

Effect of Home-Canning and Freezing on Lycopene and Vitamin C contents of Tomato (*Solanum lycopersicum*)

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ABSTRACT

The effects of preservation techniques and storage on the chemical properties of five varieties of tomato (*Solanum lycopersicum*) were investigated. The five varieties were Marzanino, Xina, NHL 158-3, Piconza 0164 and Roma VF. The preservation techniques employed were freezing and home canning. The additives were sodium chloride (0-2.5%) and lime juice (0-10%). The pH, moisture, vitamin and lycopene contents were evaluated during a storage period of 0-4 months. The results showed that the pH of fresh tomato ranged from 4.50 to 6.23 and frozen tomato from 4.39 to 5.39. The pH of tomato paste with additives was 4.01 and values for canned quartered tomato with additives ranged from 3.47 to 4.59. The moisture content of fresh tomato ranged from 92.8% to 94.9%. The vitamin C content of fresh, frozen and canned tomato ranged from 0.12mg/100g for canned tomato paste to 10.8mg/100g fresh tomato. The lycopene content of fresh, frozen and canned tomato also varied; tomato paste had the highest (120.67mg/kg) level while canned quartered tomato with no additives had the least (3.6mg/kg).

Keywords: Tomato, *Solanum lycopersicum*, Preservation, Lycopene, Vitamin C, Home-Canning, Moisture Content.

Introduction

The tomato (*Solanum lycopersicum* Sgn. *Lycopersicon lycopersicum*) belongs to the family Solanaceae. Tomatoes are widely consumed throughout the world and their consumption is believed to benefit the heart among other things. They contain lycopene, one of the most powerful antioxidants which especially when tomatoes are cooked has been found to help prevent prostate cancer (Ali *et al.*, 2020). Tomatoes consumption has also been associated with decreased risk of breast cancer, head and neck cancers and might be strongly protective against neuro degenerative diseases. Tomato extracts branded lycomato are now used for treatment of high blood pressure. Lycopene has also been shown to improve the skin's ability to protect itself against harmful UV rays (Rattanavipanon *et al.* 2021).

Generally, vegetables are rich sources of vitamins A, B and C. Oranges and tomatoes are both high in vitamin C. Oranges and other citrus fruits contain some of the highest natural concentration of vitamin C.

Other fruits such as tomatoes are rich sources of vitamin C, with some varieties containing concentrations comparable to those found in oranges. On average however, oranges are much higher in vitamin C than tomatoes. Although all tomatoes contribute to vitamin C intake, there are different amounts of vitamin C in different varieties. For example, raw green tomatoes contain 23.4mg/100g; orange tomatoes contain 16mg/100g and yellow tomatoes 9mg/100g respectively (USDA, 2010). Sundried tomatoes are much richer in vitamin C, containing 39.2mg/100g. Crushed, canned tomatoes and tomato juice contain smaller amounts respectively; contributing 9.2 and 18.3mg of vitamin C to our daily intake. Tomatoes are much richer in vitamin A than oranges (USDA, 2010). Vitamin C is an essential nutrient required by the body for the development and maintenance of scar tissue, blood vessels and cartilage. Vitamin C is also necessary for creating ATP, dopamine, peptide hormones, and tyrosine. As a powerful antioxidant, vitamin C helps lessen oxidative stress to the body and is thought to lower cancer risk.

Vitamin C deficiency causes a disease called scurvy, which is characterized by abnormalities in the bones and teeth. The current daily value (DV) for vitamin C is 60mg (Audera, 2001).

In Nigeria, tomato is used to make stews, soups and curries. Around the world, the fruit is often processed into paste, puree (Strained), sauce and juice. Thus the tomato contributes to variety in the diet. Unfortunately this fruit is not only seasonal but highly perishable. It has been estimated that 50% of tomatoes harvested in Nigeria is lost due to spoilage (Oni et al., 2021).

Methods of preservation include freezing, use of chemicals and canning. Tomatoes may be frozen whole, sliced, chopped or pureed. Apart from individual canning, tomatoes may also be home-canned. However, home-canning is not a common practice in Nigeria.

Acidification of home processed tomatoes is essential to prevent botulism (a potentially deadly illness caused by a toxin produced during growth of the bacterium, *Clostridium botulinum*). This can be achieved by the addition of lime juice which contains citric acid, malic acid, and ascorbic acids. Other acids such as acetic acid and oxalic acids may also be added. In addition to improving taste and flavour, salt (sodium chloride) is effective as a preservative because it reduces the water activity of foods.

