Post-Harvest Processing and Preservative Technology of Tomato – A Review

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ABSTRACT

Tomato (*Solanum lycopersicum* L.) is an important crop grown and consumed worldwide. It provides a wide variety of nutrients and many health-related benefits to the human body. Tomato productions could be a very good vehicle for improving the livelihoods of small-scale producers by creating jobs, serving as source of income for both rural and peri-urban dwellers and also serve as food security. Despite all these benefits, many constraints make tomato production unprofitable, among which post-harvest loses, is one of such constraints. Processed tomato can be used as animal feed supplements and non-food uses. It had been established that processing of tomato has little or no effect on its nutritional content but rather enhanced it. Tomato can make people healthier and decrease the risk of cancer, osteoporosis and cardiovascular diseases. Based on the report of the review, consumption of whole tomato and its by-products should be preferentially recommended because of greater consistency of documented positive outcomes with the whole tomato and the concomitant supply of other important essential nutrients and nonessential nutrient-like bioactive substances. Research into value-added tomato-based products with innovative flavors and ingredients, convenient meal-component sauces and natural products should be carried out to provide suitable processing conditions to industry with attendant assurance improved tomato quality and safety.

Keywords: Post-harvest, Processing, Preservation, Tomato

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INTRODUCTION

Tomato (*Solanum lycopersicum*L.) is one of the very perishable fruits widely grown and consumed throughout the world. Tomato is cultivated in both tropical and sub-tropical regions. Its production accounts for about 4.9 million hectares of harvested land area globally with an estimated production of 177 million tonnes (FAOSTAT, 2017). China leads world tomato production with about 56 million tonnes followed by India with 18.4 million tonnes (FAOSTAT, 2017). While in Africa, Egypt leads the productions with about 7.9 million tonnes followed by Nigeria with 2.2 million tonnes (FAOSTAT, 2017). Tomato production can serve as a source of income for most rural and peri-urban producers in most developing countries. Tomato is an important source of minerals, iron, phosphorus, organic acid, essential amino acids, dietary fibers, beta-carotene pigments, antioxidants such as lycopene, phenolics, and vitamins (A and C) and has been linked with reduced risk of prostate cancer and heart diseases (Rao and Agarwal, 2000). Also, Giovannucci (1999)reported that consumption of tomato and tomato-base foods can be linked to reduced incidence of a variety of cancers in general, including pancreatic, lung, stomach, colorectal, oral, bladder, breast and cervical cancers.

In the regions where it is being cultivated and consumed, it constitutes a very essential part of human's diet. Tomato and tomato-based foods provide a wide variety of nutrients and many health-related benefits to the body (Arah *et al.*, 2015). Soto-Zamora *et al.* (2005)reported that tomato fruit have grabbed the attention of millions of health seekers because of the high levels of vitamins A, E (tocopherols) and C, lycopene, b-carotene (precursor of vitamin A in the human body), fibres and phenolic compounds, namely flavonoids and phenolic acids. Tomato is produced in surplus amount during the harvesting season but its Physiological nature including high moisture content, high respiration rate, and soft texture make it more vulnerable to spoilage and difficult to transport. In order to prevent the spoilage of tomato it is processed into different products like tomato ketchup, tomato puree, tomato powder, etc. Preservation of tomato by drying is a common practice and the dried tomato products include tomato halves, slices and powders (Hussein *et al.*, 2016c).

Despite all the numerous benefits derived from tomato, many challenges are making its production unprofitable in most developing countries especially in Africa. The challenges faced by producers are seen either in production process, post-harvest management, marketing system or a combination of any of them. The purpose of this review was to re-examine the information on the post-harvest processing and preservation technology of tomato.

GLOBAL SITUATION OF TOMATO

On a global scale, the annual production of fresh tomato amounts to approximately 177 million tonnes. In comparison, three times more potato and six times more rice are grown around the world (FAOSTAT, 2017). About a quarter of these 177 million tonnes are grown for the processing industry, which makes tomato the world's leading vegetable for processing. While almost 40 million tonnes of tomato is processed every year in factories belonging to the greatest labels of the global food industry. The top 5 largest tomato producers are: China, European Union (EU), India, United States of America (USA) and Turkey (FAOSTAT, 2017). They account for 70% of global production (EUROFRESH, 2016). Tomato was ranked third in priority after Potato and Onion in India but ranks second after potato in the world. In the EU, the tomato also holds the number one position among vegetables, with a 19% share as the largest fresh vegetable crop. In 2014, the European Union countries produced 16.6 million tons, representing 12% of global production. Of these, 6.8 million tons went to the fresh market and 9.8 million were earmarked for processing (FAOSTAT, 2017).

FAOSTAT (2014) reported that per capita consumption in Germany has been stable around 25 kg over the last 10 years while it decline in comparison to other European countries.Mexico is the world's largest tomato exporter with over 1.5 million tons. Indeed, over half (52%) of the tomato consumed in the US come from Mexico. China produced an impressive 40.5 million tons of tomato in 2014, representing almost a third of global production (FAOSTAT, 2014). It was reported by FAOSTAT (2014) that in terms of exports, China ranks 8th, behind the US and North Africa is becoming an increasingly important exporter to the EU. Morocco is the leader, having doubled its tomato export volume to the EU over the last 10 years to 387,000 tons in 2014. Overall tomato exports from Morocco came to 485,373 tons in 2014, making the country the 4th largest tomato exporter. Other North African producers are gaining in importance, like Tunisia (960,000 tons produced, 10,000 exported) and Senegal (13,000 tons) (FAOSTAT, 2014).

In Sweden, the tomato is amongst the most popular vegetables with an average annual per capita consumption of around 10 kg, 84% of which is imported for €120 million (EUROFRESH, 2016). However, only 13,000 tons are produced domestically, the remainder being imported. Annually, this amounts to around 80,000 tons of imports (EUROFRESH, 2016). Other Nordic countries also import the bulk of the tomato they consume. In 2014, Denmark imported 39,391 tons and Norway bought 23,980, some of it re-exported to Russia (FAOSTAT, 2014).In 2014, Russia produced 2.1 million tons, or 1.6% of global production, and ranks 10th with that volume. It also ranks 2nd after the US as an importer of 846,955 tons. Overall, EU tomato exports market dropped by 48% in value and 44% in volume between 2013 and 2015 (EUROFRESH, 2016). It was reported by EUROFRESH (2016) that the EU was providing over 230,000 tons before.The Middle Eastern countries Turkey and Jordan have secured their places at the top of the world's tomato exporting countries. Volume-wise, they followed frontrunner Mexico and in 2014 they exported 579,780 tons and 517,176 tons respectively. Over 60% of Turkey's tomato exports are destined for Russia, while Jordan exports 98% of its tomato to the Middle East (EUROFRESH, 2016).

