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RESEARCH ARTICLE

POTENTIAL REMINERALIZING AGENTS IN PREVENTION OR REPAIR: AN OVERVIEW

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ABSTRACT

Dental caries is a pathological process of localized destruction of tooth tissue by micro-organisms. The disease is initiated via, demineralization of tooth hard tissue by organic acids produced from fermentable carbohydrates by dental plaque and cariogenic bacteria. One of the most important concepts in the field of saving tooth structure is remineralization. Fluoride ions can drive the remineralization of previously demineralized enamel in the presence of salivary or plaque calcium, phosphate ions. Thus, this review aims with the non-invasive treatment of early carious lesions by potential remineralizing agents that has been a major advance in the clinical management of the disease.

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INTRODUCTION

Dental caries is a chronic, multifactorial, transmissible, infectious disease that occurs when the presence of acids on the tooth-plaque interface and leads to a shift in the demineralization/remineralization equilibrium favoring a net demineralization of the enamel.[1] Demineralization results from complex chemistry between bacteria, diet, and salivary components. A drop in the pH in the oral cavity results in demineralization, and the oral environment becomes undersaturated with mineral ions, relative to a tooth mineral content.[2] Remineralizing agents are chemical compounds that aim at accelerating the remineralization process in non cavitated carious lesions, thus preventing future cavitation of the surface enamel and, include a wide array of agents like Fluoride, calcium artificial sweeteners, herbal agents that can be incorporated in pastes, mouth rinses, Dentifrices, Casein

ENAMEL MICROSTRUCTURE

Teeth are composed of enamel, pulp–dentine complex, and cementum.[3] Enamel is a hard calcified material during genesis is produced by cells: the Ameloblasts, which consists of inorganic material 96% and organic material and water 4%.[4,5] Enamel salt is an apatite. $Ca_{10}(PO_4)_6OH_2$. Enamel is an acellular tissue comprised of 80-90% by volume crystals of carbonated calcium hydroxyapatite and 10-20 % fluid and organic proteinaceous material.[6,7]

DEMINERALIZATION

Demineralization is the process of removing minerals ions from hydroxyapatite crystals of hard tissues, for example, enamel, dentin, cementum, and bone.[3] Chemical demineralization of teeth is caused by an acidic attack through two primary means:

- Dietary acid consumed through food or drink
- Microbial attack from bacteria present in the mouth.[3]

Understanding the Process of Demineralization[3]: In a neutral environment, Hydroxyapatite (HA) is in equilibrium with the local aqueous environment that is saliva, which is saturated with Ca^{++} and PO_4^{3-} ions. HA is reactive to hydrogen ions at or below pH 5.5 because this is the critical pH for HA.

H+ reacts preferentially with the phosphate groups in the aqueous environment immediately adjacent to the enamel crystal surface. This is termed demineralization. As pH falls the solubility of the enamel apatite will increase dramatically. A pH drop of one unit within the range of pH 7-4 gives rise to a seven-fold increase in the solubility of hydroxyapatite[3].

Three phases of attack have been identified based on the pH of the acid

- Surface softening
- Sub surface demineralization
- Surface etching[8,9]

ETIOLOGY AND RISK FACTORS

•**Extrinsic -** Include diet and medication. Several medication and asthmatic inhalers were shown to induce xerostomia by reducing salivary flow, in addition to decreasing its pH;
•**Intrinsic** – Gastroesophageal reflux, or attack of stomach acids during acid reflex, vomiting was often seen in diabetic and obese individuals, bulimia nervosa (hyperemesisgravidum) alcoholism, and dental rumination.

ACID EROSION

Dental erosion or chemical wear of tooth enamel can be defined as being the loss of hard tissues through dissolution by acids of the nonbacterial origin or mechanical damage.[3] During an acidic attack or a typical demineralization regime, chemical dissolution of both the organic and inorganic matrix components takes place. This is brought about by the water content of enamel and dentine, which facilitate acid diffusion in and mineral content out of the tooth.[9]

CHEMICAL EROSION

Irrespective of the exact type of acid in a drink, a lower pH dissolves HA in enamel at a faster rate and more severely than a higher pH acid drink. Chelation causes a destabilization of the HA surface at low pH, weakening the phosphate coordination bonds.

