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Agnieszka GRZELAKOWSKA[1*], Joanna CIEŚLEWICZ[1] and Małgorzata ŁUDZIŃSKA[1]

THE DYNAMICS OF VITAMIN C CONTENT IN FRESH AND PROCESSED CUCUMBER (*Cucumis sativus* L.)

DYNAMIKA ZMIAN ZAWARTOŚCI WITAMINY C W OGÓRKU ŚWIEŻYM (*Cucumis sativus* L.) I JEGO PRZETWORACH

Abstract: The objective of the proposed experiment was to determine changes in the content of vitamin C in the vegetable material (fresh and processed) during a certain period of time, and to determine the optimal expiry date of a product (in terms of the vitamin C content), as well as to introduce students to common factors adversely affecting the content of vitamin C in food products (with a special emphasis on oxidizing enzymes). The research revealed that regardless of the type of cucumbers (fresh, pickled in brine or in vinegar), the content of vitamin C is rapidly dropping after the destruction of the cellular structure (grating, slicing etc.). In the case of fresh cucumbers, it is a process determined by two factors: release and activation of ascorbinase from the destroyed cellular structure and availability of oxygen. Low pH values in the remaining cases reduce the effect of ascorbinase, and a decrease in the vitamin C content is related to the process of oxidation with atmospheric oxygen.

Keywords: classes for students, vitamin C, Tillman's reagent, cucumber

Introduction

Vegetable gardening is one of the most important branches of the Polish horticulture. Poland holds the second place in the EU in the production of cucumbers (the harvest in 2009 was 256,000 Mg) [1]. Poland is also the second, after Belgium, producer of frozen vegetables in the EU and the largest producer of pickled vegetables and dried carrot [2]. During the last ten years a decrease in the consumption of raw vegetables has been observed in favour of their preserves.

One of the educational methods in the fields related to food processing and analysis should be training of students for designing new food products. Food of the 21st century is mostly highly processed, but on the other hand consumers being more and more aware of healthy properties of food products expect them to meet specific requirements, and this affects the development of functional food [3-5]. When presenting a new product,

[1] Department of Environmental Chemistry, Faculty of Agriculture and Biotechnology, University of Technology and Life Sciences, ul. Bernardyńska 6/8, 85-029 Bydgoszcz, Poland, phone +48 52 374 95 02, email: joanna@utp.edu.pl, mludz@utp.edu.pl
[*]Corresponding author: agrzel@utp.edu.pl

corresponding to specific requirements of the society (related to *eg* civilization diseases - obesity or diseases of the cardiovascular system), one should be aware of transformations particular components of raw materials undergo during their processing and storage [6]. Also stability of a product after opening a sales package is important. Vitamins, and in particular vitamin C, are among the most common substances introduced into food products in order to increase their functionality. When designing a new food product, due to low stability of vitamins, it is important to take account of changes they undergo after a sales package is opened and provide an expiry date by which their properties are preserved.

Because of its chemical structure, vitamin C is a primary antioxidant, and its function in pathological conditions has been continuously researched and discussed [7]. Vitamin C plays an important role in the regulation of antioxidant mechanisms, which are associated with protection of cells and body fluids against oxidative stress (*ie* it affects the rate of ageing) [6-10]. Vitamin C is one of the least stable vitamins. It is readily oxidizable even with atmospheric oxygen, decomposable under the influence of ultraviolet radiation, at an elevated temperature and in the presence of heavy metals.

The proposed classes have the following objectives:

- introduction of students to quantitative determination of vitamin C in the plant material by Tillmans' method,
- introduction of students to restrictions of this method and potential sources of errors,
- an attempt at determining changes in the content of vitamin C in the vegetable material (fresh and processed), as well as determining the optimal expiry date of a product (in terms of the vitamin C content),
- introduction of students to common factors adversely affecting the content of vitamin C in food products (with a special emphasis on oxidizing enzymes).

Due to the differences in the biological material, all analyses should be performed during one laboratory class (4 classroom hrs, *ie* 3 hrs) - assuming that reagents are prepared by engineering-technical staff. With an exceptionally favourable schedule of classes, the last measurement can be made the following day (after 24 hours). It seems useful to have 1-2 hours of introductory seminars with active participation of students.