The water activity of a food is the amount of unbound water available for microbial growth and chemical reactions. The ability of salt to decrease water activity is thought to be due to association of sodium and chloride ions with water molecules (Potter and Hotchkiss, 1995). Adding salt to foods can also cause microbial cells to undergo osmotic shock, resulting in the loss of water from the cell and thereby causing death or retarded growth (Oni et al., 2021).

The aim of this study was to evaluate the lycopene and vitamin C contents of frozen tomatoes and home-canned tomatoes treated with different levels of lime juice and sodium chloride.

Materials and Methods

Source of Tomato

Tomato fruits (Marzanino, Xina, NHLe 158-3, Pienza 0164 and Roma VF. Varieties) were purchased at fruit Garden Market in Port Harcourt, Rivers State. The tomatoes were identified at National Horticultural and research institute (NIHORT), Okigwe. The tomato samples were collected in polyethylene bags and transported to the laboratory for analysis. The variety, local names and descriptions of the tomatoes are presented in Table 1.

Table 1: Local names and descriptions of tomatoes samples

	Variety	Local Names	Description
1.	Marzanino	Gboko variety	Determinate plant type, banana shape, plum red fruit with pointing tips.
2.	Xina	Jos UTC	Round shaped deep red when ripe and firm texture.
3.	NHLe 158-3	Kano UTC	Round, flat and lobed with fruit cracking tendency.
4.	Pienza 0164	Pankshin	Determinate plum shaped red fruits.
5.	Roma VF	Zaria	Pear shaped and red when ripe.

Preservation of Tomatoes

The methods for preservation of tomatoes were freezing and canning. Firm and ripe tomatoes were selected, washed in clean water and blotted dry with a paper napkin.

The tomatoes (150.1-154.9g) were packed in a low density (LDPF) polyethylene bag and frozen in a freezer (model BD-126, Haier Thermocool, Nigeria) at $-2 \pm 2^{\circ}\text{C}$ for 4 months.

Processing of Tomato before for canning

Tomatoes for canning were processed in two ways:-

1. The firm, ripe tomatoes (195-200 grammes) were dipped in 2 litres of boiling water for 30 to 60 seconds to split the skins. They were then dipped in cold water to slip off the skins, discolored parts were removed and the tomatoes were cut into quarters. The cut tomatoes were placed in sterile glass jars which had been submerged in boiling water for 10 minutes and allowed to drain. Adjustments were made in the weight of tomatoes for the addition of lime juice (5% and 10%) and sodium chloride (1.25% and 2.5%). The jars were filled with the cut tomatoes to within ¼ inch of the top. Lime juice was extracted from lime fruits and strained. Thereafter 100ml of boiling water (100°C) was added to each jar to ½ inch head space of the top. Air bubbles were removed by gently sliding a spoon down the sides of the jars. The jars were covered with the lids and heated in boiling water for 40 minutes. The jars were then placed on a rack to cool before storage in a cool, dark cabinet.
2. The tomato (200 grammes) was blended in a moulinex blender for 5 minutes and then boiled for 5 minutes to obtain a paste. This served as the control while adjustments were made in the weight of tomato for treated samples containing 5% or 10%

Lime juice and 1.25% or 1.5% sodium chloride.

The paste was placed in a sterile glass jar. The jar was covered with a lid, heated in a pot for 10 minutes and left to cool.

The cooled jars were checked to confirm that they were sealed properly by testing for seal (USDA, 2004). The jars were then stored in a cool, dark cabinet. The flow diagram for canning of tomatoes is shown in Figure 1.

Determination of moisture content

The moisture content of tomato samples was determined using the method of ADAC, (2000). This was determined by air-oven drying. Moisture cans were weighed and recorded.

The sample was sliced and placed in the moisture can, weighed and dried in an oven (Gallenkamp, BS 120, UK) maintained at 70°C for 12 hrs to obtain a constant weight. The moisture content (MC) was then determined by difference and the percentage composition calculated as follows:

$$\%MC = \frac{Wt\ of\ Can + Wt\ of\ Wet\ Sample - Wt\ of\ Can + Wt\ of\ Dry\ Sample}{(Wt\ of\ Can + Wt\ of\ Wet\ Sample) - (Wt\ of\ Can)} \times \frac{100}{1}$$

