CHAPTER ONE

1. Introduction

The tomato (*Lycoperssicon esculentum*), is one of the most widely consumed fresh vegetables in the industrial world. Tomato fruit quality has been assessed by the content of different chemical compounds such as citric, ascorbic and other organic acids, sugars, minerals, antioxidants and characterized with dry matter, the Brix degree as well as maturity and the taste index (**Duma *et al.*, 2015)**

The world annual production of tomato about 160 billion tons situated in the eleventh place between the commodities with greater world production. This high tomato production points this commodity as an important component in the population diets. In particular, it is a key component of the Mediterranean diet, which is recognized as a healthy diet, especially in comparison with other typical diets from Northern European and American consumers (**Hernandez *et al.*, 2015).**

The tomatoes are a good source of vitamins A, B, C and K and very rich by natural antioxidants such as lycopene, flavonoids and phenolic acids which can reduce attack by colon, rectal, stomach and prostate cancer, also considered as source of minerals such as potassium **(Mohamed, 2008).**

Mohamed (2008) reported that, Tomatoes considered as perishable food which has relatively poor storage capability; green matured tomato can be held for up to two weeks at 13- 18 ºC, but for less time at under ambient tropical temperatures, fully ripe tomatoes have only two to six days storage life. Tomatoes can be processed as number of different products such as; Tomato preserves, dried tomatoes and tomato-based food.

The tomato is consumed in diverse ways, including row as an ingredient in many dishes, sauce, salads, paste or dried coloring added to most stewed recipes and also considered as important ingredient in pizza, salted pastry, hamburger, hot dogs or other fast food sand as drinks **(Mohammed, 2015)**.

1.2 Objectives of the study

1.2.1 Main objective

The main objective of this study is to determine the nutritional value of tomato fruits and production of natural juice from tomato fruits.

1.2.2 Specific objectives

1. To determine the chemical composition and minerals content of tomato fruits.
2. To evaluate optimum extraction conditions of tomato fruits to produce tomato juice.
3. To study the suitability of production of the natural juice from tomato fruits.
4. To increase the uses of the tomato fruits.

CHAPTER TWO

2. Literature review

2.1 Tomato

Tomato belongs to the genus Lycopersicon, Solanaceae family; there are around 75000 tomato varieties grown for various purposes; the most cultivated species is *Lycopersicon esculentum* L. which was brought to Europe by the Spanish conquistadors in the 16th century and later introduced from Europe to southern and eastern Asia, Africa and the Middle East. Tomato can grow in a wide range of climatic conditions but it is sensitive to the low light and adverse temperatures. More recently, wild tomato has been distributed into other parts of South America and Mexico **(Naika *et al.*, 2005**).Common names of the tomato are: tomate (Spain, France), tomat (Indonesia), faanke'e (China), tomato (West Africa), tomatl (Nahuatl), Jitomate (Mexico), Ponodoro (Italy), nyanya (Swahili) **(Osman, 2010).**

2.1.1 Origin and history

Tomatoes are considered as second widely grown vegetable crop around the worldwide after potato, and in the Sudan also considered as second one after onion based on cultivated area. Tomato wild species are native to the Andean region that includes parts of Chile, Colombia, Ecuador, Bolivia and Peru; the Spanish introduced the tomato in Europe in the early 16th century, in the 17th century European took the tomato to the China, South- South East Asia and in 18th century to Japan and USA **(Heuvelink, 2004).**In the Sudan, tomato is grown successfully in almost every part of the country during the winter season and sometimes during the rainy season in the Blue Nile and Gezira States. Several attempts have been made to minimize productivity constrains such as high temperature by cultural practices e.g.; sowing date, spacing, intercropping and shading **(Ahmed, 2006 and Osman, 2006).**
Tomatoes is the second to onion among the most important vegetable crops grown in the Sudan, occupying about 28% of total area under vegetables, producing about 294 thousand tons annually which representing about 27% of the country's total vegetables production **(Ahmed, 1994).**

Hochmuth (2007) proposed that, the tomato can be growing in the greenhouses and produce very high yield however, the greenhouses tomatoes are highly perishable because it have thin skins which have been easily injured and the productivity was decreased.

2.1.2 Classification of tomato plant

Abdullah (2014) mentioned that, the tomato plant is classified according to the following:

Kingdom: Plantae.

Sub kingdom: Tracheobionat.

Division: Mangolioplsida.

Class: Mangolioplsida.

Sub class: Asteridae.

Order: Solanales.

Family: Solanaceae.

Genus: Lycopersicon.

Species: L. esculentum.

2.1.3 Botanical description

The tomato root vigorous taps root system that grows to a depth of 50 cm or more. The main root produces dense lateral and adventitial roots. The stem growth habit ranges between erect and prostrate. It grows to height of 2-4 m. Tomato leaves are spirally arranged, compound, 15-50 cm long and 10-30cm wide, pinnate, with 5 – 9 leaflets each leaflet is 8cm long, covered with glandular hairs .inflorescence is clustered and produces 6-12 flowers. Petiole is 3-6 cm. The flowers of tomato are 1-2cm long; yellow, with five pointed lobes on the corolla Bisexual, regular and 1.5-2 cm in diameter they grow opposite or between leaves. Calyx tube is short and hairy, sepals are persistent. Ovary is superior and with 2-9 comportments. Most self-but partly also cross-pollinated the fruit is fleshy berry, globular to oblate in shape and 2.15 cm in diameter. The fruits are classified botanically as berries, their size vary from small cherry types of less than 15gm to large beefsteak types of more than 50gm, Tomato fruits color can be yellow, orange, pink, red or even white. The tomato seeds are numerous, kidney or pear shaped 3 - 5 mm and 2 - 4 mm wide. The embryo is coiled up in endosperm. There are three different types of tomato plant can be distinguished: Tall or indeterminate type, semi indeterminate type and bush or determinate type **(Omer, 2015).**

