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TOMATO: AN OVERVIEW OF APPLICATION OF TURMERIC (Curcuma longa L.), NEEM (Azadiratcha indica) ON SHELF-LIFE EXTENSION DURING POST-HARVEST STORING OF TOMATO (Solanum lycopersicum L.)

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Abstract

Tomato (Solanum lycopersicum) has to be preserved to prevent losses and ameliorate food security. Turmeric (Curcuma longa L.) and neem (Azadirachta indica) extracts are useful to extend shelf life of tomato. This paper performed a review of tomato and use of neem and turmeric for its storage/ preservation. This paper mostly, will discuss the tomatoes under the following headings: history, biological nature, taxonomy, postharvest importance, utilization of neem and turmeric for its storage, economic benefits, and disadvantages of using artificial preservatives.

Keywords: Tomatoes, Shelf-Life, Firmness, Neem, Turmeric, Preservative's, Storage

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INTRODUCTION

Important challenges for the cultivation of tomatoes include postharvest losses and reduced quality of many tomatoes grown for fresh consumption. Many tomatoes are plucked when still firm and green stored at low temperature and exposed to ethylene to incite color and ripening before reaching market. This procedure affects properties of tomato such as flavour, aroma and texture. Moreover, the use of mutants in inducing ripening also reduces vast properties of tomato (Zhang *et al.*, 2013). It is widely believed that processing the vegetables or fruits reduced some of their properties. The tomatoes markets are faced with limited marketability due to its high moisture content and high degree of perishability which leads to extensive postharvest losses too. It is estimated that 40-60% of the harvested tomatoes go waste annually (Ali *et al.*, 2022; Mugao, 2023).

Tomatoes need cold storage but there is no enough uninterrupted power supply in most of our rural areas. This forced many to fast marketing as the only solution. However, at the peak of harvesting season of tomatoes, the supply exceeds demands leading to drop in price. Failure to have storage will spur wastage and losses. Similarly, when season of harvesting passed, the demand increases for fresh tomatoes and ultimately an increased in price (Naika *et al.*, 2005; Onyeagbula *et al.*, 2023). One should not forget that most of the nutritional contents of tomatoes, especially water-soluble vitamins are higher when they are taken in fresh (Naika *et al.*, 2005; Islam *et al.*, 2018). Our rural dwellers lack knowledge of technological innovations of storing and preserving tomatoes, as well as infrastructures and equipment for preservation after harvest (Raheja and Thakore, 2002; Sanusi *et al.*, 2020).

Shelf life after harvesting is one of the most important things to be considered for tomatoes. It is the period during which a stored tomato product remains suitable for consumption and is normally determined by the degree of softening, shriveling and rotting of fruit (Thole *et al.*, 2020; Swamy, 2023). Therefore, the storage, preservation and processing of tomatoes after harvest to enhance shelf life are very vital and indispensable. The experimentation with plants extract to preserve or enhance shelf life of tomatoes will help to solve the issues of lack of infrastructures and power supply in our communities. It equally helps to solve the issue of lack of technical know-how to utilize modern preservation implements. The research unveiling the use of plant materials as preservatives to increase the shelf life will avoid uncertainty in using chemical preservatives which could

pose biological effects to the plants, animals and the environments (Singh *et al.*, 1999; Umar *et al.*, 2020).

Invariably the use of plants as bio-preservatives would land a multipurpose, cheap and easy to use and preserve the potential health use of the tomatoes. Understanding the postharvest treatment is good in producing foods that are free from synthetic chemicals and confer benefits reduce plant pathogens, control insect infestation and maintain tomato quality (Haile, 2018; Ogah *et al.*, 2023). This would be less toxic to animals or humans and on one hand extending the shelf life of tomatoes. Moreover, the storage and preservation of tomato is vital to the economy of homes, farmers and country considering the role of tomatoes in health and food security. The ability of farmers to use plants as preservatives would help to reduce cost of preservation on farmers, reduce cost of buying by the consumers and impliedly increases supply during non-harvest season (Thole *et al.*, 2020; Gemida *et al.*, 2023; Meiramkulova *et al.*, 2023).

Lastly this study would provide available data on storage shelf-life of tomatoes using organic extract from plant source, which could be of significant importance to farmers, marketers, consumers, researchers, government and policy makers for the development of good strategies for food security in the country (Ejale and Abdullah, 2004; Chirruco *et al.*, 2023).

THE BASIC INFORMATION ON TOMATOES

Generally, tomato plants have many branches that spread with about 60–180 cm (24–72 inches), to some extent there exists a trailing during fruit formation; therewith, in few situations there exists some of them that are upright and with compact structure. The leaves in tomato plants are by and large without hair, compounded, pinnately formed, odorous and are about 45 cm/18 inches in length. Their five-petaled flowers exist as yellow, 2 cm/0.8 inch across, and exist in cluster and pendant shapes. Tomatoes fruits exist as berries with a variance in diameter like 1.5 to 7.5 cm/0.6 to 3 inches or above that. In usual situation, fruits in tomatoes exist as red, yellow and scarlet; there are also some forms that are in purple or green colors. Likewise, tomato fruits vary in their shapes, some look as oval, some are sphere in shape, some are elongated and some are pear-shaped. Every fruit possesses a minimum of 2-celled seeds that are covered with a pulp that is similar to a jelly (Thole *et al.*, 2020; Nanelo and Jose, 2023).

Tomato plant needs a nearly warmed weather, enough sunlight. On many occasions, tomato is cultivated in hothouses in cooler climates or in Africa (mostly the sub-Saharan Africa). Usually, tomatoes have to be staked, tied, or caged in order to save the fruits from the ground level (Alda *et al.*, 2009; Santhosh *et al.*, 2023). Therewith, there is the need for an unperturbed irrigation to save the plant from the crack of fruits and blossom-end rot. Some diseases and pests can attack tomato plant (such as the mosaic virus, hornworms, bacteria diseases, early blight, nematodes, and *Fusarium* wilt); but some of these problems can be curtail through methods like application of chemical pesticides, fungicides, and crop rotation strategies (Abrar *et al.*, 2016; Kabore *et al.*, 2022). Another method to protect the plant is via the breeding of tomatoes with the tiny currant tomato called *S. pimpinellifolium*; a method that has confer pest and is a pest resistance, as well as disease-resistance to tomatoes (The Editors of Encyclopedia, 2022; Ahmed *et al.*, 2023; Tenes and Kitonga, 2023).

History of Tomato

Andes Mountains in the South America are regarded as the origins of the wild tomato species, haply and mostly from Ecuador and Peru. However, the plant has been converted to domestic terms by pre-Columbian Mexico; therewith, the name of tomatoes was drawn from the "Náhuatl (Aztec) word tomatl" (Thole *et al.*, 2020). It was regarded that Spanish are the ones that brought tomatoes to the European continent in the initial phase of the sixteen century that is why people from Spain and Italy were the pioneer people to have used the plant in the continent. The French and other people from the north part of the European continent initially grow tomatoes as an ornament, and were treated with caveat because botanist then regarded it like the poisonous plants (the belladonna or the deadly nightshade) (The Editors of Encyclopedia, 2022; Swamy, 2023).

In Italy tomatoes are dubbed with a named as pomodoro that is the golden apple, may be the pioneer tomatoes fruit that have reached the Europe was in yellow color (Passam *et al.*, 2023; The Editors of Encyclopedia, 2022). There exists suggestion that in French it is dubbed as love apple because it was regarded as a plant with ability to increase sexual capability. There are some pundits that think tomatoes was initially regarded as a plant that resemble an eggplant; a plant that is called as "pomme des Mours" or apple of the Moors" due to it been a likened vegetable in the Arabian Peninsula. There some thinkers that argue

that tomato was a corruption form of a word pomodoro or pomme d'amour (The Editors of Encyclopedia, 2022; Chirruco *et al*., 2023).

