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Original Research Article

Quality Characteristics of Tomato Juice Produced and Preserved with and without its Seeds

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The aim of this study was to process tomato juice from ripe tomatoes with (JS) or without its seeds (J), and to evaluate the overall quality outcome of the final products. Proximate composition of the juice gave fat content for juice without seeds (0.79±0.05g/100g) and juice with seeds (1.62±0.02g/100g). There was significant (p>0.05) increase in protein content in the juice without seed (11.89±0.08g/100g) and juice with seed (12.38±0.06g/100g) when compared to the raw tomato (8.81±0.09g/100g). The fiber content of the juice with seed (8.15±0.04g/100g) was significantly (p>0.05) higher than in juice without seed (4.26±0.05g/100g), and the raw tomatoes (5.04±0.08g/100g). The energy value of processed tomato juice (with seed, 158.50±0.29 kcal/100g; and without seed, 142.67±0.67 kcal/100g), was significantly (p>0.05) higher than in raw tomatoes (118.63±0.32 kcal/100g). Processing significantly increased the sugar content in tomato juice to 3.62±0.01g/100g (without seed) and 3.39±0.04g/100g (with seed) from 2.79±0.01g/100g in raw tomatoes. Processing slightly decreased Vitamin C content in the processed juice (151.00±1.00 mg/100g without seed), and (154.67±0.33 mg/100g with seed), while Vitamin C concentration in the raw tomatoes was 157.33±0.33mg/100g. Vit A content decreased to 3954.67±11.35IU in juice without seed and 3943.67±34.16IU with seed, from 4126.00±83.43IU in raw tomatoes. Vit K content decreased significantly (p<0.05) in processed juice, 1.30±0.02 µg/100g without seed and 1.41±0.02µg/100g with seed) from raw tomatoes (1.49±0.04µg/100g). Processing significantly (p<0.05) reduced the titratable acidity in the juice (without seed). Significant amount of elements and vitamins were also concentrated in the juice (J). The study showed that tomato juice without seed was more stable under shelf-life when compared to juice with seed, and this was attributable to the impact of oxidative rancidity of the fat in JS. It was concluded that tomato juice can be processed locally to meet regulatory standards, and that J showed better keeping quality and can be packaged for commercial purposes. It was concluded also that J was a healthy drink for human consumption as it contains essential nutrients and was free from products of oxidative rancidity.

Keywords: Tomatoes, Juice, Vitamins, Mineral elements, Nutrients.

INTRODUCTION

Tomato products including tomato juice and concentrates are imported into Nigeria from the Western and industrialized world. Huge amounts of money are expended annually in this importation despite the fact that Nigeria is richly blessed with the crop. Tomato has widely been reported to be a good source of natural antioxidants including vitamins C, A and the B group, as well as flavonoids, and the carotenoid - lycopene. Lycopene has been implicated as an antioxidant and as a cholesterol lowering compound (Rathleen et.al. 2000).

Tomato is the fruit of the plant botanically known as *Lycopersicum esculentum*. It is not only a fruit but also a berry since it is formed from a single ovary. It belongs to the family *Solanaceae*, and may interchangeably be referred to as *Solanium lycopersium* or *Lycopersicon esculentum* (Kohlmeier et.al. 1974). The Italians and French refer to tomatoes as pomme d'amour meaning Love apples (Kohlmeier et.al. 1974). Tomatoes come in different varieties that vary in shape, size and color. There are small cherry tomatoes, bright yellow tomatoes, Italian pear-shaped tomatoes and the green tomatoes famous for its fried preparation in southern American Cuisines (Friedmann, 2009).

Tomatoes are more of an intermediate size, they don't have the dessert quality sweetness of other fruits, and instead they have a subtle sweetness that is complemented by a slightly bitter and acidic taste (Anthon et al. 2011). Tomato juice was first served as a beverage drink in 1917 by Louis Perrin at the French Lick springs Hotel in Southern Indiana, when he ran out of orange juice and needed a quick substitute. His combination of squeezed tomatoes, sugar and his special sauce became an instant success as Chicago business men

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spread the word about the tomato juice cocktail. (Hattes, 2009).