Also, these molecules are uncharged which allows for a localized increase in hydrogen ions once diffused into the HA. The temperature has a significant impact on the kinetics of dissolution. In the mouth, the ambient temperature is higher than room temperature, increasing the kinetic rate of reaction.[3]

DIET

In fruits and soft drinks, citric acid is particularly damaging teeth, commonly have carboxylic or citric acids, and it can act through two mechanisms to remove both phosphate and calcium from the HA.[3]

DENTAL CARIES

Caries lesions occur in four general areas of the tooth:

- Pit and fissure caries
- Smooth-surface caries
- Root-surface caries
- Secondary or recurrent caries.[10]

For caries to develop, three conditions must occur simultaneously:

- There must be a susceptible tooth and host;
- Cariogenic microorganisms must be present in quantity; and
- There must be excessive consumption of refined carbohydrates.[10]

BACTERIA

S. mutans is considered the primary pathogen in dental caries development. This cariogenic organism is acquired early in life but does not colonize pre-dentate infants. Cariogenic bacteria break down fermentable carbohydrates such as glucose, sucrose, and fructose and cause an acidic environment that leads to demineralization and resultant carious lesions.[11]

OTHER CAUSES

ORTHODONTIC DECALCIFICATION: Patients undergoing orthodontic therapy are at advanced risk for enamel decalcification. The removal of appliances can reveal areas of decalcification either around or under orthodontic bands.[10,11]

WHITE SPOT LESIONS: White spot lesions may be caused because of fluorosis, orthodontic decalcification, incipient carious lesion. In a white-spot caries lesion, the decalcification has occurred below the surface, and the lesion is covered by a virtually intact surface zone of enamel with a thickness of about 0.03 mm. [11]

REMINERALIZATION/TOOTH REPAIR

Remineralization starts when the salivary pH increases beyond the critical pH level. This bounds the calcium and phosphate into the enamel with the help of saliva, fluorides, or other agents resulting in the formation of rebuilt crystalline structures of fluoridated HA and fluorapatite.[9]

Understanding the Process of Remineralization: The demineralization process can be reversed if the pH is neutralized and there are sufficient Ca2+ and PO43- ions in saliva to inhibit the process of dissolution through the common ion effect. This enables the rebuilding of partly dissolved apatite crystals and is termed remineralization. As the pH increases again after an acid attack the aqueous environment of the enamel surface gradually returns to a state of super saturation concerning both apatites which in turn induces a reprecipitation of minerals in the damaged area.

ASSESSMENT METHODS OF REMINERALIZATION:[12,13] Recent studies have assessed the re-incorporation of the mineral into demineralized enamel using indirect qualitative analysis, such as polarized light

microscopy [Arnold *et al*., 2007] and TEM [Tay and Pashley, 2008], and semiquantitative analysis such as transverse micro-radiography

- **Polarized light microscopy:-**Polarized light microscopy allows for the identification of dentin birefringence.
- **Thermogravimetric analysis:-**Measures of mineral density have been obtained by this method, which is used to determine the weight of mineral gained compared to a control, and element-sensitive electron microscopy, which measures the ratio of calcium to carbon in treated specimens. [Vollenweider *et al*., 2007].
- **Microradiography:-**Transverse microradiography uses the degree of absorption of the X-ray intensity to quantify the amount of mineral incorporated into the tissue based on changes in gray levels in the through-thickness images when compared with standards. Three different micro radiographical techniques-transverse microradiography, longitudinal microradiography, wavelength-independent microradiography (TMR, LMR, and WIM).

- **Spectroscopic analyses, such as Raman and Fourier transform infrared spectroscopy:-**These methods allow the determination of the nature of the mineral and also provide quantitative information on the changes in mineral and matrix composition as mineralization occurs.[Boskey and Men- delsohn, 2005].
- **Microhardness testing methods:-**Microhardness indentation measurements have been used to determine de- and remineralization effects evidence of mineral loss or gain. If indentation length values increase, the tissue has lost mineral; if the indentation length values decrease in magnitude, the tissue most likely has gained mineral.