2.1.4 Ecology

Tomato requires a relatively cool, dry climate for high yield and premium quality. However, it is adapted to a wide range of climatic from temperate to hot and humid tropical. The optimum temperature for most varieties lies between 21℃ and 24℃. the plants can survive a range of temperature, but the plant tissues are damaged between 10c above 38c tomato plant react to temperature variation during the growth cycle, for seed germination, seedling growth, flower and fruit quality. To avoid frost damage it is best to wait until the winter is definitely over before sowing light intensity effect the color of the leave, fruit set and fruit color. Water stress and long dry period will cause buds and flowers to drop off and the fruit to split. However, if rains are too heavy and humidity too high, the growth of mould will increase and the fruit will rot. However, tomato grows well on most mineral soil that has proper water holding capacity and aeration and is free of salt **(Omer, 2015)**.

2.1.5 Varieties

Tomato has several types of varieties differing in their nature of growth, maturity period, and productivity and tolerant to diseases, pests and environmental conditions stress. They also differ in their shape, size and color of fruits. They also differ in their uses as fresh or as processed tomatoes **(Eltoum, 2000).**

Mohammed (2000) reported that, the following varieties are evaluated under Sudan condition. The suitable cultivators for fresh consumption are:

1-Early mature varieties include: Pritchard, Fire-ball, Marmande, Earliana, Strain B, Money Maker and Admiral.

2-Medium to late mature varieties: include Person, Ace, Early Pack, Marglobe and Homestead.

There were varieties suitable for processing which includes Chico, Chico 3, San Marzoneo and Roma. Most of these varieties have a berry or pear shaped fruit and are characterized by the following:

a) High productivity

b) Short period production
c) High percentage of solid materials
d) Low percentage of acidity
e) Have no green shoulders
f) Few seeds
g) Thin peel
h) At the separation of fruits from the plant, the fruits become free of calyx

2.1.6 Nutritional value

Tomatoes are very valuable vegetables due to their nutritional benefits it's containing 19 soluble amino acids such as glutamic, aspartic, alanine, threonine, proline amino acids. Also, it is rich in antioxidant such as vitamin C, lycopene, pro-vitamin A and phenolic compounds; flavonoids and phenolic acids, tomatoes good source of and minor elements for instance copper, manganese and zinc. The water content ranged from 93.09% to 96.17%, Crude ash content was ranged from 9.25% to 10.60%, The total sugar and reducing sugars contents ranged respectively from 47.00% to 53.43% and from 30.03% to 41.21%, the protein and fat contents respectively ranged from 17.09% to 25.03% and from 4.77% and 7.00%, The energy values of the samples ranged from 288.20 to 344.24 K. cal. /100g **(Sakira *et al.*, 2017).**

Lycopene ($C_{40}H_{56}$) is the carotenoid hydrocarbon that gives tomatoes their red color. It is a hydrophobic and acyclic carotenoid possessing 11 conjugated and 2 non-conjugated double bonds, and is located in the photosynthetic pigment protein complex of the thylakoid membrane in tomatoes. Particularly, this system of conjugated double bonds makes lycopene susceptible to enzymatic (intestinal enzymes) or chemical (i.e. potassium permanganate and metalloporphyrins) oxidative cleavage and isomerization from all-trans to cis-forms. Oxidation may occur by auto-oxidation, which is a spontaneous free radical chain reaction in the presence of oxygen, or by photo-oxidation produced by oxygen in the presence of light, During auto-oxidation of carotenoids, alkyl-peroxyl radicals are formed, and these radicals attack the double bonds resulting in the formation of epoxides, The lycopene content in fresh tomatoes and their products has been reported to range from 2.5 to 670 mg/ 100 g fresh weight **(Hernandez, 2004; Chauhan *et al.*, *2011* and Kumar *et al.*, 2012).**

Table 2.1: Chemical composition and minerals of tomato fruits

Component	**Values**
Moisture content (%)	93.5
Protein (%)	1.1
Fat (%)	0.2
Total carbohydrates (%)	4.7
Fiber (%)	0.5
Ash (%)	0.5
Calcium (mg/100g)	13
Phosphorus (mg/100g)	27
Iron (mg/100g)	0.5
Sodium (mg/100g)	3.0
Potassium (mg/100g)	244
Energy (calories)	22

Source: Sakira *et al.* (2017).

Table 2.2: Vitamins content of ripe tomato fruits

Vitamins	**Range (µg/ 100g)**
A (β-carotene)	540 – 760
B1(thiamine)	50 – 60
B2 (riboflavin)	20 – 50
B3 (pantothenic acid)	50 – 75
B6 complex	80 – 110
Nicotinic acid (niacin)	500 – 700
Folic acid	6.4 – 20
Biotin	1.2 – 4.0
C	15 – 23
E (α- tocopherol)	40 – 1200

Source: Sakira *et al.* (2017)

Table2.3: Nutritional composition of the tomato

Cultivars	Parameters						
	Dry matter	**Ash (%)**	**Total sugar (%)**	**Reducing sugars (%)**	**Lipid (%)**	**Protein (%)**	**Energy (Kcal/100g)**
Loumbila	95.09	9.79	47.00	30.03	4.77	25.03	331.05
Ouahigouya	9568	10.60	48.29	36.27	5.39	24.36	339.11
Ouagadougou	96.17	9.25	53.43	41.21	7.00	17.09	345.08

