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STORAGE OF FROZEN GREEN PEA AND POSSIBILITIES OF ITS DURABILITY PROGNOSIS

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A b s t r a c t. The aim of undertaken research was to determine possibilities of usage of mathematical description of frozen green pea quality changes in its durability prognosis. The research material was stored at a constant temperature of –25°C and –18°C and at a temperature varying from –25°C to –18°C with a 48-hour change cycle. On the basis of achieved storing research results, critical features were specified, that is the chlorophyll content, vitamin C content and sensory evaluation. Changes of the critical features of the studied vegetable in all storing variants were described with series of curves with specified equations. As a result of performed regression analysis and determination of fitting to empirical data, increased universality for prognosis of frozen green pea durability was stated for a model with a linear form.

K e y w o r d s: critical features, durability prognosis, frozen green pea, frozen vegetables

INTRODUCTION

Freezing as a technological process securing the product from decrease of its quality in time of storage has a limited time character (Betlińska *and* Bońca 2000, Klimczak *and* Irzyniec 2000, Postolski 2000). Loss of food products quality features is an extremely complex matter, and trying to reduce all its factors of degradation to one element would be groundless. That is why, in research on the factors forming the product quality, a wide gamut of parameters is taken into consideration and which, as a result of their time change, narrow analysis down to a few critical features (Heiss 1978, Stokłosa *et al.* 1985).

Transformations made in food have a complex character. This causes that product durability prognosis, selection of optimal storage conditions, proper type of packaging or modelling of production technological parameters must be based on results of tests made on series of products in a given group. Storage researches that aim at the determination of products quality changes in storage time are time-consuming, labour-consuming, and require significant financial resources. An alternative for those researches would be to create proper models allowing determination of product quality maintenance period under conditions determined by environment conditions, or to specify optimal environment climatic parameters with the aim of maximally extending the time in which the product will be characterized by a quality acceptable by the consumer (Horubała 1975, Palich 1993).

The aim of undertaken researches was to determine the possibilities of usage of mathematical description of frozen green pea quality changes in its durability prognosis.

MATERIAL AND METHODS

The study was realized in three stages.

In the first stage physicochemical tests were performed that aimed at determination of critical features of frozen vegetables during their storage in differentiated temperature conditions.

The tested material was green peas frozen by the fluidisation method, in the sharp freezer in Gronowo Górne near Elbląg. Temperature applied when freezing was from –38°C to –35°C during 5-6 hours, until the moment of obtaining by the product the temperature of –18°C in its thermal centre. Before freezing of green pie the blanching process was carried out, in the temperature of 98°C, during 2 minutes. The frozen vegetable was transported in transport packing of three-layer paper bags covered with polyethylene film, to the laboratory of the Gdynia Maritime University where it was repacked to polyethylene bags widely used in retail, containing ca. 500 g of the product.

Whole experimental material was divided into three parts constituting the following storage variants: variant A – material stored in a chamber freezer at permanent temperature of –18°C, variant B – material stored in a chamber freezer at permanent temperature of –25°C, variant C – material stored in a chamber freezer at variable temperature of –18°C/–25°C with 48-hour change cycle.

The experimental material was stored for 24 weeks and was a subject for physicochemical and sensory evaluation before storage and in four-week cycles during the storage time. The sensory evaluation was carried out with the five-point method (according to Baryłko-Pikielna) using the point evaluation chart of the thawed vegetable. Physicochemical determinations included chlorophyll content with the Vernon method and 1-ascorbic acid content with the Tillmans method.

The second stage of the study was the mathematical analysis of the dynamics of changes and the course of determined quality ratios to identify the critical features of frozen green pea in the course of storage.

The third stage was the construction of a mathematical model of the product critical feature changes, elements of which were parameters of linear, square, exponential, power or hyperbolic functions that could be used for evaluation, characterisation, determination of scope and dynamics of processes causing loss of quality of frozen products of plant origin in the course of storage (Pukszta 2004).

