



EFFECTS OF FOUR DIFFERENT PROCESSING METHODS ON NUTRIENTS AND BIOACTIVE PROFILES OF TOMATO (SOLANUM LYCOPERSICUM L.)

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ABSTRACT

The study was carried out to determine the variation in Phyto-nutritional and bioactive components of tomato (Solanum lycopersicum L) as affected by different processing methods. One tomato variety from local market was purchased, washed with clean water then kept inside a bowl and processed into Fresh tomato, Tomato paste, Dried Tomato and Bottle Tomato. Fresh tomato of variety Roma VF was picked from a research farm and processed into paste following the procedure of international organization for standardization (ISO). The moisture, crude fiber, crude protein, fat, ash, and cyanide content of the samples were determined using the Association of Official Analytical Chemists (AOAC). The mineral contents (elements) of tomato fruits were measured using an atomic absorption spectrophotometer. These minerals included calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu). The phytochemical analysis was determined using a standard method. All data generated were subjected to t-test using Statistical Package for the Social Sciences and means were separated using Duncan's multiple rage test (DMRT). Result obtained revealed that, dried tomato is the best method of processing as it offers the highest access to Phyto-Nutritional and Bioactive components of tomato. The result further indicated that, tomato paste has the least Phyto-Nutritional and Bioactive components. Based on the result of this findings, it is recommended that individuals should go for dried tomato to have access to the nutritional content of tomato and processing industries that deals with tomato should select a processing method that increase the Phyto-nutritional and bioactive components of tomato. While government and non- government organizations should help provide farmers with processing equipment that will enable farmers process tomato that will retain its Phytonutrients and bioactive components.

Keywords: Tomato, Phyto-Nutrient, Bioactive, Beta-carotene.

INTRODUCTION

The tomato, is a member of the Solanaceae family within the Solanales order. This diverse family encompasses 1,500 to 2,000 species, ranking it among the most varied groups of flowering plants (Sato *et al.*, 2012; Naika *et al.*, 2005). Tomato is a major vegetable crop that has achieved tremendous popularity over the last century. Total world tomato production for both processing and fresh consumption in 2021 amounted to just over 189.1 million metric tonnes, up 2% from the 184.8 million mT grown in 2020 and 4% from the average (182.7 million mT) of the previous three years (2018-2020). (FAO, 2022). The tomato industry is one of the most advanced, globalized and innovative horticultural industries. Tomato is a very popular crop which over time has been a major ingredient in human food all over the world, in Africa and especially in Nigerian dishes (Showemimo, *et al.*, 2006). In Nigeria, almost every soup from all the numerous tribes has tomato or tomato products in it. Tomato is not only used





as cooking recipe ingredients, tomato fruits are consumed fresh in salads or cooked in sauces, soup and meat or fish dishes. Tomatoes can be processed into purees, juice and ketchup, canned and dried. Tomatoes are the second most-produced vegetable around the world, behind the potato crop (FAO STAT, 2012) and one of the most important crops in West Africa (Showemimo *et al.*, 2006).

Tomato (Solanum Lycopersicum L.) is a globally significant fruit, boasting a prominent role in dietary patterns worldwide (Pinela et al., 2012). Renowned for its versatility, it is consumed fresh, canned, juiced, and incorporated into countless culinary creations. Tomatoes are a vital component of African diets, boasting immense popularity across the continent (Asoegwu *et al.*, 2017). Their versatility and affordability make them a staple food in many regions, contributing significantly to nutrient intake (Van Jaarsveld *et al.*, 2014).

