

## Is Quaffing Soda and Fruit Drinks Innocent?

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### Abstract

Non-alcoholic beverages as fruit juices or soda-pop, regarded globally as 'soft-drinks' are ubiquitously consumed as innocent refreshment, sources of nutrition or for slaking thirst. Most are acidulated to enhance flavor but are capable of decalcifying dental hard tissues. Because tooth decay is started with a locus of decalcification, neglected oral hygiene allows for areas of stagnated biofilm when supplied with regular replenishment of fermentable sugars, to sustain an acid micro-environment. This progresses to cavitation with tooth-decay and eventual tooth loss. This explains why regular consumption of acidulated carbohydrate-laden drinks have been fingered as causes of erosion and caries. This review draws attention to conclusions much derived from fundamental research which provides evidence to substantiate this theory. Acidulated carbohydrate laden soft drinks, including pop-sodas are not innocent thirst slaking beverages. Consumption of these drinks contribute to the formation of diabetes, obesity, esophagitis, tooth erosion and decay.

**Keywords:** Acid; Attrition; Abrasion; Beverages; Caries; Cola; Drinks; Decalcification; Erosion; Esophagitis; Fluoride; Obesity

### Introduction

Tooth decay is among the most ancient and prevalent diseases afflicting humankind. Tooth decay and gum disease are one of the most prevalent global diseases affecting humans, and they remain the one of the most common causes for tooth loss worldwide. Diet and oral hygiene practices affects the formation of caries and gum diseases. The ecological microbial ecology of biofilm is now better understood. The combined effect of biofilm stagnation and diet not only clarifies how gum disease, dental ravages and caries are obtained but also how pop-sodas contribute to esophagitis, obesity and diabetes. Erosion (the acidulated decalcification loss of tooth material without bacteria action) is different from caries (the destruction with cavitation of calcified tooth material with microbial action). Some research evidence about cause and effect of these phenomena exists, but clear concise, coherent summaries and deconstructions to clarify both the processes are scant [1,2].

### Aim

This appraisal describes fundamental microbial progression of oral biofilm and explains how excess consumption of sugar-laden beverages as soft-drinks, contributes to the stated pathologies. Indications to moderate the disadvantages are indicated.

### Pathogenesis, evidence and data from research

Tooth material (enamel, dentine and cementum) is made up of calcified hydroxyapatite. The critical pH at which it will be decalcified in is at pH 5.5. Most acidulated drinks and pop-drinks (like colas) have a pH < 5.5.

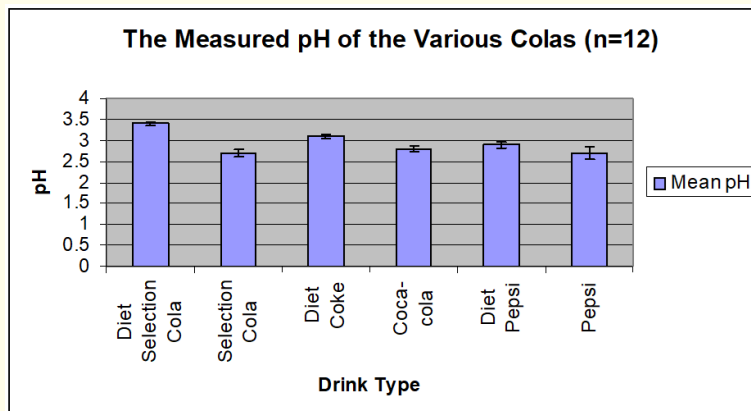


Figure 1: Acidity pH measures of various Cola pop-drinks [31].

It takes about 30 - 40 minutes for alkali saliva to neutralize the oral environment after a sugary drink [3]. Freezing juices extracts a pure water ice skeleton but also leaves behind a residual supersaturated acidic liquid, which may enhance flavor, but which takes more alkali saliva to neutralize [4]. The surface of teeth become decalcified at the micro-level each time an acidulated drink below pH 5.5 is imbibed.

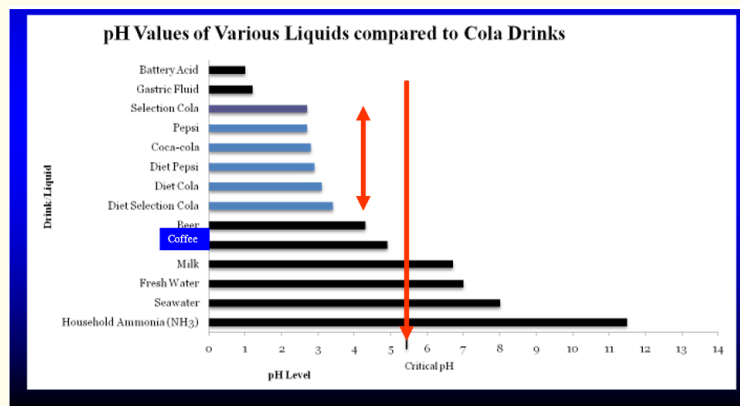


Figure 2: Acidity as pH of Common liquids; pH for various liquids (black) compared to pH of analyzed Cola pop-drinks (blue). All the Colas (short red arrow) measured have acidities below the critical pH of hydroxyapatite, (long vertical red arrow).