Source: Sakira *et al.* (2017)

2.1.7 Utilizations

2.1.7.1 as Food

Tomatoes are the one of the most widely eaten vegetable in the world. Their popularity stems from the fact that they can be eaten fresh or in multiple of processed forms; (1) tomato preserves (e.g.; whole peeled tomatoes, tomato juice, tomato pulp, tomato puree, tomato paste, pickled tomatoes); (2) dried tomatoes (e.g. tomato powdered, tomato flakes, dried tomato fruit and (3) tomato-based food (e.g. tomato soup, tomato sauces, chili sauce and ketchup) **(Hernandez, 2004 and Mohamed, 2007).**

2.1.7.2 as medicine

2.1.7.2.1Reduce Heart Disease

Tomatoes are good source of potassium that have been shown to lower high blood pressure and reduce risk of heart disease. Vitamin B6 and folate, present in tomatoes, are needed to the body to convert a dangerous chemical called homocysteine into other, benign molecules. High levels of homocysteine can directly damage blood vessel walls and are associated with an increased risk of heart attack and stroke.

2.1.7.2.2 Lower Blood Pressure

The tomatoes provide significant drop in blood pressure. After 8 weeks, ongoing tracking of daily tomato ingestion (in the form of lycopene complex a tomato extract) showed a drop in both the blood pressure top number (systolic) by 10 points and the bottom number (diastolic) by 4 points.

2.1.7.2.3 Regulates Blood Sugar

Supplements of vitamin C are beneficial to cure the diabetes as they help in processing of insulin and glucose. It can be cured by regular intake of vitamin C. Tomatoes are an outstanding source of chromium that has been shown to help diabetic patients keep their blood sugar levels under control.

2.1.7.2.4 Strengthen Bones

A serving of tomatoes provide 18% the daily value of vitamin K which is activates osteocalcinmineralizes calcium molecules inside of the bone and promotes bone health.

2.1.7.2.5 Protection from cell Damage

The tomatoes are excellent source of antioxidant lycopene. Antioxidants travel through the body, neutralizing dangerous free radicals that otherwise damage cells and cell membranes. Free radicals escalate the progression or severity of atherosclerosis, diabetic complications, asthma, and cancer of prostate, cervical, colon, rectal, and mouth. High intakes of lycopene have been shown to help reduce the risk or severity of all of these illnesses (**Kumar *et al.*, 2012).**

2.1.7.2.6 Protection of eyes diseases

The Vitamin A found in tomatoes is fantastic for improving your vision. In addition, eating tomatoes is one of the best foods to eat to prevent the development of night blindness

2.1.7.2.7 Provide essential antioxidants

Tomatoes contain a great deal of Vitamin A and Vitamin C. This is primarily because these vitamins and beta-carotene work as antioxidants to neutralize harmful free radicals in the blood. Free radicals in the blood stream are dangerous because it may lead to cell damage. Remember, the redder the tomato you eat is, the more beta-carotene it contains. In addition, you also want to keep in mind that cooking destroys the Vitamin C, so for these benefits, the tomatoes need to be eaten raw.

2.1.8 Tomato products

Srivastava and Kumar (2001) mentioned that, Tomatoes can be processed into a number of products:

2.1.8.1 Tomato juice

Plant-ripened, fully red fruits are selected, discarding all green, blemished and over-rip fruits. A good quality juice should be of deep red color, possess the characteristic taste and flavor of tomato, contain about 0.4 per cent acid (in terms of citric acid), be uniform in appearance and have high nutritive value.

F.P.O. specifications for tomato juice are in addition the juice should contain 0.5% salt, 1% sugar and 0.4% acids. Tomato juice /pulp can be extracted by hot or cold pulping. Hot pulping is superior to cold pulping because in the latter case, extraction of juice is somewhat difficult and its yield is less, vitamin C is oxidized more rapidly.

2.1.8.2 Tomato puree and paste

Tomato pulp without skin or seeds, with or without added salt, and containing not less than 9.0 per cent of salt-free tomato solids, is known as “medium tomato puree”. It can be concentrated further to “heavy tomato puree” which contains not less than 12 per cent solids. If this is further concentrated so that it contains not less than 25 per cent tomato solids, it is known as tomato paste.

2.1.8.3 Tomato sauce/ ketchup

It is made from strained tomato juice or pulp and spices, salt, sugar and vinegar, with or without onion and garlic, and contains not less than 12 per cent tomato solids and 25 per cent total solids.

2.1.8.4 Tomato cocktail

It is prepared just before serving or served from stock.

2.1.8.5 Tomato soup

Soup is becoming very popular in homes. Stored soup is warmed at the time of serving.

2.1.8.6 Tomato chili sauce

It is highly spiced product made from ripe, peeled and crushed tomatoes and salt, sugar, spices, vinegar.

