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Extraction of tea polyphenols based on orthogonal test method and its application in food preservation

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Abstract

Green tea is high in polyphenols - compounds that have a variety of physiological functions. Microwave-assisted extraction (MAE) was used in this study to extract polyphenols from green tea. The MAE of the phenols in green tea was studied using an orthogonal configuration. As a result of UV/vis spectrophotometric methods, the total phenol content of tea infusions was determined. Polyphenols are plant-based chemicals that we acquire from specific foods. They may provide health advantages and are high in antioxidants. Polyphenols are considered to enhance or aid in the treatment of cardiovascular disease, neurodegenerative illness, diabetes, weight management concerns, and digestive problems. Each of the following factors has an impact on extraction: microwave intensity, microwave irradiate time, and frequency of microwave irradiation, as well as the tea/water ratio. Microwave radiation at 600 watts for 3 minutes at a frequency of once produced the best extraction results with a tea/water ratio of 1:20. As compared to traditional methods, MAE has a number of advantages. These include shorter extraction times, energy savings, and reduced environmental impact. A significant source of worry for food suppliers and users is the oxidation of dietary lipids. Antioxidant compounds have been used to prevent the oxidation of lipids. Synthetic antioxidant additions used today include $C_{11}H_{16}O_2$ (BHA), $C_{10}H_{14}O_2$ (TBHQ), and $C_{15}H_{24}O$ (BHT). Toxicological and nutritional concerns, on the other hand, restrict their use. A variety of foods use green tea as a natural preservative because of its powerful antioxidant and antibacterial properties.

Keywords: orthogonal array design; microwave-assisted extraction; extraction; tea polyphenols; natural preservative.

Practical Application: Microwave radiation at 600 watts for 3 minutes at a frequency of once produced the best extraction results with a tea/water ratio of 1:20. As compared to traditional methods, MAE has a number of advantages. These include shorter extraction times, energy savings, and reduced environmental impact.

1 Introduction

Polyphenol extraction has been reported using a variety of methods.Microwave extraction, ultrasonic extraction, Soxhlet extraction, heat reflux extraction, and ultrahigh pressure extraction are among them;;. Water, polar organic solvents such as methanol, ethanol, acetonitrile, and acetone, or their mixtures of water, are used to extract hydrophilic polyphenols such as aglycones, glycosides, and oligomers. Depending on the solubility of the target polyphenols, liquid extracts are sometimes partitioned with solvents such as ethyl acetate. Polyphenols are more stable at low pH because the acidic environment helps polyphenols ; to remain neutral, allowing them to be easily extracted into organic solvents;

Microwave heating is used to generate a boiling solution with the raw plant material on top (or drenched inside). Different distillation methods are examined for their capacity to conserve substantial amounts of energy while simultaneously being rapid as part of the evaluation process. Study after study has demonstrated that microwave-assisted methods extract essential oils faster (up to nine times faster), employing "greener" processes, and generating a better grade essential oil with stronger sensory and antioxidant properties.

With the use of green tea phenolic components, the antioxidant status of a food is enhanced, giving the product an increase in antioxidant activity or decreasing undesirable changes in chemical processes.

MAE (Microwave Assisted Extraction), or extraction using microwaves, is a mix of microwaves and traditional solid-liquid extraction methods. By heating the solvent and plant matrix using microwave energy, this technique increases the solvent's capacity to extract. As compared to traditional extraction techniques, MAE provides a variety of advantages, such as fast extraction

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times and extraction of specific compounds while using less solvent, a higher extraction rate and overall cost-effectiveness.

