Chemical and Process Engineering Research
ISSN 2224-7467 (Paper) ISSN 2225-0913 (Online)
Vol.25, 2014
www.iiste.org

The Kinetics of Ascorbic Acid Degradation in Ogbono Soup during Cooking

Oladimeji Olusegun[1*], Idowu-Adebayo Folake[1] and Oni Kunle[1]
1 Department of Food science and Technology, Faculty of Agriculture, Federal University Oye, P.M.B 373 Oye-Ekiti, Ekiti state, Nigeria.
*E-mail and Telephone number of the corresponding author: segundimeji@yahoo.com +234-803-3932642

Abstract
Degradation kinetics of ascorbic acid was investigated in 'ogbono' soup during cooking at different temperatures between 60^{o}C and 80^{o}C. The results confirmed that mixed order kinetics (of zero- and first-order model) is adequate in describing the degradation reactions. The rate constant increased with temperature according to an Arrhenius-type relationship. The activation energy was 34KJ/mol and at the average temperature of the range tested, the rate constant was 4.2 x 10^{-4}/hr.
Keywords: Ascorbic acid, Cooking, Degradation, *Irvingia gabonensis*, Mixed order kinetics

1. Introduction

In Dikanut seeds (*Irvingia gabonensis*) the concentration of ascorbic acid is generally in the range of 9-10mg/100g (Ejiofor et.al., 1987) depending on the accession (Adebooye and Bello, 1998) and the storage conditions and length of storage (Smith, 1968).

When used along with other ingredients in the preparation of standard ogbono soup (Oguntona et.al., 1999), the ascorbic acid content may increase depend on the formulation employed (Oladimeji, 2007). Whether processed industrially and used as gums to impact desirable textural and functional properties in drug (Uzomah and Ahiligwo, 1995) or prepared at home for culinary use, dikanut seeds receive some sort of heat treatment sometimes in a medium which diffusional mass transport may increase the loss to 50-80% of the vitamin C in the raw material (Paul and Southgate, 1978).

The degradation kinetics of ascorbic acid in model systems conforms to first order kinetics and the activation energy can be expressed as a linear function of pH with a negative slope (Kincal and Giray, 1987). However in food system, the kinetics is somehow complex (Liao and Seib, 1988). The complexity of the degradation mechanisms (Tannenbaun et.al., 1985; Liao and Seib, 1988) hinders the development of mechanistic models and pseudo-kinetic model such as zero order (Kanaane et.al., 1988), first-order (Kincal and Giray, 1987) or second-order kinetics (Hsieh and harris, 1993) are often applied in order to obtain a good fit to the experimental data. Sakai *et al.*, (1987) applied a kinetic model that consist of two consecutive reactions (the first of zero-order and the second of first-order) to describe the ascorbic acid oxidation in an aqueous solution. Petriella *et al.*, (1985) suggested a mixed order kinetic model in a study of non-enzymatic browning involving reactions of sugars, amino-acids and ascorbic acid in food systems.

Assuming the reaction as zero-or first-order is rather simplistic, since the reaction may involve a complex group of reactants (Manso *et al.*,2001).

The main objective of this work was to model in an appropriate way the kinetics of ascorbic acid delegation during the cooking of traditional 'ogbono' soup.

2. Materials and Methods

2.1 Preparation of ogbono soup

The recipes were chosen as listed in Oguntona (1999). The dikanut seeds and crayfish were blended together into a fine powder. The bitter were shredded, washed and squeezed to remove the bitter taste with the aid of salt. The fish was washed first with warm water and then with cold water. The mixture ogbono seeds and fish were then added to 30ml of heated palm oil while stirring to avoid lumps. Hot water was gradually added while mixing. The ground pepper, bouillon cube and chopped okra were then added and allowed to cook at medium heat for 20mins. The bitter-leaves together with the fish were then added, and were allowed to cook in a thermostatic bath (Julabo SW 21C model) at 60^{o}C, 70^{o}C, 80^{o}C for 10mins. Finally, the salt was added to taste.

