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Elemental composition of betel nut and associated chewing materials

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Betel nut chewing (Areca catechu), whether plain or wrapped inside a betel leaf ‘quid’ together with other substances including tobacco, has been reported as a cause of the high incidence of oral and oesophageal cancers in Asian communities worldwide. Chewing of such substances results in the formation of nitrosamines, some of which may be diabetogenic to man. The incidence of Type 2 diabetes is particularly prevalent amongst Asian immigrants living in the UK and as part of a larger study we have analysed a number of popular betel nut based chewing materials to determine their elemental composition. Instrumental neutron activation analysis was used for determination of elemental concentrations of short-lived radionuclides. Ag, Al, Br, Ca, Cl, Cu, Dy, K, Mg, Mn, Na, Ti, and V were detected, some of which are implicated in diabetes. Concentrations of these, except for Ag, Dy and Ti, are reported and compared with values found in betel-nut and chewing materials from Taiwan. It is indicated that for certain elements the amount ingested by betel-nut chewers may be a significant fraction of their daily dietary intake.

Introduction

Betel nut (Areca catechu) has been chewed for hundreds of years and is currently being used by 10% of the world’s population.[1] Betel nut is a coconut like fruit of the ‘Areca Catechu’ palm that is harvested and chewed by millions of people from India, Vietnam, Sri Lanka, Indonesia, Philippines, Marianas, American Samoa, Beleau and Bangladesh. Commonly the betel nut is mixed with various chewing materials including lime and other flavorings, some of which are tobacco based, and wrapped into a betel vine-leaf ‘quid’ for chewing. Chewing of betel nut, whether plain or wrapped into a leaf, is known to play a role in various medical conditions such as cardiovascular function[2] and epidemiological studies have reported the high incidence of oral and oesophageal cancers in many oriental countries and in Asian communities worldwide.[3] Betel nut chewing populations have increased incidence of foregut cancers related to nitrosamines[4] which are extracted by saliva and lime. This suggests that betel nut consumption could be diabetogenic.[4] In addition, Areca nut mixed with lime can produce reactive oxygen species, upon the generation of which trace metal ions such as Fe^{2+} and Mg^{2+} have been found to have profound modifying effect.

In the UK 10–15% of Asian groups (Indian, Pakistani and Bangladeshi) have Type 2 diabetes (non-insulin dependent diabetes NIDDM) compared to 3% of Caucasians.[5] Asia is expected to be the home to 61% of the total global number of people with diabetes by the year 2010 suggesting that the number of people of Asian origin with Type 2 diabetes in the UK will increase further.[6] The high prevalence of the disease amongst Asians in the UK is not simply due to an increase in Western lifestyle as an equally high prevalence has been found in groups of Asians living in Fiji and in India, both in towns and rural areas.[7] A family history of diabetes is significantly more common in Asian diabetics than Europeans.[5] It has been proposed that migrant Asian communities may have brought active aetiological agents for diabetes with them in addition to genetic factors.

Diabetics are often found to have an altered elemental status compared to non-diabetics.[8] Elements found to have connections with diabetes, include lower levels of zinc, higher copper levels, and lower magnesium and manganese levels when looking at plasma samples.[8,9] Such elements are said to be involved in insulin activity, release or glucose tolerance and hence in complications of the disease, such as retinopathy and ischemic heart disease.[8] Diabetic patients tend to lose large amounts of zinc and magnesium in their urine which could account for the low levels found in their blood.[9] Zinc has been found to help with insulin secretion, as well as helping leg ulcers and wound healing, which are common problems amongst diabetics.[10] Vanadium has insulin like properties which can help improve glucose control in diabetics.[6] Research has reported the presence of cadmium, copper, nickel and zinc in US chewing tobacco.[11] It is possible that the elemental composition of betel nut and associated chewing ingredients like lime and betel vine-leaf may be connected in some way to the onset of diabetes or complications of diabetes. For example the increase in saliva production following mastication of these materials could play a role in delayed gastric emptying which is characteristic of diabetes.[12]

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Experimental

Sample preparation

Samples of the commercial products of betel nut and associated chewing materials were obtained from Bangladeshi markets in the Tower Hamlets area of the east end of London. The seven different varieties of samples chosen were all popular with the Bangladeshi community and are listed below with information about composition and provenance, whenever available or known: (a) Plain sliced betel nut, Zeera cut supari, Shaan products, produce of several countries; (b) Pan Masala and sliced betel nut, Mukhwas, Shaan products; (c) Pan Masala Pan Parag, Kothari products Ltd, Kanpur, India. Betel-nuts, catechu, lime, cardamon and flavors; (d) Najma, Zafrani Zarda, Flavoured chewing tobacco, Alam Tobacco Company, Karachi, Pakistan; (e) Hakim Pury; (f) Bat, Bat One, Baba, Zarda, Gulabi Patti; (g) Baba, Zafrani Zarda, Flavoured chewing tobacco, Dharampal Premchand Ltd, Delhi, India. Tobacco flakes, natural and synthetic flavors, silver leaves, saffron and aromatic spices.

