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Effects of mango leaves utilization during postharvest storage of tomatoes on some macroelements (Na, K, Ca, M, and P) concentrations in Sokoto, Nigeria

Abdulrahman Hamza[1*], Abubakar Mohammad Gumi[2], Aminu Umar Imam[3], Yusuf Sarkingobir[1], Umar Tambari[1], Mustapha Sahabi[4], Aliyu Sulaiman[5]

[1]*Department of Environmental Education, Shehu Shagari University of Education Sokoto, Sokoto State, Nigeria.*
[2]*Department of Biological Sciences, Usmanu Danfodiyo University Sokoto, Sokoto State, Nigeria.*
[3] *Department of Biochemistry, Sokoto State University, Sokoto State, Nigeria.*
[4]*Department of Biology, Shehu Shagari University of Education Sokoto, Sokoto State, Nigeria.*
[5]*State College of Basic and Remedial Studies, Sokoto, Nigeria.*

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ABSTRACT

The objective of this study is to determine the effect of mango leaves in preserving the varied concentrations of metals (sodium, potassium, calcium, magnesium, and phosphorus) present in two tomato varieties in Sokoto, Nigeria. After the application of different mango leaves extracts in the postharvest preservation of *Daneka* tomato fruits in a randomized control design, and atomic absorption spectrophotometry of macro elements; the most elevated concentrations noticed significant difference at ($p<0.05$) were revealed in potassium (1.20±0.002 to 3.00±0.001 ppm), and calcium (1.27±0.003 to 2.15±0.002 ppm). The lower levels of metals noticed upon storage under mango leaves are revealed by phosphorus (1.10±0.002 to1.37±0.002 ppm), and sodium (0.90±0.001 to 1.30±0.001 ppm); and the least was revealed by magnesium (0.61±0.001 to 0.86±0.001 ppm). The different concentrations of elements upon addition of mango leaves in the postharvest preservation of UTC tomatoes in Sokoto, Nigeria show, the elevated concentrations revealed by phosphorus (2.5±0.001 to 3.8±0.004 ppm), potassium (2.00±0.001 to 2.99±0.001 ppm), and magnesium (1.01±0.001 to 2.59±0.001 ppm). The lower concentrations were observed in calcium (1.34±0.001 to 1.70±0.001 ppm), and sodium (0.55±0.005 to 1.80±0.002 ppm). The mango leaves possessed potential to preserve the Na, K, Ca, Mg, and P levels in tomatoes; thus could serve as cheap, accessible, and sustainable preservative in the state when improved.

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1.Introduction

Tomato is among the foremost farm products cultivated at home, and imported worldwide across several parts of the worlds (1).

Tomato is an important vegetable in several parts of the world that serve in daily feeds to enrich our foods with a number of useful contents such as organic acids, vitamins, carotene, lycopene, sugars, amino acids, and minerals that are essential in human health and proper functioning (2, 3).

*Corresponding author. Tel.: +2349096266980
E-mail address: superoxidedismutase594@gmail.com

Mineral elements are essentially required substances that are needed for proper physiology and anatomy in humans and other animals as well (4). Particularly, macro elements are substances required by the body, but has to be taken from the diet in large chunk, such as sodium, potassium, calcium, magnesium, and phosphorus; therewith, the proper body functioning is ensured (5). Parable, magnesium has diverse biological roles, at least it acts in over 300 enzymes as cofactors; hence indicating its versatility in human metabolism (4). Sodium is vital in the human body to regulate blood pressure, stimulate nerves and muscles; calcium is termed as the peak mineral substance of the body. It is relevant in the regulation of blood clotting, production of teeth and bones, and modulation in muscle contraction (4). Insufficient availability of potassium in the body increases risks of disorders such as stroke, cancer, high blood pressure among others (6). Phosphorus is a basic parcel in DNA, RNA, and serves as energy store in metabolic reactions of the biological system (7, 8).

