

Comparative Studies on Biophysicochemical and Microbial Analysis of Three Selected *Tomatoes* Varieties Grown in Kebbi State

Yusuf, A. B.¹, Muhammad, Y. K.², Ibrahim, A. G.³, Sahabi, M. A.⁴

^{1,2,3,4} Department of Biochemistry and Molecular Biology, Federal University Birnin Kebbi, Kebbi State, Nigeria

ABSTRACT

Environmental conditions and cultivation practices can significantly enhance tomato nutritional value. For example, water deficit irrigation has been shown to increase lycopene, beta-carotene, alpha-carotene, and lutein concentrations by more than 60 percent, while also improving sugars and organic acids, which together enhance taste and nutritional quality. This study was aimed to compare the biophysicochemical and microbial analysis of three selected tomatoes varieties grown in three selected local government areas Kebbi State. Nutritional and anti-nutritional factors of the tomatoes samples were analyzed using standards methods. Minerals element were analyzed using atomic absorption spectroscopy. Bacteria and fungi were also isolated and identified. Survey has also been conducted on impact of handling and storage practices of tomatoes sample. Data were analysed by ANOVA and results expressed as mean $\pm$ standard deviation. The results revealed that the proximate shows moisture (93.6 ± 3.0 %), crude fiber (3.03 ± 0.05 %), Ash (0.51 ± 0.01 %) and crude protein (0.82 ± 0.02 %) had the highest percentage whereas crude fat (0.19 ± 0.01 %) had the least percentage. The anti-nutritional factors shows that oxalates had the highest content of (7.43 ± 0.10 mg/100g) compare to phytates (5.78 ± 0.03 mg/100g) and alkaloid (3.65 ± 0.02 mg/100g), whereas the Cyanides had the least contents of (0.0212 ± 0.01 mg/100g). The minerals composition shows that Phosphorus (P) 1.8 ± 0.01 ppm, Potassium (K) 2.2 ± 0.03 ppm had the highest concentration, whereas Zinc (Zn) 0.954 ± 0.01 , sodium (Na) 0.0630 ± 0.010 , Magnesium (Mg) 0.29 ± 0.01 , and Calcium (Ca) 0.16 ± 0.01 ppm had the least concentration. A 19 cultured (100%) of bacteria were identified: the highest frequency was recorded from *Klebsiella* sp. 5 (28.2 %), *Enterobacter* sp. 4 (22.2 %), *Salmonella typhi* 3 (13.2 %), *Bacillus* sp. 3 (13.3 %), while the least was recorded from *Staphylococcus aureus* 2 (12.7 %), and *Streptococcus pneumonia* 2 (12.7%). A 5 cultured (100%) of fungus were identified: with *Saccharomyces spp* 4 (38.5 %), *Aspergillus* spp 3 (33.8 %), and 2 (11.5 %), had the highest frequency of isolation, whereas *Fusarium* spp 1 (7.7 %), had the least frequency of isolation. The majority (68.0%) are Plum farmers while (23.2%) are heirloom farmers and (8.8%) are Cheery Farmers. In conclusion, the results of this work suggest that three tomatoes varieties can provide good industrial raw materials for paste production because their total solids are within the range of specification and can meet daily recommended intake of minerals, however the low fat values for these samples gives it a positive nutritional implication.

Published Online:
October 13, 2025

KEYWORDS: Tomato varieties, proximate composition, anti-nutritional factors, mineral analysis, microbial isolates, handling practices, Kebbi State

Corresponding Author:
Sahabi, M. A.

INTRODUCTION

Background of the Study

Food loss continues to impede agricultural productivity and undermine livelihood outcomes in developing countries such as Nigeria, where rural households often struggle with reduced income and heightened food insecurity (Brander *et al.*, 2020). Among the array of vegetables cultivated in Nigeria carrots, peppers, sweet potatoes, potatoes, onions, okra, and tomatoes the latter plays a particularly central role due to its widespread cultivation and large consumer base. According to FAOSTAT (2021), Nigeria's 2017 vegetable production totaled approximately 7.2 million metric tons. Of this, turnips and carrots contributed roughly 0.22 million

Yusuf, A. B. et al, Comparative Studies on Biophysicochemical and Microbial Analysis of Three Selected *Tomatoes* Varieties Grown in Kebbi State

metric tons, okra reached about 2 million metric tons, and tomatoes accounted for approximately 4.1 million metric tons highlighting the predominance of tomatoes in both volume and importance to smallholder farmers.

Tomato (*Solanumlycopersicum*), an essential and nutritious vegetable in Nigeria, is widely cultivated across home gardens and farmlands both rain-fed and irrigated thanks to its adaptability to diverse soils and climatic zones. Several recent studies provide updated insights into its nutritional quality, bioactive components, and processing effects. A comparative analysis of improved (breeder) vs. local tomatoes varieties in Nigeria demonstrated that breeder-improved cultivars possess significantly higher protein (0.85–2.40% vs. ~1.60%), vitamin C (119.14–194.00 mg/100 g vs. 110.00 mg/100 g), and essential minerals like potassium and magnesium, along with lower anti-nutritional oxalate content (Abejoye *et al.*, 2025).

Notably, tomatoes processing by-products are rich in phytonutrients, including carotenoids. Innovative "green chemistry" extraction methods using solvents like ethyl lactate and ethyl acetate especially when complemented with ultrasound achieved high lycopene recovery (1324 µg/g dry weight), offering sustainable routes for valorizing waste streams. Moreover, processing notably improves lycopene bioavailability. Meta-findings indicate that transforming raw tomatoes into paste substantially enhances the bio accessibility of lycopene due to isomerization and matrix disruption effects. Thus, recent evidence underscores the significance of tomato cultivar selection, nutritional profiles, and processing innovations in maximizing health benefits and reducing wastage especially in Nigerian contexts (Makinde and Adekoga, 2025).