Prior to analysis all samples were ground and homogenised using a mortar and pestle and pelletised into 5mm diameter pellets weighing 50–100 mg. The pelletised samples were kept in pre-cleaned polyethylene containers ready for irradiation.

Analysis

Instrumental neutron activation analysis (INAA) was used to determine the elemental concentrations of the selected materials. Samples were irradiated at the Imperial College's Reactor Centre. Two different irradiation systems were used, the In Core Irradiation System (ICIS) and ALVIS (Automated Large Volume Irradiation System). ICIS has a thermal neutron flux typically $2\cdot10^{12}$ $n\cdot cm^{-2}\cdot s^{-1}$ and ALVIS $1\cdot10^{12}$ $n\cdot cm^{-2}\cdot s^{-1}$. Both ICIS and ALVIS are automated irradiation systems ideal for rapid analysis of short-lived isotopes. Complete sets of samples were analysed in November 1998 (ICIS) and November 1999 (ALVIS) as a test of quality control of the products used for chewing.

ICIS: The irradiation conditions for ICIS comprised of a two minute irradiation, followed by two minutes waiting time and five minutes counting time. Samples were retrieved from the reactor pneumatically at defined intervals and counted on a Ge(Li) detector.

ALVIS: Irradiation carried out with ALVIS, as mentioned above, was a year later than the initial investigation using ICIS. ALVIS irradiation conditions were five minutes irradiation, followed by one minute waiting time and five minutes counting. Samples were counted on a different Ge(Li) detector.

In both cases the elemental concentrations were found by using the comparative method. Typical detection limits for the elements determined, at twice the standard deviation of the background, were Na 18.7 μg/g, Mg 46.3 μg/g, Al 0.4 μg/g, Cl 41.6 μg/g, Ca 121.5 μg/g, V 0.03 μg/g, Mn 0.35 μg/g, Cu 1.3 μg/g and Br 0.7 μg/g. Note that at the detection limit, quoted at twice the standard deviation of the background, the value of precision is approximately 70%. Between end of irradiation and start of counting, samples were transferred into pre-cleaned polyethylene containers to eliminate any contribution from the irradiated polyethylene vials.

Results and discussion

Elemental concentrations of all samples determined by INAA are presented in Table 1. Elemental levels for Na, Mg, Al, Cl, Ca, V, Mn, Cu and Br have been given as a range and an arithmetic mean together with the percentage standard deviation. The percentage standard deviation quoted in certain cases is high, indicating the diversity of substances comprising each material and branded product over the two year period (1998 and 1999) and suggests more thorough homogenisation of larger amounts of the samples maybe necessary in future studies to produce a more representative sample. Of these samples Mg, V, Mn and Cu have been found to play a role in diabetes. Further elements were detected for example, Ag in Pan Masala with betel nut, Ba in Pan Masala, Pan Parag, Ba, Ti, Dy in Najma, Ba, Ti, I, Dy in Bat, Bat One, Ag, Dy in Baba, Zafrani Zarda.

The values obtained for the betel nut are given in Table 2 and displayed for comparison with elemental concentrations in betel nut found by WEI et al.[13] in Taiwan. The values quoted from Taiwan are given as a range which has been taken from the elemental concentrations found in betel nuts for various areas of Taiwan during spring and summer seasons following lyophilisation of the samples. They also analysed white and red limes from different regions, separately, as these are constituents of betel 'quid' chewing in Taiwan. Excluding Al and Na, concentrations determined in this work are lower than those found in Taiwan as would be expected since our samples were analysed as chewed and were not freeze dried. A concentration of 105–216 μg/g for Na is found to lie within the range given by WEI et al.[13] Except for Al levels, the concentrations of other elements in betel nut, determined a year apart with different irradiation systems showed good consistency. In Table 2 there is a column indicating the intake through betel nut in Taiwan. This is estimated on the consumption of continuous and habitual chewers. Estimates were also made for red and white lime daily intakes. Betel nut chewing can contribute a significant fraction of daily intake of elements in Taiwan[14] for Al, Br, Ca, Mg and Mn (no values are available for Cu and V). We have calculated, using the highest estimates of the elemental intake from betel nut based chewing substances, as a percentage of the daily dietary intake of betel nut chewers in Taiwan suggest that 50% of Al, 70% of Mg and 25% of Mn are ingested through this route. A comparable study of the daily intake of elements of the Bangladeshi population in the Tower Hamlets area of the east end of London does not exist. Comparisons of course can be made, for example, with the values of elements in Indian vegetarian diets but this could be misleading.

