**CHAPTER 2**

**REVIEW OF LITERATURE**

*Terada A et al* [23] conducted a study to evaluate the supplements of tea polyphenols on the caecal flora and caecal metabolites of chicks. The study was done in eight 24-d-old and eight 56-d-old chickens, which consumed basal diet (control) or the diet supplemented with tea polyphenols (2g/kg diet) for periods of upto 56 d of age. On the day 24th, of tea polyphenol administration, the number of total bacteria and bacteroidaceae significantly decreased (p<0.01), but staphylococci increased (p<0.05). The frequency of the occurrences of pseudomonads and yeasts significantly increased (p<0.05), but that of moulds decreased (p<0.01). Also, caecal concentrations of ammonia (p<0.01), phenol (p<0.01), p-cresol (p<0.05) nd skatol (p<0.05), were significantly reduced. On day 56 of administration, lactobacilli significantly increased (p<0.05), whereas enterobacteriaceae decreased (p<0.05), as did the detection rate of proteus (p<0.05). caecal concentrations of ammonia (p<0.05) and ethyl phenol (p<0.05) were significantly reduced, but acetic and butyric acid increased greatly (p<0.05). The deodorant effect on caecal contents was noticeable during tea polyphenol administration.
**Christine W** [24] conducted a study to evaluate that drinking black tea may help prevent caries and periodontal disease. The study showed that the beverage interfered with harmful bacteria in the mouth that form dental plaque. It was found that chemical components in black tea called polyphenols suppressed the growth of caries-causing bacteria in plaque and reduced acid production levels. The polyphenols also inhibited glucosyltransferase—an enzyme produced by the bacteria—and prevented the formation of the matrix material that dental plaque uses to adhere to tooth surfaces. It was also found the size and stickiness of dental plaque were reduced because certain bacteria lost their ability to form aggregates with other bacteria when they were exposed to black tea. The study consisted of several trials in which volunteers rinsed their mouths with black tea at different intervals. In one trial, those who rinsed with black tea for one minute 10 times a day had less plaque accumulation. In another, a single 30-second rinse had no effect, but multiple rinsing’s prevented bacteria from growing further, as well as lowered acid production. It was resulted that “If sequenced properly between meals and normal oral hygiene, drinking black tea could reduce the number of cavities and prevent periodontal disease.”

**Lee K et al** [25] conducted a study to show that cocoa has more phenolic phytochemicals and a higher antioxidant capacity than teas and red wine. Black tea, green tea, red wine, and cocoa were high in phenolic phytochemicals, among
which theaflavin, epigallocatechin gallate, resveratrol, and procyanidin, respectively, were extensively investigated due to their possible role as chemopreventive agents based on their antioxidant capacities. The study compared the phenolic and flavonoid contents and total antioxidant capacities of cocoa, black tea, green tea, and red wine. Cocoa contained much higher levels of total phenolics (611 mg of gallic acid equivalents, GAE) and flavonoids (564 mg of epicatechin equivalents, ECE) per serving than black tea (124 mg of GAE and 34 mg of ECE, respectively), green tea (165 mg of GAE and 47 mg of ECE), and red wine (340 mg of GAE and 163 mg of ECE). Total antioxidant activities were measured using the 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) and 2,2'-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assays and are expressed as vitamin C equivalent antioxidant capacities (VCEACs). Cocoa exhibited the highest antioxidant activity among the samples in ABTS and DPPH assays, with VCEACs of 1128 and 836 mg/serving, respectively. The relative total antioxidant capacities of the samples in both assays were as follows in decreasing order: cocoa > red wine > green tea > black tea. The total antioxidant capacities from ABTS and DPPH assays were highly correlated with phenolic content (r^2 0.981 and 0.967, respectively) and flavonoid content (r^2 0.949 and 0.915). These results suggested that cocoa was more beneficial to health than teas and red wine in terms of its higher antioxidant capacity.
Matsumoto Met al [26] conducted a study where an oolong tea polyphenol (OTF6) showed to possess a strong anti-glucosyltransferase (GTF) activity and inhibit experimental dental caries in rats infected with mutans streptococci. The effects of OTF6 on the functional domains of GTFs of Streptococcus mutans, an N-terminal catalytic domain (CAT), and a C-terminal glucan-binding domain (GBD), were examined. The maximum velocity of glucan synthesis by recombinant GTFB (rGTFB) and GTFD (rGTFD) became significantly slower in the presence of OTF6, however, Km values remained stable when compared in their absence. These results suggested that OTF6 reduces glucan synthesis by non-competitively inhibiting the GBD of S. mutans GTFB and GTFD. Further, the recombinant proteins of CAT (rCAT) and GBD (rGBD) were expressed using Escherichia coli, and purified by affinity column chromatography. rGBD but not rCAT was found to possess dextran-binding activity, which was shown to be inhibited by OTF6. These results indicated that OTF6, a polymeric polyphenol specific for oolong tea was able to reduce glucan synthesis by inhibiting the GBD of S. mutans GTFB.

Sakanaka S et al [27] conducted a study to evaluate the effect of polyphenolic compounds isolated from green tea (camellia sinensis) on the
production of toxic end metabolites of Porphyromonas gingivalis and was investigated. Green tea polyphenols completely inhibited the production of n-butyric acid and propionic acid at a concentration of 1.0-2.0 mg/ml in general anaerobic medium (GAM). (-) – Epigallocatechin gallate (EGCg), which is a major component of tea polyphenols also inhibited the production of phenylacetic acid at 0.5 mg/ml in GAM broth. In the experiment using resting cells of P.gingivalis, phenylacetic acid was produced from L-phenylalanine and phenylpyruvic acid, but this reaction was also inhibited by EGCg, (-) –epicatechin gallate, and (-) –gallocatechin gallate. However (+) –catechin, (+) –gallocatechin, (-) –epicatechin, and (-) –epigallocatechin did not inhibit those reactions. These results indicated that the inhibitory effect in the production of toxic end metabolites of P.gingivalis can be attributed to the presence of the galloyl moiety, which was ester linked with the 3-OH of the catechin moiety in the polyphenolic compounds. This study showed that continuous application of tea polyphenols on a daily basis can be considered as a useful and practical method for the prevention of periodontal disease.

Dulloo A G et al [28] conducted a study to evaluate the thermogenic effect of tea and it was shown that it is generally attributed to its caffeine content. All studies were conducted on 7-8-week-old male Sprague-Dawley rats, which were
housed in a temperature controlled room (23°C) with a 12:12 h light-dark cycle. Chemical sympathectomy was performed using 6-hydroxydopamine (6-OHDA; Sigma, St Louis, MO) dissolved in distilled water containing 0.001 M HCL and equilibrated with nitrogen. Rats (n=5) were injected subcutaneously with 6-OHDA (50 mg/kg body wt) twice in a day (8:00 a.m. and 5:00 p.m.) and were killed 15 h after the second injection. The tissues were perifused with Krebs-Ringer bicarbonate buffer of the following composition (in mmol/l): 116.8 NaCl, 25 NaHCO$_3$, 5.9 KCl, 1.2 MgSO$_4$, 1.2 NaH$_2$PO$_4$, 1.25 CaCl$_2$, and 5 glucose. Measurement of tissue respiration rate was done. The green tea extract was added in the perifusion buffer medium, and the resulting suspension was automatically filtered before entering the respiratory chambers. Analysis of the filtrate from several samples of the green tea extract for caffeine and (-)-epigallocatechin gallate (EGCG, the most abundant of tea catechins) was performed by liquid chromatography with electrochemical detection, and yielded values, as percentage dry weight of extract, in the range of 5-10% for caffeine and 16-19% for (-)-epigallocatechin gallate. It was reported that a green tea extract stimulates brown adipose tissue thermogenesis to an extent which is much greater than can be attributed to its caffeine content per se, and that its thermogenic properties could reside primarily in an interaction between its high content in catechin-polyphenols and caffeine with sympathetically released noradrenaline (NA). Since catechin-
Polyphenols are known to be capable of inhibiting catechol-O-methyl-transferase (the enzyme that degrades NA), and caffeine to inhibit trancellular phosphodiesterases (enzymes that break down NA-induced cAMP), it was proposed that the green tea extract, via its catechin-polyphenols and caffeine, is effective in stimulating thermogenesis by relieving inhibition at different control points along the NA-cAMP axis. Such a synergistic interaction between catechin-polyphenols and caffeine to augment and prolong sympathetic stimulation of thermogenesis could be of value in assisting the management of obesity.

