING EFFLUENT

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Abstract. The study was undertaken to check the effect of freezing conditions of storing leek on the level of the thawing effluent. Research material was divided into three parts, each of them was stored in other conditions of freezing, at constant temperature of –25°C and –18°C, and at temperature varying from –25°C to –18°C, applying a 48-hour series of change. The amount of the thawing effluent was determined prior to cold storage and in 4-week series, through twenty-four weeks of storage. The said determiniations consisted in the measurement of the amount of effluent by placing frozen leek on a funnel, at room temperature. The measurements were made after three hours. An increase was observed in steady level of the thawing effluent depending on the time of cold storage. The biggest dynamics of increase in the thawing effluent was observed in the case of leek that was stored in conditions of varying temperature, whereas the smallest dynamics was achieved at the constant temperature of –25°C. The research showed that the level of effluent from thawing leek is influenced both by the rate of freezing and the time of cold storage, and by the stability of the storage temperature as well.

Keywords: frozen vegetables, fluctuation storage temperature, thawing effluent

INTRODUCTION

The common feature of raw materials and vegetable products susceptible to natural, irreversible changes in the physical, chemical and microbiological character is their short storage life. These transformations occur independently from each other, they are conditioned mutually, concerning single or more components in the product [2,9]. It is possible to slow down the rate of these transformations or to limit them through freezing the product. Both freezing as a process and long-lasting cold storage of frozen products cause a deterioration of their quality. The intensity of processes deteriorating the quality of products is related to the temperature of the products, to the time of cold storage, and to maintenance of storage temperature on a constant level [9,11].

The indicator of reversibility of the freezing process of products having tissue structure is the amount of effluent after their thawing, occurring as a result of damage to the tissue, cells and fibres by ice crystals. [3,8].

Variation in temperature is a phenomenon which is present at each step of the cooling chain, affecting the quality of food in cold storage. An estimation of the impact of the storage conditions of frozen leek on the amount of the thawing effluent was the purpose of the research carried out.

MATERIAL AND METHODS

The experimental material was leek frozen with fluidization method at a temperature from –38°C to –35°C. Prior to freezing the experimental material, no blanching had been applied. Leek is intended for consumption in crumbled form, and therefore prior to freezing it was cut up into small strips. The frozen material was stored in individual retail packages (bags made of polyethylene), containing ca 500 g of the product.

The whole experimental material was divided into three parts, each stored under different conditions at freezing: at constant temperature of –25°C and –18°C, and at temperature varying from –25°C for –18°C, applying a 48-hour series of change. The leek was subjected to physicochemical estimation prior to cold storage, repeated in a 4-week series throughout the twenty-four week period of storage. The amount of thawing effluent was determined by defrosting the experimental material.

The said determination consisted in the measurement of the amount of the effluent by placing frozen leek put on a funnel, at the room temperature. The measurements have been made after three hours. The results obtained were expressed in cm^3/100g of the product [4,12].

RESULTS AND DISCUSSION

The results of determination of the amount of thawing effluent are given in Table 1 and in Figure 1.

The data obtained show an increase in the steady level of the thawing effluent depending on the time of cold storage. The biggest dynamics of increase in the amount of thawing effluent was observed for leek that was stored in conditions of varying temperature, whereas the lowest dynamics was achieved at the constant temperature of –25°C.

The amount of the thawing effluent is impacted by the mechanical interaction between ice granules and the cellular structure of vegetables. Ice crystals are formed in intercellular space, and in quick-freezing such crystals may also appear inside the cells [1].

Table 1. Funnel-collected effluent of frozen leek depending on temperature and time of cold storage