A staple of the Mediterranean diet and a popular vegetable choice worldwide, tomato boast well-documented health benefits due to its rich nutrient profile (Salehi et al., 2019). They grace our tables in various forms, from fresh salads to processed sauces, soups, and pastes (Elbadrawy and Sello, 2016). Tomatoes are a treasure trove of essential vitamins, minerals, fiber, protein, and beneficial compounds like carotenoids, phytosterols, and essential amino acids (Akinboye, et al, 2018). These nutrients play a vital role in our well-being, aiding in digestion, blood pressure regulation, blood circulation, and maintaining healthy cholesterol levels, body fluids, and bone health (Campestrini et al 2019). The journey from farm to table can significantly impact the nutritional profile of tomatoes. Processing methods employed to extend shelf life, enhance flavor, and facilitate product creation can inadvertently alter the levels and bioavailability of these valuable phytochemicals (Koh et al., 2012). Understanding how different processing techniques influence the concentration and accessibility of these health-promoting compounds is crucial for maximizing the nutritional value of tomatoes throughout the food value chain. The impact of different processing methods on the variation in these components remains largely unexplored. Understanding how different processing techniques affect the Phyto-nutritional and bioactive components of tomato is essential for optimizing their nutritional value and promoting healthier food choices. Tomato is a rich source of vitamins, minerals, antioxidants, and bioactive compounds, such as lycopene, beta-carotene, and flavonoids. Processing methods, including pasting, bottling, drying, can significantly influence the levels and bioavailability of the Phyto-nutritional components. Assessing the impact of different processing methods on tomato's phytochemical composition will help identify the optimal processing techniques to retain and enhance the nutritional value of tomatoes, thus contributing to improved consumer health and nutrition.

Understanding the effects of various processing methods on the Phyto-nutritional and bioactive components of tomatoes can aid in the development of high-quality, nutritious processed tomato products. This knowledge will enable the food industry to optimize processing techniques and formulate products that retain or enhance the health-promoting properties of tomatoes, meeting consumer demands for nutritious and convenient food options. The study is therefore carried out to determine the effects of different Processing Methods on Nutrients and bioactive Profiles of tomato.

METHODOLOGY

Tomato fruits from a farm located in Babcock University Teaching and Research Farm of variety Roma savannah was analysed after processing using four different methods. The processing methods are Fresh tomato, Tomato paste, Dried Tomato and Bottle Tomato. All tomato fruits were picked from the same farm at 80 days after planting. Babcock University is located in the Tropical rain forest vegetation zone of Nigeria with an average annual rainfall of





1500mm and altitude of about 300 meters above sea level; while the mean annual temperature is 27°

Processing of Tomato Fruits

Fresh Tomato

Fresh tomato fruits were picked from the farm, washed with clean water then kept inside a bowl.

Tomato Paste

Fresh tomato was picked from the farm, washed with clean water and were processed into paste following the procedure described by Alkanan *et al*, 2021**Dried Tomato Powder** Fresh tomato was picked from the farm washed with clean water then sliced to thin pieces into a tray and air-dried in the shade for one week till the weight remained constant

Bottled Tomato

Fresh tomato picked from the farm was washed with clean water, the fruits were boiled at elevation 71 meters (233 ft) at room temperature and boiled at 99.7 degrees for 15 minutes, leave to cool for 1 hour, blended in a blender that had been previously sterilized, bottled in a sterile bottle then boil the bottle in water for 30 to 45 minutes. At 99.7 degrees at room temperature.

Proximate Analysis

The moisture, crude protein, fat, Dry matter, ash, crude fiber of the fresh tomato fruits, tomato paste, dried tomato powder and bottled tomato samples were determined using the Association of Official Analytical Chemists (AOAC) method.

Crude Protein Determination (AOAC Official Method 988.05)

The crude protein in the samples were determined by the routine semi-micro Kjeldahl, procedure/technique. This consists of three techniques of analysis namely Digestion, Distillation and Titration.

About 0.5g of each finely ground dried sample was weighed carefully into the Kjeldahl digestion tubes to ensure that all sample materials got to the bottom of the tubes. To this were added 1 Kjeldahl catalyst tablet and 10mL of Conc. H2SO4. These were set in the appropriate hole of the Digestion Block Heaters in a fume cupboard. The digestion was left on for 4 hours, after which a clear colourless solution was left in the tube. The digest was cooled and carefully transferred into 100mL volumetric flask, thoroughly rinsing the digestion tube with distilled water and the flask was made up to mark with distilled water.

The distillation was done with Markham distillation apparatus which allows volatile substances such as ammonia to be steam distilled with complete collection of the distillate. The apparatus was steamed out for about ten minutes. The steam generator is then removed from the heat source developing vacuum to remove condensed water. The steam generator is then placed on the heat source (i.e. heating mantle) and each component of the apparatus was fixed up appropriately.

Exactly 5 mL portion of the digest above was pipetted into the body of the apparatus via the small funnel aperture. To this was added 5mLof 40% (w/v) NaOH through the same opening with the 5 mL pipette.