Since ancient times, tea (Camellia sinensis) has been cultivated in China. Because of its health benefits, Asian Nations enjoy green tea as a health drink. Green tea has significant amounts of polyphenols (32%) and caffeine (4.5%), including flavonoid and phenolic acids. (Kopustinskiene et al., 2020; Liu et al., 2020). There have been a number of epidemiological studies linking tea drinking to a lower risk of coronary artery disease, high cholesterol, systemic skeletal disorder, and tooth decay. Two different procedures were used to determine the total amount of phenols. Phosphattungstic acid (H3P[W3O10]4) is reduced by alkaline reduction in the Folin–Ciocalteau method, yielding phosphotungstic blue (Chung et al., 2020; Ikeda et al., 2018). Considered the most accurate method for determining the total phenolic content of a substance (including tannins). This method is based on the absorption of the aromatic rings and is faster.

Nearly all green tea infusions contain phenols with maximum absorption wavelengths of around 280 nm (Lin et al., 2005; Lin & Zhu, 2004; Zijp et al., 2000). Recent decades have seen an increase in interest in tea bioactive chemical extraction, with a focus on conventional solvent extraction, which has a number of drawbacks. CO2 extraction, extraction aided by ultrasonic waves, and an extraction method that uses microwave technology are among the various extraction technologies that have been developed and published throughout the years. This method of chemical extraction employs microwave radiation and solvents. (Li & Jiang, 2010; Spigno & Faveri, 2009). Temperature and pressure that are localized within the material can cause selective migration of target compounds at a higher pace by comparable or faster recoveries, with the major benefits being a reduction in both extraction time and solvent consumption compared to traditional extraction methods. Microwaves allow for fully reproducible extractions in minutes, resulting in Greater product quality, simpler handling, an easier job, and lower energy and solvent use, and no post-treatment wastewater (Pasquet et al., 2011). Heating materials and separating active components from natural substances are ideal applications. In a variety of studies, tea polyphenols have been extracted from the leaves. Decaffeinated green tea green has, however, been the subject of relatively little research in terms of extracting tea polyphenols (Das et al., 2019; Gurley et al., 2019; Henning et al., 2018; Khoo et al., 2020; Roberts et al., 2021; Wang et al., 1994). We ran an orthogonal experiment to see how well MAE could extract polyphenols from decaffeinated green tea.

For green tea polyphenols, MWE has been examined as an alternative to traditional water extraction under conventional heating conditions (CWE). In selecting the experimental conditions, temperature and extraction time were taken into account, as well as other factors. The extraction time, total phenolic content, chemical composition (HPLC-MS analysis), and antioxidant activity of the extracts were used to measure the efficiency and selectivity of the method.

2 Materials and methods

The tea polyphenols were quantified and compared to other tea polyphenols. High-performance liquid chromatography and a Hypersil ODS (octadecylsilyl) column were used to determine the total phenols in the samples. Using calibration curves with standard Epigallocatechin gallate (EGCG), total phenols were converted to EGCG equivalents (Bailey et al., 1991; Daidone et al., 2008). The phenol removal rate was calculated based on the standard curve and the phenol content of the samples (Equation 1):

$$\text{Total polyphenols (\%)} = \left(1 - \frac{M_1 \times n \times V_2 \times 1000}{MV_1}\right) \times 100\% \quad (1)$$

In which M represents the total phenol quality of the samples in grams, M_1 represents the remnant phenol quality in the testing samples in milligrams, and V_2 and V_1 represent the total sample volume and test volume, respectively.

2.1 Extracting polyphenols from tea

MAE or microwave extraction is a relatively recent technology that combines microwave and regular solvent extracting to get high-quality results. Microwave-assisted extraction is the use of microwaves to heat solvents and plant tissues in the extraction process, increasing the extraction's kinetics. Compared to traditional methods of extracting compounds from diverse matrixes, especially natural goods, MAE has a number of advantages, including shorter extraction time, less solvent, higher extraction rate, and cheaper cost. When MAE was first used in the 1980s, it was a relatively new technology. Today, it is one of the most popular and cost-effective extraction methods, and a variety of advanced MAE instruments and methodologies are available, such as pressurized microwave-assisted extraction, or PMAE (SFMAE). An overview of the MAE is presented in this chapter, along with a number of procedures for natural product extractions. In Microwave-Assisted Extraction, there are certain theoretical considerations. Waves with high frequency are called microwaves. They are electromagnetic waves that fall between radio frequency and far infrared light, on the electromagnetic spectrum (their frequency range from 0.3 to 300 GHz corresponding to wavelengths of 1 mto 1 cm). In contrast to conventional heating, where the heat slowly penetrates from the outside to the inside of an object, microwave-assisted extraction (MAE) heats the body from the inside out. To influence molecules, the microwave energy uses ionic conduction and dipole rotation. Electromagnetic fields induce ionic conduction, which is the movement of ions in solution. The friction caused by the solution's resistance to the ion movement will cause the solution to heat up. When you rotate dipoles, you're realigning the dipoles in relation to the applied field. There are 4.9 times every second that the dipoles align and randomize at 2450 MHz, resulting in molecular "friction" and heating of the solution.Succeeding in extraction requires careful selection of the right solvent(s).