Consequently, it is indeed needed to bio-monitor the amounts of macro elements present in a vital food material like tomato to expunge its contribution to the dietary intake of nutrients daily (1, 9). However, tomatoes are fleshy, berry, and contain 90% water; that in turn after being harvested started a path of high transpiration, and moisture loss, that spur deterioration and subsequent reduction of quality (2, 10). Farmers, producers, are faced with huge loss due to post-harvest, deprived of essential nutrients due to decay of tomato, and have to pay huge amount to processed tomatoes laced with chemicals that are harmful to the biological system by increasing the risk of cancer, infertility, chronic diseases, and other effects (11, 12). The situation is aggravated by the lack of basic amenities, such as lack of transportation of tomatoes from rural areas to cities, and insufficiency of electricity to store tomatoes for optimum time, in a state raged by burden of chronic and infectious diseases, poverty, food insecurity, and malnutrition (13, 14).

Therefore, it is pertinent to seek for natural, sustainable ways to help rural and urban people in the semi-arid region of Sokoto preserve their tomatoes to ameliorate a lot of sufferings. The utilized candidate for this sustainable method is mango material owing to its metabolites contents. Impliedly, mango supposed to have the potential to preserve tomato quality parameters such as the macro elements content (15). In this line, the *Mangifera indica* leaves contain inherent constituents that include the diverse array of secondary metabolites (such as alkaloids, flavonoids, phenols, tannins, saponins, mangiferin, and many more) that possess antimicrobial activities; thereby influencing the use of mango leaves to inhibit the growth of spoilage causing microbes (especially the fungi species). In turn, it is important to test its ability on the preservation of quality (macro elements) in tomatoes. The edible nature of the mango leaves and accessibility in the area are other added advantages (11).

Certainly, tomato (*Solanum lycopersicum* L.) is widely used important crop across several parts of the world for diet purposes, health, and economic reasons. It is an invaluable for many of its contents such as lycopene, carotene, vitamins, sugars, proteins, amino acids, and mineral elements such as microelements

and macro elements. However, the fruit tomatoes are perishable, can easily transmogrified into decay during the postharvest period especially in rural areas where there are poor basic amenities (16). In this vein, food deterioration has led to huge loss of food materials due to microbial actions even in situation of using synthetic chemicals. Therefore, the search for preservatives has become eminent (17, 18). Hosea et al., (18) from Benue state, Nigeria conducted a study to determine the capacity of neem leaves in the preservation of tomatoes; and the study found out that, that the leaves of neem are able to protect the qualities of tomatoes after storage. The parameters studies include firmness, decay and the likes. No mineral elements were considered despite the wide knowledge that elements are parts of tomatoes. In a Sokoto study by Aliyu et al (19) several fungi species responsible for spoilage of tomatoes in the state were determined and restated the need to put down new ways of preservation that are sustainable. Utilization of different storage methods such as plastic crate, ash, rice straw, control, basket and revealed different levels of weight loss, shelf life, and proximate parameters (excluding the metals) in a Nigerian study (20). Sehata et al (16) recently applied some chemicals for preserving shelf life of tomatoes and found chitosan and $CaCl_2$ as the most desirable for preserving qualities of tomatoes. In another study by Zewdie et al., (15) neem leaves and Bees wax were applied to store tomatoes and found that the two treatments in some instances had potential for extension of shelf life in tomatoes for the benefits of consumers, retailers, producers, and sellers

In this study mineral elements were not determined for reasons best known to the researchers.

Therefore, it was pointed that there is scarcity of data revealing the effects of natural/ organic preservation materials (like mango leaves) in the preservation of macro elements concentrations in tomatoes during the post-harvest storage; therewith, the need to fill this gap considering the essentiality of macro elements to the humans and the other factors affecting Sokoto region.

