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Monitoring the variations of lycopene and antioxidant content of wild cherry tomatoes under processing: Case study

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Abstract

The antioxidant content, activity, and colour of two commercially grown tomatoes (Lycopersicon esculentum L. var. Excell and Aranca) grown hydroponically in glasshouses were examined. Excell tomatoes were picked and stored separately, whereas cultivar Aranca was harvested by chopping the vine, which held a cluster of eight tomatoes. Both tomato cultivars were maintained in the dark at 15°C for four days in order to replicate normal pre-purchase storage conditions. The antioxidant content of the raw tomatoes varied significantly after four days of storage, but the cut inner surfaces of the two cultivars showed similar CIE LAB colour values. Subsamples of each cultivar were boiled, baked, fried, or subjected to total phenolics, lycopene, boiling, or baking for four days after which the CIE colour, ascorbic acid, and antioxidant activity (as determined by the ABTS assay) were assessed. Boiling and baking had little effect on the cultivars' ascorbic, lycopene, and antioxidant activity, but frying significantly reduced (Po0:001) the ascorbic, total phenolic, and lycopene contents of the two cultivars. Chromatic colour analysis showed that both cultivars significantly (Po0:001) darkened and lost their redness after cooking using all techniques. In a second trial, the two tomato varieties were cut into slices and submerged for 20 minutes in either an olive oil and white vinegar combination or the mixture and white vinegar alone. The CIE colours of the two cultivars remained unchanged throughout

processing; however, the application of both the oil and vinegar treatments separately and in combination reduced the amount of red in the colours (Po0:05). Following treatment with the oil and vinegar mixture, the two tomato cultivars showed a significant reduction in ascorbic acid, total phenolic, and antioxidant activity (Po0:001). The amount of lycopene that could be extracted from the tomatoes was significantly reduced when they were treated with oil; treatment with vinegar had no effect.

Keywords: tomato, Lycopersicon esculentum L, ascorbic acid, total phenolics, antioxidant activity, lycopene, lab colour, storage

Introduction

The tomato is one of the most widely grown and versatile vegetable crops. They are used to make a range of processed goods in addition to being eaten raw [1]. Tomatoes and tomato-based products are rich in nutrients associated with health because of their high content of carotenoids (especially lycopene), ascorbic acid (vitamin C), vitamin E, folate, flavonoids, and potassium [2]. Additional ingredients are protein and dietary fibre [3]. Numerous factors, such as the cultivar, maturity, and growing environment, affect the chemical composition of tomato fruits [4]. Studies have shown that storage temperatures and ripening practices can have a major effect on the final nutrient composition of fruit [5]. There isn't much data to support the assertions made by numerous researchers that the cultivar, growing conditions, and vine-ripening position all affect tomato quality, particularly when it comes to tomatoes grown in greenhouses.

Regular tomato consumption has been associated with a decreased risk of several cancer types as well as heart disease [6]. These beneficial effects are believed to be caused by antioxidants, more especially by lycopene, b-carotene, flavonoids, and carotenoids [7]. Furthermore, in order to lower the risk of cancer and cardiovascular diseases, the American Cancer Society (1984), [8] and the World Cancer Research Fund (1997) have all suggested increasing daily intake of fruits and vegetables rich in nutrients, such as carotenoids and vitamins C and E. [9] reviewed a number of epidemiological studies before concluding that consumption of tomato products was consistently associated with a lower risk of developing various cancers, including prostate cancer.

The main antioxidants present in tomatoes are carotenoids, ascorbic acid, and phenolic compounds [10]. The overall antioxidant activity of tomatoes varies greatly depending on the genetic variety, ripening stage, and growing environment [11]. Lycopene, which gives tomatoes their red colour, is also believed to have strong biological activity as an antioxidant in the body [12]. The lycopene content of tomatoes varies greatly based on the cultivar, maturity stage, and growing conditions. Field-grown tomatoes appear to contain higher levels of lycopene, ranging from 5.2 to 23.6 mg/100 g wet matter (WM) compared to tomatoes grown in greenhouses, which are reported to contain between 0.1 and 10.8 mg/100 g WM [13]. Tomatoes that were ripened on the vine contained 33% more lycopene than tomatoes that were ripened off the vine, per [14]. Fresh tomatoes have lycopene concentrations ranging from 8.8 to 42.0 mg/100 g WM, according to [15].