Subhashini R et al [29] conducted a study to profile the phenols and flavonoids content and to assess the antioxidative capacity in both cocoa and green tea. The study was undertaken to suggest that green tea and cocoa was found to prevent cardiovascular diseases, cancers and kidney stones. Commercial cocoa powder was bought from Cadbury’s India Pvt. Ltd. Green tea was obtained from Lipton. All other reagents used were of analytical grade. The samples were prepared according to serving size of green tea and cocoa. 7.3 g (2 tables spoonful) of commercial cocoa powder was dissolved in 200ml of double distilled water at 100°C. Green tea extract was prepared by infusing 2 g of green tea in 200 ml of double distilled water at 100°C for 2 mins. The samples were then centrifuged in a refrigerated centrifuge at 12000 g for 5 mins. The resultant
supernatants were used as final samples for both qualitative and quantitative analysis of phytochemicals. Qualitative analyses of phytochemicals were carried out in the aqueous extracts of cocoa and green tea. Estimation of total phenol, total flavanoids estimation, HP analysis and oxygen scavenging capacities were determined. The values were expressed in mean ± SD. Statistical analysis was done by students ‘t’ test and ‘p’ value was arrived at to assess the statistical significance of changes observed. The results of the study had revealed that one serving of cocoa had higher amount of polyphenols than that of green tea. Hence cocoa froths with antioxidants than green tea and its consumption can improve general health.

Erol N T et al [30] conducted a study to evaluate polyphenols, alkaloids and antioxidant activity of different grades Turkish black tea. The content of polyphenols and alkaloids of seven grades Turkish black tea was investigated as well as their antioxidant activity. Polyphenol and alkaloid contents of teas were determined using HPLC method. Antioxidant activity was evaluated by DPPH radical assay. In tea samples examined, two alkaloids (caffeine and theobromine), two flavan-3-ols (EGCG and ECG), three flavonol glycosides (Q3RG, Q3G and K3RG) and four individual theaflavins (TF-f, TF-3-G, TF-3′-G and TF-3,3′-DG)
were identified and quantified. Significant differences were detected in biochemicals content and antioxidant activity between different grades black teas. In general, the contents of alkaloids, Q3RG, Q3G and theaflavins in 1st, 2nd, 3rd and 7th grade teas and the contents of flavan-3-ols in 4th, 5th and 6th grade teas were found to be higher. However, there was no significant difference in K3RG content of the teas. 1st, 2nd, 3rd and 7th grade teas showed also higher antioxidant activity.

Yang CS et al [31] conducted a study to investigate if green tea consumption was associated with longer survival rates in ovarian cancer patients, and a lower risk of ovarian, breast, and colorectal cancer, in addition to adult leukemia. Tea was derived from the leaf of *Camellia sinensis*, a natural beverage widely consumed around the world. Geological and botanical evidence suggested that the tea plant originated from China. Varying methods of processing tea leaves lead to green tea, black tea, or Oolong tea, which differed in their concentrations of polyphenols. Green tea polyphenols appeared to have anti-tumorigenic properties, and form 30-40% of the dry weight of green tea compared with only 3-10% of black tea. Numerous studies in multiple animal models and different cancer cell lines had demonstrated the anti-tumorigenesis by green tea polyphenols. One
prospective cohort study in ovarian cancer patients, and five case-control studies in ovarian, breast, and colorectal cancers, and leukemia over the past decade was conducted. Tea consumption was measured using a structured questionnaire by face-to-face interviews. The validity and reliability of the questionnaire was assessed in a preliminary study, and then evaluated by a test–retest. Cox proportional hazards regression models were used to obtain hazard ratios (HRs), 95% confidence intervals (95% CIs), and were adjusted for age at diagnosis, locality, body mass index (BMI), parity, International Federation of Gynecology and Obstetrics (IFGO) stage, histologic grade of differentiation, cytology of ascites, residual tumour, and chemotherapeutic status. Odds ratios (ORs) and 95% CIs were obtained using logistic regression analyses, which accounted for demographic, lifestyle, hormonal and family cancer factors, and potential confounders. Higher green tea consumption was consistently observed as being associated with a lower risk of mortality due to ovarian cancer, and a decreased risk of ovarian, breast, and colorectal cancers, and adult leukemia occurrences in observational studies. The adjusted HR and 95% CI for case mortality from ovarian cancer was 0.40 (0.18-0.90) in the patients who consumed green tea at the highest level compared with non-tea drinkers. Compared with never or seldom tea drinkers, the adjusted ORs ranged from 0.07 to 0.61 for ovarian, breast, and colorectal cancers, and adult leukemia in those who consumed green tea at the
highest level. Significant inverse dose-response relationships were also observed for quantity, duration, and frequency of green tea consumed. It was concluded that regular consumption of green tea enhanced survival of ovarian cancer, and decreased risks of ovarian, breast, and colorectal cancers, and adult leukemia. Evidence from the observational studies supported the protective effect of green tea against cancers, and this evidence provided a knowledge platform from which to launch interventional studies for cancer prevention in the next stage.

Pujar et al [32] conducted a study to evaluate antimicrobial efficacy of Triphala, Green tea polyphenols (GTP) and 3% of sodium hypochlorite against E. faecalis biofilm formed on tooth substrate. Human extracted teeth were biomechanically prepared, vertically sectioned and placed in wells containing E. faecalis to form a biofilm. After 2 weeks all groups were treated for 10 minutes with test solutions (Triphala, GTP, 3% of sodium hypochlorite and saline) and were analysed quantitatively. Quantitative analysis showed complete inhibition of bacterial growth with 3% of sodium hypochlorite. Groups treated with Triphala, GTP and saline showed 2.3±0.59 × 104 CFU/ml, 3.8±0.79 × 104 CFU/ml and 9.90±0.52 bacterial growth respectively. Sodium hypochlorite had shown maximum antibacterial activity against E. faecalis biofilm formed in tooth substrate. Triphala and GTP had shown significantly better antibacterial activity.
Herbal alternatives were considered as root canal irrigants, considering the undesirable effects of sodium hypochlorite.

Abd Allah A et al [33] conducted a study to evaluate the antimicrobial effect of black tea against streptococcus mutans and lactobacillus species in adult Egyptian citizens. The unstimulated saliva samples were obtained from participants (pre, immediately post and after 1 hour of tea drinking) by spit in sterilized containers. The samples were added to transporting media and transmitted to bacteriological laboratory for culturing and counting. Results showed that the black tea beverage had a highly significant effect on reducing the cariogenic bacterial counts. This reduction reached to 60 and 99.9% of streptococcus mutans and 91 and 98% of lactobacillus in the immediately post and after 1 h of tea drinking samples, respectively. Also, the moderate consumption of tea (3-4 cups/day) exhibited extremely low values of lactobacillus (2.4x10 - 4.7x10 ) and DMF 4 3 score (5.6). It could be concluded that, black tea exhibited strong antimicrobial effect against streptococcus mutans and lactobacillus bacteria. Consequently it was recommended as an effective natural beverage to combat dental caries.

