INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Prevalence of Iodine Deficiency Disorders and Urinary Iodine Excretion among Primary School Children in Makina and Kilimani in Nairobi, Kenya

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Abstract:
Objective: This study was design to determine the prevalence of IDD by measuring urinary iodine excretion among primary school age children, to assess the effect of goitrogen on urinary iodine absorption and assess the impact of salt iodization program.
Methods: A questionnaire was given to all students participating in the study to be filled out by their families regarding whether or not they used iodized salt in the preparation of food in their homes, whether they consumed cassava, kale cabbage and sorghum including the frequency of consumptions and to bring two table spoonful of salt they use at home. The iodine in urine was determined using sadell kolthoff method while iodate in salt was analysed using iodometric titration.
Results: Of the 142 respondents who participated in the study, the overall prevalence of IDD in the study population was 3.5% (excreting less than 99 µg I_2/l) which is below the WHO value of less than 5% implying sufficient iodine in the study population. In Makina, it was 5.4% with a median urinary iodine excretion (UIE) of 215.1µgI_2/l ±57.8 while Kilimani had a prevalence of 2.4% and a median UIE of 242.2 µg I_2/l. ±67.7. In addition, 18.4% of the study subjects excrete optimum UIE (100-199 µg I_2/l) while 78.1% excrete above 200 µg I_2/l. On the consumption of salt, 82.3% reported that the salt was iodated and 63.9% knew why salt is iodated while 17.7% reported that the salt was not iodated while 36.1% did not know the reason for salt iodation. All the samples (home salt) (range 8.1-341.93 mg iodate/kg salt were analysed and had a mean of 134.88 mg iodate/kg salt (± 61.8). However, there was no significant difference between the iodate levels in the salt samples from the households of the two schools (Makina and Kilimani having a mean of 145.1 mg iodate per Kg salt and 135 mg iodate per Kg salt respectively) ($t = -0.932; p > 0.05$). Analysis of the six salt brands (53 salt samples) obtained by direct purchase indicated that the brands Kay salt, Kensalt, sea salt, refined, mzuri and unknown had a mean of 159.67, 165.89, 2.02, 191.45, 150.55 and 176.58 mg iodate/Kg salt respectively. Only Kensalt was within the recommended iodate levels of 168.5 mg/kg salts. When iodate levels in the direct purchase salt brands and home salt were paired, there were significant differences ($p < 0.05$). On the association between UIE and consumption of goitrogenic foods, there was significantly increased levels of urinary iodine in non-consumers of cassava relative to the consumers ($p = 0.032$).

Conclusion: IDD prevalence in Nairobi is 3.5%, which is below the WHO value of less than 5% suggesting that the study community is iodine sufficient. Universal salt iodation is effective in controlling IDD among school children in the study population in Kenya. Many brands of salt sold in the Kenya have less and others high iodate levels than the Kenya Government recommended levels of 168.5 mg/kg salt. Consumption of kale (sukuma wiki), cabbage and sorghum has no effect on urinary iodine excretion except cassava since it affects iodine absorption that could put consumers at risk of hypothyroidism. Effective monitoring and surveillance by Kenya Bureau of standards should be encouraged to guard against consumption of salt preparations that do not meet the required standards. Health Education programs in schools should be conducted across Kenya to guard against IDD.

***Key words**: Iodized salt consumption, urinary iodine excretion in Kenya, effect of goitrogens*

1. Purpose of the study

The aim of this study was to assess the impact of fortification programme on IDD prevalence among primary school children by assessing the levels of urinary iodine, iodate level in salt and find out the effect of goitrogenic food consumption on urinary iodine excretion in the study area.

2. Study subjects

All children attending Makina and Kilimani schools in Nairobi from pre-unit to standard eight. All children not attending the two schools from pre-unit to standard eight, those that were absent on the day of sampling from the two schools and those that were present but declined to participate. Consent was also obtained from the parents prior to sample collection and each parent was given a form to fill and signed indicating that he/she has accepted his/her child to participate in the study. The study was approved by the Ministry of Education and City Education Department.