Decalcification may be reversible, but if material is lost without bacterial action, it is deemed erosion. A decalcified area that is attacked by microbes and causes progressive cavitation is called caries or tooth decay. Active fluoride ions combine with available calcium ions to form calcium-fluoride and calcium-hydroxy-fluoride, which will not decalcify at pH 5.5 but at a sustained much lower acidity of pH 3.5 [5,6].

The mouth acts as a host environment for a wide variety (> 10,000 species) of microbes and fungi. The microbes constrain growth of fungi [7], but in areas that are not cleansed with detergent chews, stagnation of the bacteria occurs. The micro-flora in the saliva are called planktonic and seed all area in the mouth. Bacteria attach to the hard surfaces and the adhering sessile colonies form and fuse to form biofilm which grows on teeth; the favored sites are in interproximal areas, cervical margins and furcal indentations which are major areas of stagnation. Topical fluorides and resin sealants are used in preventing dental caries in pits and fissures; these areas are prone to starting caries and gum disease [8,9].

Not all biofilms are the same. Biofilm is a dynamic, ionic, exchange gradient that facilitates microbial growth and metabolism. Biofilm can be readily displayed with disclosing dyes, and progresses through identifiable stages [10]. Oral biofilms make recognizable changes, from pilot pioneer ecosystems [which are mainly Gram positive (Gr+), non-motile, aerobic, non-invasive, acidogenic biofilms producing exotoxins, through intermediate stages with a mixed flora, including characteristic ‘corn-on-the-cob’ microbial morphotypes,] to climax community invasive ecosystems [which are mainly anaerobic, motile, Gram negative (Gr-), endotoxin producing, biofilms]. Various bacterial biochemical-molecules assist in the destruction of hard and soft tissues; these include acids, toxins, enzymes, antigens mitogens and other inflammatory inducing molecules. The progression *ab initio* to mature ecosystems in biofilm takes 3 - 4 weeks and may be a source for affecting both local and systemic pathologies [1,4,11,12].

### Clinical morbidity and manifestations

#### Hard tissues

Dental ravages derived from excessive drinking of acidulated beverages affects both deciduous and permanent dentition. Substituting juice for milk formula not only is deleterious for the child’s general nutrition but also will accelerate erosion and formation of caries. Freezing boxes of juice and allowing children to suck the acidic supersaturated residual liquid may enhance flavour but accelerates decalcification [13-15].

Erosion (loss of calcified tooth material without bacterial action) reduces enamel volume, increases dental sensitivity to a variety of stimuli and aggravates toothaches. Abrasion, (loss of tooth material from repeated mechanical scraping) manifests because softened decalcified enamel is removed from brushing; this is frequently seen with ‘horizontal-scrub’ brushing at cervical margins. Attrition occurs on the occlusal or incisal edges of teeth; it is from loss of softened enamel, caused by mastication when eating hard or fibrous foods. Acidulated drinks cause microscopic decalcification and after chronic repeated exposures, attrition, abrasion, and erosion will manifest. Often patients present complaining of general dental pain when eating, breathing in cold air, or drinking fluids [2,16]. Figures 3-A and 3-B.



**Figure 3A:** Healthy dentition.



**Figure 3B-Erosion:** Loss of hard tooth material from teeth without action from bacteria. The enamel crowns have been dissolved. The underlying dentine allows for stimuli to invoke dental pain while eating, drinking or breathing in cold air [2,16].

Decay is deemed to exist once bacterial destruction causes cavitation of the hard tissue. The destructive process is mediated by progressive bacterial activity and will progress from the surface, until it reaches the pulp and apices of the roots. Until the pulp is necrosed the tooth is called 'vital'; once the pulp is destroyed the tooth is 'non-vital', and although a non-vital tooth does not cause severe pain, it can remain in the mouth with its periodontal attachment intact. Teeth that are vital with caries often produce a pulpitis, which is responsible for the most severe pains experienced in life [17].