The US is the world's largest tomato importer, though internal production accounts for about 40% of their need for tomato(FAOSTAT, 2014). The remainder is imported, mostly from Mexico and to a much lesser extent from Canada. Per capita consumption of fresh tomato is stable at 9.5 kg, accounting for only 25% of their total tomato consumption, most being processed as sauces, juice and tomato paste.Spain is the largest European tomato producer for the fresh market, growing about a third of Europe's production (FAOSTAT, 2014). In 2015, Spain's exports reached 950 million kg, 7.47% less than 2013 and 1.8% less than in 2014. The number of Spanish companies exporting tomato in 2015 reached 638, of which 234 came from Almeria, 60 from Murcia, 41 from Granada and 12 from Las Palmas (EUROFRESH, 2016).France ranks amongst Europe's largest tomato-producing countries, with estimated production of 614,165 tons in 2016 (FAOSTAT, 2017). The tomato is produced on 2,298 hectares either sheltered or in open fields. Most is produced in glasshouses (599,600 tons), seeing an increase of 6%. Brittany is the largest production region, accounting for 36%. In 2014, France exported some 252,000 tons; with its export destinations including Germany, Belgium, the Netherlands, Poland and Italy (FAOSTAT, 2017).

In Africa, with an annual output of 2.2 million tonnes, Nigeria is the largest producer of tomato in Sub Saharan Africa, and the 13th in the world. FAO (2010) reported that Nigeria has the comparative advantage and potential to lead the world in tomato production and exports. Unfortunately, the country still experiences deficiency in critical inputs, lack of improved technology, low yield and productivity, high post-harvest losses and lack of processing and marketing infrastructure (Hussein *et al.*, 2016b). The demand for tomato and its by-products far outweighs the supply.

Tomato in most cases is normally used as salads and in stews to bring out the flavor in them and in other cases as tomato soup and ketchup. Apart from being consumed for the purpose of adding flavor in the dishes they do also have medicinal benefit such as they are a source of vitamin C, low in dietary nutrients, prevent cancer of the colon, breasts, stomach, pancreases, treat high blood pressure, digestive disorders among other diseases.

TOMATO AS A FOOD

Kybal (1993) reported that tomato was not eaten until the nineteenth century because Mattiolus had called it *malainsane* (unhealthy flower) and scientific textbooks kept insisting it was poisonous. Thus in many European countries it was grown as an ornamental plant in the gardens. The consumption of tomato was later accepted in Europe about 1840 but there was still strict opposition to its consumption in other parts of the world(Paran and Van-der-Knaap, 2007).Paran and Van-der-Knaap (2007)reported that the Italian people were probably the first group of Europeans to eat the tomato. This claim was extracted from a written record by Mattiolus where he is said to have described human consumption of tomato with oil and salt, which suggested that tomato was already established in the Italian cuisine by the early 16th century. This reported contradicts Kybal (1993) who reported Mattiolus to have described the tomato as poisonous. As a result of breakthroughs in technologies that made mechanized processing possible, global tomato production increased during the 1920s (Tan *et al.,* 2010). Also, with increasing knowledge in benefits derived from genetic modification of tomato, more desirable parameters have been selected for varietal improvement to enhance the crop for human consumption(Arah *et al.,* 2015). Nowadays, countless varieties of tomato is consumed all over the world in different recipes. Tomato and tomato products are well known by adults and children and have the unique advantage of meeting consumer demands on cost, convenience, availability and taste, while delivering a healthful food option with flexibility for inclusion in a variety of culturally diverse dishes (Freeman and Reimers, 2010).

NUTRITIONAL COMPOSITION OF TOMATO

Tomato is one of the most universally used fruits. Ayandiji *et al.* (2011)reported that tomato has become an important cash and industrial crop in many parts of the world. Due to its economic importance, nutritional value to human diet and subsequent importancein human health (Willcox *et al.*, 2003). Table 1 shows the nutritional compositions of tomato per 100 g value. Tomato is an excellent source of manynutrients and secondary metabolites that are important forhuman health; mineral matter, vitamins C and E, β-carotene,lycopene, flavonoids, organic acids, phenolics and chlorophyll(Giovanelli and Paradise, 2002). It is also rich in vitamins, minerals, sugars, essential amino acids, iron, dietary fibers and phosphorus (Ayandiji *et al.*, 2011).

Lycopene is the pigment responsible for the characteristic deep red colour of ripe tomato and their products.Lycopene is believed to be the main contributing compound in tomato responsible for lower risk of prostate cancer (Pohar *et al.*, 2003). Other studies have also shown that consumption of tomato and tomato-base foods can be linked to reduced incidence of a variety of cancers in general, including pancreatic, lung, stomach, colorectal, oral, bladder, breast and cervical cancers (Giovannucci, 1999). Lycopene in tomato enhance fertility by improving the quality and swimming speed of sperm whilst reducing the number of abnormal sperm in men (Innes, 2014). Tomato contain several important vitamins which are essential constituents of food (Table 1). Tomato has high sources of ascorbic acid (vitamin C) and vitamin A which are vital in warding off muscular degeneration and improve eyesight. It is also believed to be powerful blood purifier and clear up urinary tract infections. Adejumo (2013) reported that a medium sized tomato contributes 40% of ascorbic acid, which is important in forming collagen, a protein that gives structure to bones, cartilage, muscle, and blood vessels and aids in the absorption of iron. Ascorbic acid is necessary for healthy teeth, gums and is essential for proper functioning of adrenal and thyroid glands. It is also an anti-oxidant and as such acts as a general de-toxicant (Adejumo, 2013).

Table 1: Nutritional Compositions of Tomato

Nutrients	Units	Value per 100 g
Proximate		
Energy	Kcal	24.00
Protein	G	1.00
Moisture contents	G	116.26
Total lipid (fat)	G	0.34
Carbohydrate, by difference	G	4.73
Fiber, total dietary	G	1.50
Sugars, total	G	3.23
Minerals		
Calcium, Ca	Mg	1.40
Lycopene	Mcg	3165
Iron, Fe	Mg	0.24
Sodium, Na	Mg	3.00
Copper, Cu	Mg	0.07
Magnesium, Mg	Mg	1.40
Phosphorus, P	Mg	3.00
Potassium, K	Mg	292
Vitamins		
Vitamin C, total ascorbic acid	Mg	16.9
Vitamin A,	IU	676
Vitamin E, alpha-tocopherol	Mg	0.06
Vitamin K, phyloquinone	Mcg	9.70
Thiamin	G	0.05
Niacin	Mg	0.73
Pantothenic acid	Mg	0.11
Zinc	Mg	0.21
Lipids		
Fatty acids, total saturated	G	0
Fatty acids, total trans	G	0
Cholesterol	Mg	0

Source: (USDA, 2010).