Conclusions

Elemental concentrations for up to nine elements were reported for betel nut and six varieties of chewing materials. Of all samples, betel nuts showed the most similar elemental concentrations, consistent perhaps with their relative homogeneity over the two years and across the two INAA conditions and systems used. Some of the reported elements are known to have a link to diabetes and it encourages further work into this area.

Table 1. Range, arithmetic mean and standard deviation of elemental concentrations in betel nut and chewing materials

Material	Na Concentration, μg/g			Mg Concentration, μg/g			Al Concentration, μg/g			Cl Concentration, μg/g		
	Range	Mean	% sd	Range	Mean	% sd	Range	Mean	% sd	Range	Mean	% sd
Betel Nut	105-216	181	26	560-615	587	4	7-50	23	71	1100-1790	1590	17
Pan Masala +	327-869	691	26	479-1250	985	27	10-79	36	40	555-1690	1070	5
+ sliced betel nut												
Pan Masala, Pan Parag	298-11000	4140	36	4010-55200	17600	77	56-805	266	72	1280-12800	4480	62
Najma	5730-92000	28700	70	4590-80100	24700	72	811-25400	7000	87	8120-129000	40000	71
Hakim Pury	4780-4970	4880	2	7670-8100	7890	3	808-1910	1360	41	21500-21200	21300	1
Bat, Bat One	706-1170	938	25	6430-1100	9540	11	1390-2680	1880	24	9590-19900	14200	20
Baba, Zafrani Zarda	166-16200	9330	12	178-28200	12700	27	5-1530	452	70	564-53100	23200	16

Material	Ca Concentration, μg/g			V Concentration, μg/g			Mn Concentration, μg/g			Cu Concentration, μg/g			Br Concentration, μg/g		
	Range	Mean	% sd	Range	Mean	% sd	Range	Mean	% sd	Range	Mean	% sd	Range	Mean	% sd
Betel Nut	505-646	575	10	ND			10-13	11	12	4-6	5	19	1*		
Pan Masala +															
+ sliced betel nut	1350-2470	1900	29	0.2-1	0.4	62	11-24	20	12	3*			9-80	38	51
Pan Masala, Pan Parag	3880-98100	30400	83	1-7	4	75	22-179	69	44	8-53	30-73		5-40	15	56
Najma	4150-435000	127000	84	3-38	20	85	70-88	76	5	ND			41-57	47	12
Hakim Pury	31300-31400	31300	0.2	5*			163-218	191	14	ND			17*		
Bat, Bat One	22400-29600	27400	5	4-7	6	25	196-333	247	18	ND			ND		
Baba, Zafrani Zarda	560-47900	14900	63	ND			40-149	116	28	ND			2930*		

ND = Not detected.
* Detected in one sample.

Table 2. Range of elemental concentrations in betel nut

Element	This work (as chewed)	Tawain[13] (freeze-dried)	Daily intake through betel nut in Taiwan[13]
Al	7-50 μg/g	4-19 μg/g	0.01-0.05 mg/day
Br	1* μg/g	14.7-64.6 μg/g	35-155 mg/day
Ca	0.51-0.65 mg/g	4.71-12.04 mg/g	11-29 mg/day
Cl	1.1-1.8 mg/g	7.6-10.8 mg/g	18-26 mg/day
Cu	4-6 μg/g	38-188 μg/g	Not established
K	4.22-4.27 mg/g	11.9-20.4 mg/g	0.03-0.05 mg/day
Mg	0.56-0.62 mg/g	2.41-3.82 mg/g	6-9 mg/day
Mn	10-13 μg/g	102-300 μg/g	0.24-0.73 mg/day
Na	105-216 μg/g	13-423 μg/g	1-2 mg/day
V	ND	0.6-3.27 μg/g	1-8 mg/day

ND = Not detected.
* Detected in one sample.

What is also required is a study of the daily intake of the Bangladeshi community of the Tower Hamlets area of the east end of London in order to reinforce the suggestion that betel nut chewing is a significant source of the daily intake of some elements for habitual chewers. The different role that elements like Mg, V, Mn and Cu may play in diabetes does not preclude the possibility that this source of elemental intake can be both harmful and beneficial. Epidemiological studies in Papua New Guinea have indicated that despite a high frequency of betel-nut chewing, glucose intolerance was uncommon.[15] It has also been reported[16] that in a British Asian community originating from Bangladesh, a reduction in spot blood glucose was found in betel-nut chewers which could be due to the hypoglycaemic action of arecoline,[17] one of the psychoactive betel-nut alkaloids. Epidemiological data may not therefore be able to determine whether betel-nut has increased genetic susceptibility to diabetes, unless it includes the examination of appropriate susceptibilty genes and their distribution in communities with varying prevalence of diabetes.[16]

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