Microelements are types of elements that are required in much amount (more than their counterparts) due to their importance to the biological system. Sodium, potassium, calcium, magnesium, and phosphorus are examples of typical macro elements needed by the human body (21). Sodium and potassium act as electrolytes that the body enjoys to modulate acid-base balance for optimal transmission in muscles, and nerves; calcium acts in insulin divulgement; magnesium is in many enzymes acting as cofactor especially in carbohydrate metabolism; and phosphorus is needed in DNA, RNA and ATP by the body (22). The objective of this study is to determine the effect of mango leaves in preserving the varied concentrations of metals (sodium, potassium, calcium, magnesium, and phosphorus) present in two tomato varieties in Sokoto, Nigeria.

2. Materials and methods

The study was carried out in Sokoto state, Nigeria. In this vein, tomatoes varieties and mango (*Mangifera indica*) were obtained from Sokoto Metropolis, Sokoto state, Nigeria. After identification of tomato, mango leaves extracts were shuttled to the plant physiology

laboratory and cleaned, air-dried and grounded into fine powder and kept for further analysis.

Powdered leaves of mango were dissolved in distilled water to form 5%, 10% and 25% (w/v) aqueous solutions of mango leaves extract to be used in coating the tomatoes. 5 g, 10 g and 25 g powder were dissolved in 9.5, 9.0 and 7.5 L of distilled water respectively (23). The percentages of extract were set to give distinctive concentrations of secondary metabolites inherent in the mango leaves to inhibit the growth of microbes that incite spoilage.

Ripe, firm, smooth and healthy tomato fruits of the two varieties (UTC and *Daneka*) were selected and washed under running tap water, distilled water, rinsed and air-dried before treatment. The experimental treatment was done according to the methods described by (18). Detailed steps of the experiment were shown in Fig. 1.

Sodium, potassium, calcium, magnesium, and phosphorus mineral elements were analyzed on the basis of standard methods deciphered in (24). And data analysis was done using analysis of variance (ANOVA) at 5% level of significance. For Table 1, the f-ratio value is 253.56526. The p–value is < 0.0001, therefore the result is significant at $p < 0.05$. Then for Table 2, the f-ratio value is 43.82848. The p–value is < 0.0001,

therefore the result is significant at $p < 0.05$.

Data analysis was done using descriptive statistics and analysis of variance (ANOVA) at 5% level of significance.

3. Results

The results showing the effects of addition of mango leaves on the concentrations of selected macro elements during the postharvest preservation of tomatoes in Sokoto, Nigeria were shown in Tables 1 and 2.

Table 1 shows the varied concentrations of elements (sodium, potassium, calcium, magnesium, and phosphorus) after the application of different mango leaves extracts in the postharvest preservation of Daneka tomato fruits. The most elevated concentrations noticed due to addition of extract leaves were revealed in potassium (1.20±0.002 to 3.00±0.001 ppm), and calcium (1.27±0.003 to 2.15±0.002 ppm). The lower levels of metals noticed upon storage under mango leaves are revealed by phosphorus (1.10±0.002 to 1.37±0.002 ppm), and sodium (0.90±0.001 to 1.30±0.001 ppm); and the last was revealed by magnesium (0.61±0.001 to 0.86±0.001 ppm).

In Table 2, the different concentrations of elements upon addition of mango leaves in the postharvest preservation of UTC tomatoes in Sokoto, Nigeria. Comparatively, the elevated concentrations were shown by phosphorus (2.5±0.001 to 3.8±0.004 ppm), potassium (2.00±0.001 to 2.99±0.001 ppm), and magnesium (1.01±0.001 to 2.59±0.001 ppm). The revealed lower concentrations were seen in calcium (1.34±0.001 to 1.70±0.001 ppm), and sodium (0.55±0.005 to 1.80±0.002 ppm).