Tomato texture is a critical quality trait and continues to be widely studied using rheological, sensory, and morphological methods. Recent studies on tomato-based products emphasize the importance of pectin content in tomato peel for determining viscosity and firmness, thereby shaping overall rheological behavior (Bal *et al.*, 2024). The rheological properties of tomato sauces and purees generally display non-Newtonian pseudoplastic flow, with models such as Herschel–Bulkley providing the best fit for their description (Stanciu, 2023). On the biochemical level, pectin-degrading enzyme notably polygalacturonase (PG), pectin methyl esterase (PME), and pectatelyase (PL) play a central role in softening and postharvest quality loss. A recent CRISPR double-knockout study revealed that suppression of SIPG2a and SIPL significantly enhanced fruit firmness and extended shelf-life while preserving flavor and aroma (Ortega-Salazar *et al.*, 2023). Similarly, postharvest research under stress conditions, such as salinity, confirmed that increased PG and PME activity accelerates texture degradation in tomatoes (Stanciu, 2023).

Tomato classification remains consistent with earlier systems, based on fruit type (e.g., cherry, Roma/plum, beefsteak, paste, and winter-storage) and fruit color stages, as recognized by USDA standards. Importantly, the chemical composition of tomatoes nutrients, antioxidants, and texture-related compounds varies according to cultivar, maturity, environment, and cultural practices, factors that collectively determine quality attributes such as appearance, taste, and consumer acceptability (Stanciu, 2023; Bal *et al.*, 2024).

Environmental conditions and cultivation practices can significantly enhance tomato nutritional value. For example, water deficit irrigation has been shown to increase lycopene, beta-carotene, alpha-carotene, and lutein concentrations by more than 60 percent, while also improving sugars and organic acids, which together enhance taste and nutritional quality. Similarly, the use of supplemental LED lighting in greenhouse production has been shown to increase lycopene and lutein content by 18 percent and 142 percent respectively, although beta-carotene levels varied depending on cultivar and light treatment (Bal *et al.*, 2024). Therefore, the current study determined the minerals content, anti-nutritional factors and microbial contamination of the tomato varieties grown in Aleiro, Jega and Kalgo Local Government Areas of Kebbi State.

MATERIALS AND METHODS

Materials

Chemicals and Reagents

All chemicals and reagents used in this research were standard of analytical grade.

Method

Sample Collection

Three varieties of fresh tomatoes fruit (100% ripe), the ripened tomato fruits selected were fresh, undamaged, firm and healthy. The tomatoes were collected from Trans-able farms in Aleiro, Jega, and Kalgo local government of Kebbi State, and the samples were properly washed and blended using a food grade blending machine. A total of 45 tomatoes, Fifteen (15) Sample of each variety was collected in a separate sterile polythene bag and transported to the Kebbi state University of Science and Technology Aleiro, Laboratory of Botany Unit, for identification. The samples were taken to the laboratory for proximate, anti-nutrient, microbial and minerals analysis.

Nutrient Analysis

Proximate composition was determined in triplicate using standard procedures of Association of Official Analytical Chemists (AOAC, 2023). The moisture content was determined by oven drying method. Crude protein was determined by Micro-Kjeldahl

Yusuf, A. B. et al, Comparative Studies on Biophysicochemical and Microbial Analysis of Three Selected *Tomatoes* Varieties Grown in Kebbi State

Method. Fat was determined by soxhlet extraction utilizing hexane as solvent. Crude fibre was determined by neutralization method (AOAC, 2023). Ash content was determined by dry ashing method of (AOAC, 2023).

Carbohydrate Determination

Carbohydrate content was determined by difference (%Carbohydrate) = [100-(%Protein + %Moisture+ %Ash+% Fibre% + %Crude Lipid)] (Mathew *et al.*, 2015).

Determination of Anti-nutritional Factors

Phytates, oxalates, alkaloids and cyanide were determined in the *tomatoes* samples by the methods of AOAC, (2023).

Phytates

A 2g of each sample were weighed into 250cm³ conical flask. 100cm³ of 2% concentrated hydrochloric acid were used to soak each sample in the conical flask for 3 hours. This was then filtered through a double layer of hardened filter paper. Afterward, 50cm³ of each filtrate were placed in 250cm³ beaker and 107cm³ of distilled water were added in each case to give proper acidity. Then 10cm³ of 0.3% Ammonium thiocyanate solution were added into each solution as indicator. This was titrated with standard iron (iii) chloride solution which contained 0.00195g iron per ml. The end-point was slightly appeared brownish-yellow which persisted for 5mins. The percentage of the phytate in the sample was estimated using the expression below.

$$\% \text{ phytic acid} = \text{Titre value} \times 0.00195$$

Oxalates

A 2g of the sample was digested with 10cm³ HCl for one hour and made up to 250cm³ in a volumetric flask. The pH of the filtrate adjusted with concentration of NH₄OH solution until the color of solution change from salmon pink color to a faint yellow color. Thereafter, the filtrate was treated with 10cm³ of 5% CaCl₂ solution to precipitate the insoluble oxalate. The suspension is now centrifuged at 2500 rpm, after which the supernatant was decanted and precipitate completely dissolved in 10cm³ of 20% (v/v) H₂SO₄. The total filtrate resulting from the dissolution in H₂SO₄ is made up to 300cm³. An aliquot of 125cm³ of the filtrate was heated until near boiling point and then titrate against 0.05 of standardized KMnO₄ solution to a faint pink color which persist for about 30s after which the burette reading were taken. The percentage of the oxalate in the sample was estimated using the expression below.

$$\% \text{ Oxalate} = \text{Titre value} \times 0.05$$

Alkaloids

A 5g of each sample were weighed using a weighing balance and disperse into 50cm³ of 10% acetic acid solution in ethanol. The mixture was shaken and then allowed to stand for about 4 hours before it is filtered. The filtrate was then evaporated to one quarter of its original volume on hot plate. Concentrated ammonium hydroxide was added drop wise in order to precipitate the alkaloids. A pre-weighed filter paper was used to filter off the precipitated and then be washed with 1% ammonium hydroxide solution. The filter paper containing the precipitated was dried on an oven at 60°C for 30 min, transfer into desiccators to cool and then reweighed until a constant weight obtained. It was recorded. The weight of the alkaloid was determined by weight difference of the filter paper and express as a percentage of the sample weight analyzed. The experiment was repeated thrice for each sample and the reading recorded as the average of three replicates. The percentage of the alkaloids in the sample was estimated using the expression below.

