TRENDS IN CONSUMPTION OF CRUCIFEROUS VEGETABLES AMONG THE COLLEGE STUDENTS – AN EXPLORATORY STUDY

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Abstract: Goitrin is a natural compound released on hydrolysis and break down of cruciferous vegetables which are proven to interfere with the synthesis of thyroid hormones by blocking iodine uptake. This is the major reason for the elimination of cruciferous vegetables from the diet of individuals with thyroid disorders. Thus early detection of thyroid disease and adopting dietary corrections and modifications are crucial to avert the progression to life-threatening manifestations that includes thyroid storm. To our knowledge, no studies have examined whether consumption of cruciferous vegetables has changed accordingly, and what impact, if any, on thyroid function alteration may have resulted. The trend in cruciferous vegetable intake was investigated along with the symptoms associated with thyroid dysfunction and intake of iodine through salt. Hundred healthy individuals were selected from the University of Mysore campus, information regarding their socio-demographic profile, dietary habits, intake of salt and symptoms of thyroid dysfunction were elicited using a standardized questionnaire. Anthropometric measurements of individuals were assessed. Twenty seven percent of the study population were overweight and obese (BMI > 23.1). It was observed that cabbage, cauliflower and radish which are commonly available cruciferous vegetables were widely consumed in which 61% of the study population consumed higher amounts (110-150 g per week) of cabbage than other cruciferous vegetables in the form of Gobi Manchurian which is the locally available fast food. The symptoms related to thyroid dysfunctioning were also screened and the most common reported symptom was hair loss (53%). Among the sub group (n=21) the amount of salt intake ranged 7-24g/ day/individual, and within this sub-group; 47.6% of them consumed high (15-20g/day) salt corresponding to 450-600 µg iodine. The data on emerging trends in consumption of cruciferous vegetables especially cabbage in the form of deep fried product among the college students was frequently consumed on weekly basis. Hence excess intake of cruciferous vegetables and salt iodine content in addition to heavy metal and toxic chemical exposure along with life style modification like stress may increase the risk of thyroid dysfunction. Further studies are needed to clarify the potential impact on the adverse effects of cruciferous vegetables consumption and excess intake of iodine on the thyroid gland functioning.

Key words: Cruciferous vegetables, Dietary habits, Salt Iodine content, Thyroid disorder, Signs and symptoms.

I. Introduction:

The most widely consumed cruciferous vegetables include broccoli, brussels sprouts, cabbage, cauliflower, radish, kale, mustard, and turnip. When these cruciferous are digested by intestinal bacteria, they release the goitrogens that increase the need for iodine when consumed in small amounts and can damage the thyroid gland when consumed in large amounts [1]. Study by Teng W *et.al* (2006), observed that, more than adequate or excessive iodine intake may lead to hypothyroidism and autoimmune thyroiditis [2]. Another study by Tan *et. al* (2014) showed that excessive iodine intake may lead to increased prevalence of biochemical thyroid dysfunction, especially biochemical hypothyroidism [3]. These goitrogens inhibit the transfer of iodine into mother's milk and can cross maternal milk during lactation and also cross the placenta into the fetal bloodstream during pregnancy [4]. Both iodine deficiency and excess have considerable risks;

therefore, supplementation should be loomed with caution [5]. It has been reported that, in subjects who do not have thyroid disease do not show a relationship between thyroid function and mood, but in males, some studies have shown an inverse relationship though it is insignificant [6].
Normal thyroid function are accompanied by the variations in BMI possibly due to the changes in resting energy consumption. The increase incidence of the pathological disorders in thyroid function along with the strong influence of various environmental factors like diet and exercise, can increase weight with an unclear mechanism and lead to obesity [7].
Intake of goiterogenic foods interfere with the thyroid hormone synthesis coupled with deficiency of iodine. As per our knowledge there are limited studies reported on the consumption pattern of cruciferous vegetables; thus the current investigation is the first attempt, to study the trends in consumption of cruciferous vegetables along with the Iodine intake among the students of University of Mysore. The primary aim was to assess the somatic status, frequency consumption of locally available cruciferous vegetables, associated symptoms of thyroid function alterations and Iodine intake through salt consumption.