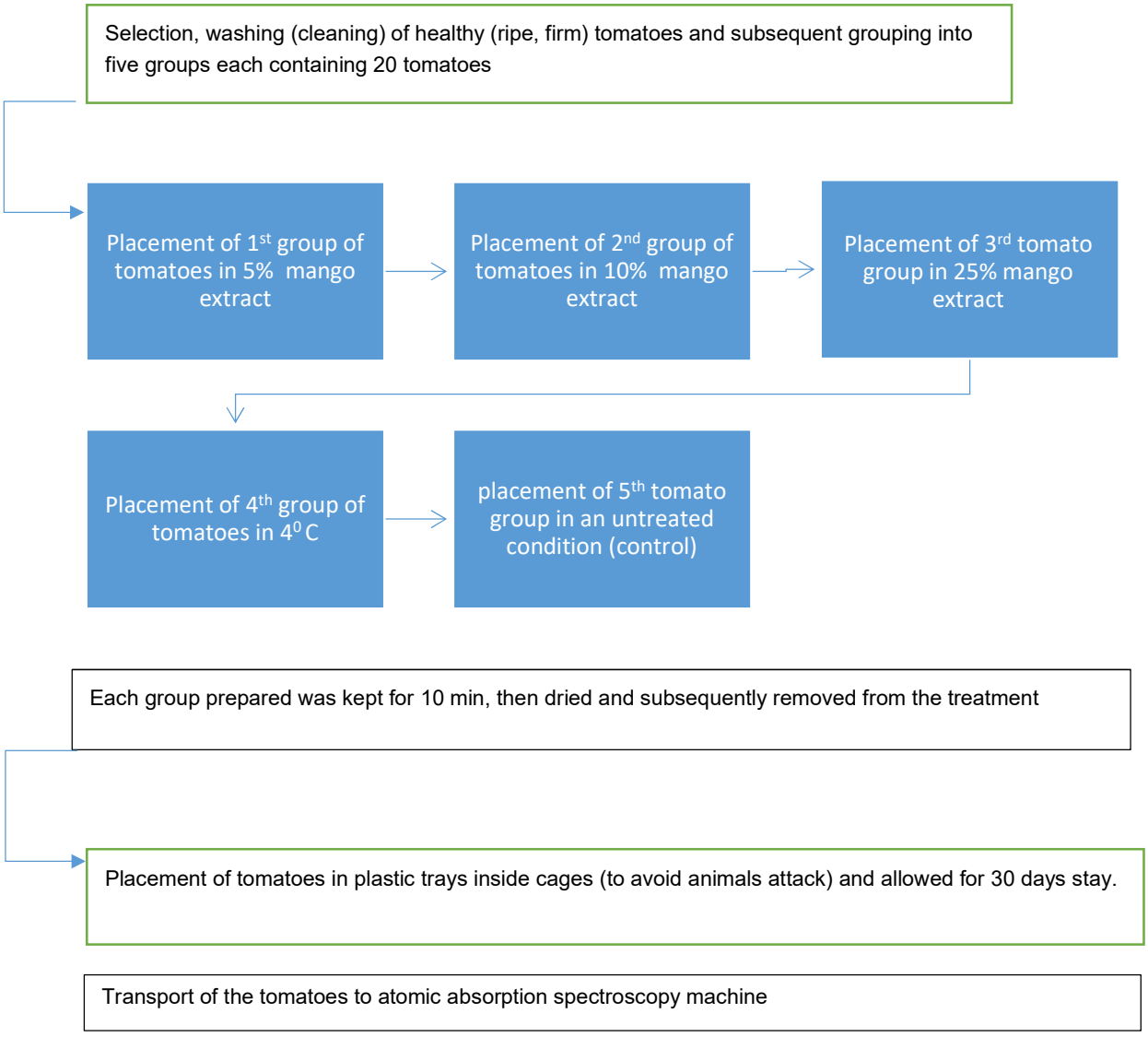

Figure 1. A flow chart of experiments for the treatment of tomatoes with mango leaves extracts (25)