Another significant ingredient in tomatoes is ascorbic acid, which is reported to be 23.7 mg/100 g WM in the New Zealand Food Composition Tables and 20.0 mg/g WM in the United States Department of Agriculture data base Nonetheless, a number of writers document readings that fall and rise above this benchmark 25 mg/100 g WM; 16 mg/100 g WM). In tomatoes, ascorbic acid is relatively stable due to the acidic environment of the tissue [16].

Levels of Press Release

According to Fox and Cameron (1995), ascorbic acid levels in fruit peak in the spring and early summer when the fruit is actively growing. These levels vary with fruit maturity [17]. As per the findings of tomatoes grown in field conditions had a content of 15 to 21 mg/100 g WM, while the mean value of tomatoes in industrial grades was 19 mg/100 g WM. Ascorbic acid content in tomatoes that have ripened on the vine has been shown to be higher than in fruits that have been harvested after harvesting [18].

It is possible to lose a significant amount of ascorbic acid during any post-harvest storage. In the process of preparing and cooking food, it may also be lost due to oxidation and leaching into the cooking liquid [19]. claim that vitamin C is better preserved in milder treatments and at lower temperatures. Shahidi and claim that tomatoes' phenolic compounds also have antioxidant qualities. Plants have powerful antioxidants called flavonoids, which have been demonstrated to inhibit tumor growth among other things [20]. There have also been numerous other documented potential advantages of flavonoids [21].
Tomatoes and tomato-based products are rich in flavonols; a study conducted in 2000 by showed that tomato flavonols were present in a variety of tomato-based products and could withstand industrial processing methods [22]. Fruit varies in flavonoid content according to variety, size, and country of origin; cherry tomatoes from warm, sunny climates have the highest concentrations. In addition, reported that the skin contained 98% of the flavonols in tomatoes. Smaller tomatoes should therefore naturally have higher levels than larger tomatoes. Light is one of the primary environmental factors that affects the synthesis of flavonols.

Food is a complex matrix of interacting factors, according to Van Boekl and Jongen (1997), so measuring a food's antioxidant capacity to provide an index of its healthiness has gained acceptance. There are numerous assays available for assessing antioxidant activity. The ABTS+ Assay is used to determine how well water-soluble antioxidants in food can scavenge a free radical or decolourize the ABTS+ radical [23]. It also evaluated the antioxidant activity of different vegetables, including tomatoes, using this assay. Tomatoes are often cooked and partially stored before being consumed.

Common processing techniques like heat treatment and/or homogenization can harm the cellular matrix of tomatoes [24]. The cellular matrix's integrity affects the bioavailability of different nutrients. Data that has been published on the effects of heat treatment is inconsistent. It can also make some nutrients more bioavailable. Making tomato paste from fresh tomatoes is one use of homogenization and heat treatment that raises the bioavailability of carotenoids.

For a variety of reasons, data about how food processing impacts the number of carotenoids in foods is contradictory. These comprise the constituents of the tomato matrix, the carotenoid type assessed, and the processing parameters. Moreover, there is considerable variation amongst studies in the techniques and processing parameters employed to determine "retention" during cooking [25]. It asserts that the thermal processing procedure raised the concentration of carotenoids. The decrease in moisture content of the processed product and the enzymatic degradation of protein-carotenoid aggregates may have contributed to this increase [26]. It also showed that although cooking or steaming the tomatoes decreased their vitamin C content, these heat treatments had no effect on the cultivar Black Persimmon's total antioxidant activity, which rose when the fruit was kept at 15 degrees Celsius. You can prepare tomato slices at home by briefly soaking them in an oil and vinegar marinade. The nutrients in the tissue may have changed even though the tomatoes are eaten raw even though there is no heat treatment involved. Studies on the effects of this widely used at-home processing method have not been published [27].