Naderi N J et al [34] conducted a study to determine the anti *Streptococcus mutans* activity of Iranian green and black tea (non fermented and fermented type).
Dental caries is a common infectious disease. *Streptococcus mutans* is the prevalent decay microorganism. The anti *Streptococcus mutans* activity of non-fermented and semi-fermented tea has been shown. The study was experimental. The aerial parts of wild-growing Camellia sinensis were collected from Lahijan province. The methanolic extract of green and black tea were examined on *Streptococcus mutans* (ATCC3566). Five different concentrations (50mg/ml, 100mg/ml, 200mg/ml, 300mg/ml and 400 mg/ml) of tea extracts were tested using the well assay method. The agar dilution method recommended by the NCCLS standards (National Committee for Clinical Laboratory Standards) was used. The minimum inhibitory concentration (MIC) was determined as the lowest concentration of extract inhibiting visible growth of the organism on the agar media plate. Minimum bactericidal concentration (MBC) was detected from MIC. The Iranian green and black tea had an antibacterial effect on 100 to 400 mg/ml concentrations. The minimum inhibitory concentration of green and black tea was 150 and 50 mg/ml, respectively. The mean diameter of inhibition zone were 9.5 mm and 10.9 mm for methanolic extract of green and black tea, respectively. Both Iranian non-fermented (green tea) and fermented (black tea) had anti *Streptococcus mutans* activity in vitro. The anti *Streptococcus mutans* activity of black tea appeared on a lower concentration than green tea.
Olosunde OF et al[35] conducted a study to conduct phytochemical screening of different black tea brands. Different commercial brands of black tea i.e. paper packed, loose and tea bags were procured from the local market. Reagents and standards were purchased from Sigma-Aldrich (Sigma-Aldrich Tokyo, Japan) and Merck (Merck KGaA, Darmstadt, Germany). The collected tea samples were stored at ambient temperature for further study. The tea samples were analyzed for moisture, ash, crude protein, crude fat and crude fiber according to their respective methods. The moisture content was estimated according to official method 44-01 by drying the sample in a hot air oven at 105±5o C till the weight of the sample became constant. The moisture content was calculated. Total ash was estimated by direct incineration of sample taken in a tarred crucible according to AACC (2000) method 08-01. Result regarding the moisture, fat, protein, fiber and ash fluctuated from 6.09 to 7.08, 7.67 to 4.02, 3.13 to 1.82, 1.36 to 2.51 and 4.95 to 5.11% respectively. Mineral contents for sodium ranged from 2.3 to 3(mg/100g) as compared to ca that ranged from 13.9 to 17.2 (mg/100g). Appreciable level of other minerals was also detected in the study. In concluding Pakistani teas performed satisfactory in context of international standards and provide additional health attribute that may be proved important to mitigate different ailments bestowed by this computer driven world.
Deshpande N et al [36] conducted a study and demonstrated the beneficial effect of green tea extracts on periodontal diseases, but very few studies have correlated the daily dietary oral intake of green tea to the periodontal status of patients. This randomized, controlled, investigator-blind trial was undertaken to correlate the periodontal status with daily dietary intake of green tea. The subjects were divided into three groups using block randomization method depending on the type of therapy received, viz., scaling and root planing alone, scaling and root planing along with green tea intake, and green tea alone. The clinical parameters were recorded at baseline, 3 and 6 months. The results of the study demonstrated the positive and statistically significant (P < 0.05) effects of oral intake of green tea on periodontal disease. This study reaffirmed the beneficial effects of green tea on periodontal diseases for prophylactic as well as therapeutic purpose.

Yashin et al [37] conducted a study to evaluate the bioavailability of active components of green and black teas--in hot brewed tea, cold tea, and dietary supplements containing tea extracts. Many publications demonstrated that consumption of tea increased the antioxidant status of a person (between 3.5-76%) and reduced the concentration of oxidative stress biomarkers in biological fluids. In 1-2 hours after tea intake, epigallocatechin gallate (EGCG), epicatechin (EC),
and epicatechin gallate (ECG) at a level of 5-150 ng/ml were detected in plasma by HPLC. The results of pharmacokinetics and metabolism of biologically active tea components analysed within 24 hours in plasma, urine, and faeces by HPLC-MS and GC-MS were presented. Dozens of metabolites were identified in urine and plasma—these are methylated, sulfated, and glucuronide conjugates of catechins. Some metabolites were shown to have high antioxidant activity. The role of the small intestine and colon in absorption of catechins was also identified.

**Shriparna Biswas et al [38]** conducted a study with the aim to evaluate and compare the effects of commercially available Green Tea mouth wash with Listerine and Chlorhexidine mouth wash in gingivitis patients. 48 patients, underwent scaling and were randomly categorized into 4 groups i.e. Group I: patients received green tea, Group II: patients received Chlorhexidine mouthwash, Group III: patients received Listerine mouthwash and Group IV: patients who received placebo mouthwash (distilled water). The plaque index, gingival index and bleeding index of the patients were recorded at baseline followed by scaling and at 14th day and 21st day, postoperatively. The results demonstrated Green tea to be equally effective in reducing the periodontal indices as Chlorhexidine. Significant reduction was seen in plaque, gingival and bleeding indices in all the groups. Use of Green tea mouthwash is an effective antiplaque agent that is
comparable to Chlorhexidine mouthwash and can be used as an adjunct to regular mechanical plaque control practices and professional scaling, in gingivitis patients.

Ali Forouzanfar et al [39] conducted a review and found that Green tea has been used as a traditional medicine since 2700 BC and several studies have shown that green tea polyphenols inhibit the growth of oral and periodontal pathogenic bacteria and can improve oral and gingival health. In this clinical study the investigation was done to check the effect of green tea mouthwash on microbial dental plaque and gingival inflammation following periodontal surgery. A total of 34 crown lengthening surgeries were included in this study. After removing periodontal dressing, green tea mouthwash for the test group and placebo for the patients in the control group were prescribed, and periodontal parameters were assessed at base line and after 2 weeks. Analysis of the data revealed the significant effect of green tea mouthwash on reducing Plaque index (PI), Gingival Index (GI) and Bleeding on probing (BOP). Therefore it was be recommended as a safe, anti-inflammatory and anti-microbial mouthwash for treating gingival inflammation and maintaining oral and gingival health.
Harjit Kaur et al[40] conducted a review and found that increasing number of people all around the world are turning to nature by using the natural herbal products. Green tea with active chemical ingredients possesses diverse pharmacological properties. The aim of this study is to compare the antiplaque efficacy of green tea catechin mouthwash with chlorhexidine gluconate mouthwash. A single blinded cross-over study was conducted among 30 participants in the age group of 18-25 years. The mouthwash samples for the study were previously labeled assigning the letters: A (0.25% of green tea catechin mouthwash) and B (0.12% of chlorhexidine mouthwash). The study subjects were randomly divided into two groups of 15 each and the study was divided into two phases. In phase I, the mouthwash A was given to one group and other group was given mouthwash B. After a 15 day washout period, in phase II, both groups were given other mouthwash. At the end of each phase of 1 week, plaque score was recorded by using Turesky modification of the Quigley-Hein plaque index. The plaque scores were compared and the difference between the green tea catechin and chlorhexidine mouthwash was determined by t-test. The difference between plaque scores were not statistically significant (P > 0.05). The results showed that both the groups that is green tea catechin mouthwash (0.25%) and chlorhexidine mouthwash (0.12%) have comparable results in plaque reduction. This study supported the effectiveness of green tea catechin mouthwash as an antiplaque...
agent. It should be explored as a cost-effective, long-term antiplaque rinse with prophylactic benefits.

Shazia Mushtaq et al[41] conducted a review to evaluate the effect of green tea on teeth. Green tea is considered a healthful beverage due to the biological activity of its polyphenols namely catechins. Among the polyphenols EpigalloCatechins 3 gallate and Epicatechin 3 Gallate are the most predominant Catechins. It can play an important role in fighting bacteria in the mouth, freshening the breath, and warding off cavities. Green tea Catechins can help fight the cavity producing effects of S. mutans by destroying them, making tooth surface more slippery, so that bacteria have harder time to cling to teeth, inhibiting production of plaque and reducing ability of bacteria to produce the enamel-eating acid. In addition antioxidant, antimicrobial, anticollagenase, antimutagenic and chemopreventive properties of these Catechins provide to be helpful in the treatment of chronic diseases like periodontal diseases.

Sweta S et al[42] conducted a review which appraises the available evidence for and against the health claims associated with green tea and its use as preventive and therapeutic products for periodontal disease. However, considerable
work is still needed to confirm these potential health benefits. Periodontal diseases, if left unchecked, can lead to major health problems. There are a number of traditional herbal remedies for the treatment and management of diseases related to periodontium and oral hygiene. Green tea has long been used in much of the world as a popular beverage and a respected medicinal agent. Early Chinese medical literature lists green tea as an antibacterial, astringent, antioxidant, anticaries, anti-inflammatory, circulatory-stimulant, haemostatic, anti-halitosis. In recent years, there has been a significant upsurge in research on the characterization and verification of the potential health benefits associated with the use of green tea. The use of green tea in promoting gastrointestinal and cardiovascular health, use in prevention of cancer and neurodegenerative diseases and other infectious conditions like periodontal disease.