2.2 Fruit Juice and drink

Fruit juices and drinks are becoming very important in modern communities, because they are beyond its use as a refreshing also contains several of minor ingredients, particularly vitamins and minerals, as well as carbohydrates, fat-free and naturally occurring phyto-nutrients that contribute to the good health of the human being **(Frank *et al*., 2005 and Ashurst, 2005).**

2.2.1 Definitions

Fruit juice is the unfermented liquid obtained from the edible part of sound, appropriately mature and fresh fruit or of fruit maintained in sound condition by suitable means including post harvest surface treatment. Some juices may be processed with pips, seeds, and peel. A single juice is obtained from one kind of fruit. A mixed juice is obtained by blending two or more fruits juices and puree **(CODEX, 2005).** Also can be defined as the product from which water has been physically removed in an amount sufficient to increase the Brix level to a value at least 50%, greater than the Brix value established for reconstituted juice from the same fruit. During the production of fruit juice that should be concentrated, suitable processes are used and may be combined with simultaneous diffusion of pulp cells or fruit pulp by water before the concentration process. Fruit juice concentrates may have restored aromatic substances and volatile flavor components, all of which must be obtained by suitable physical means, and all of which must be recovered from the same kind of fruit. Pulp and cells obtained by suitable physical means from the same kind of fruit may be added **(Babiker, 2013).**

A wide range of drinks can be made of using extracted fruit juice or fruit pulp as the base material. Many are drunk as the pure juice without the addition of any other ingredients, but some are mixed with sugar syrup. The drinks are usually preserved by a combination of natural acidity, pasteurization and packaging in sealed containers. Some drinks (syrup and squashes) also contain a high concentration of sugar which helps to preserve them **(Azam, 2008).**

2.2.2 Processing steps

2.2.2.1 Juice extraction

The first stage is the extraction of juice or pulp from the fruit after selection of mature and undamaged fruits. The fruit juice may be obtained by diffusion in water. The solids content of the finished product shall meet the minimum Brix level.

2.2.2.2 Filtering

The extracted juice or pulp the filtered through a muslin cloth or a stainless steel filter that to make a clear juice. The juice of fruits is naturally cloudy; however some consumers prefer a clear product. It may be necessary to use pectic enzymes to break down the pectin so as to have a clear juice.

2.2.2.3 Preparation

Fruit would normally contain about 25% fruit material mixed with the sugar syrup to give a final product.

The addition of sugar to the fruit pulp to achieve the recommended levels for preservation must take into a count the amount of sugar already present in the juice. The Person Square is a useful tool to use with the a batch formulation and to calculated the amount of sugar to be added for preservation.

2.2.2.4 Pasteurization

All the fruit juice and drinks need to be pasteurized at 80-95C for 1-10 minutes prior to the hot filling.

2.2.2.5 Filling and bottling

The fruit juices and drinks products should be hot filled into clean, sterilized bottles. After filling hot, the bottles are capped and laid on their sides to cool prior to labeling.

2.2.3 Quality aspects

The fruit juices should have the characteristic color, aroma and flavor of maintenance of the same kind of fruit from which it is made. Authenticity is the maintenance of the products essential physical, chemical, organoleptical, and nutritional characteristics of the fruit from which it comes. Total soluble solids (T.S.S.) contents are related directly to both the sugars and fruit acids as these are the main contributors. Pectin, glycosidic materials and the salts of metals (sodium, potassium, calcium etc.) when present, will also register a small but insignificant influence on the solids figure **(Babiker, 2013).**

CHAPTER THREE

3. Materials and Methods

3.1 Materials

The tomato fruits (*Lycopersicon esculentum* L.) used in this study was obtained from Omdurman market, Khartoum state. The whole fruits sample was carefully cleaned and tightly kept in polyethylene bags at 4℃ until required for different investigations.

3.2 Methods

3.2.1 Chemical methods

3.2.1.1 Moisture content

The moisture content was determined according to the standard method of the Association of Official Analytical Chemists **(AOAC, 2003).**

Principle: The moisture content in a weighed sample is removed by heating, the sample in an oven 105 ± 1 °C. Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

Procedure: A sample of 2 ± 0.001 g was weighed into a pre-dried and tarred dish. Then, the sample was placed into an oven (No.03-822, FN 400, Turkey) at 105 ± 1 °C until a constant weight was obtained. After drying, the covered sample was transferred to desiccators and cooled to room temperature before reweighing. Triplicate results were obtained for each sample and the mean value was reported to two decimal points according to the following formula:

Calculation:

$$\text{Moisture content (\%)} = \frac{(W_s - W_d) \times 100\%}{\text{Sample weight (g)}}$$

[eq.1]

Where:

W_s = weight of sample before drying.

W_d = weight of sample after drying.

3.2.1.2 Crude protein content

The protein content was determined in different samples by micro-Kjeldahl method using a copper sulphate-sodium sulphate catalyst according to the official method of the **AOAC (2003).**

Principle: The method consists of sample oxidation and conversion of its nitrogen to ammonia, which reacts with the excess amount of sulphuric acid forming ammonium sulphate. After that, the solution is made alkaline and the ammonia is distilled into a standard solution of boric acid (2%) to form the ammonia-boric acid complex which is titrated against a standard solution of HC1 (0.1N). The protein content is calculated by multiplying the total N % by 6.25 as a conversion factor for protein.

Procedure: A sample of two grams(2 ± 0.001 g) was accurately weighed and transferred together with, 4 ± 0.001 g $NaSo_4$ of Kjeldahl catalysts (No. 0665, Scharlauchemie, Spain) and 25 m1 of concentrated sulphuric acid (No.0548111, HDWIC, India) was added into a Kjeldahl digestion flask. After that, the flask was placed into a Kjeldahl digestion unit (No.4071477, type KI 26, Gerhardt, Germany) for about 2 hours until a colorless digest was obtained and the flask was left to cool to room temperature. The distillation of ammonia was carried out into 25 m1 boric acid (2%) by using 20 ml sodium hydroxide solution (45%). Finally, the distillate was titrated with standard solution of HC1 (0.1N) in the presence of 2-3 drops of bromocreasol green and methyl red as an indicator until a brown reddish color was observed.