Functional properties of samples

Tomatoes and their products are recommended due to their antioxidant activity, which is generally attributed to carotenoids, primarily lycopene, phenolic compounds, and ascorbic acid [28]. The first step in determining each tomato variety's functionality was to ascertain its ascorbic acid concentration and the profiles of carotenoids and phenolic compounds (Table 1). Ascorbic acid is essential for many biochemistry processes, such as growth regulation, senescence, and photosynthesis. According to [29]. It serves as an enzyme cofactor and affects the expression of genes linked to hormonal signaling pathways and defense. It was discovered that all tomato varieties examined had similar levels of ascorbic acid attributed their lower ascorbic acid values (ranging from 0.025 to 0.1 mg. g−1) to the tomatoes' greenhouse cultivation [30]. Tomatoes are thought to be the primary food source of lycopene for humans. The pigment known as β-carotene is found in photosynthetic tissues, but at high ripening degrees—which are usually accompanied by lycopene accumulation—its concentration drops. Table 2 demonstrates that the Cherry and Long-Life samples had the highest lycopene concentrations. The generated colour parameters and the behavior are in agreement. Croma b was twice as valuable as Cherry and Long life due to the inverse relationship between their β-carotene concentrations, even though Croma a was similar for both [31]. It was reported that 78.6 mg. g−1, a level of lycopene that is comparable to other finding reports, all of which had higher levels than those found in this study. Growth stages and ripening are two factors that may affect carotenoid content [32]. Tomato samples grown in the field had a higher lycopene content than tomatoes grown in greenhouses, according to a study examining the lycopene content of tomatoes grown in greenhouses. It shows that exposure to intense sunlight prevents lycopene from being synthesized [33]. This investigation's low lycopene content may have resulted from the tomatoes' field-grown cultivation. As defense mechanisms, fruit produces secondary metabolites of the free phenolic families; these compounds are primarily inherited and reflect plant stress. Each variety therefore exhibited a distinct distribution of phenolic families (Table 3). Each sample contained comparable amounts of phenolic acids, but their ratios differed. The levels of vanillic, gallic, and ferulic acids were below detection thresholds. P-coumaric acid was only detected in the Italian variety (9.0 µg. g−1), while syringic acid was only found in Cherry samples (141.5 µg. g−1). The two main acids in the Cherry variety were caffeineic and chlorogenic [34]. It noticed that two Cherry tomato varieties (Summer brix and Lazarino) contained gallic, hydroxybenzoic, coumaric, caffeic, and chlorogenic acids in addition to the flavonoid quercetin. They discovered that depending on the ripening stage, these compounds' contents varied significantly. The concentrations of coumaric, caffeic, and chlorogenic acids dropped by 48%, 52%, and 20%, respectively, in underripe tomato samples. Elevated levels of phenolic compounds were also linked to radiation that reached the fruit. This study is unable to make any conclusions regarding this issue because the samples were collected in markets, where customers actually shop. Even though the colour and sugar/organic acid ratio were selected as maturity indicators to minimize the impact of maturity on the composition, the environmental conditions could not be controlled. However, that is the real situation with their diet for those who consume this fruit as a source of beneficial compounds. Fruit was described in terms of flavonoids (Table 3).

Figure 1. Wild cherry tomato and its plant (Solanum peruvianum L, local name - Khamen asinba macha; Solanaceae family)

Table 1. Ascorbic acid, carotenoids, and free phenolic compounds in tomato samples.

Tomato variety	mg, g-1 Macro carotene B	Lycopene (mg. g-1)	Phenol negative (mg. g-1)	Ascorbic acid content (mg. g-1)
Extended lifespan	0.15b,	15 c	30.5 b	3.2c
Foreign tomato Italian variety	10b	32-34 c	3.2c	0.5a
Khaki	10.1b	41 a	4.1a	0.17b
Cherry local	30 – 33.5 1a	35.1c	2.7b	0.03c

Plots of different tomato samples are represented by different letters in the same column ($p<0.05$).

Table 2: Concentrations of ascorbic acid, total phenolics, lycopene, and antioxidant activity for raw, boiled, baked, and fried Excell and Aranca cultivars

Cooking technique/cultivar	**Acid ascorbic (mg/100 g DM)**	**Phenolic content overall (mg GAE/100 g DM)**	**Lycopene (mg/100 g dry matter)**	**Activity of antioxidants (mmole TEAC/100 g DM)**
Foreign Italian and Greek (µg.g-1)				
Raw	290.2±7.4	44.5±3.3	42.1±1.5	1890.1±88.2
Boiled	190.3±1.2	228.6±10.2	30.0±5.7	990.±737.8
Baked	180.5±6.1	290.1±7.7	26.0±7.5	1349.1±61.4
Fried	160.4±4.4	249.7±42.0	20.2±1.4	1740.6±52.7
Khaki (µg.g-1)				
Raw	170.2±11.0	350.8±15.5	45.9±0.2	1390.0±36.1
Boiled	184.1±2.5	228.8±28.1	31.2±0.3	855.5±14.7
Baked	123.9±3.9	232.0±12.9	28.8±0.2	921.5±15.8
Fried	112.5±6.7	342.3±11.5	41.3±1.4	1385.2±20.3
Cherry (µg.g-1)				
Raw	583.1±4.2	235.5±15.2	102.7±80.9	542.8±135.5
Boiled	175.5±4.5	220.2±7.3	33.5±3.2	920.2±695.2
Baked	160.3±1.2	145.5±10.2	22.2±0.1	880.2±12.2
Fried	132.3±5.9	126.5±8.5	12.2±1.2	1358.1±13.1