3. Methods of study

Descriptive statistics was used on a sample of one hundred and forty two (142) school children participated in the study. Makina had 56 with 29 (51.8%) males and 27 (48.2%) females and Kilimani (86) with 32 (37.2%) males and 54 (62.8%) females). All gave out urine samples for urinary iodine analysis and two table spoonful of salt from their homes. The age range was 5-17 years. A questionnaire was given to the selected child through the class teacher for the guardian to fill so as to ascertain the types of food and salt consumed. In addition, different brands of salt samples were bought from various markets around Nairobi. Urinary iodine was analysed using sandel-kolthoff reaction while the iodate in salt was determined using iodometric titration.

4. Results Presentation and Data Analysis

A total of 256 students' were selected using systematic sampling method to achieve a homogeneous distribution. Of these, one hundred and forty two (142) gave out urine samples, brought salt they consume at home and a complete filled questionnaire. The rest brought one or two of the samples while others never brought the questionnaire and were therefore excluded during the analysis.

Characteristics	**Makina**		**Kilimani**	
Male **Female**	**29 (51.8%)** **27 (48.2%)**		**32 (37.2%)** **54 (62.8%)**	
Age-range	6-17		5-15	
Class levels	Male	Female	Male	Female
Pre-unit	3	3	1	5
Class 1	5	3	3	4
Class 2	1	2	4	7
Class 3	5	4	1	3
Class 4	2	1	9	9
Class 5	5	2	7	15
Class 6	0	2	3	6
Class 7	4	5	3	2
Class 8	3	4	1	3
TOTAL	29	27	32	54

Table 1: Characteristics of 142 pupils

One hundred and forty two (142) pupils returned completely filled questionnaire, a spoonful of table salt and provided urine sample shown in Table 1. Of the 142 pupils, 56 (39.4%) were from Makina and 86 (60.6%) Kilimani. They comprised of 29 (51.8%) males

and 27 (48.2%) females in Makina while in Kilimani, 32 (37.2%) and 54 (62.8%) were males and females respectively. The age range was 15-17 years.

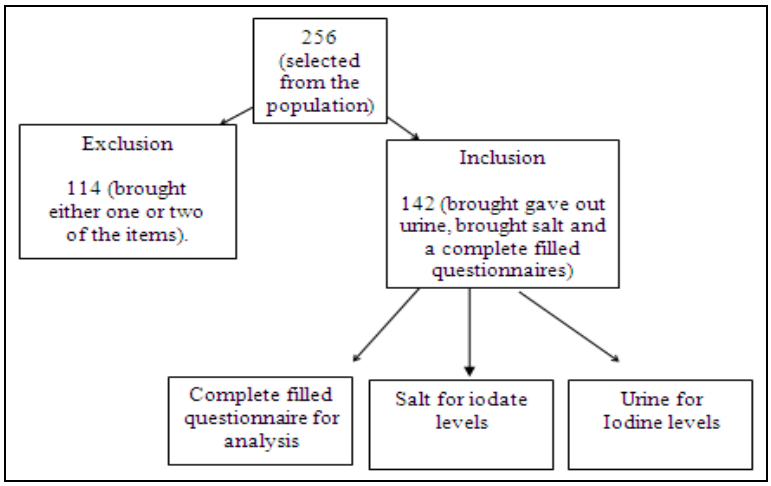

Figure 1: Flow diagram of showing satisfying criteria for inclusion and exclusion

Table 2 presents the overall median urinary iodine concentration (UIC) for the 142 pupils in the two schools .Of the 142 children, the overall median UIE was 229.1 µg I_2/L. There was significant different between Makina (215.1 µg I_2/L) and Kilimani (242.2 µg I_2/L) (χ^2 = 6.88; DF = 2; p = 0.032). No difference was seen between the median urinary iodine concentration of girls (225.7 µg I_2/L) and boys (232.9 µg I_2/L) (t = 0.964; p = 0.336). The UIC were not related to sex, age or class level (p > 0.05).

