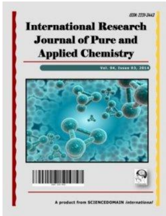

International Research Journal of Pure & Applied Chemistry

17(2): 1-10, 2018; Article no.IRJPAC.44839
ISSN: 2231-3443, NLM ID: 101647669

Effect of Ohmic Heating and Lye-Salt Concentrations on Quality Characteristics of Tomato Puree

Sawant Sanket Ramnath[1*], Pandey Jai Prakash[2], Anupama Singh[2] and Om Prakash[3]

[1]Division of Agricultural Engineering, IARI, New Delhi, India.
[2]Department of Post-Harvest Process and Food Engineering, GBPUAT, Pantnagar (UK), India.
[3]Department of Chemistry, GBPUAT, Pantnagar (UK), India.

Authors' contributions

This work was carried out in collaboration between all authors. Author SSR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author PJP managed the analyses of the study. Author AS managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IRJPAC/2018/44839
Editor(s):
(1) Dr. Li Cai, Associate Professor, Department of Chemistry, University of South Carolina Lancaster, Lancaster, SC 29721-0889, USA.
Reviewers:
(1) Mariana-Atena Poiana, Banat University of Agricultural Sciences and Veterinary Medicine, Romania.
(2) Kartika Rathore, Jai Narain Vyas University, India.
(3) S. Uhiara Ngozi, The Federal Polytechnic, Bauchi, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/27294

Original Research Article

Received 11 August 2018
Accepted 29 October 2018
Published 17 November 2018

ABSTRACT

Objectives: To study the effect of ohmic heating and lye-salt concentrations on quality characteristics of tomato puree. The quality characteristics of tomato puree by using ohmic heating and lye-salt concentrations were investigated. Ohmic heating is also termed as 'resistance heating or electro heating' in which an alternating electric current is passed through a food, and electric resistance of the food causes the power to be translated directly into heat. Electroporation has been regarded as the main mechanism of ohmic heating.
Study Design: Full factorial design.
Place and Duration of Study: Department of Post-Harvest Process and Food Engineering and department of Chemistry, GBPUAT, Pantnagar (UK), India, between September 2016 and April 2017.

**Corresponding author: E-mail: sanketsawant476@gmail.com;*

Methodology: Tomato fruit has remarkable concentration of vitamin E, vitamin A, folate, vitamin C and vitamin A as leading source. The quality characteristics of final product were evaluated in terms of β –Carotene, vitamin A (retinol) and vitamin C (ascorbic acid) of tomato puree.

Results and Conclusion: The value of β –Carotene was observed ranking first in salt (NaCl) solution followed by KOH and NaOH lye solutions for all experimented concentrations. Therefore it reveals that as the temperature of puree increases it resulted increase in β –Carotene which has been computed as vitamin A. The percentage range of retention of ascorbic acid was observed ranking first in NaOH solution (86.01-91.35%) followed by KOH (61.91-77.06%) and Nacl (34.64-56.12%) for all experimented concentrations. It reveals that as the temperature of puree increases it resulted decrease in ascorbic acid which has been computed as vitamin C. No previous work dealing with the comparison of the impact of ohmic heating processing on bioactive components of tomato products has been found therefore this study aims to address this deficiency.

Keywords: Ohmic heating; lye and salt concentrations; field strength; β –Carotene; retinol ascorbic acid.

1. INTRODUCTION

Tomatoes (*Lycopersicon esculentum)* are an important food crop worldwide. In terms of dollar value, tomato ranks second to potatoes among all vegetables produce [1]. More than 80% of tomatoes produced are consumed in the form of processed products such as tomato juice, paste, puree, ketchup, sauces and soups. However, the nutritional value of tomato products depends on processing and storage conditions [2]. Vitamins are organic compounds that are indispensable in very small amounts in the diet. Vitamins form a heterogeneous group of substances and are vital nutrients. They are regulate metabolic processes, control cellular functions, and prevent diseases, such as scurvy and rickets. Conventional nutritional science now recognizes 13 vitamins divided into two categories, the fat-soluble vitamins of which there are four, and the water-soluble vitamins of which there are nine [3]. Vitamins are unstable in foods. Processing and cooking conditions causes loss of vitamins. The losses vary widely according to cooking method and type of food. It is degradation depends on specific parameters during the culinary process, e.g., temperature, oxygen, light, moisture, the few authors expressed vitamin A as β-carotene, retinol or retinol equivalent. Hence, to clarify, β-carotene provides 80% of vitamin A value. Ascorbic acid is one of the more reactive compounds present and, thus, it is particularly vulnerable to treatment and storage conditions [4].