Sinija V. R. et al [43] reviewed the major health benefits of green tea, focusing on the catechins. The plant Camellia sinensis yields a variety of white, green and black tea. Tea is one of the most widely consumed beverages in the world, next only to water for enjoyment and health. In general, green tea has been found to be superior to black tea in terms of health benefits. The major components of interest are the polyphenols which are responsible for the antioxidant and other health benefits of green tea. The major polyphenols in green tea are flavonoids.
The four major flavonoids in green tea are the catechins, epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG) and epigallocatechin gallate (EGCG). Epigallocatechin gallate is viewed as the most significant active component. The processes used in the manufacture of black tea are known to decrease levels of the monometric catechins to a much greater extent than the less severe conditions applied to other teas. Much research is available depicting the health benefits of green tea for a wide variety of implications, including different types of cancer, heart disease, liver disease, etc. There is also a wide range of uses for green tea in diabetes, exercise enhancement, inflammatory bowel disease, skin disorders, hair loss, weight loss and iron overload.

Abdolhosein Moghbel et al[44] showed that compounds present in both green and black teas have been shown to inhibit the growth and activity of bacteria associated with mouth infections. The aim of this study was to assess the effects of green tea leaves extract on the aerobic mouth bacterial load. A total of 25 volunteer female students, aged 20-25 years, were selected and then evaluated by green tea extract and mouthwashes containing 0.2, 0.5, and 1% tannin, as the most effective antibacterial complex in green tea. Then a comparative study was conducted on a green tea mouthwash containing 1% tannin with 10% ethanol, a alcohol free mouthwash, and a green tea herbal mouthwash with a chlorhexidine 0.2% sample,
as and chemical brand. Green tea mouthwash containing 1% tannin was more effective than other concentrations (P<0.05). The herbal green tea mouthwash could reduce the aerobic mouth bacterial load and may prevent plaque formation on teeth and come over halitosis due to infection of the bacteria. Also, it is a safe and nontoxic mouthwash especially for children and pregnant women.

**Srividhi P. B et al**[45] conducted a study to demonstrate the beneficial effect of tea on dental caries. The aim of the present study was to compare and evaluate the effect of green tea and black tea infusions on salivary pH in caries free and with caries individuals. Randomized double-blinded concurrent parallel study. Forty healthy subjects, aged 18-20 years participated in the study. Commercially available green tea (Tetley Pure Green Tea) and black tea (Tetley Black Tea) were used in the study. The pH of saliva and of the tested tea products was determined with a digital pH meter. pH of whole saliva was measured at baseline and immediately after the intake of product (0), 5, and 10 min later. Data analysis was carried out by Student’s t-test and repeated measure ANOVA. Results: In vitro pH determination of infusion showed pH value of green tea (6.27 ± 0.02) was higher compared to black tea (6.13 ± 0.03). Both green and black tea infusion intake led to a statistically significant rise in salivary pH, both in caries-free and with caries groups, which remained above the base salivary pH over the whole period of
measurements. The present study demonstrated that after intake of both green and black tea there was an increase in salivary pH both in caries-free and with caries groups. The pH rise was more in green tea intake compared to black tea.

*Carmen C. et al*[46] reviewed that tea is the most consumed drink in the world after water. Green tea is a ‘non-fermented’ tea, and contains more catechins, than black tea or oolong tea. Catechins are in vitro and in vivo strong antioxidants. In addition, its content of certain minerals and vitamins increases the antioxidant potential of this type of tea. Since ancient times, green tea has been considered by the traditional Chinese medicine as a healthful beverage. Recent human studies suggest that green tea may contribute to a reduction in the risk of cardiovascular disease and some forms of cancer, as well as to the promotion of oral health and other physiological functions such as anti-hypertensive effect, body weight control, antibacterial and antivirasic activity, solar ultraviolet protection, bone mineral density increase, anti-fibrotic properties, and neuroprotective power. Increasing interest in its health benefits has led to the inclusion of green tea in the group of beverages with functional properties. However, although all the evidence from research on green tea is very promising, future studies are necessary to fully understand its contributions to human health, and advise its regular consumption in Western diets, in which green tea consumption is nowadays limited and sporadic.
Sabu M Chacko et al [47] found that the health benefits of green tea for a wide variety of ailments, including different types of cancer, heart disease, and liver disease, were reported. Many of these beneficial effects of green tea are related to its catechin, particularly (-)-epigallocatechin-3-gallate, content. There is evidence from in vitro and animal studies on the underlying mechanisms of green tea catechins and their biological actions. There are also human studies on using green tea catechins to treat metabolic syndrome, such as obesity, type II diabetes, and cardiovascular risk factors. Long-term consumption of tea catechins could be beneficial against high-fat diet-induced obesity and type II diabetes and could reduce the risk of coronary disease. Further research that confirms to international standards should be performed to monitor the pharmacological and clinical effects of green tea and to elucidate its mechanisms of action.

Balappanavar AY et al [48] conducted a study to evaluate and compare the effectiveness of tea, neem, and chlorhexidine mouthwashes on oral health. A randomized triple blinded controlled trial was performed over 2 weeks. Thirty healthy human volunteers of age group 18-25 years were included & were randomly assigned to 3 groups of 10 each i.e., chlorhexidine gluconate, neem and tea. Plaque, gingival, and simplified OHI scores as well as salivary pH were recorded at baseline, immediately after 1st rinse, after 1 week, 2nd week, and 3rd
week. Plaque and gingival scores were reduced significantly for experimental and control groups. Anti-plaque effectiveness was highest in tea ($P < 0.05$). Neem and tea showed comparative effectiveness on gingiva better than chlorhexidine ($P < 0.05$). Authors concluded that a cost-effective and easily available herbs as adjuvant to oral hygiene maintenance may have a far reaching effect on the prevention as well as prevalence of oral diseases.

**Jenabian et al [49]** conducted a clinical trial to assess the efficacy of Green tea mouthwash on plaque-induced gingivitis as the most common form of periodontal disease. A single blinded placebo controlled clinical trial was conducted among 50 High school female students with chronic generalized plaque-induced gingivitis were distributed to receive either 5 ml of Green tea 5% two times/day or normal saline with the same dosage. At Baseline and five consecutive weeks Gingival index (Sillness & Loe), plaque index (Sillness & Loe) and bleeding index (Barnett) were recorded. A statistically significant improvement was observed in all periodontal indices during the study ($P < 0.001$). Although total amount of improvement was higher in mouthwash group, the differences did not reach a statistically significant level ($P > 0.05$, observed power for GI: 0.09, PI: 0.11 and BI: 0.07). Authors concluded that Green tea mouthwash may be a safe and feasible adjunct treatment for inflammatory periodontal diseases.
Kaur H et al [50] conducted a study to compare the antiplaque efficacy of green tea catechin mouthwash with chlorhexidine gluconate mouthwash. 30 participants were equally divided into two groups of 15 each and the study was divided into two phases. In phase I, the mouthwash A was given to one group and other group was given mouthwash B. After a 15 day washout period, in phase II, both groups were given other mouthwash. At the end of each phase of 1 week, plaque score was recorded by using Turesky modification of the Quigley-Hein plaque index. The plaque scores were compared and the difference between the green tea catechin and chlorhexidine mouthwash was determined by t-test. It was observed that both the groups have comparable results in plaque. This study supports the effectiveness of green tea catechin mouthwash as an antiplaque agent.

Rassameemasmaung S et al [51] conducted a study to determine the effect of green tea mouthwash on oral malodor, plaque, and gingival inflammation. Sixty Gingivitis subjects who had over 80 parts per billion of volatile sulfur compounds (VSC) in the morning breath were randomly assigned into green tea or placebo mouthwash group. At baseline, VSC, Plaque Index (PI) and Papillary Bleeding Index (PBI) were recorded. Participants were instructed to rinse with the assigned mouthwash twice daily, and VSC level was remeasured at 30 minutes and 3 hours
post-rinsing. It was found that, VSC level in the green tea group was significantly reduced in the Green tea group when compared to the placebo. PI and PBI were significantly reduced in both groups. Authors concluded that green tea mouthwash could significantly reduce VSC level in gingivitis subjects after rinsing for 4 weeks.

