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INVESTIGATION OF THE POSSIBLE ROLE OF GOITROGENS IN THE DEVELOPMENT OF IODINE DEFICIENCY DISORDERS IN GHANA

BY

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DECLARATION

This project was conducted by me as presented under the supervision of Dr. E. Asibey-Berko of the Department of Nutrition and Food Science, University of Ghana.

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DEDICATION

Dedicated to my husband, John Pwamang, Son, Wudior, and the family for their love and support both materially and spiritually.

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ABSTRACT

The important role of iodine deficiency in the development of endemic goitre and cretinism is well established. However, it has been found that adequate iodine intake (75-300 μg/day) does not always eradicate goitre. Therefore, it is understandable that other environmental factors, known as goitrogens, present in the staple foods or drinking water contribute to the persistence of the disease.

This paper reports on the possible role of goitrogens in the development of goitre in Axim (Western region, Ghana), Sekoti (Upper East region, Ghana) and Accra (Greater Accra region, Ghana)

Examinations for thyroid size were carried out on 249 school children aged between ten and fourteen years inclusive in Sekoti, 220 in Axim, and 210 in Accra. With the target of analysing urine sample from at least 10% of those examined for goitre, urinary iodine and thiocyanate analysis were done on 43 pupils in Sekoti, 59 in Axim and 55 in Accra.

Total goitre prevalence (visible and invisible) ranged from 56.2% in Sekoti, 20.5% in Accra and 17.3% in Axim. Mean urinary iodine levels in Sekoti was 22.93μg/dL, 46.9μg/dL in Axim and 20.5μg/dL in Accra. The mean urinary thiocyanate was 3.30mg/dL, 1.13mg/dL and 1.84mg/dL respectively in Axim, Accra and Sekoti.

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Based on goitre prevalence alone, Sekoti could be considered a severe endemic goitre area, while Accra and Axim could be classified as mild. However, the mean urinary iodine level in all the areas were highly in excess of the 5 ug/dl or less defined to be an indication of iodine deficiency. Moreover, goitrous pupils in all the areas were also excreting iodine levels (18.95 μg I/dl, 47.8 μg I/dl and 21/42 μg I/dl respectively in Sekoti, Axim and Accra) far higher than would be expected in people with dietary iodine deficiency. It may be concluded that the goitre endemia of the areas of study may be contributed to by goitrogens either in the food or water.

The urinary iodine to thiocyanate ratio (I/SCN ratio) was used as an index to the exposure to dietary goitrogens, in this case, thiocyanate. This ratio was found to be almost statistically the same by analysis of variance in the three areas. The mean I/SCN ratio in Sekoti was 21.4 μg/mg; 42.2 μg/mg in Axim and 29.1 μg/mg in Accra. Since the thiocyanate exposure is almost the same in the three areas, it could suggest that the high incidence of goitre seen in Sekoti may be contributed to by other goitrogens.

Analyses of nutrient intakes based on the 24-hour dietary recall method showed that mean protein intakes were adequate and comparable to the Recommended Dietary Allowances, (RDA) in all the areas. However, the mean energy requirements in all three areas were not met. Axim had the lowest (64% of the RDA) while Accra and Sekoti met 74% and 73.7% respectively. The low energy intakes observed especially in Axim may explain the higher incidence of chronic malnutrition.

25% of the children in Axim were found to be stunted (less than 90% of mean height-for-age). Malnutrition was also found to be severe in

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Sekoti in terms of wasting where 26.5% of the children examined had weight-for-height values of less than 80% of standard. 17.2% of Sekoti children were also found to be chronically malnourished.

Mean vitamin A intake was also found to be low in Sekoti (81% of the RDA) compared with Accra (1460% of the RDA) and Axim 1988% of RDA). Millet and sorghum contributed about 64% of the total daily caloric intakes according to the 24-hour recall. Thus the possible role of the goitrogenic effect of millet in the aetiology of the high incidence of goitre in the Upper East cannot be ruled out.

A multiple logistic regression analysis revealed that about 90% of the variability in goitre prevalence could be attributed to a low iodine/high thiocyanate ratio (I/SCN ratio) chronic malnutrition and vitamin A deficiency. Another possible contributing factor to the goitre seen in the areas of study may be attributed to polluted drinking water since most of the water samples collected in the study had a high bacterial and coliform counts as well as E. Coli.