In the North America tomato was introduced by the European people, for example record has shown that Mr. Thomas Jefferson cultivated tomatoes in the year 1781 in a place called Monticello. Louisans have seen the tomatoes in their food in the 1812, but it was on the year 1835 that the northeastern regions seen the fruit as their food. The 20th century was the time when the plant got wide acceptance across the nook and crannies of the United States of America. However, in the present days, the plant has got a popularity throughout the world (Mes *et al*., 2008; The Editors of Encyclopedia, 2022; Sheetal *et al*., 2023).

Some Description of Tomato

In some cases, tomatoes are grown annually, but in most cases, the plants are cultivated as perennial herbaceous crop. There are other forms like the biennial and perennial crops of tomatoes (OECD, 2017). The plants are planted in the temperate and temperate climatic conditions through open field, and sometimes in greenhouse in temperate conditions in a large-scale type of production. When there is warm climate, enough light, the plant can only take forty-five days to germinate to make an thesis; and 90-100 days are required to attain ripening. Usually, farmers used different cultivars in accordance with their different aim of using the fruit like in processing, fresh selling, and other factors considered (Ogofure and Ologbosere, 2023).

The plant grows in different growth patterns like determinate or indeterminate and can be about 3 metres in height. The plant primary root can reach a length of several metres. The stem looks in angular pattern and is surrounded in hairy and glandular trichomes responsible for the known smell of the plant (OECD, 2017; Tenes and Kitonga, 2023).

The pattern of leaves is in an alternate arrangement on the stem with a 137.5° phyllotaxy; therewith, leaves look in form of lobes or compounded, with an arrangement of segments in pinnate fashion. The plants compound leaves usually possessed 5-9 leaflets that are dentate as well as petiolated. However, all the leaves in the plant are sealed with trichomes that have hairs and glands (OECD, 2017; Tesfaye, 2023). The tomatoes exist as globular or sometimes ovoid fruit that botanist regarded as a plant that acquire all features shared by berries; that is, having a simple fleshy fruit storing it's seed in the pulp. The surrounding skin of the tomato fruit has a thin fleshy tissue taking remains of the fruit wall and the

placenta of the fruit. The fleshy part of the fruit gives the fruit its colour as result of the activities of the cells embedded in the flesh tissue (Pamell 200OECD, 2017).

Binocular and multilocular are the features of tomato; therewith, about fifty to two hundred seeds (enclosed with a gelatin formed membrane) are housed in the locular cavities of the fruit. An ideal seed is lentil in shape and small of about (5 x 4 x 2 mm). Inside the seed there exists an embryo, endosperm protected with a hard coat, known as the testa. Upon fertilization, a fruit is made within the period of 7 or 9 weeks (OECD, 2017).

Taxonomy of Tomato

The famous tomato fruit belongs to a genus called *Solanum*, which is in turn a parcel of the family dubbed as *Solanaceae*; the *Solanaceae* is popularly termed as a family of nightshade. In the family of *Solanaceae* other members apart from tomatoes are the potato, chilly, eggplant, and tobacco (OECD, 2017). Much has been discussed about the classification of tomatoes because of its diversity in its genus; coupled with much reassessment of the past works. Initially, tomato was called *Solanum lycopersicum* according to the famous Linnaeus in 1753; and *Lycopersicon lycopersicum* (L.) Karsten was utilized as well. Another changed was noticed when Miller in the year 1768 in The Gardener's Dictionary called tomato as *Lycopersicon esculentum*. There are 9 species of the *Lycopersicon* genus (Swamy, 2023).

Over a long period of time, tomato was named as *L. esculentum*, until when new study disgorged that, tomato is a part of the *Solanum* leading to a change of name to *Solanum lycopersicum* (OECD, 2017). There are about 1500 species belonging to the genus *Solanum*. There is the tomato clade (*Lycopersicon*, earlier dubbed as the genus *Lycopersicon*) comprising the cultivated tomato (*Solanum lycopersicum*) and other twelve tomatoes from the wild that are origins of western South America. The Tomato botanically called as *Solanum lycopersicum* has an origin from 2 ancient species that are the *Solanum pimpinellifolium and Solanum cerasiforme*. There is need to use other wild species of tomatoes to confer resistance to diseases, improve color and confer other suitable features as well. In the 12 wild members belonging to the *Lycopersicum* clade there have been a large scale variation in terms of genetic and phenotypic traits; there exists also variation in mating methods and other reproduction terms (OECD, 2017; Swamy, 2023).

In the year 2008, 12 recognized species of wild tomato were discovered in addition to the earlier nine species determined. Among the 12 newly recognized species, there exists an

informal species groups as follows: four closely-related species that have green fruits. They are the *S. arcanum*, *S. huaylasense*, *S. peruvianum* and *S. corneliomulleri*; allotted to the group of the *S. peruvianum sensu lato* (sensu lato, is a large concept of species). The other groups that have fruits with orange yellow species possess the 2 species of *S. galapagense* and *S. cheesmaniae* that are endemic in the Galapagos Islands (OECD, 2017).

Economic Importance of Tomato

Tomato is one of the most popularly grown vegetables worldwide serving as source of minerals and vitamins. Tomato contains huge amount of phytochemicals, carotenoids, polyphenols and Vitamins. It remains second most important vegetable crop cultivated worldwide (Ilesanmi *et al.*, 2023). In Nigeria, about one million hectares of total land area is used for its cultivation and this crop makes up about 18% of the average daily consumption of vegetables in Nigerian homes (Swamy, 2023). Nigeria ranks second to Egypt in Africa and 13th globally in tomato production (Nishizono et al., 2023). Tomato is an important condiment in daily diets, consumed both fresh and in paste form and a very cheap source of vitamins A, C, E and minerals which protect the body against diseases. It contains lycopene, a flavonoid antioxidant together with carotenoids which protect the body cells and other structures in the human body (Bhowmik *et al.*, 2012; Thou, 2017; Labbo *et al.*, 2021).

STORAGE SHELF LIFE OF TOMATO

Shelf lives of tomato fruits were evaluated by counting the number of days tomato fruits were still acceptable for marketing. It was decided based on appearance and spoilage of fruits. Consumers buy fruits according to quality fruits and ripening values. However, alterations in physiological properties in the course of storage, ripening must determine the fitness of tomato for fresh consumption and marketing. Therewith, scientific literatures across the world have reported certain studies on tomato physiology during storage and the use of methods to preserve their quality, but they are not adequate or conclusive, especially northwestern part of Nigeria. Here, some related literatures will be broached. Silva *et al.* (2023) reported that visual color was not affected by over ripening but the texture softened, chlorophyll content reduces and P-carotene, lycopene contents reduce.

There exists strong correlation between the coefficient of elasticity and visual color in the course of ripening. An Indian study by Bhowmik *et al.* (2012) reported that tomato fruits exert lowest physiological of 7.7-7.9% after 6days storage under ambient conditions.

Bhowmik *et al.*, (2012) reported that highest weight loss was recorded in those tomatoes stored under perforated polythene bag because the rate of transpiration was lower in a sealed polythene bags. Therewith, the weight loss of tomatoes relied upon the transpiration and respiration of the fruit during the storage, which are lower when sealed. Zhang *et al.* (2013) reported that tomatoes harvested at mature green, breaker, half ripe and red ripe, stages of maturity stored under ambient conditions to examine shelf-life.

Zewdie *et al.* (2022) reported that tomato shelf-life was longer in fruits picked at mature green stage with poor quality after storage. They added that tomatoes harvested at breaker stage were better and had a fair shelf life (8 to 10days), no 0.5 day. It was observed that weight loss was more at an early stage of maturity and increase with increase in temperature. Also, green mature and breaker stages tomato stored at 4℃ and 8℃, the total weight loss in 35days is 3-8% accordingly. Osaili *et al.,* (2023) observed that tomato fruits of the lines TMO-830 and TMO 854 a shelf-life of 14-17 days when stored at ordinary storage condition. Zewdie *et al.* (2022) conducted a study on time of evaluation of tomato quality parameters versus storage condition. It results showed that cool containers are better alternatives for shuttling tomatoes to distant countries.