School	**Pre-unit to Standard 2**		**Standard 3 to Standard 5**		**Standard 6 to Standard 8**		**Total**	
Makina	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
	225.8	203.9	214.5	199.8	215.6	217.9	217.1	208.6
	(9)	(8)	(12)	(7)	(7)	(11)	(28)	(26)
	115.6 – 255.4	84.5 – 265.1	106.1 – 269.7	78.4 -236.3	145.4 – 437.2	160.4 -363.4	106.1437.2	78.4 -363.4
Kilimani	211.9	215.8	247.0	242.4	254.1	257.6	241.1	242.4
	(8)	(16)	(17)	(27)	(7)	(11)	(32)	(54)
	152.8 -347.9	69.9 – 320.9	109.0 -412.4	102.8 -359.7	222.0 – 264.5	226.3 – 268.3	109.0 -412.4	69.9 – 359.7

Table 2: Median levels of urinary iodine concentration for pupils in Makina and Kilimani Schools for all the classes in three clusters (Pre-unit to standard 8)

Results are expressed as µg/l for each class per school. Values in parenthesis indicate number of pupils in that class in each of the schools.

Table 3 shows results to a comparison of the UIC value between the two schools according to WHO classification. The UIE values for the study subjects in both schools varied significantly (χ^2 = 26.0; p < 0.001, χ^2 = 50.6; p < 0.001, χ^2 = 91.0; p < 0.001, χ^2 = 33.5; p < 0.001, χ^2 = 62.1; p < 0.001, χ^2 = 195.1; p < 0.001, χ^2 = 88; p < 0.001, χ^2 = 189; p < 0.001, χ^2 = 283.9; p < 0.0 µg I_2/01) between WHO classes. The UIC for all the children were in the moderate (20-49 µg I_2/l) to greater than (300 µg I_2/l) ranges of iodine concentration; none were in severe range (less than 20 µg I_2/l). Urinary iodine concentration for 3(2.1%) of the children were in the moderate range (20-49 µg I_2/l) iodine deficiency ; 2(1.4%) in the mild range (50-99 µg I_2/l); 26 (18.4%) in the optimum iodine nutrition (100-199 µg I_2/l) ;105(73.9 %) in the more than optimum (200-299 µg I_2/l), risking of iodine induced hyperthyroidism and 6 (4.2 %) in the excess range (more than 300 µg I_2/l), risking of adverse health consequences. Acording to WHO classification, 3.5% (2.1% and 1.4%) excreted less than the WHO recommendations (<99µg I_2/l), 18.4% excreted the normal requirements (100-199 µg I_2/l) and 78.1% excreted more than the required levels (>200 µg I_2/l). There was significant difference between those excreting urinary iodine below the optimum WHO requirement (3.5%) and those excreting urinary iodine above the optimum WHO requirement (78.1%) (χ^2 = 102.2; df = 1; p < 0.001.

	Makina			Kilimani			TOTAL OF TWO SCHOOLS		
WHO UIE Class ($\mu gI_2/L$)	**Males 29 (%)**	**Females 27(%)**	**TOTAL 56%**	**Males 32(%)**	**Females 54(%)**	**TOTAL 86(%)**	**Males 61(%)**	**Females 81(%)**	**ALL 142 (%)**
20-49	1(3.4)	1(3.7)	2(3.6)	0(0.0)	1(1.9)	1(1.2)	1(1.6)	2(2.5)	3(2.1)
50-99	0(0.0)	1(3.7)	1(1.8)	1(3.1)	0(0.0)	1(1.2)	1(1.6)	1(1.2)	2(1.4)
100-199	5(17.3)	4(14.8)	9(16.1)	9(28.1)	8(14.8)	17(19.7)	14(23.0)	12(14.8)	26(18.4)
200-299	19(65.5)	20(74.1)	39(69.6)	21(65.6)	45(83.3)	66(76.7)	40(65.6)	65(80.2)	105(73.9)
>300	4(13.8)	1(3.7)	5(8.9)	1(3.2)	0(0.0)	1(1.2)	5(8.2)	1(1.3)	6(4.2)
	$\chi^2 = 26.0$; $p < 0.001$	$\chi^2 = 50.6$; $p < 0.001$	$\chi^2 = 91.0$; $p < 0.001$	$\chi^2 = 33.5$; $p < 0.001$	$\chi^2 = 62.1$; $p < 0.001$	$\chi^2 = 195.1$; $p < 0.001$	$\chi^2 = 88$; $p < 0.001$	$\chi^2 = 189$; $p < 0.001$	$\chi^2 = 283.9$; $p < 0.001$

Table 3: Urinary iodine concentration value based on WHO classification by study site

Results are expressed as the number of pupils in each of the WHO UIE classifications. The values in parenthesis are the percentage of the pupils in the specific WHO UIE classification in each school per sex.

