Kinetics Modeling of Thermal Degradation of Ascorbic Acid (vitamin C) in White Sorrel Leave Vegetables

B. DAUDA*[1], I. M. IBRAHIM[1] ,I. WAZIRI[2] AND B. ABDULLATEEF[2]

[1]Chemical Engineering Department, University of Maiduguri, Maiduguri, Nigeria.
[2]Chemistry Department, University of Maiduguri, Maiduguri, Nigeria.
Correspondent e-mail:deebaba4u@gmail.com.

Abstract

Kinetics modeling of thermal degradation of ascorbic acid (vitamin C)in White sorrel leavesvegetables at 60, 70, 80 and 90^oC was investigated. The vegetables were blanched for 30, 60, 90, 120, 150 and 180 seconds for each temperature variation. The vitamin C concentration decreases as the blanching time and temperature increased. It was found that the white sorrel leavesvegetables has high retention rate during blanching. It also shown that ascorbic acid kinetic in the white sorrel leavesvegetables can be described by 0.7thorder kinetics at temperature between 60 to 90^oC with reaction rate 0.004, 0.01, 0.006 and 0.013 (mg/100g)/seconds. The activation energy for the kinetic model was alsofound to be 1373.5kJ/mol.

Keywords: Vegetables,White sorrel, Ascorbic acid, Blanching,andKinetics.

Introduction

Green leafy vegetables are highly seasonal in nature, in order to make them available to consumers all year round at low prices; they are subjected to postharvest technological treatment such as blanching, drying or freezing. Green leafy vegetables being good sources of essential vitamins, minerals, fibers and disease-fighting phytochemicals which the human body needs to maintain good health, they are usually in short supply in daily diets, in addition to their high concentration of micronutrient, vegetables provide little dietary energy making them valuable in energy limited diets [1].

Roselle (*Hibiscus sabdariffa*) is commonly kwon as Sorrel andis among the important leafy vegetable in the drier parts of West and Central Africa. It is enriched with vitamin C and has been cultivated for centuries. The leaves may be pureed in soups and sauces or added to salads; they have a flavour that is similar to kiwifruit or sour wild strawberries. The plant's sharp taste is due to oxalic acid. In small quantities sorrel is harmless; in large quantities it can be fatal. In northern Nigeria, sorrel is known as *yakuwa* or *sure* (pronounced suuray) in Hausa or *karassu* in Kanuri. It is also used in stews usually in addition to spinach. In some Hausa communities, it is steamed and made into salad using *kuli-kuli* (traditional roasted peanut cakes with oil extracted), salt, pepper, onion and tomatoes. The recipe varies according to different levels of household income. A drink called Zobo in Nigerian is made from a decoction of the plant calyx [2].

Some vegetables can be taken raw but most are commonly cooked before being consumed. Generally preparations of vegetables at home are based on taste preference and convenience rather than retention of nutrient and health promoting compounds. Vitamin C also known as ascorbic acid is a water soluble vitamin found in fruits and vegetables.

Vitamin C occurs naturally in many fruits and vegetables particularly in sorrel, tomatoes, spinach, green paper, cabbage etc. it has a number of biochemical and physiological functions in the body which are largely dependent on its ability to provide reducing equivalents in various biochemical reactions,

while it deficiency in human lead to a disease known as scurvy, whose symptoms include hemorrhaging especially in gums and skin, loosening of the teeth, joint pains and exhaustion [2]

Vitamin C is required for the prevention of scurvy and maintenance of healthy skin, gums and blood vessels. Vitamin C is also known to have many biological functions in collagen formation, absorption of inorganic iron, reduction of plasma cholesterol level, inhibition of nitrosamine formation, enhancement of the immune system, and reaction with singlet oxygen and other free radicals. Vitamin C, Epidemiological studies revealed that diets rich in fruits, vegetables and grains are associated with a lower risk of several degenerative diseases, such as cancers and cardiovascular diseases [3]