In another experiment that immersed matured green tomatoes in water at 38℃, 42℃, 46℃, 50℃ or 54℃ for 30, 60 0r 90minutes before storage at 2℃ for 2, 4, or 6weeks. Control was immerged in water at 20℃. Hot water treated fruits are less injured, faster chlorophyll degradation and lycopene synthesis, lower acidity, lower CO2 and ethylene production, and less electrolyte leach compared to controls. Among the hot water treated tomatoes, the lowest injury and lowest CO_2 release were found in the fruits treated at 46℃ chlorophyll and ethylene production were lowest in fruits treated at 54℃, while electrolyte leach was lowest in fruits at 42℃. Increased immersion reduced injury and ethylene production (Zhang *et al.*, 2013). Kim *et al.* (1996) examined the effect of storage temperature (0-3 5℃) on the quality of tomato and strawberry fruits, stored for 21 and 8 days, respectively.

In tomatoes, the respiration rate of fruits increased at higher storage temperature, but decreased with storage period. Ethylene production was suppressed at 0, 5, 10, 30 or 35℃,

but was high for fruits stored at 20℃ because of mold infection; mold infection was noticed on fruits stored at 15 or 25℃. Fruits firmness was preserved after storage at 0, 5, 10, 30 or 35℃, but at 15, 20 or 25℃ softening happened. The a/b values of fruit skin color were lower for fruits stored at 0, 10, 30 or 35℃ than for fruits stored at 15, 20 or 25℃. (Bhowmik *et al.*, 2012).

A 1996 study at Ahmadu Bello University Zaria, Nigeria stored dried samples in polythene bags at room temperature (25-35℃) for up to 10months. Organoleptic observation shows that the pastes made from the rehydrated products were acceptable after 10months of storage, oxidative rancidity and microbial growth during storage were not sufficient to affect quality. Reconstitution study shows that tomatoes dehydrated in this fashion reach 75% of their moisture content after 40 minutes (Tesfaye, 2023).

In a study to determine bio-preservative potential of turmeric on tomato, observed that there was improvement in physiochemical characteristics (like pH, lycopene, dry matter, total phenolic content) of tomatoes. The turmeric also has antimicrobial effects in tomatoes (Sheetal *et al.*, 2023).

Garuba *et al.*(2018) conducted another study of shelf-life and proximate composition of tomato fruits as influenced by storage methods of plastic crate, raffia, basket, pot-in-pot refrigerator, plant extracts (wood ash of Shea butter, saw dust, rice straw); shows that life of all varieties was enhanced by pot-in-pot refrigerator, with higher moisture, higher carbohydrate in all the methods and varieties. Pot-in-pot refrigerator was the fit method to enhance shelf-life of tomatoes at preserve quality. Garuba *et al.*(2018)

In Taraba, Nigeria, effect of plant extracts on post-harvest shelf-life and quality of tomato in storage found that, tomatoes varieties (Seria and Tangino), neem, garlic, ginger extracts were effective in reducing the mycelia growth, extending shelf-life and preserving quality of tomato. The extracts reduce weight loss, post-harvest decay, increases shelf-life, and marketability, and firmness decrease with increase in storage (Tunwari *et al.,* 2019). Lastly, Ahmad *et al.* (2020) treated tomato varieties (UTC and Tandilo) with guava and cashew nut leaf extracts to enhance tomato shelf life. Their results indicated that guava displayed higher effectiveness in enhancing tomato shelf life than cashew nut.

From the forgoing, it has been shown that post-harvest shelf-life is an issue in tomato farming for quite long, which has been on constant study. There was move by researchers

to proper solutions to the rising effects of pollution of farm chemicals, through the use of plant extracts to enhance shelf-life. However, there is scarce data on use of plants extracts to treat tomatoes to extend shelf-life, therefore this study is imperative (Passam *et al.*, 2007).

SIGNIFICANCE OF POST-HARVEST HANDLING, AND CHARACTERISTICS OF TOMATO AFFECTING POST-HARVEST LIFE

Tomato (*Solanum lycopersicum*) is a popular vegetable crop consumed in many parts of the world. It has benefits of encompassing many nutrients such as vitamin A, C, K elements like Na, carotenoids, and likes (FAO, 2018). Proper post-harvest handling is pivotal in maintaining and safeguarding the safety of the fruit to relay to consumers on time, and meeting their demands. Good post-harvest handling safeguards quality and quantity between harvest and consumption to scuttle losses due to immaturity, over ripening, rough handling, improper packaging and storage. It is indeed proper to properly store fruits to realize gains and avoid waste of resources like energy, land, labour, water, fertilizer among others (Malick, 2021).

Some properties of tomato determine ability to stay for long after harvest or to deteriorate. These characteristics affecting shelf-life of tomato are as follows: Tomato follows programmed changes tomato is a living tissue which follows a continuous changing phase until it completely spoiled (Arthur *et al.*, 2023). The process of ageing and programmed dying in a living plant tissue is known as senescence, along the course changes affects appearance, flavor, texture, and nutrients of the fruit. Albeit, these changes can be slowed, they are natural and they cannot be halting (FAO, 2018).

Tomato loss water; naturally, tomatoes consisted of water embedded therein and when harvested the capacity to replace water loss has ceased, thereby affecting market value because of shriveling (Harbone, 1998; New Zealand Institute for Crops and Food Research Limited, 2005; Freeman and Reimers, 2010).

Tomato fruits are prone to injury there with, injury (shape, quality, size etc.) instigates some biological processes such as respiration, ethylene, making to run at very fast rate and in turn deterioration. Many practices of handling tomatoes such as basket packaging, or during transport usually injure the fruit, which will eventually show up later. Additionally, insects and decay causing microbes are very readily to affect tomato, and result in deterioration

(Trease and Evans, 1989; Sofowora, 1993; Mohammed *et al*., 2017; FAO, 2018; Thole et al., 2020).

Post-harvest handling techniques are activities carried out to the fresh tomato fruits in order to prepare them for market requirements. The activities are carried out in the field, in the storage house etc. provided the storage is of hygienic condition, and away from sun or rain. In cleaning, soil or muds which cling to the fruits are removed to get rid of decay microbes, disinfectants are added to the cleaning water for this operation. Tomatoes can also be clean through wiping with moist cloth (Ministry of Fisheries, Crops and Livestock, 2017; FAO, 2018; Collius *et al*., 2023).

Sorting is the act of grouping fruits based on specific determined criteria such as; shape, size, quality, defect etc. This is done to suit the demands of the buyers, because they dislike insect and disease-damaged fruits, mechanically damaged or deformed fruits (FAO, 2018). Packaging is another essential practice in product quality during transport and handling to contain the products (FAO, 2018; Rao and Lakshman, 2018). Furthermore, hygienic, careful and clean packaging is very important. Likewise, transport of tomatoes is required to make sure the produce arrive the ulterior market in good quality (FAO, 2018).

Hosea *et al.,* (2017) reported that among the variety's UTC and Shase displayed lower post-harvest decay of 0.00-10.00days than Hoozua (1.00-10.00days) and the lower post-harvest decay were found in the treated tomatoes. Marketability and firmness reported 10.00-0.00, 4.00-2.00days respectively in all the varieties. The findings pointed that powder of neem can be used to extend the shelf-life and quality of tomatoes.

NEEM AND TURMERIC HAVE POTENTIALS FOR STORING TOMATO

Neem and Possible Phytochemicals to Delay Tomato Deterioration

Neem (*A. indica*) is versatile plant serving as a source of numerous compounds with diverse chemicals and biological effects. It is used significantly, therapeutically and industrially. *A. indica* is known as anti-bacterial, anti-fungal, anti-viral, and with many anti-microbial activities (Ukaoma *et al.,* 2019). Moreover, phytochemical nature of neem has made it applicable to be used as insecticide, fungicide, miticide, nematocides, insect anti-feeders and insect repellents. It is also used in cosmetics, toothpaste, ointment, gargle, poultries, lubricants, human consumption, medication and the likes (Ukaoma *et al*., 2019). For used

as to increase shelf-life of tomato during storage, neem has certain good properties for that purpose p arable, its anti-microbial chemicals can be used to kill or inhibit de-decay causing microbes, it is biodegradable that is environmentally friendly cheap and non-toxic. It is a natural product with a long history of renewability and application as anti-microbial agent (Ukaoma *et al.,* 2019, Ujah *et al.,* 2021).

