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MINIMALLY PROCESSED TOMATO USING A SIMPLE DEVELOPED FILTRATION DEVICE, COMMON SALT AND VEGETABLE OIL CAN PRESERVE TOMATO CONCENTRATE

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Abstract: In attempt to produce and preserve tomato concentrate, without destroying some useful nutrients, in a rural area where there is no electricity, a minimal processing method is necessary. In this study, a simple filtration unit was developed. Fresh tomatoes (*Solanum lycopersicum*) (3.50 kg) were bought, cleaned and blended. Initial moisture content (MC) of the slurry (3.0 g) was determined and 3.0 kg slurry filtered. The amounts of concentrate, filtrate and filtration period were noted. Initial MC of the concentrate was also found. A mixture of concentrate (200 g), vegetable oil (30 ml) and salt (12.0 g) was prepared for preservation as sample A. This was re-prepared but with 10.0 and 8.0 g of salt as samples B and C. pH, colour and lycopene content of the test samples were found before and during preservation at a week-interval for 2 months in duplicates. The results showed that the initial MC of the fresh tomato / slurry and concentrate were 93.5 and 73.3%, respectively. Test sample pH before preservation was 4.22. Sample A recorded 18.79% decrease in pH while B and C had 9.2% and 54% increase in pH, respectively.

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Visual observation after 8th week of preservation showed that the tomato concentrate was still reddish but colour change (ΔE) from the colorimeter revealed that sample

A had the least value of 6.09 while B and C were 7.31 and 8.53, respectively. Initial lycopene concentration was 14.11 mg /100 g product.

After preservation, Sample A had the least decrease (19.63%) compared to sample B (29.91% decrease) and sample C (33.3% decrease). Hence, common salt (12.0 g) and vegetable oil (30 ml) were able to maintain the acid content and minimize the reduction in lycopene content in the tomato concentrate.

Keywords: Simple filtration unit, processing method, tomato concentrate, preservation.

INTRODUCTION

Tomato (*Solanum lycopersicum*) is a common fruit consumed in many parts of the world. Its origin is traced from South America. The tomato fruit can be consumed as fresh product or processed product such as tomato juice, sun-dried tomato, tomato jam and pulp, canned whole tomato, ketchup (sauce), tomato paste, tomato leathers, tomato chutney and chill sauce [1]. The tomato fruit is like berry. It is red or yellow in colour, and between 15 – 75 mm in diameter. It varies in shape from oval, elongate to pear shape (Fig.1).



Fig.1. Fresh tomato (*Solanum lycopersicum*)

Whole tomato has some valuable nutrients such as vitamin C, lot of minerals and sugars [2]. The fruit has lycopene which is so beneficial to human health [3]. Proximate analysis of the ripe tomato fruit showed the presence of water (93.80%), carbohydrate (2.52%), protein (1.0%), ash (0.85%), crude fibre (1.21%) and crude fat (0.62%) [4]. Many tomato cultivars have between 4.5 to 7.8% soluble solids. The pH of fresh tomatoes is within 4.3 to 4.9. However, for the purpose of processing and preservation to avoid microbial spoilage, its pH should be 4.6 [5, 6]. The major organic acid present in tomato juice is the citric acid and malic acid among others. These acids play important roles in the manufacture and release of energy; while some major amino acids found are the glutamic acid, methionine and 5 methyl methionine, etc. Fruits and vegetables have important daily dietary functions in terms of promoting good health based on their composition: vitamins, antioxidants, microelements, etc. However, consumers give more preference to less processed, more convenient and safer foods.

This has led to the formulation of minimally processed foods [7]. Parameters such as pH, temperature, water activity, etc., could play very vital role in the preservation of processed food [8, 9, 10].