The mixture was steam-distilled for 2 minutes into a 50 mL conical flask containing 10 mL of 2% boric acid plus mixed indicator solution placed at the receiving tip of the condenser. The Boric Acid plus indicator solution changes colour from red to green showing that all the ammonia liberated have been trapped.

The green colour solution obtained was then titrated against 0.01N HCl contained in a 50 mL burette. At the end point or equivalent point, the green colour turns to wine colour which





indicates that all the nitrogen trapped as ammonium borate [(NH4)2BO3] have been removed as ammonium chloride (NH4Cl).

The percentage nitrogen in this analysis was calculated using the formula: % N=Titre value x Atomic mass of Nitrogen x Normality of HCL used x 4 or % N=Titre value x Normality/Molarity of HCL used x Atomic mass of N x Volume of flask containing the digest x 100/1

Weight of sample digested in milligram x Vol. of digest for steam distillation. The crude protein content is determined by multiplying percentage Nitrogen by a constant factor of 6.25 *i.e.*, % CP = % N x 6.25.

Crude Fat or Ether Extract Determination (AOAC Official Method 2003.06)

About 1g of each dried sample was weighed into fat free extraction thimble and pug lightly with cotton wool. The thimble was placed in the extractor and fitted up with reflux condenser and a 250 mL soxhlet flask which has been previously dried in the oven, cooled in the desiccator and weighed. The soxhlet flask is then filled to 3/4 of its volume with petroleum ether (b.pt. 40 °C – 60 °C). The extractor plus condenser set was placed on the heater. The heater was put on for six hours with constant running water from the tap for condensation of ether vapor. The set is constantly watched for ether leaks and the heat source is adjusted appropriately for the ether to boil gently. The ether is left to siphon over several times until it is short of siphoning. It is after this is noticed that any ether content of the extractor is carefully drained into the ether stock bottle. The thimble containing sample is then removed and dried on a clock glass on the bench top. The extractor, flask and condenser is replaced and the distillation continues until the flask is practically dry. The flask which now contains the fat or oil is detached, its exterior cleaned and dried to a constant weight in the oven. The initial weight of dry soxhlet flask is Wo and the final weight of oven dried flask + oil/fat is

W1, percentage fat/oil is obtained by the formula: W1-W0/Wt.of Sample x 100/1

Dry Matter and Moisture Determination (AOAC Official Method 967.08)

About 2 g of the sample was weighed into a previously weighed crucible. The crucible plus sample taken was then transferred into the oven set at 100°C to dry to a constant weight for 24 hours overnight. At the end of the 24 hours, the crucible plus sample was removed from the oven and transferred to the desiccator, cooled for ten minutes and weighed.

The weight of empty crucible is Wo

weight of crucible plus sample is W1

weight of crucible plus oven-dried sample W3 (%DM)% Dry Matter= W3-W0/W1-W0x100/1 % Moisture= W1-W3/W1-W0 x 100/1 or % Moisture=100-%D.M

Determination of Ash (AOAC Official Method 942.05)

About 2.0 g of the sample were weighed into a porcelain crucible. This was transferred into the muffle furnace set at 550°C and left for4 hours. By this time, it had turned to white ash. The crucible and its content were cooled to about 100°C in air, then room temperature in a desiccator and weighed. This was done in duplicate. The percentage ash was calculated from the formula below: *Ash content= wt.of ash/original wt.of samplex100/1*

Fiber Determination (AOAC Official Method 958.06)

About 2 g of the sample was accurately into the fiber flask and 100mL of 0.255N H2SO4 added. The mixture was heated under reflux for 1 hour with the heating mantle. The hot mixture was filtered through a fibre sieve cloth. The filterate obtained was thrown off and the residue was returned to the fibre flask to which 100 mL of 0.313N NaOH was added and heated under reflux for another 1 hour. The mixture was filtered through a fiber sieve cloth and





10 ml of acetone added to dissolve any organic constituent. The residue was washed with about 50 ml hot water on the sieve cloth before it was finally transferred into the crucible. The crucible and the residue were oven-dried at 105 °C overnight to drive off moisture. The oven-dried crucible containing the residue was cooled in a desiccator and later weighed to obtain the weight W1. The crucible with weight W1 was transferred to the muffle furnace for ashing at 550° C for 4 hours.