An orthogonal evaluation is one in which a variety of factors are evaluated using orthogonal tables. The implementation allows for a thorough understanding of the test, and statistical analysis can be used to identify the test's primary and secondary elements (Dong et al., 2011). As a result of the orthogonal experimental design, not only do the experimental parameters improve, but the workload is also greatly reduced.

An orthogonal L (3)4 array design was used to determine the optimal tea polyphenol extraction condition (Table 1). There were four factors and levels in the experiment (Table 1) (Bian et al., 2014; Masoumi et al., 2011): microwave intensity (200 W), Time taken for microwaves to radiate (1, 2, 3, 4 minutes), the ratio between tea and water (1:5, 1:10, 1:15 and 1:20), and the number of times microwaves are radiated (four) (1, 2, 3, 4). The single-factor test was used to determine the range of each factor level. Variables that were dependent on each other were tea polyphenol extraction yield and tea polyphenol EGCG content. The single-factor test was used to determine the range of each factor level (Liu et al., 2019; Luo et al., 2020; Park et al., 2020). Variables that were dependent on each other were tea polyphenol extraction yield and tea polyphenol EGCG content. A total of three extraction tests were carried out on each sample. It appears that microwaves did not disrupt the structure of tea polyphenols, based on preliminary results (Luo et al., 2020).

2.2 Statistical analysis

Statistica software (Sarumathi et al., 2015) was used to calculate the mean and standard deviation results. Analysis of variance and Duncan's multiple range test were used to determine the effect of microwave radiate time and multiple extractions on the concentration of extracted tea polyphenols.

3 Results and discussion

The chromatogram was examined for any possible anomalies. On the Hypersil ODS column, run under isocratic conditions, the standard solution contained 2.00 ppm EGCG. The flow rate was 1 mL/min, and the mobile phase was water:methanol: acetic (73:23:2), as shown in Figure 1a (Piacentini et al., 2018). When peak areas versus concentration were plotted for the detector, the response was linear for a set of standards varying from 0.05 to 3.00 ppm. Our next step was to analyze the raw material, which is depicted by the chromatogram shown in Figure 1b (Bailey et al., 1991).

Variations in flow rate and liquid phase contents were used in a series of studies in an attempt to enhance peak uniformity. With this method of analysis, we hoped that we could simplify the chromatography and reduce the analysis time. This was determined by measuring the peak area of a standard curve. As a result of regression analysis, it was possible to establish a linear relationship between EGCG concentration and peak area (Kim et al., 2016; Lee & Lee, 2008). A strong linear relationship

Table 1. Microwave tea polyphenol extraction using an orthogonal study approach.