Ohmic heating is also termed as 'resistance heating or electro heating' in which an alternating electric current is passed through a food, and electric resistance of the food causes the power to be translated directly into heat. The principle of ohmic heating is dissipation of electrical energy into heat which results in internal energy generation [5]. The food product is heated rapidly as the rate of heating is only relevant to the electrical resistance of the particular food and not limited by the heat transfer coefficient [6]. The physical effects of ohmic heating are caused by the phenomenon referred to as electroporation. Electroporation is defined as the formation of microscopic pores on the cell membrane. Due to alternating current and forces exerted on these ions by the electrical field, the formation of microscopic pores may occur. Since electroporation has been regarded as the main mechanism of ohmic heating, [7].

No previous work dealing with the comparison of the impact of ohmic heating processing on bioactive components of tomato products has been found. This study aims to address this deficiency. One major characteristic of antioxidant vitamins, carotenoids and polyphenols is their antioxidant potential in either lipophilic or hydrophilic compartments [8]. In this sense, there is no previous work that evaluates the antioxidant activities of tomato puree hydrophilic and lipophilic ´ fractions when comparing different technologies of tomato processing Thus, the aim of this study was to compare the effect different field strengths and lye or salt concentrations on β –Carotene, vitamin A (retinol) and vitamin C (ascorbic acid) of tomato puree. In addition, the range of changes temperature during treatments was assayed. Therefore this study will deal with the effect of ohmic heating, salt and lye solutions on quality characteristics of ohmically heated tomato puree. Keeping all above cited issue in mind, the present work has been undertaken with the objective to study the effect of ohmic heating and lye-salt concentrations on quality characteristics of tomato puree. The full factorial design experiment was used to analyze the dependent parameters. Statistical analyses of the data obtained from experiments run were performed by using stpr 2 software.

2. MATERIALS AND METHODOLOGY

Standard methods for measurement of quality attributes were followed for entire experiments. Some of these methods were modified as per literature review to provide better, more precise quality estimation. Analytical grade chemicals and glass wares (borosil make) were utilized for conducting the experiments. Applied field strength, salt levels and lye levels were taken as independent variables for the study and their ranges were finalized based on the observations and results obtained in preliminary experiments.

2.1 Raw Materials

Fresh, fully matured, red in colored cherry type tomatoes of variety pant bahar was selected as the raw material for ohmic heating. The tomatoes were washed in clean water to remove dust or other foreign materials on it and then wiped with cotton cloth.

2.2 Experimental Plan

Certain constant parameters were fixed for entire experiments, decided on the basis of trial runs. The Conclusive lists of these parameters are number of tomato (one), Variety of tomato (pant bahar) and Weight of sample (60 gm App). Standard ohmic heating variables consisting of salt concentration, lye concentrations and field strength were selected. The levels of the variables have been chosen based on preliminary runs and literature reviewed. The levels and values of each of these variables are 4, 4, 4 and 0.1%, 0.2%, 0.3% and 0.4% respectively. The applied field strength levels and values are 3 and 1214.28 V/m, 1071.42 V/m and 928.57 V/m respectively. Full factorial design was selected for the present study.

2.3 Preparation of Salt and Lye Concentrations Solution

Salt and lye concentrations were prepared on the basis of weight / volume percentage. For 0.1% of salt concentration dissolved 0.1 g of salt in 100 ml of distilled water similarly for 0.2%, 0.3% and 0.4% dissolved 0.2g, 0.3g and 0.4g of salt in 100 ml of distilled water respectively. For 0.1, 0.2, 0.3 and 0.4% of Lye concentrations (NaOH and KOH) dissolved 0.1, 0.2, 0.3 and 0.4 g of lye powder in 100 ml of distilled water respectively.

2.4 Experimental Setup

The laboratory type ohmic heating setup was to carry out the experiments was designed and fabricated by Kautkar in 2016 [9]. The ohmic heating chamber is very important for efficient heating employed a circular geometry was constructed by PVC pipes of 7 cm diameter, 16.8 cm in length and 2 mm in thickness. The electrodes have well grade, non-corrosive and chemically inert made from stainless steel (SS) with 5.5 cm diameter. The distance between two electrodes has kept 14 cm to pass maximum voltage gradient of 16.5 V/cm from Indian household electric supply of 230 V. Bestronics made digital temperature controller with stainless steel probe was used monitor the temperature inside the heating chamber. Teflon coated, J type thermocouple which can withstand a temperature of 0-600°C is placed at the geometric centre of the ohmic heating cylinder to control the temperature during ohmic heating. A base is used to fix entire ohmic setup and control panel.