Calculation:

$$\text{Crude Protein (\%)} = \frac{(\text{ml HCl sample} - \text{ml HCl blank}) \times N \times 14.00 \times F \times 100\%}{\text{Sample weight (gm)} \times 1000} \quad \text{[eq.2]}$$

Where:

N: normality of HCl. (0.1N)

F: protein conversion factor = 6.25

3.2.1.3 Fat content

Fat content was determined according to the official method of the **AOAC (2003).**

Principle: The method determines the substances which are soluble in petroleum ether (65-70 °C) and extractable under the specific conditions of Soxhlet extraction method. Then, the dried ether extract (fat content) is weighed and reported as a percentage based on the initial weight of the sample.

Procedure: A sample of 5 ± 0.00l g was weighed into an extraction thimble and covered with cotton that previously extracted with hexane (No.9-16-24/25-29-51, LOBA Cheme, and India). Then, the sample and a pre-dried and weighed extraction flask containing about 100 ml hexanes were attached to the extraction unit(Electro-thermal, England) and the extraction process was conducted for 6 hrs. At the end of the extraction period, the flask was disconnected from the unit and the solvent was redistilled. Later, the flask with the remaining crude ether extract was put in an oven at 105 ±1º C for 3 hrs., cooled to room temperature in a desiccators, reweighed and the dried extract was registered as fat content according to the following formula;

Calculation:

$$\text{Fat content (\%)} = \frac{(W_2 - W_1) \times 100\%}{W_3}$$

[eq.3]

Where;

W_1 =Weight of the empty flask

W_2 =Weight of the flask and ether extract

W_3=initial weight of the sample

3.2.1.4 Total carbohydrates

Total carbohydrates were calculated by difference according to the following equation:

Total carbohydrates (%) =100% - (Moisture% + Protein% + Fat% + Ash %).

[eq.4]

3.2.1.5 Crude fiber content

The crude fiber was determined according to the official method of the **AOAC (2003).**

Principle: The crude fiber is determined gravimetrically after the sample is being chemically digested in chemical solutions. The weight of the residue after ignition is then corrected for ash content and is considered as a crude fiber.

Procedure: About 2 ± 0.001 g of a defatted sample was placed into a conical flask containing 200 m1 of H_2SO_4 (0.26 N). The flask was then, fitted to a condenser and allowed to boil for 30 minutes. At the end of the digestion period, the flask was removed and the digest was filtered (under vacuum) through a porcelain filter crucible (No.3). After that, the precipitate was repeatedly rinsed with distilled boiled water followed by boiling in 200 ml NaOH (0.23 N) solution for 30 minutes under reflux condenser and the precipitate was filtered, rinsed with hot distilled water, 20m1 ethyl alcohol (96%) and 20 ml diethyl ether. Finally, the crucible was dried at 105 °C (overnight) to a constant weight, cooled , weighed, ashed in a Muffle furnace (No.20. 301870, Carbolite, England) at 600 °C until a constant weight was obtained and the difference in weight was considered as crude fiber.

Calculation:

$$\text{Crude fiber (\%)} = \frac{(W_1 - W_2) \times 100}{\text{Sample weight (gm)}}$$

[eq.5]

Where;

W_1 = weight of sample before ignition (gm).

W_2 = weight of sample after ignition (gm).

3.2.1.6 Available carbohydrates

Available carbohydrates were calculated by difference according to the following equation:

Available carbohydrates (%) = Total carbohydrates% – Crude fiber%.

[eq.6]

3.2.1.7 Ash content

The ash content was determined according to the method described by the **AOAC (2003).**

Principle: The inorganic materials which are varying in concentration and composition are customary determined as a residue after being ignited at a specified heat degree.

Procedure:

A sample of 5 ± 0.001 g was weighed into a pre-heated, cooled, weighed and tarred porcelain crucible and placed into a Muffle furnace (No.20. 301870, Carbolite, England) at 600 °C until a white gray ash was obtained. The crucible was transferred to desiccators, allowed to cool to room temperature and weighed. After that, the ash content was calculated as a percentage based on the initial weight of the sample.

Calculation:

$$\text{Ash (\%)} = \frac{[(\text{Wt of crucible} + \text{Ash}) - (\text{Wt of empty crucible})] \times 100\%}{\text{Sample weight (g)}} \quad \text{[eq.7]}$$

3.2.1.8 Food energy value

The energy value of tomato fruits was calculated based on Atwater factors as indicated by **Leung (1968).**

Protein = 3.87 K. cal. /g

Fat = 8.37 K. cal. /g

Carbohydrate = 4.12 K. cal. /g

K. cal. = 4.184 kj

3.2.2 Minerals content

Ten milliliters (10 ml) of HCL (2N) were added to the remaining ash sample and placed in a hot sand path for about 10-15 min. Then, the sample was diluted to 100 ml in a volumetric flask and filtered. The trace elements ferrous (Fe^{++}), and manganese (Mn^{++}) were determined according to **Perkin Elmer (1994)** by using Atomic Absorbance Spectroscopy (JENWAY 3110, UK). Sodium (Na) and potassium (K) were determined by using Flame Photometer (Model PEP7 JENWAY). While, calcium (Ca), phosphorus (P) and magnesium (Mg) were determined as described by **Chapman and Parratt (1961).**

3.2.3 Determination of optimum extraction conditions of tomato fruits

Take 50 gm from tomato fruits and were minced at a room temperature in distilled water at different fruits : water ratio (1:2 , 1:4 , 1:6 , 1:8 and 1:10) . After that filtered the extraction with fine silk sieve . Finally, the weight of each ratio was recorded and checked for pH , total soluble solids (%) , volume of extraction , weight of extraction and yield (%). The yield (%) of flakes extraction was calculated from this is equation :

The yield **(%) =**weight × TSS (%) [eq.8]