Tier	The intensity of microwave radiation	Time for microwave radiation	The ratio of tea to water.	The number of times microwaves are radiated
4	800	4	1:20	4
3	600	3	1:15	3
2	400	2	1:10	2
1	200	1	1:5	1

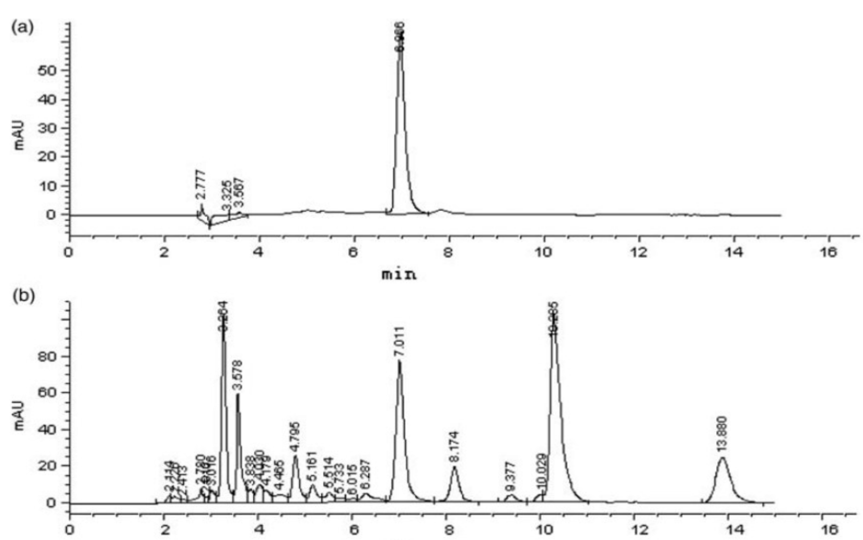

Figure 1. In addition, the raw materials were analyzed using the same reference solution that included 2.00 parts per million of EGCG. In this case, the ratio of wastewater to water was 73:23:2. water:methanol:acetic. This was done by injecting 10ml of sample into an auto-sampler, which had a detection wavelength of 278nm.

was found between the concentrations of EGCG, which was in the range of 0.0176 to 0.1056 mg/mL.

$$y = 8946.42857x - 24.93333 \left(R^2 = 0.99945\right) \quad (2)$$

Equation 2, where y is the EGCG mass, and x is the peak area, respectively. Decaffeinated material had a polyphenol concentration of 0.86 percent, which was greater than the norm of 0.6–0.8 percent, based on Equation 1.

3.1 Single factor test

The water capacity and recovery duration were set at 400 mL and 3 minutes, correspondingly., in Figure 2a. A linear upward trend was observed for tea polyphenol extraction as microwave intensity increased, particularly when microwave intensity exceeded 600 W. Due to increased extraction temperature and increasing microwave intensity, catechin content and quality may be affected.

As a result, a 600 W microwave was sufficient. Catechins did not oxidize at 600 W microwave power. Using 400 mL of water and 600 W of microwave power, tea polyphenol extraction yield increased rapidly., respectively (Figure 2b). Four minutes of microwave radiation were chosen to conserve energy, improve performance, and limit polyphenol degradation, transformation, and mutual interactions between complexes (Kim et al., 2016; Lee & Lee, 2008).

It was decided to extract tea polyphenols at 600 W for 4 minutes with 400ml of water, using microwaves that were radiated one to five times. Figure 2c shows the results of the study. When the microwave was radiated twice, the tea polyphenol extraction yield increased significantly, but the tea polyphenol extraction yield increased only slightly when it was radiated more than twice. So, the number of times the microwave could be emitted increased to two.

A ratio of 1:5 to 1:20 (g/mL) of tea to water and a consistent tea weight., we extracted tea at 600 W for four minutes and twice with microwave radiation (35 g). Figure 2d shows the results of the study. Initially, the extraction yield increased as the tea-to-water ratio was increased. The extraction rate peaked with a tea/water ratio of 1:10; after that, it plateaued and dropped significantly when the ratio increased to 1:15. This could be because the extract solution heated more efficiently when the tea/water ratio was set to 1:10. Caffeine and polyphenols undergo a complex reaction that results in more complexes than free caffeine when the tea/water ratio is increased to 1:10, and tea polyphenol extracts are increased. A ratio of 1:10 allows you to extract more tea with less work and less energy during the concentration and drying phases. Therefore, a ratio of 1:10 between tea and water was sufficient.