$$\% \text{ Alkaloids} = \frac{\text{Weight of Alkaloids Residue}}{\text{Weight of Sample}} \times 100$$

Cyanides

Alkaline picrate paper was prepared by dipped strips of Whatman 1 paper into 1% picric acid solution and dried. Then, dipped into 10% of Na₂CO₃ solution and dried. The paper was stored in stoppered bottle. A 0.5g of sample was placed in test tube the piece of moistened alkaline picrate paper was insert in tube. The tube was closed immediately and allowed to stand for 16 – 24 hours at room temperature (280 – 32%). The picrate paper attached to the plastic strip (HNW reacted water in a paper) was removed and immersed in 5cm³ – distilled water (DH₂O) in a test tube with occasional string for 30min. The uncreated yellow picrate paper was treated similarly as blank. The absorbance of the solution of HNC reacted pirated paper was measured against the bank at 510nm using the expression below.

$$\% \text{ Cyanides} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times \text{Concentration of standard}$$

Mineral Analysis

Procedure for Digestion

Each of the prepared samples (2g) were accurately transferred into a digestion tube, 30cm³ of the acid mixture was added to the samples in the digestion tubes. The digestion tubes containing the mixtures were placed on the digestion block, it was allowed to digest until the brown fume disappeared and the white dense fume of perchloric acid was observed with the total volume of the whole mixture reduced to about 5cm³. The digestion process was terminated and the digest were diluted with distilled water. The

Yusuf, A. B. et al, Comparative Studies on Biophysicochemical and Microbial Analysis of Three Selected *Tomatoes* Varieties Grown in Kebbi State

digests were transferred quantitatively into different volumetric flasks of a known volume and were made up to the mark with distilled water. The digests were then transferred into well Stoppard rubber containers and made ready for the analysis.

Determination of minerals using an AAS machine

Sample analysis was done using AA240FS atomic absorption spectrophotometer (AAS) equipped with a hollow cathode lamp, current 10 mA, wavelength 217 nm, band pass 0.5 nm, with a flame type consisting of air/acetylene and stoichiometric fuel flow at 0.9-1.2 dm³ /min. Levels of Minerals (Phosphorous, Potassium, calcium, Magnesium, Sodium, Zinc) in the tomato samples were determined by weighing 1.0 g of the ashed samples into a digestion tube and digesting it with 10 ml of a mixture of concentrated nitric acid (HNO₃) and concentrated HCl on a hot plate. On cooling, the digested sample was filtered using a whatsmann filter paper into a 50 ml volumetric flask and made up to mark with distilled water. The filtration was aspirated into the AAS and levels of the minerals were determined.

Isolation of Bacterial and Fungal species from *Tomatoes* Sample

Serial dilution of the samples was done adopting a method as described by Fawole and Son, (2009). Plating and Bacterial count was done according to the procedure as described by Cheesbrough, (2018).

Identification of Fungal Isolates

Fungal isolated were identified adopting a method as described by Fujita, (2020). The fungal isolates were identified using Czapek Dox Agar (CDA) for macroscopic identification, while the microscopic features were identified using slide culture techniques.

Identification of Bacterial Isolates

Bacterial isolates were identified according to the procedure as described by Chees brough, (2018). The bacterial identification was based on morphological characteristics such as colony appearance; shape, elevation, edges, consistency, colony surface and pigmentation were observed for each bacterial colony after 24 hours of growth. This also included biochemical characterization. The key tests that were used for identification include: Gram staining, catalase, indole, citrate, lactose, motility and sucrose. Gram staining techniques were conducted according to the procedure described by Hardy, (2024).

Statistical Analysis

Results were presented as mean values and standard deviations. Data were subjected to analysis of variance (ANOVA) and a difference was considered significant at $p < 0.05$. Values were analyzed statistically using Graph Pad PRISM version 6.05 software (Statcon, Witzenhausen, Germany).

RESULTS

Nutritional and anti-nutritional composition *tomatoes* sample

Proximate Composition of *tomatoes* Sample

Table below shows the proximate composition of three varieties of tomatoes collected from different location in Kebbi state, the results revealed that Heirloom has the highest moisture contents of 93.6%, followed by *Plum* with 92.2% and *Cherry* with 92.1%, respectively. *Plum* and *Cherry* have the lowest crude ash with 0.43% each whereas Heirloom had the highest with 0.51%. Similarly, the result also showed that *Plum* has the highest crude fat of 0.23%, followed by *Cheery* with (0.21%) and Heirloom (0.19%). Conversely, the highest crude proteins of 0.82% were recorded in *Cheery* which was as twice as that in *Plum* (0.82%) and Heirloom (0.71%). On the other hand, *Plum* has the highest crude fibre (3.03%), followed by *Cheery* and heirloom with 4.50% and with 4.30% respectively. The carbohydrate content in *Plum* was the highest content (3.50%), followed closely by *Cheery* (3.07) and Heirloom (2.66%).

Table 1: The proximate composition of three varieties of tomato

Samples	Moisture content	Crude Ash	%CrudeFats	%Crude Protein	%Crude Fibre	% Carbohydrate
Plum	92.2±2.4 ^a	0.51±0.0 ^a	0.23±0.0 ^a	0.71±0.01 ^a	3.03±0.05 ^a	3.50±0.02 ^a
Heirloom	93.6±3.0 ^a	0.43±0.0 ^a	0.19±0.0 ^b	0.82±0.0 ^b	2.30±0.03 ^b	2.66±0.01 ^b
Cheery	92.1±2.7 ^a	0.43±0.0 ^a	0.21±0.01 ^a	1.69±0.03 ^a	2.50±0.04 ^b	3.07±0.04 ^a

Values are means ± standard deviation of triplicate determination. Values with different superscript in the same column differ significantly at ($P < 0.05$).

