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Anticariogenic And Cariostatic Potential Of Components Of Diet: A Review

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Abstract
Dental caries is a complex microbial disease of the calcified tissues of the teeth, characterized by the demineralization of the inorganic portion and destruction of organic substances of the tooth. This process is an interaction between host, diet, and dental plaque over time. Host factors include the tooth surface, saliva composition, flow rate, and composition of the acquired pellicle. Dietary factors include the amount, composition, and frequency of cariogenic foods and drinks. Carbohydrates have been considered to be the most cariogenic component of the diet. Sucrose has been designated as the arch criminal. A diet composed of highly cariogenic carbohydrates is metabolized readily by the plaque bacteria to produce acids. These acids diffuse into the enamel as minerals diffuse out from the tooth, eventually leading to cavitation.
In this review we have made an attempt to study various components of diet that have a potential of anticariogenicity. Various studies were reviewed to understand the role of cariogenic substrate in etiology of dental caries and the modifications in these substrates that can be done to prevent tooth decay.

Key Words
Dental Caries, Anticariogenicity, Cariostatic

Introduction:

Caries, a Latin word which means decay or rottenness. According to WHO, caries is defined as a localized post eruptive, pathological process of external origin involving softening of the hard tooth tissue and proceeding to the formation of a cavity.[1] Shafer described the dental caries as the microbial disease of the calcified tissues of the teeth, characterized by the demineralization of the inorganic portion and destruction of organic substances of the tooth.

Since the time of early Greek Philosophers, the diet has been suspected of influencing the etiology of caries. Carbohydrates have been considered to be the most cariogenic component of the diet. As early as in 1746, Pierre Fauchard, the founder of dental profession wrote that "all sugary foods contribute not a little to the destruction of teeth and that those who like 'les sucrenes' and use them frequently rarely have good teeth. The adherence of S mutans to smooth surfaces is greatly increased by the production of glucans in the presence of sucrose, these lower levels. Colonization of tooth surfaces is now seen as a two-step process. The initial attachment is to the acquired pellicle of the tooth and is mediated by cell – surface proteins rather than the glucans. Evidence for the protein-mediated attachment is the reduced adherence of S mutans when treated with proteases. The second step involves cellular accumulation mediated by sucrose-derived glucans and cell surface lectins.

Becks and his associates (1944) [2] studied the effect of carbohydrate restriction on the L.acidophilus index and caries experience in a group of 1250 persons with rampant caries and 265 caries free persons. Replacement of refined carbohydrates with meat, eggs, vegetables, milk and milk products resulted in 82% reduction in the lactobacillus index and in clinical evidence of arrest of caries. The observation was made that some persons consumed large amounts of carbohydrates without acquiring caries, while others had rampant caries even though consuming very little carbohydrate. These workers suggested that in addition to excessive amounts of refined carbohydrates, other factors contribute to the disease.

Other Historical studies such as Hopewood House in Australia and Vipeholm study in Sweden, Turku studies clearly established relationship between diet and dental caries.

Preventive strategies for caries management

The diet of primitive man consisted of raw unrefined foods containing a great deal of roughage, which cleanses the teeth of adherent debris during the usual masticatory excursions. In modern soft diet, food tends to cling tenaciously to the teeth and not removed because of lack of roughage. It has been demonstrated that masticatory food reduces the number of cultivable oral microorganisms by causing mechanical cleansing. These foods are known as detergent foods which help in making the tooth immune to caries.

In this review we have made an attempt to study various components of diet that have a potential of anticariogenicity. Various studies were reviewed to understand the role of cariogenic substrate in etiology of dental caries and the modifications in these substrates that can be done to prevent tooth decay. These food materials have been discussed in detail in this article. These food materials are as follows:

1) Sugar Substitutes : The sweeteners have been grouped as “nutritive” or “nonnutritive”. Nutritive sweeteners may be referred to as caloric and include sugars and sugar alcohols. Nonnutritive sweeteners offer no energy and can

sweeten with little volume. Both sugar alcohols and nonnutritive sweeteners can replace the sugars and are sometimes referred to as sugar substitutes, sugar replacers, or alternative sweeteners.[3]
There are two main groups of sugar substitutes are non caloric sweeteners and caloric sweeteners.[4]

Caloric Sweeteners

i) Sorbitol (D-Glucitol)