Cooking in high temperature also destroys vitamin C, since it easily leaches in to cooking water being a soluble vitamin or by exposure to air and light. Vitamin C can also be loss in vegetable during blanching. The idea of controlling the loss will be dependent on the proper understanding of how factors such as temperature and duration or different preservation methods affect the loss. Ascorbic acid is the most difficult vitamins to preserve during blanching and dehydration [4]

Since ascorbic acid degradation cause problem for the quality loss in vegetables during blanching, it is necessary to study the influence of temperature on ascorbic acid degradation and investigate kinetics of ascorbic acid loss in green leafy vegetables. This study is aimed at the development of mathematical modeling of the temperature dependency of ascorbic acid degradation through hot water blanching of green leave vegetable (White sorrel leave) [5].

Material and Method

The *White sorrel* vegetable *leaves*samples used for this study were purchased locally from Monday market, in Maiduguri, Nigeria. All chemicals/reagents used were of analytical gradeand all solutions were prepared using distilled water.

Experimental procedure

Determination of the ascorbic acid content was done using literature procedure [6].The samples were washed with a suitable proportion of water to remove dirt and allowed to drain before sealing them in the polythene bag. 25g of the sample was weighed into 50ml of meta-phosphoric acid (which is prepared by dissolving 25g of the pure salt in 500ml of the distillate water). The mixture was macerated thoroughly to extract the ascorbic acid in the vegetable sample, and the resultant mixture was then filtered immediately. 10ml of the extract was then titrated with standard 2, 6-dichlorophenol-indophenol to determine the concentration of the ascorbic acid.

Thermal Treatment (Blanching)

100ml of distilled water was measured into a beaker and heated on a hot plate to a temperature of 60^0C; the temperature was then measured and monitored. 25g of the weighed vegetable sample was dipped into the hot water for 30seconds, after which the blanching water was immediately drained and blanched vegetable was immediately dipped into a mortar containing 50ml of meta-phosphoric for subsequent ascorbic acid determination. This procedure was repeated for 60, 90,120,150 and 180 seconds of blanching time. The whole procedure stated above was repeated at 70^0C, 80^0C, and 90^0C. The ascorbic acid was determined at each of the variation for all the samples and the result obtained was recorded as shown in Table 1.

Resuits and Discusions

Theresults of different volume of extract used with blanching temperature and blanching time are presented in table one (1). The ascorbic acid concentration at various blanching temperatures and time for the White sorrel leavesvegetables during the experiment are tabulated in Table 2:

Table 1: Titration Result of the White sorrel leave.

Blanching Temperature (oC)		**60**		**70**		**80**		**90**	
Blanching time (seconds)	**No. of trials**	**Volume Used (ml)**	**Average Volume Used (ml)**	**Volume Used (ml)**	**Average Volume Used (ml)**	**Volume Used (ml)**	**Average Volume Used (ml)**	**Volume Used (ml)**	**Average Volume Used (ml)**
0	1	5.9	5.8	6.6	6.75	7.8	7.6	7.8	7.6
	2	5.7		6.9		7.4		7.4	
30	1	5.4	5.5	5.6	5.55	6.2	6.1	7.1	6.45
	2	5.6		5.5		6		7.8	
60	1	5	4.95	4.9	4.9	5.4	5.6	6.3	6.2
	2	4.9		4.9		5.8		6.1	
90	1	4.7	4.85	4.2	4.35	5.9	5.85	4.5	4.35
	2	5		4.5		5.8		4.2	
120	1	4.9	4.9	3.5	3.55	5.3	5.2	3.8	3.8
	2	4.9		3.6		5.1		3.8	
150	1	4.5	4.45	4.1	4.2	4.9	4.95	4.3	4.2
	2	4.4		4.3		5		4.1	
180	1	4.2	4.05	2.5	2.45	4.5	4.5	2.9	2.8
	2	3.9		2.4		4.5		2.7	
Standardization of dye	1	9.3	9.25	10.2	10.3	11.7	11.7	10.3	10.65
	2	9.2		10.4		11.7		11	