### Gum pathologies

Biofilm is also responsible for the formation of gum disease as gingivitis and periodontitis. Stagnated biofilm may calcify to form calculus (Tartar). Gingivitis if neglected may progress to form periodontitis (loss of tooth attachment to bony alveolar support). Not all gingivitis progresses to periodontitis: about 30% of gingivitis cases progress to periodontitis. Predisposing systemic cofactors may allow aggravated initiation and progress of periodontitis, like Diabetes mellitus, Herpes infection, or being immuno-compromised) [18-20].

### Discussion

Moderating the prevalence of decay or other dental hard-tissue tooth ravages (like erosion, abrasion, and attrition), as well as gum-diseases, may be achieved through prevention. This is mediated through fluoridation of potable municipal water, oral hygiene practices and diet modification.

For severe cases of periodontitis precipitated by systemic co-factors, appropriate medical management is necessary as well as specialist oral and dental care.

Fluoride (from water, diet or topical application) will not only reduce decalcification from acids, but also inhibit bacterial growth in biofilm. Also, regular disruption of sessile biofilm inhibits calcium removal, allows for re-calcification of decalcified loci, stops transformation to climax invasive biofilm. This consequently moderates the initiation and progress of caries and gum disease [21,22].

Topical application of fluoride is feasible for populations who can afford attending modern qualified dentists. But most populations in the world cannot afford modern dental care, and it behoves ruling authorities at national, provincial, and local levels to provide optimal prophylaxis against tooth decay by eufluoridation of potable drinking water. This is the cheapest, safest, and most effective model for prevention of caries. This is firmly established at between 0.7 and 1 p.p.m. (1p.p.m. = one part per million = 1 mg/Litre) [21-23].

The vast majority (> 90%) of infective gum diseases start with gingivitis (no gingival pocket exceeding 3 mm probing depth). About a third from this population, if neglected and have poor oral hygiene, may progress to periodontitis (destruction of the periodontal ligament attachment from tooth to bone, and probing depths > 5 mm). Among this group, a small but significant proportion will develop a rapidly progressive form of periodontitis because of systemic predisposing co-factors, like diabetes, Human-Herpes viral infection, or being immuno-compromised [17-19,23].

To control the initiation and progress of all gum disease, prevention of formation and disruption of stagnant biofilm is necessary. This is achieved with successful daily oral hygiene practices of brushing, flossing, irrigation, and mouth-rinsing. This disrupts the formation of extracellular surface gelatinous polysaccharides and deprives the Biofilm Gr+ and G- microbes of an ionic exchange media for acidification, decalcification, or and/or progressive destruction. Available fluoride also strengthens calcified loci, inhibits bacterial growth, and stops areas of initial decalcification from being attacked by cariogenic microbes [9,24].

Oral Hygiene practices evolved over centuries. Primitive tribes used natural twigs, branches, or roots to clean their teeth. This was known in the Islamic world as «the Miswak [25]. The major mission of oral hygiene is to remove all dentally attached biofilm, to avoid stagnation and subsequent maturation into climax microbial ecosystems. Commonly called 'Plaque', the undisturbed sessile biofilm tends to accumulate between the teeth and along the gingival margin on the cervical edges of enamel and dentine, as well as pits and fissures [1,11,12,26].

Biofilm bacterial colonies also penetrate the pits and fissures of teeth, places virtually inaccessible to commonly practised oral hygiene methods. Detergent chews may reduce but does not eliminate, biofilm from these areas. Should the diet include items, such as soft drinks and juices, with easily fermentable sugars (e.g. sucrose, lactose or maltose; fructose, glucose or galactose) the acidification of biofilm increases, starting in local areas of decalcification with subsequent destruction and cavitation producing caries. Should all plaque be removed by oral hygiene practices (regular brushing, flossing, irrigation) no dental decay or gum disease will develop. Cleaning and closing-off pits and fissures (with polymerizing sealants) significantly reduce the prevalence of decay starting in these vulnerable areas [27]. For millennia belief that fibrous foods like apples, carrots or celery would act as 'detergent chews' and remove biofilm. These were labelled as 'Nature's Tooth-brushes.' Eating fibrous fruits and vegetable does not remove biofilm from these caries susceptible areas, nor from the interproximal stagnating areas under inter-dental contacts. Detergent chews are not an adequate substitute for brushing and flossing [29].