3.2 An investigation of the optimal parameters for extracting tea polyphenol

MAE must be optimized because of the many factors that influence it. A single factor test was used in an orthogonal experiment (L9(3)4) to investigate the combined effects of Tea/water ratio, microwave intensity, and the number of radiate times in order to determine the optimal extraction conditions (Asiri & Isloor, 2020; Cerbin-Koczorowska et al., 2021).

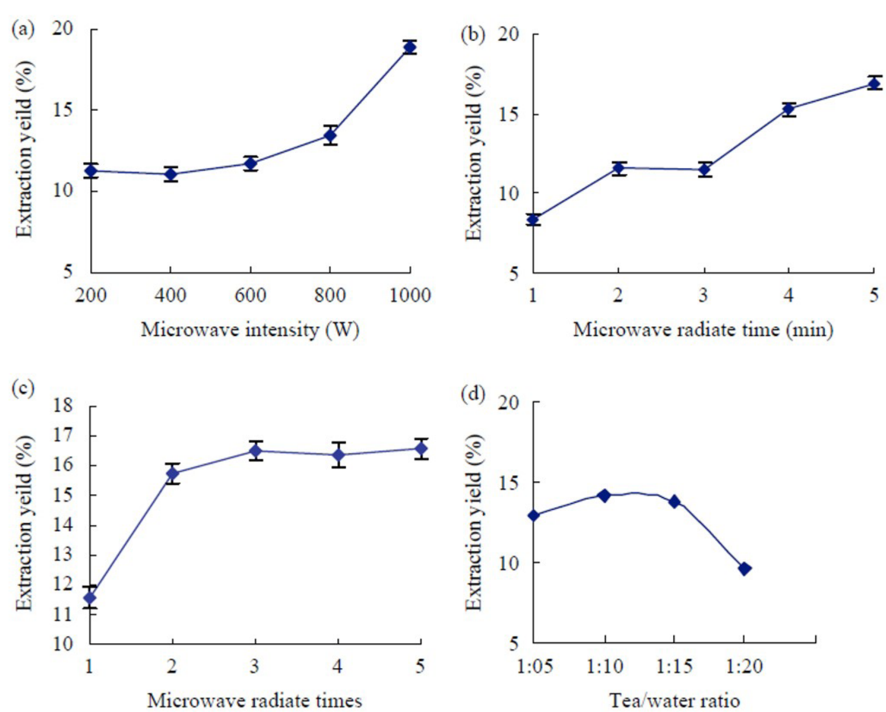

Figure 2. Effect of different (a) microwave intensity, (b) time for microwave radiation, (c) Number of times microwaves are radiated (d) The effect of tea/water ratio on the extraction rate of polyphenol.

Table 2 presents the results of orthogonal experiments. We use statistical software to determine K (range analysis) and R (variance analysis) values. The results are shown in Table 2 and Table 3. As shown in Table 3, the microwave radiation period is the most important factor in extracting polyphenols, followed by microwave intensity, tea/water ratio, and microwave radiate time. Their relative importance is in terms of the number of times they radiate (R values). On average, the microwave intensity was 600 W, the microwave radiate time was 3 minutes, the microwave radiate frequency was 1, and the ratio of tea to water was 20:1.

Microwave irradiation time played an important role; longer microwave irradiation times led to higher extraction yields. The extraction yield increases with microwave intensity. Increasing the ratio of tea to water increases the extraction yield, whereas reducing the radiation frequency reduces the yield.

3.3 Autoxidation in food

Lipid autoxidation begins with radical lipid formation and continues with lipid peroxyl radicals and lipid hydroperoxides, respectively. Fish and meat products are also susceptible to lipid autoxidation, especially dry foods like milk powder, crackers, and breakfast cereals. Natural antioxidants, such as thyme, rosemary, and grape seed extract, are replacing synthetic antioxidants in increasing numbers. However, natural antioxidants should have no taste or odor. They should also not change the food's flavor or taste in any way possible. As a result, while rosemary extract was used as a food ingredient, it suffers from a very strong herb flavor. A growing number of industrial products, including cosmetics, foods, and beverages, contain tea extracts.