II. Methods and Methodology:

2.1. Study population: An exploratory study was conducted to recruit 100 healthy subjects through convenience sampling technique from life science departments of Manasagangothri campus at University of Mysore. A total number of 100 healthy subjects of both the genders in age group of 20-35years were randomly selected and anthropometric measurements were assessed as an indicator of nutritional status. The inclusion criteria was subjects without any apparent health problems; and those with pre-existing thyroid disorders and medications interfering with thyroid function, dietary supplements, and metabolic diseases were excluded. The study was reviewed and approved by the Institutional Human Ethics Committee (IHEC- UOM No.53/M.Sc/2016-17, dated 1-12-2016).

2.2. Data collection

A semi structured questionnaire was developed and validated to collect information regarding dietary intake of cruciferous vegetables and anthropometric measurements. The frequency of consumption of cruciferous vegetables was assessed using food frequency questionnaire (FFQ).

2.3.11 Anthropometric measurements

Anthropometry is a key component to assess nutritional status. It reflects the general health status and dietary adequacy. BMI is used to determine nutritional status and was calculated by dividing weight in kilograms by the square of height in meters [kg/m^2]. The height was measured in centimeters and weight was measured in kilograms using standard anthropometric techniques (WHO, 1996) using Seca 2131 stadiometer and Seca 8131 scales and the subjects were categorized into Underweight < 18.5, Normal 18.5 – 23, Over weight 23.1- 27.5, Obese >27.5 [8]

2.4. Consumption pattern of cruciferous vegetables

Dietary component consists of the assessment of food or nutrient intake which provides information on food consumption. The FFQ is a form which evaluates the frequency of food intake of food groups rather than specific nutrient intake. To carry out the dietary survey in our present study, the subjects were asked about the meal pattern, frequency intake of the foods rich in goiterogenic substances consumed on daily, weekly, monthly or occasional basis. Standardized measuring cups and visual guides were shown in order to measure accurately the portion size of the foods.

2.5. Iodine content from salt

Using CODEX STAN 150-2001 report the salt iodine content was calculated in sub group (n-21) on daily basis/day/head by collecting salt samples of each day's in small sachets for the period of 7 days. The sub sampling was done by convenient sampling in order to obtain data appropriately.
Symptoms associated with thyroid dysfunctioning were assessed using a structured questionnaire developed by the authors. The symptoms suitable for the study were selected based on the similar research study with slight modification (12).

2.6. Statistical analysis

All statistical analyses were performed with SPSS version 16 (SPSS Inc., Chicago, IL, USA). Mean and standard deviation (SD) were calculated for anthropometric measurements. For significant differences in continuous variables across categories of weight, height and BMI were assessed using the independent *t*-test and was employed at 95% CI between the anthropometric measurements of male and female.

III. RESULTS AND DISCUSSION

Table: 1 **Anthropometric measurements (n = 100)**

Characteristics	Male (n=24) Mean ± SD	Female (n= 76) Mean ± SD	t- value	p-value
Age (years)	21.83±0.761	22.11± 1.823	-0.710	0.480
Weight (kg)	62.22±12.85	52.22± 8.95	4.255	<0.001
Height (cm)	169.73±7.29	158.48± 6.12	7.490	<0.001
Body mass Index (kg/m ^{2})	21.56±2.84	20.75 ± 3.16	1.116	0.267
MUAC (cm)	25.31±3.66	23.82 ± 4.88	1.376	0.172
SFT (mm)	16.79±4.88	18.03 ± 5.11	-1.045	0.299
WHR	0.88±0.04	0.86 ± 0.59	-0.550	0.584

The total number of subjects recruited for the study were 100, which included 24 male and 76 female. Mean ± SD value of different anthropometric variables such as height (cm), weight (kg), BMI (kg/m^2), MUAC (cm), SFT (mm) and WHR for both males and females are given in Table 1. A significant difference was found in weight (kg) and height (cm), because both the parameters are highly variable.

3.1. Body mass index (BMI)

Table: 2 B**ody Mass Index (BMI) Profile (n= 100)**

Variable	Under weight < 18.5		Normal 18.5 – 23		Over weight 23.1- 27.5		Obesity >27.5	
	Mean BMI	% of sub	Mean BMI	% of sub	Mean BMI	% of sub	Mean BMI	% of sub
Male	17.63±0.50	4	20.51±1.29	12	23.77±0.79	6	27.6±0	2
Female	17.20±0.85	24	20.96±1.21	33	24.42±1.27	17	28.65±0.91	2
Total		28		45		23		4

Source: WHO cutoff levels,

The optimal cut-off values of anthropometric measurements mean ± SD values were generated separately for men and women as shown in Table 2. It was found that 45% of the study population were found to have normal mean BMI for male and female subjects. Twenty seven percent of the study population had increased BMI, categorizing them into overweight and obese, and 28% were categorized into underweight as shown in Table 2.