Adejumo (2013) also reported that tomato supplies 20% of vitamin A which plays a role in vision, human immune system, skin health and other health benefits. Vitamin A is needed for maintenance of skin, mucous membranes, bones, teeth, hair, vision and reproduction. Tomato contribute 15%of vitamin K, which is known as the blood clothing vitamin (Smith, 1994; Andrew, 2000; Rao and Agarwal, 2000; Etminan *et al.*, 2004; USDA, 2009). Thiamine is needed for nervous system and helps release energy from carbohydrates. Riboflavin helps release energy from foods and is essential for healthy eyes, skin, nails and hair. Pyridoxine helps form red blood cells and is needed for metabolism, normal reproductive process and healthy pregnancies. Vitamin E also acts as an antioxidant and protects cell walls (Harper, 1999; Rao and Agarwal, 2000; Wardlaw and Kessel, 2002; Etminan *et al*., 2004; USDA, 2009).

Tomato is high in fibre which aids easy digestion and can assist in weight loss. These numerous health benefits of tomato and tomato-based foods may be linked to its high production globally (Arah *et al.*, 2015). High levels of antioxidants present in tomato and tomato products help prevent oxidative damage that is hazardous for humans. Moreover, it is widely recognized that the protective role of tomato consumption is due to the synergistic effect among the different classes of antioxidants (Hussein *et al.*, 2016b).

Several interacting factors affect the quality of fresh tomato ranging from pre-harvest, harvest and/or post-harvesting. Borguini and Da-Silva-Torres (2009) reported that the chemical composition of tomato depends on genetics, environmental factors (temperature, light, water and nutrient availability, air composition), agricultural techniques (varieties, plant growth regulators, ripening stage at harvest, training and irrigation system), and on post-harvest storage conditions. Isack and Monica (2013)reported that wilting due to water loss, senescence associated discolouration (yellowing or browning), mechanical injury, high respiration rate, and decay or rotting are the main causes of quality deterioration of post-harvest loss of tomato. More so, many cultural practices such as types of nutrient, water supply, and harvesting methods are also believed to be factors influencing both pre- and post-harvest quality of tomato (Deribe *et al.*, 2016).

PROCESSING TECHNIQUES OF TOMATO

Food processing entails combined procedures to achieve intendedchanges to the raw material and the processing technologies in the food industry (Fellows, 2000). The processing issubdivided into two main groups (Oke and Workneh, 2013);

(i) Processing of foods with non-thermal methods(Lebovka *et al.*, 2004; Lebovka *et al.*, 2007) such as high pressureprocessing, pulsed electric field (PEF) (high-voltage arcdischarge, magnetic fields, dense phase carbon dioxide), electronic beams,ionizing radiation (pulsed X-ray, ultrasound) and hurdle technologies.

(ii) Processing of foods with the application of heat(Leeratanarak *et al*., 2006; Yadav *et al*., 2006; Ahmed et al., 2010; Fernando *et al*., 2011; Singh and Pandey, 2012) such as blanching, pasteurization, sterilization,evaporation or concentration, drying or dehydration,microwave and infra-red heating.

Processing of Foods with Non-Thermal Methods

Non-thermal methods of processing food do not use heat in inactivate pathogens and ensure foods safe for consumption, retaining the sensory attributes and nutrient content similar to raw or fresh products. Foods treated with non-thermal process are safer to eat than untreated products but still require refrigeration to delay spoilage (Jan et al., 2017). Over the last ten years, consumer demand has increasingly required processed foods to have a more 'natural' flavour and colour, with a shelf life that is sufficient for distribution and home storage before consumption. There have been significant developments in processes that do not significantly heat the food and are thus able to retain to a greater extent their nutritional quality and sensory characteristics (Fellows, 2000).

Advantages of non-thermal processes

(i) The non-thermal processing is used for all foods for its better quality, acceptance, and for its shelf life.
(ii) That they are environmentally friendly and act at ambient or sub-lethal temperatures resulting in minimal impact on colour, flavour and nutritional quality of foods.
(iii) They help in retaining the “fresh-like” characteristics of food and may also help to preserve functionalities.
(iv) They are also considered to be more energy efficient and used to preserved better quality attributes compare to convectional thermally based processes.

Processing by application of non-thermal methods that can be used inproduct development from tomato can be carriedout using five methods including:

(i) Application of radiation eg Irradiation, Ultraviolet radiation Mahmoud (2010); Adam *et al.* (2014); Atuobi-Yeboah *et al.* (2016).
(ii) Application of pressure e.g. High pressure processing (HPP), High pressure carbon dioxide (HPCD) Maitland et al. (2011); Parton *et al.* (2007); Bizzotto *et al.* (2009); Hsu *et al.* (2008); Ahmed and Ramaswamy (2006).
(iii) Pulsed electric field (PEF) Min *et al.* (2003); Luengo *et al.* (2014).
(iv) Natural antimicrobials e.g. Extracts from vegetables, Extracts of herbs and spices Gündüz *et al*. (2010); Djadouni *et al.* (2015); Arnal *et al*. (2018).
(v) Hurdle technology or synergism Krebbers *et al.* (2003); Aganovic *et al*. (2017).

Processing of Foods with Thermal Methods

Heat treatment is one of the important methods used infood processing to extend the shelf life of foods either by destroying the enzymatic and microbial activity or byremoving water to inhibit deterioration that results fromhigher water activity(Oke and Workneh, 2013). Fellows (2000) enumerated theadvantages of heat processing as:

(i) Simple control of processing conditions.
(ii) Production of shelf-stable products that need norefrigeration.
(iii) The destruction of anti-nutritional factors (e.g. trypsininhibitor in some legumes); and
(iv) The enhancement of availability of nutrients forhuman consumption (e.g. improves digestibility ofproteins and gelatinization of starches).

Processing by application of heat that can be used inproduct development from tomato can be carriedout using four methods including:

(i) Heat processing with the use of hot air e.g.drying, baking, roasting (Mayeaux *et al*., 2006; Gaware *et al.*, 2010; Bashir *et al.*, 2014; Hussein *et al.*, 2016b).
(ii) Heat processing with the use of water or steam e.g.blanching, pasteurization (Pérez-Tejeda *et al*., 2016).
(iii) Heat processing with the use of hot oils e.g. frying(Mayeaux *et al.*, 2006).
(iv) Heat processing using radiated and direct energy e.g.ohmic heating, di-electric heating, infrared heating(Jun and Sastry, 2005; Boldaji *et al*., 2015).

PROCESSING OF TOMATO INTO PRODUCTS

An important consideration for processed foods is that it is the quality of theprocessed product, rather than the raw material, that is important. For minimallyprocessed foods, such as those subjected to modified atmospheres, low doseirradiation, mild heat treatment or some chemical preservatives, the characteristics of the raw material are a good guide to the quality of the product.For more severe processing, including heat preservation, drying or freezing, the quality characteristics may change markedly during processing. Hence, those raw materials which are preferred for fresh consumption may not be most appropriate for processing.