Many varieties of tomatoes grow in Nigeria, all of which may be rich in a myriad of macro- and micro-nutrients. The role of tomato intake in daily nutrition and its health benefits, as well as the development of the human body cannot be overemphasized. Lippi and Targher (2011) reported that tomato is rich in nutrients, including vitamins C, A and the B group, as well as mineral elements. The health benefits of tomato include prevention of cancer, protection against heart disease, decreases plasma cholesterol and protects against cervical and prostate cancer. Tomato may be used in weight loss programmes.

There is significant harvest of tomatoes annually with poor preservation and processing techniques in sub-Sahara Africa. In Nigeria for instance, there are no processing factories for tomato juice drink. Annually huge tons of ripe tomatoes are harvested by farmers who also lack the technology to preserve the crop. As a result of which much of the produce is lost due to its perishability and lack of preservation facilities. Thus the farmer gets little or nothing from his effort and these impacts negatively on the overall household incomes and the economy of the country. The farmer also becomes de-motivated due to lack of encouragement to carry on with farming in subsequent farming seasons. There is also a huge market for tomato juice in West Africa, mainly because of its health benefits, and the fact that the crop is available all year round.

Tomato is rich in various macro- and micro-nutrients which may be delivered whole or in part to the consumer depending on its ripening condition, period of harvest, and type of processing, preservation and cooking conditions (Rao and Agarwal, 2000). Tomato juice is processed from ripe tomatoes and serves as a beverage drink around the world. It is produced from selected tomato varieties having solids content not less than 5%. Some producers prefer not to blend different tomato varieties so as to obtain a juice with a consistent and homogeneous flavour. According to Rao and Agarwal (2000), tomato juice contains Asuza factor that inhibits platelets in the blood from clumping together and forming blood clots. Lycopene a major carotenoid in tomatoes has been reported to lower plasma cholesterol, lower hypertension, protect against breast, cervical and prostate cancer, myocardial infarction and other cardiovascular diseases.

Tomatoes contain very important phytochemicals, including saponins, alkaloids, sterols, flavonoids and polyphenols. Tomatoes are also rich in fiber, carbohydrates and proteins. Tomato serves as a vegetable for culinary purposes because of its savory flavor and beneficial effects to health, especially the human heart, liver, kidneys and the pancreas (Aldrich H.T 2010).

PRODUCTION OF TOMATO JUICE

Many commercial manufacturers of tomato juice also add salt. Other ingredients are also often added such as sugar, garlic powder, onion powder and other spices. In the United States, mass produced of tomato juice began to be marketed in the mid 1920's and became a popular breakfast drink a few years thereafter (Anthon et.al. 2011). Drinkable tomato juice is normally produced during the tomato season, when tomatoes ripen in commercial quantities. It is usually produced from selected tomato varieties having 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 flavour (Anthon et.al. 2011).

Production Technology for Tomato Juice

The technology for the production of tomato juice drink is basically the same with that used for the production of tomato paste. The process involves selection of ripen and wholesome fruits, followed by washing, chopping, removal of seeds, hot break, pre-heating demineralized water, and then screened over 0.3-0.4mm meshes to extract finer juice with less suspended solids and to remove free fatty acids and oily matter. The juice obtained may be concentrated by heating under vacuum. Salt, sugar and spices may be added to taste. The finished product is usually stored in compatible packaging materials made of glass or aluminium coated containers (Anthon et.al. 2011).

Health Benefits of Raw Tomatoes and Tomato Juice

Tomato has been referred to as a "functional food" that goes beyond providing basic nutrition but also providing essential mineral elements and vitamins necessary for well-being, preventing chronic diseases, and delivering other health benefits. Tomatoes contain a wide array of beneficial nutrients and antioxidants, including Vitamins A and C, α-lipoic acid, lycopene, choline, folic acid, β-carotene and lutein. α-lipoic acid helps the body to convert glucose into energy.