3.2. Frequency consumption pattern of average intake of cruciferous vegetables among subjects

Table: **3 Frequency consumption of commonly available cruciferous vegetables (n=100)**

Sl. No	Vegetables containing goiterogens	Frequency of consumption						
		Daily (%)		Weekly		Monthly (%)	Occasionally (%)	Never (%)
			Once (%)	Twice (%)	Thrice (%)			
1	Cabbage	-	10	20	31	19	20	-
2	Cauliflower	-	32	12	-	28	28	-
3	Radish	-	32	2	10	37	-	19
4	Kale	-	-	-	-	-	12	88
5	Broccoli	-	-	-	-	-	41	59

Data on frequency consumption of foods rich in goiterogenic substances were collected and compiled as shown in Table 3. Overall, the frequency of consumption of commonly available cruciferous vegetables like cabbage, cauliflower and radish was on weekly basis but, on contrary it was observed that the consumption of cabbage was predominantly high.

Intake frequency of cruciferous vegetable among the subjects are shown in the Table 4, this was calculated as portion size which was measured in standard cups. The average consumption of cruciferous vegetables per week was calculated, it was observed that around 61% of the study population consumed cabbage, 43% and 60% of the study population consumed 60-100g of radish and cauliflower respectively. Whereas the consumption of Kale and Broccoli was negligible. Intake of cabbage was very high that is 110-150g per week which was mainly in the form of gobi manchurian.

Table: 4 Average intake of Cruciferous vegetables by the subjects (n=100)

Sl. No	Sources of vegetables containing goiterogenic compounds	Amount consumed (%)			
		<50 g	60-100g	110-150g	Never
1	Cabbage	13	26	61	-
2	Cauliflower	26	43	31	-
3	Radish	11	60	29	-
4	Kale	-	5	7	88
5	Broccoli	5	17	19	59