Anti-nutritional composition of *tomatoes* Sample

The table below shows the oxalate content of the *Cherry* tomato specie was observed to be lower than the Heirloom tomato specie and *Plum* tomatoes specie with 6.12%, 6.89% and 7.43% respectively. The phytate content in the heirloom tomato was seen to be less as compared to the *Cheery* and *Plum* with 5.12%, 5.78 and 6.43% respectively. The Alkaloid content in the *Plum* is appear to

Yusuf, A. B. et al, Comparative Studies on Biophysicochemical and Microbial Analysis of Three Selected *Tomatoes* Varieties Grown in Kebbi State

be larger compared to Heirloom and Cherry tomato with 4.73%, 3.65% and 3.85% respectively. For this research the Cyanide content in the both Heirloom, Plum, and Cheery is appear to very less, and negligible with 0.0265%, 0.0212%, and 0.0289% respectively.

Table 2: Anti-nutritional factors of the three varieties *tomatoes*

S/NO	Samples	Oxalate	(Mg/g) Percentage (%)	Cyanides	Alkaloid
			Phytate		
1	Heirloom	7.43±0.10 ^a	5.12±0.02 ^a	0.0265±0.01 ^a	3.65±0.02 ^a
2	Plum	6.89±0.09 ^b	6.43±0.03 ^b	0.0212±0.01 ^a	4.73±0.02 ^b
3	Cheery	6.12±0.08 ^b	5.78±0.03 ^a	0.0289±0.01 ^a	3.85±0.02 ^a

Values are means ± standard deviation of triplicate determination. Values with different superscript in the same column differ significantly at ($P < 0.05$).

Mineral Composition of Three Varieties of Tomato

Table below shows the mineral composition of three varieties of *tomato* collected from different location in Kebbi state. The results revealed that *Heirloom* has the highest Phosphorous contents with 1.8ppm followed by *Cheery* 1.5ppm and *Plum* 0.9ppm respectively. The results also showed that *Heirloom* has the highest potassium with 2.2ppm, *Cheery* 1.6ppm and *Plum* with 1.4ppm. On the calcium contents, *Heirloom* and *Plum* has the same contents of 0.18ppm little more than the *Cheery* (0.16ppm). The results for magnesium contents revealed that *Cheery* has the highest content of 0.35 ppm, followed by *Plum* (0.32ppm) and *Heirloom* (0.29ppm). Similarly, the Sodium contents in *Cheery* was the highest with (0.0985ppm) followed by *Heirloom* with 0.0875ppm. *Plum* was recorded to have the least Sodium (0.0630ppm) contents. The results revealed that *Heirloom* has the highest zinc contents with 0.0954ppm followed by *Cheery* 0.0912ppm and *Plum* 0.898ppm respectively.

Table 3: The Mineral composition of the three varieties of *tomatoes*

Sample	Phosphorous	Potassium	(Mg/g) Percent(%)	Magnesium	Sodium	zinc
			Calcium			
Heirloom	1.8±0.01 ^a	2.2±0.03 ^a	0.18±0.01 ^a	0.29±0.01 ^a	0.0875±0.010 ^a	0.0954±0.01 ^a
Plum	0.9±0.01 ^b	1.4±0.02 ^b	0.18±0.01 ^a	0.32±0.01 ^b	0.0630±0.010 ^b	0.898±0.01 ^b
Cheery	1.5±0.02 ^a	1.6±0.02 ^b	0.16±0.01 ^a	0.35±0.01 ^b	0.0985±0.020 ^b	0.0912±0.01 ^a

Values are means ± standard deviation of triplicate determination. Values with different superscript in the same column differ significantly at ($P < 0.05$).

Identification of Bacteria and Fungi Associated with *tomatoes* Samples

Microbial Counts

Numerous colonies were seen on the Nutrient agar medium and potato dextrose agar medium. The total microbial count was observed higher in heirloom sample followed by Plum Sample, and Cheery sample (Table 4).

Table 4: Number of colonies in CFU obtained from three *tomatoes* varieties

Name of Sample	Number of Colonies in CFU/g
Heirloom	4.4×10^{-7}
Plum	2.8×10^{-7}
Cheery	1.97×10^{-8}

Key: NA= CFU= Colony Forming Unit

Yusuf, A. B. et al, Comparative Studies on Biophysicochemical and Microbial Analysis of Three Selected *Tomatoes* Varieties Grown in Kebbi State

Biochemical Characterization of Bacterial Isolate

Biochemical test results revealed the presence of *Escherichia coli*, *Micrococcus luteus*, *Streptococcus pneumonia*, *Staphylococcus aureus*, *Enterobacter sp.*, *Salmonella typhi*, *Klebsiella sp.*, and *Bacillus sp.* (Table 5).

Table 5: Identification of bacterial isolates from three varieties *tomato* sample

Test Organism	Gram Stain	Shape	Cell	Mot	Gas	Suc	Lact	Glu	Cat	Cit	Ind
<i>Escherichia coli</i>	Gram Negative	Rod	Singly	-	+	+	+	-	+	-	+
<i>Micrococcus luteus</i>	Gram Positive	Cocci	Cluster	-	-	+	+	+	+	-	-
<i>Streptococcus pneumonia</i>	Gram Positive	Cocci	Chain	-	+	+	+	+	-	+	-
<i>Staphylococcus aureus</i>	Gram Positive	Cocci	Cluster	-	-	-	+	+	+	+	-
<i>Enterobacter sp.</i>	Gram Positive	Cocci	Cluster	-	-	-	+	-	+	-	+
<i>Salmonella typhi</i>	Gram Positive	Cocci	Chain	+	-	+	-	-	+	+	-
<i>Klebsiella sp.</i>	Gram Positive	Cocci	Cluster	-	-	-	+	+	-	-	+
<i>Bacillus sp.</i>	Gram Positive	Cocci	Chain	+	-	+	-	-	+	-	-

Key: Suc= Sucrose, Cat= Catalase, Ind= Indole, Lact= Lactose, Cit= Citrate, Mot= Motility, Glu= Glucose, += Positive, -= Negative.