Some evidence suggests that α-lipoic acid can aid in blood glucose control, improve vasodilation and protect against retinopathy in diabetic patients and may even help preserve brain and nerve tissue (Aldrich et.al. 2010). Choline is an important nutrient found in tomatoes that ameliorates sleep disorder, muscle movement, learning and retention of memory. Choline also helps to maintain the structure of cellular membranes, aids in the transmission of nerve impulses, assists in the absorption of fat and reduce chronic inflammation (Anthon et.al. 2011).

The health benefit of tomatoes also includes, improved eyesight, good stomach health, and reduced blood pressure as well as relief from diabetes, aging skin and skin infections and urinary tract infections. Tomatoes 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 (Heinemann, 1996; Etminan et. al. 2004. Friedman et.al. 2009).

MATERIALS AND METHODS

Source of Fresh Tomatoes

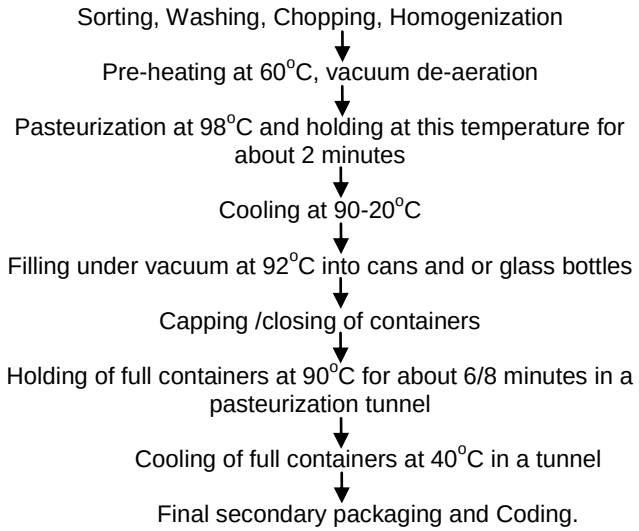
One (1) kg of fresh tomatoes of mixed shape was sorted and purchased from Akim market in Calabar metropolis. The sample was confirmed as tomatoes (*Lycopersicum esculentum*) by Dr. Michael Eko, a taxonomist in the Department of Botany, University of Calabar, Nigeria.

Preparation of Plant Material

Five Hundred (500) grammes of tomatoes was washed under running tap water, and rinsed thrice to remove all dirt and impurities. The tomatoes were de-seeded and washed again free of seeds. The sample was grinded and homogenized using a kitchen blender and filtered using a cheese cloth. The extract was concentrated by heating at $<50^{o}C$. This was stored under refrigeration at $<4^{o}C$. Separately 500g of washed fresh tomatoes which was not de-seeded was homogenized using a

Kitchen Warring blender, and then filtered with a cheese cloth, and oven concentrated at <50^{o}C using a microwave oven, and stored at <4^{o}C under refrigeration.

Processing Scheme for tomato Juice



Product Shelf Life Studies

One cup full or 25g of each sample was placed in transparent glass bottles and covered with aluminium foil, and allowed to stand on the laboratory shelf under ambient conditions (temperature 24±2.2^{o}C; humidity 65±3.4^{o}C; 12 light/dark cycle) for shelf life studies. Colour change, oxidative rancidity, including bacterial spoilage, objectionable odour and taste were monitored.

Proximate analysis

The analysis of the proximate composition of tomato pulp and juice was carried out using the official methods of analysis of the Association of Official Analytical Chemists (AOAC, 1984) and the FAO (1986).

Phytochemical Analysis

Phytochemical analysis for tannins, phenolics, flavonoids, saponins, carotenoids, sesquiterpenoids, cardiac glycosides and alkaloids were carried out according to known and standard methods. Tannins were estimated using the Folin-Denis spectrophotometric method (Pearson 1976). Saponin content was determined using the method of Birk et al. (1963) as modified by Hudson and El Difrawi (1979). Tannins, polyphenols, phenolics, flavonoids, saponins, carotenoids, sesquiterpenoids and alkaloids were carried out according to known and standard methods. Flavonoids were determined according to the method described by Igile et. al (1994).