The findings of this study confirm what has been observed by Ingeenbleek, 1986 that protein energy malnutrition, hypovitaminosis A, and endemic goitre all of which were once considered distinct clinical entities resulting from specific alimentary deficiencies, might soon prove to be closely interrelated nutritional disorders.

It is recommended that plasma thyroid hormones and serum vitamin A levels should be measured to confirm the findings of this study.

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CHAPTER ONE

1.0 INTRODUCTION

It is estimated that one billion people are exposed to the risk of goitre because of a deficiency of iodine, and most of them dwell in the tropical regions of the Third World (Hetzel, 1988).

In Africa, endemic goitre is still a major public health problem affecting 227 (two hundred and twenty seven) million people. Owing to its benign appearance, endemic goitre ranks low in the hierarchy of acute and chronic diseases plaguing developing countries. Moreover, the full extent of its many complications, all of them deleterious to the well-being of the population as well as to the health budget of the country involved, is by no means fully appreciated. The most notable of these include: an increased rate of cretinism, whether myxedematous or neurological; severe post surgical complications such as hypoparathyroidism and laryngeal nerve paralysis; an association with impaired fertility and mental impairment of school children; and a higher prevalence of cancer (Benmiloud, 1982).

It was considered until recently that iodine deficiency by itself would invariably result in the development of goitre and endemic cretinism. However, in the last few years, several groups of investigators have reported situations in which no goitre or endemic cretinism was evident despite severe dietary iodine deficiency (less than 25 ug/day) (Gilbert, 1984). These reports challenge the concept that iodine deficiency by itself invariably results in endemic goitre and cretinism. Therefore, it was logical to postulate the existence of other factors that, acting in conjunction with iodine deficiency, determine the development of these two pathological conditions. In the presence of other environmental goitrogenic factors, iodine deficiency results in the highest incidence of endemic goitre. More than half of the population can be affected by the disease, with up to 10%

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suffering from anomalies characteristic of endemic cretinism (Gaitan et al, 1978).

The important role of iodine deficiency in the development of endemic goitre and cretinism is well established by several observations indicating that iodine supplementation consistently results in a marked decrease in the prevalence of endemic goitre and the disappearance of endemic cretinism. However, it has been found that adequate iodine intake (75-300 ug/day) does not always eradicate goitre as a prevalence rate of 6-40% persists in some areas (Gaitan, 1982). Therefore, it is understandable other environmental factors are thought to contribute to the persistence of the disease.

Under these circumstances, goitrogens in staple foods and water appear to be most important as environmental factors in the development of endemic goitre. Environmental goitrogens may, normally, be ineffective when low in concentration, but may become significant when the supply of iodine is low. In other situations, they may be sufficiently potent in themselves to cause goitre despite an abundance of iodine (Gaitan et al, 1978).

In Ghana there has been no formal epidemiological survey to systematically investigate the distribution, prevalence, and severity of goitre since the W.H.O. report (1958) and the National Food and Nutrition Survey (1961) reported that goitre is prevalent in the Northern and Upper Regions. Recently also undocumented incidences of goitre have been reported in the Volta Region, Kokofu in Ashanti and in some villages in the Akwapim hills belt (Asibey-Berko, 1990).

There has also been no research to identify and assess the contribution of dietary goitrogens in the development of goitre in Ghana.

1.1 AIMS AND OBJECTIVES

The aim of this project is to investigate the possible role of goitrogens in the development of goitre in Axim (Western region, Ghana), Sekoti (Upper East region, Ghana) and Accra (Greater Accra region, Ghana).

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Specific Objectives:

(1) To conduct goitre surveys in some selected areas.

(2) To determine the iodine nutritional status in these areas (ie. urinary iodine concentrations).

(3) To study the nutrient intake of the people with special reference to Vitamin A, protein and energy.

(4) To estimate urinary thiocyanate (SCN).

(5) The food habits of the people with respect to consumption of vegetables, staples, seaweeds and fish.

(6) To determine the total bacterial count, that is gram positive and E. coli in the sources of water.

(7) To make a list of tables of foods containing hydrocyanic acid (HCN).

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CHAPTER TWO

LITERATURE REVIVIEW

2.1 DEFINITION OF IODINE DEFICIENCY DISORDERS

Iodine is an essential micro-nutrient which is required for the synthesis of the hormone, thyroxine by the thyroid gland. The thyroid hormones have extensive effects throughout the body. They influence metabolic rate, protein synthesis, enzyme function, cellular transport, and other physiological processes. They are essential for normal growth and development and function of the brain and nervous systems, and for maintenance of body heat and energy. When people do not have enough iodine, they cannot make enough thyroid hormones. This deficiency of iodine has several important health consequences that together are called "Iodine deficiency disorders" or I.D.D. (Dunn, 1990).