Two different types of hardness measurements must be distinguished

- Where the indenter load is perpendicular to the polished tissue surface (SMH, or surface microhardness); and
- Where the indenter load is parallel to the tissue's anatomical surface [CSMH, or cross-section microhardness (Arends *et al*., 1980)].

The difference between Knoop and Vickers hardness measurements is mainly the penetration depth of the indenter. For an indentation length of 100 urns, the Knoop indenter penetrates about 3.5.~, whereas the Vickers diamond reaches a depth of about 14µm.

Iodine (^{125}I) absorptiometry Iodine (^{125}I) source uses a method that provides quantitative mineral loss and gains data with a sensitivity comparable to that of LMR.

Light scattering: The visually observed "whiteness" of a caries lesion can be used as a basis for optical measurements, in which the amount of mineral is quantified. Light scattering by enamel is caused by the enamel crystallites in their environments.

The iodide permeability (Ip) test: -Bakhos *et al*. (1977) introduced a method. The Ip test. Ip measurements are related to the pore volume of enamel and can give, in principle, sensitive estimates of the initial stages of de- and remineralization.

Wetchemical analysis: -The determination of Ca and/or phosphate in solutions in which a hard tissue is dissolved using acid is, in principle, a good method to quantify de- and remineralization of the tissue. This method has been used in in vitro studies.

Scanning electron microscopy (SEM):-SEM has been tried extensively but provides only qualitative information on" more or less porosity" or on "more or less" deposited material. Also, the microanalytical techniques EDAX and SIMS can, in principle, be employed to estimate quantitatively the amounts of minerals in tissues.

IDEAL REQUIREMENTS OF A REMINERALIZING AGENT[14]

- Should deliver calcium and phosphate into the subsurface.
- Should not deliver any excess calcium.
- Should not favor calculus formation.
- Should work at an acidic pH to stop demineralization during a carious attack.
- Should work in xerostomic patients also, as saliva cannot effectively stop the carious process.
- Should be able to boost the remineralizing properties of saliva.
- The novel materials should be able to show some benefits over fluoride.

CLASSIFICATION [15]

Remineralizing agents have been broadly classified into the following:

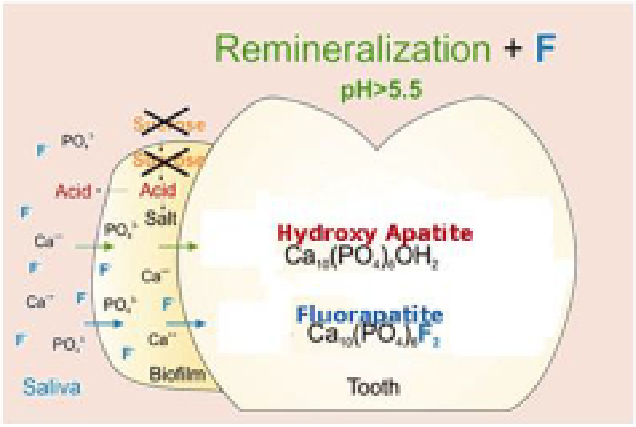
Fluorides

- **Fluorides**
- **Non-fluoride remineralizing agents**
  - Alpha tricalcium phosphate (TCP) & beta TCP (β-TCP)
  - Amorphous calcium phosphate
  - Casein phosphopeptides - Amorphous calcium phosphate (CPP–ACP)
  - Sodium calcium phosphosilicate (bioactive glass)
  - Xylitol
  - Dicalcium phosphate dehydrate (DCPD)
- **Nanoparticles for remineralization**
  - Calcium fluoride nanoparticles
  - Calcium phosphate-based nanomaterials.
  - Nano hydroxyapatite (Nano HAP) particles
  - Amorphous calcium phosphate (ACP) nanoparticles
  - Nanobioactive glass materials
- **Polydopamine**
- **Oligopeptides**
- **Theobromine**
- **Arginine**
- **Self-assembling peptides**
- **Electric field-induced remineralization.**