Hirasawa M et al [52] conducted a study to examine the inhibition of acid production from dental plaque and mutans streptococci by epigallocatechin gallate (EGCg), one of the green tea catechins. 15 Subjects were selected from among laboratory staff and dental students. They were instructed to rinse their mouths with 2 mg/ml EGCg solution and then, after 30-min interval, rinsed their mouths with 10% sucrose. Plaque samples were collected at appropriate times and the pH was measured. It was found that the pH values of plaque samples from 15 volunteers were significantly higher after treatment with catechin than after treatment with water. EGCg and epicatechin gallate inhibited lactate dehydrogenase activity much more efficiently than epigalocatechin, epicatechin, catechin or gallocatechin. These results suggest that EGCg is effective in reducing acid production in dental plaque and mutans streptococci.
Neturi RS et al [53] conducted a crossover clinical trial to assess the effect of rinsing with green tea in comparison with chlorhexidine and plain water on *Streptococcus mutans* count. Study includes a total of 30 subjects aged 20 to 25 years divided into three groups that is green tea group, chlorhexidine group, and plain water group. Baseline plaque samples were collected and under supervision of examiner all the subjects rinsed with 10 ml of respective solutions for one minute. Plaque samples were collected at five minutes after rinsing. All the 30 subjects were exposed to all the three rinses with a wash out period of seven days between the interventions. All the samples were sent to microbial analysis. The study showed that both chlorhexidine and green tea significantly reduced *Streptococcus mutans* colony counts compared to plain water.

Awadalla HI et al [54] conducted a pilot study to assess the possible protective properties of green tea on oral health. The following measurements: Streptococcus mutans count in saliva and plaque, Salivary and plaque pH values, Gingival Bleeding Index were used. A total number of 25 patients were selected to participate in study and were asked before and after rinsing with green tea for 5 min. Dental plaque and saliva samples were collected in sterile polypropylene tubes using sterile curettes or probes at the beginning before intervention and then at 3, 7, 11, 20 and 30 min intervals. Collected samples were used for estimation of
salivary and plaque pH, determination of S. mutans counts in saliva and plaque. It was found that there was a statistically significant difference among subjects pre- and post-rinsing with 2% green tea for 5 min concerning S. mutans count in saliva and plaque, salivary and plaque pH values and GBI. Authors concluded that the local application of green tea as antibacterial agent is better as it decreases the acidity of the saliva and plaque, so it is a cost-effective prevention measure.

Gianmaria F et al[55] conducted a study to test in vivo the effectiveness of an experimental green tea extract in reducing levels of mutans streptococci and lactobacilli in saliva by means of selective culture medium. Sixty-six healthy patients ranging in age from 12 to 18 years were recruited and randomly divided into two groups: Group A (n = 33) and group B (n = 33). Group A subjects were asked to rinse their mouths with 40 mL of an experimental green tea extract, for 1 minute, three times a day for a week, whereas Group B subjects were asked to rinse with 40 mL of a placebo mouth rinse. Saliva samples were obtained at baseline, 4 days, and 7 days. The counts of mutans streptococci and lactobacilli were investigated by chair-side kits. Data were statistically processed. A regression binary logistic analysis was done. The statistical significance level was established at P < .05. The experimental group showed a statistically significant reduction in colony counts of mutans streptococci and lactobacilli relative to the control
group. These findings showed the efficacy of a green tea extract against cariogenic oral flora, opening a promising avenue of clinical applications in the preparation of specific and natural anticariogenic remedies.

**Luczaj W et al [56]** conducted a review on the effects of black tea on health with a focus on its antioxidative activity. A review of the different issues and studies relating to composition, manufacturing, and antioxidative effects of black tea and its components in vitro as well as in vivo was presented. It was found that polyphenols such as theaflavins and thearubigins as well as catechins as major constituents of black tea are mainly responsible for antioxidant actions. Antioxidative properties of black tea are manifested by its ability to inhibit free radical generation, scavenge free radicals, and chelate transition metal ions. Black tea, as well as individual theaflavins, can influence activation of transcription factors such as NFκB or AP-1. Theaflavins have been also proved to inhibit the activity of prooxidative enzymes such as xanthine oxidase or nitric oxide synthase.

**Yu et al [57]** studied the effects of green tea extract on caries inhibition of hamsters and on acid resistance of human tooth enamel. Both in vivo and in vitro experiments showed that original extract of green tea had the significant effects on
these points. The dialyzed tea solution in which the fluoride was removed almost completely, also showed the remarkable effects both *in vivo* and *in vitro* experiment as is similar to the original tea extract. The results obtained from this study suggested that fluoride in green tea may play a role to increase the cariostatic action in cooperation with other components in tea.

**Touyz and Amsel [58]** conducted a study to determine whether consumption of black tea influences cariogenesis in young, caries-prone rats. They concluded that consumption of black tea for 2 weeks attenuated development and progression of caries in caries-prone young rats.

**Linke and LeGeros**[59] conducted a study to determine the effect of a standardized black tea extract (BTE) on caries formation in inbred hamsters on a regular and a cariogenic diet. The results of the study indicated that frequent intake of black tea can significantly decrease caries formation, even in the presence of sugars in the diet.

**Mao-Jung et al [60]** conducted study to determine the usefulness of green tea leaves and black tea extract for the delivery of catechins and theaflavins to the oral cavity, high concentrations of catechins and theaflavins were observed in
saliva in the 1st hour. They concluded that tea leaves can be used as a convenient, slow-release source of catechins and theaflavins and provide information for the possible use of tea in the prevention of oral cancer and dental caries.

Yoshiharu et al[61] evaluated the influence of a bottled green tea beverage on dentin demineralization with a demineralization gel system. The green tea treatment showed significantly lower mineral loss. The sugar-free bottled green tea beverage inhibited dentin lesion progression, presumably due to the effect of sub-ppm fluoride levels.

Betul Rahman et al [62] conducted a study to compare the antiplaque and antigingivitis effects of a mouthwash containing tea tree oil (TTO) with a cetylpyridinium chloride (CPC) mouthwash. A randomized 4 × 4, controlled, cross-over trial was performed, involving 20 healthy volunteers in a 5-day plaque re-growth model. Test mouthwashes were TTO (Tebodont®) and a mouthwash containing CPC 0.05% (Aquafresh®). A 0.12% chlorhexidine (CHX) mouthwash (Oro-Clense®) was used as positive and colored water (placebo [PLB]) as negative controls. Gingival bleeding index (GBI) and plaque index (PI) scores were recorded before and after each test period. Test periods were separated with 2 weeks washout period. All four mouthwashes significantly \((P < 0.001)\) reduced the
GBI scores when compared to the baseline GBI scores. There was no significant difference between PLB and active mouthwashes in the GBI scores. CHX and CPC mouthwashes were found more effective in reducing the PI scores than TTO and PLB mouthwashes. There was no significant difference in PI scores of CHX and CPC mouthwashes. 0.05% CPC mouthwash can be an alternative to CHX mouthwash since it is alcohol free and found as efficient as CHX in dental plaque reduction with lesser side effects.