Furthermore, immediately after crop harvesting, deterioration process sets in, much rapid, especially in fruits and vegetables within few days. This is more predominant in rural areas where there are no adequate technologies to minimize the effects (spoilage and wastage). Typically, as soon as tomato fruits are harvested, deterioration begins. Heat application, during processing to preserve them, destroys some valuable natural ingredients and even eludes their freshness [11]. Common salt has an important role in reducing pathogens and organisms' growth that spoil food products. Vegetable oil in contact with fresh food material in a sealed container would inhibit further deterioration [12]. Therefore, the main objective of this study was to employ minimal processing methods in preserving tomato concentrate using a simple fabricated filtration device, common salt and vegetable oil.

MATERIALS AND METHODS

DESIGN OF SIMPLE FILTRATION DEVICE

Design Concept and Consideration

The design perception behinds the device is that the slurry is filtered under the influence of gravity and atmospheric pressure. The materials used for construction do not contaminate the products.

Design Calculations and Analysis of Some Major Parts of Simple Filtration Device

(I) Hopper

This is a cylindrical vessel with a lid and handle. It is made from stainless steel plates. The lid is perforated with 6 holes (10 mm in diameter) which allow the filtration process under the influence of gravity and atmospheric pressure. Under the lid is impregnated with a clean white cloth to shield the system from extraneous materials. The surface area of the lid (S_l), curve surface area (S_c) and volume of the cylindrical vessel (V_c) are given in Equations 1, 2 and 3.

$$S_l = \frac{\pi}{2} d_l^2 \quad \dots\dots\dots(1)$$

$$S_c = \pi \cdot d_c \cdot h \quad \dots\dots\dots(2)$$

$$V_c = \frac{\pi}{4} d_i^2 \cdot h \quad \dots\dots\dots(3)$$

Where,

d_l = external diameter of the lid (cover) (mm),

d_c = external diameter of the cylindrical vessel (mm),

h = height of the cylindrical vessel (mm),

d_i = internal diameter of the cylindrical vessel (mm).

(II) Filter Material

Muslin cloth is used as filter material. It is cut in the form of a circular surface with allowance to cover the rim of the funnel. Its surface area (S_{MC}) was calculated using Equation 1. However, its diameter is greater than d_l by 10 mm.

(III) Funnel

This is a conical segment of the filter with a short cylindrical tube that allows the dripping of the filtrate. It is made from stainless steel plate. The total surface area ($f_{t,s}$) and volume of the funnel (f_v) were calculated using Equation 4 to 8 as:

$$\text{Area of the curved surface of funnel} = \frac{\pi \cdot d_{ef} \cdot l_f}{2} \dots\dots\dots (4)$$

$$\text{Slant height of the conical segment, } l_f = \frac{d_{ef}}{2 \cos \theta} \dots\dots\dots (5)$$

$$\text{Area of the curved surface of short cylindrical tube} \\ = \pi \cdot d_{short\ cyl.} \cdot h_{short\ cyl.} \dots\dots\dots (6)$$

$$f_{t,s} = \left(\frac{\pi \cdot d_{ef} \cdot l_f}{2} \right) + \left(\pi \cdot d_{short\ cyl.} \cdot h_{short\ cyl.} \right) \dots\dots\dots (7)$$

$$f_{vol.} = \frac{\pi \cdot d_{if}^2 \cdot h_f}{3 \times 4} \dots\dots\dots (8)$$

Where

d_{ef} = external diameter of the funnel (mm),

θ = angle depression of the conical segment ($^\circ$),

$d_{short\ cyl.}$ = diameter of the short cylindrical tube (mm),

$H_{short\ cyl.}$ = height of a short cylindrical tube (mm),

d_{if} = internal diameter of the funnel (mm),

h_f = height of the funnel (30 mm).

(IV) Filtrate Collector

This is a transparent container that receives the filtrate during filtration. It is used to monitor the rate of flow. It has a lid with 6 perforated holes for the release of internal pressure. Under the lid too, is impregnated with a clean white cloth to prevent extraneous materials. Its volume was estimated using Equation 3 and based on expected volume of the filtrate per experimental run.