2.2 Sources and Requirements of Iodine in Man

The nutritional need of iodine depends on:

(1) The rates of iodine excretion in the urine and feces, and

(2) Individual "host" factors including growth, age, body-weight, sex, nutrition, reproductive functions, climate, disease, and the presence or not of goitrogens (Koutras, 1990).

Inorganic iodine in the plasma (PII, plasma Inorganic Iodine) is one of the key factors controlling thyroid function. There is no renal homeostatic mechanism to keep the PII constant, so this varies with the iodine intake and the iodine excretion rates, urinary and fecal (Koutras, 1990, Wayne et al, 1964) When the PII falls below 0.08μg/dl, iodine deficiency may occur (Koutras, 1990, Alexander et al, 1962).

Iodine intake itself varies greatly from area to area, and even in the same area from individual to individual. Wayne et all (1964) have calculated that in order to ensure a safe PII level of 0.010μg/dl a dietary intake of 70μg iodine daily is required on average. This would allow for 50μg of urinary iodine and 20μg for fecal excretion. Since the renal and fecal excretion rates may differ from person to person, individual requirements may

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range from 40 to 120μg/day. Querido et al (1974) have defined an average urinary iodine excretion of 50μg/day or 5μg/dl as the minimum for adequate thyroid hormone synthesis (Koutras, 1990). The Food and Nutrition Board of U.S.A. National Research Council recommended an intake of 35μg/day for babies up to 6 months, of age, 45μg/day for those 6-12 months, and 60-110μg/day for children 1-10 years of age, and 150μg/day for older children and adults. The daily requirement in adults is placed at about 1-2μg/kg of body weight. An iodine intake between "a minimum of 50μg and a maximum of 1000μg/day" is considered safe (NAS, Food and Nutrition Board, 1971). An additional 25μg and 50μg are recommended during pregnancy and lactation respectively. These additional increases in pregnant and lactating women is due to the transfer of iodine to fetus or the milk. Furthermore, in pregnancy, the renal iodine clearance increases by 107% according to Aboul-Khair et al (1964). This leads to a fall in the PII, hence an increased prevalence of goitre during pregnancy (Koutras, 1990, Crooks et al 1964).

2.3 The Cycle of Iodine in Nature and The Iodine content of Foods

Iodine intake depends on its concentrations in the food. This also depends on the iodine content of the soil where the food has been produced.

In general, there are great variations in the iodine content of the soil. Iodine present in the original earth surface has been leached away by rain and carried to the oceans. However, from the oceans iodine evaporates, is concentrated in the rain, falls to the ground and gradually enriches the superficial soil. For this reason, old soils have a higher iodine content than newly formed ones. It also explains why proximity to the sea can affect iodine content of soil, plants and food. There is thus in nature an iodine cycle (Fig. I). Miyake and Tsunogai (1963) estimated that about 400,000 tons of iodine escape every year from the ocean surface. The iodine content of the ocean water averages 50μg/l; whereas in the rain and river water it is 10 times less i.e. 5μg/l and it only 0.7μg/l

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Fig 1 : The iodine cycle in nature. Iodine from the oceans (50 µg/l) evaporates, is concentrated in the rain (5 µg/l), falls on the earth, and the rivers carry it back to the oceans (Adapted from Koutras 1986).

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in the atmosphereic air (Matovinovic, 1983, Koutras, 1990). Heavy rain on slopy ground washes away the superficial iodine-rich soil layers, exposing the iodine - poor ones below them. Soil erosion is therefore accompanied by iodine deficiency.

This happened also with the last glacial period, 8,000 to 18,000 years ago. Glaciation swept away the iodine rich superficial humic soil, and so areas subjected to intense glaciation are now afflicted with endemic goitre.

The Iodine Content of Foods

Iodine intake is based on the iodine content of the foods. Drinking water makes usually a small contribution, but its iodine concentration is an index of the iodine in locally produced foods, hence, its negative correlation with endemic goitre.

In general, food contains widely different amounts of iodine, depending not only on the particular item, but also on the place where it has been produced. As a general rule, seafood contains the largest quantities, followed by terrestrial animal food, whereas legumes and fruits contain very little.