The crucible containing white or grey ash (free of carbonaceous material) was cooled in the desiccator and weight to obtain W2. The difference W1 – W2 gives the weight of fibre. The percentage fiber was obtained by the formula: % *Fibre=* W1-W2/wt.of(g)100/1

Lycopene, Vitamins and Sugar Determinations Determination of Lycopene

About 1 g of fresh tomato was weighed into a 250 mL beaker and crushed with a glass rod. Exactly 25 mL of HPLC grade acetone was added and shaken for 10 min. Exactly 25 mL of methanolic NaOH solution was added and a reflux condenser attached. The mixture above was heated in boiling water bath for 1hr with frequent shaking. The mixture was cooled rapidly and 50 mL of distilled water added. The hydrolysate obtained was transferred into a separatory funnel. The solution was extracted thrice with 50 mL of HPLC acetone, and 1 g of K2SO4 added to remove any traces of water. The organic layer was carefully removed into a 250mL beaker and subsequently filtered into a 100 mL volumetric flask and made up to mark with HPLC acetone.

Standard solutions of lycopene of range 0-50 μ g/ml was prepared from 100 ppm stock lycopene solution. The different concentrations of lycopene standard solutions were treated similarly like sample. The absorbances or optical density of sample extracts as well as standard solutions of lycopene were taken on a Spectronic 21D Spectrophotometer made by Artisan Technology Group [®]101 Mercury Drive Champaign, IL, at a wavelength of 340 nm.

Amount of lycopene in ug/g or mg/kg =

Absorbance of sample x Gradient factor x Dilution factor / Weight of sample taken(g)

Determination of Vitamin C

About 10 g of the sample slurry was weighed into a 100 ml volumetric flask and diluted to 100 mL with 3% metaphosphoric acid solution (0.0033M EDTA). The diluted samples were filtered using a Whatman Filter Paper No. 3.

About 10 mL of the filtrate was pipetted into a small flask and titrated immediately with a standardized solution of 2.6 dichlorophenol-in-dephenol to a faint pink end point. The ascorbic acid content of the fruit was calculated from the relationship below.

VxT/W(g) x100 = mg ascorbic acid per 100g sample where

V = --ml dye used for titration of aliquot of diluted sample.

T = ascorbic acid equivalent of dye solution expressed as mg per mL of dye.

W = gram of sample in aliquot titrated.

Determination of β -carotene

Stock solution of beta carotene was prepared by taking 10 mg in 100 mL n-hexane. The concentration of stock solution was equal to 100 ppm. The stock solution was diluted to different known concentrations: 20, 40 and 60 ppm. Dilutions were obtained in 5 mL of each n-hexane solutions. Each working standard solution was injected into HPLC system installed at the Laboratory of Department of Agricultural Chemistry, Peshawar, Pakistan and chromatographic condition was Perkin Elmer HPLC Programme containing LC-1000 pump (Isocratic), having C18 column and connected with LC 250 UV/VIS detector was used. Peak





identification and quantification was made by "CSW 32 software" for HPLC system. HPLC was calibrated by running mobile phase (Acetonitrile, dichloromethane and methanol by the ratio of 70:20:10, respectively) at the rate of 2 ml per minute. Wavelength was fixed at 452 nm. The pressure of the column was kept 1800-2000 PSI. Each standard solution (20μ l) of beta carotene was injected when the injector was in load mode. The standard beta carotene peak was achieved at the retention time of 4.7 minutes (Rt = 4.7). The concentrations of the beta carotene standards were plotted against the peak area to obtain a straight line.

Determination of Vitamin B3

About 5g of sample was blended and 100mLof distilled water added to dissolve all Nicotinic acid or Niacin present. About 5mL of this solution was drawn into 100mLvolumetric flask and made up to mark with distilled water. Exactly 30 ppm of Niacin stock solution was also prepared. The absorbance of the diluted stock solutions and sample extract were measured at a wavelength of 385 nm on a Multiskan SkyHigh Microplate Spectrophotometer, made by Thermofischer Scientific in the United States of America. Different concentrations of standard stock solutions were read on the spectrophotometer for absorbance at the specified wavelength to obtain the Gradient Factor. Amount of Niacin in sample was calculated using the formula: mg/100 g Niacin = Absorbance x Dilution x Gradient Factor Stock

Mineral Analysis

The analysis was conducted According to the procedures outlined by the Association of Official Analytical Chemists, the mineral contents (elements) of tomato fruit will be measured using an atomic absorption spectrophotometer (AAS-Buck 205). These minerals included calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) (AOAC, 2000).

