DEGRADATION KINETICS OF ASCORBIC ACID IN HOME-MADE JUICES

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Introduction

Vegetables and fruits are an accessible source of food which contains a great amount of nutrients, including antioxidants (vitamin C, vitamin E, phenols, flavones, etc.). Ascorbic acid (vitamin C) is a powerful reducing agent and it oxidizes irreversibly to dehydroascorbic acid [1]. AA (ascorbic acid) is involved in numerously physiological functions, the most important being the synthesis of collagen. Also, the studies revealed great antibacterial and antiviral properties [2]. Degradation of AA has been discovered to follow a first order kinetics, but can be modeled also using a zero order or a Weibull model [3, 4]. In this article, the stability of AA was studied in orange, lemon, kiwi, mangosteen, granadilla, ginger juices and mixed half-lemon, half-ginger juices, during storage, at room temperature and refrigerated. The results showed the degradation of AA respects the ones found in literature. The degradations of the juices were slowed down by the low temperature, in comparison with the ones at room temperature. Also, it was discovered that the ginger and lemon juices degradations are faster than the mixed juice (half-lemon, half-ginger).

Matherials and methods

Juices samples

The juices were obtained from fruits bought from the supermarket and were manually squeezed and centrifuged. Half of them were kept in the fridge, and the other half were kept at room temperature

Matherials

The determination was made using a JASCO V-530 spectrophotometer and 1 cm cuvettes. The centrifuge used was Centric 322A. The regents used were: 1, 10- phenantroline 10^{-3}M, ferric chloride 10^{-3}M and HCl 1M.

Methods

AA was determined using a 1, 10-phenantroline- Fe(III) complex (yellow color), reaction based on its property of reducing Fe(III) to Fe(II), with the formation of Fe(II) -1,10-phenantroline complex which is reddish and the absorbance was measured after 30 minutes, at 515 nm.

Results and discussions

Calibration curve

The calibration curve was obtained for concentrations of AA between 0-10 µg/ml. The results are sown in Figure 1.

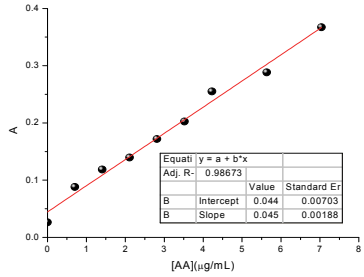

Figure 1. Calibration curve for AA.

The determination of AA is possible in the ranges of 0-10 µg/ml using the following equation (1):

$A=0.044+0.045C_{AA}$, (1)

where A- the absorbance of the sample

C_{AA}-the concentration of AA in the sample

Comparison of the juices

Using equation (1) the AA content of diluted juices (1:10) was measured from time to time, for 72 hours. Some of the results are shown in figure 2 for ginger juice (comparison between room temperature and refrigerator), in figure 3 for lemon juice (also comparison) and in figure 4 for the mixed juice (also comparison).

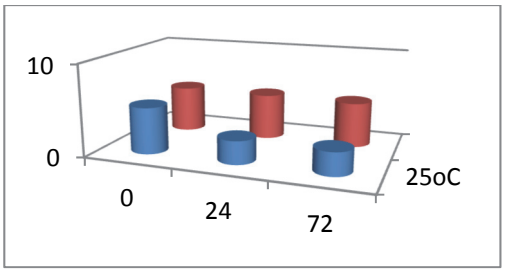

Figure 2. Degradation of AA in ginger juice at 25^0 and 4^0.

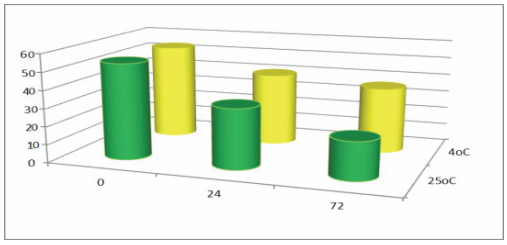

Figure 3. Degradation of AA in lemon juice at 25^0 and 4^0.

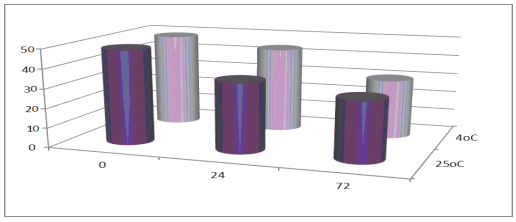

Figure 4. Degradation of AA in mixed juice(lemon and ginger) at 25^0 and 4^0.

From the results obtained for the three juices, it appears the mixed juice has a better stability than the single ones.

Ascorbic acid content in juices

The initial content of AA and the content after 24 hours have been compared and the results can be viewed in Table 1. By comparing the two sections it is easily to see how much the concentration of AA decreases. Also, it gives great information about the amount of AA contained by the fruit.