3.4 Antioxidant activity

Electron transfer, hydrogen atom transfer, and chelation of catalytic metals are some of the putative antioxidant processes in polyphenols. In polyphenols, the fast conversion of a hydrogen atom to active radicals leaves fairly stable phenoxyl radicals behind. By reacting with other free radicals, the PP percent intermediate is able to effectively halt the propagation process. The antioxidant capacity of a substance varies depending on its chemistry. O-diphenolic groups on positions 3 and 5 of the flavonoid A-ring contribute less to antioxidant activity than do hydroxyl groups on positions 3 and 5 of the flavonoid B-ring. Two to three conjugated double bonds confer increased activity on flavonoids.

3.5 Antibacterial properties

Researchers have studied the antibacterial activity of green and black tea extracts against bacteria such as Salmonella typhi, Staphylococcus aureus, Plesiomonas shigelloides, and Vibrio cholerae. Listeria monocytogenes have also been shown to be

Table 2. Results of orthogonal experiments on polyphenol extraction using microwaves and a comparison of extraction yields at various factor levels.

Trial	Microwave intensity, A (W)	microwave's radiation period B (minute)	number of times that microwaves radiate, C	the ratio of tea to water, D	The yield of extraction (%)	amount of EGCG (%)
9	3	3	2	1	17.03	28.37
8	3	2	1	3	16.02	25.15
7	3 (800)	1	3	2	14.32	22.68
6	2	3	1	2	15.77	24.78
5	2	2	3	1	14.89	26.39
4	2 (600)	1	2	3	13.56	18.75
3	1	3 (5)	3 (3)	3 (1:20)	14.74	23.15
2	1	2 (3)	2 (2)	2 (1:10)	13.14	25.71
1	1 (200)	1 (1)	1 (1)	1 (1:5)	12.35	20.31
			Range analysis			
Rj	2.377	2.433	0.140		0.363	
K3	15.787	15.843	14.650		14.773	
K2	14.740	14.683	14.573		14.410	
K1	13.410	13.410	14.713		14.753	

Table 3. Extraction yield variance analysis based on factor levels.

Factor	the sum of squares of deviance	Degrees of freedom	Ratio	F critical value	Significance
Tea/water ratio	0.250	2	0.007	4.460	
number of times that microwaves radiate	0.029	2	0.007	4.460	
microwave's radiation period	8.888	2	2.011	4.460	*
Microwave intensity	8.513	2	1.926	4.460	*
Error	0.25	8			

*The factor has a large influence (P, 0.05). (P, 0.05).

susceptible to an extract of tea methanol. Many microorganisms have been studied using tea extracts and polyphenols as antibacterial agents. All Helicobacter pylori isolates were killed in less than 5 hours using both black and GTE antimicrobial agents. The antimicrobial activity of EGCG was investigated against a variety of Staphylococcus and gram-negative rods, including S. typhi, E. coli, and P. aeruginosa. The growth of Staphylococcus was inhibited at concentrations of 50–100 g/mL, and gram-negative germs were also inhibited at concentrations greater than 800 g/ml. Irradiated polyphenol extracts of green tea had a greater antibacterial effect on Streptococcus than nonirradiated extracts. Because of their antibacterial properties, tea extracts have been studied as antimicrobial additives and food packaging.

3.6 Antioxidant food additives based on tea extract

Food oxidation is primarily caused by temperature and oxygen. Odor and flavor are affected, as well as quality. Antioxidant compounds have therefore become popular in the industry as a result. Synthetic antioxidants such as BHT, BHA, ethoxyquin, TBHQ, and ascorbyl palmitate can be found in foods. They are highly stable and cost-effective, but their potential health effects should be taken into consideration. As a result of safety and health concerns, research into the development of effective and beneficial natural antioxidants is on the rise. Plant extracts such as rosemary, grape seeds, and sage, among others, contain natural antioxidants. As a result of their widespread availability, accessibility, and low cost, this is where tea extracts and polyphenols shine. Astringency and bitterness are added to many foods and beverages by polyphenols, which are also natural antioxidants.