2.5 Analytical Techniques for Quality Parameter

2.5.1 Vitamin A

Vitamin A called as retinol which is precursor of β –carotene. Extraction of vitamin A was accomplished by HAE method [10]. The method utilizes reagent like acetone, anhydrous sodium sulphate and potassium ether. The concentration of which can be identified by spectrophotometric analysis at 452 nm.

2.6 Sample Preparation and Measurement

The sample preparation was done by taken 5 g of tomato puree sample in a beaker and crushed in 10-15 ml of Acetone. Then waiting for some time few crystals of anhydrous sodium sulphate (ASS) were added simultaneously for absorbing the water present in the tomato puree. Then allowing the mixture to settle for some time the supernatant was decanted into the beaker without disturbing the sediment. The process was repeated twice. The supernatant obtained from the two processes were combined and transferred to a funnel.10- 15 ml of petroleum ether was added to the funnel and the contents were mixed thoroughly. The upper layer hence formed was collected in a 100 ml conical flask and the volume was making up with Petroleum ether to 100 ml. The Optical Density (OD) at 452 nm was read using Petroleum ether blank. The extraction of vitamin A is shown in Plate 1.

$$\beta\ Carotene\ (mg/100mg) = \frac{OD\ x\ 13.9\ x\ 10^4\ x\ 100}{Wt\ of\ sample\ x\ 560\ x\ 1000} \tag{2.1}$$

$$Vitamin\ A = \frac{\beta\ Carotene\ (mg/100mg)}{0.6} \tag{2.2}$$

2.6.1 Vitamin C

The amount of ascorbic acid provides an estimate of the vitamin C content in food. Ascorbic acid retention in food is therefore, a necessity. There are many techniques to estimate ascorbic acid content the most common method was proposed by Ranganna [9]. Standard indophenol method was used as described by Ranganna (1986). The dye acts as an indicator and reduces to a colorless solution on addition of ascorbic acid. The end point of titration is indicated by a rose-pink color due to excess unreduced dye. The preparations of the chemicals required for the procedure has been shown in Table 1.

Ascorbic acid standard was titrated against 2, 6-dichlorophenol-indophenol. The titre value obtained was used to calculate the dye factor using the following expression:

$$Dye\ factor = \frac{\text{Titre Value}}{0.5} \tag{2.3}$$

The dye factor obtained is later used in the calculation of total ascorbic acid content.

2.7 Sample Preparation and Measurement

A known amount of ohmically heated tomato puree sample for which the ascorbic acid content was to be determined was first taken to form a liquid. 10 mL of 3% metaphosphoric acid was then added to it and kept in stable condition for thoroughly mixed for 10 min at room temperature. The solution of 5 mL of the aliquot was taken for titration against the standardized dye. The chemical preparation of indophenols method for determination of ascorbic acid as shown in below Table 1.

Table 1. The chemical preparation of indophenols method for determination of ascorbic acid

S. No	Chemical and it is concentration	Preparation method
1	2,6-dichlorophenol-indophenol	Dissolve 50 mg sodium salt of 2, 6-dichlorophenol-indophenol in warm 150 mL distilled water containing 42 mg sodium bicarbonate. Cool and dilute by volume make up to 200 mL
2	Ascorbic acid standard	Weight 100 mg L-ascorbic acid and make up volume to 100 mL with 3% HPO_3. Dilute 10 mL to 100 mL of 3 % HPO_3
3	3% metaphosphoric acid (HPO_3)	Dissolve 15 g crushed methaphosphoric acid crystal in distilled water and make up volume to 500 mL

The total ascorbic acid content is determined using the following formula:

$$\text{Ascorbic Acid mg/100 g} = \frac{\text{Titre}\times\text{dye factor}\times\text{volume make up}\times 100}{\text{Aliquot of extract taken}\times\text{weight taken}} \tag{2.4}$$

Plate 1. Ohmically heated tomato puree

Plate 2. Extraction of vitamin A from ohmically heated tomato puree

3. RESULTS AND DISCUSSION

The quality of ohmically heated tomato puree with different field strengths and lye-salt concentrations were evaluated in terms of quality parameters namely, β –Carotene, Vitamin A (Retinol) and vitamin C (Ascorbic acid). The ohmically heated tomato puree was evaluated and compared. The results of experimented data along with discussions are presented below.