Frequency and Percentage Occurrences of Bacterial Isolate

The result revealed that a total of 19 cultured (100%) bacterial isolates identified in *tomatoes* samples obtained from Heirloom, Plum and Cheery *tomato* samples (Table 6).

Table 6: Frequency of isolation and percentage of bacterial isolate in *tomato* sample

S/No	Sample Labeled	Bacteria	Number of Colonies	Frequency
1	Heirloom	<i>Enterobacter sp.</i>	4	22.2
		<i>Salmonella typhi</i>	3	13.3
2	Plum	<i>Klebsiella sp.</i>	5	28.2
		<i>Streptococcus pneumonia</i>	2	12.7
3	Cheery	<i>Staphylococcus aureus</i>	2	12.7
		<i>Bacillus sp.</i>	3	13.2
Total			19	100%

Frequency and Percentage Occurrences of Fungal Isolate

The result revealed that a total of 5 cultured (100%) fungal isolates identified in *tomatoes* samples obtained from Heirloom, Plum and Cherry tomatoes samples, (Table 7).

Table 7: Frequency of isolation and percentage of fungal isolates in *tomatoes* sample.

S/No	Sample Labeled	Fungus	Frequency	Percentage
1	Heirloom	<i>Saccharomyces spp</i>	4	38.5
2	Plum	<i>Aspergillus spp</i>	3	33.8
		<i>Fusarium spp</i>	2	11.5
3	Cheery	<i>Rhizopus spp</i>	2	11.5
		<i>Fusarium spp</i>	1	7.7
Total			12	100%

Yusuf, A. B. et al, Comparative Studies on Biophysicochemical and Microbial Analysis of Three Selected *Tomatoes* Varieties Grown in Kebbi State

Knowledge Statements on the impact of Handling and storage practices of Tomato

Knowledge statement on handling and storage of tomatoes	(%)
<i>Heirloom</i> farmers	68.0
<i>Plum</i> farmers	23.2
<i>Cheery</i> farmers	8.2
Sorting	98.2
Effective picking	95.5
Proper storage facilities	91.7
Short-term storage	81.4
Smooth surface	83.6
Proper packaging during transportation	76.7
Use of oversized basket	64.2

DISCUSSION

There are no significant differences in the proximate contents among the three major *tomato* Varieties collected. Among this Varieties Cheery has relatively lower moisture content compared to that of Heirloom and Plum. High moisture content of fruits is associated with rapid microbial attack due to abundant water activity. Thus, Cheery would have longer shelf lives compared to Heirloom and Plum Varieties. Various levels of moisture content for tomatoes have been reported and the results of this finding were in conformity with that of Mohammed *et al.* (2017) have reported the moisture contents of the three cultivars with an average level of 90.75 ± 0.03 , 88.43 ± 0.04 and $84.15 \pm 0.01\%$ for Roma VF, Ronita, and UTC, respectively.

The results showed that there is a generally low percentage ash content in all of the *tomato* varieties. Lower content of acid- insoluble ash indicates the presence of a small amount of non- physiological components like silica and silicates whereas higher content of acid-soluble ash suggests larger amount of acid soluble compounds like oxalates, carbonates, phosphates and oxides. This finding is closely in agreement with the results of Islaryet *al.* (2016) reported low ash content in the fruits containing salt of metals and trace minerals.

The results of the fat, fibre, and protein and carbohydrate contents of tomato fruits presented showed no significant differences among the varieties; Heirloom has the lowest crude fat this is because it has low moisture content. There is inconsistency in the values obtained in this study for the tomato varieties used; this is in conformity with the finding of Rickman *et al.* (2010)

A part from carbohydrate contents which was not significantly different, tomato varieties varied a lot in terms of nutrient composition such that no single variety was identified with the higher amount of all the nutrients analyzed with the exception of Plum that was analyzed with higher amount of crude fibre. This implies that these tomato varieties can equally serve the same purpose.

Oxalic acid is an organic acid produced in animals and plants when sugar, carbohydrates and other carbon sources are metabolized. The presence of oxalate in *sample* above acceptable levels causes irritation in the mouth and the lining of the gut (Abezaet *al.* 2007) and also hinders the absorption of divalent minerals, particularly calcium (Ola and Oboh, 2010). This in effect makes calcium inaccessible by the body, especially for maintenance of strong bones, teeth, co-factor in enzymatic reactions, nerve impulse transmission and blood clotting (Unuofinet *al.*, 2017). A distinctive property of oxalic acid that makes it so dangerous is that once it has linked with calcium, it is practically insoluble at the acidic pH normally found within the body. An unusual characteristic of calcium oxalate is that nothing can dissolve it and that makes it such an exasperating problem (Ola and Oboh, 2010). Over consumption of food with high concentration of oxalate causes kidney stones. The study indicates that the level of oxalate in *tomatoes* sample is not high to pose any dangers to consumers.

Phytate is the salt form of phytic acid known as inositol hexakisphosphate (IP6). Phytic acids are found in abundance in fiber rich foods and are recommended because they protect human from cardiac vascular diseases and some form of cancer (Norhaizan and NorFaizadatul-A, 2009; Akanemeet *al.*, 2014). With this advantage, yet phytic acid reduce the bioavailability of minerals because of its strong binding affinity to them. They chelate metal ions such as calcium, copper, iron, zinc, magnesium and molybdenum forming insoluble complexes that are poorly absorbed from gastrointestinal tract (Bello *et al.*, 2008; Adebijiet *al.*, 2015). Generally, the more phytic acid in food the more minerals are blocked from the heart. Therefore, the study shows that the value obtained is below toxic levels and so does not pose any danger to consumers.

Alkaloids are large group of substances found in plant and fungi. It's useful as diet ingredients, supplements, and pharmaceuticals. Alkaloids are considered to be anti-nutrients because of their action on the nervous system, disrupting or inappropriately augmenting electrochemical transmission. For instance, consumption of high tropane alkaloids will cause rapid heartbeat, paralysis and in fatal case, lead to death. Uptake of high dose of tryptamine alkaloids will lead to staggering gate and death. Indeed, the physiological effects of alkaloids have on humans are very evident. Cholinesterase is greatly inhibited by glycoalkaloids, which also cause

Yusuf, A. B. et al, Comparative Studies on Biophysicochemical and Microbial Analysis of Three Selected *Tomatoes* Varieties Grown in Kebbi State

symptoms of neurological disorder. Other toxic action includes disruption of the cell membrane in the gastrointestinal tract (Fernando *et al.*, 2020). The study indicates that the level of alkaloids obtained in *tomatoes* sample is not high to pose any dangers to consumers.