Material and methods

Cucumbers were selected for the study because of their considerable contribution in the diet of the European population, both fresh and in the form of preserves. In Poland, apart from fresh cucumbers, the most frequently consumed preserves include cucumbers pickled in brine and vinegar. Furthermore, cucumbers are an interesting educational material due to high content of ascorbinase - an enzyme from the group of oxidizing enzymes, which due to its considerable activity reduces the vitamin C content in a product.

We used fresh cucumbers, as well as those pickled in vinegar and in brine (from retail packages). The study material consisted of whole vegetables together with peel.

The content of dry matter was determined in the analysed material applying the gravimetric method according to PN-90/a-75101/03. The method consists in drying the samples to constant weight in defined conditions of pressure and temperature, and computing the percentage of dry residue in a sample before drying.

The content of dry matter was calculated from the formula:

$$S = (m_2 - m)/(m_1 - m) \cdot 100\%$$

where: m - the weight of an empty weighing vessel, m_1 - the weight of an empty weighing vessel with a weighed sample before drying, m_2 - the weight of an empty weighing vessel with a weighed sample after drying.

The content of vitamin C was determined in the homogenized material at the following four intervals: after 10 minutes, after 2 hours, after 4 hours and after 24 hours applying Tillmans' method according to PN-71/A/75101. This is a titrimetric method based on the colour reaction of ascorbic acid with a solution of 2.6-dichloroindophenol (Tillmans' reagent). Titrant solution (2.6-dichloroindophenol) with a concentration of *ca*. $3.5 \cdot 10^{-4}$ mol/dm^3 was standardized directly before the analysis to a standard solution of ascorbic acid. The homogenized biological material was weighed (the average weight of analytical samples was 3 g - defined on the basis of the literature data and the authors' own research on the vitamin C content in cucumbers - Table 1), and 25 cm^3 of 2% solution of hydrochloric acid was added and titrated till light pink colour was obtained and lasted for 10 sec. Each determination was performed in triplicates. The pH value for samples was determined in the homogenized material. In the case of cucumbers pickled in brine and in vinegar, the pH value of pickle and brine solution, as well as the vitamin C content were also determined by Tillmans' method.

Table 1

The content of vitamin C in mg/100 g of edible parts

The type of cucumbers	Vitamin C	References
fresh	5.5-10.4	[1, 10-13]
pickled in brine	2	[1]
pickled in vinegar	5	own research

Results

Table 2 presents the content of vitamin C at the studied moments of time. The highest content of vitamin C was determined for samples of fresh cucumber 10 min after a sample was prepared. Both cucumbers pickled in brine and in vinegar were characterised by a lower content of vitamin C. In the case of fermented preserves (cucumbers pickled in brine), both the process of fermentation [14] and final pasteurization (high temperature) result in a lower content of vitamin C compared with fresh cucumbers (Table 1). In the case of cucumbers pickled in vinegar, low content of vitamin C in the studied product is related to heat treatment during the manufacturing process. As compared with initial determinations, a decrease in the vitamin C content was observed in all analysed variants.

Table 2

The content of vitamin C in mg/100 g of edible parts [in mg/100 g of dry matter]

The type of cucumbers	10 min	2 h	4 h	24 h
fresh	9.87 (237.24)	7.46 (179.45)	3.71 (89.30)	2.75 (66.12)
pickled in brine	7.38 (120.28)	4.42 (71.95)	2.87 (46.81)	2.98 (48.48)
pickled in vinegar	5.29 (81.52)	3.60 (55.55)	3.47 (53.49)	2.95 (60.85)

It should be noted that cucumbers pickled in vinegar were characterised by the most stable vitamin C. Fresh cucumbers proved to be the most susceptible to losses of vitamin C - Figure 1. This is related to high activity of oxidation enzymes (in particular ascorbinase).

A lower pH value for preserves (Table 3) reduces the activity of ascorbinase [11, 14, 15], therefore no such rapid reduction of the vitamin C content has been observed. The presence of vitamin C in pickle and brine solutions (Table 4) can be accounted for by water solubility of this vitamin.