(V) Frame

This is a stand with 4 supports that is made from 10 mm thickness iron rod. The length of the rod that forms the stand was calculated thus:

$$L_{t.rod} = L_{c.rod} + (4L_{l-shaped\ rod}) \dots\dots\dots (9)$$

$$L_{c.rod} = \pi \cdot d_{c.rod} \dots\dots\dots (10)$$

$$L_{l-shaped\ rod} = \text{rod height} + \text{rod base} \dots\dots\dots (11)$$

Where,

$L_{t.rod}$ = total length of the rod (mm),

$L_{c.rod}$ = circumference of the circular rod (mm),

$L_{l-shaped\ rod}$ = length of the *l*-shaped rods (mm) and
 $d_{c.rod}$ = diameter of circular rod (mm).

PROCEDURE

Tomatoes (*Solanum lycopersicum*) (3.50 kg) were bought from Akpan Andem Market, Uyo, Akwa Ibom State. They were selected at random, washed in distilled water to eliminate extraneous materials, and mopped with clean cloth to remove the surface moisture. The wounded or perishable samples were removed and the good ones stored in clean containers. The samples were weighed using digital weighing balance. The bulk sample (3.05 kg) was blended using an electric blender. The slurry (30.0 g) was used in determining initial moisture content of the bulk samples by oven dry method as described by ASABE [13], Assian and Alonge [14], Antia *et al.* [15] using Equation 12. Exactly 3.0 kg of the slurry was taken out for filtration using simple fabricated filtration device (Fig. 2). Mass of tomato concentrate obtained was measured and its moisture content found. Approximately 200 g of the concentrate was measured into a transparent container. Then, 12.0 g of common salt (NaCl) and 30 ml of vegetable oil were added and mixed properly. The pH, colour and lycopene content of the test samples were determined before preservation, and then the transparent container was covered. These readings were taken at a week-interval for 2 months. The experiment was repeated with the same amount of tomato concentrate and vegetable oil but with 10.0 and 8.0 g of common salt as samples B and C. The experiment was conducted in duplicates. The plots of pH, colour and lycopene content against period of preservation were made.

Moisture Content Determination

The sample moisture content percent wet basis (% M_{wb}) was determined using Equation 12.

$$\% MC_{wb} = \frac{M_i - M_{bd}}{M_i} \times 100\% \quad \dots\dots\dots(12)$$

Where,

M_i = initial mass of the sample (g),

M_{bd} = sample mass at bone dry condition (g).

Determination of pH

The test sample pH was found using Jenway pH meter as described by HACH, [16].

Determination of Colour Using Colorimeter

The colours of the control and preserved samples were examined using colorimeter (CA 10). The corresponding values of “*L*”, “*a*” and “*b*” which indicate lightness, redness and yellowness degree, respectively, were read and noted for the control and preserved samples. Then, colour difference (ΔE) was computed thus [17, 18]:

$$\Delta E = \sqrt{(L_o - L)^2 + (a_o - a)^2 + (b_o - b)^2} \quad \dots\dots\dots(13)$$

Where,

L_o , a_o and b_o represent the colour parameters for the control samples (i.e., samples at zero minutes of preservation) while

L , a and b represent that of the preserved samples after several days.

Extraction and Determination of Lycopene Concentration Using Spectrophotometer SSI UV 2101

Lycopene content was extracted from the concentrate and the preserved samples with the mixture of hexane: ethanol: acetone in the ratio 2:1:1 (v/v). The mixture (25 ml) and test sample (1.0 g) were homogenized for 30 mins in a test tube using rotary mixer for 30 min. Distilled water (10 ml) was added and mixing continued for extra 3 min. The solution was kept to separate into polar and non-polar layers. Then, the absorbance was read at 502 nm, using hexane as a blank. The concentration of lycopene was computed using its specific extinction coefficient (E 1%, 1 cm) of 3150 in hexane at 502 nm, [19].

$$\text{Lycopene content (mg / 100 g)} = \frac{E \times 20}{3.15 \times M} \dots\dots\dots (14)$$

Where, E= extinction coefficient, M = mass of the test sample (g)

RESULTS AND DISCUSSIONS

Simple Filtration Device

Based on the designed formulas in Materials and Methods, the following were obtained:

(i) Hopper

$d_l = 160$ mm, $d_C = 150$ mm), $h = (50$ mm), $d_i = 140$ mm, $S_l = 40217.6$ mm²,
 $S_C = 23565$ mm² and $V_C = 769790$ mm³ (≈ 0.77 litres).