Storage time (week)	Amount of the funnel-collected effluent (cm^3/100 g)											
	Storage temperature											
	–18°C				–25°C				–18°C/–25°C			
	Y_{av}	Δ%	Se(Y)	Ve	Y_{av}	Δ%	Se(Y)	Ve	Y_{av}	Δ%	Se(Y)	Ve
0	12.80	–	0.458	3.58	12.80	–	0.458	3.58	12.80	–	0.458	3.58
4	13.77	7.8	0.651	4.73	13.00	1.6	0.436	3.35	14.80	15.6	0.265	1.79
8	15.27	19.3	0.493	3.23	14.90	16.4	0.854	5.73	16.00	25.0	0.608	3.80
12	16.03	25.0	0.305	1.91	15.40	20.3	0.436	2.83	16.90	32.0	0.781	4.88
16	17.20	34.4	0.436	2.71	16.60	29.7	0.751	4.77	17.85	39.4	1.044	5.83
20	18.35	43.4	0.954	5.68	17.80	39.1	0.436	2.76	20.00	56.3	0.702	3.79
24	20.60	60.9	0.889	4.31	19.83	54.7	0.379	1.91	22.70	77.3	0.854	3.76

Source: Pukszta T.: The forecast durability of frozen food during storage [12]
n = 9, $Y_{av.}$ – arithmetic mean, Δ% – percentage change in level of the tested feature in relation to the output level, Se(Y) – standard deviation, Ve – coefficient of variation (%).

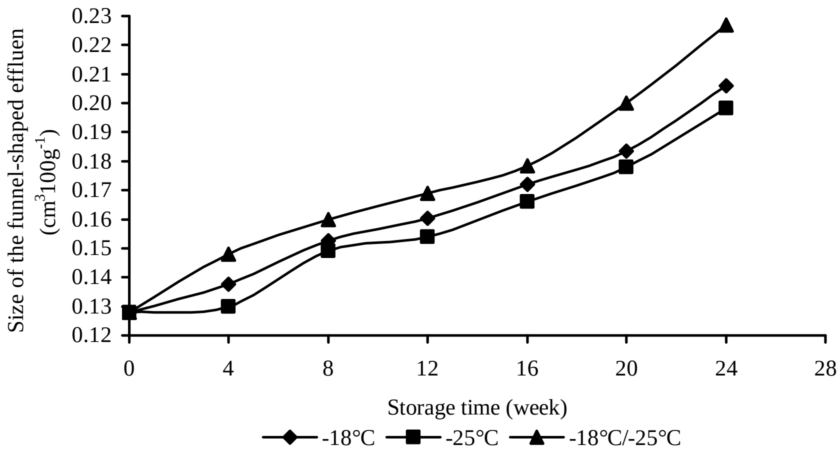

Fig. 1. Changes of the funnel-collected effluent of frozen leek stored in diversified temperature conditions [12]

With an increase in freezing rate and temperature, the number of crystals is considerably larger, but their sizes smaller. Therefore, too slow freezing causes the emergence of a small number of crystallizing centres, and ice granules increase in size to a much larger extent than the sizes of cells. This causes an increase in the thawing effluent. The formation of a network of small crystals requires quick temperature transition within the freezing range from –1°C to –5°C [8,10].

Research carried out by Woodroof [13] showed that during slow freezing of fruit and vegetables forming crystals of 0.2 x 0.8 mm destroyed more than 90% of cellular walls. With increasing freezing rate, the average diameter of ice crystals was smaller and smaller, however at freezing at the temperature of –18°C and using an immersion method crystals were situated entirely inside the cells.

The dependence of the amount of thawing effluent on freezing rate does not completely explain the phenomenon of its increase during cold storage. This increase is caused probably by the phenomenon of re-crystallization, resulting from increase in the size of ice crystals formed in the process of freezing at the cost of smaller vanishing crystals formed as a result of the variation in temperature during cold storage. This results in an increase in average size of crystals, leading to a decrease in the quality of stored products [5]. The steady increase in size of crystals resulting from re-crystallization systematically causes destruction of cellular walls and increases the amount of thawing effluent. This phenomenon takes place even in products stored at relatively constant temperature, although its extent is insignificant and dependent on storage time and temperature [1].

It was found that variation in the amount of the thawing effluent already after the first month of cold storage was conditioned by the level of storage temperature and its fluctuation (Tab. 1). The smallest amount of the effluent was reported at constant temperature of –25°C and a somewhat bigger during cold storage at constant temperature of –18°C. It was connected with the higher storage temperature which formed bigger crystals of ice, causing more damage to the cellular structure the leek stored. The biggest amount of the thawing effluent was observed in leek stored under the conditions of storage temperature fluctuating within the range from –25°C to –18°C (Fig. 1).