Analysis of Anti-nutrients

Total oxalate was determined according to the procedure of Day and Underwood (1986). Phytate content was determined using the method described by Reddy and Love (1999). Hydrocyanic acid content was determined using the alkaline titration method of AOAC (1990).

Vitamin analysis

The composition of the water-insoluble vitamins, riboflavin, thiamine and pyridoxine, were determined by the method described by Scalar (2000), while ascorbic acid content was determined by the method of AOAC, (1980). Vitamin A concentration was determined by the spectrophotometric method described by Pearson (1976).

Mineral Analysis

Minerals were determined after the dried powdered samples were first digested with nitric acid and perchloric acid and the filtered aliquots were used for the determination of sodium, potassium, calcium, magnesium, phosphorus, iron, copper, zinc, selenium, chromium, cobalt and manganese content. Potassium and sodium were determined by the Flame photometric method. Iron, copper, zinc, manganese, chromium, cobalt, selenium calcium and magnesium were determined by atomic absorption spectrophotometric method described by James (1995; AOAC, 1990).

Statistical Analysis

The results were analyzed for statistical significance by one-way ANOVA (Analysis of variance) with a Post Hoc Dunnet at P<0.05, using SPSS software. All data were expressed as mean ± SEM.

RESULTS

Tables 1–7 shows the results of the various analyses conducted on the two variants of tomato juice produced in the laboratory. Table 1 shows the result of the proximate composition of the juice compared with the raw and unprocessed tomato pulp. The fat content of the juice with seed was higher (1.62±0.02g/100g) than the fat content of the juice without seed (0.79±0.05g/100g). The significant (p<0.05) reduction in fat content of J may be due to the de-seeding process.

The fat in tomato is mostly found in the seed. The protein content in JS and J were higher than in raw tomato (RT), and this may be due to the fact that RT contains more water, and J and JS have been significantly concentrated and contain less water. In the same vein the carbohydrate contents of J and JS were significantly (p<0.05) higher than in RT, due to difference in moisture contents. The moisture content in RT is significantly (p<0.05) higher than in J and JS. The fibre content in J (4.26±0.05g/100g) was significantly (p<0.05) lower than in JS (8.15±0.04g/100g).

The total energy value of JS (153.50±0.29Kcal/100g) was found in this study to be higher than energy value of J (142.67±0.67Kcal/100g) and RT (118.63±0.32Kcal/100g), due to its low moisture content and high fat, protein and carbohydrate contents, when compared to J and RT. Table 2 shows the regulatory quality attributes of the finished products of J and JS compared to RT. The dry matter and total sugar contents of J were higher than in JS and this may have accounted for the higher solids content observed in J (5.89±0.02%) and JS (6.44±0.12%) when compared to RT (4.24±0.01%). The Vit C and titratable acidity contents of RT were higher than in J and JS and this was found to be responsible for the higher pH of RT (4.6 @ 25^{o}C).

Table 1: Proximate Composition of Tomatoes Juice Extract (g/100g)

	Raw Extract	Oven con Juice	Oven con juice +seed
Fat	1.49 ±0.03	0.79 ±0.05*	1.62 ±0.02*, a
Protein	8.81 ±0.09	11.89 ±0.08*	12.38 ±0.06*, a
CHO	17.13 ±0.07	20.67 ±0.36*	21.84 ±0.04*, a
Fibre	5.04 ±0.08	4.26 ±0.05*	8.15 ±0.04a
Ash	17.84 ±0.15	19.68 ±0.07*	20.18 ±0.03*, a
Moisture	48.00 ±0s.58	42.12 ±0.06*	35.45 ±0.23*, a
Energy (kcal/100g)	118.63 ±0.32	142.67 ±0.67*	153.50 ±0.29*, a

Values are presented as mean ±SEM of 3 determinants
* = significantly different from raw extract at p<0.05
a = significantly different from oven dried juice at p<0.05