Sorbitol is used extensively in foods manufactured for diabetics and as sweeteners in sugar less syrup medicines and is fermented slowly by plaque organisms, much slower than that of sucrose and hence very little drop in pH of dental plaque.

ii) Xylitol

This is found widely in fruits (strawberries, plums, raspberries) and vegetables (lettuce, Cauliflower, mushrooms) and is commercially prepared from coconut shells & birch trees. Xylitol modifies the synthesis of polysaccharides from sucrose in S. mutans thereby decreasing the ability of the cells to adhere to hard surfaces. In vitro studies also suggested that xylitol could cause ultrastructural changes in streptococci which in turn could affect the adhesion properties in the organisms.
Giertsen E et al (1999)[5] in their studies proposed that Xylitol has inhibitory effect on growth and acid formation by S.sobrinus and S.mutans. Xylitol induced inhibition of acid formation and growth of dental bacteria has been explained by 'Futile Xylitol Cycle' which involves depletion of phosphoneol pyruvate & ATP through uptake of Xylitol via induction of fructose specially phosphotransferase.

iii) Starch Hydrolysates

Lycasin: is hydrogenated glucose syrup produced from corn syrup and other starches by partial hydrolysis and subsequent hydrogenation and is fermented slowly compared with sucrose & causes minimal depression of plaque pH when taken as a syrup or boiled sweet.

iv) Isomalt (Palatinit): it is a mixture of two disaccharide alcohols and is said to be particularly useful in the manufacture of sugar-free chocolate.

Low Caloric Sweeteners

I) Saccharin

It is an aromatic organic compound, O-sulfobenzimide and commercially it is available as tablets containing between 15 and 60 mg. sodium saccharin, admixed with lactose, gelatin or dextran to give bulk. Saccharin is not fermented to acid by oral bacteria and therefore cannot lower the pH of plaque and it is commonly used in alternative food products without added sugar e.g. sweet drinks, jams, biscuits etc.

ii) Cyclamate

Cyclamate is an organic sweetener, about 30 times as sweet as sucrose. When ingested, it is absorbed into blood stream and excreted unchanged in the urine. It is also not metabolized by oral micro organism.

iii) Aspartame

Aspartame is composed of 2 amino acids: L-aspartic acid and the methyl ester of L – phenylalanine. It is effective in enhancing acid fruit flavour & extending sweet taste as in chewing gum. If replaced even part of sugar in the diet, it would be expected to reduce caries simply by limiting the amount or frequency of fermentable sugar in the diet.
A speculative explanation being that it might raise plaque pH by forming amines by decarboxylation. Aspartame is used in drawing gum tablets etc. Ikeda T[4] prescribed a new sugar substitute coupling sugar which is sugar mixture of monosaccharides, glucosylsucrose, oligosaccharides and oligosaccharides terminated at the reducing end by sucrose. Compared with sucrose, these substances are definitely low in cariogenic action. The coupling sugar has a sweetness rescrubbing that of sucrose and no deleterious effects of its use have been found.
Neta T et al (2000)[6] in their study found that trehalose is not only, low cariogenic but also anticariogenic and can be a promising sugar substitute.

2) Phosphates in diet

Phosphates have played a prominent role as caries preventive component in diet. Experiments have shown that sodium phosphates are more effective than calcium phosphate (because they are more soluble & enter plaque more readily) and that the acid salts (NaH2PO4) are more cariostatic than a neutral mixture (NaH2 PO4 + Na2HPO4). The cariostatic effect of phosphate is greatest if it is provided soon after tooth eruption and when given with fluoride, the effects of the two substances are additive.[7]

Cariostatic activity of poly phosphates in descending order is as follows:

Trimeta phosphate > tripoly phosphate > hexametaphosphate > pyrophosphate.
Calcium sucrose phosphate, a synthetic substance similar to a constant of crude sugar cane juice, was shown to reduce caries in rats. Two other organic phosphates – Calcium glycerol-phosphate and sodium phytate (inositol hexa phosphate) were effective both in rats & monkeys.[8],[9],[10],[11]
Phosphates have local effect in mouth rather than a systemic influence through ingestion. This local effect is attributed to a number of factors viz.
Phosphate ions reduce the rate of dissolution of hydroxyapatite of enamel.
Supersaturated solutions of phosphate ions to redeposit Ca3(PO4)2 particularly in areas of enamel that have been partially demineralized.
Phosphates tend to buffer organic acids formed by fermentation of plaque micro flora.
Phosphate ions tend to desorb proteins from enamel surface thereby modifying acquired pellicle.
Vogel, Zhang et al and Winoston Bhaskar S et al (1998)[12] reported in their studies that calcium phosphate additives used as tooth paste and chewing gum additives and as alpha tricalcium phosphate aids in remineralization and prevent demineralization of tooth surface.