3.1 Effect of Electric Field Strength and Concentrations on β –Carotene and Vitamin A

The study evaluated the levels of β –Carotene and vitamin A in tomato puree. The β –Carotene extraction was carried out using the spectrophotometric analysis method [11]. The range of rise in temperatures for various solutions of NaOH, KOH and NaCl concentrations at different field strengths were found 77ºC to 83.1ºC; 79ºC to 93.3ºC and 78ºC to 93.7ºC respectively. Tomato puree was analyzed for their β-carotene content because it is the precursor of vitamin A [12]. It is observed from the experiment that the values of β –Carotene and vitamin A varied from 0.547 to 0.867 mg/100 g and 0.913 to 1.445 mg/100 g respectively. The maximum value of β –Carotene (0.867 mg/100 g) and vitamin A (1.445 mg/100 g) were observed for the sample treated with 0.3% NaOH at 1214.28V/m field strength.

Figs. 1, 2 and 3 shows the relationship between lye-salt concentrations and vitamin A at 1214.28V/m field strength, relationship between lye-salt concentrations and vitamin A at 1071.42V/m field strength and relationship between lye-salt concentrations and vitamin A at 928.57V/m field strength respectively which supported by the experimented data. The reported β–Carotene were observed in the range of 0.638 mg/100 g (minimum value) to 1.284 mg/100 g (maximum value) for 0.1% KOH at 928.57 V/m and 0.3% KOH at 1214.28 V/m respectively. The higher (1.422 mg/100g) and lower values (0.694 mg/100g) of β –Carotene were recorded under the conditions of 0.3% NaCl at 1214.28 V/m and 0.1% NaCl at 928.57 V/m respectively. The value of β –Carotene was observed ranking first in salt (NaCl) solution followed by KOH and NaOH lye solutions for all experimented concentrations. The similar trends were also observed at 1214.28V/m, 1071.42V/m and 928.57V/m respectively. From the figures it reveals that as the temperature of puree increases it resulted increase in β –Carotene which has been computed as vitamin A. Similar observations has been recorded by slimestad and verheul in 2005 [13].

From the figures it was observed that the values of vitamin A increased from 0.1% to 0.3% concentration for experimented field strengths (1214.28V/m, 1071.42V/m and 928.57V/m) further the values of vitamin A decreased from 0.3% to 0.4% concentration for NaOH, KOH and NaCl solution. The increase and decrease trend of vitamin A was found similar in 1214.28V/m, 1071.42V/m and 928.57V/m which are supported by experimented data and figure.

A comparative study of effect of lye-salt concentrations and field strengths on vitamin A is shown in Fig. 4. The ohmically heated tomato puree with higher concentration of NaCl at high field strength gave highest values of vitamin A (2.371 mg/100 g) as compared to KOH (2.141 mg/100 g) and NaOH (1.445 mg/100 g) concentrations.

3.2 Effect of Electric Field Strength and Concentration on Vitamin C (Ascorbic Acid)

Indophenol titration method was used for determination of vitamin C (ascorbic acid) in ohmically heated tomato puree samples. Fresh sample showed 39.77 mg/100 g vitamin C while after treatment, vitamin C ranged between 13.78 – 36.33 mg/100 g. the percentage retention of vitamin C was in the range of 34.64-91.35% which was in accordance with the results obtained by Ismail et al in 2016 [14] who reported an 82% retention for the same. The range of rise in temperatures for various solutions of NaOH, KOH and NaCl concentrations at different field strengths were found 77ºC to 83ºC; 79ºC to 93.3ºC and 78ºC to 93.7ºC respectively. It is observed from the experiment that the values of vitamin C varied from 34.20–36.33 mg/g. The maximum value (36.33 mg/100 g) and minimum value (34.20 mg/100 g) of vitamin C were found for the sample treated with 0.1% NaOH at 928.57V/m and 0.4% NaOH at 1214.28V/m field strength respectively.

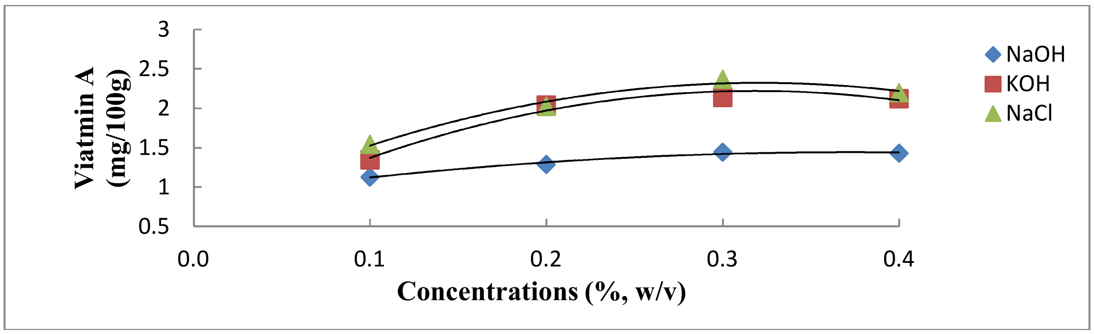

Fig. 1. Relationship between concentrations and vitamin A at 1214.28V/m field strength

