FACTORS AFFECTING THE EXTRACTION OF FLUORIDE FROM TEA: APPLICATION TO THREE TEA SAMPLES

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SUMMARY: Infusion time and water hardness were examined for their effects on fluoride extraction from three different brands of tea (Çaykur-Kamelya, Rize-Turist, and Lipton-Ceylon). With soft water (18 mg eq $CaCO_3$/L), extraction after 10 min at 80°C was over 90% complete but only 75% complete with hard water (79 mg eq $CaCO_3$/L). After extraction for 20 min with soft water, the water-soluble fluoride contents of the three brands of tea were determined as 98, 53, and 83 ppm, respectively. Addition of lemon or lemon juice to the tea extract did not change the free fluoride content.

Keywords: Ceylon tea, Fluoride in tea, Tea infusion, Turkish tea.

INTRODUCTION

Tea is known to contain high concentrations of fluoride; tea consumption, therefore, can contribute significantly to total fluoride intake. Recently, green tea has been studied for its fluoride content and for improving its brewing conditions.[1] The effect of carbon treatment on fluoride levels in various kinds of teas and fruit and vegetable juices has been examined.[2] King, and Tsang[3] determined the fluoride content of Chinese teas available in Hong Kong. The fluoride content in tea and soil from tea plantations has been assayed using a fluoride ion selective electrode.[4] Different varieties of teas were examined such as green tea, black tea, oolong tea, and brick tea from China, England, and Sri Lanka. Moody *et al*[5] studied the determination of fluoride in coffee and tea using a microprocessor coupled with a fluoride ion selective electrode. In another investigation the amount of fluoride released from powdered tea leaves treated with artificial gastric and intestinal juices was determined.[6] Direct eating of powdered tea leaves, which is a custom in Japan, was found in that study to increase the amount of fluoride intake. In some countries it is customary to drink tea with lemon or lemon juice, thereby changing the acidity of the medium and possibly liberating some complexed or bound fluoride. It is of interest therefore to determine whether this practice will change the amount of free fluoride in the tea extract. In this study the effects of infusion time, water hardness, and acidity have been studied for three different varieties of tea.

MATERIALS AND METHODS

For the electrochemical potential measurements, a JENWAY 3040 Ion Analyser was used with a double junction Ag/AgCl Orion 924036 reference electrode, and an Orion 9409BN fluoride selective electrode was used as the working electrode. pH determinations were made with an Orion 924005 pH electrode.

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All reagents were of analytical reagent grade (Merck). In order to hold the ionic strength constant 0.1 M $NaNO_3$ was used during all measurements. To prevent complex formation of aluminum and iron with fluoride ion, TISAB solution was used with the tea extracts.

The TISAB solution was prepared by dissolving 22.05 g of sodium citrate dehydrate and 0.8 g of sodium hydroxide in water and diluting to 100 mL. The pH was then adjusted to 5.3 with $HClO_4$.

Three different black tea samples were used; two were Turkish of Black Sea origin and one a Ceylon brand.

For determination of water hardness, 100-mL water samples were taken and 3 mL of concentrated HCl was added. After warming to boiling to expel CO_2, each water sample was adjusted to pH 10 with a pH 10 buffer. It was then titrated with a standardized EDTA solution in the presence of Eriochrom black T.

Tea was extracted similar to a Turkish way of tea infusion. To each 2 g of dried tea, 50 mL of boiling soft water was added and the mixture left on a water bath for extraction of fluoride for 5–20 minutes at 80°C. At the end of the infusion period, the tea was sieved, washed with water, and the tea extract was diluted to 100 mL. A 16-mL aliquot was taken from each 100 mL of solution after different infusion times. To each aliquot 2.0 mL of 0.1 M $NaNO_3$ and 2.0 mL of TISAB buffer solution were added, and potential measurements were made with the fluoride ion selective electrode. To duplicate the effect of lemon juice on the tea extract, 1 mL of 1 M $HClO_4$ was added to 16 mL of tea extract, 1 mL TISAB and 2 mL $NaNO_3$ were added, and the solution was allowed to stand at 60°C for 5, 10, and 15 minutes.

RESULTS AND DISCUSSION

Water hardness and fluoride extraction: By the eriochrom-EDTA method, the soft (drinking quality) water was found to have 18 mg eq $CaCO_3$/L and the hard (tap) water 79 mg eq $CaCO_3$/L. As shown in Table 1, the mean concentration of fluoride ion from four infusions of 2-gram samples of the Turkish blend Çaykur-Kamelya tea with 50 mL of water at 80ºC gradually increased after 5, 10, and 20 min. After 10 min the extraction with soft water was 97% complete but only 72% complete with hard water. After 20 min the extractions were nearly complete with either the soft or hard water. Accordingly, the soft water was used for the rest of the experiments.

Fluoride extraction from other tea samples: Results of the same infusion procedure with soft water on all three brands of tea examined are summarized in Table 2. Rize-Turist tea is seen to have the lowest water-extractable fluoride content; a higher level is present in Lipton-Ceylon tea, and the highest level in Çaykur-Kamelya tea. Also shown in Table 2 is the estimated amount of fluoride from these three brands of tea consumed per day in Tur-

key from the customary ten 100-mL cups of tea, each containing half (25 mL) of the original 50-mL extract. As can be seen, the highest fluoride intake (0.98 mg/day) came from Çaykur-Kamelya tea after 20 min of infusion.

Table 1. Effect of water hardness and infusion time at 80ºC on fluoride concentration (ppm) in 50 mL of extract from 2.0 g of Çaykur-Kamelya tea ($x \pm ts / n^{1/2}$, n = 4, 95 % confidence interval).

	5 min	10 min	20 min
Tap water	2.60	2.84	3.76
Soft water	2.72	3.80	3.92

Table 2. Fluoride extracted and daily fluoride consumption from tea, according to variety of tea and infusion time (average of ten small glasses, each containing 25 mL of tea extract).

Tea	Infusion time	mg F^-/50 mL of tea extract	mg F^- in ten glasses of tea
Çaykur-Kamelya	5 min	0.136	0.68
	10 min	0.190	0.95
	20 min	0.196	0.98
Rize-Turist	5 min	0.092	0.46
	10 min	0.100	0.50
	20 min	0.106	0.53
Lipton-Ceylon	5 min	0.136	0.68
	10 min	0.156	0.78
	20 min	0.166	0.83

Effect of acid on fluoride in the tea extracts: The fluoride concentrations in the tea infusions with either soft or hard water were unchanged by addition of 1 M perchloric acid after as much as 15 min standing at 60ºC. Therefore, addition of lemon or lemon juice, which is a common way of drinking tea in some countries, is not expected to affect the quantity of free fluoride in tea.

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