Polyphenol tea extracts for antioxidant supplements have been the subject of many patent applications. Antioxidants from green tea leaves are reportedly being used as food additives. According to the authors, these additives are suitable for fry oils, pastry noodles, potato chips, and soy milk and poultry products, among other items. They also mention frozen fish and frozen pizza, as well as cheese and animal foods, in addition to dairy and meat. Aside from protecting food colors, the extracts have also been shown to lower cholesterol and protect against mutations.

3.7 Tea extracts and meat

As a result of lipid oxidation, meat and meat products degrade. Heme pigments cause rancidity and alterations in meat's flavor, odor, and color in muscle tissues. Any heating technique accelerates a meat's oxidative processes. On the other hand, a cooked protein is less resistant to the formation of free radicals than raw protein. Die lipid-oxidation-sensitiveness of meat is further affected by iron and unsaturated fat content. In order to prevent the oxidation of meat products, animals are fed antioxidant-rich food, the oxygen concentration in packages is reduced, antioxidants are added during the food processing process or incorporated into food packaging materials, among other things. There has been an increased interest in natural antioxidant supplements as a result of the trend toward adding them to foods. Several research on the utilization of polyphenols in meat products has been done. Other plant extracts and artificial antioxidants were also tested to see how effective they were. The majority of fish fat is made up of unsaturated fats like arachidonic acid. As a result, fish is more vulnerable to lipid oxidation than other forms of meat, including beef. Green tea and its catechins were tested for antioxidant activity in the fish, and artificial antioxidant additions were compared to green tea. According to this study, the catechin activity order is EGCG > ECG > EGC > EC. They were similar to or superior to artificial antioxidants such as TBHQ, BHT, and BHA in their ability to suppress the formation of thiobarbituric acid reactive substances (TBARS). The actions of tea catechins and green tea, on the other hand, were identical to those of EGCG, ECG, and EGC; in addition, catechins had the same activity order as BHT but were more active in a pork meat system.

Green, black tea extracts were tested for their ability to inhibit lipid oxidation in sardine, a tiny fish that degrades quickly after being caught in a net. Linoleic acid oxidation was inhibited by all the tea extracts examined. Further, the antioxidant activity of the extracts was found to be more closely related to the amount of total catechins than the number of total polyphenols present. EGCG was found to be the primary antioxidant polyphenol responsible for inhibiting lipid oxidation as a result of the testing teas (Camellia sinensis). Also, Researchers showed that black tea's oxidatively polymerized polyphenols could not protect sardines against deterioration.

Raw and cooked pig patties were studied for their antioxidant effects when tea catechins, ginseng, aloe vera, rosemary, and soya protein were added. Both raw and cooked meat showed varying levels of antioxidant activity. Cooked and uncooked meat both benefited from tea catechins. Rosemary, BHA, and BHT. For tea catechins, 0.25 percent was chosen as the ideal TBARS level.

Fresh and previously frozen pig patties were subjected to a study to determine the antioxidant effects of several natural food and plant extracts, such as tea catechins. Tea catechins had the highest antioxidant activity of any of the extracts tested.

Green tea extract was also tested on raw and cooked pork samples. Extracts were irradiated for a more vibrant color the storage durations on lipid oxidation and color were studied. The extract was added to meat to reduce lipid oxidation. The panelists preferred irradiation extracts added to patties for their odor. In food products, freeze-dried GTEs that have been irradiated can act as antioxidant additives, according to the study's findings.

In another study, the following antioxidant activities were ranked in order of importance: The following are the differences between GTE and BHT: In addition, green tea has been shown to enhance the sausage's sensory qualities. Aside from that, the addition of GTE had no impact on the pH level of the sausage. Naturally occurring antioxidants were also shown to be more effective than BHT at reducing putrescine, a poisonous chemical molecule formed during amino acid degradation. The use of GTE-enhanced sausages improved the safety of food., according to a recent scientific study. It was found that green tea powder reduced lipid oxidation in pork sausages but did not protect the color.