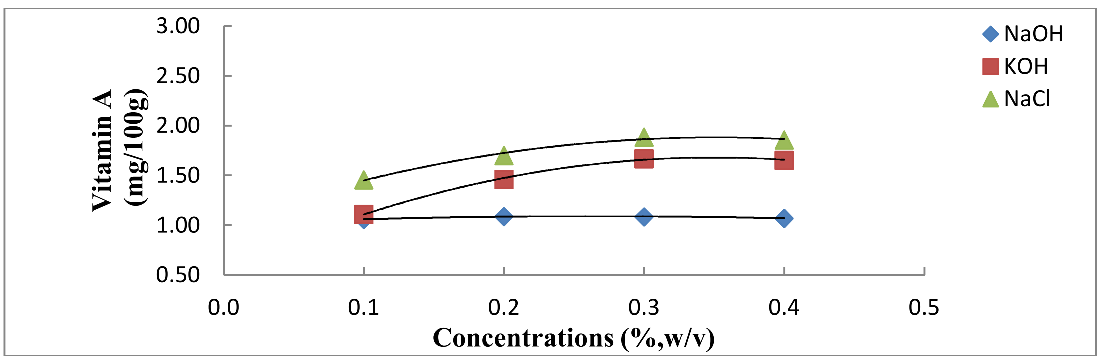

Fig. 2. Relationship between concentrations and vitamin A at 1071.42V/m field strength

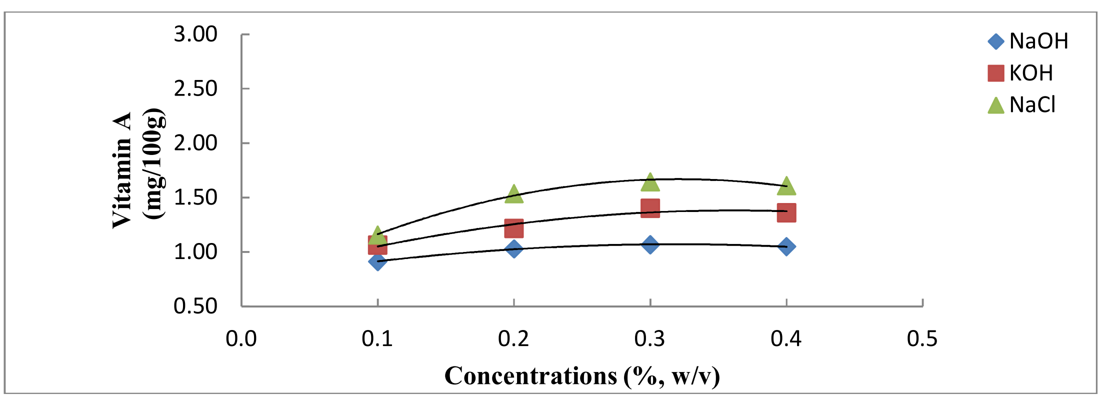

Fig. 3. Relationship between concentrations and vitamin A at 928.57 V/m field strength

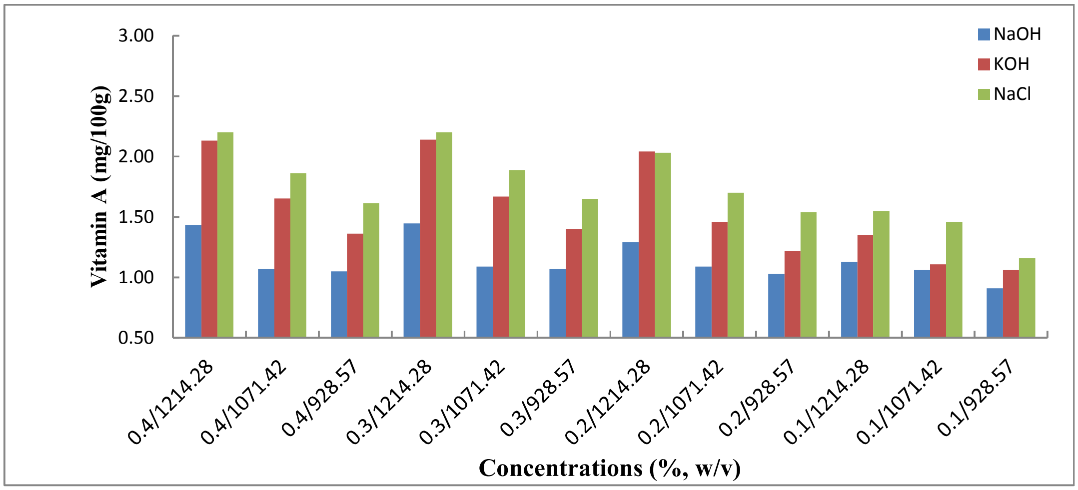

Fig. 4. Comparative effect of concentrations and field strengths on vitamin A

Key: - %w/v- weight per volume percentage basis.