RESULTS AND DISCUSSION

Achieved results of the study on frozen green pea storage indicate a permanent decrease of its quality during the storage time.

As a result of mathematical analysis of changes of the dynamics and course of determined quality indices, critical features of the frozen product were identified in the storage time, among which accepted were the chlorophyll content, vitamin C content and sensory evaluation. Also the critical values for particular features were determined. On the basis of literature (Kramer *et al*. 1982), for the content of chlorophyll and vitamin C, limits of 40% product quality critical losses were accepted. However, for the sensory evaluation a critical value was accepted at the level of 3.50 points. Changes of those features during the storage of frozen pea are presented in Figures 1, 2 and 3.

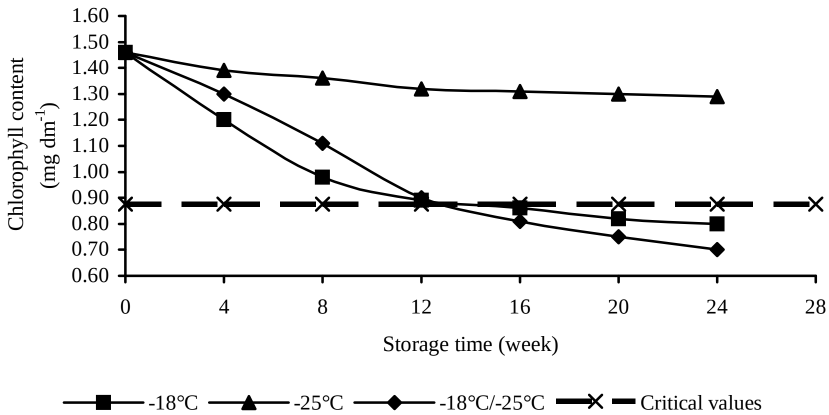

Fig. 1. Changes of chlorophyll content in frozen green pea stored in diversified temperature conditions (Pukszta 2004)

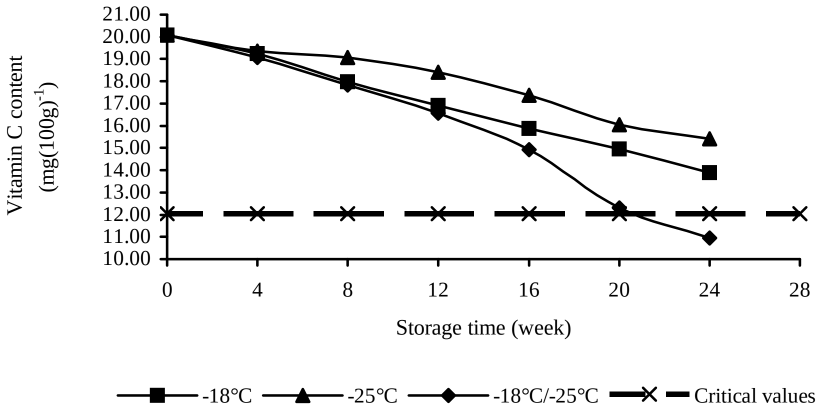

Fig. 2. Changes of vitamin C content in frozen green pea stored in diversified temperature conditions (Pukszta 2004)

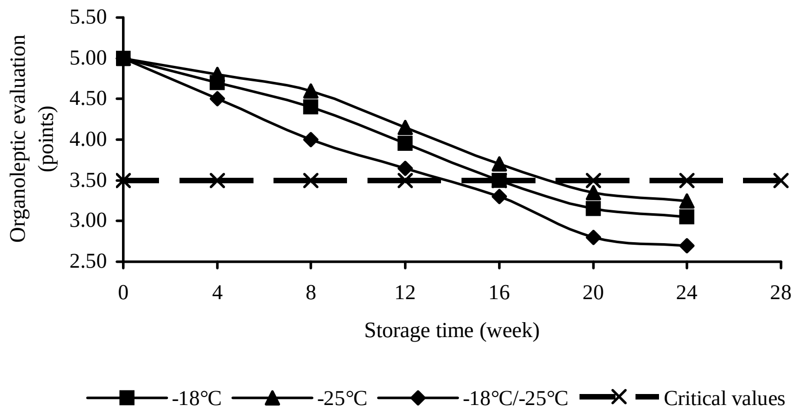

Fig. 3. Changes of sensory evaluation of frozen green pea stored in diversified temperature conditions (Pukszta 2004)