Moleeratanond and his collaborators [7] tested the thawing effluent of fruits and vegetables stored at four given temperatures: constant –23°C and variable temperature ranges of: –23°C to –18°C, –21°C to –18°C, and –18°C to –15°C. They found that there was a substantial dependence of the effluent amount on the storage temperature and its fluctuation. The amount of the effluent was the lowest at the first given temperature, but it was absolutely the highest for the last range of the given temperatures. Moreover, they showed a correlation between the amount of the effluent and the location of the product in the chamber. A higher level of thawing effluent was reported by them for packages located in outside layers, which showed that there is a bigger range of occurrence of phenomena of variation in the internal temperature of a product in outside layers than in layers closer to the centre of the storage chamber.

The results obtained from the experimental studies were subjected to statistical variance analysis (ANOVA). A null hypothesis has been formulated about the lack of interaction of the temperature and time of freezing storage of leek with the amount of the thawing effluent. The calculated F relations were higher if compared with those of tabular critical F values [6] for the effect of temperature and time of freezing storage on changes in the amount of the thawing effluent. The null hypothesis was rejected on this basis, with the probability of error on the level of 0.001% (Tab. 2). The statistical analysis carried out for determining the variance of experimental results showed average substantial differences in the dynamics of changes in the amount of the thawing effluent of frozen leek, depending on the temperature and time of cold storage.

Table 2. Statistical variance analysis (ANOVA)

Sources of variability	SK	df	OW	$F_{calculated}$	$F_{critical}$ for significance level				P
					0.05	0.025	0.01	0.001	
Temperature	8.474	2	4.237	18.59	3.88	5.10	6.93	12.97	<0.001
Storage time	144.3	6	24.06	105.5	3.00	3.73	4.82	8.38	<0.001
Error	2.735	12	0.228						
Total	155.5	20							

SK – number of squares, df – degree of freedom, OW – estimation of variance, F – relations of F distribution, P – probability of making the error of the first kind (%).

SUMMARY

To sum up, it is possible to state that the amount of effluent from thawing leek is influenced both by the freezing rate and the time of cold storage, as well as by the stability of the storage temperature. The course of the process of transformation of phase water into ice depends on the freezing rate; however, variation in storage temperature results in intensification of re-crystallization phenomena causing destructive changes in the cellular structure of the stored product. After thawing, changes appear that include deteriorated texture and an increase in the effluent of juices. The loss of soluble components, caused by the effluent, results in a substantial deterioration of the quality of vegetables stored in the frozen form.

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WPŁYW ZAMRAŻALNICZYCH WARUNKÓW PRZECHOWYWANIA PORA NA WIELKOŚĆ WYCIEKU ROZMRAŻALNICZEGO

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S t r e s z c z e n i e. W pracy podjęto badania dotyczące wpływu zamrażalniczych warunków przechowywania pora na wielkość wycieku rozmrażalniczego. Materiał badawczy przechowywano w temperaturze stałej –25°C i –18°C oraz w temperaturze zmiennej od –25°C do –18°C z 48 godzinnym cyklem zmiany. Wielkość wycieku rozmrażalniczego oznaczono przed przechowywaniem oraz w cyklu czterotygodniowym przez dwadzieścia cztery tygodnie przechowywania. Oznaczenie polegało na pomiarze objętości wycieku pora umieszczonego na lejku, w stanie zamrożonym, w temperaturze pokojowej. Pomiaru dokonywano po trzech godzinach. Stwierdzono stały wzrost wielkości wycieku rozmrażalniczego w raz z czasem przechowywania. Największą dynamiką wzrostu wycieku rozmrażalniczego charakteryzował się por przechowywany w warunkach fluktuacji temperatury, najmniejszą zaś w temperaturze stałej –25°C. Przeprowadzone badania wykazały, że na wielkość wycieku rozmrażanego pora wpływa zarówno szybkość zamrażania jak i czas przechowywania oraz stałość temperatury przechowywania.

S ł o w a k l u c z o w e: zamrożone warzywa, fluktuacja temperatury przechowywania, wyciek rozmrażalniczy