(ii) Filter Material

$S_{MC} = 45401.9$ mm²

(iii) Funnel

$d_{ef} = 160$ mm, $\Theta = 20^0$, $d_{short\ cyl.} = 20$ mm, $h_{short\ cyl.} = 15$ mm,
 $d_{if} = 154$ mm, $h_f = 30$ mm,

Area of the curved surface of funnel = 21399.69 mm²,

$l_f = 85.13$ mm, area of the curved surface of short cylindrical tube = 942.6 mm²,

$f_{t.s} = 22342.2905$ mm² and $f_{vol.} = 186289.18$ mm³ (≈ 0.19 l).

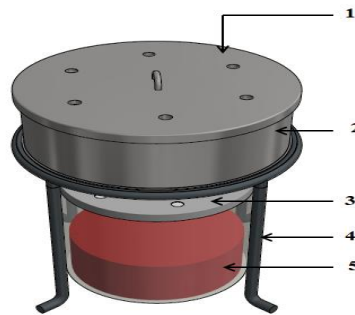
(iv) Filtrate Collector

d_{fC} = filtrate collector diameter (100 mm), h_{fC} = filtrate collector height (120 mm) and V_{fC} = filtrate collector capacity (942600 mm³ or 0.943 litres); hence, one litre container was purchased.

(v) Frame

$d_{c,rod}$ = 180 mm, rod height = 178 mm, rod base = 30 mm and $L_{t,rod}$ = 1397.56 mm.

However, the 3-D model of simple filtration device is presented in Fig 2.



1- Cover; 2-Hopper; 3- Filtrate lid; 4- Frame; 5-Transparent container

Fig. 2. Simple filtration device

Average Moisture Contents of the Fresh Tomato Slurry and Concentrate

The average moisture contents of the fresh tomato slurry and concentrate were $93.5 \pm 2.5\%$ and $73.3 \pm 2.9\%$, respectively. The observed MC of tomato concentrate was lower than that of the slurry due to the fact that part of it had filtered away. Approximately 1.2 kg of the concentrate and 1.74 liters (≈ 1.74 kg) of filtrate were got from 3.0 kg of tomato slurry after about 66 minutes of filtration (Fig. 3).



Fig. 3. Tomato slurry, filtrate and concentrate

Test Samples pH before and during Preservation

The plots of test samples pH before and during preservation are presented in Fig. 4.

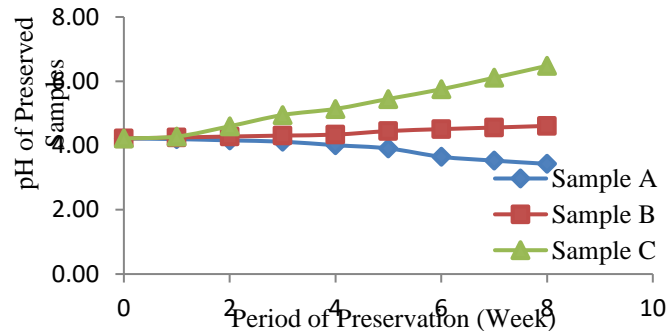


Fig. 4. Plots of pH test samples pH before and during preservation

As seen in Fig. 4, the initial pH of the test samples before preservation was 4.22. Sample A (12.0 g of salt) recorded 18.79% decrease in pH value during the period of preservation whereas samples B (10.0 g of salt) and C (8.0 g of salt) had 9.2% and 54% increase in pH values, respectively. This implies that the more the amount of salt in the tomato concentrate the more acidic it becomes. Hence, it is difficult for microbial attack on sample A with the pH of 3.43 at the 8th weeks of preservation, and so, there was no spoilage. Sample B recorded a very slow deterioration rate. Sample C was closed to neutrality; hence, the tomato concentrate may no longer safe for consumption according to CODEX Alimentarius [20] standard for processed tomato concentrate with acceptable pH value of 4.6.