3.3. Symptoms

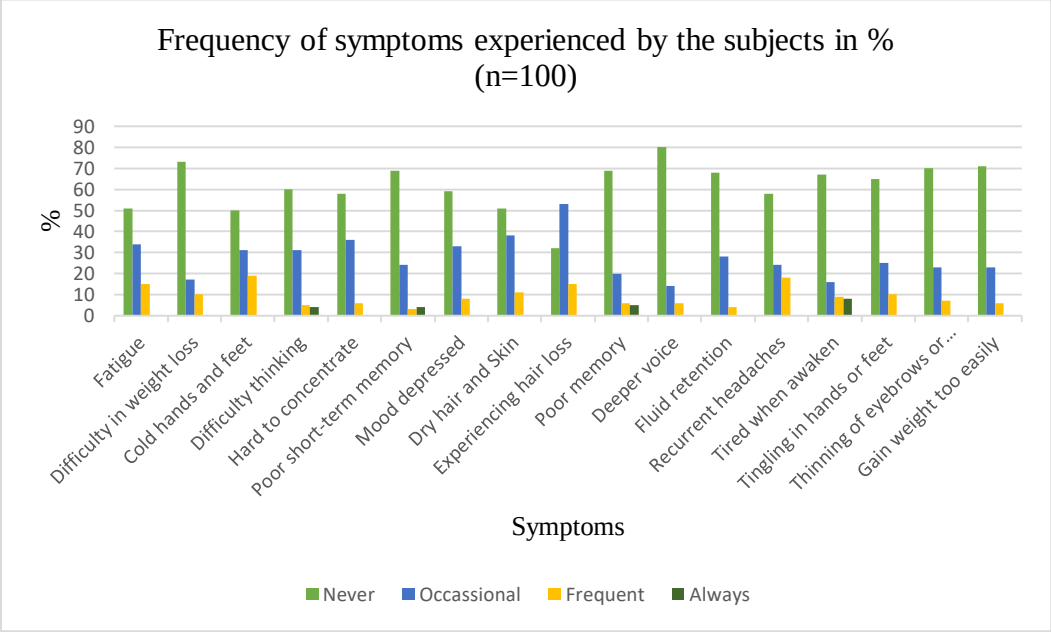

Figure 1: **Frequency of symptoms experienced by the subjects in % (n=100)**

Information on symptoms associated with thyroid function alteration were obtained from the subjects, as shown in the Fig. 1. Among the total population, 1-10% of the study population had poor short term memory, difficulty in thinking, hard to concentrate, poor memory, mood depression, deeper voice, tired when awaken, fluid retention, thinning of eyebrows and eyelashes, gain weight too easily. 10-20% experienced dry hair and skin, hair loss, recurrent headaches, tingling in hands or feet, fatigue, difficulty in weight loss, cold hands and feet. 4%, 5% and 8% experienced difficulty in thinking & poor short term memory, poor memory and tired when awaken respectively on frequent basis.

On occasional basis, 10-20% experienced poor memory, tired when awaken, deeper voice, difficulty in losing weight, 20-30% experienced cold hands and feet, difficulty in thinking, hard to concentrate, poor short term memory, mood depression, dry hair and skin, fatigue, fluid retention, recurrent headaches, gaining weight too easily, tingling in hands or feet, thinning of eyebrows and eyelashes, and 53% of them experienced hair loss.

3.4. Average salt consumption

Table: **5 Average salt intake of selected subjects (n=21)**

Sl. No	Salt intake (g)	Iodine content (µg)	No. of subjects (n) (%)
1	5-9	150-270	1 (4.7)
2	10-14	300-420	9 (42.8)
3	15-20	450-600	10 (47.6)
4	21-25	630-750	1 (4.7)

The levels of fortification of iodine allowed in Indian salt is 30 ppm on dry basis (FSSAI, 2006). And accordingly the Iodization of food grade salt of the Codex Standard for Food Grade Salt (CODEX STAN 150-2001) states 5 gram of salt at 30 ppm fortification of iodine yields 150 µg of iodine from salt source alone [9]. ICMR, 2010 recommended that an average intake of iodine per day 150µg/day (0.15g/day) for Indian adults.

Based on these reports the average salt consumption per head per day was calculated from the sub-group (n=21) depending on their willingness. The amount of salt intake by the subjects is as shown in Table 6, and accordingly the amount of salt intake ranged from 7g being the least and 24g being the highest per day, per individual. Fourty seven percent (n=10) of the sub group consumed 15-20g of salt and corresponding iodine intake was 450-600 µg/ day.

The present study was an attempt to identify the trends in consumption of cruciferous vegetables which are locally available in the region along with the iodine intake from salt among college students. It was observed that 23% and 4% of the study population were found to be overweight and obese respectively. A study conducted by Musa (2017) revealed that increasing BMI was observed with increase in serum TSH levels [10]. Another study by Milionis et.al (2013) in euthyroid subjects reported a statistically significant positive correlation between BMI and thyroid function in women, while in men the correlation was not statistically significant [8].

Frequency of consumption of cruciferous vegetables were evaluated and was observed that intake of cabbage was found to be high among the commonly available cruciferous vegetables viz. cauliflower and radish. Studies have shown that consumption of excess amount of cruciferous vegetables has its impact on thyroid functioning. The toxicological study done on male Wistar rats has reported that intake of cabbage or carrot (have negligible amount of iodine) about 40 g both or any one, for 60 days showed significant increase in thyroid glands and had less iodine per gram of gland and the plasma bound iodine was also significantly decreased [11]. This therefore suggests that enlarged thyroid gland is due to low content of iodine in the food consumed. In the present study, though the consumption of these cruciferous vegetables is high; the frequency is not on daily basis, hence it can be assumed that higher the frequency higher will be the chances of thyroid functioning alterations.

In the study by Karnath B.M and Hussain N (2006) states that the common signs and symptoms of hypothyroidism are lethargy, cold intolerance, weight gain, constipation, coarse dry skin, hair loss, hoarse voice, bradycardia, psychomotor retardation and hyperthyroidism are nervousness, fatigue, palpitations, weight loss, and heat intolerance and also they reported that onset of signs and symptoms may be subtle [12]. Our findings are in agreement with the above mentioned study. It was confounding to note that majority of the study population i.e 53% experienced hair loss occasionally which is one of the major symptom found in thyroid alteration individuals and this is a major concern as the study population fall under the younger generation category. Although these symptoms are related to thyroid imbalance, in the absence of biochemical diagnosis, it is not possible to confirm thyroid dysfunction.

It was interesting, to observe that subjects belonging to sub-group (n=21), who were selected to evaluate the intake of iodine from salt, were consuming high level of iodine than the recommended level. Studies have proven that higher consumption of iodine results in thyroid dysfunctioning [13]. More than adequate amount of iodine intake can lead to hypothyroidism and autoimmune thyroiditis, especially among susceptible populations with recurring thyroid disease [14]. Therefore, from our extrapolatory study, it is evident that though the intake of cruciferous vegetables was minimal the intake of iodine was found to be high. Hence higher the iodine intake, higher is the risk of thyroid alterations, to confirm this, it is important to have corroborated biochemical tests (thyroid tests - urinary iodine test, TSH, T3, T4).

V. LIMITATION OF THE STUDY

Since, it is an exploratory study and has some limitations on biochemical parameters, also the data obtained is from the convenience sampling and literature reviews has been generalized for consumption patterns, symptoms and iodine intake through salt of the subjects.

VI. CONCLUSION

Our study revealed that though the average consumption of cruciferous vegetables was more but it was not on daily basis and iodine intake of salt was found to be high. Consumption of excess amount of cruciferous vegetable and iodine in addition to heavy metal and toxic chemical exposure along with life style modification like stress may increase the risk of thyroid dysfunction. However, further large scale multi-centric and longitudinal studies are required to confirm the association between serum thyroid levels and BMI of euthyroid adults and to understand the consequences of excess intake of cruciferous vegetables and iodine content and its association with thyroid alterations, biochemical analysis of thyroid profile should be validated for the confirmation. Hence this area warrants continuous research.

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VIII. REFERENCES:

1. Parchami, A., & Dehkordi, R. F. (2012). Sex differences in thyroid gland structure of rabbits. International Journal of Medical and Biological Sciences, 6, 270-273.
2. Teng, W., Shan, Z., Teng, X., Guan, H., Li, Y., Teng, D., & Yang, F. (2006). Effect of iodine intake on thyroid diseases in China. New England Journal of Medicine, 354(26), 2783-2793.
3. Tan, L., Sang, Z., Shen, J., Liu, H., Chen, W., Zhao, N., & Zhang, W. (2015). Prevalence of thyroid dysfunction with adequate and excessive iodine intake in Hebei Province, People's Republic of China. Public health nutrition, 18(9), 1692-1697.
4. Vidinov, K., Vidinov, N., Kalniev, M., & Krastev, D. (2013). Changes in the connective tissue element of the thyroid gland in normal and recurrent euthyroid goiter. BioDiscovery, 9, e8951.
5. Dean, S. (2008). Medical nutrition therapy for thyroid and related disorders. Krause's Food, Nutrition, & Diet Therapy. 13th ed. Philadelphia, PA: Saunders, 711-724.
6. Dayan CM, Panicker V. (2013). Hypothyroidism and depression. European thyroid journal. 2 (3):168-79.
7. Who, E. C. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet (London, England), 363(9403), 157.
8. Milionis, A., & Milionis, C. (2013). Correlation between body mass index and thyroid function in euthyroid individuals in Greece. ISRN biomarkers, 2013.
9. Gassmann, B. (2006). On the setting of maximum and minimum amounts for vitamins and minerals in foodstuffs. *ERNAHRUNGS-UMSCHAU*, *53*(9), 336.
10. Al-Musa, H. M. (2017). Impact of obesity on serum levels of thyroid hormones among euthyroid Saudi adults. Journal of thyroid research, 2017.
11. International Agency for Research on Cancer, IARC Working Group on the Evaluation of Cancer-Preventive Strategies, & World Health Organization. (2004). Cruciferous vegetables, isothiocyanates and indoles (No. 9). IARC.
12. Karnath, B. M., & Hussain, N. (2006). Signs and symptoms of thyroid dysfunction. Hosp Physician, 42(10), 43-48.
13. Leung, A. M., & Braverman, L. E. (2014). Consequences of excess iodine. Nature Reviews Endocrinology, 10(3), 136.
14. Sun, X., Shan, Z., & Teng, W. (2014). Effects of increased iodine intake on thyroid disorders. Endocrinology and Metabolism, 29(3), 240-247.