Out of 142 respondents, 71.5% obtained salt from the shop, 12.7% from the Kiosks and 5.7% from the supermarkets while 10.1% bought it from either of the above three sources On the type of salt consumed, 89.2% consumed fine salt while 10.8% consumes coarse salt. In addition, the frequency of salt consumption among the respondents interviewed was: 75.3% in every meal, 20.3% at least once daily while 0.6% with every dish that needed salt. Only 4 (2.5%) of the respondents reported that they did not take salt because of hypertension (students and parents).

Of the same subjects, 82.3% reported that the salt was iodated while 17.7% reported that the salt was not iodated. In addition, 63.9% respondents knew why salt iodation is necessary while 36.1% did not know the reason for salt iodation. All the home salt samples analysed had a mean of 134.88 mg iodate/kg salt (± 61.8). However, there was no significant difference between the iodate levels in the salt samples from the households of the two schools with Makina and Kilimani having a mean of 145.1 mg iodate per Kg salt and 135 mg iodate per Kg salt respectively ($t = -0.932$; $p > 0.05$). The iodate means of the six salt brands (53 salt samples) purchased that includes Kay salt, Kensalt, sea salt, refined, mzuri and unknown were 159.67, 165.89, 2.02, 191.45, 150.55 and 176.58 mg iodate/Kg salt respectively (Table 4). Only Kensalt was within the Kenya Goverment recommended iodate levels of 168.5 mg/kg salts. The highest value of iodate was in the unknown bags (288.0 mg iodate/kg salt) and the lowest was in the imported sea salt brand (1.02 mg iodate/kg salt).

Parameter	**SALT BRANDS**						
	Keysalt Mean ± SD (10)	Kensalt Mean ± SD (10)	Mzuri Mean ± SD (10)	Sea salt Mean ± SD (10)	Refined Mean ± SD (10)	Unknown Mean ± SD (3)	Home salt Mean ± SD (119)
Iodate in mg/Kg salt	159.67 (42.99)	165.89 (63.68)	150.54 (48.41)	2.02^{chl} (0.54)	191.47^{mp} (13.26)	176.57 (97.14)	134.88^{fkortu} (61.80)

Table 4: Iodate levels (mg/kg salt) in different salt brands analyzed

Results are expressed as Medians (±standard deviation) of the number of salts shown in parenthesis. [a]p < 0.05 represents significance difference between Keysalt and Kensalt; [b]p < 0.05 represents significance difference between Keysalt and mzuri; [c]p **< 0.05** represents significance difference between Keysalt and sea salt; [d]p < 0.05 represents significance difference between Keysalt and Refined salt; [e]p < 0.05 represents significance difference between Keysalt and Unknown; [f]p < **0.05** represents significance difference between Keysalt and Home salt; [g]p < 0.05 represents significance difference between Kensalt and Mzuri; [h]p < **0.05** represents significance difference between Kensalt and sea salt; [i]p < 0.05 represents significance difference between Kensalt and Refined; [j]p < 0.05 represents significance difference between Kensalt and Unknown; [k]p < **0.05** represents significance difference between Kensalt and Home salt; [l]p < 0.05 represents significance difference between mzuri and sea salt; [m]p < **0.05** represents significance difference between mzuri and Refined; [n]p < 0.05; [o]p < **0.05** represents significance difference between mzuri and Home salt; [p]p < **0.05** represents significance difference between Sea salt and Refined; [q]p < 0.05 represents significance difference between Sea salt and Unknown; [r]p < **0.05** represents significance difference between Sea salt and Home salt; [s]p < 0.05 represents significance difference between Refined and Unknown; [t]p < **0.05** represents significance difference between Refined and Home salt; [u]p < **0.05** represents significance difference between unknown and Home salt; Means are compared by paired t-test.