Diets consist of what is ingested; nutrition is the products of the digested components consumed in the diet. All foods are classified as either solid, semi-solid or liquid. A diet high in fermentable carbohydrate, such as sweets and soda pops, promotes biofilm growth, because these diets are acidogenic, decay formation is prevalent in populations who consume large amounts of candies. All fruit juices and soft drinks are man-made products, and they are not natural beverages. Pop-colas are essentially chemical concoctions, and fruit-juicing removes most of the natural «packaging fibres», to yield the sapid contents as a carbohydrate- laden drink. The juiced beverages are automatically naturally acidulated with carboxylic acids (malic, citric and tartaric) to enhance flavour, and have pH's well below the critical pH of dissolving calcium-hydroxyapatite in teeth. Most pop-drinks are acidulated with acids (like carbonic acid from CO<sub>2</sub> and others), and sweetened with fermentable carbohydrates (like sugar, fructose, and glucose); these contents are major contributing causal factors of attrition, abrasion, and erosion. Even acidulated diet-colas sweetened with synthetic sweeteners, also show mordant effects of calcium because they have high acid contents (like phosphoric acid). Research show that if acidulated pop-drinks-are rinsed in the mouth, they erode calcium from teeth. This is also shown with fruit juices, like apple and grape juice; both these fruit juices are highly erosive. The evidence is irrefutable as research compares leaching of calcium from people-with-teeth, against people-without-teeth [30,31].

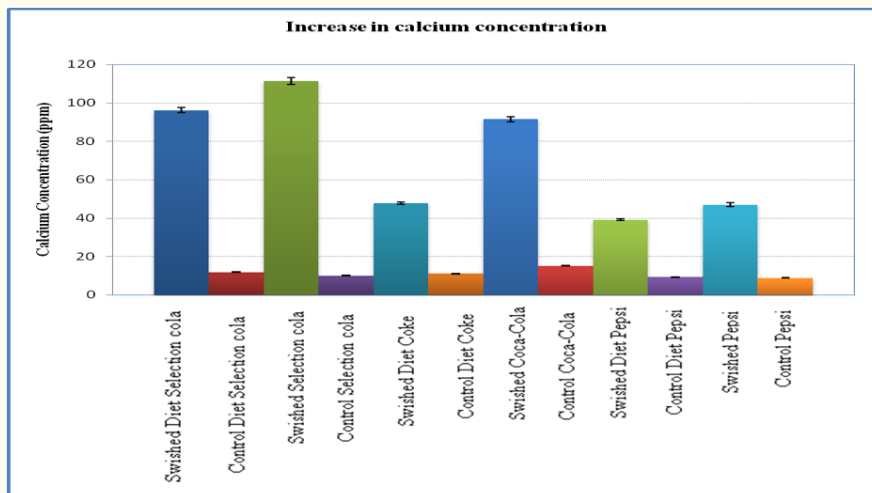


Figure 4: Calcium measures direct from the source (can) and after swished test-liquids.

Significant increases ( $p < 0.01$  Student-t) of calcium, found in all the colas tested, when swishes with cola from subjects *with-teeth* are compared to swishes of colas from subjects *without-teeth*. The calcium content in the water controls are negligible [30,31].

### Concluding Remarks

Pop-sodas are not innocent thirst quenchers and have been strongly associated with obesity, diabetes, Barrett esophagitis, osteoporosis and even caffeine addiction [30,31].

Although fruit juices are derived from natural fruit, to claim the manipulated extracted liquid from fruit as ‘natural’, is egregious and disingenuous as a distortion of reality. Marketed fruit juices are highly industrialized, manipulated, and distorted products. Fruit-juice boxes and bottles filled with juice. do not grow naturally on trees.

A fundamental principle of basic science is repeatability of experiments; when the research cited was repeated, they yielded similar-, or close to exactly-, the same data. This is true with experiments testing pop-drinks and fruit-juices, rinsed by people-with-teeth, and compared to people-without-teeth [30,31].

To moderate and/or improve the morbidity derived from drinking these acidulated beverages, personal drinking habits and preferences should be changed. Drinking these beverages less frequently, reducing the amount imbibed, drinking in large swallows as opposed to sustained sipping; choosing non acidulated liquids (like tea, coffee, flavoured water, milk, or soups); and not drinking these drinks last thing at night before retiring’ all these would significantly assist in reducing the prevalence of dental stigmata.

Treatment of oro-dental ravages (attrition, abrasion, erosion, gingivitis and periodontitis) is primarily and optimally through prevention. Specialist management and treatment by dental professionals is essential to maximize benefit and to sustain healthy dentition throughout life.

### Conclusion

Quaffing acidulated pop-sodas and/or fruit juices is major cause of erosion and contributes to formation of dental caries. Stagnated biofilm causes tooth decay and gum disease. Optimal management of these two major afflictions of Mankind can be realized through prophylaxis. This involves fluoridation of dentitions and practice of regular oral hygiene methods to remove plaque and avoid biofilm stagnation.

### Author's Statement

The author has no conflicts of interest to declare.

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