3) Fats[1]

Fats consumed post operatively in diet have been correlated with caries reduction. The mechanism of action of fats in reducing caries can be explained by the facts that they act by replacing carbohydrates in diet.It forms protective barrier on enamel or surrounded carbohydrate so as to make it less available for bacteria. It speeds up the clearance of carbohydrate from oral cavity thus decreases the cariogenic potential.
Also Medium chain fatty acids (C8-C12) and their salts exhibit some antibacterial properties at low PH. Changes in cell permeability may also be involved. They serve as anionic surfactants and uncouple substrate transport and oxidative phosphorylation from electron transport in bacteria.

4) Cheese:

Herod EL (1991)[13] reported that cheese:

Increases the Salivary flow: Increase in saliva increases the alkalinity which buffers the acids formed in plaque.

Chewing cheese promotes the rate of sugar clearance

It may reduce the levels of cariogenic bacteria when chewed.

High calcium and phosphorus content seems to be another factor in cariostatic mechanism of cheese.

Both casein & cheese protein seem to be involved in reduction of enamel demineralization.

Casein phosphopeptides may also be responsible for some of anti cariogenecity.

Many animal studies and experimental studies suggest that cheese is anticariogenic.[14]

Cheese also contains amorphous calcium phosphate nanocomplexes which play a role in remineralisation process.[15]

5) Trace Elements (minerals)[8] (Table 1)

Various other elements other than fluorides were also investigated for anticariogenic effect.

Molybedenium, selenium, vanadium, strontium and variety of other elements may have an influence on prevalence of caries in man.

Relationship of Mineral Elements to Caries

6) Vitamins

According to some investigators vitamin content of diet may have a role to play in dental caries incidence.

Vitamin A: vitamin a deficiency has definite effects on developing teeth, and this deficiency may lead to increased risk of dental caries.

Vitamin B: conflicting results regarding deficiency of vitamin b and incidence of dental caries exists in the literature. Some investigators, Dreizen[16] and his coworkers suggest that vitamin b complex deficiency may exert a caries-protective influence on the tooth, since several of B vitamins are essential growth factors for the oral acidogenic flora and also serve as components of the conenzyme involved in glycolysis.

Table 1

Effect	Mineral
Cariostatic	Fluoride, Phosphate
Mildly Cariostatic	Mo,V,Cu,Sr,B,Li, Au, Fe
Doubtful	Be,Co,Mu,Su,Zu,Br,I,Y
Caries Inert	Ba, Al, Nl, Pd, Ti
Caries Promoting	Se, Mgn, Cd, Pt, Pb, Si

Vitamin B6: (pyridoxine): has been proposed as an anti-caries agent on the hypothetical ground that it selectively alters the oral flora by promoting the growth of non cariogenic organisms which suppress the cariogenic forms (Strean,1957)[1]

Vitamin C: vitamin C is well recognized as producing severe changes in the periodontal tissues and pulps of the teeth but available scientific evidence indicates that there is no relationship between scurvy and increased caries incidence in the human beings.

Vitamin D: Vitamin D deficiency may lead to malformations, particularly enamel hypoplasia, has been described in the deficiency state by many workers. The only possible way in which this deficiency could influence dental caries incidence is through an alteration in tooth structure making it more susceptible to caries.

Vitamin K: Vitamin K has been tested as a possible anticaries agent by virtue of its enzyme inhibiting activity in the carbohydrate degrading cycle.

7) Phytates

Phytate is anticariogenic and acts by adsorbing to the enamel surface to form a protective barrier against plaque acids. But phytate is not released in food before being swallowed and also prevents the absorption of iron, magnesium, calcium and zinc so it is unsuitable as a cariostatic food additive.

8) Oolong Tea Extract (OTE)[17]

OTE has been shown to inhibit experimental dental caries in rats infected with either Streptococcus sobrinus or Streptococcus mutans when given in both diet and drinking water.