When iodate levels in the direct purchase salt brands and home salt were compared, there was significant differences in the following pairs (Table 4); Keysalt and sea salt ($p < 0.05$), Keysalt and Refined salt ($p < 0.05$), Keysalt and Home salt ($p < 0.05$), Kensalt and Sea salt ($p < 0.05$), Kensalt and Refined salt ($p < 0.05$), Ken salt and Home salt ($p < 0.05$), Mzuri and Sea salt ($p < 0.05$), Mzuri and Refined salt ($p < 0.05$), Mzuri and Home salt ($p < 0.05$), Sea salt and Refined salt ($p < 0.05$), Unknown and Home salt ($p < 0.05$), Refined salt and Unknown salt ($p < 0.05$) and Refined and Home salt ($p < 0.05$).

5. Goitrogens consumption in Makina

Among the respondents interviewed on sukuma consumption in Makina, (59) 98.3% consumed it (Table 5). Of the 98.3%, 57% consumed daily, 39.3% weekly and only 3.7% depending on the availability of funds. In the same population, 98.30% consumed cabbage. Of the 98.30%, 57% ate it daily, 39.3% weekly, and 3.70% subject to availability of funds. On Sorghum, 78% consumed it. Of the 78%, 14.6% ate it daily, 68.8 % weekly, 6.3% monthly, 8.3% rarely and 2.0% depending on the availability of funds. On cassava consumption, 81.4% consumed it. Of the 81.6%, 25.1% fed on daily, 62.5% weekly, and 8.4% monthly while 2.0% rarely and depending on the availability of funds respectively.

Foods		**Percentage**	**Frequency of consumption**				
			Daily	**weekly**	**Monthly**	**Rarely**	**Depends on funds**
Sukuma	Yes	98.30%	57%	39.30%			3.70%
	No	1.70%					
Cabbage	Yes	98.30%	57%	39.30%			3.70%
	No	1.70%					
Sorghum	Yes	78.00%	14.6%	68.80%	6.30%	8.30%	
	No	22.00%					
Cassava	Yes	81.40%	25.1%	62.5%	8.4 0%	2.00%	2.00%
	No	18.60%					

Table 5: Goitrogen consumption and frequency in Makina

Results are expressed as a percentage on the frequency of goitrogen consumption among the study population.

6. Goitrogens Consumption in Kilimani

Among the respondents interviewed in Kilimani, 99% consumed cabbage. Of the 99%, 46.8% fed on it daily and 53.2% weekly (Table 6). On Sukuma wiki (Kale) consumption, all the respondents consumed it. Of the 100%, 29.9% ate sukuma wiki daily, 64.9% weekly, 4.1% rarely and 1.1% ate it depending on the availability of funds. On sorghum consumption, all the respondents interviewed consumed it. Of the 100%, 29.9% ate it daily, 61.9% weekly, 3.3% monthly, 4.1% rarely and 1.1% depending on availability of funds. On cassava consumption, 50% consumed it. Of the 50%, 10.4% ate it daily, 62.5% weekly, and 4.2% monthly while 22.9% rarely.

Foods		Percentage	Frequency of consumption				
			Daily	Weekly	Monthly	Rarely	Depends on funds
Cabbage	Yes	99.00%	46.80%	53.20%			
	No	1.00%					
Sukuma wiki	Yes	100%	29,9%	64.9%		4.10%	1.10%
	No	0.00%					
Sorghum	Yes	100%	29.9%	61.9%	3.30%	4.10%	1.10%
	No	0.00%					
Cassava	Yes	50%	10.40%	62.50%	4.20%	22.90%	
	No	50%					

Table 6: Goitrogen Consumption and Frequency in Kilimani

Results are expressed as a percentage on the frequency of goitrogen consumption in Kilimani.

7. Association between UIE and Consumption of Goitrogenic Foods

Table 7 shows the urinary iodine excretion in consumers and non-consumers of goitrogenic foods. The results show that there was no significant difference in urinary iodine excretion between consumers and non-consumers of goitrogenic foods such as sorghum, sukuma wiki and cabbage. However, there were significantly increased levels of urinary iodine in non-consumers of cassava relative to the consumers ($p = 0.032$).