Table 1. Potential of mango leaves in preserving mineral elements present in Daneka tomato type from Sokoto

Storage condition	Sodium (ppm)	Potasium (ppm)	Calsium (ppm)	Magnesium (ppm)	Phosphorus (ppm)
Control (0%)	0.10±0.001	0.90±0.002	1.00±0.002	0.60±0.001	1.00±0.002
5%	0.90±0.001	1.20±0.002	1.27±0.003	0.61±0.001	1.10±0.002
10%	0.95±0.001	2.00±0.002	2.00±0.002	0.64±0.001	1.22±0.001
25%	1.30±0.001	3.00±0.001	2.15±0.002	0.86±0.001	1.37±0.002
$4^{O}C$	0.80±0.001	2.15±0.002	2.38±0.001	0.46±0.001	1.30±0.005

Key: Values are expressed as mean standard deviation. The f-ratio value is 253.56526. The p–value is < .0001, therefore the result is significant at $p<0.05$

Table 2. Potential of mango leaves in preserving mineral elements present in UTC tomato type from Sokoto

Storage condition	Sodium (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)	Phosphorus (ppm)
Control (0%)	0.05±0.001	1.20±0.001	1.34±0.001	1.00±0.001	2.0±0.001
5%	0.55±0.005	2.00±0.001	1.56±0.001	1.01±0.001	2.5±0.001
10%	1.39±0.001	2.90±0.003	1.60±0.001	2.07±0.001	3.6±0.003
25%	1.80±0.002	2.99±0.001	1.70±0.001	2.59±0.001	3.8±0.004
$4^{O}C$	0.65±0.005	1.90±0.002	1.90±0.005	1.50±0.001	2.7±0.002

Key: Values are expressed as mean standard deviation. The f-ratio value is 43.82848. The p–value is <. 0001, therefore the result is significant at $p<0.05$

4. Discussion

As denoted in Table 1 and 2 the different concentrations of elements (sodium, potassium, calcium, magnesium, and phosphorus) due to the application of different mango leaves extracts in the postharvest preservation of *Daneka* tomato fruits, are higher than the concentrations magnesium, calcium, and sodium observed in a Katsina study done on fresh three varieties of tomatoes (involving the UTC, Daneka and other one variant) (26). This has shown how comparatively the preservative extract (mango leaves) have potential in preserving the mineral elements in the fruit tomatoes. In this vein (as shown in Tables 1 and 2) the amounts of metals in the mango leaves treated tomatoes (UTC and Daneka) are more preserved (concentrated) than in the control (untreated tomatoes) because the extracts have the phytochemicals that will act to inhibit the growth of microbes that cause deterioration. Inhibiting deterioration is a preservation of integrity/ quality of tomatoes including the levels of metals (1, 26). There exists another study that was conducted on elemental compositions of tomatoes from Austria, showing very higher calcium, sodium, magnesium, phosphorus, and potassium than the values revealed in Table 1 and 2 of this study (1). The differences between the values of Austrian study and this work are due to the differences in varieties examined and the long-term of storage of tomato in this study, because quality parameters in tomatoes usually reduce over the days of storage (1, 26). It can be noted vividly that, the concentrations of Sodium, potassium, calcium, magnesium, and phosphorus revealed in tomatoes in this study are not sufficient enough to serve as the sole provider of recommended dietary intake per day; but, they can significantly contribute in the proper functioning, health growth, and development of the human biological system (10, 14, 19, 27-29).