If the tomato is to be processed right after harvesting, little handling is required before they are transported to the processing plant in the shortest possible time. Tomato can be processed into many forms to be consumed instantly or preserved for future use. For example, Kitinoja and Gorny (2009) reported that horticultural produce are usually processed to become part of the following categories: Beverages (juices, sparkling fruit-flavoured waters), Condiments (salsas, pickles, chutneys, herb-vinegars, jams, jellies and preserves), Confections (fruit-based candies, cookies, cakes) and Miscellaneous (bottled herbed-mushrooms, fruit or vegetable-based snack-foods). The flow chart in Figure 1 summarizes the various tomato-processing methods for processing tomato into juice, paste, whole, sliced, or diced tomato and powder/dried tomato.

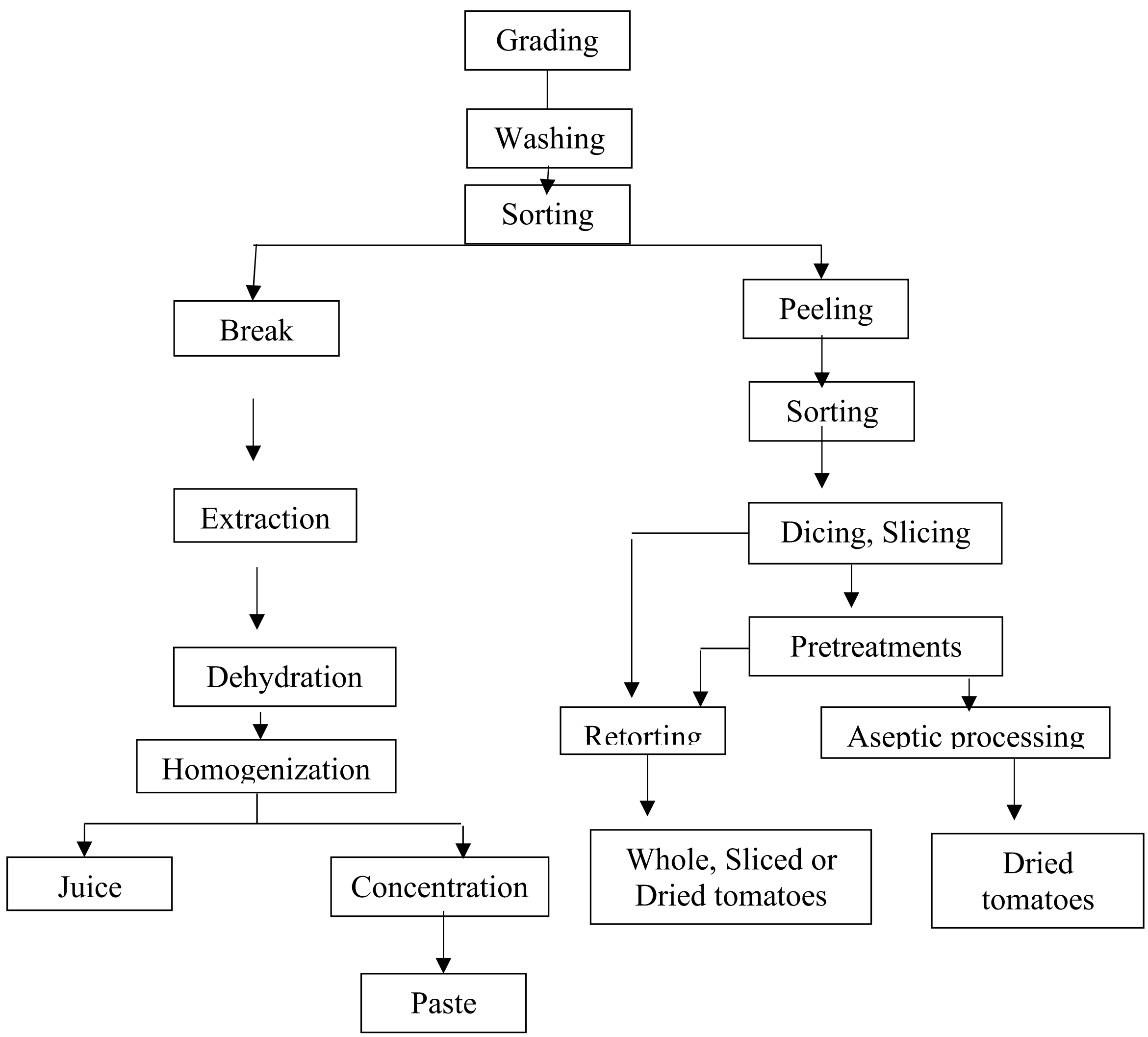

Figure 1: Flow Chart for Tomato Processing

Tomato Powder

Traditionally in food processing industries, more stress has been given to thermal processing for preservation and microbiological safety of tomato with limited attention toward nutritional quality but there has been an increased concern for tomato quality during thermal processing. Drying is one such thermal process that offers an alternative way of preventing these losses and increases commercial value of tomato (Hussein *et al*., 2016a). In general, dried tomato undergo the following process steps: pre-drying treatments, (such as size selection, washing, pretreatments and tray placing), drying or dehydration, and post-dehydration treatments, such as inspection, screening and packaging Andritsos *et al.* (2003).

There are different methods of producing tomato power depending on the drying methods used. The acceptability of the product will now depend on the optimum processing conditions used for the drying process. The mechanisms whereby heat is transferred to food provide a convenient way of classifying the drying methods used today to produce tomato powder.

On this basis there are five categories of drying methods to produce tomato powder (Hussein, 2016),they are:

(i) Drying by heated air: The tomato sample is placed in a current of heated air. This method is also known as convective or convection drying methods. Examples are: convective hot air, foam-mat drying, Tunnel Dryer, distributed-type natural-circulation solar-energy dryers and distributed-type active solar dryers (Hussein *et al.*, 2016c); (Purkayastha *et al.*, 2013); (Doymaz and Ozdemir, 2013);

(ii) Drying by heated surface: Here, the tomato sample is placed in contact with a heated surface, usually a metal surface. Most of the heat is transferred to the tomato by conduction from the hot surface. An example is Spray drying (Sousa *et al.*, 2008); (Abdulmalik *et al*., 2014).

(iii) Drying by radiation: Here, the tomato sample is exposed to radiant heat, and radiation is the main mechanism of heat transfer. This method is also known as radioactive drying methods. An example is Sun drying (Andritsos *et al.*, 2003); (Amer *et al.*, 2010); (Hussein *et al.*, 2016c).

(iv) Drying by microwave and dielectric energy: Refractance Window (Al-Harahsheh *et al.*, 2009); (Abdul-Fadl and Ghanem, 2011); (Abano *et al.*, 2012)

Tomato Juice and Paste

Tomato juice is a juice produced from tomato. It is usually served as a beverage, either plain or in cocktails such as a Bloody Mary or Michelada. The technology for the production of tomato juice drink is basically the same with that used for the production of tomato paste. It is normally produced during the tomato season when tomato ripens in commercial quantities. The selected tomato varieties usually have a solid content not less than 5 brix.

Some producers prefer not to blend different tomato varieties so as to obtain juice with more homogenous flavor (Anthon *et al.*, 2011). Figure 2 shows the flow chart for the production of tomato juice.