The mineral composition of tomatoes revealed that Cherry tomatoes have the higher concentration of sodium, magnesium and phosphorus this could be due to low fat content. The finding is in conformity with that of Shina *et al.* (2018) the outstanding values of the tomato as a source of special nutrient needed in the diet are indicated by the nutritive values. All the three *tomatoes* varieties are good sources of quality and mineral elements. The variation in the nutritive values of different varieties of tomato used in this study might be due to the size, shape aroma and lycopene contents. Also, distribution of minerals needed for human health in the fruits can be affected by cultural production methods Olaniyi *et al.* (2010).

Enterobacter sp. have been implicated in food infections and intoxication leading to different forms of diarrhoeal diseases among other complications especially in young children, the elderly and the immune-compromised (Prescott *et al.*, 2002). Hence, *Enterobacter sp.* are considered pathogenic as it can cause food borne disease when ingested, and its presence in *Tomatoes* sample indicates potential fecal contamination, raising concerns about food safety. Therefore, finding *Enterobacter sp.* in tomatoes sample is a sign of potential health risk including diarrhea, loss of appetite and stomach pains.

Staphylococcus pneumonia, a well-known commensal of human microbiota (Prescott *et al.*, 2002) can contaminate food process and handled with bare hands as such their presence in the samples suggest possible contamination from direct contact or aerial-droplet mechanisms such as coughing or sneezing by Tomatoes processors/retailers or handler (Prescott *et al.*, 2002). Indeed, *Staphylococcus pneumonia* can be pathogenic if present in tomatoes sample. It causes food poisoning and other disease in humans. Therefore, finding *Staphylococcus pneumonia* in tomatoes sample is a sign of potential health risk including liver damage and cancer.

Salmonella typhi are opportunistic environmental pathogens that can cause serious ailment in individuals with suppressed immunity (Prescott *et al.*, 2002). It generally spoiled tomatoes and has been detected in the air, water, soil, plants, and food. *Salmonella typhi* are considered as non-pathogenic, harmless, commensal organism, but it can cause disease in people with certain conditions. Therefore, finding *Salmonella typhi* in *tomatoes* sample is a sign of less health risk including hepatic and brain abscess.

Streptococcus aureus can cause both minor infections, such as otitis and sinusitis, and severe invasive infections, such as community-acquired pneumonia and meningitis (Prescott *et al.*, 2002). Indeed, *Streptococcus aureus* is pathogenic if present in tomatoes sample. It causes food poisoning and other disease in humans. Therefore, finding *Streptococcus aureus* in tomatoes sample is a sign of potential health risk including pneumonia in children and meningitis.

The fungi recovered from the tomatoes samples are of public health importance. For example *Aspergillus sp.* and *Saccharomyces spp.*, and have been implicated in different mycotic infections ranging from superficial dermatophytosis to deep-seated organ infections (Prescott *et al.*, 2002; Kabak *et al.*, 2006). The presence these fungi in tomatoes could be linked to poor handling and unhygienic spreading on of tomatoes on the floor/ground/open basin in the farms for sale thereby giving room for the spores of these fungi which are ubiquitous in the surrounding to gain access to the commercial *tomatoes*.

This is consistent with findings by Osho *et al.* (2010), moulds such as *Aspergillus* *Saccharomyces sp.*, *Fusarium* have been associated with *tomatoes* during storage and their growth results in changes in the organoleptic, microbiological and nutritive quality which lead to spoilage (Amadi and Adebola, 2008). Akano, (2011) had reported that all the food contents of *tomatoes* diminished following infection with these microbes. The fungi detected in this study were considered pathogenic causing food intoxication to consumers. Therefore, finding these fungi in tomatoes sample is a sign of less health risk including lung disease and or asthma.

The result reveals that the majority (68.0%) are *Plum* farmers while (23.2%) are heirloom farmers and (8.8%) are *Cheery* farmers. So also (98.2%) of the respondents knew that sorting is necessary for the removal of rotten, damaged, or diseased fruits from healthy and clean ones. Fruits that are infected or damaged can generate large amounts of ethylene, which can have an impact on nearby fruits. (Pokhrel, 2021) stated that it is necessary to remove diseased tomato fruit to avoid contamination of other healthy fruits; if not, this will lead to contamination, which results in rotten products and post-harvest loss of tomatoes.

Also the majority (95.5%) of the respondents knew that efficient and effective picking can increase the shelf life of tomatoes. According to (Mohan *et al.*, 2023), careful tomato selection extends its shelf life, but careless treatment of tomatoes during and after harvest results in low yields, waste, and financial losses for farmers (Rajapaksha *et al.*, 2021). estimated losses for fruits and vegetable crops to range from 4–12% as a result of poor harvesting practices, including mechanical damage due to rough picking and handling in the field.

The result shows that the majority (91.7%) of the respondents knew that proper storage facilities help to protect tomatoes from deteriorating. Due to their high moisture content, tomatoes are exceedingly difficult to keep for an extended period at room temperature. Tomatoes can be kept for up to 7 days at room temperature. For a longer period, tomatoes can be stored at a temperature of 13°C–15°C and a relative humidity of 80–85% (Silva *et al.*, 2021). To guarantee a steady supply of raw materials for processors,

storage is typically necessary throughout the tomato value chain. Non-availability of storage facilities to local farmers implies that farmers will have to sell at reduced prices as they cannot keep the highly perishable products from deteriorating (Tongbram *et al.*, 2021). However, in most cases, tomatoes are not stored fresh because of their high perishable nature.