Taking into consideration the fact that storage studies aimed at the determination of existence of feature changes in products stored in different temperature conditions are time-consuming and require notable financial resources, studying each product in, for example, a 24-week cycle, is impossible. In connection with the above, the presented achieved results are generalized via a construction of universal mathematical models.

Changes of critical features of the studied products in all storage variants are described with a series of curves with determined equations. Many functions were tested, from among which those best fitting to empirical data were chosen, which is presented in Tables 1, 2 and 3.

Table 1. Mathematical models of chlorophyll content changes in frozen green pea

Temperature	Function form	Parameters of function			Fitting measures				
		a	b	c	R	S	φ^2	Se	Ve
–18°C	$Y = a + bx$	1.311	–0.004	–	0.906	0.064	0.180	0.113	11.29
	$Y = a + bx + cx^2$	1.449	–0.009	$3 \cdot 10^{-5}$	0.993	0.005	0.015	0.036	3.63
–25°C	$Y = a + bx$	1.427	–0.001	–	0.936	0.003	0.125	0.024	1,75
	$Y = a + bx + cx^2$	1.456	–0.002	$-7 \cdot 10^{-6}$	0.994	$3 \cdot 10^{-4}$	0.012	0.008	0.61
–18°C/ –25°C	$Y = a + bx$	1.403	–0.005	–	0.972	0.028	0.056	0.075	7.52
	$Y = a + bx + cx^2$	1.493	–0.008	$2 \cdot 10^{-5}$	0.996	0.004	0.008	0.031	3.08

Source: Pukszta T.: The forecast durability of frozen food during storage (Pukszta 2004)
R – correlation coefficient, S – square of sum of deviations, φ^2 – indetermination coefficient (concurrence), Se – average miscalculation error, Ve – coefficient of variation (%).

Table 2. Mathematical models of vitamin C content changes in frozen green pea

Tempera-ture	Function form	Parameters of function			Fitting measures				
		a	b	c	R	S	φ^2	Se	Ve
–18°C	$Y = a + bx$	20.158	–0.037	–	0.999	0.048	0.002	0.098	0.58
	$Y = a + b x + cx^2$	20.203	–0.039	$1 \cdot 10^{-5}$	0.999	0.042	0.001	0.103	0.60
–25°C	$Y = a + bx$	20.388	–0.028	–	0.984	0.571	0.031	0.338	1.88
	$Y = a + bx + cx^2$	20.043	–0.014	$-8 \cdot 10^{-5}$	0.994	0.203	0.011	0.225	1.25
–18°C/ –25°C	$Y = a + bx$	20.705	–0.056	–	0.989	1.440	0.021	0.537	3.36
	$Y = a + bx + cx^2$	20.125	–0.032	$-1 \cdot 10^{-4}$	0.997	0.404	0.006	0.318	1.99

Source: Pukszta T.: The forecast durability of frozen food during storage (Pukszta 2004)
R – correlation coefficient, S – square of sum of deviations, φ^2 – indetermination coefficient (concurrence), Se – average miscalculation error, Ve – coefficient of variation (%).

