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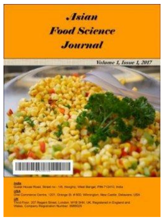

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Evaluation of Goitrogenic Content of Common Vegetables in South West Nigeria

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Authors' contributions

"This work was carried out in collaboration between all authors. Author OAA designed the study, performed the statistical analysis and wrote the protocol. Author OMA wrote the first draft of the manuscript. Authors OAS and JKF managed the analyses of the study. Author KJA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Endemic goiter and associated iodine deficiency disorders (IDD) are prevalent in south west Nigeria. The present study was undertaken to identify the role of dietary goitrogen in the etiology of endemic goiter. Perchlorate, fluoride, nitrate, bromide, chloride, phosphate and cyanide content of common vegetables viz., cabbage, African Eggplant, Giant pigweed, Scent leaf, Amaranth, Tree Spinach, Black nightshade, consumed by the population of the region were measured. All the dietary goitrogen content in the investigated vegetables were found to be within the Acceptable

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Daily Intake and this observation suggests that in addition to iodine deficiency dietary intake of a cyanogenic plant, the combination of chemicals may play some role for the persistence of endemic goiter in Southwest Nigeria.

Keywords: Goiter; vegetables; goitrogens.

1. INTRODUCTION

Vegetables often mean the part of a plant that is edible other than a sweet fruit or seed. It thus typically implies the leaf, stem or root of a plant [1]. Vegetables play a vital role in human nutrition; they serve as the most rapid and lowest cost source of fibers, minerals and vitamins to the majority of people in developing countries, where they are often eaten in relatively small amounts as a side dish or relish with the staple foods [2]. The broad variation in taste, texture and colors of diverse vegetables is an exciting additional touch to the meals [3]. The use of many plants for food is often limited by the composition of goitrogenic substances in them as they remain hazardous to both man and animals [4]. Hence, vegetables are widely cultivated and consumed for their flavors and nutritional benefits [5]. Vegetables may also contain goitrogenic substances, which are detrimental to nutrition and health [6].

Goitrogens are substances which cause an enlargement of the thyroid gland, a condition known as goiter. They may act directly or indirectly on the gland by altering the regulatory mechanisms of the gland and peripheral metabolism and excretion of triiodothyronine (T3)/ thyroxin (T4) [7]. The thyroid gland is one of the sensitive endocrine hormone producing glands that enhance protein synthesis and oxygen utilization, which in turn, influence the basal metabolic rate (BMR). The thyroid accomplishes the task of metabolic regulation through the secretion of three important hormones, T4 (thyroxine) and T3 (triiodothyronine) [8,9], as well as calcitonin [10], which is important for calcium metabolism in the blood plasma. When there is difficulty in making thyroid hormone, the thyroid gland enlarges as a way of trying to compensate for this inadequate production of the hormone. The level of thyroid hormone production is determined by the level of thyroid stimulating hormone (TSH) released from the pituitary gland; and by the availability of iodine and tyrosine. A number of compounds, however, have the ability to prevent the synthesis of these thyroid hormones. These compounds include perchlorate, fluoride, nitrate, bromide, chloride, phosphate and cyanide. These compounds are generally gotten from food and water [7]. Association between goitrogens and goiter has been studied in detail [11]. Cassava (*Manihot utilissima*) [12,13], Cabbage (*Brassica oleracea* L.) [14,15] and Pearl Millet (*Pennisetum americanum*) [16,17,18] are few common examples of foods rich in goitrogens, which have been reviewed extensively. In spite of numerous reports on goitrogen contents in food, there is a dearth of literature report on the goitrogen levels in leafy vegetables. Hence, Investigation of the levels of goitrogens in vegetables is thus needed to discern the contribution of the vegetable to nutrition and health. This study thus evaluates the composition of goitrogens in some Nigerian leafy vegetables.

2. MATERIALS AND METHODS

2.1 Plant Materials

Samples of fresh vegetable leaves were collected from a farmland in Ado Ekiti, Ekiti State, Nigeria. The geographical coordinate of the farmland is Latitude: 7°37.3974′ N; Longitude: 5°13.2522′ E. Authentication of the plants was carried out at the Department of Plant Science and Forestry, Ekiti State University, Nigeria. The leaves were separated from the stalk, rinsed with distilled water and were oven-dried at 40^{o}C. The dried samples were grounded into fine powder and sieved through 2.0 mm mesh prior to analysis.

2.2 Goitrogen Analysis

The Goitrogenic component of the samples was determined using the method as described by Tel and Rao [19]. Briefly, 20 g of each blended sample was mixed with 20 ml of distilled water and filtered through Whatman no. 2 filter paper, and the filtrate was passed through a glass column fitted with a tape and filled with activated alumina, in order to separate the green colour (chlorophyll) and get a transparent solution. The transparent solution, free from turbidity was used for the determination of the goitrogenic parameters.