Mechanism of Action of Oolong tea in caries prevention

Cell surface hydrophobicity is one of the important factors for oral bacteria to adhere to the tooth surface. Oolong tea products reduce the cell surface hydrophobicity of S. mutans. It also showed a reduction in acid production by Mutans Streptococci by its strong anti Glucosyltransferase activity.

9) Milk[18],[19],[20],[21]

Previously milk was considered cariogenic but now it is established that it is not milk but the appropriate environment that causes caries, rather milk contains many cariostatic components.

a) Protease Peptone Fraction

This is a term introduced in the 1930s to cover a variety of minor proteinacious substances present in milk at a total concentration of upto 1gm/l. The two protease peptones that showed the greatest protective action were fraction 3 and 5.

b) Casein

The casein fraction has long been postulated to be the main caries inhibiting component of milk based diets as suggested by Schwergent et al (1946), Shaw et al (1950), Osborn et al (1966).

Mechanism of Action of milk casein in caries prevention

Milk casein in the form of soluble caseinate and casein derived glyco and phosphopeptides, buffer the formation of acid in dental plaque thus reducing the dissolution of hydroxyapatite from enamel.

10) Apis Mellifera Propolis[22]

Propolis is a resinous substance made by Apis mellifera bees from various parts of plants (buds, bark Lesions) and mixed with bees wax. Basically propolis is used by bees as glue to seal the opening of the hives and to embalm dead invading insects.

Polyphenolic compounds mainly flavanoid aglycones are considered the primary biological active substances in propolis although there are additional active components such as hydroxyl cinnamic acid and diterpene derivatives.

Mechanism of Action of Propolis in caries prevention

Ethanolic extract of propolis (EEP). Inhibit GTF enzymes, consistent with a reduction in caries observed with mutans streptococci.

11) Funoran [23]

Funoran is a sulfated polysaccharide extracted from the gloiopeltis family (red seeweed). In general funoran and carragenon are known to contain higher amounts of sulfate than x-carrageenon and furcellaran.

Mechanism of Action

The sulfate of polysaccharides may

interfere with the interaction of the streptococcal surface with the acquired pellicle because the sulfate binds strongly to the protein of acquired pellicle. Funoran also exhibited strong desorption action in the experimental system in vitro. It is composed of D-galactose and 3,6 - anhydro - L - galactose which might be responsible for adsorption inhibition and desorption activity of Funoran. This desorption activity of Funoran suggested that this agent could be useful in inhibiting dental caries, even on teeth already colonized by cariogenic bacteria.

12) Shiitake (An Edible Mushroom)[24]

Shiitake extract is the common Japanese name for the edible mushroom Lentimus erodes and is also the common name now used in the world. Three kinds of antibacterial substances are obtained by chloroform, ethylacetate or water from shiitake mushrooms. Out of which only the water extract among these three extracts showed anticariogenic properties.

Mechanism of Action

The supernatant of the water extract precipitated with 4 volume of ethanol was shown to contain an H-GTase activity and showed antiplaque formation effect. Purified 4 volume of ethanol + OH sup inhibited firmly adherent plaque formation by S.mutans and S sobrinus. These results are important for prevention of dental caries and suggest that S.mutans, S sobrinus or other oral bacteria may not be able to co-aggregate and adhere to teeth surfaces in vivo in the presence of 4 VE + OH sup.

13)Black Tea (Camellia Sinensis)[25]

Black tea is an international mix of camellia sinensis, dried tea leaves (Tetley, World blend tea) and its consumption for 2 weeks can attenuate development and progression of caries.

Mechanism of Action

The mechanism has not been fully elucidated but they may involve the fluoride content, polyphenolic compounds, tannins or other substances in tea leaves.

14) Areca Nut[26]

Areca nut extracts inhibited the growth of the selected organisms in a concentration dependent manner, baked and boiled nuts being significantly more potent than raw nut.