Phytochemical Analysis

The quantitative phytochemical analysis was determine using the methods describe by (Iwuozor. 2019). Saponins, Alkaloids, Tannins, and Flavonids. All determinations were done in duplicates.

Statistical Analysis

All data generated were subjected to t-test and level of significance was accessed using Statistical Package for the Social Sciences. SPSS Version 22 (SPSS 2012) and means were separated using Duncan's multiple rage test (DMRT).

RESULTS AND DISCUSSION

Proximate Composition

Table 1 showed the results of proximate composition of four tomato processing methods: bottle, fresh, paste, and dried. The composition is measured in terms of %crude protein, %crude fat, %crude fiber, %ash, and %moisture content. The result also indicated that there are significant (P \leq 0.05) differences in the composition of some nutrients between the processing methods. For instance, dried tomatoes have a significantly (P \leq 0.05) higher crude protein content (7.485%) compared to all other processing methods (bottle: 1.0000, fresh: 1.2300, paste: 2.1350). Similarly, dried tomatoes also have a significantly (P \leq 0.05) higher crude fat content (2.4500%) compared to bottle (0.1900), fresh (0.2850), and paste (0.1700). On the other hand, bottle-dried tomatoes have the highest moisture content (94.255%) among all processing methods, which is significantly (P \leq 0.05) different from dried tomatoes (5.3500%).

Moisture Content: Bottle-dried tomatoes retain the most moisture (94.255%), followed by fresh (93.6900%) and paste (83.8500%). Drying significantly ($P \le 0.05$) reduces moisture (5.3500% in dried tomatoes), concentrating other nutrients but affecting texture and shelf life.





This aligns with studies by Akinboye *et al*, 2021 who compared tomato varieties, moisture content and shelf life. Degwale *et al*, 2022, also opined that reduction of moisture in tomato processing can concentrate other nutrients present.

Protein Content: Dried tomatoes exhibit the highest protein content (7.4850%), likely due to moisture removal concentrating the existing protein. This finding is corroborated by Degwale *et al*, 2022, who observed a similar increase in nutrients content upon drying tomatoes.

Fat Content: Similar to protein, dried tomatoes also have the highest fat content (2.4500%). While the absolute fat content might not be substantial, drying concentrates it, potentially impacting flavor and nutritional profile. However, some studies may suggest minimal changes in fat content during drying, which warrants further investigation.

Crude Fiber and Ash: Drying seems to have the most significant impact on protein and fat content. Crude fiber and ash content show some variation across methods, but the differences might not be substantial based on the statistical groupings.

The preference for retaining moisture during processing, as seen with bottle-drying, is often driven by preserving the fresh-like texture and minimizing the need for rehydration before consumption. However, this method might have a shorter shelf life due to higher water activity. Drying techniques like those used for dried tomatoes can be employed for long-term preservation and offer concentrated nutrients. However, the trade-off is a change in texture and the potential for flavor alteration due to Maillard reactions at high drying temperatures The specific drying methods used (air drying) can influence the final composition.

	1		1 0		
Treatment	%crude protein	%crude fat	%crude fibre	%ash	%moisture
BOTTLE	$1.0000 \pm 0.31^{\circ}$	0.1900 ± 0.04^{b}	0.7750 ±0.33°	$0.6500\pm0.28^{\rm c}$	94.2550± 13.90 ^a
FRESH	$1.2300 \pm 0.59^{\circ}$	0.2850 ± 0.71^{b}	1.0500 ± 0.08^{b}	0.7450 ± 0.69^{b}	93.6900 ± 9.70^{b}
PASTE	$2.1350\pm0.24^{\text{b}}$	$0.1700 \pm 0.002^{\circ}$	0.6650 ± 0.55^{d}	0.7900 ± 0.29^{b}	$83.8500 \pm 11.00^{\circ}$
DRIED	$7.4850\pm4.28^{\mathrm{a}}$	2.4500 ± 1.01^{a}	1.7400 ± 0.73^{a}	1.8350 ± 0.91^{a}	5.3500 ± 2.61^{d}
LS	**	**	**	**	**
SE±	2.71	0.50	0.85	1.08	18.60

Table 1: Proximate Composition of four tomato processing methods

Mean followed by the same alphabet within a column are not significantly different. (P < 0.05) according to the DMRT at 5% probability.