NaOH: Sodium hydroxide, KOH: Potassium hydroxide, NaCl: Sodium chloride.

The reported vitamins C were found in the range of 24.62 mg/100 g (minimum value) and 30.65 mg/100 g (maximum value) for 0.4% KOH at 1214.28 V/m and 0.1% KOH at 928.57 V/m respectively. The higher (22.32 mg/100g) and lower values (13.78 mg/100g) of vitamin C were recorded under the conditions of 0.1% NaCl at 928.57 V/m and 0.4% NaCl at 1214.28 V/m respectively. The percentage range of retention of ascorbic acid were observed ranking first in NaOH solution (86.01-91.35%) followed by KOH (61.91-77.06%) and NaCl (34.64-56.12%) for all experimented concentrations. The similar trend was also observed at 1214.28V/m, 1071.42V/m and 928.57V/m respectively. From the experiment it reveals that as the temperature of puree increases it resulted decrease in ascorbic acid which has been computed as vitamin C. similar observations has been recorded by slimestad and verheul [13].

A graphical representation of relationship between lye-salt concentrations and vitamin C at 1214.28V/m field strength, relationship between lye-salt concentrations and vitamin C at 1071.42V/m field strength and relationship between lye-salt concentrations and vitamin C at 928.57V/m field strength shown in Figs. 5, 6 and 7 respectively which supported by the experimented data. As indicated in Figs. 5, 6 and 7 that the retention of ascorbic acid maximum under NaOH concentrations at different field strengths (1214.28V/m, 1071.42V/m and 928.57V/m) having temperature range was 77 ºC to 88.3ºC while the retention of ascorbic acid decreased under NaCl concentration at different field strengths (1214.28V/m, 1071.42V/m and 928.57V/m) having temperatures range was 79.7ºC to 93.7ºC.

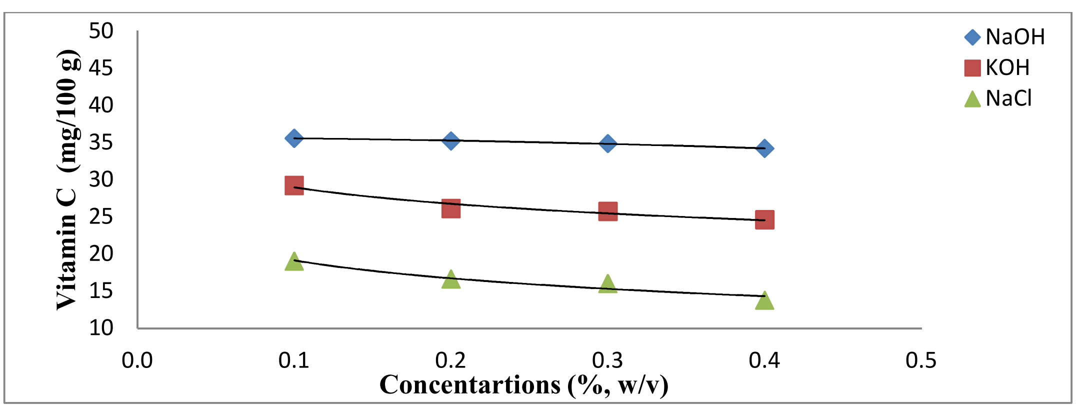

Fig. 5. Relationship between concentrations and vitamin C at 1214.28 V/m field strength