Entries show that the majority (83.3%) of the respondents indicated that for short-term storage (up to a week), tomato fruits can be stored at room temperature provided there is enough ventilation to reduce the accumulation of heat from respiration. (Rutta, 2022) stated that the majority of tomato farmers in Nigeria stored their vegetables under normal temperature conditions. This research revealed that the majority of farmers spread tomatoes on the floor of the room while leaving the windows open to allow for cross-ventilation. Respondents stated that this helps prolong the shelf life of tomatoes.

Result from the survey reveals that the majority (81.4%) of the respondents also knew that using smooth surfaces and shallow containers would prevent overloading, thereby reducing mechanical injuries to the harvested tomato. According to the respondents, the use of the “happy family” bowl is a result of the smooth surface, which prevents tomatoes from spoilage, especially during transportation. (Njilar *et al.* 2023) noted that packaging containers with sharp edges must be discouraged to avoid bruising and puncturing of the produce.

The majority (76.7%) of respondents were aware that in order to minimize excessive movement or vibration during transit, the produce should be immobilized by adequate packing and stacking. According to Tkaczyk and Szpotaski (2023), physical damages might occur during transit due to package sizes (big bags), vehicle overloading, and unsuitable packing materials, resulting in excess vibration.

Results reveals that a greater proportion (64.2%) of the respondents knew that an oversized woven basket results in excessive crushing forces on tomatoes located at the base of the basket. According to Anyoha *et al.* (2014), inefficient packaging of produce during transportation results in excess crushing of tomato fruits at the base of the basket as they are usually heaped on top of one another.

CONCLUSION

This study revealed that tomatoes varieties collected from various farms in Kebbi state, vary in their proximate, anti-nutritional and minerals composition. Current dietary guidelines to combat chronic diseases, such as cancer and coronary artery disease, recommend increased intake of plant foods, including fruits and vegetables, which are rich sources of antioxidants, and many studies have shown that a close relation exists between the intake of vegetables and cancer prevention. Therefore, tomatoes as one of the most versatile and widely used food plants could play an important role in human diet. These local varieties grown in Kebbi State are also good source of nutrient (Heirloom, Plum and Cheery) with no significant difference in the physiological quality parameters such as moisture, ash, fat, carbohydrate, protein, and lipid, and minerals. The anti-nutritional contents of Heirloom and plum tomatoes pod where moderately low meanwhile cherry tomato had a lower anti-nutritional concentration. Bacteria and fungi detected are of public health relevance. Hence, these tomatoes samples are good for human consumption and its compositions levels do not have any adverse effect on human health. Tomatoes wastage/loss is as a result of lack of storage facilities and lack of knowledge on the simple techniques for tomato preservation which discourages the farmers after channeling all their limited resources to production. The weather-related factors that contribute to tomatoes post-harvest loss include high humidity, excessive heat, pests and diseases, and inadequate ventilation.

REFERENCES

1. Abejoye, O.A., Bamkefa, B.A. and Olowe, B.M. (2025). Comparative nutritional and antinutritional qualities of local and breeder tomato improved varieties. *Advances in Research*, 26:283–292. <https://doi.org/10.9734/air/2025/v26i11253>
2. Abeza, C.T., Ogungbade, A. M. and Wusu, A. D. (2007). The proximate and mineral composition of three leafy vegetables commonly consumed in Lagos, Nigeria *African. Journal. Pure and Applied. Chemistry*. **3**:102107.
3. Adebisi, E. O., Soetan, K. O. and Olayemi, F. O. (2015). Comparative Studies on the proximate composition, minerals and antinutritional factors in the leaves and stems of *Grewia carpinifolia*. *Annals Food Science Technology*, **16**:207-217.
4. Akano, G. O. (2011). Phytochemical, Proximate and nutrient composition of Vernoniaceae vaona Hook (*Asteraceae*): Agreen-leaf vegetable in Nigeria. *Journal. Food Research*, **2**:1-11.
5. Amadi, O. A. and Adebola, A. A. (2008). Quality characteristics of bread produced from composite flours of wheat, plantain and soybeans. *African Journal of Biotechnology*, **5**:1102-1106.
6. Anyoha, N. O., Aja, O.O., Udemba, H. C. and Okoroma, E.O. (2023). Causes of cassava post harvest losses among farmers in Imo State, Nigeria. *Journal of Agricultural Extension. Journal of Agricultural Extension*, **27**: 73-79. <https://dx.doi.org/10.4314/jae.v27i2.7>
7. AOAC, Association of Official Analytical Chemists. (2023). *Official methods of analysis of the Association of Analytical Chemists International*. (18thed.). AOAC, Gaithersburg, MD.