Table 2: Quality Characteristics of the Tomato Juice Samples

	Raw Extract	Oven conc Juice	Oven conc juice + seed
Dry matter (%)	5.72 ±0.01	6.74 ±0.02*	6.26 ±0.05*, a
Total sugar	2.79 ±0.01	3.62 ±0.01*	3.39 ±0.04*, a
pH (direct 25)	4.59 ±0.02	5.28 ±0.02*	5.58 ±0.10*, a
Soluble solids (%)	4.24 ±0.01	5.89 ±0.02*	6.44 ±0.12*, a
Titratable acidity (%)	0.26 ±0.01	0.17 ±0.01*	0.13 ±0.01*, a
Vit. C (mg/100g)	157.25 ±0.38	54.00 ±0.58*	62.58 ±0.30*, a

Values are presented as mean ±SEM of 3 determinants
* = significantly different from raw extract at p<0.05
a = significantly different from oven dried juice at p<0.05

Table 3: Microbiological Integrity of the Tomato Juice Sample

	Raw Extract	Oven con Juice	Oven con juice + seed
Coliforms (E. coli)	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00
TVC (cuf/mg)	9.90 ±0.31	2.35 ±0.18*	3.12 ±0.07*, a
Salmonella typhi (cuf/mg)	2.07 ±0.16	0.00 ±0.00*	0.00 ±0.00*, a
Staph. aureus (cuf/ml)	6.27 ±0.21	1.08 ±0.08*	1.33 ±0.07*

Values are presented as mean ±SEM of 3 determinants
* = significantly different from raw extract at p<0.05
a = significantly different from oven dried juice at p<0.05

Table 4: Mineral Elements in the Tomato Juice Samples

	Raw Extract	Oven con Juice	Oven con juice + seed
Mo (µg/100g)	0.23 ±0.01	0.15 ±0.01*	0.18 ±0.00*, a
Zn (mg/100g)	1.19 ±0.01	0.86 ±0.02*	1.07 ±0.01*, a
Se (µg/100g)	0.56 ±0.03	0.32 ±0.01*	0.42 ±0.01*, a
Fe (µg/100g)	0.05 ±0.01	0.03 ±0.00*	0.04 ±0.00
Mg (mg/100g)	25.33 ±0.88	18.33 ±0.06*	21.50 ±0.29*, a
Mn (µg/100g)	0.05 ±0.01	0.02 ±0.00*	0.03 ±0.01*
Ca (mg/100g)	10.00 ±0.58	7.03 ±0.09*	8.47 ±0.37*, a
Cu (mg/100g)	0.04 ±0.00	0.01 ±0.00*	0.02 ±0.00*
Na (mg/100g)	27.10 ±0.21	21.33 ±0.33*	24.30 ±0.35*, a
K (mg/100g)	197.00 ±1.15	173.33 ±0.88*	181.67 ±1.45*, a
Ni (µg/100g)	0.02 ±0.01	0.01 ±0.00	0.03 ±0.00 a
P (mg/100g)	10.60 ±0.42	6.83 ±0.07*	8.60 ±0.46*, a

Values are presented as mean ±SEM of 3 determinants
* = significantly different from raw extract at $p<0.05$
a = significantly different from oven dried juice at $p<0.05$

Table 5: Heavy Metals concentration in Juices (mg/100g)

	Raw Extract	Oven con Juice	Oven con juice + seed
Pb	0.25 ±0.01	0.17 ±0.00*	0.19 ±0.01*
Hg	0.10 ±0.01	0.06 ±0.00*	0.08 ±0.01*
As	0.57 ±0.02	0.37 ±0.01*	0.45 ±0.01*, a
Cd	0.07 ±0.01	0.05 ±0.00*	0.06 ±0.01ns
Cr	0.19 ±0.01	0.15 ±0.01*	0.16 ±0.01ns

Values are presented as mean ±SEM of 3 determinants
* = significantly different from raw extract at $p<0.05$
a = significantly different from oven dried juice at $p<0.05$
ns = not significantly different ($p>0.05$).