3.2.4 Experimental processing method

3.2.4.1Fruits juice extraction method

The cold extraction method has been used, three replicates from the sliced tomato and carrot sample (50g) were mixed together and blended for (7min) in tap water at different ratios (1:2,1:4, 1:6, 1:8 and 1:10). Then the mixtures were immediately filtered with a muslin cloth to make a clear juice and weighed. After that, the filtrates were examined for total soluble solids (T.S.S.%), hydrogen ions concentration (pH), volume of extract (ml), weight of extract (g), and yield (%).The yield of each extract was calculated by using the following.

$$\text{Yield\%}= \frac{(\text{T.S.S\%}\times\text{weight of extract (g)})\ 100\%}{\text{Initial weight of sample (g)}}$$

[eq.9]

3.2.4.2 Tomato juice processing

The processing method used in this study for production of tomato and carrot fruits juice is described in fig. (1), in this method the ripped, fully and red tomato and carrot fruits: water (1:6) was manually washed, removed green portion and stem, sliced and weighed (166,66g). Then the fruits juice was extracted by adding a tap water (833,34ml) blended mechanically, filtrated with a muslin cloth to make a clear juice and placed in plastic container. After that, sugar (135.3g), pectin (3g) and citric acid (2g) were immediately added and the mixture was filled in a clean glassy flask and sterilized in water path (70℃ /10 min), tightly closed, cooled and stored at (2℃) until needed for the different investigations.

3.2.5 Physcio-chemical methods

3.2.5.1 Hydrogen ion concentration

The PH is defined as the logarithm of reciprocal of hydrogen ion concentration in (gm\liter). The pH of a different samples was measured following the method that described by **Ranngana (2001).**

Principle: The pH of a sample is measure potentio-meterically with a pH-meter after standardization of the meter electrodes with buffer solutions and the reading is taken when the equilibrium potential across the electrodes is achieved.

Procedure: After standardization of the pH-meter (pH-meter model pHs – 2F) electrodes with two buffer solutions (pH 4.01- 6.89). The electrodes of pH meter were rinsed with distilled water, immersed in the sample solution (28◦ C) and left to stand until stable reading was achieved. All the reading was expressed as pH then earest decimal point (0.01) pH units.

3.2.5.2 Total soluble solids (TSS %)

The total soluble solids of tomato juice extraction and tomato natural juice were measured by using a hand refractometer (Erma-Tokyo No. 40382 ″45-82″ Japan and Erma-Tokyo No. 50015 ″0-32″ Japan) and were expressed as (%) sucrose degree brix according to **AOAC (1984).**

3.2.5.3 Titerable of acidity

The total acidity was conveniently determined according to the method described by **Ranngana (2001).** Take10 gm of the sample, diluted with 100ml distilled water and then filtered by using what man filter paper No. 4, 10 ml of prepare sample was titrated against 0.1 N Sodium hydroxide and using phenolphthalein as an indicator, total acidity (mg\100gm) expressed as a citric acid .

Calculation

$$T.A = \frac{\text{Titer ml} \times \text{normality of NaOH} \times \text{vol. of dilution} \times \text{equivalent wt.} \times 100}{\text{wt. of sample} \times \text{vol. taken for estimation} \times 1000} \quad [eq.10]$$

3.2.5.4 Total volume

The total volume of end product in different sample was measured by volumetric cylinder and nearest decimal point (0.01).

3.2.5.5 Total weight

The total weight of samples using in sensory evaluation and end Product was measured by sensitive balance and nearest decimal point (0.01).

3.2.6 Organoleptic evaluation method

The sample of tomato natural juice without flavor, flavored by strawberry and orange flavors sensory evaluated by using the hedonic scoring test method as described by **Watts *et al.* (1989)** .

In this method, 16 trained panelists from Sudan university of sciences and technology (college of agricultural studies) were asked to evaluate the products with regard to their taste, color, flavor, appearance and overall quality using the following hedonic scale, 1= unacceptable, 2= acceptable, 3= good , 4= very good, 5= excellent.

3.2.7 Statistical analysis method

The results were subjected to Statistical Analysis System (SAS) by using One-Factor Analysis of Variance (ANOVA). The Mean values were also tested and separated by using Duncan's Multiple Range Test (DMRT) as described by **Steel *et al.* (1997).**