8. Bal, L.M., Prasad, S. and Sahoo, N.R. (2024). Effect of pectin content in tomato peel on viscosity and quality of tomato-based products. *Journal of Food Science and Technology*, **61**:1124–1135. <https://doi.org/10.1007/s13197-023-05821-6>
9. Bello, M. O., Farade, O. S., Adewusi, S.R.A. and Olawore, N. O. (2008). Studies of some lesser known Nigeria fruits. *African. Journal. Biotechnology*, **7**:3972-3979.
10. Brander, M. M., Hankinson, T.R., Zhuang, H. and Breidt, F. (2019). Microbiological spoilage of fruits and vegetables. In W.H.S perber and M.P.Doyle (Eds.), *Compendium of the microbiological spoilage of foods and beverages*, **5**:135–183.
11. Cheesbrough, M. (2018). *District Laboratory Practice in Tropical Countries Second Edition London English Language Book Society*, Pp:100-194.
12. Fernando, H. F. and Ratta, N. (2020). Antinutritional factors in plant foods: Potential health benefits and adverse effects. *International. Journal. Nutrition. Food Science*, **3**:284-289.
13. Food and Agriculture Organization of the United Nations (FAO). (2021). *FAOSTA Tstatistical database*. FAO. <https://www.fao.org/faostat>
14. Food and Agriculture Organization of the United Nations (FAO). (2017). *FAOSTAT statistical database: Crops*. <http://www.fao.org/faostat/en/#data/QC>
15. Fujita, S. (2020). Simple modified method for fungal slide preparation. *Med Mycotoxin. International Journal*, **54**:141–146.
16. Hardy, T.M. (2024),. *Handbook of Microbiological Media* CRC Press, Boca Raton/London. Pp:1-65.
17. Islary A., Sarmah J. and Basumatary, S. (2016). Proximate composition, mineralcontent, phytochemical analysis and invitro antioxidant activities of a wild edible fruit found in Assam of North-East India. *Journal of Investigational Biochemistry*, **5**: 21-31.
18. Kabak, B., Dobson, A. and Var, I. (2006). Strategies to prevent mycotoxin contamination of food and animal feed: a review. *Critical Review in Food Science and Nutrition*, **46**:405-593.
19. Makinde, F.M. and Adekoga, A.E. (2025). Chemical properties and nutritional quality of Nigerian-grown tomato (*Solanumlycopersicum*) cultivars. *Journa lof Applied Sciences and Environmental Management*, **29**:25-31
20. Malhotra, N. and Birks, D. (2007) *Marketing Research: An Applied Approach*. Prentice Hall.
21. Mohan, A., Ravindran, K., Kaur, A., Vandore, J. and Ramanathan, U. (2023). Management of Postharvest losses and wastages in the Indian Tomato Supply Chain—A Temperature-Controlled Storage Perspective. *Sustainability*, **15**: 1331. <https://doi.org/10.3390/su15021331>
22. Muhammad S.M., Abdurrahman A.A. and Attahiru M. (2017). Proximate Analysis and Total Lycopene contents of Some Tomato Cultivars from Kano State,Nigeria. *Journal of Chemical society of Nigeria*, **8**:64-69.
23. Njilar, R. M., Ndam, L. M., Ngosong, C., Tening, A. S. and Fujii, Y. (2023). Assessment and characterization of postharvest handling techniques in the value chain of Malay apple (*Syzygium malaccense* [L.] Merr. & L.M. Perry) in the Mount Cameroon region.
24. Norhaizan, M. E. and Faizadatul-A, A. W. (2009). Determination of phytate, iron, Zinc, Calcium contents and their molar ratios in commonly consumed raw and prepared food in Malaysia. *Malaysia Journal. Nutrition*, **15**:213-222.
25. Ola, F. L. and Oboh, G. (2010). Anti-nutritional factors in nutritional quality of plant foods. *Journal Technology*, **4**:1-3.
26. Olaniyi, J. Akanbi, W. Adejumo, T. and Akande, O. (2010). Growth, fruit yield and nutritional quality of tomato varieties. *African Journal of Food Science*, **4**:398-402
27. Ortega-Salazar, J.A., García-Gaytán, V., Ramírez-Trejo,C., Guevara-González, R.G. and Torres-Pacheco, I. (2023). CRISPR/Cas9-mediated double knock out of SIPG2a and SIPL enhances firmness and shelf life in tomato fruits with out affecting organol eptic quality. *Plant Physiology and Biochemistry*, **201**, 107706. <https://doi.org/10.1016/j.plaphy.2023.107706>
28. Osho, A. Hore, M. Chakraborty, K. and Roy, S. (2010). Phytochemical Analysis and Antioxidant Activity of methanolic extract of leaves of Corchorusoliterius. *International. Journal. Current Pharmaceutical Research*, **9**:59-63.
29. Pokhrel, B. (2021). Review on post-harvest handling to reduce loss of fruits and vegetables. Pp. 48–52. <https://doi.org/10.33545/26631067.2020.v2.i2a.52>
30. Prescott, L. M., Harley, J. P. and Klein, D. A. (2002). *Food and Industrial Microbiology*. In: Microbiology 5th Edition. The WCBMc Graw-Hill companies, Boston, USA. Pp:26-57.
31. Rajapaksha, L., Gunathilake, D. C., Pathirana, S. and Fernando, T. (2021). Reducing post harvest losses in fruits and vegetables for ensuring food security – Case of Sri Lanka. *MOJ Food Processing & Technology*, **9**: 7–16.
32. Rickman, B. C. M. and Barrett, D.M. (2010). Nutritional Comparison of fresh, frozen and canned fruits and vegetables. Part2. Vitamin A and carotenoids, vitaminE, minerals and fibre. *Journal of Science Food and Agriculture*, **2**: 85-87.
33. Rutta, E. W. (2022). Understanding barriers impeding the deployment of solar-powered cold storage technologies for post-harvest tomato losses reduction: Insights from small-scale farmers in Tanzania. *Frontiers in Sustainable Food Systems*, **6**.

34. ShinaI., S. T. And Aliyu, D. (2018). Comparative Nutritional Composition of Raw and Canned Tomatoes *Solanumly copersicum (Lycopersiconesculentum)* Dutse Market Jigawa State, Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS)*, **4**: 424-435
35. Silva, C. J., Van Den Abeele, C., Ortega-Salazar, I., Papin, V., Adaskaveg, J. A., Wang, D., Casteel, C. L., Seymour, G. B. and Blanco-Ulate, B. (2021). Host susceptibility factors render ripe tomato fruit vulnerable to fungal disease despite active immune responses. *Journal of Experimental Botany*, **72**: 2696–2709.
36. Stanciu, S. (2023). Rheological behavior and modeling of tomato sauces and purees: A review. *Food Hydrocolloids*, **139**:108594. <https://doi.org/10.1016/j.foodhyd.2023.108594>
37. Thomas, D. R. and Hodges, I. D. (2010). Designing and managing your research project: *Core skills for social and health research*, SAGE Publications.
38. Tkaczyk, S. and Szpotański, M. (2023). Damage to palletized loads in road transport. *WUT Journal of Transportation Engineering*, **137**: 19–38. <https://doi.org/10.5604/01.3001.0053.9656>
39. Tongbram, K., Singh, Y. C. and Singh, O. K. (2021). A Study on Production and Marketing Constraints of French Bean (*Phaseolus vulgaris L.*) Growers in Bishnupur District of Manipur. *Asian Journal of Agricultural Extension, Economics & Sociology*, **9**: 37–41. <https://doi.org/10.9734/ajaees/2021/v39i930639>