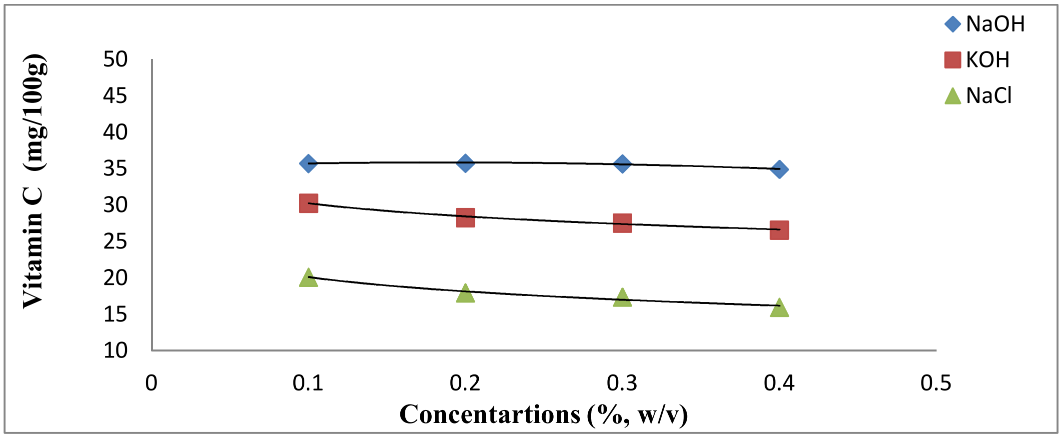

Fig. 6. Relationship between concentrations and vitamin C at 1071.42 V/m field strength

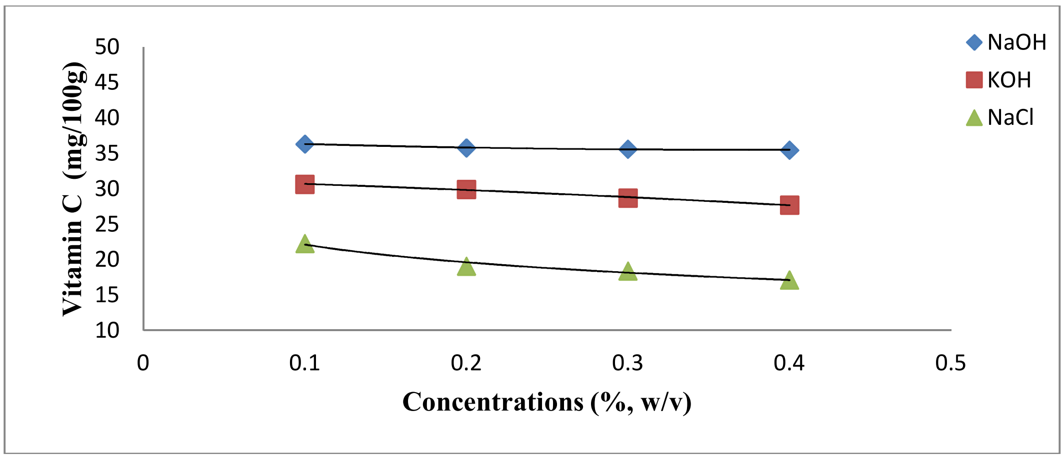

Fig. 7. Relationship between concentrations and vitamin C at 928.57V/m field strength

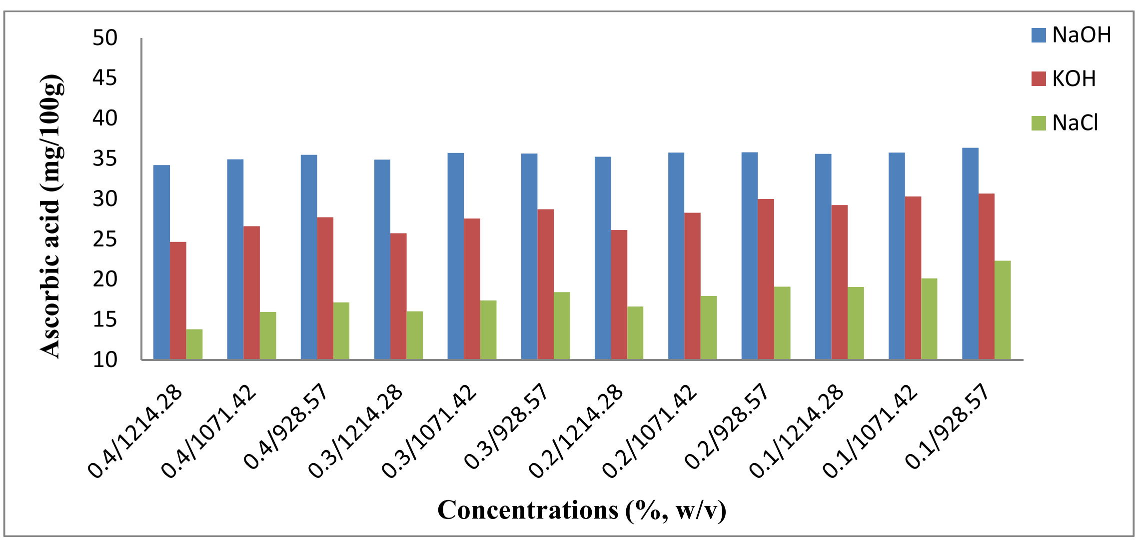

Fig. 8. Comparative effect of concentrations and field strengths on vitamin C

Key: - %w/v- weight per volume percentage basis.