Mineral Composition

Table 2 presented the result of mineral composition of four different processing methods: bottle, fresh, paste, and dried. The minerals analyzed include potassium (K), iron (Fe), calcium (Ca), sodium (Na), and phosphorus (P).

Potassium (K): Dried tomatoes have the highest potassium content (0.2775%), followed by paste (0.2670%), fresh (0.2545%), and bottle (0.2445%). The differences in potassium content between dried and the other processing methods are statistically significant (p < 0.05).

Iron (Fe): Dried tomatoes also have the highest iron content (0.2300%), significantly higher than the other methods (bottle: 0.0400, fresh: 0.0700, paste: 0.1200).

Calcium (Ca): Dried tomatoes again have the highest calcium content (0.0850%) but the difference is only significant compared to bottle tomatoes (0.0345).

Sodium (Na): Dried tomatoes have the highest sodium content (0.0655%) but the difference is





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Treatment	%K	%Fe	%Ca	%Na	%P
BOTTLE	0.2445 ^d	0.0400 ^c	0.0345 ^d	0.0270 ^c	0.0750 ^d
FRESH	0.2545 ^c	0.0700 ^c	0.0465 ^c	0.0380 ^b	0.0850 ^c
PASTE	0.2670 ^b	0.1200 ^b	0.0550 ^b	0.0445 ^b	0.1020 ^b
DRIED	0.2775 ^a	0.2300 ^a	0.0850 ^a	0.0655 ^a	0.1270 ^a
LS	**	**	**	**	**
SE±	0.17	0.06	0.002	.008	.013

Table 2: Mineral	Compositio	on of four tomate	processing methods
	Compositio	m of four tomat	processing methods

Means followed by the same alphabet within a column are not significantly different. (P < 0.05) according to the DMRT at 5% probability level. LS = Level of significance *,**, & *** = significant @ 0.10, 0.05 & 0.01 probability level.

Phosphorus (P): Dried tomatoes have the highest phosphorus content (0.1270%), followed by paste (0.1020), fresh (0.0850), and bottle (0.0750). The difference in phosphorus content between dried and bottle-dried tomatoes is statistically significant. (p < 0.05).

Drying tomatoes concentrates most minerals, including potassium, iron, calcium, and phosphorus. This is likely because drying removes water, leaving a more concentrated mixture of nutrients in the remaining solids. The increase in mineral content observed in dried tomatoes can be beneficial from a nutritional standpoint. However, it's important to consider that drying can also alter the sensory qualities (texture, flavor) of tomatoes. Studies like that of Ke and Boersig, 1996, support the findings of this table, reporting that drying tomatoes significantly increases their mineral content, particularly potassium, iron, and calcium.

Phytochemical Composition

Table 3 reveals the phytochemical composition of 4 different ways of preservation of tomato, bottle, fresh, paste, and dried.

Phytochemicals: The table focuses on four main phytochemicals:

Saponins: These plant compounds have various functions, including acting as antioxidants and antimicrobial agents.

Alkaloids: These are a diverse group of nitrogen-containing molecules with a wide range of biological effects, some of which can be beneficial in small amounts.

Tannins: These are astringent plant compounds that can influence taste perception and potentially have antioxidant properties.

Flavonoids: This is a large class of antioxidant and anti-inflammatory compounds.

Dried tomatoes: Generally, dried tomatoes have the highest concentration of all four phytochemicals (%saponins: 0.2280, %alkaloids: 0.3350, %tannins: 0.0061, %flavonoids: 0.0075). This could be due to the concentration effect of drying, where water is removed, leaving behind a higher proportion of bioactive compounds per gram of dried product.

Fresh vs. Processed: For saponins and flavonoids, fresh tomatoes have slightly higher levels compared to bottle and paste. This suggests that some of these compounds might be slightly diminished during those processing methods.

Alkaloids: Levels are relatively similar across all processing methods.

Impact of Processing on Phytochemicals:

Drying: As observed in the Table, drying often leads to increased concentrations of phytochemicals. However, it's important to note that drying methods and temperatures can influence the outcome. For instance, some studies suggest that gentler drying techniques like freeze-drying might better preserve certain heat-sensitive phytochemicals.