2.2 Analytical Determinations

50g of the soup was weighed and 200ml of metaphosphoric-acetic acid solution, freshly prepared, was added in a conical flask and the mixture shaken (AOAC, 1975). The mixture was filtered through a large fluted filter paper. 50ml of the filtered extract and a blank solution were tiltrated with a solution of 2, 6 dichlorophenol-indophenol. The dyestuff solution had previously been standardised against a standard solution of ascorbic acid (Sigma). The samples were run in triplicates and the average ascorbic acid content calculated.

2.3 Data Analysis

The models tested were fitted by non-linear regression to the experimental data in order to estimate the model parameters. Fits were made for each set of experimental data at a given temperature in order to assess the quality of the fit of the model and to analyse further the dependence of the parameters on temperature.

3. Results and Discussion

3.1 Ascorbic acid degeneration

Plot of experimental retention values against time are shown in Fig. 1 for ogbono soup prepared according to Oguntona's formulation. Various models were fitted to the experimental data, but while the fits were good for the models tested, the kinetic parameters only showed a logical relation with temperature with the mixed-order kinetic model (Petriella et.al., 1985).

3.2 Modeling ascorbic acid degeneration with the Mixed-order kinetic model

This model is flexible owing to the inclusion of anaerobic situations and it has proved to an interesting potential for describing microbial, enzymatic and chemical degradation kinetics (Cunha et.al., 1998). When mixed order kinetic model is applied to ascorbic acid degradation, it can be described by the following equation:

$C_t = C_o \times e^{-(t/a)} e^b$ …………. (1)

Where C_t = the ascorbic acid concentration at a time, t

C_o = initial concentration of ascorbic acid

a= scale constant = 1/k

b= sharp constant and is independent of time, t

t = time (mins)

Fig. 1 shows examples of the fit of the mixed order kinetic model to the experimental data ($0.942<r^2<0.986$). The rate constant increased with temperature (T) according to an Arrhenius-type relationship (Fig.2). The straight line obtained when (log K) was plotted against 1/T suggests that the ascorbic acid degradation kinetics during the cooking of ogbono soup obeyed the Arrhenius relationship for temperature dependence. From the correlation coefficient, it is affirmed that the degradation kinetics is of mixed-order model. This agrees with the findings of Petriella *et al.,* (1985) for non-enzymatic browning in model food systems. In actual fact, more of non-enzymatic browning is expected during the thermo-induced chemical reactions in ogbono soup during cooking than enzymic reactions. The activation energy of 34KJ/mol (r^2=0.975) was obtained for ogbono soup for a temperature range between 60oC and 80oC giving a rate constant (1/a) of 4.2 x 10^4/hr. This value (34KJ/mol) obtained at pH 5.3 compares well with the typical activation energy of 37KJ/mol for ascorbic acid in orange juice, but differs from the value (44KJ/mol) reported by Kincal and Giray (1987) during potato blanching and also from that (48KJ/mol) reported by Svennson (1977) for enzyme-catalyzed reactions. The possible biochemical pathway for ascorbic acid degradation will determine the mechanism and the kinetics of ascorbic acid degradation (sakai, *et al.,* 1987). The ascorbic acid degradation kinetics of ogbono soup is of mixed-order model (zero-and first-order kinetic model) at higher temperatures (sakai, *et al.,* 1987).