Recently, the contribution of adventitious sources of iodine is increasingly recognized. Several drugs contain large quantities of iodine, including, clioquinol, formerly widely used in developing countries for any diarrhea, and amiodarone, commonly used in some countries as an anti-arrhythmic. Furthermore, fish flour as chicken feed as well as iodoform as disinfectant may greatly increase the iodine content of poultry and eggs. Iodate as dough-conditioner in bread and erythrosine as a colouring substance in candies and pills are other examples of adventitious sources of iodine.

The iodine content of the food consumed is not the same with the iodine intake. Part of the iodine of the raw food may be lost during cooking. Harrison et al (1965) found that frying reduced the iodine content of fish by 20% and boiling

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by 58%. Furthermore, from what is left, absorption is not always complete. Hence, the food consumed must contain more iodine than the minimum requirements listed above, so as to allow for these losses.

2.4 Metabolism of Iodine

The normal human thyroid weighs 20-25g in adults. It contains 8-10mg of iodine, 95% of it bound to thyroglobulin. Some 45% and 3% of iodine in the diet absorbed from the intestine as inorganic iodide is normally taken up by the thyroid gland to produce thyroid hormones, thyroxine (T4) and tri-iodothyronine (T3) respectively. 42% occurs in the T3 and T4 precursors, mono and di-iodotyrosines (MIT and DIT).

Thyroid structure and function are regulated by two inter-related systems. The first regulator is iodine itself and it controls both the thyroid hormone secretion and the reserves of iodine in the form of iodotyrosines in thyroglobulin. When the iodine supply is low, all functions of the thyroid gland are accelerated; at short or prolonged excessive iodine intake, all processes in the thyroid are slowed or modified.

The second regulatory system, the pituitary thyroid stimulating hormone (TRH) of the hypothalamus, controls the thyroid function, serving to maintain the normal concentration of free thyroid hormone in the blood. Thyroid stimulating hormone is also known as thyrotropin or throtropic hormone (Taber's cyclopedic Dictionary, 1973). Both control systems, the iodine and the TRH-TSH, regulate the intermediary metabolism of the thyroid cell, largely via the adenyl-cyclase-cyclic adenosine monophosphate. Under physiological conditions, their effects are complementary (DeGroot et al, 1975).

The production of thyroid hormone involves the following processes:

1. <u>Iodide Transport</u>:

The transport of iodide from the plasma across the cell membrane is an active process against electrical and mass gradients. The normal concentration of iodide in thyroid cells is 30-40 times higher than in the serum.

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2. Synthesis of Thyroid Hormones

At the interface of the cell and the colloid, a peroxidase is instrumental in oxidizing iodide (^-I) into an "iodine - intermediate". It facilitates the formation of MIT and DIT by incorporating iodine into the tyrosyl/residues of thyroglobulin. These are called the processes of "organification". The subsequent oxidative coupling of iodotyrosines into T4 and T3 is also carried out by the same peroxidase that is the thyroidal peroxidase.

3. Secretion of Thyroid Hormones

Thyroglobulin is engulfed by the cytoplasm of the thyroid cells and it undergoes proteolysis. The secretory phase ends by diffusion of the hormones into the capillaries via extracellular space (DeGroot et al 1975).

Definition of Endemic and Spordic Goitre

"Goitre" is defined as any enlargement of the thyroid gland, and as such it is a symptom and not a specific disease.

"Non-toxic goitre is due to several causes (iodine deficiency, goitrogenic substances, inborn error of thyroid hormone synthesis, and action, and auto immunity). But the pathogenesis is more or less the same. It is a process aiming at keeping at normal levels the amount of thyroid hormones secreted, when this is threatened by any of the etiologic factors mentioned above. The compensatory hyperplasia (excessive increase in the number of normal cell in the tissue) leading to non-toxic goitre formation is in general initiated by an increased thyroid stimulating hormone (TSH) secretion. If the compensation is adequate and the supply of thyroid hormones stays normal, the TSH level may fall back into the normal range, otherwise, it stays elevated (Koutras, 1990b). Non-toxic goitre may be sporadic i.e. affecting less than 10% of the population, or endemic, affecting more than 10%. The limit of 10% is of course arbitrary, but in any case when it is exceeded, an environmental cause, such as iodine deficiency or goitrogens is usually at play, hence the separate description of endemic goitre.

According to Perez et al (1960), "A thyroid gland whose lateral lobes have a volume greater than the terminal phalanges of the thumb of the person examined, will be considered goitrous".