Tomato
↓
Washing
↓
Sorting and trimming
↓
Cutting and chopping
↓
Heating at 70-90°C for 3-5 minutes
↓
Pulping/extraction of juice
↓
Addition of salt, sugar, citic acid
↓
Homogenization
↓
Heating at 82-88°C for a minute
↓
Filling hot into bottles/cans
↓
Sterilization in boiling water for 30 minutes
↓
Cooling
↓
Sealing

Figure 2: Flow Chart for the Production of Tomato Juice
Source: (Igile *et al.,* 2016).

After grading, tomato is washed to remove dirt, insects, mold, and other possible contaminants. Proper washed tomato, result into products that are of better quality microbial and hygienically. Sorting is the next step after washing. It helps to sort tomato optically from the fruit stream because colour is an important attribute of tomato juice. Reyes-De-Corcuera et al. (2014) reported that unripe (green) tomato do not adversely affect the colour of the juice in small quantities while pink tomato significantly affect the red colour of tomato juice even small quantities. After sorting, tomato is either hot break or cold break depending on the end products. The hot break is most common for juices that are further processed into concentrate while the cold break process is favoured by tomato juice processors who do not necessarily require a high viscosity product or who might be using or selling the juice as an ingredient in another beverage (Reyes-De-Corcuera *et al.*, 2014). Briefly, the hot break method involves chopping the tomato and heating the resultant mixture to at least 85ºC to inactivate pectolytic enzymes that would, if not inactivated, result in the loss of desirable high viscosity in the tomato product. As most tomato juice is converted into tomato paste, the retention of viscosity is a desirable quality attribute. Most hot break processes are conducted at 92–99ºC for fast inactivation of enzymes (Reyes-De-Corcuera *et al.*, 2014). In this case of cold break, the tomato is chopped and mildly heated to temperatures around 60–66ºC, the optimum range for enzymatic activity. The resultant tissue breakdown leads to higher yields, as well as slightly lower viscosity of the resulting juice (Reyes-De-Corcuera *et al*., 2014). After the break process (hot or cold), the seeds and skins are removed through a finishing or pulping step that also serves as the juice extraction method. Many commercial manufacturers of tomato juice also add salt. Other ingredients are also often added, such as onion powder, garlic powder, and other spices.

Tomato juice is then homogenized to prevent separation of solids from the serum, and this can also cause a slight increase in viscosity. Tomato juice is commonly packaged in cans that are hot filled and heat treated, bottles that are hot filled, or aseptically packaged. Alternatively, the juice can be pasteurized and filled into plastic (usually PET) bottles and sold as a refrigerated product. The nutritional quality of tomato juice is thought to be due to high levels of the antioxidant lycopene, which is also responsible in large part for the red colour of the tomato juice. Processing and storage techniques have developed with the purpose of maintaining as high levels of lycopene as possible. The ascorbic acid content, whether endogenous or added, also contribute to antioxidant activity of tomato juice (Jacob *et al.*, 2008), which enjoys a relatively healthy image, especially in low-sodium forms.

If the final product is not juice, the juice is next concentrated to paste. Tomato paste is a thick paste made from ripened tomato with skin and seeds removed. Depending on its manufacturing conditions, it can be used to make either ketchup or reconstituted tomato juice. Concentration occurs in forced circulation, multiple-effect, vacuum evaporators. Typically, three- or four-effect evaporators are used, and most modern equipment now uses four effects (Reyes-De-Corcuera *et al.*, 2014). To maintain quality, the temperature in the evaporator must be as low as possible; therefore, a vacuum is created above the pulp so that water will boil at 70ºC (FAO, 2009). Once the paste has the required concentration, measured in Brix, it leaves the evaporator to be pasteurized and packaged. The paste must be bright red and have the right consistency: solid, not liquid. It must have a true tomato aroma and be free from off-tastes or smells (FAO, 2009). Commercial paste is available in a range of solids contents, finishes, and Bostwick consistencies. The larger the screen size used for extraction, the coarser the particles and the larger the finish (Reyes-De-Corcuera *et al.*, 2014).

Tomato Squash

Tomato squash is tomato pulp with added sugar syrup to give a concentration of 30-50% total solids (°Brix) measured by a refractometer. It is not a very common product as people tend to prefer squashes made from other fruits but it may well be worth investigating in your own area. It is processed in a similar way to juice and may contain up to 100ppm of sodium (or potassium) benzoate preservative (check with your local Bureau of Standards for the legal limits in your country) to help preserve it after opening the bottle.

Tomato Jam and Marmalade

Jam is a product made by boiling fruit and sugar to a thick consistency without preserving the shape of the fruit while marmalade is a soft clear translucent jelly holding a suspension pieces or slices of fruit and fruit rind. They are bread dressings served alone or together with margarine or fresh butter. Jam and marmalade can be made from all kinds of tomato(Çağlar and Çağlar, 2015). Figure 3 shows the standard cooking technique utilized to prepare the fresh tomato jam as reported by Özdoğan and Yılmaz (2011). Tomato were sorted, washed, peeled, cooked with addition of ingredients, cooled and closed hermetically.

Tomato

↓

Washing and Sorting

↓

Peeling and Seed Removal

↓

Immersion in Sugar (tomato: sugar in 1:1 g/g ratio at room temperature for 12h)

↓

Cooking (at 103-106ºC under atmospheric pressure for 60-65 min)

↓

Citric acid and Vanilin Addition (1% citric acid and 0.5% vanilin over tomato weightis added and additionally 15-20 min cooked)

↓

Pectin Addition (0, 1 or 2% pectin over tomato weight is added and cooked for 15-20 more minutes)

↓

Cooling (temperature of the jam is reduced to 80-90ºC)

↓

Filling (jam is filled into sterile glass jars at 80-90ºC and closed hermetically)

↓

Final Cooling (filled jars are immediately cooled to 20-30ºC)

Figure 3: Standard Cooking Technique Utilized to Prepare the Green Tomato Jam Sample
Source: Özdoğan and Yılmaz (2011).

To produce Marmalade, place tomato into the boiling water and blanch for 20 seconds to loosen their skins. Using a slotted spoon, transfer the tomato to a cutting board and let cool slightly then Peel the tomato. After, place tomato in a large kettle. Add sugar and salt; stir until dissolved. Add oranges, lemons and spice bag.

Bring to a boil, stirring constantly. Continue to boil rapidly, stirring constantly, until thick and clear tomato marmalade is formed. Remove from heat and skim off foam. Hot fill the marmalade and closed hermetically. Çağlar and Çağlar (2015)reported that processing tomato to jam or marmalade will provide an economically profit for our country. Thus, farmer won't lose money from tomato and tomato which have short shelf life but earned more to their income. Tomato is rich source of vitamins, minerals and especially flavonoids (karotetenoids). The main carotenoids in tomato fruit; phytoene, phytofluene, z-carotene, neurosporene, lycopene, beta-zea-carotene, beta and y-carotene, and beta-carotene (Çağlar and Çağlar, 2015). Tomato which have all these nutrients as well as high amount of vitamin C and vitamin E, is a leading food that is recommended for protecting the cardio- vascular health, supplementing the bones and preventing cancer (Çağlar and Çağlar, 2015).