Similarly, as denoted in Tables 1 and 2, it is evident that, the treatment of tomatoes during storage has the potential to preserve the concentrations of Na, K, Ca, Mg, and P depending on the increasing concentration of the mango leaves extract applied for the storage. It was also noticed that, the low temperature of 4 ˚C is effective in preserving the concentrations of elements in tomatoes under storage. The low temperature might have actually achieved that due to its ability to slow the growth of microbes that cause spoilage in tomatoes; and the mango leave extracts were able to preserved the concentrations of metals because of the phytochemicals present in the plant that have the ability to inhibit the growth of spoilage causing microbes (18, 29). Spoilage microbes when present unabated are parasites that consume nutrients in the tomatoes, and cause deterioration that is capable in reducing all other qualities of tomatoes including the elemental contents (17, 18, 29). The current trend in the region of sokoto, the semiarid area, that is known with extent of poverty, double burden of diseases, malnutrition, low basic social amenities in rural areas, and food insecurity among others called for better improvement in food preservation to ameliorate the present undesirable trend (14, 31). Tomato, a popular vegetable fruit that is produced and consumed in the area is essential to provide important nutrients including the macroelements, (sodium, potassium, calcium, magnesium, and phosphorus) (32). This is in tandem with what was divulged by the concentrations of

elements in the findings of this study. Additionally, the study proved the ability of mango leaves in ensuring the preservation of mineral elements contents in tomatoes, and quality parameters by extension. The effective behavior of mango leaves to preserve tomatoes indicates the ability of organic materials in preserving mineral contents like indicated by other studies as well (32, 33). Also, it portrays a way to save the public from the detrimental effects linked with the addition of synthetic food additives/ preservatives (34-37). In the same vein, providing cheap, sustainable, greener ways that are desirable to preserve the environment, reduce poverty, increase shelf life of crops, among other benefits (30, 34, 35).

Albeit, the levels of macro elements depicted by this study are not up to the recommended dietary intake for humans; but the fruits have considerable amount of elements that on daily basis can significantly add to the daily requirement of the body and help in the proper functioning of the body. They can also be helpful in reducing the prevalence of macro elements related deficiencies in the state (38). Likewise, the presence ability demonstrated to preserve some extent of macro elements in tomatoes after storage is an indication that the microbes responsible for spoilage might be drastically reduced and in turn conferring the fruits with reduced spoilage causing microbes that can cause public health risks when taken along with the tomatoes (17).

5. Conclusion

Tomatoes are cheap, available source of a diverse array of compounds such as macro elements, Na, K, Ca, Mg, and P needed by human body especially in areas like Sokoto state, where there are challenges like food insecurity, malnutrition, hunger, and low basic social amenities in rural areas. However, the tomato is affected by its tendency to rot in a short period of time that is why there is need to devise a way of increasing shelf life effectively. This study shows the application of a natural material (mango leaves) for preservation of tomatoes in Sokoto has yielded fruits by preserving the amount of sodium, potassium, calcium, magnesium, and phosphorus elements found in tomato to a certain extent. Therefore, the potential of mango leaves should be harnessed and further studies are needed to ascertain and divulge more values of using mango leaves to preserve tomatoes.

Conflicts of Interest

The authors declare no conflict of interest.

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References

1. Malick PK. Medicinal values of tomato (*Lycopersicon esculentum* Mill. –Solanaceae). Int J Appl Sci 2021; 9: 166-168. http://doi.10.312/ijasbt.v9i3.39789.

2. Emmanuel AO, Olugboyega AO, John, AO, et al. The effects of shelf life on vitamins, lycopene, and sugar composition of some common Nigerian tomato varieties. Europ J Biotechnol Biosci 2018; 6: 56-60.

3. Qu F, Zhang J, Ma X, et al. Effects of different N, P, K, and Ca levels on tomato yield, quality and fertilizer use efficiency. Plant Soil Environ 2020; 6: 569-75.

4. Klee HJ, Giovannoni JJ. Genetics and control of tomato fruit ripening and quality attributes. Ann Rev Genet 2011; 45: 41–59.

5. Kumar S, Gowda PHR, Mallikarjuna NM, et al. Evaluation of selected F6 tomato lines for extended shelf life. SABRAO J Breed Genet 2015; 47: 326-34.