**Otake S et al [63]** conducted both in vitro and in vivo study. They found that the crude tea polyphenolic compounds (designated Sun-phenon®) from the leaf of *Camellia sinensis* were effective in inhibiting the attachment of *Streptococcus mutans* strain JC-2 (serotype c) to saliva-coated hydroxyapatite discs. Sunphenon was also inhibitory to water-insoluble glucan formation from sucrose by crude glucosyltransferase of *S. mutans*JC-2 (c). Among the tea catechins tested, (—)-epigallocatechin gallate and (—)-epicatechin gallate showed the most potent inhibition of the glucosyltransferase activity. Finally, significantly lower caries scores were observed in specific pathogen free rats infected with *S. mutans* JC-2 (c) and fed a cariogenic diet and/or drinking water containing 0.05% Sunphenon as compared with control rats not receiving polyphenolic compounds.
Yu, H. et al [64] conducted an in vitro experiment to determine the effects of tea components on the acid resistance of human tooth enamel. A further study focused on the action of tannin, the main component of tea, in combination with fluoride. Some components such as tannin, catechin, caffeine and tocopherol were demonstrated to be effective for increasing acid resistance, and their effects increased dramatically when they were used in combination with fluoride. A mixed solution of tannic acid and fluoride showed the highest inhibitory effect (98%) on calcium release to an acid solution. Tannin in combination with fluoride showed obvious inhibition of the formation of artificial enamel lesions in comparison with APF as determined by electron probe microanalysis, polarized-light microscopy and Vickers microhardness measurement. These results demonstrate that besides the fluoride, the organic components of tea also possess the property of increasing the acid resistance of tooth enamel. They also suggest that the organic components appear to play a primary role in their actions rather than fluoride.

Anand J et al [65] conducted a comprehensive study in which the methanolic, acetone and aqueous extract of leaves of Camellia sinensis var. sinensis [Kashmir (KW), Uttarakhand (IP & PN)] and Camellia sinensis var. assamica (Assam, AT) were explored for their phytoconstituents. Solvent extracts of Green Tea cultivars showed rich presence of phytoconstituents in comparison with aqueous extracts. The methanolic extract of AT and acetone extract of KW
showed highest total phenol content (18.32 ± 0.357 mg of GAE equivalent/g of sample) and total flavonoid content (29.25 ± 0.015 mg of catechin equivalent/g of sample), respectively. All the cultivars revealed higher free radical scavenging activity in the range of 73.80 ± 0.152 to 82.40 ± 0.004 % confirming antioxidant potentials. The HPLC analysis of purified residue procured from solvent partitioning depicted AT with highest concentration of epigallocatechin gallate (EGCg) i.e., 154.7 ± 4.949 mg/g followed by Kashmir and Uttarakhand GT cultivars. The study also revealed that Assam GT could be a potent herbal candidate with multiple nutraceutical applications.

Forouzanfar A et al [66] in a clinical study investigated the effect of green tea mouthwash on microbial dental plaque and gingival inflammation following periodontal surgery. A total of 34 crown lengthening surgeries were included in this study. After removing periodontal dressing, green tea mouthwash for the test group and placebo for the patients in the control group were prescribed, and periodontal parameters were assessed at base line and after 2 weeks. Analysis of the data revealed the significant effect of green tea mouthwash on reducing Plaque index (PI), Gingival Index (GI) and Bleeding on probing (BOP).

Sharma et al [90] conducted a prospective study on green tea where an increasing number of people all around the world are turning to the nature by using the natural herbal products in both prophylaxis and treatment of different diseases. Green tea
with active chemical ingredients possesses diverse pharmacological properties that include anti-inflammatory, anticariogenic, antioxidant, and antibacterial effects. The aim of this study is to assess the protective properties of green tea on periodontal health and also to know whether any side effect of green tea prevails in terms of staining of teeth. This is a prospective randomized clinical intervention study. Three dependent variables: probing depth (PD), clinical attachment loss (CAL), and bleeding on probing (BOP) were measured to reflect periodontal diseases. The three dependent variables, namely, PD, CAL, and BOP showed statistically significant reductions following introduction of green tea as a conjunct oral hygiene measure in study group as compared to control group. Green tea has shown the antioxidant, antimicrobial, and anticollagenase activities on periodontal health.

Ferial Taleghani et al [91] conducted a study to investigate the effects of daily intake of green tea herbal on clinical criteria in Periodontitis. Thirty patients with chronic periodontitis were randomly divided into control and experimental groups after scaling and root planning (SRP). Experimental group consumed green tea herbal for 6 weeks and the control group received no intervention. Clinical indices were measured before and 6 weeks after the intervention, and compared for each groups by non-parametric Wilcoxon test and between two groups by Man-Whitney test. Significance level of the test was considered at 95%. The results show that
probing depth (PD) and bleeding index (BI) reduced significantly in both groups before and after SRP, this reduction in the intervention group was higher than the control group (p=0.003 & 0.031, respectively) On the other hand, reducing the amount of plaque index (PI) despite being significant in each group, was not significant between the two groups.(P=0.135)According to the results of this study, daily consumption of green tea herbal can have a positive impact on the treatment of periodontal diseases and can be applied as a supplement for boosting the effects of a periodontal treatment's phase.

Han et al [92] performed to assess the relationship between the amount of green tea that is consumed and periodontitis. It is based on data obtained from the Korea National Health and Nutrition Examination Survey, conducted between 2008 and 2010. A community periodontal index equal to code 3 was defined as moderate periodontitis, and code 4 was defined as severe periodontitis (n = 16,726). Consumption of green tea less than one cup per day was associated with a decreased prevalence of periodontal disease among Korean adults. The association between the consumption of green tea and periodontal disease was independent of various potential confounding factors, such as age, sex, body mass index, smoking, drinking, exercise, metabolic syndrome, frequency of tooth brushing per day, use of secondary oral products, the number of dental examination per year, diabetes, hypertension, and white blood cell count. Adjusted odds ratio and 95% confidence
interval of no consumption was 1.360 (1.156, 1.601) when participants with consumption of two times per week did not exceed 7 times per week was considered as a reference. However, consumption of one or more cups per day increased the prevalence of moderate and severe periodontitis. In conclusion, excessive consumption of green tea may be considered as a risk factor for periodontal disease among Korean adults.

Samar. S [93] conducted a study to evaluate the effect of the daily intake of the green tea on the periodontal diseases. 60 systemically healthy female patients (age range 26-49 years) with chronic periodontitis and minimum of 20 teeth were selected from the outpatient department of the faculty. Pregnant and lactating mothers were excluded from the study. Patients were divided into three groups using a block randomization method. The first group received scaling and root planning alone (SRP). The second group (SRP+GT) received scaling and root planning at baseline along with green tea for a period of 4 months. The third group received only green tea (GT) for a period of 4 months without any professional SRP. All the three groups showed significant (P < 0.05) improvement in all the parameters measured at baseline and compared at 2 and 4 months. The comparison of Plaque Index 2 and 4 months was highly significant (P < 0.05) for all the three groups. Comparison of gingival index among the three groups at 4 months showed statistically significant results (P > 0.05). These results suggest significant
improvement in the oral hygiene status between groups as compared to baseline and at 2 months. The Periodontal Index comparisons between the groups at baseline scores, 2 months and 4 months did not showed any statistically significant outcomes \((P < 0.05)\). This study has reaffirmed the beneficial effects of green tea on periodontal diseases for prophylactic as well as therapeutic purpose.

Raju.R et al [94] conducted a study to compare the efficiency of green tea mouthwash, Listerine mouthwash and Chlorhexidine mouthwash in plaque reduction among orthodontic patients. The study employed a double blinded, simple randomized, cross over design with a control group consisting of 30 orthodontic patients undergoing fixed appliance therapy. All the subjects were divided into group 1 (Green tea), group 2 (Listerine) and group 3 (Chlorhexidine) as 10 subjects per group. Gingival status was assessed using Sulcus Bleeding Index and plaque accumulation was assessed using Turesky-Gilmore-Glickman modification of Quigley Hein Index. After a relapse period of 15 days, group 1 and 2 were crossed over, however, group 3 remained the same. Indices were again recorded at baseline and 15\(^{th}\) day. The mean gingival and plaque score was reduced in all the three groups. However, green tea mouthwash was estimated to have the highest mean difference from \(2.17 \pm 0.610\) at baseline to \(1.48 \pm 0.474\) on the 15\(^{th}\) day. Effective use of mouthwashes as supplements for tooth brushing has proved to be beneficial in oral hygiene and maintenance. The findings of this study
provide useful insights on the effectiveness of different compositions of mouthwashes.