Colour of the Test Samples before and during Preservation

The colour and plots of colour change in the test samples (ΔE) before and during preservation are presented in Fig. 5 and 6.

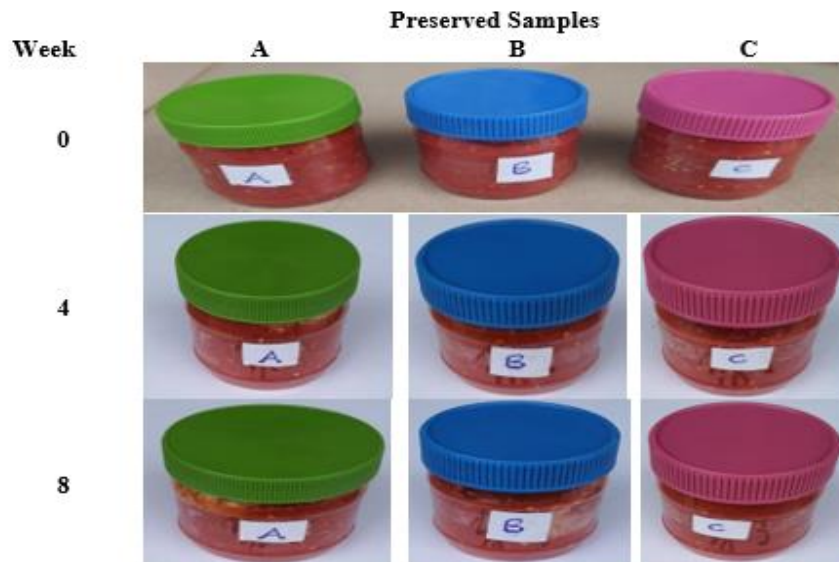


Fig. 5. Colour of the test samples before and during preservation

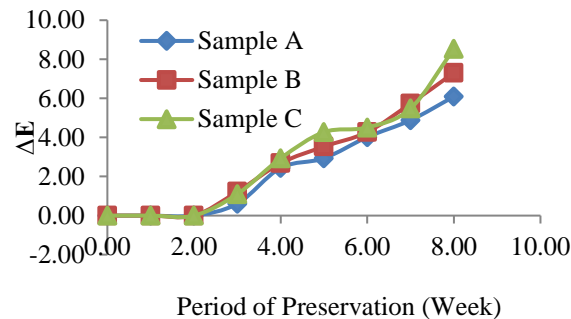


Fig. 6. Plots of ΔE in the test samples against period of preservation

From Fig. 5, visual observation after 8th week of preservation revealed that the colour of the tomato concentrate was still reddish. However, based on instrumentation, there was no ΔE at the end of the 2nd week of preservation, and after this period, a steady increase in ΔE was noted till the 8th week in all the test samples as seen in Fig 6. Besides, sample C recorded the highest ΔE (8.53); followed by sample B (7.31) and Sample A (6.09) being the least. The least ΔE in sample A might have been due to the ability of the mixture of the vegetable oil and such amount of salt to keep the lycopene in the tomato concentrate intact.

Lycopene Content of the Test Samples before and during Preservation

The plots of lycopene concentration versus period of preservation are shown in Figure 7.