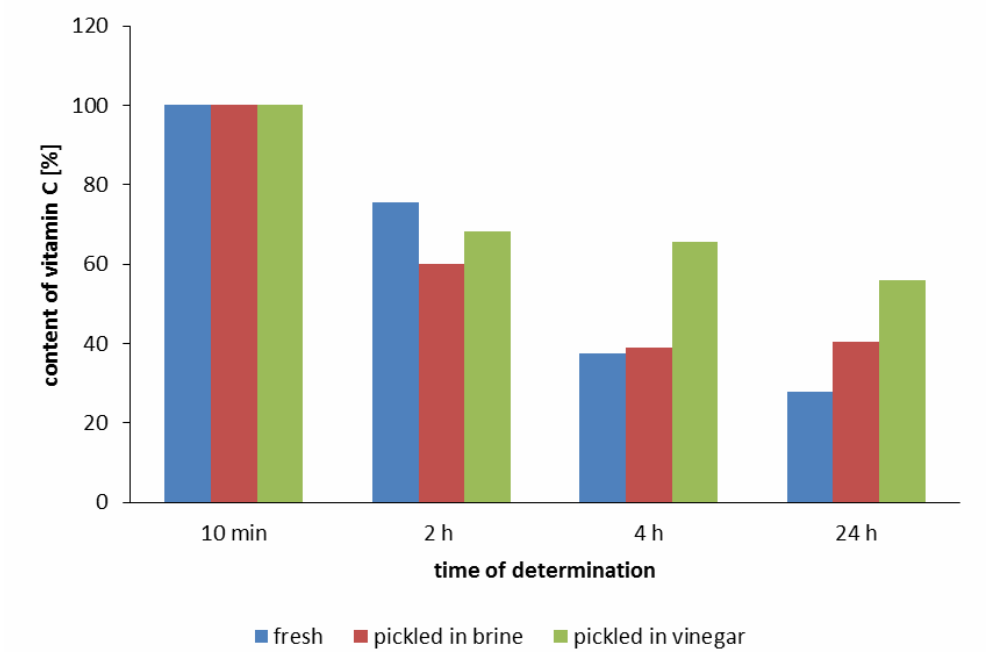

Fig. 1. Vitamin C residue expressed as a percent of the initial value for each variant

Table 3

pH values for homogenized cucumbers

The type of cucumbers	10 min	2 h	4 h	24 h
fresh	5.85	5.98	6.00	5.68
pickled in brine	3.94	3.94	3.93	3.96
pickled in vinegar	4.29	4.28	4.26	4.28

Table 4

The content of vitamin C in the solution from cucumbers pickled in brine and vinegar [mg/100 cm^3] and pH values for the solution

Brine/vinegar solution	Vitamin C [mg/100 cm^3]	pH
cucumbers pickled in brine	5.56	3.96
cucumbers pickled in vinegar	2.58	4.29

Summary

The research revealed that regardless of the type of cucumbers (fresh, pickled in brine or in vinegar), the content of vitamin C is rapidly dropping after the destruction of the cellular structure (grating, slicing *etc*.). In the case of fresh cucumbers, it is a process

determined by two factors: release and activation of ascorbinase from the destroyed cellular structure and availability of oxygen. Low pH values in the remaining cases reduce the effect of ascorbinase, and a decrease in the vitamin C content is related to the process of oxidation with atmospheric oxygen. It is noteworthy that pickle or brine solution is a rich source of vitamin C, particularly in the case of cucumbers pickled in brine. In the winter season, when field cucumbers are not available, when making a choice between cucumbers pickled in brine or vinegar, one should consider that the content of vitamin C in the latter is more stable during 24 hours after preparation for consumption.

A report should include recommendations as to the form and expiry date of the analysed products in order to preserve their valuable properties.

The experiment can be performed for other plant materials, but this requires adjusting the size of weighed amounts.

This approach to the problem can constitute a valuable experiment and preparation for solving the development tasks as part of the engineering work.