Table 3: Phenolic compound profile of different tomato variety

Phenolic acids	Enhanced longevity (µg. g-1)	Foreign Italian and Greek (µg. g-1)	Khaki (µg.g-1)	Cherry (µg. g-1)
Chlorogenic	<LOQ	21.3	49.5	575.1
P-hydroxybenzoic	22.1	8.9	<LOQ	5.4
Rutin	60.6	46.2	25.2	19.2
Siringic	<LOQ	<LOQ	<LOQ	141.5
Gallic	<LOQ	<LOQ	<LOQ	<LOQ
Caffeic	<LOQ	9.6	32.0	104.7
p-cumaric	<LOQ	9.0	<LOQ	<LOQ
Quercetin	67.3	92.2	72.6	96.8
Feruli	<LOQ	<LOQ	<LOQ	<LOQ
Catechin	89.1	100.4	83.8	548.8
Vanillic	<LOQ	<LOQ	<LOQ	<LOQ
Siringic	<LOQ	<LOQ	<LOQ	141.5

LOQ stands for limit of quantification. LOQ is 5 ng. mL-1 for the following: ferrulic and siringic; 20 ng. mL-1 for galic; 30 ng.mL-1 for catequin; 10 ng.mL-1 for caffeineic, clorogenic, p-cumaric, p-hydroxybenzoic, protocatecoic, vanilic, quercetin, and rutin. Cherry tomatoes, which have a high peel/pulp ratio, are rich in phnolic compounds, with catechin being the most common at 548.8 µg/g. Many reports indicate that the most common flavonoid in tomatoes is quercetin, closely followed by naringenin [34]. The highest quercetin content (96.8 µg. g−1) was found in cherry tomatoes. Long Life tomatoes had the highest rutin content (60.6 µg. g−1), while cherry tomatoes had the lowest (19.2 µg. g−1).

Antioxidant activity

Regular intake of tomato-based products has been associated with a lower risk of diseases like heart disease and different types of cancer [35]. Oxidative reactions that are not initiated by the same thing cause them. The mechanisms by which chemical compounds mitigate damage must therefore also vary. An antioxidant compound's ability to inhibit the spread of radicals is determined by its molecular makeup and reactivity to affect oxidative processes in vivo. The main factor causing beneficial effects is the chemical groups' capacity for reduction, not the antioxidant concentration of a source. In vitro methods have been employed to evaluate the antioxidant potential of chemical groups under different oxidation-reduction scenarios [36]. Since every tomato variety had a different profile of reduction compounds in carotenogenic and phenolic extracts, the reduction potential was evaluated using a variety of techniques. Antioxidant activity was expressed as the concentration (µug. mL–1) of phenolic compounds or carotenoids needed to support 50% inhibition (IC50) of the oxidative process (Table 4). As each method is based on a kinetic condition specific to its stoichiometry and mechanism, this approach allows comparison of the effects of antioxidants. Because of this, comparing inhibition expressed as a percentage may not accurately reflect the actual capacity of extracts to lower oxidative damage across all varieties. When it comes to protecting health, the extract with the lowest IC50 is the most effective. The oxidative reactions mediated by radical hydroxyl, radical peroxyl, and metallic compounds (ABTS) were effectively inhibited by phenolic extracts (DPPH). However, carotenogenic extracts required high concentrations to be effective. Given that carotenoids are hydrophobic compounds, these reactions make sense, so these results were expected for these methods [37].

Table 4: The IC50 (ug. mL–1) values of antioxidant-rich carotenoid and phenolic compound extracts.