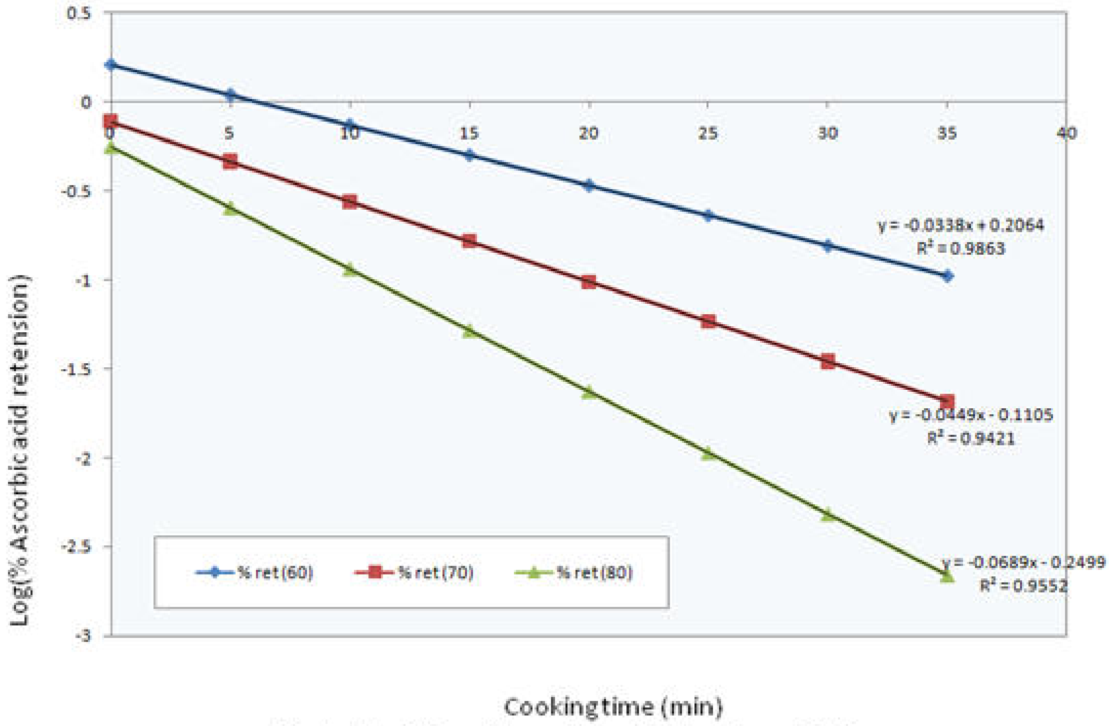

Fig. 1: Variation of Ascorbic acid retension with time

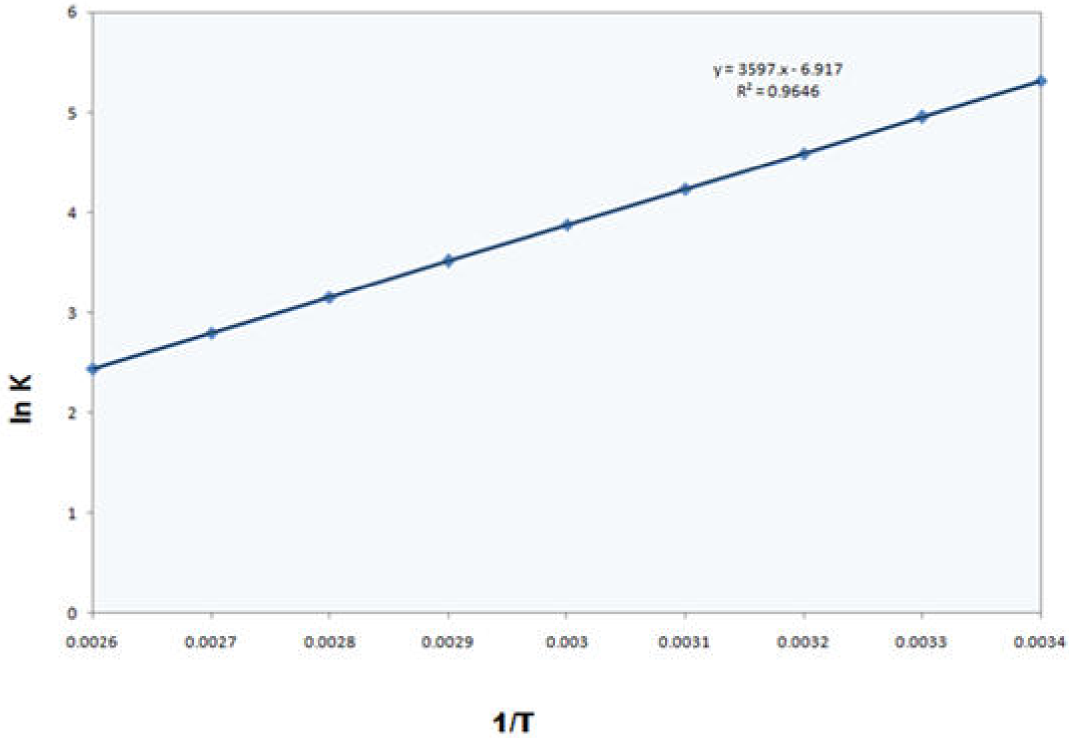

Fig. 2: Variation of K with Temperature

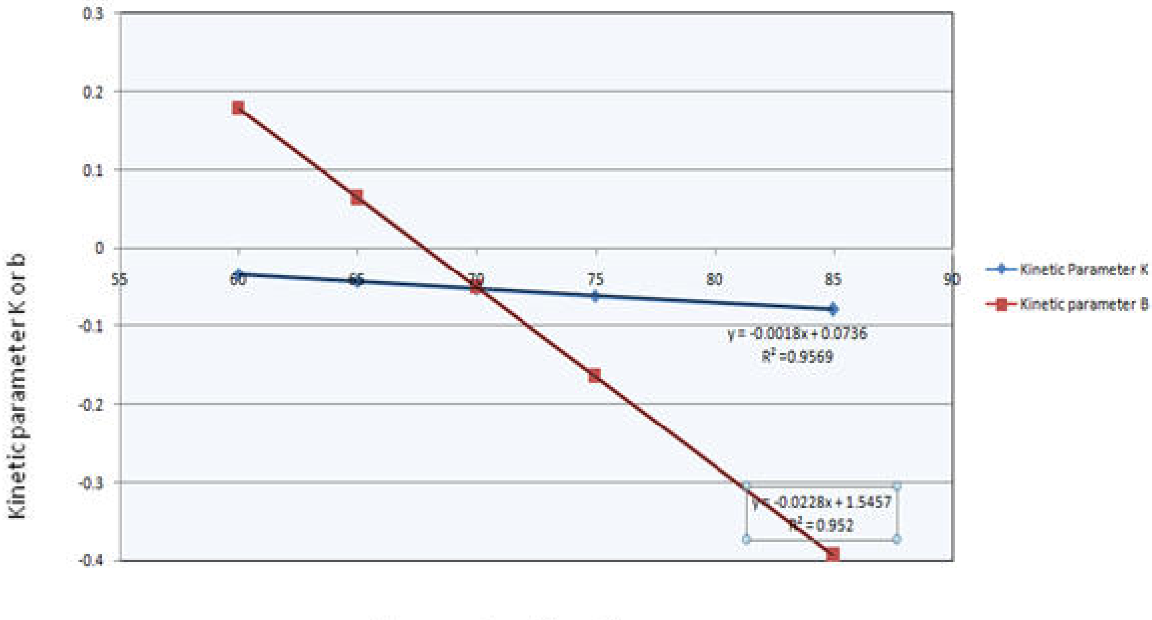

Fig. 3: Plot of Kinetic parameter, K and b against temperature of cooking

Equations 1and 2 describe the linear relationship between parameters, k and b and temperature of cooking:

K = -0.0018T (^{o}C) + 0.0736 ………… (1)

b = -0.0228T (^{o}C) + 1.5457 ……….. (2)

At 70^{o}C the kinetics reduces to first-order model as represented by point of intersection in Fig.3.