Table 2: Ascorbic acid concentration (mg/100g) at various blanching temperatures and time

Temperature oC	**Time (Sec.)**					
	30	**60**	**90**	**120**	**150**	**180**
60	3.26	2.11	9.41	14.21	18.81	22.27
70	5.08	7.71	13.52	22.46	23.71	25.38
80	2.94	9.41	12.15	17.83	20.56	24.69
90	3.88	13.38	18.99	21.34	24.05	25.8

Kinetics of ascorbic acid thermal degradat

Degradation of ascorbic acid is described using the process reaction rate and the influence of temperature on the reaction rate using Eq. (1). The temperature dependence of the degradation of rate, k, was then modeled by the Arrhenius equation (1):

$$k = k_0 \exp\left[-\frac{E}{RT}\left(\frac{1}{r}-\frac{1}{T_{ref}}\right)\right] \quad (1)$$

where, k_o is frequency factor or pre-exponential constant at a reference Temperature $T_{ref} = 25^0$; E (kJ/mol) is the activation energy of the reaction; T is the absolute temperature of the medium in K; and R is the universal gas constant (8.314kJ/mol.K). Linearization of Eq. (1) by taking natural logarithm of both sides yields;

$$\ln K = \ln K_0 - \frac{E}{R}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right) \quad (2)$$

The parameters E and k_o in equations (1) or (2) are of fundamental interest since they both represent the activation energy and pre-exponential constant associated with a reference absolute temperature for activation reaction, respectively. Both values were obtained from the plots of ln K versus $\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)$ values. Activation energies E (kJ/mol) was calculated as a product of universal gas constant, R (8.314kJ/mol.K) and the slope of the graph obtained by plotting ln K versus $\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)$. Fig. 1 shows the Arrhenius plots for ascorbic acid degradation in the White sorrel leavesvegetables.From the graph, the activation energies, E and frequency factor$k_o$was found to be 1373.5kJ/mol and 3.2 respectively.

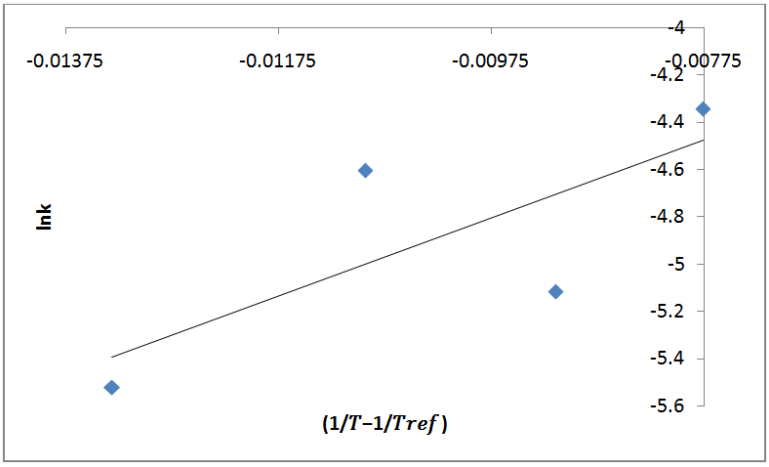

Figure 1: Arrhenius plot of the thermal degradation of ascorbic acid in green leave vegetable

Conclusion

With increasing blanching time and temperature, the vitamin C concentration decreases. This implies that the loss of vitamin C is influenced mostly bytemperature and the model equation is valid for this study, similar observation was made by [7]. The kinetic of ascorbic acid thermal degradation in White sorrel leaves at all temperature were described as 0.7^{th} order kinetics. Blanching at 80^oC should be the optimum blanching temperature since there was less ascorbic acid loss compared to other blanching temperatures, for most of the time intervals considered during the experiment.

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