References

[1] Rocznik Statystyczny Rolnictwa. Produkcja roślinna. Warszawa: GUS;2010.
[2] Filipiak T, Maciejczak M. Produkcja warzyw w Polsce i w wybranych krajach UE. Rocz Nauk Roln. 2010;97(Seria G):1-11.
[3] Grajeta H. Żywność funkcjonalna w profilaktyce chorób układu krążenia. Adv Clin Exp Med. 2004;13(3):503-510.
[4] Kunachowicz H, Kłys W. Żywność funkcjonalna. Wpływ dodatku prebiotyków i probiotyków na wartość odżywczą żywności. Pediatr Współ Gastroenterol, Hepatol Żyw Dziecka. 2002;4(1):33-40.
[5] Pieszka M, Pietras MP. Nowe kierunki w badaniach żywieniowych - nutrigenomika. Rocz Nauk Zoot. 2010;37(2):83-103.
[6] Mazurek A, Jamroz J. Stabilność witaminy C w sokach owocowych i nektarze z czarnej porzeczki podczas przechowywania. Acta Agrophys. 2010;16(1):93-100.
[7] Kleszczewska E. Biologiczne znaczenie witaminy C ze szczególnym uwzględnieniem jej znaczenia w metabolizmie skóry. Pol Merk Lek. 2007;XXIII(138):462-465.
[8] Gallie DR. Ascorbic acid: A multifunctional molecule supporting plant growth and development. Scientifca. 2013; Article ID 795964. DOI: 10.1155/2013/795964.
[9] Gallie DR. Increasing vitamin C content in plant foods to improve their nutritional value successes and challenges. Nutrients. 2013;5:3424-3446. DOI: 10.3390/nu5093424.
[10] Maćkowiak K, Torliński L. Współczesne poglądy na rolę witaminy C w fizjologii i patologii człowieka. Now Lek. 2007;76(4):349-356.
[11] Elmadfa I, Muskat E. Wielkie tabele kalorii i wartości odżywczych. Warszawa: Muza SA; 2003.
[12] Wierzbicka B, Kuskowska M. Wpływ wybranych czynników na zawartość witaminy C w warzywach. Acta Sci Pol, Hort Cult. 2002;1(2):49-57.
[13] Meiklejohn GT, Stewart CP. Ascorbic acid oxidase from cucumber. Biochem J. 1941;35:755-760.
[14] Pierzynowska J, Prędka A, Drywień M, Ostrowska K. Porównanie zawartości witaminy C w wybranych świeżych i fermentowanych sokach warzywnych. Bromat Chem Toksykol. 2007;XL(4):341-344.
[15] Zhou A, McFeeters RF, Fleming HP. Inhibition of formation of oxidative components in fermented cucumbers by ascorbic acids and turmeric. J Agric Food Chem. 2000;48:4910-4912.

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Katedra Chemii Środowiska, Wydział Rolnictwa i Biotechnologii
Uniwersytet Technologiczno-Przyrodniczy w Bydgoszczy

Abstrakt: Celem proponowanego ćwiczenia było podjęcie próby określenia zmian zawartości witaminy C w surowcu roślinnym oraz jego przetworach w czasie i określenia optymalnego czasu spożycia produktu (ze względu na zawartość witaminy C) oraz zapoznanie studentów z powszechnie występującymi czynnikami niekorzystnie wpływającymi na zawartość witaminy C w produktach żywnościowych (ze szczególnym uwzględnieniem enzymów z grupy oksydaz). Przeprowadazone badania wykazały, że niezależnie od rodzaju ogórków (świeże, kiszone, konserwowe) po zniszczeniu stuktury komórkowej (tarcie, krojenie itd.) zawartość witaminy C gwałtownie spada. W przypadku ogórków świeżych jest to proces determinowany przez dwa czynniki: uwolnienie i aktywacja askorbinazy ze zniszczonych struktur komórkowych oraz dostęp tlenu. Niskie wartości pH w pozostałych przypadkach ograniczają działanie askorbinazy, a spadek zawartości witaminy C jest związany z procesem utleniania tlenem atmosferycznym.

Słowa kluczowe: ćwiczenie dla studentów, witamina C, odczynnik Tillmansa, ogórek