4. Conclusions

Although ascorbic acid degradation is a complex phenomenon, the present experiments were designed to study the magnitude of thermal degradation by minimizing variations in other factors. The mixed-order kinetic model provided a good description of the kinetics of degradation of ascorbic acid in ogbono soup in the range of temperatures tested and therefore is appropriate for predictive purposes.

References

Adebooye, O.C. and Bello, S.A.(1998). Fruit characteristics and nutrient analysis of fifteen accessions of Irvingia gabonensis var, dulcis of Southwest ,Nigeria. Nigeria Journal of Tree Crop Research. Vol.2 No.1 pp30-40.

AOAC (1975). Official Methods of analysis, 12th edn. (edited by W. Horwitz), Washington D.C.

Cunha,L.M., Oliveira, F.A.R. and Oliveira,J.C. (1998). Optimal experimental design for estimating the kinetic parameters of processes described by Weibull probability distribution function Journal of food Engineering, 37: 175-191.

Ejiofor.M.A., Okafor,J.C. and Onwubuka,S.M. (1987). Developing improved methods of processing and utilization of kernels of Irvingia gabonensis var gabonensis and var excels. Journal of International Tree Crops, vol. 14, pp 283-290.

Hsieh,Y.P. and Harris,N.D.(1993). Effect of sucrose on oxygen uptake of ascorbic acid in a closed aqueous system. Journal of Agricultural and Food Chemistry, 41:259-262.

Kaanane,A., Kane,D. and Labuza, T.p (1988). Time and temperature effect on stability of Moroccan processed orange juice during storage. Journal of Food science, 53: 1470-1473, 1489.

Kincal,N.S. and Giray,C.(1987). Kinetics of ascorbic acid degradation in potato blanching. International Journal of Food Science and Technology,22:249-254.

Liao,M.L. and Seib,P.A(1988). Chemistry of L-ascorbic acid related to Foods. Food Chemistry, 30:289-312.

LIN,S.H. and agalloco,J.(1979). Degradation kinetics of ascorbic acid. Process Biochemistry, 14: 22-26, 32

Manso,M.C., Oliveira,F.A.R., Oliveira,J.C. and Frias,J.M.(2001) Modelling ascorbic acid thermal degradation and browning in Orange juice under aerobic conditions. International Journal of Food Science and Technology. 36:303-312.

Oguntona,C.R.B., Odunmbaku,J.A. and Ottun,B.O.(1999). Proximate composition of ten standardized Nigerian dishes. Nutrition and Food Science.6:295-302.

Oladimeji,O.(2007). A Parametric analysis of thermal processing of Canned ogbono soup. Unpublished report

Paul,A.A. and Southgate,D.A.T.(1978). The composition of Foods 4th edn. London: Her majesty's Stationery Office.

Petriella,C., Resnik,S.L., Lozano,R.D. et.al.(1985). Kinetics of deteriorative reactions in model food systems in high water activity. Color changes due to non-enzymatic browning. Journal of Food Science, 50: 622-626.

Sakai,Y., Watanabe,H. Takai,R. et.al.(1987). A kinetic model for Oxidation of ascorbic acid and beta-carotene. Journal of Food Processing and Preservation, 11: 197-207.

Svensson,S.(1977). Inactivation of enzymes during thermal processing. In: Physical, Chemical, and Biological Changes in Food Caused by Thermal Processing (editing by T. Hoyem and O.Kvale).pp 202-217.London: Applied Science Publishes.

Tannenbaum,S.R. Young,V.R. and Archer,M.C.(1985). Vitamins and minerals In: Food Chemistry, 2nd edn (edited by O.R. Fennema). Pp 489-491, New York: Marcel Dekker,Inc.

Uzomah,A. and Ahiligwo,R.N.(1995). Rheological properties and functional potentials of acha seed gum and ogbono seed gum. Nigerian Food Journal, 13: 63-68.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar