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# Efficacy of Multi-micronutrient Fortified Biscuits on Urinary Iodine Levels of Adolescent Girls from Jaipur, India

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## ABSTRACT

**Introduction:** Iodine deficiency disorders are a public health problem in India. The aim of the study was to examine the effect of multi-micronutrient-fortified biscuits on urinary iodine levels of adolescent girls (n=51, 10-16 years) studying in a government school in Jaipur city, India. **Methods**: The study was designed as an intervention study. Biscuits fortified with 150 mcg iodine, 30 mg iron, 100 mcg folic acid, 600 mcg vitamin A and 40 mg vitamin C were provided daily to the subjects on all working days over a 4-month period. The iodine status of the adolescent girls was determined through urinary iodine levels. **Results**: Supplementation with biscuits resulted in a significant increase in the mean urinary iodine level from 118.2 to 157.2 mcg/l and in the median value from 121 to 149 mcg/l. Prior to the intervention, 21.6% of the subjects had mild iodine deficiency but at the end of the intervention period, all the girls were iodine sufficient. Hence, iodine supplementation using biscuits resulted in improved iodine status of Indian adolescent girls. **Conclusion**: It is, therefore, recommended that the school system be used for micronutrient supplementation interventions to improve the nutritional status of children and adolescents as there is more regimentation in a school setting for distribution of nutrient fortified food products to students.

**Key words:** Adolescent girls, India, iodine-fortified biscuits, urinary iodine levels

## INTRODUCTION

Iodine deficiency disorders (IDD) are a major health problem in India. In fact, India is one of the major endemic iodine deficient countries in the world. Nearly, 167 million persons are exposed to the risk of IDD, of which 54 million have goiter, 2.2 million are cretins and 6.6 million have mild neurological disorders. Several studies have shown the widespread problem of IDD in India (Singh & Ahmad, 2002; Kapil *et al*., 2003).

Iodine deficiency can be avoided by using salt that has been fortified with iodine. Iodine supplementation in most studies has been done through iodised salt. Availability and use of iodised salt has been analysed in many regions of India (Chandra *et al.*, 2004; Kapil *et al.*, 2006). Nonetheless, IDD persists

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in many areas of India (Chandra *et al*., 2006; Sarkar, Mohanty & Basu, 2007).

Multiple micronutrient supplementations have been used for improving anaemia, micronutrient status, growth and morbidity in children and adolescents. van Stuijvenberg & Benade (1998) used a biscuit fortified with beta carotene, iodine and iron with a cold drink as a carrier for vitamin C to address micronutrient deficiencies in primary school children in South Africa. The 12-month intervention resulted in significant improvements in blood levels of vitamin A, ferritin, iron, haemoglobin, haematocrit and in urinary iodine levels (van Stuijvenberg *et al.*, 1999; van Stuijvenberg *et al.*, 2001).

The intake of nutrients like vitamin A, iron and iodine can be increased by fortifying snack foods well liked by children. Biscuits are an obvious choice as they are easy to distribute and have a long shelf life. They are also easy to monitor and therefore, less open to misuse and contamination(van Stuijvenberg & Benade,1998). Moreover, van Stuijvenberg (2005) has advocated that school feeding be used as a vehicle for micronutrient fortification.

Multiple micronutrient malnutrition is most rampant in slums. Adolescent girls are a marginalised group in many societies, especially when they belong to the low socio-economic group.

The present study was designed to be an intervention study where biscuits fortified with nutrients as iodine, vitamin A, iron, folic acid and ascorbic acid were used to supplement the diet of adolescent girls attending a government school. The girls suffer from malnutrition and have multiple micronutrient deficiencies. Hence, this study was an attempt to ameliorate their micronutrient status.

## METHODOLOGY

Ten government schools in Jaipur city were visited. The willingness of the Principal of the school to participate in the study, an adequate number of female students in a separate section in higher classes and the school being close to the University campus were the criteria for consideration in the selection of the school. All adolescent girls (n=148, 10-16 years) studying in classes VI to VIII in a government school fulfilling all inclusion criteria, and residing in a slum where the school was situated, comprised the sample for the study.

Biscuits were prepared with 35 g whole wheat flour , 15 g soyabean flour, 30 g sugar, 20 g of hydrogenated fat and 20 ml of milk. The biscuits furnished 497 kcal and 11.36 g of protein. Hundred grams of biscuits fortified with iodine (150 mcg), vitamin A (600 mcg), iron (30 mg), folic acid (100 mcg) and vitamin C (40 mg) at one RDA level were provided to adolescent girls. Due to absenteeism of students, and problems in collection of urine samples, pre- and post-intervention data were available only for 51 adolescent girls. The biscuits were sent to the Food Research and Analysis Centre, Federation House, Tansen Marg, New Delhi for determining nutrient losses during baking. The biscuits were prepared with added nutrients taking losses into consideration.

Biscuit distribution commenced from 1st September 2004 and continued till 18th December 2004 for all working days. Considering the holidays during this period, the biscuits were distributed for a total of 75 days in these four months. The mean attendance of the girls was 73.76 ± 18.775%. As the school had closed for winter vacation from 23 - 31 December 2004, urine collection was made in the month of January 2005. Pre-intervention data were collected in the month of August 2004. Prior to intervention, the adolescent girls were dewormed with 400mg of albendazole. The subjects were asked to take the tablets in the school in the presence of the investigator.

Sterile plastic urine containers were purchased, labeled and distributed to the students in the morning. Plastic trays were placed in each class and the students were asked to collect urine in plastic containers

and place them in the plastic trays. The school was visited again in the last two periods and the filled urine plastic containers were collected. The urine samples were frozen and transported to the Department of Gastro-enterology and Human Nutrition, All India Institute of Medical Sciences, New Delhi for estimation of urinary iodine levels by the second author. The urinary iodine levels were determined by the method given by Dunn *et al*. (1993). Iodine nutrition was classified into different degrees of deficiency using cut-off points based on urinary iodine concentrations (WHO, 2001). The pre- and post-intervention data were analysed for significant differences using paired *t*-test (Gupta, 2005). The study was approved by the Departmental Ethics Committee and informed consent was obtained from the parents of the students for participation in the study.

## RESULTS

### Demographic profile of the families of adolescent girls

As the school was located in a slum, the children attending the school resided in the slum. The slum was in the 'developed' category as it had water and electricity facilities. The families resided in *pucca* houses which were mostly owned by them and in a few cases were being rented. The girls were well clad and handled most of the household work. However, the economic status of the families was not too good.

A majority of girls belonged to nuclear families (77.0%) which had a family size of 6.6±1.345 family members (Table 1). About 37% of the fathers and 84.7% of the mothers were illiterate while others had received some form of education. The fathers of the girls were mainly construction workers (37.1%) and the mothers were engaged in appliqué work/ embroidery work/ *moti* work/ maxi work (24.7%), construction work (14.8%), or were involved in other income generating activities (Goyle, 2009).

### Effect of supplementation on urinary iodine excretion levels of adolescent girls

On intervention with iodine fortified biscuits, significant improvements in urinary iodine excretion levels were observed; the mean urinary iodine levels increased from 118.2±18.02 to 157.2±17.34 mcg/l and the median value from 121 to 149 mcg/l (Table 2). Prior to the intervention, 21.6% subjects had mild deficiency, but at the end of the intervention period, there was not a single girl who had iodine deficiency. The results were very heartening as marked improvements in the iodine status of the female subjects were seen.

There was a higher percentage of girls who were iodine deficient in the older age groups (Table 2). However, on intervention with iodine fortified biscuits, all the adolescent girls became iodine sufficient with their mean iodine levels seeing an increase. Hence, the benefit of supplementation was evident in all the age groups.

## DISCUSSION

van Stuijvenberg *et al*. (1999; 2001) determined the micronutrient status of 115 primary school children aged 6-11 years from a rural community in South Africa before and after consumption of biscuits (fortified with iron, iodine and beta carotene) for 43 weeks over a 12-month period. The median urinary iodine improved significantly from baseline to 12 months (20 mcg/l vs 225 mcg/l) while the prevalence of low urinary iodine dropped from 97.1% before the intervention to 4.8% after 12 months of intervention. In the present study too, intervention with elemental iodine through biscuits improved the iodine status of adolescent girls studying in a government school in Jaipur city, India.

**Table 1.** Demographic profile of families of adolescent girls

| | *Families (n=148)* |
|---|---|
| Type of family | |
| Nuclear | 114 (77.0) |
| Extended | 27 (18.2) |
| Joint | 7 (4.7) |
| Subject's nuclear family size | |
| Adults | 1.9±0.301 |
| Children | |
| Male | 1.7±0.902 |
| Female | 2.9±1.378 |
| Total | 6.6±1.345 |
| Educational status of parents | |
| Father (n=140) | |
| Illiterate | 52 (37.1) |
| Class I-V | 24 (17.1) |
| Class VI-VIII | 26 (18.6) |
| Class IX-XII | 35 (25.0) |
| Graduate | 3 (2.1) |
| Mother (n=144) | |
| Illiterate | 122 (84.7) |
| Class I-V | 12 (8.3) |
| Class VI-VIII | 8 (5.6) |
| Class IX-XII | 2 (1.4) |
| Main occupations of parents | |
| Father (n=140) | |
| Construction work | 52 (37.1) |
| Government service | 18 (12.9) |
| Others | 70 (50.0) |
| Mother (n=81) | |
| Applique work, embroidery work, moti work, maxi work | 20 (24.7) |
| Construction work | 12 (14.8) |
| Others | 49 (60.5) |

Figures in parentheses denote percentages.
8 fathers and 4 mothers were not alive.
Mean ± SD.

In another study, a 9-month intervention programme with iron, vitamin A and iodised salt was carried out in the tea plantation community in South India (Gopaldas & Gujral, 2002). The prevalence of iodine deficiency was found to decrease from 17 to 7% and common health problems decreased from 88 to 54%. Another study (Goyle & Sexena, 2008) had used iodised salt to improve the iodine status of iodine deficient school children (n=22, 10-13 years) in Jaipur city, India. The mean urinary iodine levels increased from 8.39 ± 1.62 mcg / dl to 16.14 ± 3.18 mcg / dl resulting in all children being iodine sufficient.