<u>Goitrogenesis Induced By Iodine Deficiency</u>

Endemic goitre is a direct consequence of the thyroid's adaptation to iodine deficiency. (fig 2) Dietary iodine deficiency causes depletion of thyroid iodine stores with reduced daily production of thyroid hormone (T4). A fall in serum T4 triggers the secretion of increased amounts of pituitary thyroid - stimulating hormone (TSH) which increases thyroid activity. The thyroid cells grow and multiply; the colloid of the follicle's empties; the vascularisation of the gland develops intensely and the size of the gland increases, even if a goitre as such is not detected clinically. Also there is increase in the activity of the iodide pump. The concentrating process of iodide by the thyroid gland is markedly enhanced through an increased number of thyroid cells. Thyroid iodine uptake is increased so as:

(1) to maintain a daily incorporation of about 100ug iodide into the gland; and

(2) to adjust the renal excretion of iodine at the level of its dietary supply. (Koutras, 1990).

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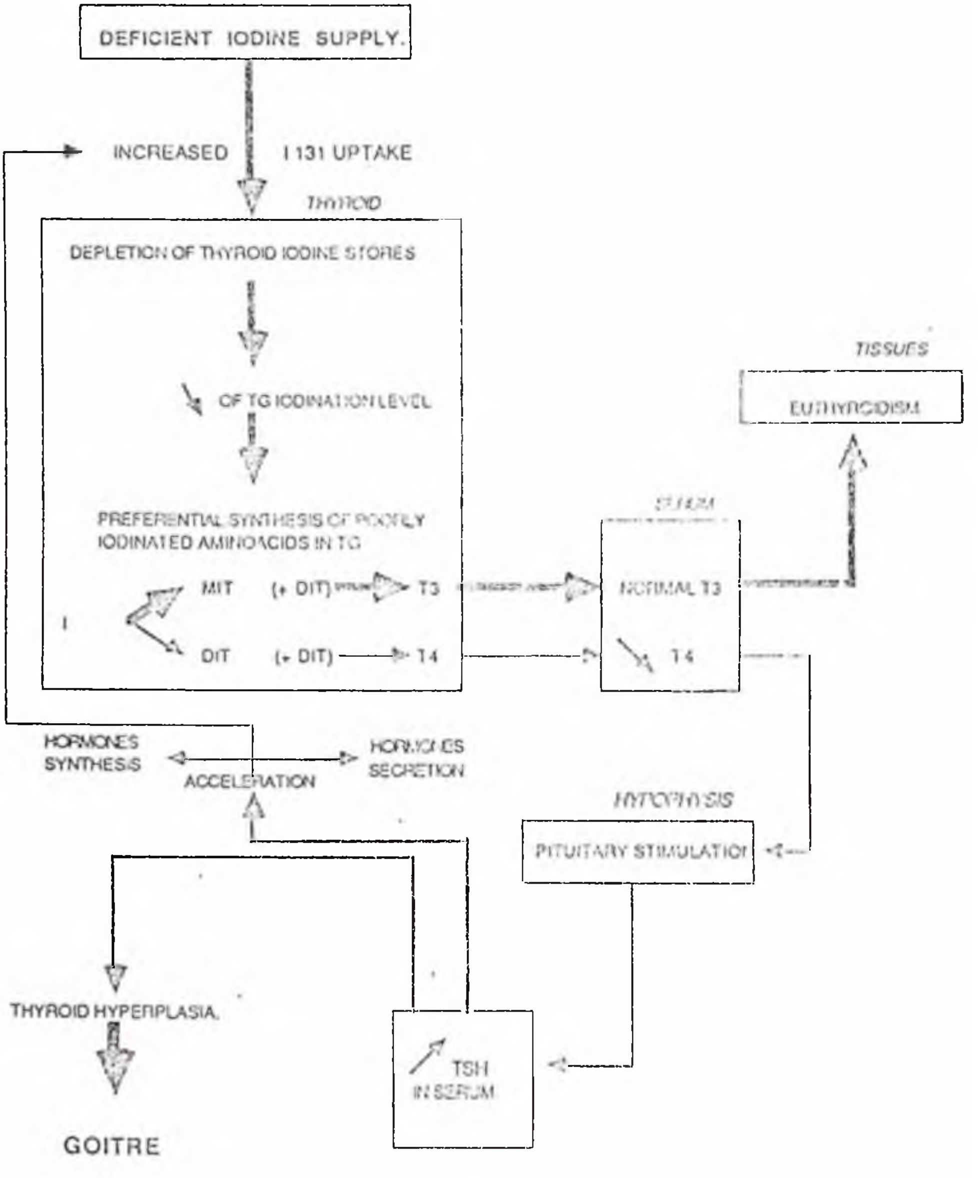

Fig 2: PATHOGENESIS OF ENDEMIC GOITER.