Parameter	Sukuma wiki		Sorghum		Cabbage		Cassava	
	Consumers 152 (98.7%)	Non consumers 2 (1.3%)	Consumers 101 (67.3%)	Non consumers 49 (32.7%)	Consumers 152 (98.7%)	Non consumer 2 (1.3%)	Consumers 96 (62.3%)	Non consumer 58 (37.7%)
$U.I_2$ Mean	224.3	197.50	221.68	229.45	223.42	203.24	217.92	234.02
SD	(54.42)	(6.82)	(58.33)	(46.16)	(53.66)	(14.94)	(55.90)	(49.98)
Median	227.8	197.5	223.90	233.95	227.80	203.24	221.30	237.70[a]
Range	69.93-437.2	192.68-202.32	69.93-437.20	106.10-359.65	69.93-437.20	192.68-213.80	69.93-437.20	106.10-412.40

Table 7: Urinary iodine excretion ($\mu gI_2/L$) in consumers and non-consumers of goitrogenic foods

Results are expressed as median (range) of urinary I_2 ($\mu gI_2/L$) excretion. [a]$p < 0.05$ represents significance difference between Cassava consumers and non Cassava consumers by Mann-Whitney

8. Discussion

The results of this study have shown that in a representative sample of school children in Nairobi, the IDD prevalence is 3.5% with a median urinary iodine excretion (UIE) of 229.1$\mu gI_2/L$, which is below the iodine sufficient population value of 5% according to World Health Organization. A similar report by FAO indicated a reduction in IDD with median UIE of 115$\mu gI_2/L$ in Kenya (FAO, 2005). These studies suggest an effective iodination programme towards the elimination of IDD in Kenya has taken place. They also indicate that now Kenyan Health Authorities should focus its attention on constant monitoring in order to sustain this iodination level. Additionally, capacity building as a strategy to perform the iodized salt testing as well as equipment for regular measurement and continuous monitoring of salt consumed at the household level will also contribute to the success of the programme in Kenya.

Similar progress towards elimination of IDD through iodination has also been reported in other African countries (Simsek *et. al*., 2003; Cherinet and Kelbessa, 2000; Festo *et. al*., 1988). However, this observation disagrees with a study that found primary school children in New Zealand had IDD prevalence of over 30% with a median UIE of 66 μgI_2/L (Skeaff *et. al*., 2002).

High levels of urinary iodine excretion (200 to 299μg I_2/L from pre-unit to standard eight was observed in both schools. These high levels of UIE after salt iodation programmes observed in this study agrees with an observation from Uganda that showed an increase of median urinary iodine excretion from 50 μg I_2/L before the introduction of iodation programme to 310μg I_2/L after the introduction of the iodation programme in Uganda (Gabriel *et. al*., 2002). However, a study done in Lesotho showed a UIE median of 26.3μg I_2/l indicating that a mild to moderate iodine deficiency still exist (Masekonyela *et. al*., 2003). However, the current study showed a UIE median of 229.1μg I_2/L, indicating that the communities studied, had reached iodine sufficiency. The 78.1% prevalence of over 200 μg I_2/L UIE is likely to increase the risk of iodine-induced hyperthyroidism as it happened in Zimbabwe where the introduction of compulsory iodization resulted into an increased median UIE from 64 in 1990 to 386 μg I_2/l in 1993 (IDD Newsletter, 2003).

The median UIE levels for the entire 142 study subjects in both Kilimani and Makina was 229.1 μg I_2/L per day. This value was more than the WHO recommended median UIE value of 100-200 μg I_2/L suggesting an increased iodine uptake among the study population. The median UIE for Makina school children (215 μg I_2/L) was significantly lower than that of Kilimani school children (242.1 μg I_2/L). This difference between the two schools could be explained by either the consumption of goitrogens such as cassava and high iodate levels in salt brands consumed in the study area or both.

Of the foods analyzed, cassava contain (624 mg %) of goitrogenic compounds, sorghum (206-280 mg %), cabbage 2-8 mg/Kg and kale (0-287 μmol/Kg) (Oluremi *et. al*., 2007; Adams and Carmen, 2000). Percentage cassava consumption was higher in Makina (81.4%) compared to Kilimani (50%). This is consistent with the significantly decreased median UIE iodine in cassava consumers (221.30 μg I_2/L compared to non-consumers (237.70 μg I_2/L; $p = 0.032$). A similar observation was made in Ethiopia, which showed an increased prevalence of IDD in form of goitre in study subjects after introduction of cassava consumption compared to that before the introduction of its consumption (Abuye *et. al*., 1998). These results indicate that the processing of cassava such as boiling (tuber, leaves) and roasting (tubers) does not completely destroy cyanoglycosides in cassava. In contrast, goitrogenic foods such as sorghum and cabbage did not affect UIE in children consuming them compared to those not consuming suggesting that the levels of cyanogenic glycosides in them could be within the tolerable levels (Gaitan, 1973).