	Phenolic compounds			Carotene		
A Range of Tomatoes	DPPH	ABTS	radical hydroxide	DPPH	ABTS	Radical hydroxide
Cherry	1.5b	1.1a	0.11a	555a	2500a	160a
Khaki	1.8a	1.2a	0.03c	400	1670	140b
Italian	1.5b	1.1a	0.11a	446b	1000c	156a
Longlife	1.7a	1.1a	0.07b	357d	1667b	162a

For each tomato sample, variations are shown by subscribed letters in the same column ($p<0.05$). The primary substances that inhibit antioxidant activity are phenolic compounds. The OH radical in Long Life tomatoes and the DPPH and ABTS radicals in Italian tomatoes were the primary free radicals that these compounds inhibited. Protocatecoic acid and catechin, two phenolic compounds that may be involved in inhibiting the release of free radicals through any mechanism, were particularly high in these tomatoes. While the free phenolic content of cherry and Italian tomatoes was similar, their antioxidant profiles were different. Consequently, the correlation between the different parameters influencing the functional properties of tomatoes was explained by the multivariate statistical technique called principal component analysis (PCA) [38].

Extraction methods of Lycopene

To reduce Lycopene losses from oxidation or isomerization, Lycopene must be extracted, stored, handled, and analysed under carefully regulated environmental conditions. It has been suggested that cis-lycopene is more bioavailable in food than any trans-lycopene; however, lycopene's isomerization from trans-to cis-form appears to be promoted by vivo mechanisms, the precise nature of which is still unknown. However, since lycopene typically occurs in the all-trans configuration—exactly the most thermodynamically stable form—there is obviously interest in preventing trans-cis isomerization when incorporating it into functional foods or nutraceuticals [39].

Super Critical Fluid Extraction (SCFE)

SCF Lycopene from tomatoes was successfully isolated through extraction, according to Gomez-Prieto et al. (pear type). The original tomatoes, according to them, were only kept at 7°C for a maximum of 48 hours. Subsequently, the tomatoes (seeds and all) were dried in a freezer dryer, ground, and divided into batches before being placed in Teflon screw-cap tubes that had been nitrogen-flushed, covered with aluminium foil, and maintained at -18°C until the extraction process was completed. Every batch was extracted at a different CO2 density for reasons that will become clearer later. At least two duplicates of each extraction were performed. The extractions were carried out using a Hewlett-Packard 7680A extraction module that was outfitted with a 7-ml thick-walled stainless-steel thimble as the extraction cell. The supercritical fluid can be instantly depressurized, and the pressure and flow rate of the supercritical fluid can be independently controlled, thanks to a nozzle-trap assembly that serves as a controllable variable restrictor [40]. The fully automated extraction system holds the extracted analysts in an internal trap after the supercritical fluid evaporates and leaves the system. Throughout the experiment, different CO2 density values (i.e.,

0.25, 0.35, 0.45, 0.55, 0.60, 0.70, 0.75, 0.80, 0.85, and 0.90 g/ml) were tested, and a 30-minute extraction period was established. Additional experimental conditions included the following:

Purification

Lycopene is usually identified and isolated using the HPLC technique. Chromatography, thin-layer chromatography, high-performance thin-layer chromatography, and other techniques have also been reported as haphazard techniques. The photodiode detector has a wavelength range of 200–600 nm. Before the SF extract was added to an HPLC system, the solvent (CO2) was first evaporated under a nitrogen stream and then redissolved in one millilitre of dichloromethane. Eluent B, methyl tert-butyl ether, and eluent A, methanol-water 96:4 w/v, were mixed and utilized as the mobile phase at a flow rate of 1000 ml/min. A linear gradient was applied for 60 minutes to go from the initial conditions (A: B, 83:17 v/v) to the conditions that were kept throughout the analysis (A: B, 33:67 v/v). Prior to use, methanol and methyl tert-butyl ether were filtered and gassed with helium. A 250 mm X 4.6 mm Develosil UG C30 column (Nomura Chemical, Solo, Japan) operating at 20°C was the main column used for the HPLC analysis. Multiple carotenoids were discovered in the same run by monitoring the chromatograms at 285, 347, 450, and 472 nm. Based on measured peak areas, the percentages of carotenoid compounds were computed. In the supercritical fluid, the solubility of all trans-lycopene rises with increasing pressure, while the solubility of cis-lycopene decreases exponentially at $\rho = 0.55$ g/ml trans-lycopene = 31% and at $\rho = 0.90$ g/ml trans-Lycopene = 88% [41]. These results are in line with several authors' experiments [5, 14, 15, 16,]. It is specifically demonstrated by Gomez-Prieto et al. When the authors worked at 40°C and pressure ranged from low 77 bar to intermediate value 281 bar, an increase in temperature would either have a negative or negligible impact on extraction yield due to the balance between changes in solute vapor pressure and CO2 density. In supercritical fluid extraction, the addition of different solvent modifiers—such as acetone, methanol, hexane, and dichloromethane—is avoided since it negatively impacts the extraction process. The chromatograms obtained from the corresponding extracts, monitored at 285, 347, and 450 nm, demonstrated that we were unable to extract significant amounts of carotenoids during our experiments conducted at the lowest density of 0.25 g/ml. Nevertheless, we detected distinct compounds when we increased the solubility of the carotenoids at higher densities. The temperature of the extraction cell was maintained at 40 °C, but a rise in solvating power allowed the pressure to be raised from 77 bar ($\rho = 0.25$ g/ml) to 281 bar ($\rho = 0.90$ g/ml). This allowed for the extraction of various carotenoids, including lycopene, phytoene, phytofluene, and β-carotene. In these cases, where the cis-isomers are not well separated from them, the analysis will significantly overestimate the all-trans forms because their peaks will partially or completely co-elute with the cis-isomer peaks. In this case, the use of a polymerically synthesized C30 column allowed us to obtain acceptable separations between the individual cis-isomers as well as sufficient selectivity and selectivity for the identification of all-trans-isomers from the cis-counterparts [42]. For the extraction of other carotenoids, like phytoene, phytofluene, and β-carotene, densities of CO2 lower than 0.98 are used, i.e., 0.85, 0.80, 0.75, 0.70, 0.60, and 0.55 g/ml. The yields of total lycopene were 23.6, 14.5, 8.6, 4.5, 0.6, and 0.2%, respectively.
The mobile phase in solvent extraction is methanol. THF: Water (67:27:6), flow rate of 2 ml/min. At 475 nm, the maximum lycopene adsorption in the mobile phase, a sample injection volume of 20 µl is typically detected using a standard procedure.

Effect of heat and time on amount and stability of lycopene

More surprisingly, in terms of lycopene absorption from dietary sources, there was no increase in lycopene serum levels after a single large tomato juice consumption. After consuming 180 g or even 700 g of tomato juice—equivalent to a single dosage of 12 or 80 mg, respectively—there was no change in the serum's lycopene levels [43]. Lycopene plasma levels in human serum increased significantly when processed tomato juice was consumed as opposed to unprocessed juice. After adding 1% corn oil and boiling the tomato juice for an hour, the bioavailability of the lycopene

increased significantly. Peak serum concentrations of lycopene are observed 24 to 48 hours after consuming processed tomato juice, as individual absorption varies. Lycopene has a half-life of approximately two to three days, which means it leaves human plasma a little faster than β-carotene. Human serum has been reported to contain derivatives of hydroxylated lycopene [44]. They include lycopene 5,6-epoxide, which might have changed the organism's enzymatic or chemical makeup.

Effect of Cooking

Three alternative methods of cooking were used to prepare the two tomato cultivars: boiling, baking, and frying. Table 3 displays the two tomato cultivars' final dry matter and fat contents along with the cooking times and temperatures. Cultivars lost moisture during cooking, and the total fat content of the cooking oil significantly increased in the fried tomatoes [45]. Table 4 displays the concentrations of the cooked tomatoes' ascorbic acid, total phenolics, lycopene, and antioxidant activity in relation to the raw tomato values. In their raw forms, the cultivars differed significantly (Po0:001) in terms of ascorbic acid, total phenolics, and antioxidant activity. Compared to the larger tomato cultivar, Excell, the smaller tomato, Aranca, has significantly greater levels of total phenolics and ascorbic acid. Compared to raw Aranca tomatoes, the lycopene concentration of raw Excell tomatoes was substantially higher (Po0:01). As compared to the corresponding raw cultivar, both tomato cultivars' ascorbic acid, total phenolic, and lycopene concentrations were significantly reduced (Po0:01) after boiling, baking, and frying [46]. While heating the tomatoes seemed to reduce their antioxidant activity, statistical analysis revealed that the alterations did not differ significantly from the raw tomato activity. While it appeared that cooking the tomatoes reduced their antioxidant activity, statistical analysis revealed that the changes did not differ significantly from raw tomato activity. The red colour (a value) of both tomato cultivars fell dramatically when cooked (Po0:05); otherwise, the a/b ratio did not change significantly, with the exception of when the tomatoes were fried. Because higher temperatures are required for this method, frying found to result in the largest loss of antioxidant activity and nutrients. The effect of boiling was comparable to that of baking [47]. Because the cooking water was not removed after the tomatoes were boiled, there was no nutrient leaching.