6. Bukar A, Magashi, AM. Efficacy of some plant aqueous extracts and waxes in the preservation of some fruits and vegetables. Br J Appl Sci Technol 2013; 3: 1368-79. https://doi.org/10.9734/bjast/2014/2213

7. Oves M, Iqbal, IMI. Phosphate availability and importance in a living system. Acta Sci Microbiol 2019; 2: 40-41.

8. Serna J, Bergwitz, C. Importance of dietary phosphorus for bone metabolism and healthy aging. Nutr 2020; 12: 1-44.

9. Veselina VH, Dinev NS. Mineral content and quality parameters of tomato fruits as affected by different potassium fertilization treatments and cultivar specifics. Indian J Agric Res 2021; 55: 169-74.

10. Abdullahi II, Abdullahi N, Abdu AM, et al. Proximate, mineral and vitamin analysis of fresh and canned tomato. Biosci Biotechnol Res 2016; 13: 1163-69.

11. Garcia MA, Ventosa, M, Diaz R, et al. Effects of Aloe vera coating on postharvest quality of tomato. Fruits 2014; 69: 117-26.

12. Sager M. Main and trace element contents of tomatoes. J Food Sci Eng 2017; 7: 239-48.

13.Umar AI, Umar RA, Wasagu RSU, et al. Assessment of State Iodine levels of secondary schools girls in Sokoto Nigeria. Int J Food Nutri Sci 2017; 2: 020-027.

14. Kabore K, Konate K, Sanou B, et al. Tomato by-products, a source of nutrients for the prevention and reduction of malnutrition. Nutr 2022; 14: 1-16. http://doi.org/10.3390/nu1414287.

15. Zewdie B, Shonte TT, Woldestsadik K. Shelf life and quality of tomato (*Lycopersicon esculentum* Mill.) fruits as affected by neem leaf extract dipping and beeswax coating. Int J Food Prop 2022; 25: 570-92.

16. Sehata SA, Megahed, MMA, Abdeldaym, EA, et al. Extending shelf life and maintaining quality of tomato fruit by calcium chloride, hydrogen peroxide, chitosan, and ozonated water. Hort 2021; 7: httpp://doi.org/10.3390/horticulturae70903390.

17. Aliyu LS, Usman AY, Musa A, et al. Evaluation of nutritional compositions of healthy and infected dried tomato chips sold in Sokoto metropolis, Sokoto state, Nigeria. Int J Innov Food Nutr Sustain Agric 2018; 6: 1-4.

18. Hosea ZY, Liamngee K, Owoicho, AL, et al. Effect of neem leaf powder on post-harvest shelf life and quality of tomato fruits in storage. Int J Dev Sustain 2017; 6: 1334-49.

19. Aliyu LS, Usman AY, Musa A, et al. Fungi associated with dried tomato chips marketed in Sokoto metropolis. J Adv Bot Zool 2018; 6: 1-3.

20. Garuba TJ, Mustapha I, Oyeyiola GP. Shelf life and proximate composition of tomato (*Solanum lycopersicum L.*) Fruits as influenced by storage methods. Ceylon J Sci 2018; 47: 387-93.

