

Tooth surface pH during drinking of black tea

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Objectives To investigate the composition of black tea in terms of its erosive potential. To determine the pH profile at the palatal surface of anterior and posterior sites of the dentition after drinking black tea.

Methods Tea solution was analysed for its pH and anion composition to provide information on its acid content. A group of ten healthy subjects, aged 21–23 years were monitored for tooth surface pH on the palatal aspects of the maxillary anterior dentition and the maxillary molar dentition after drinking tea using a micro-pH electrode mounted on a vinyl splint.

Results The pH of the tea solution was 4.9 and the major anions detected were oxalate and citrate. Tooth surface pH monitoring indicated that only small decreases in pH of less than 1pH unit were observed after drinking tea and the minimum mean pH reached was 5.45. Maximum decrease in pH was observed after 20–25 seconds and resting pH levels were restored within approximately 2 minutes after drinking.

Conclusion The pH and anion profile of black tea are indicative of low acid composition. The very small pH decreases observed at the tooth surface after drinking tea indicate that it may be safely recommended as a substitute for more acidic drinks as a part of preventive measures for dental erosion.

A number of studies have reported significant levels of dental erosion amongst both children and adults in the UK.^{1–6} Dental erosion may be of both intrinsic⁷ and extrinsic,⁸ ie endogenous (recurrent vomiting, regurgitation, reflux) or exogenous (principally diet), origin and the relative importance of these two origins will be determined by a number of factors. An extrinsic origin for erosion will be influenced both by dietary and host factors, the former of which provides a possible way to reduce the prevalence and severity of the condition.

A variety of dietary components may contribute to erosion,^{4,6,9–13} but acidic drinks appear to be of particular importance. An association between consumption of acidic drinks and erosion has been demonstrated^{4,6,14,15} and attempts have been made to re-formulate citrus-based drinks to reduce their erosive potential.¹⁶ However, the increasing consumption of these acidic drinks¹⁷ continues to be a matter of concern in terms of erosion. There is a need to identify drinks of low erosive potential, which may be safely recommended to patients for substitution for more acidic drinks in the diet.

Tea has long been an important fluid component of the diet in the UK. Whilst traditionally it has largely been consumed as a hot bev-

erage, the American practice of consuming iced tea without milk is also appearing in the UK. The majority of the tea consumed in the UK is black tea rather than the green variant, which is more popular in the Far East. Much of the tea habitually consumed in the UK is with the addition of milk, which may confer nutritional benefits on the beverage. Tea has a complex composition and its consumption has been recognised as having some beneficial dental effects because of its appreciable fluoride content.^{18–19} However, little is known of the acid content of black tea and its influence on oral acidity during consumption. The aim of the present study was to characterise the acid composition of black tea and to assess the influence of its consumption on tooth surface pH in human subjects to provide a basis for dietary advice to patients.

Materials and methods

Tea infusion solutions (1% w/v) were prepared from black tea (World Blend – Tetley USA Inc) using a commercial Bunn-O-Matic tea brewer (Bunn-O-Matic Corp, USA) with 40 g tea leaves and 4 L double distilled deionised water. Solutions were prepared fresh daily and allowed to cool to room temperature prior to use.

The anion composition of the tea solution was quantitated by ion chromatography using a Dionex DX-500 ion chromatograph and an AS15 high capacity separation column eluted with a water-potassium hydroxide gradient to assess possible acid components (Dionex UK Ltd, Camberley, Surrey, GU15 2XA, UK). Separated components were detected by conductivity with ion suppression and the digitised data quantitated by calibration of the system with standard solutions of the acids.

Ten healthy subjects, aged 21–23 years, with good standards of oral hygiene were monitored for tooth surface pH after drinking tea. Ethical approval for the study was received from the South Birmingham Local Research Ethics Committee. The influence of black tea on tooth surface pH was assessed using an *in situ* pH monitoring approach previously reported by our group.²⁰ Essentially, this involved the manufacture of vinyl splints from individual alginate impressions and plaster casts of the subjects' maxillary dentition. Short lengths of small-bore plastic tubing were mounted on the splints at two positions with cold cure acrylic to provide mounting points for a micro-pH electrode (0.6 mm diameter). The micro-electrode was of the type routinely used for oesophageal pH monitoring. The two positions were those previously chosen to reflect areas of higher and lower dietary erosion — palatal aspect of the maxillary anterior dentition and palatal aspect of the maxillary molar region. Using a skin reference electrode and patient-isolated pH meter, the pH at the dentition surface was monitored in subjects under resting conditions and after drinking tea. The resting pH essentially provided an internal control of tooth surface pH in the absence of ingested dietary acids. The pH changes in the presence of such acids have been previously reported.²⁰ All measurements were made at the same time of day (midday) to avoid diurnal variation and subjects refrained from drinking or eating for 3 hours prior to the experiment. Each subject was calibrated to the pH meter with two standard pH buffer

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solutions and after assessment of resting pH, the subject drank 100 ml of the tea solution and the pH was recorded for periods of up to 20 minutes.

Results

The pH of the tea solution was 4.9. The anion profile for the tea solution indicated that oxalate and citrate were the major anions detected (Table 1).