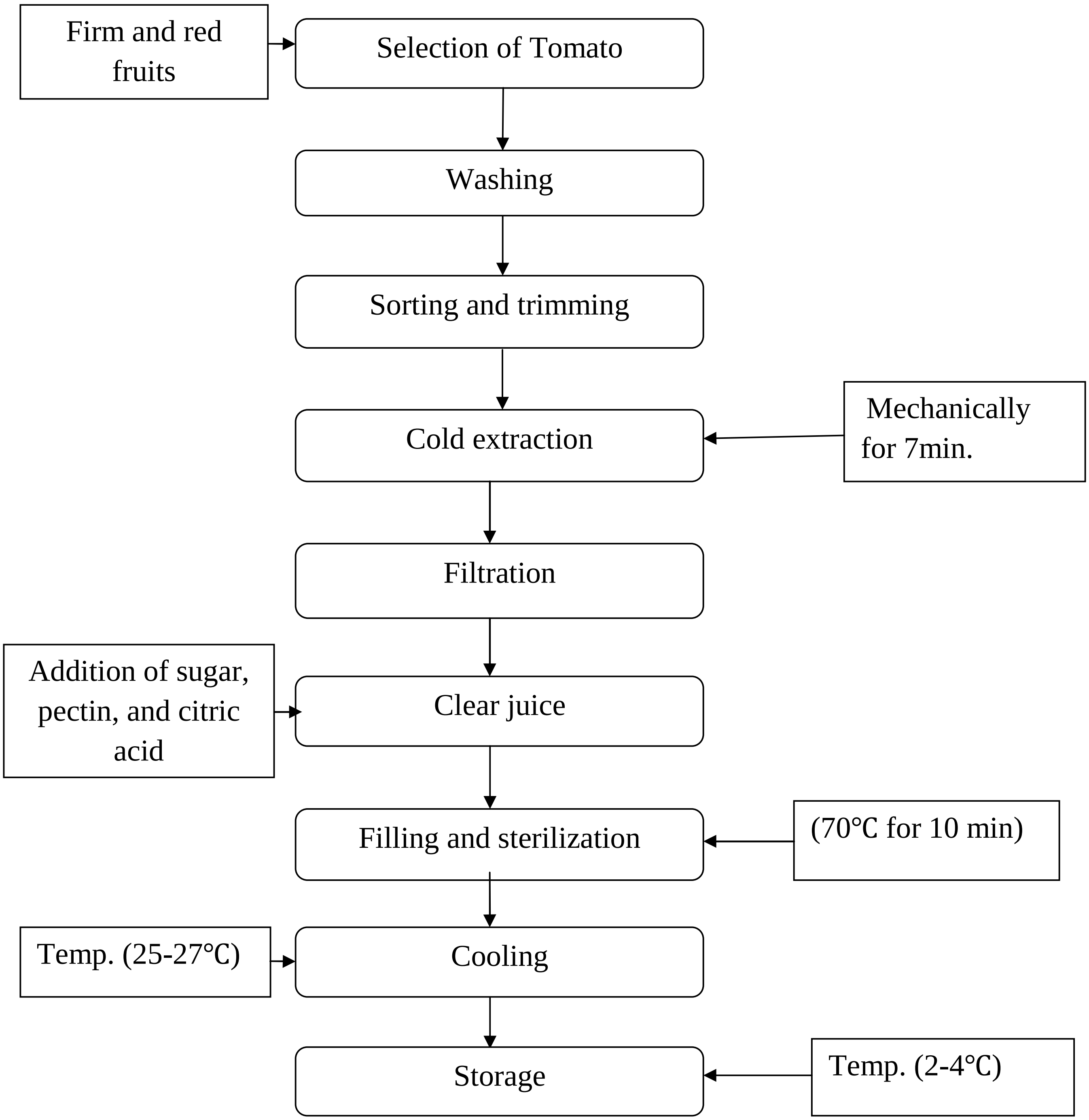

Figure (1): Flow processing diagram for production of tomato juice

CHAPTER FOUR

4. Results and Discussion

Table (4.1) shows the chemical composition of tomato fruits on wet and dry basis. The dry matter, protein, fat, total carbohydrates, fibers and ash contents were found to be 6.17%, 18.80%, 3.24%, 69.30%, 20.58%, 8.59%, respectively on dry basis. The results obtained in this study were well agreed with those reported by **Sakira *et al.* (2017).**

Table (4.2) shows the minerals content of tomato fruits on wet and dry basis as mg/100g, Magnesium, Potassium, Calcium, Sodium, Phosphorus, Iron and Manganese, content were found to be 147.00, 52.5, 33.15, 20.74, 3.56, 1.73 and 0.16 respectively, these results disagree with those reported by **Sakira *et al.* (2017)** these differences may be refer to the variety, soil type, irrigation water minerals content.

Table (4.3) shows the extraction conditions (fruits: water ratio), weight of fruits, weight of extract, volume of extract, hydrogen ions concentration (pH), total soluble solids (T.S.S.%) and yield of extract of (1:2) ratio were found to be 50, 111.7, 116, 4.45, 2.8, 3.13 respectively, ratio (1:4) weight of fruits, weight of extract, volume of extract, pH, T.S.S.% and yield of extraction were found to be 50, 199.4, 204, 4.62, 2.2, 4.38 respectively, in ratio (1:6) weight of fruits, weight of extract, volume of extract, (pH), (T.S.S.%) and yield of extraction were found to be 50, 298.7, 306.6, 4.75, 1.7, 5.08 respectively, in ratio (1:8) weight of fruits, weight of extract, volume of extract, (pH) (T.S.S.%) and yield of extraction were found to be 50, 405.9, 414, 5.0, 0.9, 3.65 respectively, and ratio (1:10) weight of fruits, weight of extract, volume of extract, (pH), (T.S.S.%) and yield of extraction were found to be 50, 528.1, 538, 5.42, 0.7, 3.69 respectively. From the results the highest weight of extract, volume of extract, (pH), were represented in (1:10), and the highest T.S.S. % in (1:2), whereas the ratio of (1:6) has been chose to produce tomato juice because it has highest yield.