The plant kingdom is a rich stare house of organic compounds utilized for medicinal and anti-microbial reasons. Therewith, neem plant is believed to be the richest source of antibiotics (anti-microbial, neutral-chemicals, food supplements, folk medicine, and useful metabolites) and the likes. Some of the phytochemicals of neem are the leads for why plant has been efficient against microorganisms. Some of the phytochemicals are; alkaloids, flavonoids, saponins, steroids, phenols, oxalic acid and glycosides (Ukaoma *et al.,* 2019, Ujah *et al.,* 2021).

Turmeric and some of its Phytochemicals that Affect Tomato Deterioration

Curcuma Longa L. is a member belonging to the family called Zingiberaceae. The plant is popularly called with the name turmeric. The plant turmeric is a leafy one, erect, and lives a perennial life. Its leaf is large and looks like a lily that is about 1.2 meters in length (Utoo and Asemaye, 2022). It possesses a pointed leave, oblong, and has yellow flowers looking like a funnel (Yadav and Tarun, 2016). People use its rhizome for various medicinal purposes after boiling, cleaning, drying, to give a yellow powdered form (Yadav and Tarun, 2016; Iweala *et al*., 2023). After drying the *Curcuma longa* rhizomes the spice turmeric is yielded, an important yellowish curry used for various purposes in foods, flavor, and in traditional ways as in the Ayurveda and Chinese medicinal practices that yield many medicinal purposes (Yadav and Tarun, 2016; Arthur *et al*., 2023).

Turmeric is widely applied in food preservation, spicing, color inducement and coloring in many parts of the world (Malick, 2021). Turmeric is also used in many countries of the world as pigment in food, spice in food, medicine to cure many problems (Yadav and Tarun, 2016). It is indeed utilized in curing cough, hepatic disorder, wound, sinusitis, biliary problems, anorexia, and rheumatism (Yadav and Tarun, 2016; Obeta *et al*., 2023). Powder of turmeric mixed with slaked lime is a household remedy for the treatment of sprains and swelling caused by injury, applied locally over the affected area. Safety evaluation studies indicate that both turmeric and curcumin are well tolerated at a very high dose without any

toxic effects. Thus, both turmeric and curcumin have the potential for the development of modern medicine for the treatment of various diseases (Garane, *et al.*, 2023).

Geographical Distribution, History of Turmeric

Around the world, turmeric is found in India, Nigeria, Nepal, Malaysia, China, Indonesia, Cambodia, Viet Nam, Madagascar, Philippines, and Niger Republic (Obeta *et al.*, 2023).

Turmeric has been used as old as in the 4000 years in the history of mankind, in the Vedic culture in India as a culinary spice and in many religious functions (Obeta *et al.*, 2023). Haply, China has an initial contact with turmeric in the 700 A.D, while turmeric reaches East Africa in the 800 A.D. It has been in West Africa for the first time in 1200 A.D and has been in Jamaica during the 18th century (Ray *et al.*, 2023). Turmeric was described in the year 1280 by Marco Polo as a marvelous vegetable that has several traits like saffron. It has been recorded that, turmeric has a long antecedent of utilization in medicine purposes in South Asia as related by Sanskrit medical treatises, Ayurvedic, and Unani systems. As far back as 250 B.C, turmeric was recommended to be used as an ointment for the cure of food poisoning by the Sushruta's Ayurvedic Compendium (Ray *et al.*, 2023).

Cultivation of turmeric

Climate: Typical turmeric plant is best cultivated in temperatures between 20°C and 30°C, a significant rainfall amount. The plant is fit to reach a height of 1 meter with a lengthy oblong leaves. It is herb of the tropics sub-tropic parts of the world. It needed shade and make large mostly only when it is grown in open space and needs humid climatic situation (Yadav and Tarun, 2016; Obeta *et al.*, 2023). Soil: turmeric needs a soil that is enriched, friable, and better sand. Several soils are suited to grow turmeric, like the sandy loamy, light black, clay loamy, and red types of soils. Turmeric can also be grown on stiff loamy soil, light black soil, ashy loamy soil, and reddish loamy soils using rainy season downfall or irrigation water supply (Utoo and Asemaye, 2022).

Harvesting: the usual time for harvesting turmeric is between January down to the March or April. Fast turmeric varieties are harvested after seven or eight months of planting; medium plants are harvested after eight or nine months. Signs of readiness for harvest are noticed when the crop turns yellowish leaves and started falling down or drying. When mature, leaves are sliced near the ground, the soil is treated with ploughing, rhizomes are collected via by hand pick methods or the clumps have to be properly lifted using a spade (Arthur *et al.*, 2023; Ray *et al.*, 2023). Irrigation: Soil and climate for growing turmeric are

suitable indicators that determine the amount of irrigation needed by the plant. Based on the type of soil, for example a medium soil takes fifteen or twenty-five irrigation, while a light texture red soils takes thirty or forty irrigations as needed by the plant (Yadav and Tarun, 2016).

Storage: Rhizomes for seed usually are put in heap in the tree shade or in properly ventilation shed shrouded using leaves from turmeric. Also the seed rhizome may be preserved in pit using sawdust (Yadav and Tarun, 2016; Sakthivel *et al*., 2023).

Some Uses of Turmeric

There are many health advantages of turmeric, some of them are: It enhances balanced mood, it is important to heal wounds, it is important in relieving joint pains, it is useful in maintaining blood sugar level, it calm an irritation of tissues, it is useful to optimized cholesterol, it is useful in treatment of acute allergy, tonic, eczema, and asthma (Yadav and Tarun, 2016; Sakthivel *et al*., 2023). In many traditions, turmeric is utilized in homes as a cure for wound healing, digestive problems, cancer, menstrual problems, liver disorder, bacteria disease, eye problem, atherosclerosis, osteoarthritis (Ray *et al*., 2023). Also, turmeric has been applied in curing inflammation of mucous membrane in the lungs, throat, intestine, and stomach (Pennington Biomedical Research Center, 2012; Sakthivel *et al*., 2023).

Phytochemical Constituents in turmeric

An analysis of quality and quantity of phytochemicals housed by turmeric has revealed a number of important substances such as steroids, alkaloids, terpenoids, saponins, flavonoids, phenols, tannins, phytosterols, amino acids, protein, glycosides, and volatile oils (Ray *et al*., 2023). There is a recorded phenol amounting to 151.33 ± 13.9 μg/mg and has a garlic acid content (Jain and Parihar, 2017), there is about 265 ± 1.08 mg/g ascorbic acid in turmeric, total flavonoids amounting to 106.8 ± 2.76 μg/mg eq; to 175 ± 1.56 mg/g (Gul and Safdar, 2009; Umar *et al*., 2020). Therefore, there exists important presence of the phytochemical composition which indicates that the turmeric has ability to cause protection and prevention of diseases (Guneri, 2020; Umar *et al*., 2020).

ADVANTAGES AND DISADVANTAGES OF ARTIFICIAL FOOD PRESERVATIVES

Food preservatives are able to serve several functions in foods that are often taken for granted. They are advantageous in making food in a good/ palatable and beautiful when conveyed to markets over a long distance from where farm products are cultivated. Food preservatives are beneficial in preserving the nutrients of many food materials to satisfy the demands of the consumers through an improvement in texture, colour, taste, etc. (Kumar *et al*., 2015; Udah, 2021). Ideally, preservatives addition in foods helps to maintain several different qualities. Parable, emulsifiers ensures a consistent texture and deters separation of food products. Uniform smooth texture is given to products through addition of stabilizers or thickeners. Free flow of substances (like salt) is accorded due to the addition of anti-caking agents. (Abdulmumeen *et al*., 2012; Udah, 2021).