Monitoring of tooth surface pH indicated that only small decreases in pH were detected at both palatal incisor and molar sites after drinking tea (Fig. 1). The mean resting pH for the subjects at

Table 1 Anion profile of tea solution

Anion	Concentration (mg/l)
Fluoride	3.8
Acetate	2.2
Chloride	9.5
Sulphate	24.3
Oxalate	120.8
Nitrate	0.9
Phosphate	24.8
Citrate	44.2

the two sites was: incisor = 6.40, molar = 6.59. The maximum decrease in pH was observed at 20 and 25 seconds respectively for the two sites, which represented: incisor = 0.94, molar = 0.65. These corresponded to minimum pHs of 5.45 and 5.95 respectively at these two sites. The inter-subject variation in pH both at rest and after drinking tea was small. The standard deviation for the pH at both sites in the group were generally in the range 0.30 to 0.35 and did not exceed 0.65 at any time point. The minimum and maximum pH decreases at the incisor site were 0.82 and 1.60 and at the molar site were 0.45 and 0.98 respectively for the subject group. Resting pH was restored within approximately 2 minutes at both sites after drinking the tea. The mean time for the drinking of the tea was 27.3 and 22.0 seconds respectively for the incisor and molar site experiments.

Discussion

The increasing awareness of dental erosion and the need for good preventive advice²¹ requires that practitioners and other healthcare professionals should be aware of what drinks can safely be recommended to patients. Such advice must be realistic and any recommendations should generally be as a part of a well-balanced diet.

The present study has demonstrated that black tea does not have a

low pH in comparison with many of the beverages currently consumed and has an anion profile indicative of low acid composition. Citrate and oxalate were the major anions present. Under acidic conditions, the concentrations of these anions would suggest molar concentrations of no greater than 0.23 and 1.3 mM for citric and oxalic acids respectively. To put these figures in dietary context, tea would have less than 1% of the citric acid concentration found in pure orange juice.

The low acidity of the tea is reflected in the pH profiles at the dentition surface recorded. The decreases in pH observed after drinking tea were minimal compared with those previously observed after drinking 1% citric acid (similar concentration to some fruit-based acidic drinks) where pHs as low as 2 were reached.²⁰ Not only were the pH decreases very small but also, they occurred very rapidly (maximal at 20 to 25 seconds) and resting pH levels were restored within approximately 2 minutes. Although there was a greater decrease in the incisor region compared with the molar region, this would not be clinically significant. Thus, drinking tea led to only small and short-lived decreases in pH at the tooth surface. It seems unlikely that such pH changes would be significant in the development of erosive lesions and that tea could be safely recommended as a substitute for more acidic drinks. The limited sample of young, healthy subjects in the present study was dictated by the nature of the pH monitoring procedures. However, there is little reason to expect that the results observed would differ from the general population unless salivary function was compromised in some way. Diet can be influenced by life-style pressures and the American trend of consumption of iced tea and cold tea in soft-drink type cans may allow tea to be successfully targeted at younger as well as older age groups. However, addition of lemon to tea to enhance flavouring should be avoided as should sugar, the latter of which may contribute to dental caries. Further oral health benefits might also accrue from drinking tea as a result of its appreciable fluoride content.¹⁸⁻¹⁹ Despite these possible advantages of tea, excessive consumption may lead to problems of staining of the dentition. Such staining is likely to be caused by interaction of components of the tea with both surface integuments like the acquired salivary pellicle and possibly, the mineral crystals of dental enamel. Whilst there is no evidence to indicate that this staining is detrimental to tooth structure and function, it can represent a cosmetic problem. In groups at risk of iron deficiency, eg young infants and the elderly, excessive consumption of tea should be avoided to prevent possible effects on intestinal mineral absorption. However, such potential problems relate to excessive consumption and recommendation of any beverage should be as a part of a well balanced diet.

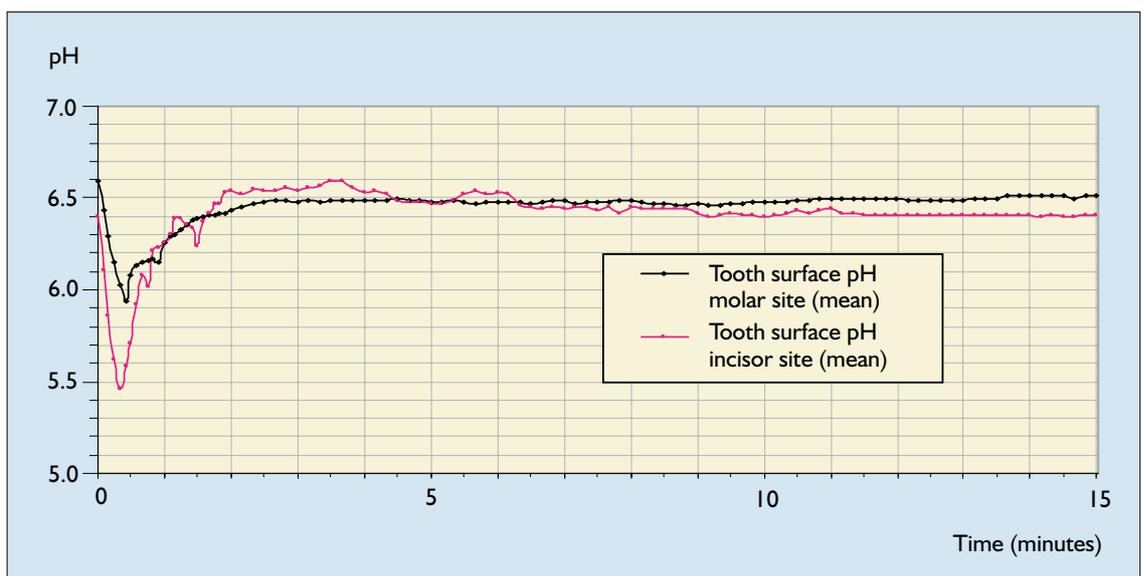


Fig. 1 Mean pH at the palatal incisor and molar sites after drinking tea

Whilst erosion is clearly multi-factorial in nature, dietary advice to reduce the consumption of acidic drinks may have significant benefits in its prevention. The present study has demonstrated that tea could provide a useful substitute for more acidic drinks in the diet.

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