Where MC = Moisture content; Wt = Weight

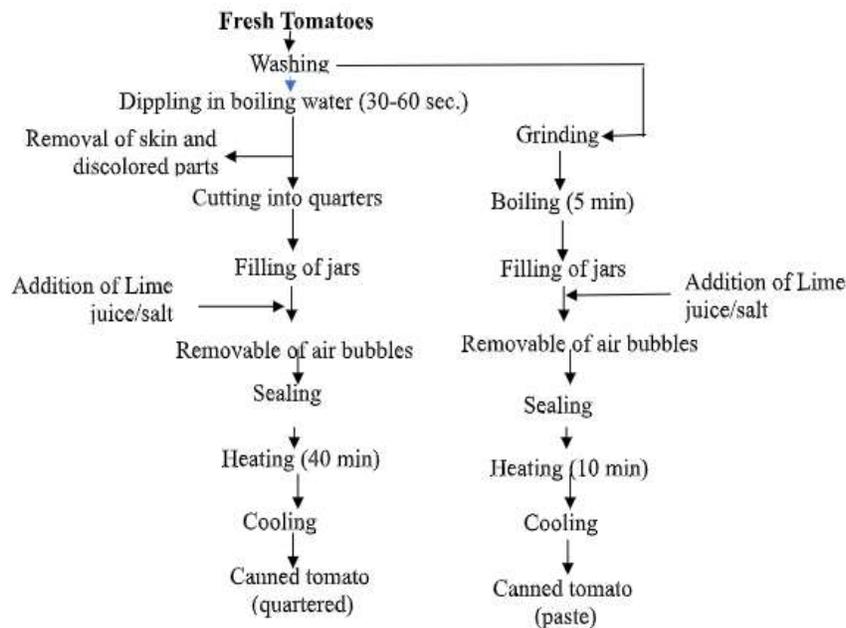


Fig. 1: Flow diagram for the preparation of canned tomato fruit

Determination of pH

The pH of tomato samples was determined using a pH meter (model ME 963 P, China) after it had been calibrated with buffer solution of pH 4.0 and 7.0. The tomato sample was blended in a blender (moulinex, Paris, France) without adding water and poured onto 100ml beaker (Pearson, 1992).

The electrode was dipped into the beaker and the pH was read. Each canned tomato sample was shaken and 10 milliliters was dispensed into a beaker. The reference electrode was inserted into the beaker and the pH was read.

Determination of lycopene content

The extraction of lycopene was performed according to the methods of Fish *et al.* (2002) and Markovic *et al.* (2006). The sample (0.6 grammes) was mixed with 5ml of 0.05% butylated hydroxytoluene (BHT) in acetone, 5 millilitre of ethanol and 10 millilitre of hexane. The absorbance of the hexane layer was measured in a spectrophotometer (UV-Visible 754, siemens, China) at 503nm.

Determination of Vitamin C

The vitamin C content of the tomato was determined by the AOAC (1984) titrimetric method using 2,6-Dichlorophenol indolephenid (DCPIP). Five grammes of each tomato sample were weighed and crushed in a blender (Moulinex, Paris, France). Fifty milliliters extraction solution (0.5% oxalic acid) was added and stirred with a glass rod. The mixture was than filtered through a Whatman – No.1 filter paper (Whatman

International Ltd. Maidstone, England). The extracts (10ml) from tomato samples were titrated against DCPIP, until a faint pink colour was obtained.

Preparation of Tomato Stew

The ingredients used for the preparation of tomato stew are shown in Table 2. Fifty millilitres of vegetable cooking oil (Devon King's, Malaysia) was poured into a clean pre-heated frying pan.

For the three tomato samples without additives, 2.5g of NaCl was added to the hot oil, followed by the onions before the addition of the sample. Whole and quartered tomatoes were diced separately and poured into the hot oil, followed by the addition of ground red pepper. The mixture was stirred and allowed to cook for 10 minutes. A similar procedure was used to prepare stew from tomato paste except that there was no size reduction.

Statistical Analysis

The data obtained from this investigation was analysed using t - test and analysis of variance (ANOVA) for determination of mean difference (Snedecor and Cochran, 1976). T – Test shows differences between the means at a chosen probability level while LSD represents difference between any two means.

Results

The ingredients in tomato stew prepared from raw and freshly canned Xina variety are presented in Table 2.

Table 2: Ingredients in tomato stew prepared from raw and freshly canned Xina variety

	Tomato sample	Weight (g)	Salt (g)	Onions (g)	Maggi (g)	Ground Cayenne Red Pepper (g)	Vegetable oil (ml)
1	Fresh tomato	226.2g	2.5g	35.9g	4.2g	5.0g	50ml
2	Canned quartered tomato (control)	224.2g	2.5g	36.4g	4.2g	5.0g	50ml
3	Canned (+10% + 2.5% NaCl)	229.5g	0	35.7g	4.2g	5.0g	50ml
4	Canned paste (No salt, No lime)	230.5g	2.5g	35.4g	4.2g	5.0g	50ml
5	Canned paste (+10% lime + 2.5% NaCl)	232.1g	0	35.9g	4.2g	5.0g	50ml

The moisture content of fresh tomatoes and pH values for fresh and frozen tomatoes are shown in Table 3. The moisture content ranged from 93.9 to 99.8%. The pH of fresh tomato ranged from 4.50 to 6.23, while the pH of frozen tomato ranged from 4.39 to 5.39.