Other Processing Methods: Bottle and pasteurization might cause some reduction in specific phytochemicals like saponins and flavonoids compared to fresh tomatoes. More research is needed to understand the extent of these changes and the influence of processing parameters. The specific processing conditions (temperature, time) can influence the impact on phytochemicals.

The bioavailability of these phytochemicals, which is how well they are absorbed by the body, might also be affected by processing.

Treatment	%saponins	%alkaloides	%tannins	%flavonids
BOTTLE	0.1140 ^d	0.2080 ^c	0.0019 ^c	0.0030 ^d
FRESH	0.1305 ^b	0.2225 ^b	0.0030 ^b	0.0039 ^c
PASTE	0.1195 ^c	0.2175 ^b	0.0037 ^b	0.0048 ^b
DRIED	0.2280 ^a	0.3350 ^a	0.0061 ^a	0.0075 ^a
LS	**	**	**	**
SE±	0.08	0.16	0.001	0.002

Table 3: Phytochemical Composition of Four Tomato Processing Methods

Means followed by the same alphabet within a column are not significantly different. (P < 0.05) according to the DMRT at 5% probability level. LS = Level of significance *,**, & *** = significant @ 0.10, 0.05 & 0.01 probability level.

Vitamins and Bio-active Components

Table 4. Presented results of the vitamin C, lycopene, β -carotene, and vitamin B3 (niacin) content of tomatoes processed using four methods: bottle, fresh, paste, and dried. The result indicated a significant (P < 0.05) difference between processing methods used. The result further revealed that:

Vitamin C: Fresh tomatoes have the highest vitamin C content (13.81 mg/100g), followed by paste (13.86 mg/100g) and bottle (13.59 mg/100g). Dried tomatoes have the lowest vitamin C content (8.10 mg/100g), which is significantly different from all other methods.

Lycopene: There are no statistically significant differences in lycopene content between any of the processing methods. All methods show similar lycopene content (around 2.6 mg/100g). **\beta-Carotene:** Dried tomatoes have the highest β -carotene content (443.81 µg/100g), although the difference is only significant compared to paste (441.83 µg/100g). There are no significant differences in β -carotene content between fresh (439.86 µg/100g) and bottle (440.74 µg/100g) tomatoes.

Vitamin B3 (Niacin): Dried tomatoes have the highest niacin content (2.798 mg/100g), but the difference is only significant compared to fresh tomatoes (2.696 mg/100g). Bottle (2.336 mg/100g) and paste (2.565 mg/100g) tomatoes show no significant differences in niacin content from each other or from fresh tomatoes.

Drying tomatoes significantly reduces vitamin C content but appears to have minimal impact on lycopene content. Drying may slightly increase β -carotene and niacin content compared to other processing methods, although the differences are not always statistically significant. Fresh tomatoes seem to be the best choice for preserving vitamin C content, while dried tomatoes might offer slightly more niacin and possibly β -carotene





Treatment	Vit.C	Lycopene	ß-Carotene	B3 Niacin
	(MG/100G)	(MG/100G)	(MG/100G)	(MG/100G)
BOTTLE	13.5900 ^b	2.6355 ^b	440.74 ^a	2.336 ^a
FRESH	13.8050 ^a	2.6465 ^a	439.86 ^a	2.696 ^b
PASTE	13.8550 ^a	2.6495 ^a	441.83 ^b	2.565 ^{ab}
DRIED	8.0950 ^c	2.2995 °	443.81 °	2.798 ^{bc}
LS	**	**	**	**
SE±	4.13	0.42	23.99	1.76

Table 4: Vitamins and Bio-active Components of Four Tomato Processing Methods

Note: a,b; Means with different superscripts along the same column are significantly different (P<0.05) according to the DMRT at 5% probability level. LS = Level of significance *,**, & *** = significant @ 0.10, 0.05 & 0.01 probability level.

CONCLUSION AND RECOMMENDATION

From the result obtained, it can be concluded that drying is the best method of processing tomato as it offers the highest access to the Phyto-Nutritional and Bioactive components. Tomato paste has the least accessed Phyto-Nutritional and Bioactive components. The study recommends that the individuals should go for dried tomato to have access to the nutritional content. Agro-processing industries that deals with tomato should select a processing method that increase the Phyto-nutritional and bioactive components of tomato. Government and non-government organizations should help provide farmers with processing equipment that will enable them process tomato that will retain the Phyto-nutrients and bioactive components.

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