Cassava contains thiocyanite compounds, which have been implicated as being goitrogenic and thus inhibit iodine absorption in the gut, perhaps by binding to the iodine, similar to the effects of aluminium hydroxide on phosphates (Osman *et. al*., 1993). After ingestion of goitrogenic foods, cyanogenic glucosides and glucosinolates are readily converted to active goitrogenic/ anti-thyroid agents, viz; thiocyanate and isothiocyanate by glucosidases, sulphur transferase enzymes and myrosinase present in plant itself and animal tissues. Thiocyanate like compounds primarily inhibits iodide-concentrating mechanism of thyroid gland and stimulates the iodide efflux from thyroid gland resulting to an increase in iodine excretion through urine (Maloof and Soodak, 1959).

Boys excreted similar levels of urinary iodine (225.7 μg I_2/L) as girls (232.9 μg I_2/L) indicating no gender differences in the study population. This result corresponds to a study in Kenya, which showed that there was no significant difference in UIE among the sexes (Hanegraaf, 1977). A similar observation was made in Turkey that showed the same median UIE levels among boys and girls ($p = 0.336$) (Egri *et. al*., 2006).

Based on the reported IDD prevalence of 3.5%, this study established that all the salt reaching the consumers was iodated and 100% consumed iodized salt leading to successful iodation program in the country. However, this study disagrees with an observation in Indonesia where 66.6% and 67.2% of families from urban slums and rural areas consumed iodated salt (Richard *et. al*., 2008). Although all the salt samples analyzed contain iodate as required by law, some had less such as sea salt while others excess, for example, refined salt. Only one brand was close to the legal requirement of 168.5 mg/kg salt according to WHO through a task force for IDD in Africa (Muture and Wainaina, 1994). This could be due to either low iodation of salt by manufacturers, for example, the case of sea salt and mzuri which were packed in plastic bags or to losses of iodate during transportation and storage as in the case of home salt which had been stored in cans which were loosely closed.

This could expose salt to moisture and subsequent loss of iodate from the salt. This variation in iodine levels in different brands could put consumers at risk of hypothyroidism or hyperthyroidism conditions. For example, a study in Morroccan children showed that before introduction of oxidized salt, 72% were goitrous (a form of IDD). One year later after introduction of iodized salt, the goitrous rate reduced to 34% (Zimmermann *et. al*., 2004). Fourteen months after discontinuation of iodized salt, the rate of goitre again was similar to the rate before salt iodization while the prevalence of hypothyroidism was 10% compared with 3% before introduction of salt iodation (Zimmermann *et. al*., 2004). These findings underline the importance of sustainability in IDD control in the country especially among the vulnerable groups in the study population.

9. Conclusion and Recommendation

9.1. Conclusion

This study has shown an IDD prevalence of 3.5%, which is below the WHO value of less than 5% suggesting that the study community is iodine sufficiency. Universal salt iodation is therefore effective in controlling IDD among school children in Kenya. Many brands of salt sold in the country have less WHO recommended iodine level. Consumption of kale (sukuma wiki), cabbage and sorghum has no efficiency on urinary iodine excretion except cassava since it affects iodine absorption.

9.2. Recommendation

Update on the current status of IDD prevalence is recommended country wide since IDD may vary from one region to the other. Monitoring of iodated levels from factory, in retail shops and households to make sure the community are consuming iodated salt should be done by the Ministry of Health through Kenya Bureau of Standards. There is need for the creation of awareness to the communities that consumption of cassava as a potential goitrogen may undermine the effectiveness of universal salt iodations programme. Processing procedures which lower the levels of goistrogens in cassavas should be investigated in order to promote its use as drought resistant crop in Kenya with minimal effect on iodations programme.

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