Mechanism of Action

Tannin fraction in the areca nut is responsible for its antibacterial properties. Hydrolysable tannins in the tannin fraction which include tannic acid precipitates protein and hence antibacterial

15) Calcium Lactate (CL)[27]

The concentration of calcium ions in plaque appears to be of critical importance in determining the rate of enamel demineralization following the ingestion of fermentable carbohydrates. Thus, Mcclure (1960), Shresto et al (1982) and Vader Hoeven (1985) found that calcium lactate and Grenby ad Bull (1975) found that calcium glycerophosphate reduced caries in rats. Chow et al (1994) demonstrated that salivary calcium could be elevated after chewing gums made with either monocalcium phosphate monohydrate or mixture of tricalcium phosphate plus dicalcium phosphate.[28]

Mechanism of Action

S. Kasket in 1997[27] concluded that CL containing cookies can modify conditions with the streptococcal organisms. Cookies can modify conditions with the streptococcal plaque such that the mineral is spared for sometime inspite of a progressively increasing acidity.

16) Tooth Friendly Sweets

Use of non-cariogenic sweeteners has proved to be excellent measures in the control of caries. A short term plaque study was undertaken by Tandon et al (1997)[29] to evaluate effect of Lactitol 4 - 0 (b - Galactosyl) - D - glucitol on plaque by incorporating it as a sweetener in biscuits. Significant reduction was found in plaque formation, carbohydrate content, increase in calcium, phosphate and protein with lactictol when compared with the control.

17) Chewing Gums

A novel technique involves the use of chewing gums after meals in order to counter the pH drop that occurs with the intake of sugar. Various sugar free gums have been tried out with additions such as Xylitol, lactitol and urea. Chewing gum containing urea showed the highest pH followed by fluoride and sugar. Short term chewing cycles of xylitol gum significantly reduce the salivary levels and plaque proportions of S.mutans as xylitol due to its organoleptic properties, stimulate salivation thereby increasing plaque pH and promote remineralisation.[30]

Chewing gum such as Fluomin(0.25mg F) may be used as vehicle for delivery of fluoride. In the first five minutes, after ingestion, 15-25 ppmfluoride concentrations were obtained which reduced to 1ppm after 30 mins. With regular use of such chewing gums which act as cariostatic agents a significant reduction in rate of caries induction and progression may take place.[31]

18) Cavistat (an arginine bicarbonate calcium carbonate complex)[32]

It was evident from a clinical trial that mint confections containing CaviStat are able to inhibit both caries onset and caries progression. As a result, one can conclude that CaviStat mint confection technology is a simple and economical means for reducing substantially one of the most prevalent diseases in these children.

19) Oleic acid in caries prevention

Many studies have been done on various herbal extracts from plant sources such as Murraya koenigii[33], Prunus salicina[34], Dryopteris crassirhizoma[35] etc. for their antibacterial properties against dental caries. These studies revealed the presence of oleic acid as a major component which served as a cariostatic agent.

20) Red wine in caries prevention[36]

Studies suggest that dealcoholised red wine, interferes with Streptococcus mutans adhesion to saliva-coated hydroxyapatite (sHA) beads, promotes its detachment from sHA, and powerfully inhibits in vitro biofilm formation. The main components responsible for such activities were found to be proantho cyanidins. The ability of red wine to inhibit ex vivo S. mutans biofilm formation on the occlusal surface of natural human teeth also was demonstrated. Data indicates that protection of the oral cavity from the cariogenic action of S. mutans may be another beneficial effect of the moderate consumption of red wine.

21) Other food products that may prevent caries

Among additional natural products that exert such antibacterial effect are plant

extracts containing phenolic compounds, such as propolis, green tea, cocoa[37], grapes and coffee. Several studies have raised the potential of these agents in the prevention of oral diseases, particularly diseases caused by the presence of biofilm on the tooth surface.

In the last years, in addition to the popularity inherent to its sensory properties coffee has attracted scientific and popular interest in relation to its therapeutic effects demonstrated in clinical and epidemiological studies, such as anti- inflammatory, antifungal and hypoglycemic properties. The in vitro antibacterial activity of coffee against gram-positive and gram-negative bacteria has also been reported. This activity seems to change according to coffee's chemical composition and is influenced by species and processing such as roasting and decaffeination.[38],[39],[40],[41] Green tea[42], Apple, Barley, Chicory, nutmeg, Red grape seeds, Cocoa, Cranberry[43] and Garlic[44] have also found importance in caries prevention in the recent years.

22) Dietary Fluoride Supplementations in prevention of Dental Caries

These are administered in following forms:

1. Fluoridated salt

Wespi (1961)[45] pioneered the addition of fluoride to salt for caries prevention like Iodine is added to prevent goiter.