Table 1. Selected leafy vegetables identified in Ekiti State

Scientific name	Common name	Vernacular name
Brassica oleracea	Cabbage	'Araasa'
Solanum macrocarpon	African Eggplant	'Igbagba'
Trianthema portulacastrum	Giant pigweed	'Esisan'
Ocimum gratissimum	Scent leaf	'Efinrin'
Amaranthus cruentus	Amaranth	'Arowojeja'
Amaranthus viridis	Amaranth	'Tete Adayeba'
Cnidoscolus aconitifolius	Tree Spinach	'Iyana-ipaja'
Solanum nigrum	Black nightshade	'Odu'

Table 2. Goitrogen composition of Nigerian leafy vegetables

Leafy vegetable	Nitrate (ppm)	Perchlorate (ppm)	Fluoride (ppm)	Bromide (ppm)	Chloride (ppm)	Phosphate (ppm)	Cyanide (ppm)
Brassica oleracea	0.15	0.08	2.15	0.08	0.54	0.04	0.45
Solanum macrocarpon	0.54	0.11	3.21	0.12	0.80	0.06	0.60
Ocimum gratissimum	0.20	0.05	1.48	0.04	1.17	0.12	0.32
Amaranthus cruentus	0.48	0.08	2.14	0.08	0.54	0.04	0.21
Amaranthus viridis	0.18	0.04	1.22	0.04	0.30	0.02	0.37
Solanum nigrum	0.27	0.09	2.48	0.09	0.62	0.05	0.53
Cnidoscolus aconitrifolius	0.28	0.06	1.81	0.07	0.45	0.04	0.44
Trianthema portulacastrum	0.28	0.13	3.70	0.14	0.92	0.07	0.71

3. RESULTS AND DISCUSSION

The results of the Goitrogen analysis of the leafy vegetables are represented in Table 2. Nitrate, a naturally occurring compound and a vital component of vegetables because of its potential to a mass is formed naturally in living and decomposing plants and animals, including humans [20,21,22,23]. Nitrate by itself is relatively nontoxic, but its metabolites, nitrite, nitric oxide and N-nitroso compounds, make nitrate of regulatory importance because of their potentially harmful health implications. Nitrate majorly gets into the human body exogenously from vegetables, water, and other foods, but is also formed to a minute extent endogenously [21,22]. Nitrate is present in the investigated vegetables at different concentrations. The toxicity of Nitrate is due to its conversion to nitrite and its ability to react to form N-nitroso compounds whose effects have been identified to range from methemoglobin formation, hyperplasia of the zona glomerulosa of the adrenal cortex and gastric neoplasia [24]. The safety of this compound is therefore dependent on its availability in food. However, the levels of nitrate in all the investigated vegetables are within the limit of the Acceptable Daily Intake (ADI) of 0-4000ppm/ day [25].

Perchlorate is a contaminant present in the environment naturally and as a result of human activity [26]. Hence, the use of natural fertilizers and perchlorate contaminated irrigation water may lead to considerable concentrations in leafy vegetables. Perchlorate is often found as the anion component of salt usually associated with cations such as ammonium, sodium or potassium. Perchlorate acts as a goitrogenic substance because it competitively blocks iodide from entering the thyroid due to its similarity in ionic radius to iodide by an effect on the Na^+/I^- symporter thus preventing the further synthesis of thyroid hormone, thereby inhibiting growth and development [27]. Severe iodine deficiency as a result of insufficient iodine intake or sustained exposure to goitrogenic substances such as perchlorate at levels that induce depletion of the thyroid hormone stores can result in hypothyroidism. However, a mild to moderate iodine deficiency can lead to the development of toxic multinodular goiter and can result in hyperthyroidism. Besides its potential to cause endocrine system and reproductive problems, perchlorate is considered to be carcinogenic to humans [28]. The widespread presence of perchlorate in vegetables and its toxicological properties has however made perchlorate an emerging chemical of concern. From this study, the levels of perchlorate in the investigated vegetables are within the tolerable daily intake (TDI) of 0-0.3 ppm per day [29]. Meanwhile, previous research on perchlorate and possible thyroid-related health effects has paid slim emphasis on the other common environmental Sodium-iodide co-transporter inhibitors, thiocyanate and nitrate. The focus on perchlorate grow in part due to its relative potency as a Sodium-iodide co-transporter inhibitor is 10-200 times that of thiocyanate, and nitrate respectively on a molar basis [30,31]. However, based on average daily intake of perchlorate equivalents of nitrates and thiocyanates, a person’s exposure to both thiocyanate and nitrate from food account for a larger proportion of iodine uptake inhibition than does perchlorate exposure [32]. Moreover, *in vitro* studies of NIS indicate that perchlorate, nitrate, and thiocyanate act synergistically to inhibit iodide uptake [31]. Therefore, it seems very vital to study the combination of these chemicals.

Bromide and chloride have been reported to have similar biological behavior on the thyroid gland. High bromide intake has been shown to decrease the amount of iodide accumulated in the thyroid [33], thus influencing their iodine metabolism by reducing the accumulation of iodine in the thyroid gland and skin as well as by a rise in iodide excretion by the kidneys, thereby exerting goitrogenic effects. Very high consumption of bromide has been linked to a short biological half-life of iodine in the thyroid of rats [33]. However, the concentration of these compounds in the investigated vegetables is far below that which can result in acute and chronic toxicity [34]. Phosphate is widely distributed in the body and is involved in cell signaling, energy metabolism, nucleic acid synthesis as well as maintenance of acid-base balance. Excess phosphate in the blood can lead to calcium deposits in the soft tissues of the body; a condition evident in the patient with reduced kidney function. The level of phosphate observed in the investigated vegetables is however far from that which can be toxic to humans [28].

4. CONCLUSION

The goitrogenic potential of a plant or food depends upon the amount of active goitrogen present in it. The consumption of vegetables, though rich in nutrients could be limited and dangerous to health if their goitrogenic content is high beyond the acceptable limit. However, the results of this study showed that the goitrogenic substances in Nigerian vegetable are in safe amount. Hence, consumption of these vegetables is beneficial to health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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