Vinodkumar *et al.* (2007) assessed the efficacy of double fortified salt (DFS) and iodised salt in improving the iodine status

**Table 2.** Effect of supplementation on urinary iodine levels of adolescent girls

| | *Pre-intervention* | | | | *Post-intervention* | | | |
|---|---|---|---|---|---|---|---|---|
| | *UIE (mcg/l)* | *Median (mcg/l)* | *Normal ( =>100 mcg/l)* | *Mild ( 50-99 mcg/l)* | *UIE (mcg/l)* | *Median (mcg/l)* | *Normal (=>100 mcg/l)* | *Paired t-test values Pre vs post* |
| Total Sample (n=51) | 118.2 ±18.02 | 121 | 40 (78.4) | 11 (21.6) | 157.2 ±17.34 | 149 | 51 (100.0) | 11.110* |
| 10+ - 11+ years (n=15) | 121.0 ±16.17 | 125 | 13 (86.7) | 2 (13.3) | 155.4 ±17.89 | 147 | 15 (100.0) | 6.260* |
| 12+ - 13+ years (n=26) | 119.2 ±17.56 | 120 | 21 (80.8) | 5 (19.2) | 157.7 ±18.51 | 150 | 26 (100.0) | 7.378* |
| 14+ - 16+ years (n=10) | 111.7 ±21.86 | 105 | 6 (60.0) | 4 (40.0) | 158.5 ±14.57 | 155 | 10 (100.0) | 5.583* |

UIE Urinary iodine excretion.
Mean ± SD.
Figures in parentheses denote percentages.
*Significant at 5% level.

of one cluster of an Indian community. The experimental group had used DFS and the control group had used iodised salt over a one-year period. The results showed that the median urinary iodine levels increased from 200 mcg/l at baseline to 205 mcg/l at the end of the study in the experimental group and decreased from 225 mcg/l to 220 mcg/l in the control group. A statistically significant ($p<0.05$) improvement in the median urinary status of subjects who were iodine deficient (urinary iodine <100 mcg/l) in both the experimental and control groups was also observed. In another study, Asibey-Berko *et al.* (2007) also tested the efficacy of double fortified salt with iron and iodine, and iodised salt on the iodine deficiency of women and children of rural Ghana. After intervention, it was seen that double fortified salt and iodised salt had significantly reduced iodine deficiency in women and children to a similar degree.

Bautista *et al.* (1982) studied the effects of oral iodised oil on thyroid status in school age children from an area of endemic goiter in Bolivia. One hundred goitrous school children received 475 mg iodised oil by mouth, while 100 controls received mineral oil, on a double-blind basis. On follow up, 22 months later, the urinary iodine had increased and goiter size had decreased in both the groups, more strikingly in the iodine-treated children.

Salarkia *et al.* (2003) evaluated the impact of an iodine supplementation programme on severely iodine-deficient school children with hypothyroidism from the northern rural areas of Teheran. In 1989, the inhabitants of these villages received an injection of iodised oil, followed by iodised salt distribution in 1993. After 10 years of supplementation, a significant increase in median urinary iodine excretion was observed (2.0 vs 19.0 mcg/dl, $p<0.001$). In Uganda, the Universal Salt Iodisation Programme had shown remarkable results. In 1991, 36% of 95 urine samples of school children aged 6-12years analysed had iodine levels below 50 mcg/l while this percentage came down to 5% of the 293 urine samples studied in 1999 (Bimenya *et al.*, 2002). The urinary iodine status, coverage of supplementation of iodised oil capsules and current use of iodised salt in school children in Lesotho was determined by Sebotsa *et al.* (2003). The results indicated that the median urinary iodine concentration was 26.3 mcg/l which suggested moderate iodine deficiency. However, 94.4% of salt samples were iodised, and coverage of supplementation with iodised oil capsules was 55.1%. Hence, mild to moderate iodine deficiency existed in Lesotho in 2003 even after supplementation with iodised oil capsules and salt iodisation in the country.

Szybinski *et al.* (2001) studied the effect of iodine prophylaxis based on iodisation of household salt on IDD in school children of some schools from Poland. Goiter prevalence was found to decrease from 38.4 to 7.0% and urinary iodine concentration increased from 60.4 to 96.2 mcg/l mean values between 1994 and 1999. In 1999, 70% of children excreted over 60 mcg iodine /l and 36% over 100 mcg iodine /l, whereas in 1994 the values were 44 and 13%, respectively. It was concluded that iodine prophylaxis based only on iodised household salt was highly effective.

## CONCLUSION

The problem of IDD still exists and is prevalent in many regions of India (Kapil *et al.*, 2004; Pathak & Kapil, 2005). In the present study, intervention with iodine fortified biscuits had a beneficial effect on improving the iodine status of Indian adolescent girls. It is, therefore, recommended that the school system be used for micronutrient supplementation interventions to improve the nutritional status of children and adolescents, as the school setting is more regimented and suitable for distribution of nutrient fortified food products to students.

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