Table (4.1): Chemical composition of tomato fruits

Parameters	Values [n = 3 ± SD]		p-value	SE
	On wet basis	**On dry basis**		
Moisture& dry matter	93.83 ± 0.070	06.17 ± 0.0702	0.0000	0.0406
Protein	01.16 ± 0.015	18.80 ± 0.0702	0.0001	0.0088
Fat	00.20 ± 0.000	03.24 ± 0.0531	0.0000	0.0000
Total carbohydrates	04.28 ± 0.107	69.3o ± 1.0025	0.0002	0.0617
Fibers	01.27 ± 0.058	20.58 ± 0.7540	0.0007	0.0333
Available carbohydr.	03.01 ± 0.056	48.78 ± 0.3690	0.0001	0.0321
Ash	00.53 ± 0.058	08.59 ± 1.0262	0.0039	0.0333
Caloric value	23.80 ± 0.499 K. cal./g 99.58 K J	385.39 K. cal./g 1612.47 K J	0.0001	0.2879

SD ≡ Standard deviation.

n ≡ Number of independent determinations

Table (4.2): Minerals content of tomato fruits

Minerals		On wet basis	On dry basis
		[mg/100g]	
Sodium	[Na]	20.74	336.14
Potassium	[K]	52.5	850.89
Calcium	[Ca]	33.15	537.28
Magnesium	[Mg]	147.00	2382.50
Iron	[Fe]	1.73	28.04
Manganese	[Mn]	0.16	2.59
Phosphorus	[p]	3.65	59.16

Table (4.3): Optimum extraction conditions (Tomato fruit: water ratio)

Parameters	**1:2**	**1:4**	**1:6**	**1:8**	**1:10**	**P-value**
	n=3					
Weight of tomato	50	50	50	50	50	0.000
Weight of extract	111.7	199.4	298.7	405.9	528.1	0.0021
Volume of extract	116	204	306.6	414	538	0.0174
Total soluble solids	2.8	2.2	1.7	0.9	0.7	0.361
PH	4.45	4.62	4.75	5.00	5.42	0.0785
Yield	3.13	4.38	5.08	3.65	3.69	0.0003

n ≡ Number of independent determinations

Table (4.4) shows the recipe formulation of processed tomato natural juice, the weight of the fruits (g), water (g), sugar (g), citric acid (g), pectin and total weight of mixture (g) were found to be 166.66, 833.34, 135.3, 2, 3, and 1140.3, respectively. And the formula (%) was found 14.26, 73.08, 11.87, 0.17, 0.26, and 100 respectively.

Table (4.5) shows the chemical and physico-chemical characteristics of tomato natural juice, From the results the TA as % citric acid, total soluble solids (T.S.S. %) and hydrogen ions concentration (pH) were found to be 0.32 %, 15% and 3.20 respectively. the T.S.S. %, T.A and pH of produced tomato natural juice are well agree with Standard specifications of those mentioned in CODEX- STAN247-2005.

Table (4.6) shows the Organoleptic evaluation of tomato natural juice, the color, taste, flavor, appearance and overall acceptability of tomato natural juice without flavor (A) were found to be 3.6, 2.44, 2.50, 2.72 and 2.56, the tomato natural juice with strawberry flavor (B) were found to be 4.67, 3.67, 3.53 and 3.72, and the tomato natural juice with orange flavor (C) were found to be 2.28, 4.06, 3.72, 3.67 and 4.06 respectively; from the results obtained the color and appearance of product (B) is better than (A) and (C), whereas the best taste, flavor and over all acceptability was found in the product (C).

Table (4.4): Recipe formulation of tomato natural juice

Ingredients	Weight (g)	Formula (%)
Tomato and carrot fruits	166.66	14.62
Water	833.34	73.08
Sugar	135.3	11.87
Citric acid	2	0.17
Pectin	3	0.26
Total	1140.3	100

Table (4.5): chemical and physic-chemical characteristics of tomato juice

Parameters	Values
Titrable acidity	0.32
T.S.S%	15
Ph	3.20

Table (4.6): Organoleptic evaluation of tomato natural juice

Product	Color	Taste	Flavor	Appearance	Overall quality
	Hedonic score (n = 18 ± S.D)				
A	$3.00^{b} \pm 1.00$	$3.00^{b} \pm 0.00$	$2.67^{b} \pm 1.155$	$3.33^{b} \pm 0.577$	$3.00^{b} \pm 0.00$
B	$4.00^{a} \pm 0.00$	$3.67^{a} \pm 0.577$	$3.67^{a} \pm 0.577$	$4.00^{a} \pm 1.00$	$3.67^{a} \pm 0.58$
C	$4.33^{a} \pm 1.155$	$3.67^{a} \pm 0.577$	$4.00^{a} \pm 0.00$	$3.76^{a} \pm 0.577$	$4.00^{a} \pm 0.00$
p- value	0.2365	0.216	0.1537	0.5787	0.0270
SE	0.5092	0.2722	0.4303	0.4303	0.1925

(A) =Tomato natural juice without flavor

(B) = Tomato natural juice with strawberry flavor

(C) = Tomato natural juice with orange flavor.

S.D = Standard deviation.

n = number of independent determination.

1= Unacceptable 2= Acceptable 3= Good 4= Very good 5= Excellent

CHAPTER FIVE

5. Conclusion and Recommendations

5.1 Conclusion

From the results obtained in this study, it can be concluded that the tomato fruits were found with high nutritional value especially in antioxidants, and the tomato fruits it can be easily extracted with cold extraction to ensure that is no loss for antioxidants and vitamins in its extracted juice; this extract suitable for production of high quality natural juice. Also, the juice made out of tomato fruits is found very rich in Magnesium, Calcium, Potassium and Sodium and with high energy value and highly accepted by the panelists.

5.2 Recommendations

1. The tomato fruits containing appreciable amounts of dietary fibers and minerals e. g. Mg, Ca and K

2. The tomato fruits also have a high percentage of anti-oxidants which they have good health effects and must be consumed to cure some of the diseases.

3. Industrial utilization of tomato fruits in a production of some tomato based products such as natural juice to add economical value.

4. Additional studies are definitely needed to ensure safety, storage conditions, self life and economic feasibility for the product.

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APPENDICES

(A) Tomato natural juice without flavour

(B) Tomato natural juice with strawberry flavour

(C) Tomato natural juice with orange flavour