Degradation kinetics

The degradation kinetics was studied for the orange juice, at 25^0C (room temperature). The concentration of AA is shown in figure 5.

Juice	$[AA]_0$ (mg/100ml juice)	$[AA]_{24h}$ (mg/100ml juice)
orange	41.7	36.2
lemon	53.7	33.5
ginger	5.08	2.53
ginger/lemon	48.6	35.5
kiwi	108.2	82.1
mangosteen	2.73	2.34
granadilla	26.6	22.2

Tabel 1. The initial content of AA in juices and after 24 hours.

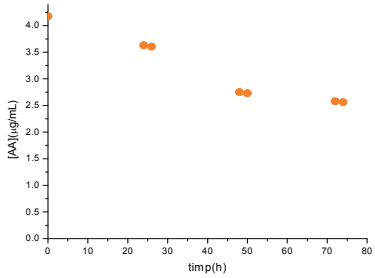

Figure 5. AA degradation in orange juice at room temperature.

The degradation of AA in juices can be described by several kinetic models. Among them, zero order kinetic is characterized by equation (2):

$[AA]=[AA]_0-kt$ (2)

where [AA]- concentration of AA at the time of the measurement

$[AA]_0$- initial concentration of AA

The model is shown in figure 6.

Also, a first order and a Weibull model were constructed. The results are shown in table 2.

From the results we can appreciate that the best model is the first-order one (R^2=0.9517), but there is a fine delimitation between this and the Weibull one. Also, for the other juices, the first-order kinetic model gives the best results (shown in table 3). Based on the results, we can conclude that the juices that are kept at room temperature degrade faster than the ones that are refrigerated.

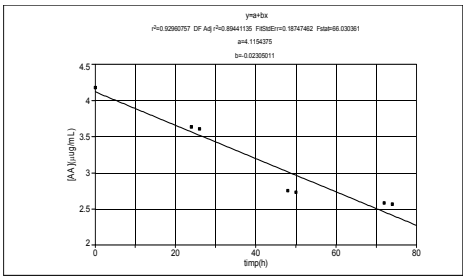

Figure 6. Zero-order kinetic for the degradation of AA in orange juice

Also, a first order and a Weibull model were constructed. The results are shown in table 2.

Model	R^2	k
$[AA]=[AA]_0-kt$	0.9296	0.023 ($\mu g/mL\ h^{-1}$)
$[AA]=[AA]_0\ exp(-kt)$	0.9517	0.0119 (h^{-1})
$[AA]=[AA]_0\ exp-(t/\alpha)^{\beta}$	0.9484	0.0072 (h^{-1})

Table 2. Results obtained for the first, second and Weibull model for the degradation of AA in orange juices.

Juice	$k(4^0C)/h^{-1}$	$k(25^0C)/h^{-1}$
orange	-	$1.2\ 10^{-2}$
lemon	$5\ 10^{-3}$	$1.3\ 10^{-2}$
ginger	$5\ 10^{-4}$	$8\ 10^{-3}$
ginger/lemon	$6\ 10^{-3}$	$7\ 10^{-3}$
kiwi	$7.8\ 10^{-3}$	$8\ 10^{-3}$
mangosteen	$5\ 10^{-3}$	$6\ 10^{-3}$
granadilla	$1.2\ 10^{-2}$	$1.4\ 10^{-2}$

Table 3. First-order kinetic degradation constants for the juices storaged at room temperature and refrigerated ones.

Conclusions

The degradation kinetics of AA have been studied on a variety of juices, and the results obtained were consistent with the ones found in the literature. We can also conclude that freshly prepared, home-made juices, should be consumed in less than 24 hours in order to maintain the nutritive properties, also in this time is better to keep them in a refrigerator (this slows down the degradation). Interesting results have been obtained for the mixed juices, which can be an interesting point of study for the future.

References

M. Carocho, I. C.F.R. Ferreira. A review on antioxidants, prooxidants and related controversy: Natural and synthetic compounds, screening and analysis methodologies and future perspectives, Food Chem. Toxicol 51, (2013), p.15–25

A.Hacisevki, *An overview of ascorbic acid biochemistry*. J. F. Pharm., Ankara (2009), p.234-237.

B.K. Tiwari, C.P. O' Donnell, K. Muthukumarappan, P.J. Cullen. Ascorbic acid degradation kinetics of sonicated orange juice during storage and comparison with thermally pasteurised juice. Food Sci. Technol. 42 (2009), p. 700–704.

H. Remini, C. Mertz, A. Belbahi, N. Achir, M. Dornier, K. Madani. Degradation kinetic modelling of ascorbic acid and colour intensity in pasteurised blood orange juice during storage. Food Chem. 173 2015), p. 665–673.