FLUORIDE: Fluorides are the most important and oldest remineralizing agents of the tooth structure. They are introduced in the oral environment via personal (dentifrices, rinses) or professional application (varnish, foam, gels, and fluoride-releasing restorative materials).[16]

MECHANISM OF ACTION

- Fluoride inhibits demineralization if ions are present at the crystal surface in sufficient concentration before or during demineralization which can adsorb onto the surface of the crystals and markedly inhibit demineralization by acid.
- Fluoride ions react with the partially dissolved enamel crystallites and attract calcium and phosphate ions in the saliva to the demineralized dental enamel. This enhances new mineral deposition and crystallite re-growth fluoride enhances remineralization.
- Fluoride may inhibit the essential bacterial activity of acid-producing carious bacteria by interfering with the production of phosphoenolpyruvate(PEP) which is a key intermediate of the glycolytic pathway in bacteria.



FLUORIDE CONTAINING DENTIFRICES:-

Toothpaste can contain fluoride in various chemical forms mainly as sodium fluoride (NaF), sodium monofluorophosphate (Na2 FPO3), amine fluoride (C27 H60 F2 N2 O3), stannous fluoride (SnF2), or combinations of these.[15]

Acidulated-Phosphate-fluoride solutions: Brudevold *et al.* (1963) developed a preparation based on acidification of sodium fluoride solutions with phosphoric acid, to obviate the disadvantages of stannous fluoride and to incorporate the positive effect of lower pH on fluoride uptake. The preparation is chemically stable, does not cause any staining of teeth, and is easily formulated as gel and solutions.[17]

Fluoride varnish: Fluoride varnish is a fluoride-concentrated form, which is used as a type of topical fluoride treatment. Due to its easiness and similar efficiency with fluoride gel system, varnishes especially in Pre-school children are recommended. Due to its sticky nature, it can remain in contact with the tooth surface for several hours.[18] Enamel Pro Varnish is formulated to deliver ACP (Amorphous Calcium Phosphate).

Fluoride Lasting Defense™ Varnish, a 5% neutral sodium fluoride varnish used to alleviate sensitivity associated with gingival recession and cervical abrasions.

Fluoride mouth rinses:-They raise the concentration of fluoride in saliva for several hours after use. Use of 0.05 % sodium fluoride mouth rinses is better than brushing with conventional fluoride toothpaste.

Commercially available ACT mouth rinse contains 0.05% sodium fluoride which is the highest concentration of sodium fluoride rinse available over the counter.

Silver Diamine Fluoride (SDF):- {Silver Nanoparticles (Ag-Nano)}: 38%SDF is a colorless liquid containing silver particles, 38% (44,800 ppm) fluoride ion at pH 10 i.e., 25%

silver, 8% ammonia, 5% fluoride, and 62% water.[58] SDF application reduces the demineralization process; inhibits the growth of cariogenic multispecies and also treats dentine hypersensitivity. The silver ion contained in the SDF acts as an antimicrobial agent, and fluoride ion helps the remineralization process while ammonia plays a role in stabilizing the SDF solutions.[18]

ENAMEL REMINERALIZING SYSTEMS

An ideal remineralization system should supply stabilized bioavailable calcium, phosphate, and fluoride ions that favor subsurface mineral gain rather than deposition only in the surface layer.

Amorphous calcium phosphate (ACP): ACP is the initial solid phase that precipitates from a highly supersaturated calcium phosphate solution and can convert readily to stable crystalline phases such as octacalcium phosphate or apatitic products. The ACP technology requires a two-phase delivery system (e.g., from a dual-chamber device) to keep the calcium and phosphorous components from reacting with each other before use. The current sources of calcium and phosphorous are two salts, calcium sulfate, and dipotassium phosphate. When the two salts are mixed, they rapidly form ACP that can precipitate onto the tooth surface. This precipitated ACP can then readily dissolve into the saliva and can be available for tooth remineralisation.[8]