**Mathur. A et al [95]** conduct a systematic review and if appropriate a meta-analysis of the efficacy of daily rinsing with green tea-based mouthwashes in terms of plaque index (PI) and/or gingival index (GI) as compared to other mouthwashes in plaque-induced gingivitis patients. MEDLINE, Cochrane Central Register of Controlled Trials, IndMed, Google Scholar, and major journals were searched for studies up to December 2016. A comprehensive search strategy was designed, and the eligible articles were independently screened for eligibility by two reviewers. Randomized controlled trials in which individuals were intervened with oral mouthwashes of interest were included. Where appropriate, a meta-analysis was performed and standardized mean differences (SMDs) for GI and PI were calculated. A total of 9 articles out of the 311 titles met the eligibility criteria. A meta-analysis was performed for five studies that compared green tea-based mouthwashes with chlorhexidine (CHX). The SMD for PI was $-0.14$ (95% CI: $-1.70, 1.43$; $P = 0.86$ and $I^2 = 94\%$), while that for GI was $0.43$ ((95% CI: -0.63, 1.49; $P = 0.43$, $I^2 = 89\%$). Both these estimates suffered from significant heterogeneity. For both PI and GI, two studies were in favor of green tea while three studies were in favor of CHX. Green tea-based mouthwashes can be
considered an alternative to CHX mouthwashes in sustaining oral hygiene, especially because of the added advantages provided by such herbal preparations.

**Chigasaki et al[96]** conducted a cross-sectional study to examine the periodontal status and prevalence of “red complex” bacteria (Porphyromonas gingivalis, Treponema denticola, and Tannerella forsythia) in Japanese adults. A total of 977 participants were enrolled in the study. Probing depth (PD), bleeding on probing (BOP), and bone crest level (BCL) were recorded, and the presence of red complex bacteria in the saliva was examined using polymerase chain reaction. The mean BCL value and the percentage of sites with a PD ≥4 mm or the presence of BOP were significantly higher in older participants. The detection rates of P. gingivalis, T. denticola, and T. forsythia were 46.3%, 76.4%, and 61.1%, respectively. The P. gingivalis detection rate significantly increased with age, while those of T. denticola and T. forsythia were comparably high for all age groups. A close correlation between P. gingivalis and the percentage of sites with PD ≥4 mm was indicated by nonlinear canonical correlation analysis. Current smokers exhibited a more advanced disease condition and a significantly higher P. gingivalis detection rate than non-smokers. In conclusion, periodontal condition worsens with age, and P. gingivalis appears to be the red complex bacterium most closely associated with periodontitis.

**Lagha.AB et al [97]** conducted a study on green tea polyphenols where the
gingival epithelium, a stratified squamous tissue that acts as an interface between the external environment and the underlying connective tissue, plays an active role in maintaining periodontal health. The aim of the present study was to investigate the ability of green tea catechins to enhance gingival epithelial barrier function and protect against the disruption of epithelial integrity induced by *Porphyromonas gingivalis*. Both the green tea extract and epigallocatechin-3-gallate (EGCG) dose- and time-dependently increased the transepithelial electrical resistance (TER) of a gingival keratinocyte model and decreased the permeability of the cell monolayer to fluorescein isothyocyanate-conjugated 4.4-kDa dextran. This was associated with the increased expression of zonula occludens-1 (ZO-1) and occludin, two tight junction proteins. Treating the gingival keratinocyte monolayer with *P. gingivalis* caused a reduction in TER and affected the distribution of ZO-1 and occludin, allowing *P. gingivalis* to translocate through the cell monolayer. These deleterious effects mediated by *P. gingivalis* were abolished by the green tea extract and EGCG. This protection may be in part related to the ability of tea catechins to inhibit the protease activities of *P. gingivalis*. Given the above properties, green tea catechins may represent promising preventive and therapeutic molecules against periodontal disease.

Chaterjee.A et al[98] summarized that green tea is particularly rich in health-promoting flavonoids (which account for 30% of the dry weight of a leaf),
including catechins and their derivatives. The most abundant catechin in green tea is epigallocatechin-3-gallate, which is thought to play a pivotal role in the green tea's anticancer and antioxidant effects. Catechins should be considered right alongside of the better-known antioxidants like vitamins E and C as potent free radical scavengers and health-supportive for this reason. It has been suggested that green tea also promotes periodontal health by reducing inflammation, preventing bone resorption and limiting the growth of certain bacteria associated with periodontal diseases.

Pietta.PG. et al [99] conducted a study on green study, concluding green tea contains relatively large amounts of catechins, that have been recognized to be efficient free-radical scavengers. In spite of a largely described antioxidant effect, the metabolic fate of catechins in humans has been scarcely studied. An infusion of green tea (about 400 mg of catechins) was given to healthy volunteers; plasma and urine samples were collected for 5 h and 2 days, respectively. Epigallocatechin gallate and epicatechin gallate were detected in plasma samples, reaching the maximum concentration (2 microM) at 2 h. Urine samples collected at 6-48 h contained detectable amounts of final catechin metabolites, including 4-hydroxybenzoic acid, 3,4-dihydroxybenzoic acid, 3-methoxy-4-hydroxy-hippuric acid and 3-methoxy-4-hydroxybenzoic acid (vanillic acid). The total content of these metabolites averaged 60 mg. The levels of free plasma catechins account
only partly for the increased (approximately +20%) total radical-trapping antioxidant parameter (TRAP) detected after green tea intake. Catechin conjugates (glucuronide and sulphate) and metabolites may add further contribution and explain the measured TRAP increase.

Radafshar G et al [100] conducted a study to explore the effects of Iranian green tea mouthwash containing 1% tannin on dental plaque and chronic gingivitis. In this randomized, double-blinded, parallel, controlled clinical trial, 40 volunteer dental students with a gingival index ≥1 were enrolled. At baseline, gingival, plaque, and bleeding indices were recorded and all the participants received dental polishing. Based on random allocation, 20 participants used the test and 20 used chlorhexidine mouthwash with no change in regular toothbrushing methods. The participants were asked to use 15 mL of the respective mouthwash for 1 min, twice a day for 28 days. All indices, as well as stain index, were recorded after 1 and 4 weeks post-rinsing. Data were analyzed using repeated-measures ANOVA and Bonferroni tests.

Significant in-group differences, but not between-group differences, were observed in all indices after 1 and 4 weeks compared to baseline. The test mouthwash resulted in significantly less tooth staining than the control. The 1% tannin green tea mouthwash could be a safe and feasible adjunct to mechanical plaque control.
The tested green tea mouthwash could be considered a good alternative for chlorhexidine in contraindicating situations.

_Antunes P et al_ [101] conducted a study to evaluate the effect of aqueous extract of green tea and the oral antiseptic without alcohol, on _Candida albicans_ biofilm formation to heat-curing acrylic resin plates. _Candida_ is associated with oral candidiasis in poorly cleaned dentures. Standardised specimens of heat-cured (Conv; \( n = 30 \)) or microwave-cured acrylic resin (Mw; \( n = 30 \)) were obtained and divided into six groups (\( n = 10 \)): G1 = Conv resin and green tea aqueous extract, G2 = Conv resin and mouthwash, G3 = control of Conv resin, G4 = Mw resin and green tea aqueous extract, G5 = Mw resin and mouthwash and G6 = control of Mw-cured resin. The specimens were contaminated with 10 ml of Sabouraud dextrose broth inoculated with 0.1 ml of standard suspension containing \( 1 \times 10^6 \) cells/ml of _C. albicans_ and incubated for 24 h at 37°C. After this period, they were immersed in the aqueous extract or in mouthwash for 15 min. The control groups were treated with sterile distilled water. Aliquots of 0.1 ml were plated on Sabouraud dextrose agar and incubated at 37°C for 24 h. The numbers of colony-forming units per test specimen (CFU/TS) were calculated, and the results statistically analysed by two-way ANOVA and Tukey's tests (5%). Statistically significant difference was observed for the aqueous extract groups (G1; 33.65%) and mouthwash (G2; 17.06%), when compared to control (G3; 100%), for Conv
resin. For the Mw resin, there was significant difference between mouthwash (G5; 43.16%) and control (G6; 100%). The aqueous extract of green tea and mouthwash led to a reduction in the number of viable fungal cells in biofilm formed on acrylic resin.