Table 3: Moisture content of fresh tomatoes and pH of fresh and frozen tomatoes

Sample	Fresh tomato		Frozen tomato pH
	Moisture (%)	pH	
Marzanino	93.9	6.16	4.54
Xina	94.6	5.06	4.89
NHLe 158.3	94.6	6.23	4.98
Picenza 0164	93.0	4.50	4.39
Roma VF	94.9	5.42	5.39

The average pH values for canned tomato samples and lime juice are shown in Table 4. Canned tomato paste containing lime juice and sodium chloride had a pH of 4.01, while the value for canned quartered tomato ranged from 3.47 to 4.59. The pH value for lime juice was 2.02.

Table 4: Average pH values for canned tomato samples and lime juice

Canned Tomato Sample	pH
Canned tomatoes (Quartered)	4.59 ^d
+ 10% lime juice	3.96 ^b
+1.25% NaCl	4.43 ^d
+5% lime juice + 1.25% NaCl	4.25 ^c
+ 10% lime juice + 1.25% NaCl	3.99 ^b
Tomato paste + 5% lime juice + 1.25% NaCl	4.01 ^c
Tomato paste + 10% lime juice + 1.25 NaCl	4.01 ^c
Lime Juice	2.02 ^a

Note: Each value represents means of three (3) replicates. Different superscript differ significantly @ P< 0.05).

The vitamin C and lycopene contents of fresh, frozen and canned tomato samples are presented in Table 5. Cooking and processing of tomatoes increases the concentration of lycopene four times more than in fresh tomatoes. Again lycopene has high melting point of 172-173°C which is enhanced and released by cooking. Lycopene is fat-soluble, it is insoluble in water, so the oil is said to help absorption. Table 6 presents Vitamin C and Lycopene contents of (Xina variety) stew samples.

Table 5: Vitamin C and lycopene contents of fresh, frozen and canned tomato samples

Tomato Sample	Vitamin C (mg/100g)	Lycopene (mg/kg)
Raw		
NHLe 158-3	10.8	87.83
Roma VF	8.28	51.69
Xina	8.07	75.40
Frozen		
NHLe 158-3	8.90	95.20
Roma VF	8.12	83.34
Xina	7.49	78.90
Canned		
Xina (Quartered)	0.30	3.68
+10% lime juice	0.38	40.35
+ 1.25% NaCl	0.39	34.88
+ 5% lime juice + 1.25% NaCl	0.62	14.52
+10% lime juice + 1.25% NaCl	0.16	20.27
+10% lime juice +2.5% NaCl	0.17	7.03
Canned tomato paste + 10% lime juice + 1.25% NaCl	0.012	120.67
Canned tomato paste + 5% lime juice + 1.25% NaCl	0.012	120.67

Table 6: Vitamin C and Lycopene contents of (Xina variety) stew samples

Stew samples	Lycopene (mg/kg)	Vitamin C (mg/100g)
Fresh tomato (control)	50.81	0.4541
Canned quartered (No salt, No lime)	50.62	0.5019
Canned quartered (10% lime + 2.5% NaCl)	87.85	0.4541
Canned paste (No salt, No lime)	181.41	0.3970
Canned paste (10% lime +2.5% NaCl)	205.89	0.3218

Discussion

This study has revealed the lycopene and Vitamin C content of tomatoes preserved by home-canning and freezing. Results in Table 2 provide a detailed comparison of the ingredients used in tomato stew prepared from both fresh and canned Xina variety tomatoes. The ingredients used in the preparation of stew sauce from fresh and stored Xina variety are common and readily available in our local market. It is also a common traditional method of stew preparation in Nigeria. Although in some cases the quantity of the ingredients and concentration differ.

The analysis reveals that the weight of the tomato samples varied slightly, with canned paste (+10% lime + 2.5% NaCl) being the heaviest at 232.1 g, while fresh tomatoes were used at 226.2 g. Salt content was consistent across most samples, with the fresh and canned paste (no salt) formulations incorporating 2.5 g. Notably, the canned stew with added salt and lime completely omitted salt, suggesting a strategic choice to balance flavor while reducing sodium intake. This adjustment may appeal to health-conscious consumers.