Amorphous calcium phosphate (ACP) -filled Composites: A biologically active restorative material containing ACP as a filler encapsulated in a polymer binder was introduced by Skrtic, which can stimulate the repair of tooth structure by releasing significant amounts ofcalcium and phosphate ions. [15]

Amorphous calcium phosphate (ACP)Nanoparticles: They are small spheroidal particles with a dimension in the nanoscale (40–100 nm). ACP nanoparticles, as a source of calcium and phosphate ions, have been added to composite resins, ionomer cement, and adhesives. [15]

Alpha-tricalcium phosphate: It is used in products such as Cerasorb, Bio-Resorb, and Biovision. Tricalcium phosphate (TCP) has also been considered as one possible means for enhancing the levels ofcalcium in plaque and saliva.[8]

Beta Tricalcium Phosphate (TCP): Alpha tricalcium phosphate is a breakdown product of enamel. TCP is a new hybrid material created with a milling technique that fuses beta-tricalcium phosphate (ß-TCP) and sodium lauryl sulfate or fumaric acid. This blending results in "functionalized" calcium and a "free" phosphate, designed to increase the efficacy of fluoride remineralization.[7]

Enamelon: Enamel consists of unstabilized calcium and phosphate salts with sodium fluoride. The calcium salts are separated from the phosphate salts and sodium fluoride by a plastic divider in the center of the toothpaste tube.

Limitation: Calcium and phosphate are not stabilized, allowing the two ions to combine into insoluble precipitates before they come into contact with saliva or enamel.[8]

Commercially available enamelon® fluoride:- Enamelon® offers the remineralizing properties of Amorphous Calcium Phosphate technology. Introducing calcium and phosphate, which are naturally present in the saliva, back into the surface of the tooth enamel is an ideal strategy to reverse the demineralization process.

Commercially available minerals™ enamel booster: It is a remineralizing and desensitizing gel. Remineralizing gel significantly increases the micro-hardness of tooth enamel after teeth whitening.

Dicalcium phosphate dehydrate (DCPD): Inclusion of dicalcium phosphate dehydrate (DCPD) in a dentifrice increases the levels of free calcium ions in plaque fluid, and these remain elevated for up to 12 hours after brushing when compared to conventional silica dentifrices.[15]

CALCIUM PHOSPHATE-BASED REMINERALIZATION DELIVERY SYSTEMS

For fluorapatite or fluorhydroxyapatite to form, calcium and phosphate ions are required as well as fluoride ions. There are three calcium phosphate-based remineralizing systems

- Crystalline
- un-stabilized amorphous
- Stabilized amorphous

CASEIN PHOSPHOPEPTIDES - AMORPHOUS CALCIUM PHOSPHATE

Casein is the predominant phosphoprotein in bovine milk accounting for 80% of its total protein, primarily as calcium phosphate stabilized micellar complexes. Casein phosphopeptide amorphous calcium phosphate (**CPP-ACP**)

nanocomplexes are derived from milk protein, casein, calcium, and phosphate. Casein is the major protein group found in milk.

TOOTH MOUSSE: Tooth Mousse is a water-based, sugar-free cream containing Recaldent® CPP-ACP (Casein Phosphopeptide – Amorphous Calcium Phosphate). Recaldent™ is derived from the milk protein, casein. This complex of CPP-ACP (Recaldent™) is an ideal delivery system for bio-available calcium and phosphate ions.

Clinical Applications for Tooth Mousse:

- White spot prevention/removal (during/after orthodontic bracket treatment)
- Post bleaching
- Post scaling and root planning
- Dentinal hypersensitivity
- Treatment of erosion and incipient carious lesions
- Caries prevention
- Promote fluoride uptake.
- It should not be used on patients with milk protein allergies. RECALDENT™ (CPP- ACP)

NANOMATERIALS: Nanoparticles have better ion release profiles than microparticles. These materials are often added to restorative materials as inorganic fillers, such as resin composites to release calcium, phosphate, and fluoride ions for remineralization of dental hard tissues. Eg: Calcium Fluoride Nanoparticles, Nano Hydroxyapatite (HAP) Particles.[15]

BIOACTIVE GLASS: Bioactive glass has also been shown capable of inhibiting and reversing initial caries progression in enamel. In addition to remineralization, bioactive glasses have antibacterial effects, as they can raise the pH of an aqueous solution.