Effect of marination treatment

The two tomato cultivars were soaked in either oil and vinegar or vinegar and oil separately. These treatments had no effect on the dry matter content of the two tomato cultivars, but soaking in oil or oil and vinegar resulted in a significant increase in the fat content of the tissue of both tomato cultivars (Table 3). The values in Table 4 are based on the original dry matter content of the tomato tissue, which accounts for the rise in oil from the marinade treatment [48].

Overall, soaking the processed tomato samples in oil, vinegar, and oil/vinegar considerably reduced (Po0:001) their antioxidant content and antioxidant activity (Table 4). The oil/vinegar treated tomato suffered the largest losses. When compared to the untreated samples, the ascorbic acid level of these samples was lower. Soaking in vinegar resulted in the smallest drop in all studies, and these results were comparable to the untreated tomato samples. Soaking tomatoes in vinegar for 20 minutes did not diminish the lycopene level of the treated tomatoes appreciably [49].

Application of lycopene

Its ability to quench singlet oxygen indicates that it has antioxidant activity. Lycopene is oxidized by plant serum as well as human serum. The primary oxidation product in human serum that arises from the reaction with chloroperbenzoic acid is lycopene-5,6-epoxide. Rearranging the molecules, Stahl used preparative high-performance liquid chromatography (HPLC) on human serum in 1996 to isolate the epimers of 2,6-cyclolycopene-1, 5-diol. In plants, singlet oxygen is quenched by lycopene at a second-order rate ($K = 7 \times 10{-}9\ M{-}1\ s{-}1$). Figure 3 shows the chemical pathway of lycopene

oxidation in the plant [41]. After generating active oxygen in step one, lycopene and 2-methyl-2-hepten-6-one combine to form Apo-6-lycopenal. Because lycopene is a naturally occurring colouring substance, it does not have the harmful effects of artificial food colouring. The process through which some leaves take on colour other than green as they ripen or fruits turn from chloroplasts to chromoplasts. Carotenoids like lycopene will be esterified with different fatty acids during this process in order to eliminate and stabilize oxygen free radicals generated during this process. The process of photosynthesis depends on lycopene [50]. Because chloroplasts are associated with photosynthesis, many of the components of cells are also related to it. Carotenoids such as lycopene self-esterify, protecting these cell materials from photooxidative damage. Lycopene is a precursor to vitamin A. In its general structure, lycopene is an aliphatic hydrocarbon with eleven conjugated carbon-carbon double bonds. Lycopene exhibits symmetrical planarity and is acyclic. Through particular biochemical reactions, this structure forms provitamin A, which is then converted into vitamins. It also supports several essential in vivo biological functions, such as growth control, hormone regulation, and cell-to-cell communication. It is advantageous for chemo preventive treatment against cancer. investigations using tumor cells from humans, rats, and rabbits have shown that lycopene inhibits the cells' uncontrollably rapid growth. One type of cancer that is very challenging to treat in humans is leukaemia. Lycopene is an alternative that can help with treatment in its early phases. Additionally, lycopene has been demonstrated to be advantageous for prostate, pancreatic, and stomach cancers [43].

Conclusion

Lycopene inhibits different types of cancer cells, including prostate cancer cells, as demonstrated by its effects on tumor cells. Furthermore, we have determined that, in comparison to other sources, tomatoes have the highest concentration of lycopene, with an approximate concentration of 11.21 mg/100 g wet weight, based on a number of published analyses. There are other methods for extracting lycopene as well, but the supercritical fluid extraction of lycopene with CO2 produces better results than other methods. The extracted lycopene can be included in the diet in circumstances where natural sources of lycopene are not available. In some industrial processes where oxygen quenching is required, extracted lycopene finds use. The results of the experiments show that foods that have undergone heat processing have higher levels of readily available lycopene than foods that have not; however, high temperatures hasten the extraction of lycopene. These divisive characteristics are still unaccounted for. Lycopene's importance in the domains of pharmacology, epidemiology, and nutraceuticals makes it a necessary part of the human diet.

Declarations

Ethical approval: The authors declares that ethical approval was not required for this study or not applicable.

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Authors contribution

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the design of research questions, data and framing the objective of the review in searching literature reviews, computing etc.

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