The onion content remained stable around 35.4 g to 36.4 g across all samples, indicating that onion flavor was preserved regardless of the tomato form used. The Maggi seasoning was uniformly added at 4.2 g, maintaining consistency in flavor enhancement across all preparations. Red pepper, though unspecified in species, was consistently added at 5.0 g in all samples, contributing to the stew's flavor profile. The use of ground red pepper is particularly relevant, as it could influence both the aesthetic and sensory qualities of the stew. The vegetable oil component was also constant at 50 ml, suggesting a standardized fat content intended to enhance taste and mouth feel across the different tomato bases.

In summary, the table underscores the importance of ingredient consistency in achieving desirable flavor and nutritional profiles in tomato stew, while also highlighting variations in the use of canned versus fresh tomatoes.

In the present study, there was variation in the moisture content of tomato. Roma VF variety had more moisture content than Xina variety, thus Xina variety was chosen for canning. The pH of fresh and frozen tomato also varied, fresh tomato had higher pH than frozen tomato (Usher *et al.*, 2013). Freezing reduces pH of tomatoes due to thawing. The pH values for canned tomatoes were less than 4.6 the value recommended by USDA (2009) for home-canned foods.

Values of the vitamin C and lycopene contents of fresh, frozen and canned tomato showed that, fresh tomato has more vitamin C than canned tomato. This shows that heat and cooking affects the vitamin C content of tomato. Canned tomato paste had less vitamin C than the quartered canned tomato ($p \leq 0.05$). This work supports the study by (Ali *et al.*, 2007). Lycopene from frozen tomato is higher than that from fresh. While amongst the processed tomato, canned tomato paste had more lycopene than quartered due to more concentration of the paste as a result of heating. Also the removal of the skin in the quartered tomato also resulted in the loss of lycopene since lycopene is accumulated in the tomato skin (Usha *et al.*, 2013 and Ali *et al.*, 2020). The skin was removed before canning because it becomes tough and chewy which makes it undesirable when used for soups and stews. The effect of cooking on vitamin C and lycopene content of fresh and processed tomato showed that cooking reduces the amount of ascorbic acid in foods. The high solubility of ascorbic acid in water and the rate of oxidation which is affected by temperature accounts for the loss during cooking.

The vitamin C content of fresh tomatoes ranged from 8.07 to 10.8mg/100g while values for frozen tomatoes ranged from 7.49 to 8.90mg/100g. Heating and cooking had the most adverse effect and caused significant lower ($P \leq 0.05$) vitamin C content than canned quartered tomato which ranged from 0.16 to 0.62mg/100g. The lycopene content of fresh tomato samples ranged from 51.69 to 87.83 mg/kg while values for frozen samples ranged from 78.90 to 95.20mg/kg. Frozen tomato had higher lycopene content than fresh tomato. This may be because there was loss of moisture in thawed tomatoes, thereby increasing the dry matter content. Canned tomato paste had higher lycopene (120.6mg/kg) than canned quartered tomato because the paste is more concentrated due to heating and cooking. This is supported by the study of Usha et al, 2013. The lycopene content of canned quartered tomato ranged from 3.68 to 40.35mg/kg.

The effect of cooking on vitamin C and lycopene contents of tomatoes is indicated in the stew samples from the tomatoes (Table 7). The vitamin C contents for stew samples were generally less than 0.5mg/100g. Stew prepared from canned tomato paste had the highest lycopene content (205.8mg/kg) which is four times more than the value for fresh tomato (50.81mg/kg). This support the findings of Khan (2008); Rao and Rao (2007) which found out that lycopene in tomato paste is four times more than in fresh tomatoes. This work supports the findings of Ali et al., 2020. Lycopene has a high melting point and the concentration of the canned tomato paste due to heating results in the increased amount of lycopene in canned tomato paste in relation to fresh tomato.

Conclusion

Heat destroys vitamin C as observed in this study but it enhanced the release of lycopene due to its high melting point and solubility in oils and fats. Since lycopene is more in canned tomato paste, being an anti-cancer agent. Canned paste with 10% lime juice + 2.5% NaCl has more lycopene and vitamin C. While the canned quartered with 10% lime juice + 2.5% NaCl also had more lycopene than canned quartered with no salt, and No lime. The vitamin C content is less than 1mg/100g. Vitamin C content of fresh tomato control is the same with canned quartered tomato with 10% lime juice +2.5% NaCl. Therefore simple home canning of tomatoes should be encouraged.

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