Bioactive glass compositions have demonstrated a significant antimicrobial effect toward caries pathogens (S. mutans, S. sanguis) upon exposure to bioactive glass powders as well as solutions and extracts. [15]

NOVAMIN: Calcium sodium phosphosilicate (NovaMin) is an agent that is claimed to release calcium and phosphate ions intraorally to help the self-repair process of enamel. It is used extensively as a desensitizing agent, but the chemical reactions that occur may promote apatite formation enhancing remineralisation.[20]

Commercially available product:

Dr. Collins Restore Toothpaste-4 oz (Quantity of 3)

XYLITOL

Xylitol, sorbitol, saccharin, and aspartame have all been used as sugar substitutes to reduce dental caries.[7,49] Increase in salivary pH can raise the falling pH to its neutral pH within a few minutes of xylitol consumption. This indicates that xylitol can induce remineralization of deeper layers of demineralized enamel by facilitating Ca2+ movement and accessibility.

Xylitol has the ability to[21]

- Reduce dental plaque formation, and Neutralize plaque acids by decreasing the production of lactic acid
- Reduce the levels of S. mutans.
- Reduce cavities by up to 80%
- Demonstrate significant long-term reduction in caries (88-93%)
- Assist in the remineralization of tooth enamel
- Reduce gum tissue inflammation
- Help with dry mouth and bad breath.

Commercially available products

Squigle tooth builder sensitive toothpaste (4 oz): It contains 36% Xylitol which is a great prohibitor for fighting the growth of plaque bacteria. It helps remineralize as it has the ingredient soluble calcium, which aids in replacing calcium that has been lost by food decay and acidic foods.

Some of the things this toothpaste helps with are halitosis, gingivitis, bleeding gums, cavities, and plaque. This particular toothpaste has a spearmint flavor.

Gums:-Chewing xylitol gums shows a good report of reduction in the caries incidence up to 5 years even after the therapy is discontinued. A minimum of 5-6 grams and three exposures per day (from chewing gum and/or candies) are proven to give clinical effects.[22]

SELF ASSEMBLING PEPTIDE: Recent developments in tissue engineering, material sciences, and stem cell research offer considerable potential to dental therapies. Peptide treatment for early caries lesion in the area of current research. A single application of P114 can be beneficial in the treatment of early caries lesions.[7,15]

OZONE: Ozone (O3) is a powerful oxidizing agent which neutralizes acids and affects cell structures, metabolism of micro-organisms. O3 attacks many biomolecules - cysteine, methionine, histidine residues of proteins and changes the surface ecology of the carious lesion. Ozone plays an important role in caries reversal by shifting the microbial flora in carious lesions to one containing normal oral commensals. Ozone alters the metabolic product of bacteria that inhibit remineralization. It also removes plaque pyruvate which may suppress the development of tooth demineralization.

CALCAREA FLUORICA: Calcarea Fluorica (calc-f) or fluoride of lime (CaF2) has been used for the treatment of various dental problems as it contains mineral salts that play role in the mineralization of teeth and bone. Teeth treated with Calc-f tablets, on artificial carious lesions, showed increased surface hardness.[23]

Calcarea Fluorica

GIC

Mode of Action of GIC for Remineralization: When GIC is placed in direct contact with affected/demineralized dentin, the migration of apatite forming elements F and Strontium from GIC to carious dentin occurs. GIC has a high fluoride content (10-23%) which allows for a greater degree and more prolonged release of fluoride compared with other dental materials.