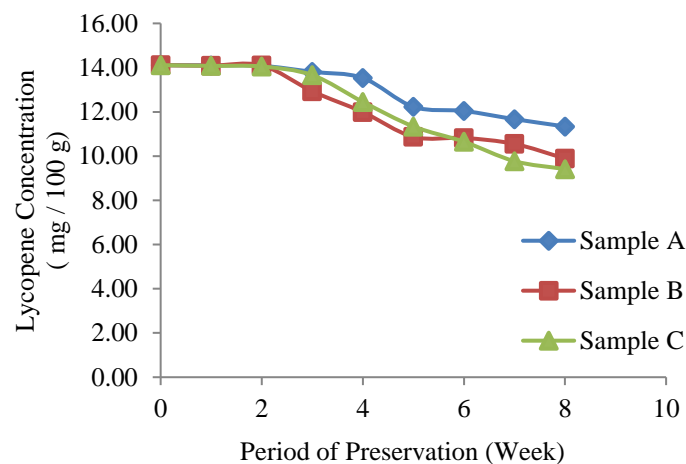


Fig. 7. Plots of lycopene concentration versus period of preservation

From Fig.7, the initial lycopene concentration found for test sample before preservation was 14.11 mg /100 g product. There was no significant variation in lycopene concentration in the test samples at the end of 2nd week of preservation as 14.08, 14.10 and 14.05 mg / 100 g of samples A, B and C, respectively.

Beyond this period, the concentration decreased till the 8th week as 11.34, 9.89 and 9.41 mg / 100 g of samples A, B and C, respectively. However, sample C recorded the highest % decrease (33.30%), followed by sample B (29.91%) and lastly sample A (19.63%). Sample A with the least decrease might have been due to more acidic content of the concentrate.

CONCLUSION

In this study, fresh tomato samples minimally processed into concentrate using simple fabricated filtration unit, 12.0 g common salt and 30 ml vegetable oil were able to maintain the acid medium and minimize the decrease in lycopene content.

In rural areas where there is no electricity, this method could be used in making and preserving healthy and safe tomato concentrate without application of heat or the use of refrigeration.

CONFLICT OF INTEREST

None is declared.

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**MINIMALNO PRERAĐEN PARADAJZ POMOĆU JEDNOSTAVNO
RAZVIJENOG UREĐAJA ZA FILTRACIJU, -OBIČNA SO I BILJNO ULJE
MOGU OČUVATI KONCENTRAT PARADAJZA**

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Abstrakt: U pokušaju da se proizvede i sačuva koncentrat paradajza, a da se pritom ne unište neke korisne hranljive materije, u ruralnom području Nigerije, gde nema struje, neophodna je minimalna metoda prerade. U ovoj studiji razvijena je jednostavna jedinica za filtriranje. Sveži paradajz (*Solanum lycopersicum*) (3,50 kg) je otkupljen, očišćen i izmešan. Određen je početni sadržaj vlage (MC) suspenzije (3,0 g) i filtrirano 3,0 kg kaše. Ustanovljene su količine koncentrata, filtrata i perioda filtracije. Nađena je i MC koncentrata.

Mešavina koncentrata (200 g), biljnog ulja (30 ml) i soli (12,0 g) pripremljena je za konzervaciju kao uzorak A. Ovo je ponovo pripremljeno ali sa 10,0 i 8,0 g soli kao uzorci B i C.

Vrednost pH, boja i sadržaj likopena testiranih uzoraka su pronađeni pre i tokom čuvanja u nedeljnom intervalu tokom 2 meseca.

Rezultati su pokazali da je početni MC svežeg paradajza/kaše i koncentrata bio 93,5 73,3%. Vrednost pH uzorka testa pre konzervisanja bio je 4,22.

Uzorak A je imao smanjenje pH od 18,79%, dok su B i C imali povećanje vrednosti pH od 9,2% i 54%, respektivno.

Vizuelno posmatranje posle osme nedelje čuvanja pokazalo je da je koncentrat paradajza i dalje bio crvenkast, ali je promena boje (ΔE) na kolorimetru pokazala da uzorak A ima najmanju vrednost od 6,09 dok su B i C 7,31 i 8,53, respektivno.

Početna koncentracija likopena bila je 14,11 mg/100g proizvoda. Nakon konzervacije, uzorak A je imao najmanje smanjenje (19,63%) u poređenju sa uzorkom B (smanjenje od 29,91%) i uzorkom C (smanjenje od 33,3%).

Dakle, obična so (količina 12,0 g) i biljno ulje (30 ml) su bili u stanju da održe sadržaj kiseline i minimiziraju smanjenje sadržaja likopena u koncentratu paradajza.

Ključne reči: Jednostavna jedinica za filtriranje, metoda prerade, koncentrat paradajza, čuvanje.

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