Initially supplementation was 90mg F/kg. of salt. Recently it has been recommended in the range of 200 to 250 mg F/kg. salt.

Commonly used salts are potassium fluoride (250 mg / kg) and sodium fluoride 225 mg / kg).

Advantages

Ingestion is systemic
Fluoride salt is safe
No supervision of water works necessary.
Low cost.
Individual monitoring not required.

Disadvantages

There is not a precise control since salt intake varies greatly among people.
No control of hypertension.

2. Fluoridated Milk

Zielger (1956)[46] first mentioned this method. Both bovine and human milk contains low levels of Fluoride about 0.03 ppm

Doses recommended

Initially, it was 0.2 mg F/200 ml of milk. Later, it was raised to 0.5 mg F / 250 ml of milk and 0.625 mg F / 250 ml of milk.

Advantages

Milk is a staple food for children and its consumption can be confined to groups who need it most.

Disadvantages

In India, majority of population cannot afford milk in their diet every day. There is no central milk supply in India.

Variation of intake and quantity of milk cannot be controlled due to socio-economic, religious and ethnic factors.

3. Fluoride in Sugar

Several studies have shown that adding fluoride to sugar and sugar products has potential to reduce the cariogenic effect of sugar or fermentable carbohydrates among population groups, especially where it is impractical to use other fluoride vehicles .42% reduction in caries was observed in a 3 year clinical trial (Luoma et al 1979).[47]

Disadvantages

It is believed that the marketing of cariologically harmless fluoridated sucrose products would increase the general consumption of sucrose and thus will promote a nutritional imbalance. One type of fluoridated sugary product may not reach all those needing the fluoride supplements.

4. Fluoride in citrus beverages

Citrus beverages may also be considered as a potential vehicle for the administration of fluoride as dietary supplements. (Galon et al 1983)[48]

23) Indigenous food products in caries prevention

In the recent times some plant and fungal products that alter the adhesion of cell surface glucans are also being identified. In this context, cheaper modalities that are accessible to the masses are being tested in the form of indigenous products. Rajesh et al (1997) tested the efficacy of Mango Leaf, Neem Leaf and Tea extracts and found that all the three products were effective in reducing the plaque formation as well as the streptococcus mutans count.[49]

Recent advances and future prospects in caries prevention: Genetically Modified foods in Preventing tooth Decay

We are looking into an era of genetically modified food products that may have a role in privation of dental caries. Certain modifications by means of genetic engineering can lead to production of food material containing inherent property of anticariogenicity without altering the oral ecology. It is a transgenic crop that contains genes known for their desirable qualities.[50] Some research has been going on, on the following:

Genetically Modified Yogurt

Bacteria can prevent tooth decay, as well as cause it. Researchers have genetically engineered the bacterium in Yoghurt to fight the bugs that rot teeth. Lennart Hammarstorm of Karolinsha Institute, Stockholm, Sweden and his colleagues engineered Lactobacillus zeae to carry an antibody against streptococcus mutans on their surface. The antibody sticks to the molecule on S.mutans that normally sticks to the teeth. The two species clump together & slide harmlessly down the throat. This is the first time that such bacteria have been used to deliver passive immunity – antibodies from a source other than the immunized subject.[51]

Genetically Modified Milk

Science may make milk better for tooth health. A team of European researchers has genetically engineered a germ (lactobacillus) often found in milk to make it capable of neutralizing the bacteria that cause tooth decay in rats. They figured that if they genetically engineered lactobacillus so that its surface was studded with antibodies targeting the bad bacteria, the souped up milk microbes could neutralize tooth decay.

3. Genetically Modified Apple

Recently antagonist peptides have been searched to work against the specific enzyme system (GTF) of S.mutans. These 'antagonist peptides' can be successfully incorporated to various GM crops e.g.: Apple, Strawberries etc. Thus we can say no to caries without altering oral ecology. The peptide works by controlling the growth of Streptococcus mutans, the bacteria that cause tooth decay. It stops the microbes from binding to the tooth, preventing dental caries for upto 80 days at a time without using antibiotics which also kill 200 other

species of mouth bacteria that cause no harm and which promote the development of resistant superbugs.[52],[53] Clinical & Biological research is still going on & only time will tell that whether by genetically modifying the oral micro organisms in one way or other will we be able to safely tackle the problems that has crippled our oral health for generations.

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