During demineralization, GIC would release fluoride to the environment which forms fluorapatite and during remineralization, the fluoride would be taken up by the enamel.[24,25]

CHEESE: Dairy products (milk, milk concentrates, and **cheeses)** have been shown to have anticarcinogenic properties.
Mechanism of action:

- **Effect on salivary flow rate:** Cheese is a powerful sialogogue.[26]
- **Effect on the number of ions in plaque:** Cheese elevates levels of calcium, and/or possibly phosphorus, in dental plaque which might inhibit demineralization through a common-ion effect or might enhance remineralization during periods of high pH.[27]
- **Effect on plaque pH:** Increased calcium levels are associated with greater plaque pH levels.[28]

HERBAL PRODUCTS FOR REMINERALIZATION: In ancient India, problems such as deformities of the oral cavity, plaques, and infections could be managed and even cured.

GRAPE SEED EXTRACT (GSE): Remineralization is an effective treatment that may stop or reverse early tooth decay. Grape seed extract (GSE) is the potential remineralizing agent under investigation. Grape seed extract can act as a potential adjunct or alternative for fluoride in the treatment of root caries during minimally invasive therapy, in elderly patients.[29]

MECHANISM OF ACTION: GSE may positively affect the remineralization process through two distinct mechanisms:

- It inhibits the glucosyltransferase enzyme produced by S mutants resulting in inhibition of Dental Caries.

- GSE may interact with the organic portion of the root dentin through PA

GINGER, HONEY, AND ROSEMARY EXTRACT:-

Among natural food sources, ginger rhizome (Zingiberofficinale Roscoe, Zingiberaceae) and rosemary (Rosmarinus officinalis L., Lamiaceae) are natural herbals with their antimicrobial activities. Their antifungal and antimicrobial effects on oral cavity pathogens have been reported. The average pH value of honey is 3.9 and can show the bacteriostatic effect on pathogens as most thrive at a pH between 4.0 and 4.5.[30]

HERBAL TOOTHPASTE: Herbal-based toothpaste can protect the enamel from demineralization according to the components they have. Researchers used commercial herbal toothpaste for observation of protective effects on enamel demineralization.[31]

REMINERALIZATION EFFECT OF MISWAK: The miswak (miswaak, siwak, sewak) is a tooth cleaning twig made from a twig of the Salvadorapersica tree, also known as the arak tree or the peepul tree, and features in Islamic hygiene jurisprudence. If the miswak stick is chewed, a saturation of calcium in the saliva may support enamel remineralization. [31]

REMINERALIZATION EFFECT OF TEA: Tea, especially green tea, is rich in catechins like epigallocatechin gallate, epicatechin gallate, epigallocatechin, epicatechin58. Jose *et al*. stated in their study, tea was increased in microhardness of enamel through these components. [31]

REMINERALIZATION EFFECT OF LEMON OIL: Lemon oil is obtained from peels of lemon and contains Limonene as the main component. Researchers stated that these essential oils have antibacterial effects against cariogenic bacteria and inhibit their properties cariogenic.[31]

REMINERALIZATION EFFECT OF OIL PULLING: Oil pulling, in CAM (Complementary and Alternative Medicine), is a procedure that involves swishing oil in the mouth for oral and systemic health benefits. In traditional Indian culture, oil pulling which uses edible oil like sunflower oil or sesame oil, as a mouthwash is observed commonly for many years to prevent decay, oral malodor, bleeding gums, dryness ofthroat, cracked lips and for strengthening teeth, gums, and the jaw .The reducing effect of S.mutans growth of coconut oil has been proved with remineralizing effect also.[31]

CONCLUSION

The worldwide contribution of dental caries to the burden of oral diseases is about 10 times higher than that ofperiodontal disease than other common oral conditions. Fluorides were the first such agents, used for the remineralization of enamel. While fluoride ions play an integral part in the demineralization-remineralization process, helping in the long-term repair of subsurface demineralization. Among new materials, casein phosphopeptide-containing materials seem to show the greatest promise in terms of remineralization of cavitated and non cavitated lesions. Diagnosis, preventive interventions, and conservative mineralizing therapies still will require regular dental visits by patients. Treatment of early lesions with remineralizing therapy will require follow-up visits so that dentists can evaluate patients' responses and modify treatment according to their progress.

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