However, there are several attached disadvantages due to addition of food preservatives in food products nowadays. Due to preservatives harmful effects emerged immediately or over a very long time. Immediate effects of food additives include change in energy, change in mental behavior, headache, and immune response (Udah, 2021). Food preservatives are capable to instigate effects when taken above certain levels. Several foods are composed of diverse types of preservatives that can exert specific health effects on humans albeit some of the additive emanates from natural materials like corn, salt, honey, vinegar (ElSherif *et al*., 2023). The use of preservatives from synthetic production, like benzoates, sulphites, sorbates etc. in food materials is capable of stimulating certain health problems (Udah, 2021; *Silva et al*., 2023).

Some artificial preservatives exert reactions henceforth after consumption and others causes reaction later. Consequently, there is urgent need to come up with new products (natural ones) to displace the synthetic old ones as a way to safeguard public health preservatives with natural preservatives that is much safer for human and environment (Udah, 2021; Garane *et al*., 2023).

Long term use of synthetic preservatives is likely to stimulate cancer, increase risk of cancer, cardiovascular diseases and related degenerative disorders. There is evidence showing that some modern synthetic preservatives are capable of eliciting of respiratory or other health issues (Garane *et al*., 2023). It is reported that the popular sodium benzoate in food is capable of extending shelf life in tomato paste for more than 40 weeks coupled

maintained quality; but, when reacted with vitamin C a toxic benzene is formed that is why some producers are trying to reform their product, but there still exists issues (ElSherif *et al.*, 2023).

There are reactions as a result of these additives that can sometimes turn to a mild to life-threatening effect immediately or accumulate over a long period of time (Tenes and Kitonga, 2023. Synthetic preservatives attack the cells of the body and several disorders. Thus, there is certain concern that modern food preservatives like benzoates, sulphites, and sorbates are capable of causing acute or chronic health effects such as mental disorders, change in energy level, low immunity and increase risk of cancer, alteration of behavior, cardiovascular diseases and certain degenerative disorders (Udah, 2021; Osaili *et al.*, 2023). Some other certain harmful effects due to chemicals preservative are: allergies, palpitations, cancer. Nitrates and Nitrites used in food preservation as curing agents like in meat products are transformed to nitrous acid in the human body, a compound that elicits stomach cancer. Benzoates used as an antimicrobial in foods are potential candidates that elicit asthma, allergies and skin rashes. Sorbates/sorbic acid in foods acts against microbes of spoilage, but often are reported to cause urticaria and dermatitis disease (Shazia *et al.*, 2017; Calvo and Uribarri, 2023).

Moklesur Rahman (2006) echoed that, in order to alleviate losses after harvesting fruits and for maintaining highest quality, storage in low temperature condition is better than the higher temperature. Therewith, an experiment revealed that temperature refrigeration at 10^{o}C is the better temperature. Tomatoes stored with the absence of packaging polythene there is an attack chilling injury and spoilage of color. Therefore, black polythene is a better storage material in all the tests. Storage of fruits at 10℃ temperature in black polythene better reduces weight loss (%), preserving time of color development, preservation of firmness and moisture. Based on this study, it is suggested that use of packaging of black polythene in storing tomato fruits at low room temperature.

However, the utilization of plastics exerts many effects on humans, animals, and the environment, Therefore, the methods might be harmful idea. Noteworthy, Garuba *et al.* (2018) demonstrated in a study, that temperature in pot refrigerator has enhanced the shelf-life of tomato fruits, recording the highest shelf life in the pot-in-pot refrigerator. Similarly, Malick (2021) reported that evaporative cooler system was a promising storage mechanism that enhanced the shelf life of fruits and vegetables. Chemical preservatives had previously

used to preserve fruits. Mohammed *et al.* (2017) related that, chlorine-treated tomato fruits, stored in a perforated polyethylene bag at room temperature had a shelf life of 17 days which fell within the range of pot-in-pot storage system without preservative.

The use of chlorine to preserve fruits had been banned in several European countries such as Germany, Belgium, Switzerland and Netherlands due to the potential of forming carcinogenic chlorinated compounds in water (Rao and Lakshman, 2018). Tomato fruits stored with calcium carbide help to prolong the storage life of tomato up to 18 days. This chemical was reported to pose health implications which include cancer, mouth ulcer, food poisoning and eye contact may result in permanent blindness (Samad *et al.*, 2017). Botanical preservatives involve the use of plants or plants-based in preserving food materials. Botanical materials are effective in extending the storage life of fruits while inhibiting the growth of pathogens and increasing the physical quality of fruits (Sarkingobir *et al.*, 2022). The utilization of botanicals in lieu of chemicals as preservatives of fruits is efficacious and less toxic to human. These botanical preservatives are affordable and convenient for local farmers (Klee and Giovannoni, 2011; Ahmad *et al.*, 2020).

According to Scarano *et al.* (2020), sawdust can be used to maintain the freshness and firmness of tomato for a long period. Haile (2018) reported that, packaging of tomato fruits in perforated low density polyethylene bags resulted in longer shelf life with better-quality of the tomato. A study in Gombe by Ahmad *et al.*, (2020), found that, the surface washing of tomatoes with aqueous extract of *Psidium guajava and Jatropa curcas* leaves at different concentration enhances shelf life and reduces deterioration of tomato varieties. A property suggested being a result of bioactive components (alkaloids, tannins, saponins and steroids) present in the leaf extracts. Also, factors that aided in increasing the shelf life of tomatoes treated with aqueous extract was the treatment time and method employed in applying the extracts. This agrees with Bukar and Magashi (2013), who reported preservative activities of aqueous suspension of *Balanites aegyptiaca*, *Guiera senegalensis* and *Parkia biglobosa* leaves on tomatoes, oranges and pepper. They also added that duration of treatment and vehicle used in treatment application of extract help in extending shelf life (Sharma, 2015; Ahmad *et al.*, 2020).

Turmeric (*Curcuma longa* L.) is a historical plant popularly utilized in many aspects of human medicine especially in the treatment of several diseases. C. *longa* as fondly refer to it by the botanists, it is a plant that relates with the ginger (*Zingiber officinale* L) and is usually

cultivated on a perennial period of time. The plant possesses a short stem, large oblong leaves and possesses ovate, and has an often branching, brownish to yellow color pyriform/oblong type of rhizomes. In many instances, turmeric has finds its way into foods as an additive/ spice, color agent, and preservative in many countries (Ahmad *et al.*, 2020). In some regions the plant is tied to success and applied for religious services. In a wide range of places, it is applied to cure injuries, swollen body parts, and sprain (Ahmad *et al.*, 2020).

Recently, traditional healers apply turmeric to treat cough, diabetic wounds, sinusitis, biliary disorders, in recent times, hepatic issues, cough, anorexia, and rheumatism, abdominal pain among others (Ahmad *et al.*, 2020). Turmeric possesses valuable components like carbohydrates (69.4%), minerals (3.5%), fat (5.1%), protein (6.3%), and moisture (13.1%). It has also been recorded that turmeric contains essential oil (5.8%) as a result of subjecting its rhizomes to still distillation; therein, there exist borneol (0.5%), sesquiterpines (53%). sabinene (0.6%), zingiberene (25%), a-phellandrene (1%), and cineol (1%). Turmeric has also an important compound known as curcumin (diferuloylmethane) (3–4%) that account for its yellowness, and consists of mostly (94%) curcumin I, then (6%) curcumin II and lastly (0.3%) curcumin III. Some isolation has derived a Demethoxy and bisdemethoxy compounds from curcumin (El-Saadony *et al.*, 2023). Similarly, turmeric powder, curcumin and relations have been reported to possess bioactive capacity, a potential that serve as make the plant susceptible to be used a preservative (Ahmad *et al.*, 2020).