Tomato Sauces

Tomato sauce can refer to a large number of different sauces made primarily from tomato, usually to be served as part of a dish, rather than as a condiment. Tomato sauces are common for meat and vegetables, but they are perhaps best known as sauces for pasta dishes. Tomato have a rich flavour, high water content, soft flesh which breaks down easily, and the right composition to thicken into a sauce when they are cooked (without the need of thickeners such as roux). All of these qualities make them ideal for simple and appealing sauces. Tomato sauces are used in many products including frozen foods, pasta sauces and pizza toppings, etc. A typical tomato sauce would be based on sieved or whole tomato, and/or tomato paste. It would also contain water, sugar, vinegar, salt and seasoning. The desired product viscosity would normally be achieved using a starch-based thickener. Since the tomato is acidic in nature, it is easy to preserve tomato paste and sauces at home.

Tomato Ketchup

Tomato ketchup is a sauce made from tomato or residues from the processing of tomato to which salt and spices are added as well as one or more nutritive sweetening ingredients, vinegar or onion, garlic or other vegetable flavouring ingredients (FAO, 2009). The product is made from concentrated tomato juice or tomato paste, to which ingredients such as vinegar, salt, sweetener, flavouring, onions, garlic and spices are added. After which the product is boiled, fine sieved, placed in bottles and pasteurized in an autoclave as described by FAO (2009). The processing ratio of 0.3–0.4 kg of tomato paste is needed for 1 kg of ketchup. The higher the sugar content (measured in Brix) of the tomato paste, the better/lower the processing ratio (FAO, 2009).

Tomato ketchup can as well be made from fresh tomato by washing, chopping and precooking. The chopped and washed tomato go through the pulping phase where the skin, seeds and stems of the tomato is filtered out and the rest is turned into pulp. After comes the cooking phase, where the pure tomato pulp is placed in a pot, and the necessary secondary ingredients are added. The mixture is cooked for 30-45 minutes and constantly stirred in order for it to form its pasty state. Finally, the ketchup goes through the finishing machine where it gets its perfect ketchup consistency, as well as being de-aerated before getting cooled off and then packaged in its appropriate bottle. FAO (2009) reported that a Ketchup must be red in colour, liquid but not too fluid with a good aroma of tomato and ingredients and be free from off-tastes or smells. Tomato ketchup have delicious taste, flavour and used widely with other eatables to give very good taste and flavor to it. It has very good domestic use and having a good demand in hotels and restaurants to serve the customers and preparation in different foods.

Tomato Leather

Tomato pulp can be mixed with spices according to local taste and availability and used to make a fruit leather. The pulp is heated and spread in a thin layer which is dried. After drying, the leather is cut and rolled into balls or cubes which can be rehydrated and used in a range of soups, stews and sauces.

MARKET FOR PROCESSED TOMATO IN NIGERIA

For a nation that wants to develop, it must focus on area where she has comparative advantage and surely Nigeria does have a comparative advantage in the agricultural sector especially in tomato production and processing. Nigeria produces millions of tons of tomato per year but over 50% of these values are lost majorly through poor storage system and bad road network thereby leading to lack of availability of the product during certain period of the year and also making it expensive. The above loophole makes tomato processing a viable business in Nigeria. The demand for tomato and its bye-product far outweighs the supply. With a population of over 140 million people and an estimated national population growth rate of 5.7% per annum, an average economic growth rate of 3.5% per annum in the past five years, Nigeria has a large market for processed tomato product (FAOSTAT, 2017). Also the Investors can also take advantage of the trade liberalization in the West African market to sell their product.

In Europe and America, tomato is either presented fresh in supermarkets or packed in tins for consumers. The packaged tomato is used in the export market and Nigeria is one of the countries involved in its importation which also speaks of our consumption rate. However, since tin tomato does not come in large packs, it cannot meet the needs of large size market consumers like those used for weddings, restaurants, parties, hotel and this market is very huge in Nigeria. Also the high exchange rate has made imports very expensive so consumers have to depend on local processors to meet their needs. Apart from the Nigerian market, the advantage of the trade liberalization in the West African market could be used to enhance the sale of processed tomato products in this region (Ugonna *et al.*, 2015).

OPPORTUNITIES FOR EXPANDING TOMATO PROCESSING

Opportunities for expanding the use of tomato lie in three categories: (1) fresh and processed for human consumption, (2) fresh and dried for animal feed and (3) non-food uses.

Fresh and processed for human consumption

Tomato is the biggest source of dietary lycopene; a powerful antioxidant that, unlike nutrients in most fresh fruits and vegetables, has even greater bioavailability after cooking and processing. Freeman and Reimers (2010) reported that eating more tomato and tomato products can make people healthier and decrease the risk of conditions such as cancer, osteoporosis and cardiovascular disease. Tomato also contains other protective mechanisms, such as antithrombotic and anti-inflammatory functions. Freeman and Reimers (2010) also reported that eating tomato lower the risk of certain cancers as well as other conditions, including cardiovascular disease, osteoporosis, ultraviolet light-induced skin damage, and cognitive dysfunction.

Tomato juice blends came into being as a result of interest in vegetable juices are tasty and have high nutrients. From the nutritional standpoint, these tomato juice blends can yield increased nutritive values. The tomato juice blends and tomato juice cocktails are not only used as a beverage, but are also employed as mixers for alcoholic beverages. Mojatahedi *et al*. (2013) produce tomato juice-based beverage from the blend of soy milk with tomato juice.

Beverage showing a better average of sensory with off- taste of soy protein and high antioxidant activity according to consumer preference was produce. Karthika *et al.* (2016) blends corn flour, rice flour and tomato pomace (peel and seed) and processed in a co-rotating twin-screw extruder to produce a ready -to-eat expanded product. They concluded that the sensory acceptability of the product was most dependent on the pomace content. Thus, the snack potentially improved its nutritive properties with high fiber and protein enriched snack product. The health benefit of tomato such as, improved eyesight, good stomach health, and reduced blood pressure as well as relief from diabetes, aging skin and skin infections and urinary tract infections have increased its consumption. Tomato have been reported to increase digestion, stimulate blood circulation, reduce cholesterol levels, improve fluid balance, protect the kidneys, detoxify the body, heals open wounds and sores, prevent premature aging and reduce inflammation and related conditions (Etminan *et al.*, 2004; Friedman *et al.*, 2009).