NaOH: Sodium hydroxide, KOH: Potassium hydroxide, NaCl: Sodium chloride.

A comparative study of effect of lye-salt concentrations and field strengths on ascorbic acid is shown in Fig. 8. The ohmically heated tomato puree with lower concentration of NaOH at low field strength gave highest values of ascorbic acid (36.33 mg/100 g) as compared to KOH (30.65 mg/100 g) and NaCl (22.32 mg/100 g) concentrations. Ascorbic acid is a heat instable vitamin; thus, high temperatures led to a loss of vitamin C.

4. CONCLUSIONS

Ohmic heating keeps the β –Carotene and vitamin A of tomato puree well within the acceptable range. The optimal values of independent variables in terms of lye, salt and electric field strength for β –Carotene and vitamin A are 1.422 mg/100g and 2.371 mg/100g at 0.3% NaCl/1214.28V/m respectively. The ohmically heated tomato puree with higher concentration of NaCl (0.3%) at high field strength (1214.28 V/m) gave highest values of vitamin A (2.371 mg/100 g) as compared to KOH (2.141 mg/100 g) and NaOH (1.445 mg/100 g) concentrations. The value of β –Carotene was observed ranking first in salt (NaCl) solution followed by KOH and NaOH lye solutions for all experimented concentrations. Therefore it reveals that as the temperature of puree increases it resulted increase in β –Carotene which has been computed as vitamin A. Ascorbic acid is a heat instable vitamin; thus, high temperatures led to a loss of vitamin C. It was indicated that the independent parameters play major role on the ascorbic acid. The percentage retention of ascorbic acid was in the range of 34.64-91.35%. The percentage range of retention of ascorbic acid was observed ranking first in NaOH solution (86.01-91.35%) followed by KOH (61.91-77.06%) and NaCl (34.64-56.12%) for all experimented concentrations. It reveals that as the temperature of puree increases it resulted decrease in ascorbic acid which has been computed as vitamin C.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Toor RK, Savage GP. Antioxidant activity in different fractions of tomatoes. Food research international. 2005;38(5):487-494.
2. Conesa DP, Javier GA, Veronica GV, Maria DI, Karin J, luis MS, Gasper R, Maria JP. Changes in bioactive compounds and antioxidant activity during homogenization and thermal processing of tomato puree. Innovative Food Science and Emerging Technologies. 2009;10: 179-188.
3. Doreo MLJS. The history of tomato. International Journal of Tropical Agriculture. 2009;12:193-225.
4. Davey MW, Montagu VM, Inz´e D, Benzie IJJ, Strain JJ, Favell D, Fletcher J. Plant L-ascorbic acid: Chemistry, function, metabolism, bioavailability and effects of processing. J Sci Food Agric. 200;80:825–860.
5. Eliot SC, Goullieux A, Pain JP. Application of firming effect of low temperature long time pre-cooking to ohmic heating of potatoes. Science des Aliments. 1991; 20(2):265-280.
6. Fellow P. Food processing technology. 2nd Edition. England, Woodhead Publications Limited. 2000;373-377.
7. Bhat A, Joshi VK. Ohmic processing of foods, the concept, application, present status and future outlook. Alimentaria. 1998;289:83-88.
8. Hernandez RD, Williamson SH, Zhu L, Bustamante CD. Context-dependent mutation rates may cause spurious signatures of a fixation bias favoring higher GC-content in humans. Molecular Biology and Evolution. 2007;24(10):2196-2202.
9. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. 2nd Edition. New Delhi, Tata McGraw-Hill Publishing Company Limited. 1986;1112.
10. Stephens TS, Saldana GU, Brown HE. Effects of different submergence times in hot calcium chloride on peeling efficiency of tomatoes. Journal of Food Science. 1973;38:512-516.
11. Adubofour J, Zakpaa HD, Mak-Mensah EE. Postharvest quality of grape tomatoes treated with 1-Methylcyclopropene at advanced ripeness stages. HortScience. 2010;41(1):183-187.
12. Gary RB. Nutrient content of tomatoes and tomato products. Journal of Society for Experimental Biology and Medicine. 2014; 98:97-100.

13. Slimestad R, Verheul MJ. Content of chalconaringenin and chlorogenic acid in cherry tomatoes is strongly reduced during postharvest ripening. Journal of Agriculture and Food Chemistry. 2005;53:7251-7256.

14. Ismail IA, Nasiru A, Abdullahi MA, Abdullahi SI. Proximate, mineral and vitamin analysis of fresh and canned tomato. Biosciences Biotechnology Research Asia. 2002;13:1163-1169.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/27294