In Deb *et al.* (2013) found that addition of small amount of turmeric in solution-based environment delayed the contamination of pattern of yoghurt observed in control set from Day-2 to Day-4. This requires extensive validation to use it at commercial level. Additionally, Hosea *et al.*, (2017) in a shelf life study of tomato applied neem leave extract to keep three distinct varieties of tomato fruits (Shase, Hoozua and UTC) their results revealed significant improvement in post- harvest marketability, firmness, and related quality parameters 22 days after storage. This shows that neem plant extract has potential to replace the hazardous chemicals used in preservation of food materials in a view to extend shelf life and safeguard public health (Chattopadhyay *et al.*, 2004; Hosea *et al.*, 2017).

CONCLUSION

Tomato is a widely consumed product worldwide, and it envisages a diverse array of useful nutrients beneficial to humans. However, its shelf life is short due to many factors, in turn a move to extend shelf life is necessary. On many occasions people use artificial materials to store tomatoes, but these chemicals are harmful; therefore, a need to look for bio based materials arises. The use of neem and turmeric has been reported as a bio-based method that will possibly help in providing safe, cheaper, accessible materials for tomato storage; therefore, this area needs to be explored more.

REFERENCES

Abdulmumeen, H.A., Ahmed, N.R. and Agboola, R. S. (2012). Food: Its Preservatives, additives and applications. *International Journal of Chemical and Biochemical Sciences*, **1**:36-47.

Abrar, S., Abera, D., Simegne, K., and Ali, M. (2016) Effect of storage conditions and packing materials on shelf life of tomato. *Food Science and Quality Management,* ***56***, 2224-6088.

Ahmad, M., Abubakar, M.M. and Sale, S. (2020). Enhancing the shelf life of tomato fruits using plant material during storage. *Journal of horticulture and Postharvest Research*, **3**(2): 347 – 354.

Ahmed, A.U., Auwalu, B.M., Garba, H.M., Halilu, I.G., and Adamu, M.B. (2023). Response of tomato (*Solanum lycopersicum* L.) and Onion (*Allium cepa* L.) to different intercrops in Sudan savanna Ecological zone of Nigeria. *Direct Research Journal of Agriculture and Food Science*, **11**(3): 49-53.

Alda, L.M., Gogoasa, I., Bordean, D., Gergen, I., Alda, S., Moldovan, G., and Nita, L. (2009). Lycopene content of tomatoes and tomato products. *Journal of Agroalimentary processes and Technologies*, **15**(4): 540-542.

Ali, M.Y., Sina, A.A.I., Khandker, S.S., Neesa, L., Tanvir, E.M., Kabir, A., Khalil, M.I., and Gan, S.H. (2022). Nutritional composition and bioactive compounds in tomatoes and their impact on human health and disease: A review. *Foods*, **10**(45):1-32.

Arthur, S., Mukim, M., Sharma, P., Devi, S., Nagar, J.C. and Khalid, M.C. (2023). Curcumin: A review for health benefits. *International Journal of Research and Review*,**7**(1):273-290.

Bhowmik, D., Kumar, S., Paswan, S., Srivastava, S. (2012). Tomato- A natural medicine and its health benefits. *Journal of Pharmacognosy & Phytochemistry*, **1**(1): 33-43.

Bukar, A. and Magashi, A. M. (2013). Efficacy of some plant aqueous extracts and waxes in the preservation of some fruits and vegetables. *British Journal of Applied Science and Technology*, **3**(4): 1368-1379. https://doi.org/ 10. 9734/ bjast/2014/2213

Calvo, M.S. and Uribarn, J. (2023). Food additives use in ultra-process of foods: can processing use of industrial additives contribute to adverse health outcomes in children. *Academy of Nutrition and Diabetes*, 861-864.

Chattopadhyay, I., Biswas, K., Bandyopadyay, I. and Bawerjee R. (2004). Turmeric and curcumin: biological actions and medicinal applications. *Current Science*, **87**(1):44-53.

Chirruco, J.A., Jose, A.E., Ezequiel, C.M., and Nanelo, R.F. (2023). Quality of tomatoes produced in the irrigated area of Chokwa. *American Academic Scientific Research Journal for Engineering, Technology, and Sciences*, **94**(1):139-157.

Collius E, Bowyer C, Tsouza A, Chopra M (2022). Tomatoes: An extensive review of the associated health impacts of tomatoes and factors that can affect their cultivation. *Biology*, **11** (23a): 1-44.

Deb, R., Kanthanin, M. and Bhowmik, S. (2013). Food shelf life enhancement: the preservative potential of turmeric. *International Journal of Agriculture*, **4**(2): 30-32.

Ejale, A., and Abdullah, H. (2004) Preservation of ripe tomato (*Lycopersicon esculentum* Mill.) fruits with dried powder of Neem (*Azadirachta indica* A. Juss). *Nigerian Journal of Applied Science*, **22**, 344-350.

El-Saadony, M. T., Yang, T., Korma, S. A., Stohy, M., AbdEl-Mageed, T. A., Selim, S., Aljaouni, S. K., Salem, H. M, Mahmmod, Y., Soliman, S. M., Mo'men, S. A. A., Mosa, W. F. A., El-Wafa, N. A., Abou-Aly, H. E., Stohy, B., Abdel-Hack, M. E., El-Tarabily, K. A. and Saad, A. M. (2023). Impacts of tumeric and its principal bioactive curcumn on human health: *Pharmaceutica, Medicinal and Food Applications*: A comprehensive review. *Frontiers of Nutrition*, 91040259

Elsherif, H.M., Elkhondary, M.M., Abdulsalam, R.A., Hadad, E.M., and El-gindy, A. (2023). A review of food additives from definition and types of methods of analysis. *Records of Pharmaceutical and Biomedical Sciences*, **7**(1): 49-64.

FAO (2018). Postharvest management of tomato for quality and safety assurance: Guidance for horticultural supply chain stakeholders.

Freeman, B.B. and Reimers K (2010). Tomato consumption and health: Emerging benefits. *American Journal of Lifestyle Medicine*, Doi: 10.1177/1559827610387488. htt: llajl. Sagepub.com/content/early/2010.

Garane, M., Leener, P.D., Ovedraogos, Gas part, F., Legreve, A., Somda, and Toe, P. (2023). Willingness to pay for biopesticides for tomato cultivation in Burkinafaso. *International Journal of Agricultural policy & Research*, **11**(2): 57-73.

Garuba, T.J., Mustapha, I., and O.T Oyeyiola, G.P. (2018). Shelf life and proximate composition of tomato (*Solanum lycopersicum L.*) Fruits as influenced by storage methods. *Ceylon Journal of Science*, **47**(4): 387-393.

Gemida, J.V., Ardara, R.A., and Pillones, C.T. (2023) Shelf life of tomato (*Solanum lycopersicum*) in different post-harvest treatments. *International Research Journal of Science, Technology, Education and Management*, **3**(2): 41-49.

Gul, S., and Safdar, M. (2009). Proximate composition and mineral analysis of Cinnamon.*Pakistan Journal of Nutrition*, **8**(9):1456-1460.

Guneri, N. (2020). A review of turmeric (*Curcuma longa* L.) and usage in seafood. *Marine Science Bulletin*, **10**(1):71-84.

Gupta, R. and Yadav, R.K. (2021). Impact of chemical food preservatives on human health. *PalArchs Journal of Archaelogy of Egypt/ Egyptology*, **18**(15):811-818.

Haile, A., (2018). Shelf life and quality of tomato (*Lycopersiconesculentum* mill.) fruits as affected by different packaging materials. *African Journal of Food Science*, **12**(2):21-27.

Harborne, J.B. (1998). Textbook of Phytochemical Methods. A Guide to Modern Techniques of Plant Analysis (5th ed.). London: Chapman and Hall Ltd.