Fresh and dried for animal feed

Boyles (2017) reported that tomato and its by-products (pomace, skins (peels) and tomato seeds) can be used as feed to livestock but they should not be free choice because unripe tomato and the green parts of ripe tomato contain a solanine-like alkaloid (saponin) called tomatine that may be toxic to insects, dogs and, to a lesser extent, herbivores (diarrhea, vomiting, intestinal irritation). However, it disappears as the tomato ripens. Tomato and its by-products has been evaluated to be used in rations for poultry (Mansoori *et al.*, 2008), dairy cows (Weiss *et al.*, 1997) and small ruminants (Gasa *et al*., 1989; Fondevila *et al.*, 1994; Denek and Can, 2006; Ben-Salem and Znaidi, 2008). Tomato has the energy and protein content of high quality hay. The calcium level is less than that of phosphorus so you may need to supplement calcium if high levels of tomato is fed (Boyles, 2017).

Tomato by-products are usually fed to ruminants though, they are not excellent feed ingredients, being less digestible than most major oil meal and protein sources but they are high in fibre content (Feedipedia, 2016). Tomato pomace is relatively rich in protein (17-22% DM) and fat (10-15% DM) (Feedipedia, 2016). Tomato skins have a lower protein and fat content, and a higher fibre content than pomace and also contain appreciable amounts of carotenoids (about 500 mg/kg DM), mostly in the form of lycopene (Knoblich *et al.*, 2005). Tomato seeds have a high protein (25-28% DM), fibre (54% ADF) and fat (20-24% DM) content (El-Boushy and Van-der-Poel, 2000; Persia *et al.,* 2003). Tomato pomace inclusion of up to 50% of the daily roughage requirement irrespective of whether it was fresh, dried or ensiled was recommended by (Caluya *et al.*, 2003). They can be bitter and should be used together with more palatable feeds.

Tomato and its by-products are valuable and cost-effective source of protein, energy and fibre (Caluya *et al*., 2003). Feedipedia (2016) reported that fresh tomato pomace was found to have potential as a supplementary feed for grower and finisher pigs. Feeding growing pigs with 6% fresh tomato pomace significantly increased feed consumption compared to those fed a commercial mash (Feedipedia, 2016). Dried tomato pomace can be used in poultry feeds, but its high fibre limits the metabolizable energy (ME) content to 8.4-9.5 MJ/kg (Kavitha *et al.*, 2005; Lira *et al.*, 2011). Feedipedia (2016) reported that inclusion of dried tomato pomace in broiler diets is possible if taking into account its low energy value in feed formulation. Dotas *et al.* (1999) reported that dried tomato pomace was included successfully in diets for layers, which require a lower energy concentration than broilers. Also Mansoori *et al.* (2008) substitute dried tomato pomace for wheat bran and founded a similar energy content in the diets.

Non-food uses

Tomato is loaded with all kinds of health benefits for the body. They are in fact, a highly versatile health product and due to their equally versatile preparation options, there's really no reason to neglect the tomato as part of a healthy diet (Bhowmik *et al.*, 2012). Besides eating, they are also non-food uses of tomato and tomato by-products. Tomato ispacked full of vitaminsthat are beneficial to body and can help treat oily skin, acne and wrinkles. They are used in making pricy facial cleansers due to their high level of lycopene. Bhowmik *et al.* (2012) reported that if you want to try tomato for skin care, you need to start with about eight to twelve tomato. Peel the tomato and then place the skin on your face with inside of the tomato touching your skin. Leave the tomato on your face for a minimum of ten minutes, then wash. Your face will feel clean and shiny. Some redness may occur, but should fade with time.

Besides treating acne and wrinkles, tomato can also help to cool sunburned skin by directly applying it to your skin to relieve pain.Tomato paste or ketchup can be used in cleaning copper pots. Once you have a decent amount, apply the paste to your copper pots with a cloth and scrub until the cookware’s original shine is restored. Though, it requires a little bit of extra work but it definitely gets the job done. No need for expensive cleaners full of chemicals. Both ketchup and tomato juice can also be used to clean brass. Tomato is also used in creating a Centerpiece. They can be put on the vine, combine with flowers, or leave them sitting in a berry basket, the possibilities are endless. Tomato can be used in making fashions. Artist Zoe Einbinder who specializes in preserving fruit and creating stunning pieces of jewelry, make a real tomato jewelry (Reed, 2018).

FACTORS AFFECTING THE QUALITY OF PROCESSED TOMATO

Colour quality change on processed tomato

The quality of processed tomato products is influenced by the particular variety of the tomato as well as its properties (e.g. structure, ripeness), methods of processing and storage conditions. Several physical, chemical, biochemical and/or microbiological changes may occur in food during processing and storage, resulting in significant quality losses(Kumar *et al.*, 2015). Colour is an important quality attribute of food products. It is perceived as part of the total appearance, which is the visual recognition and assessment of the surface and subsurface properties of the object. A good colour represents freshness of a fruit or vegetable, while discoloration is undesirable to consumers.Colouring of tomato is determined especially by lycopene content. Lycopene belongs to the carotenoid natural colorants, tomato and products made from them have characteristic red colour (Acton, 2012).

Processing conditions such as high temperature, long duration of exposure and the presence of oxygen shown to contribute to increased degradation of lycopene (Preedy, 2012).Ahmed and Ramaswamy (2006) reported that colour change may be influenced by several factors including handling, transportation, processing, storage, packaging, etc. The colour of processed fruits and vegetables such as tomato ketchup or canned pineapple has been shown to be influenced by process temperature, time and pH, and significantly by added ingredients (Ahmed and Ramaswamy, 2006). Thus, it is desirable to maintain uniform process parameters and ingredients in order to obtain manufacture uniform quality.

Effect of browning reactions on the processed tomato

Browning reactions decrease nutritional value and solubility, create off-flavours, and induce textural alterations in the food. They are classified into enzymatic and non-enzymatic reactions. The former are enzyme-mediated reactions while the later are formed as a result of reactions between carbonyl groups of reducing sugars, aldehydes and ketones with amino compounds such as amino acids, peptides and proteins (Kumar *et al.*, 2015). Examples of non-enzymatic reactions include sugar caramelization, sugar-amine reactions (Maillard reactions) and ascorbic acid oxidation (Okos *et al*., 1992; Rahman and Perera, 1999; Krokida and Maroulis, 2000). Browning index, which is an indicator of the extent of browning, was high during heat processing (Kumar *et al.*, 2015). Perretta (1991)reported that in the case of a thermally stabilized product, in which enzymatic activity has been almost completely destroyed by heat, particular attention should be paid to non-enzymatic browning reactions.

Browning occurred rapidly in tomato juice stored at higher temperatures and this high heat processing causes colour change of tomato juice. Typically, the red colour of tomato turns reddish brown and later brown. It is considered that colour changes are due to non-enzymatic browning or Maillard reaction (Porretta and Sandei, 1991; Zanoni *et al.*, 1999).Perretta (1991)reported that the main components of processed tomato influence non-enzymatic reactions which in turn affect that quality of tomato products. The interaction between glutamic acid and galacturonic acid or fructose was also found to accelerate the non-enzymatic browning of tomato juice. The browning by heating of galacturonic acid with or without amino acids was larger than that of sugars or amino acids (Perretta, 1991).