Hirshi T S et al [102] conducted a study to evaluate the effect of a locally prepared green tea dentifrice on specific parameters assessing gingival inflammation and severity of periodontal disease, when used as an adjunct to scaling and root planing (SRP) in the management of chronic periodontitis by comparing with a fluoride–triclosan-containing control dentifrice. Thirty patients, with mild to moderate chronic periodontitis, were randomly allocated into two treatment groups, ‘test’ and ‘control’ after initial SRP. The test group was given green tea dentifrice with instructions on method of brushing, while the control group received a commercially available fluoride and triclosan containing dentifrice. Clinical parameters of Gingival Index (GI), Plaque Index (PI), percentage of sites with bleeding on probing (BOP), probing depth (PD) and clinical attachment level (CAL) along with biochemical parameters of total antioxidant capacity (TAOC) and glutathione-S-transferase (GST) activity in gingival crevicular fluid (GCF) were recorded at baseline line and 4 weeks post-SRP. Intragroup analysis at 4 weeks showed statistically significant improvements of GI, PI, BOP, PD, CAL and TAOC in both groups. GST activity
however, was increased only in the test group. At the end of the study period, the test group showed statistically significant improvements in GI, BOP, CAL, TAOC and GST levels compared to the control group. On comparison with fluoride–triclosan dentifrice, green tea showed greater reduction of gingival inflammation and improved periodontal parameters. Green tea dentifrice may serve as a beneficial adjunct to non-surgical periodontal therapy.

Chava K Vijay et al [103] attempted to develop a thermo-reversible sustained-release green tea gel and to study its clinical effects on patients with chronic periodontitis (CP). Thermo-reversible sustained-release green tea catechin gel was prepared and tested for its in vitro release characteristics. An in vivo controlled, randomized, split-mouth single-evaluator masked study was conducted. Thirty patients with two sites in the contralateral quadrants having probing depths (PDs) of ≥4 mm were selected. Assessment of gingival index (GI), PD, and relative clinical attachment levels (rCALs) was done at baseline and at 4 weeks. Green tea and placebo gels were placed at test and control sites as an adjunct to Phase 1 periodontal therapy. Comparison of the mean ± SD GI, PD, and rCAL values within the test group at baseline (1.92 ± 0.24, 4.93 ± 0.58, and 9.97 ± 0.72, respectively) and the end of 4 weeks (0.01 ± 0.04, 2.87 ± 0.51, and 7.87 ± 0.51, respectively) showed high statistical significance ($P < 0.001$). Comparison of mean ± SD of GI, PD, and rCAL within the control group at baseline (1.95 ± 0.16, 4.77 ±
0.50, and 9.73 ± 0.45, respectively) and the end of 4 weeks (0.16 ± 0.11, 3.8 ± 0.48, and 8.76 ± 0.43, respectively) showed significance with P<0.001. High significance was observed between the delta of measurements (0 to 4 weeks) of GI, PD, and rCAL between test (1.91 ± 0.20, 2.06 ± 0.07, and 2.1 ± 0.21, respectively) and control (1.79 ± 0.05, 0.97 ± 0.02, and 0.97 ± 0.02, respectively) groups.

Adjunctive local drug therapy with thermo-reversible green tea gel has shown to reduce pockets and inflammation during the 4 weeks of the clinical trial in patients with CP.

Hara K et al [104] reviewed green tea as a popular drink throughout the world, and it contains various components, including the green tea polyphenol (−)-epigallocatechin gallate (EGCG). Tea interacts with saliva upon entering the mouth, so the interaction between saliva and EGCG interested us, especially with respect to EGCG–protein binding. SDS-PAGE revealed that several salivary proteins were precipitated after adding EGCG to saliva. Matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS) peptide mass fingerprinting indicated that the major proteins precipitated by EGCG were alpha-amylase, S100, and cystatins. Surface plasmon resonance revealed that EGCG bound to alpha-amylase at dissociation constant ($K_d = 10 \times 2.74 \times 10^{-6}$ M), suggesting that EGCG interacts with salivary proteins with a relatively strong affinity. In addition, EGCG inhibited the activity of alpha-amylase by
non-competitive inhibition, indicating that EGCG is effective at inhibiting the formation of fermentable carbohydrates involved in caries formation. Interestingly, alpha-amylase reduced the antimicrobial activity of EGCG against the periodontal bacterium *Aggregatibacter actinomycetemcomitans*. Therefore, we considered that EGCG–salivary protein interactions might have both protective and detrimental effects with respect to oral health.

**Suke Deepak Kumar et al [105]** conducted a study on antiplaque agent with minimal side effects that can be used as an effective adjunct to mechanical plaque control is needed. The current study is designed to evaluate efficacy of triphala (TRP) mouthwash in reduction of plaque and gingivitis. Ninety individuals with chronic generalized gingivitis were randomly assigned to three groups: 1) group I, placebo mouthwash; 2) group II, TRP mouthwash; and 3) group III, chlorhexidine (CHX) mouthwash. All individuals were instructed to rinse with their respective mouthwash twice daily. 1) Plaque index (PI); 2) gingival index (GI); 3) oral hygiene index-simplified (OHI-S); and 4) microbiologic colony counts were recorded at baseline and at 7, 30, and 60 days. All three groups showed gradual reduction in PI, GI, and OHI-S levels from baseline to 7, 30, and 60 days. There was also significant reduction in microbial counts in all groups at all time intervals except in group I. A significant difference was noticed with respect to reduction in PI, GI, OHI-S, and microbiologic counts in group I compared with groups II and
III. However, no significant differences were found between groups II and III for any parameters at any time intervals. TRP mouthwash was found to decrease inflammatory parameters from baseline to follow-up intervals. Because improvement in gingivitis was comparable with that of CHX mouthwash, TRP mouthwash can be considered a potential therapeutic agent in the treatment of gingivitis.

Ruxton C et al [106] reviewed as tea is the most commonly consumed beverage in the world, after water. Associations between regular tea drinking and a reduced risk of coronary heart disease are well established. The mechanism may relate to bioactive compounds found in tea, which exert anti-arteriosclerotic, anti-oxidative and anti-inflammatory effects. However, evidence for other diverse health benefits is emerging. The aim of this review was to evaluate research on three new areas of interest in relation to tea drinking: (1) weight management (and glycaemic control); (2) oral health; and (3) gut health. Databases were searched for meta-analytical, human intervention and epidemiological studies published between 1990 and 2013. For weight management, modest, positive effects were found for green tea when ingested by overweight/obese adults, possibly related to thermogenic effects. Epidemiological studies indicate that tea drinking in general may protect against tooth loss, certain oral/digestive cancers and *Helicobacter pylori* infection, although the studies were few in number with differing
methodologies. A growing body of mechanistic studies suggests that tea has anti-cariogenic, anti-adhesive, anti-bacterial and possible pre-biotic effects – all with the potential to impact positively on the pathogenesis of chronic diseases. Clearly, larger trials are needed to confirm these effects in humans and establish optimal intakes. In the meantime, tea drinking appears to be a simple and beneficial way to support health.

**Suyama E et al [106]** conducted a study on remineralization and acid resistance of enamel lesions. Evaluated enamel remineralization and the acquisition of acid resistance by using sugar-free chewing gum containing fluoride extracted from green tea. Forty five volunteers participated in a crossover, double blind study and wore intraoral appliances with human demineralized enamel. Subjects chewed fluoride chewing gum (FCG: 50 μg fluoride) or placebo gum. Remineralization and acid resistance were evaluated using the mineral change ($\Delta Z$, in vol%·μm).

Fluoride concentrations in saliva and remineralized enamel were analysed. The peak salivary fluoride concentration was 3.93 ±1.28 ppm (mean ± SD). The elevated salivary fluoride concentration resulted in a higher fluoride concentration of 656 ± 95 ppm in the remineralized region versus 159± 26 ppm for placebo gum (p <0.001). After remineralization, the $\Delta Z$ of the FCG group was higher than that of the placebo gum group. After an acid challenge, $\Delta Z$ of the FCG group was lower than the placebo gum group. Both $\Delta Z$ were statistically significant.
produced a superior level of remineralization and acid resistance, as compared to the placebo gum. The in situ results suggest that regular use of FCG is useful for preventing dental caries.