Hosea, Z.Y., Liamngee, K., Owoich, A.L., and Agasta, T.D. (2017). Effect of neem leaf powder on post harvest shelf life and quality of tomato fruits in storage. *International Journal of Development and Sustainability*, **6**(10): 1334-1349.

Ilesanmi, F.F., illesanmi, O.S., Afolabi, A.A., Ogungbemi, K.M., Asemaduhun, E., Olaleye-Oriowo, P.I., and Balogu, B. (2023). Impact of COVID-19 lockdown on tomatoes and scotch bonnet losses among farmers and marketers in Southwest Nigeria. *Nigerian Agricultural Journal*, **54**(1): 113-119.

Irokanulo, E.O. Egbezien I.L. and Owa, S.O. (2015). Use of *Moringa oleifera* in the Preservation of Fresh Tomatoes. *Journal of Agriculture and Veterinary Science* **8**(2): 127-132.

Islam, M.Z., Mele, M.A., Baek, J.P. and Kang, H. (2018). Iron, iodine and selenium effects on quality, self life and microbiological activity of cherry tomatoes. *Not Bot Horti Agrobo*, **46**(2): 388-392.

Iweala, E. J., Uche, M. E., Dike, D. D., Etumni, L. R., Dokunmu, T. M., Oluwapelumi, A. E., Okato, B.C., Dania, D. E., Adebayo, A. H., and Ugbogu, E. A. (2023). *Curcuma longa* (Turmeric): Ethnomedicinal uses, phytochemistry, pharmacological activities and toxicity profiles- A review. *Pharmacological Research-Modern Chinese Medicine*, **6**(100222):1-15.

Kabore, K., Konate, K., Sanou, B., Compaore, E.W.R. and Dicko, M.H., (2022). Tomato by-products, a source of nutrients for the prevention and reduction of malnutrition. *Nutrients*, **14**(2871): 1-1-16. http://doi.org/10.3390/nu1414287.

Klee, H. J. and Giovannoni, J. J. (2011). Genetics and control of tomato fruit ripening and quality attributes. *Annual Review in Genetics*, **45**: 41–59.

Kumar, S., Ramanjini, Gowdam, P.H, and Mallikarjuna, N.M.J. (2015). Evaluation of selected F6 tomato lines for extended shelf life. *SABRAO Journal of Breeding and Genetics*, **47**(4): 326-334.

Labbo, A.M., Umar, A.I., Shehu, Z., Isah, M., and Ayuba, S.A. (2021). Heavy metals and Physicochemical Assessment of Some Selected Sachet Water Around Sokoto Metropolis, Nigeria. *Caliphate Journal of Science and Technology (CajoST)*, **3** (1): 69 – 75

Malick, P.K. (2021). Medicinal values of tomato (*Lycopersicon esculentum* Mill. –Solanaceae). *International Journal of Applied Sciences*, **9**(3): 166-168. http://doi.10.312/ijasbt.v9i3.39789.

MeiramKulova, K., Derishor, D., Adylbek, Z., Kydybekova, A., Zhangazin, and Ualiyeva, R., Temibe kova, A., Adilbettegi, G., and MKilima, T. (2023). The Impact of Various LED light spectra on tomato preservation. *Sustainability*, **15**(111): 1-22.

Mes, P.J., Boches P., and Myers, J.R (2008). Characterization of tomatoes expressing anthocyanin in the fruit. *Journal of American Society of Horticultural Sci*ence, **133**(2): 262-269.

Ministry of Fisheries, Crops and Livestock (2003). Tomato post-harvest care and market preparation.Technical bulletin no.9.

Mohammed, S. M., Abdurrahman, A. A., and Attahiru, M. (2017). Proximate analysis and total lycopene content of some tomato cultivars obtained from Kano state, Nigeria. *ChemSearch*, **8**(1): 64-69.

Mohammed, S.M., Abdurrahman, A.A. and Attahiru, M. (2017). Proximate analysis and total lycopene content of some tomato cultivars obtained from Kano State, Nigeria. *ChemSearch Journal* **8**(1): 64-69.

MoklesurRahman, M. D. (2006). Determination of postharvest losses and shelf life of tomato as influenced by different types of polythene and temperature. An MSc thesis submitted at the Sher-e- Bangla Agricultural University, Dhaka.

Mugao, L.G. (2023). Factors influencing tomato postharvest losses in Mwea, kenya. *International Journal of Multidisciplinary Research and growth Evaluation*, **4**(4):41-48.

Naika, S., Lidt de jeude, J., Goffau, M., Hilmi, M. and van Dam, B. (2005). Cultivation of tomato: production, processing and marketing.

Nanelo, R.F., and Jose, A.E. (2023). Variation of physiochemical characteristics of tomato under different traditional forms of conservation. *International Journal of food studies*, **12**: 112-122.

New Zealand Institute for Crops and Food Research Limited (2005). Nutritional attributes of tomatoes. Crop and Food Research confidential report no.1391.

Nishizono, M., Issasi, C.S.C., Agutaya, J.K.C.N., Sasaki, M., and Mizukam, H. (2023). Production of dried tomato powder with a high concentration of functional components and nutrients. *Journal of Antioxidant Activity*, **2**(4): 1-21.

Obeta, U.M., Jaryum, P.L., Ejinaka, O.R., and Utibe, E.(2023). Turmeric is medicinal and cosmetic in nature, the production of obeturmeric powder and cream. *International Journal of Pharmaceutical and Phytopahrmacological Research*, **13**(2):18-24.

OECD (2017). Chapter 2: Tomato (*Solanum lycopersicum*). www.oecd-ilibrary.org>tomato-sol...

Ogah, A.C. Inekwe, I.E., and Olorunmaiye, O. (2023). Logistics management and seasonal price variation of fresh tomato in Nigeria market. *African Scholars Journal of Business Development and Management*, **28**(7): 197-208.

Ogofure, A.G. and Ologbosere, A.O. (2023). Microbiological and proximate properties of Health and Disease/ Spoilt (Broken) tomatoes (*lycopersicum esculentum* L.) sold in open markets in Benin city: public health implications. *Journal of Materials and Environmental Science*, **14**(4), 395-409.

Onyegbula, A.F., Fashanu, T.A., Babatunde, O., Yusuf, K.A., and Adole, E.B. (2023a). Studies on post-harvest loss assessment of tomato fruits using aloe vera gel as mitigating agent. *Magna Scientia Advanced Research and Reviews*, **8**(1): 114-122.

Onyegbula, A.F., Nzebude, C.P., and Igwe, C.U. (2023b). African elemi oil incorporated coating for quality improvement and shelf life extension of tomato fruit. *GSC Biological & Pharmaceutical Sciences*, **23**(1): 46-60.

Osaili, T.M., Obaid, R.S., Alkayyal, S.A.I., Ayman, H., Bunni, S.M., Alkhaled, S.B. etal. (2023). Consumers knowledge and attitudes about food additives in the UAE. *PLoS ONE*, **18** (3): 1-14.

Parnell, T. L., Suslow, T.V. and Harris L.J. (2004). Tomatoes: state methods to store, pressure, and enjoy. Publication 8101p http:// ancatalog.uc davis.edu.

Passam, H.C, Karapanos, I. C., Bebeli, P.J. and Savvas, O. (2007). A review of recent research on tomato nutrition, breeding and post-harvest technology with reference to fruit quality. *The European Journal of Plant Science and Biotechnology*, **1**(1):1-21.

Pennington Biomedical Research Center (2012). Tumeric. Pennington Nutrition Series No.91.

Raheja, S., and Thakore, B. (2002). Effect of physical factor, plant extracts and bioagent on *collectrichum gloeosporioides* Penz, the causal organism of anthacnos of yam. *Journal of Mycology and Plant Pathology*, **32**, 293-294.

Rao, M.R.K. and Lakshmanan, V. (2018). Study of bio-preservative potential of turmeric on tomato. *Indo American Journal of Pharmaceutical Sciences*, **5**(50): 3818-3829.