Effect of packaging material on quality of processed tomato

Tomato must be packed in such a way that they are protected properly. The materials used inside the package must be new, clean, and of a quality such as to avoid causing external or internal damage to the produce. There are many key points to be considered in assessing the quality of Tomato. The minimum quality requirements for Tomato after preparation and packaging include: intact, fresh-looking, clean, free of excessive moisture, sound, and free of any foreign smell and/or taste (Sargent and Moretti, 2002).Oxygen and light which intrinsically related to storage temperature are targeted storage parameters for lycopene stability of tomato products(Martınez-Hernandez *et al.*, 2015).

Modified atmosphere packaging (MAP) is commonly employed in packaging of fresh produce. This is simply done by keeping tomato in polymeric films which is a simple and inexpensive method to improve the post-harvest life of perishable produce by reducing the rates of respiration and the metabolic processes associated with ripening or senescence (Buntong and Kong, 2015).Some common packaging materials used in most developing countries for processed tomato include plastic bottle, nylon sacks, and polythene bags (Idah *et al*., 2007). Famurewa *et al*. (2013) reported that the use of plastic bottles in packing tomato paste is better than polythene because it retained more of the nutrients in the paste. Famurewa *et al.* (2013) concluded that bottles retained tomato paste nutrients more than those in polythene and can be stored for ten weeks while polythene samples can only be stored for seven weeks.

Davoodi et al. (2007)reported that the low permeability of metalized polyester film better retained (approximately 10–20 %) the lycopene content of tomato powder compared to low-density polyester film after 6 months at 22 ºC but the light conditions was not specified. No clear influence of packaging material on lycopene stability was found, when several oxygen impermeable packages such as glass, metalized laminated cardboard, or plastic were used to stored different commercial tomato products (juice, sauce, and ketchup) while avoiding direct light or heat, for 12 months at room temperature (22 ºC)(Camara *et al.*, 2012). Likewise, Garcia-

Alonso *et al.* (2009) did not find relevant differences on lycopene content between tomato juice samples obtained after heating at 96 ºC for 30 s in the 'hot break' of tomato puree, packaged in either glass bottles or paperboard cartons (Tetra-pack) and stored for 12 months at 8, 22, or 37 ºC in dark conditions.

In general, packaging material will not only hold the food substance, but will also protect it from contamination. They also extend the marketable life of the product. Packaging plays an important role in achieving the objectivesof safety and waste prevention.

Quality changes during storage of processed tomato

It was reported by several researchers that oxidative damage takes place in tomato during the drying process and storage periods (Sharma and Le-Maguer, 1996; Zanoni *et al*., 1999; Zanoni *et al*., 2000; Toor and Savage, 2006). This oxidative damage causes loss of antioxidants present in processed tomato. Lavelli and Giovanelli (2003) reported that during storage of tomato and tomato-based products the most ascorbic acid undergoes a degradation that is very dependent on the storage temperature and on the initial oxidative/heat damage of the product, which has a destabilizing effect. Browning index, which is an indicator of the extent of browning, was high during heat processing (Kumar *et al.*, 2015). Shi and Le-Maguer (2000) reported that the main causes of lycopene degradation during processing and storage are isomerisation and oxidation.

Tomato products storage may contribute to lycopene loss depending on several factors such as temperature, light, oxygen, and water activity (Martınez-Hernandez *et al*., 2015). The isomerization of all-*trans* to *cis* isomers typically occurs during processing, while the storage of tomato products favours reversion (reisomerization) from *cis* to all-*trans*, because of the relatively unstable state of *cis* isomers compared to all-*trans* isomers (Shi *et al.*, 2002). Martınez-Hernandez *et al.* (2015)reported that temperature plays an important role in lycopene loss during storage. Increasing storage temperatures significantly increases degradation, which occurs mainly through oxidation without isomerization in the range 25–50 ºC and with isomerization at temperatures in the range 75–150 ºC. Both degradation and isomerization pathways depended on the initial lycopene content of the tomato variety (Hackett *et al.*, 2004). Carotenoids have been shown to undergo both isomerisation and oxidation under processing and storage conditions (Sharma and Le-Maguer, 1996). However, Zanoni et al. (1999) and Khachik *et al.* (1992) reported that they have been found to be stable during tomato processing, even under severe heat and air exposure.

The degrading antioxidant compounds, influences the antioxidant activity of the final tomato products. Lavelli *et al.* (1999) and Lavelli *et al.* (2000) reported that the antioxidant activity of the hydrophilic fraction decreases with processing, but is retained in the lipophilic fraction. Lavelli and Giovanelli (2003) also reported that degradation reactions could also occur during storage of tomato products thus, affecting their antioxidant activity. ß-Carotene and the antioxidant activity of the lipophilic fraction undergo a slower degradation that depends little on the storage temperature but Lycopene is stable, even in the most drastic storage conditions (Lavelli and Giovanelli, 2003).

FUTURE RESEARCH AREAS IN THE PROCESSING AND PRESERVATION OF TOMATO

Notwithstanding the number of researchers that have obtained good results in tomato processing and preservations, more research is needed, mainly to develop processing and preservation technologies that minimize post-harvest loss of this fruit. The method should be able to make a comparison not only in terms of the antimicrobial efficacy between methodologies, but also their shelf-life prolonging effects. Research in this field should be carried out to provide processing recommendations conditions to industry to assure and improve tomato's quality and safety. Also, growing trends in tomato preparation production: Value-added tomato-based products – innovative flavours and ingredients, convenient meal-component sauces.

Further to this knowledge, the developed alternative technologies should be environmentally friendly and it is also necessary to take into account the compatibility, regulatory provisions and cost factors. The new technologies must be more effective and cheaper than the existing ones in order to become an alternative.

CONCLUSION

Tomato is quantitatively the most important non-starchy vegetable in the human diet. They offer significant nutritional advantages, including providing a significant source of dietary lycopene and other carotenoids, vitamin C, potassium, and fiber in a low energy dense food. Emerging research underscores the relationship between consuming tomato and tomato products with reduced risk of certain cancers, heart disease, ultraviolet light–induced skin damage, osteoporosis, and other conditions. Although lycopene has been extensively investigated apart from the tomato, the preponderance of evidence suggests that consumption of whole tomato and tomato by-products should be preferentially recommended because of greater consistency of documented positive outcomes with the whole tomato and the concomitant supply of other important essential nutrients and nonessential nutrient-like bioactive substances.

In addition to the specific nutritional benefits of tomato consumption, encouraging greater tomato and tomato product consumption may be a simple and effective strategy for increasing overall vegetable intake. Tomato is widely available, has an established record of acceptability among people of all ages and across cultures, is cost-effective, and offers the convenience of multiple forms. Notwithstanding, tomato and by-products are used in animal feed supplements and also have non-food uses. These factors increase the likelihood for compliance and high potential for improving overall dietary patterns in general. In the present days, the demand for the tomato is increasing steadily with an increase in population and its likeliness towards tomato.

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