Beef, chicken, and duck were cooked, and the effects of adding tea catechin were investigated. This study investigated the fatty acid, lipid, and iron contents of beef samples. Additionally, salt was given to the non-treated beef samples in order to enhance lipid oxidation. Tea catechins were given in addition to untreated and salted meat samples. This indicates that tea catechins inhibited NaCl's prooxidant effect. At a dosage of 300 mg/kg, tea catechins were found to have substantial antioxidant action. It was necessary to use a greater amount of tea catechin on mackerel fish due to its higher levels of lipids and unsaturated fats.

The impact of adding tea catechins and vitamin C to cooked and raw beef and chicken meat burgers was examined. It was discovered that tea catechin concentrations of 200 mg/kg or 400 mg/kg protected lipids in cooked or raw beef patties. When it comes to lipid protection, catechins beat vitamin C. Tea catechins were found to be superior to vitamin C as natural antioxidant additions. As a beef patties preservative, GTE has also been shown to improve SO2's antioxidant and antibacterial properties.

3.8 Tea extracts and bread, rice, apple

When tea polyphenols were added to instant noodles, their shelf life was extended from nine days to three months. For up to nine weeks, GTCs remained stable when kept frozen at 20 degrees Celsius, and a GTE was used as an anti-oxidant in bread. After four days of storage at room temperature, catechin levels did not drop. Tea catechins are affected by temperature and pH. When the pH rises above 5, especially at high temperatures, catechins become unstable. It has also been speculated that when disulfide linkages in the gluten network cross-link during dough preparation, catechins could be lost due to interactions with wheat proteins. It was found that 93 percent of catechins were recovered from bread dough. Bread-making lost only 16 percent of the catechin. A 34 percent decrease was observed in the enzymes EGC, EGCG, and ECG concentrations, respectively. As a result of adding catechins, approximately 84 percent of the GTCs remained after baking, with no change to the color of the bread. Because it increases antioxidant intake, adding the extract to bread has a health benefit, say researchers. There are 28 mL of catechins in one 53-gram piece of bread that contains 150 mL of GTE per 100 g of flour, which is 35 percent more than the amount found in one green tea bag, according to a study (2 g).

Due to their anti-regressive properties, tea polyphenols have been used to extend the shelf-life of rice. The use of tea polyphenols as a rice supplement has been found to delay retrogradation. Amylose and amylopectin chains in gelatinized starch realign during retrogradation. GTE had a greater antioxidant effect on lipid oxidation in biscuits at a concentration of 1 percent than BHA did. In a second study, GTE was added to a dry apple product. It was also determined whether or not the antioxidative activity and color changes occurred. However, the color, scent, and taste did not change as a result of adding GTE to the dry apple.

4 Conclusion

The complexity of dietary polyphenols' chemical structures makes it hard to determine their overall quantity in foods and comprehend their function in health and disease prevention. Researchers found that MAE was especially effective at extracting tea polyphenols from green tea. Time spent in the microwave is the most important parameter, while the ratio of tea to water is the least important. The tea/water ratio and the number of microwaves radiates were found to be the most important factors affecting the extraction rate.

The best extraction performance was obtained with a microwave intensity of 600 W, microwave radiate time of 3 min, and a number of microwaves radiates of once in a 1:20 tea/water ratio. In terms of extracting phenols from tea leaves, microwave extraction appears to be a viable option. Antioxidants synthesized from synthetic materials can be replaced with plant extracts, such as green tea and catechins. They're anti-oxidants and antibacterial agents, which are beneficial to health. Therefore, they can improve a wide range of food products' quality and shelf life by utilizing GTEs Directly into food or packaged with food, and they can be used as additives. In addition, incorporating it into animal-based products has the potential to improve meat quality indirectly.

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