Ray, M.K., Santra, D.K., Mishra, P.K., Das, S.(2023). Indigenous Lakadong turmeric of Meghalaya and its future prospects. *Journal of Applied Biology and Biotechnology,* **11**(5): 133-142.

Sakthivel., M., Mohammed, H.S., Karthikeyan, R., Kaviya, M., Kowaslya, S., and Krishnapriya, R. (2023). Formulation and evaluation of herbal ointment containing neem and turmeric extract. *International Journal of Pharmacy Science and Review*, **78**(2): 134-139.

Samad N., Ara, N., Ali, S.J., Fahad, S., Hussain, Q.J. Samad, M., and Hizar, U. (2017). Evaluation of tomato accessions for quantitative and qualitative traits under agro-climatic condition of peshwar. *Pure and Applied Biology*,**6**(4):1345-1353.

Santhosh, S., Chitedeshwari, T., and Chinnasamy, K. (2023). Calcium influences biochemical and antioxidant enzymatic activities in tomato fruits storage. *Journal of Applied Biology & Biotechnology,* **11**(2): 158-64.

Sanusi, J., Habsatu, S., Abubakar, N., Suleiman, I., and Musa, D.D. (2020). Comparative study of proximate and minerals composition of tomato cultivars in Sokoto, Sokoto state, Nigeria. *FUDMA Journal of Sciences*, **4**(4): 409-414.

Sarkingobir, Y., Hamza, A., Dikko, M., Abubakar, M., Yabo, A.G., and Muhammad, B.I. (2022). Antibacterial study of guava leaves on some enteric bacteria (*E. coli* and *Shigella dysentriae*) from Sokoto state, Nigeria. *International Journal of Science, Technology, Education, and Management*, **2**(4):1-7.

Scarano, A., Olivieri, F., Gerardi, C., Liso, M., Chiesa, M., Chieppa, M., Frusciante, L., Barone, A., Santino, A., and Rigano, M.M. (2020). Selection of tomato landraces with high fruit yield and nutritional quality under elevated temperatures. *Journal of Science, Food and Agric*ulture, **100**, 2791–2799.

Sharma, S. (2015). Food preservatives and their harmful effects. *International Journal of Scientific and Research Publications*,**5**(4):5-4.

Shazia, K.M., Asema, U.K., and Sayyad, S.K. (2017). To study the harmful effects of food preservatives on human health. *Journal of Medicinal and Drug discovery*, **02**:(02): 610-616.Available online at www.jmcdd.org. 1135, ISSN: 2347-9027.

Sheetal, S., Bahadur, V., Khae, P., and Kushwaha, A. (2023). Effect of TA41 on growth yield and quality of tomato (*Solanum lycopersicum* L.). *The pharma Innovation Journal*, 12(4):1568-1572.

Silva, F.O., Garcia, V.A. d., Vanin, F.M., Yoshida, C.M.P., and Carvalho, R.A. (2023). Application of tomato byproduct in food products- A review. *Food science Journal and Engineering*, **4**(1):103-115.

Singh , H., Korpraditskul, D., and Singh, P. (1999). Evaluation of some plant extracts for control of *Colletotrichum capsici* the causal agent of *Chilli antharacnose. Journal of Science and Food Agriculture*, **55**(5), 1-2.

Sofowora A. Medicinal Plants and Traditional Medicine in Africa (2nd ed.). Ibadan, Nigeria: Spectrum Books Ltd. 1993.

Swamy, K.R.M. (2023). Origin, distribution, taxonomy, botanical description, genetic diversity and breeding of tomato (Solanum lycopersicum L.) *International Journal of Development Research*, **13**(4): 62364-62387.

Tenes, C.M.G. and Kitonga, L.M. (2023). The competitiveness of tomato value chain, Kenya. *The International Journal of Science and Technology*, **11**(7): 13-19.

Tesfaye, G. (2023). Effect of packing materials on shelf life of tomato (*lycopersicum esculentum* mill) under laboratory condition. *International Journal of Food Engineering and Technology*, **7**(1): 68-72.

The Editors of Encyclopedia (November, 21 2022). Tomato. www.britannica.com.

Theu, M.P.K.J. (2017). Use of locally available materials to increase shelf life of ripe tomatoes. Available at www.cabi.org/gara/FullTextPDF/2008/20083327078.pdf. Retrieved 02/06/2017.

Thole, V., Vain, P., Yang, R.Y., Almeida Barros da Silva, J., Enfissi, E.M.A, Noguirica, M.J., Price, E.J., Alseekh, S., Fernie, A.R., Fraser, P.D., Harson, P., and Martin, C. (2020). Analysis of tomato postharvest properties: Fruit color, Shelf life, and Fungal susceptibility. Current protocols in plant Biology, S, e 20108. do: 10.1002/Cppb.20108.Turmeric and curcumin biological actions and medicinal applications. *Current Science*,**87**(1): 44-53.

Trease, G.E., and Evans, W.C. (1989). Pharmacognosy (11th ed.). London, UK: Macmillan Publishers.

Tunwari, B.A., Labakan, A.G., Aji, P.O., Kyugah, J.T., and Williams, W.S. (2019). Effect of plant extracts on postharvest shelf life and quality of tomato fruits in storage at wukari, Taraba state. *International Journal of Agriculture, Environment and Bioresearch*, **4**(6): 420-430.

Udah, S.C. (2021). Analysis of health consequences of preservatives on agricultural foods. *Direct Research Journal of Agriculture and Food Science*, **9**(1):1-6.

Ujah, I.I, Nsude, C.A., Ani, O.N., Alozieuwa, U.B., Okpako, I.O., and Okwor, A.E. (2021). Phytochemicals of neem plant (*Azadirachta indica*) explains its use in traditional medicine and pest control. *GSC Biological and Pharmaceutical Science*, **14**(02): 165-171.

Ukaoma, A.A., Nwachukwu, M.O., Ukaoma, V.O., Adjeroh, L.O., and Urenus, I. (2019). Phytochemical and anti-microbial activity of neem seed oil (*Azadgirachta indica*) on bacteria isolates. *International Research Journal of Natural Sciences*, **7**(2): 1-19.

Umar, A.I., Sarkingobir, Y., Dikko, M., Shagari, K.A., and Sulaiman, B. (2023). Antinutrients in herbal products: An assessment of nitrate, phytate, oxalate, and cyanide in commonly consumed herbal snuffs in Sokoto, Nigeria. *Nurse and Holistic Care*, **3**(2): 104-111.

Umar, M.N., Parumasivan, T., and Aminu, N., and Toh, S. (2020). Phytochemical and pharmacological properties of Curcuma aromatic Salisb (wild turmeric). *Journal of Applied Pharmaceutical Science*, **10**(10):180-194.

Utoo, P.M., and Asemave, K. (2022). Quality analysis of turmeric modified tomato powder. *International Journal of Food Science and Nutrition*, **7**(2), 49-55.

Vaselina, V.H. and Dinev, N.S. (2021). Mineral content and quality parameters of tomato fruits as affected by different potassium fertilization treatments and cultivar specifics. *Indian Journal of Agricultural Research,* **55**(2):169-174.

Yadav, R.P. and Tarun, G. (2016). Versatility of turmeric; A review the golden spice of life. *Journal of Pharmacognosy and Phytochemistry*, **6**(1):41-46.

Zewdie, B., Shonte, T.T. and Woldestsadik, K. (2022). Shelf life and quality of tomato (*Lycopersicon esculentum* Mill.) fruits as affected by neem leaf extract dipping and beeswax coating. *International Journal of Food Properties*, **25**(1): 570-592.

Zhang, Y., Butelli, E., Destefano, R., Schoonbeek, H., Magusin, A., Pagliarani, C., Wellner, N., Hill, L., Orzaez, D., Granell, A.J., Jones, J.D.G., and Martin C. (2013). Anthocyanins double the shelf life of tomatoes by delaying over ripening and reducing susceptibility to gray mold. *Current Biology*, **23**:1094-1100.