21. Siddiqui K, Bawazeer N, Joy SS. Variation in macro and trace elements in progression of type 2 diabetes. Sci World J 2014; 461591. http://dx.doi.org/10.1155/2014/461591.
22. Musa A, Birnin-Yauri UA, Muhammad C, et al. Proximate composition and mineral analysis of Nymphaea lotus seeds. Afri J Food Sci Technol 2012; 3: 1-4.
23. Sarkingobir Y, Dikko M, Tukur M, et al. Determination of some macro elements (Sodium, Pottasium, Calcium, Magnesium and Phosphorus) in some selected eggs (chicken, duck, quail, pigeon, guinea fowl and turkey in Sokoto Metropolis. J Sci Technol Res 2020; 2: 162-66.
24. Sanusi J, Habsatu S, Abubakar N, et al. Comparative study of proximate and minerals composition of tomato cultivars in Sokoto, Sokoto state, Nigeria. FUDMA J Sci 2020; 4: 409-14.
25. Hamza A, Gumi AM, Aliero AA, et al. Potential of neem leaves on preservation of selected elemental compositions in two tomato cultivars from Sokoto, Nigeria. J Biore Environ Sci 2023; 2: 14-20.
26. Adebayo Q, Shittu, LT, Sogunle KA, et al. Nutritional qualities of three common tomato cultivars (UTC, dan-Eka and Dan-Masari) in Dutsinma local government area Katsina state. Eur J Agri Food Sci 2020; 2: 1-6.
27. Hassan LG, Sokoto AM, Ngaski MA, et al. Nutritional and ant-nutritional analyses of *Hura Crepitans* seeds cultivated in Sokoto North L.G.A. North Western Nigeria. Bayero J Pure Appli Sci 2018; 11: 126-130. Htttp://dx.doi.org/10.4314/bajopas.v11i1.22.
28. Gada ZY, Samaila, A. Assessment of some selected edible wild fruits (EWFs) as potential remedy to malnutrition in the rural areas of Sokoto state, Nigeria. J Agr Envi 2021; 17: 123-31.
29. Nefasa AN, Nisa, EZ, Christwardana M. Effect of storage on the chemical quality of pasteurized milk with supplemented soybean oil and phycocyanin. J Biores Environ Sci 2022; 1: 52-56.
30. Salau IA, Shehu K, Kasarawa AB, et al. A fungi associated with postharvest rot of commonly consumed fruits in Sokoto metropolis, Nigeria. J Advan Bot Zool 2015; 3: 1-4.
31. Maurya, VN, Aremu, B, Odugbemi K. Contribution to impact of COVID-19 and sustainable approach in Africa. Int J Res Analys Sci Eng 2022; 2: 30-50.
32. Cvijanovic Saric B, Dramicanin A, Kodranov I, et al. Macroelements, microelements and rare-earth elements in different tomato varieties as promising tool for monitoring the distinction between integral and organic systems of production in Zeleni hit-Official Enza and Vitalis trial and breeding station. Agric 2021; 11: 1-16. http://doi.org/10.3390/agriculture/11101009.
33. Ciudad-Mulero M, Pinela J, Carvalho, AM, et al. Bioacessibility of macrominerals and trace elements from tomato (*Solanum lycopersicum* L.) farmers' varieties. Foods 2022; 11. https://doi.org/10.3390/foods111131968.
34. Shrestha S, Pandey B, Mishra BP. Effects of different plant leaf extracts on postharvest life and quality of mango (*Mangifera indica* L.). Int J Env Agri Biotech 2018; 3: 422-32.

35. Akbarieh N, Sadighara P, Shariatifar N, et al. Lipid peroxidation in sheep and cow traditional butter obtained from southern Tehran, Iran. J Food Safe Hyg 2022; 8: 237-42.
36. Islam S, Jhily NJ, Parvin N, et al. Dreadful practices of adulteration in food items and their worrisome consequences for public health. J Food Safe Hyg 2022; 8: 223-36.
37. Paul PK, Sinha RR, Baby P, et al. Usability engineering, human computer interaction and allied sciences: with references to its uses and potentialities in agricultural sectors-a scientific report. Sci Rev 2020; 6: 71-78.
38. Dobrowolska-Iwanek J, Zagrodzki J, Szlosarczyk M, et al. Determination of essential minerals and trace elements in edible sprouts from different botanical families-Application of chemometric analysis. Foods 2021; 11: 1-13.
39. Shehu K, Asmau MM, Salau, IA. A preliminary study on microbial contamination of leafy vegetables in Sokoto metropolis, Nigeria. Aceh Int J Sci Tech 2014; 3: 140-44.