Table 6: Anti-nutrients Composition of the Juices (mg/100g)

	Raw Extract	Oven con Juice	Oven con juice + seed
Oxalates	1.19 ±0.02	0.47 ±0.01*	0.45 ±0.02*, a
Phytates	1.28 ±0.02	0.69 ±0.02*	0.82 ±0.02*, a
Cyanates	0.64 ±0.02	0.17 ±0.01*	0.14 ±0.02*, a
Tannates	0.55 ±0.01	0.26 ±0.01*	0.29 ±0.02*

Values are presented as mean ±SEM of 3 determinants
* = significantly different from raw extract at p<0.05
a = significantly different from oven dried juice at p<0.05

Table 7: Vitamin Composition of the Juices (mg/100g)

	Raw Extract	Oven dried Juice	Oven dried juice + seed
Vit. A (IU)	4126.00 ±83.43	3954.67 ±11.35^{ns}	3943.67 ±34.16^{ns}
Vit. B_1(IU)	0.07 ±0.01	0.06 ±0.00^{ns}	0.07 ±0.00^{ns}
Vit. B_2(IU)	1.07 ±0.01	0.90 ±0.01*	0.96 ±0.03*
Vit. B_6(IU)	0.18 ±0.02	0.15 ±0.00*	0.16 ±0.01^{ns}
Vit. B_{12} (µg/100g)	0.05 ±0.01	0.04 ±0.00^{ns}	0.05 ±0.00^{ns}
Vit. C	157.33 ±0.33	151.00 ±1.00*	154.67 ±0.33*, a
Niacin	1.11 ±0.02	0.98 ±0.04*	1.04 ±0.01^{ns}
Vit. E	0.50 ±0.02	0.42 ±0.01*	0.44 ±0.01*
Vit. K (µg/100g)	1.49 ±0.04	1.30 0.02*	1.41 ±0.00^{a}
Vit. H (µg/100g)	0.68 ±0.03	0.47 ±0.02*	0.56 ±0.01*, a

Values are presented as mean ±SEM of 3 determinants
* = significantly different from raw extract at p<0.05
a = significantly different from oven dried juice at p<0.05
ns = not significantly different (p>0.05)

Table 3 shows the microbiological performance of the juice compared to the raw tomato pulp. The results showed that processing considerably reduced microbial load (Total Viable Count) in J (2.35±0.18cfu/mg) and JS (3.12±0.07cfu/mg) when compared to RT (9.90±0.31cfu/mg). The reduction in total viable count may be due to heating to concentrate the juice. Table 4 shows the mineral elements in the juice. The results showed that tomatoes and tomato products contain significant levels of mineral elements including zinc, selenium, iron, manganese and copper, among others.

Table 5 shows the heavy metals composition of the tomato juice compared to the raw and unprocessed tomato pulp. Processing considerably reduced heavy metals concentration in the processed juice, including Cd, hg, Cr, Pb and As. Table 6 shows the result of the anti-nutrient composition of the processed juice (J and JS). Processing including heat treatment significantly reduced the anti-nutrient concentration in J and JS.

Table 7 shows the vitamin composition of the products, when compared to the raw tomato pulp. Processing did not significantly affect the vitamin composition of the products (J and JS) when compared to RT. The result showed that tomatoes and its processed products contain significant levels of vitamins. The vitamin A content of tomatoes was found to be high and this is an indicator of the level of carotenoid content in tomatoes.

DISCUSSION

Although tomatoes ripen in large quantities annually in Nigeria, there is lack of basic processing and preservation facilities to make the commodity perennially available to consumers. Processing the ripen fruits into juice for nutritional and recreational consumption is an option that has not been explored in the country. Tomatoes juice is an excellent source of several nutrients including mineral elements and vitamins. The juice is also a rich source of beneficial phytochemicals including carotenoids, flavonoids, polyphenols, saponins and the antioxidant lycopene. The juice can be used for nutritional interventions especially in anemia and protein energy malnutrition (PEM).

Tomato juice has long been a staple in western and international cuisines due to the awareness in the Western world about the rich composition of tomatoes and its products, and the supply of health beneficial nutrients from tomato products. Tomato juice is low in calories and fat and it can serve as an excellent source of body weight control (Jonathan, 2006).