Table 3. Mathematical models of sensory evaluation changes of frozen green pea

Temperature	Function form	Parameters of function			Fitting measures				
		a	b	c	R	S	φ^2	Se	Ve
–18°C	$Y = a + bx$	5.032	–0.013	–	0.992	0.053	0.015	0.103	2.61
	$Y = a + b x + cx^2$	5.079	–0.014	$1 \cdot 10^5$	0.993	0.047	0.013	0.108	2.73
–25°C	$Y = a + bx$	5.103	–0.011	–	0.988	0.069	0.023	0.118	2.85
	$Y = a + bx + cx^2$	5.087	–0.011	$-4 \cdot 10^6$	0.989	0.068	0.023	0.131	3.17
–18°C/ –25°C	$Y = a + bx$	4.900	–0.014	–	0.992	0.071	0.016	0.119	3.21
	$Y = a + bx + cx^2$	5.024	–0.019	$3 \cdot 10^5$	0.997	0.023	0.005	0.076	2.05

Source: Pukszta T.: The forecast durability of frozen food during storage (Pukszta 2004)
R – correlation coefficient, S – square of sum of deviations, φ^2 – indetermination coefficient (concurrence), Se – average miscalculation error, Ve – coefficient of variation (%).

The basis for selection of curve equation was the correlation coefficient (R), at established confidence level ($\alpha = 0.01$) and square of sum of deviations (S). Analysis of determined fitting measures showed that the best fitting to given empirical changes of frozen green pea critical features, at established confidence level, characterized the square and the linear functions.

Determined function equations describing the course of researched features with specified probability allow for determination of feature's level after optional storage time and for stored green pea durability prognosis. Comparison, depending on the storage temperature and critical features, of storage durability of a frozen product counted on the basis of determined mathematical models with experimental values is presented in Table 4.

Application of square function for prognosis of changes beyond the scope of temperatures included in the experiment, despite of better fitting to the empirical values being the basis of model derivation, creates a possibility to make a mistake in the durability prognosis. After exceeding the range of temperatures on which the square model was established, a limitation of function course character can occur (inversion of tendency after exceeding the extreme). Therefore bigger universality for prognosis of frozen green pea critical features changes has been specified for a linear model. Mathematical model constructed on the basis of square function can be used for this purpose only within the range of temperatures used during the experiment that is the basis for derivation of this model.

Table 4. Comparison of storage time of frozen green pea on the basis of mathematical model with experimental values

Critical features	Temperature	Durability of the product (days)		
		Experimental values	Model on the basis of linear function	Model on the basis of square function
Chlorophyll content	–18°C	97	121	83
	–25°C	>168*	613	168
	–18°C/–25°C	91	121	95
Vitamin C content	–18°C	>168*	217	220
	–25°C	>168*	293	240
	–18°C/–25°C	145	155	167
Sensory evaluation	–18°C	112	122	140
	–25°C	128	139	138
	–18°C/–25°C	96	100	93

* – researched quality coefficient did not exceed the critical value during 24-week storage period.
Source: own composition.

CONCLUSIONS

1. Quality features of frozen green pea stored in differential temperature conditions that are subject to the quickest change are: chlorophyll content, 1-ascorbic acid content. Those features should be considered as critical in evaluation of those products quality.

2. Mathematical model constructed on the basis of square function can be used for durability prognosis only in the range of temperatures being the basis for its derivation.

3. Mathematical model using the linear function equation can be used for quality prognosis for stored frozen green pea in any temperature conditions.

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PRZECHOWYWANIE MROŻONEGO GROSZKU ZIELONEGO I MOŻLIWOŚCI PROGNOZOWANIA JEGO TRWAŁOŚCI

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Streszczenie. Celem podjętych badań było określenie możliwości wykorzystania matematycznego opisu zmian jakości zamrożonego groszku zielonego w prognozowaniu jego trwałości. 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. Na podstawie uzyskanych wyników badań przechowalniczych wyznaczono cechy krytyczne, za które uznano zawartość chlorofilu, zawartość witaminy C i ocenę organoleptyczną. Zmiany cech krytycznych badanych warzyw we wszystkich wariantach przechowalniczych opisano szeregiem krzywych o ustalonych równaniach. W wyniku przeprowadzenia analizy regresji funkcji i oceny jej dopasowania do danych empirycznych, większą uniwersalność do prognozowania trwałości zamrożonego groszku zielonego, stwierdzono dla modelu o postaci liniowej.

Słowa kluczowe: cechy krytyczne, prognozowanie trwałości, zamrożony groszek zielony, zamrożone warzywa