Evaluation of the chemical composition and anti-nutrient content of raw tomato sample, oven dried tomato juice without seeds and oven dried tomato juice with seeds shows that there were variations in the proximate composition of the two tomato juice samples studied. The different tomato juice preparations were high in mineral elements with the raw tomato juice extract having the highest value of mineral elements and vitamins. A similar trend was also observed for anti-nutrients results. Fruits generally are low in lipids and protein, but their seeds are known to contain high lipid content.

The raw juice extract and oven dried juice with seeds had shown high lipid values but protein and carbohydrate content were high in oven dried juice with and without seeds and this could have been as a result the fact that the heat treatment liberate them from the bound complexes and could be utilized successfully as sources of edible oils and protein for human consumption, and animal feed and have great potentials for addition to food system as nutrient supplement, due to their high elemental composition. Also, TVC, *S. typhi* and *S. aureus* were found to be far higher in the raw tomato sample when compared to the two juice samples (J and JS) as a result of heat treatment. The heat treatment of the J and JS samples in turn caused decreased levels of microbial load and total *Coliform* count (Cfu/ml).

The present study showed that sample J contained less fat because the seeds have been removed before being processed into juice. This was found to be the reason for its better shelf life and keeping quality, and overall quality characteristics. JS sample keeping quality was significantly lower (< 3 days @ 31^{o}C, humidity 67%) and the product turned rancid due to oxidative lipid peroxidation.

This study further showed that J and JS contained significant amounts of ash, crude fibre, moisture, carbohydrate, protein, vitamins, and mineral elements similar to the nutrient content of known and existing tomato juice in the international market. Overall, the different tomato preparations were found have varied nutrients which are high enough to provide certain health benefits. Finally, the mineral elements and antioxidant composition of J and JS tomato juice preparation and can serve as a source of essential elements and vitamins of high quality and high nutritive value.

The proximate composition of J and JS showed that Tomatoes and tomato consumption may help get rid of the free radicals in the body, provide anti-oxidation in the body and thus help the human body remain young and energetic. There is a common adage that “instead of drinking a cup of coffee, try drinking a glass of tomato juice to get that energy and vitality and disease free body”. Tomato juice consumption has been shown to be very beneficial to skin, vision and as an anti-cancer product. Consumption of tomato juice has been reported to help in getting rid of tanning, counter discoloration of skin, help in treating and preventing acne, shrinks open pores and regulates secretion of sebum in oily skin.

Vitamins and iron present in tomato juice help in preserving as well as adding shine to dull, damaged and lifeless hair. It also helps in getting rid of itchy scalp as well as dandruff (Moneruzzaman et. al., 2008) .

The high carotenoid , vitamin C and the key carotenoid lycopene concentration in tomatoes and tomato juice suggest that the consumption of tomatoes and tomato juice can protect against oxidative stress of all types and fight free radicals including reactive oxygen species (ROS) in human systems. Vitamins C also play an essential role in mineral metabolism and cellular functions (Coila, 2011).

Tomatoes are a low calorie foods, with only 33 calories per tomato fruit. Tomatoes contain high concentrations of vitamin C, A and K. It also contain high concentrations of mineral elements including potassium and manganese. Tomatoes are a good source of fiber, which helps keep the digestive tract healthy by increasing stool bulking and defecation, and preventing constipation and colon cancer (Coila, 2011).

Proximate composition of tomato juice

The results of the proximate composition of raw tomato extract, oven dried juice without seed and oven dried juice plus seed as presented in table 1, shows the following details.

Fat: The result showed that the fat content of tomato raw extract and that of oven dried tomato juice plus seed (1.49±0.03mg/100g) and (1.62±0.02mg/100g) respectively were higher compared with that of oven dried juice without seed (0.79±0.05/100gmg).

Protein*:* Oven-dried juice with seed (12.38±0.6mg/100g) and oven dried juice without seed (11.89±0.08mg/100g) gave significantly higher protein content when compared to values of raw tomatoes (8.81±0.09mg/100g).

Carbohydrate*:* Similar trend as in protein result was also observed for carbohydrate result where the CHO content of oven dried juice plus seed (21.84±0.04mg/100g), oven dried juice without seed (20.67±0.36mg/100g) ~~where~~ were all significantly ($p \leq 0.05$) higher than that of raw tomato extract (17.13±0.07mg/100g).

Fibre*:* The oven dried juice with seed (8.15±0.04mg/100g) and raw tomatoes (8.04±0.08mg/100g) gave high fibre content when compared to oven dried juice without seed (4.26±0.05mg/100g). High fibre content in tomatoes is the reason for its stool bulking and anti-constipation properties.

Ash*:* The ash content of oven dried juice with seed (20.18±0.03mg/100g) and oven dried juice without seed (19.68±0.07mg/100g) were found to be higher when compared to the raw tomatoes (17.84±0.15mg/100g). The high ash content in tomatoes and its products is an indication of the high mineral elements concentration in the crop.

Moisture*:* Raw tomatoes (48.0±0.58mg/100g) gave higher moisture values when compared to the values of oven dried

juice without seed (42.12±0.06mg/100g) and oven dried juice with seed (35.45±0.23mg/100g).

***Energy**:* The energy value of oven dried juice with seed (153.5±0.29Kcal/100g) was higher than those of oven dried juice without seed (142.67±0.67kcal/100g) was higher than that of raw extract (118.63±0.32mg/kcal).

Quality characteristics of tomato juice

The quality characteristics of tomato juice extract is presented in table 2.

Dry matter: The result showed that the dry matter values in all the tomato samples evaluated fell within the same range, raw tomatoes (5.72±0.01mg/100g), oven dried juice without seed (6.74±0.01mg/100g) and oven dried juice with seed (6.26±0.05mg/100g). Raw tomatoes gave the lowest value.

***Sugar**:* Oven-dried juice without seed (3.62±0.01mg/100g) gave the highest sugar content, followed by oven dried juice with seed (3.39±0.04mg/100g). The raw tomatoes gave the lowest sugar value (2.79±0.01mg/100g).

pH: Oven-dried juice with seed gave the highest pH value (5.58±0.01), followed by oven dried juice without seed (5.28±0.02). The pH value of raw tomatoes was the least (4.69±0.27) at 25^{o}C.

***Soluble Solids and Titratable Acidity**:* Oven-dried juice with seed gave highest concentration of total soluble solids with a value of (6.44±0.12 mg/100g) when compared to oven dried juice without seed (5.89±0.01 mg/100g). Also, the titratable acidity of raw tomatoes gave a significantly ($p<0.05$) higher value (0.26±0.01 mg/100g) when compared to oven-dried juice without seed (0.13±0.01).

Microbial load of tomato juice extract

***Coliform**:* Coliforms were not detected in all products tested. Although, the Total Viable Count (TVC cfu/mg) was within regulatory limits of the Nigerian Industrial Standards (NIS). However, it coliform concentration was found to be higher in raw tomatoes than in the processed juice with and without its seeds.

The mineral composition of tomato juice extracts

***Mineral**:* Processing and heat treatment caused a decrease in mineral elements in the tomato juice with and without its seeds. The raw tomatoes gave significantly ($p<0.05$) higher values of mineral elements when compared with oven dried juice without seed and oven dried juice plus seed.

Heavy metals: The concentration of heavy metals including Pb, Hg, Ag, Ad, Cr were higher in raw tomato juice extract when compared to processed and oven dried juice with and without seed.

The anti-nutrient composition of tomato juice extracts

Anti-nutrient concentration, including phytates, oxalates, cyanates and tannates were all higher in raw tomatoes when compared with the juice with and without its seed. The concentrations of anti-nutrients were lowest in tomato juice produced without its seed. This may be attributable to processing and heat treatment of the juice extract, which may have degraded the anti-nutrient concentrations.

CONCLUSION

One way of making tomato and its nutrients available to consumers is to produce sufficient juice from it in season. This study showed that tomato juice produced without its seeds preserved better and longer, and gave better taste and odour; and enjoyed higher consumer acceptability. It was concluded that tomato juice can be produced and preserved for drinking as beverage in Nigeria. A deliberate consumer awareness through advocacy may be created and domiciled in the Federal Ministry of Health, because of the health benefits of tomatoes and its products.

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