SOURCE : Koutras, 1990.

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2.5 The Role of Naturally - Occurring Goitrogens in the Development of Endemic Goitre

Goitre can arise from causes other than primary iodine deficiency, due to a variety of agents named as goitrogens (Gaitan, 1980). Goitrogens are antithyroid compounds that may be present in food or water and interfere with the formation of thyroid hormones by the thyroid gland and cause enlarged thyroid (Goitre).

Agents known to have goitrogenic and/or antithyroid effects on the thyroid of humans and other animal species are listed in Table 1.

Environmental compounds may cause goitre by acting directly on the thyroid gland but also indirectly by altering its regulatory mechanisms and/or the peripheral metabolism and excretion of thyroid hormones.

Agents Acting Directly on the Thyroid

The various environmental goitrogenic and anti thyroid compounds and their sites of action in the thyroid gland are shown in Figure 3. Goitrogens act in thyroid gland to interfere with the process of hormonal synthesis, but the mechanisms that induces the trophic changes leading to goitre formation is not yet well understood. Anti thyroid compounds can be divided into three categories according to the way they act on iodine metabolism in the thyroid (Gaitan, 1990).

CLASS I:

The thiocyanates or thiocyanate - like compounds which appear primarily to inhibit the active concentrating mechanism of iodine, and their goitrogenic activity can be overcome by iodine administration. These ions have a molecular volume and charge similar to those of iodine. This is the reason they compete with iodine for transport in the follicular cell (Gaitan, 1990).

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Table 1: Naturally - Occurring Agents Producing Goitrogenic and/or Antithyroid Effects

Compounds	Goitrogenic/Antithyroid Effects		
	In Vivo		In Vitro
	Human	Animals	Systems
Sulfurated Organics			
Thiocyanate (SCN-)	+	+	+
Isothiocyanates	NT	+	+
L-5-Vinyl-2-Thio-oxa Zolidone (Goitrin)	+	+	+
Disulfides (R-S-S-R)	NT	+	+(?)
Flavonoids (Polyphenols)			
Glycosides	NT	+	+
Aglycones	NT	+	+
C-ring fission metabolites (ie. Phloroglucinol, Phenolic acids)	NT	+	+
Phenolics			
Phenol	NT	NT	+
Catecol (1,2, dihydroxy-benzene)	NT	NT	+
Resorcinol (1,3-dihydroxy benezene)	+	+	+
Hydroquinone (1,4 - dihydroxy benzene)	NT	NT	+
m- dihydroxy acetophenones	NT	NT	+
2 - methylresorcinol	NT	+	+
5 - methyresorcinol (orcinol)	NT	+	+
4 - methylcathecol	NT	NT	+

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Compounds	Goitrogenic/Antithyroid Effects		
	In Vivo		In Vitro
	Human	Animals	Systems
Pyrogallol (1,2,3-tri hydroxy benzene)	NT	+	+
Phloroglucinol (1,2,3,- trihydroxy benezene	NT	+	+
<u>Pyridines</u>			
3-hydroxy pyridine	NT	NT	+
Dihydroxy pyridines	NT	+	+
<u>Phtalate Esters and Metabolites</u>			
Diisobutyl phtalate	NT	NT	0
Dioctyl phtalate	NT	NT	0
O-phtalic acid	NT	NT	0
m-phtalic acid	NT	NT	0
3,4 - dihydroxy benzoic acid (DH BA)	NT	NT	+
3,5, dihydroxy benzoic acid	NT	NT	+
<u>Polycyclic Aromatic Hydrocarbons (PAH)</u>			
3,4 - benzpyrene (Rap)	NT	+(?)	NT
3, methylcolanthrene (MCA)	NT	+	NT
7, 12-dimethyl-benzanthracene (DMBA)	NT	+	NT
<u>Inorganics</u>			
Excess iodine	+	+	+
Lithium	+	+	+

+ = Active
0 = Inactive
NT = non tested

Source: Gaitan, 1990

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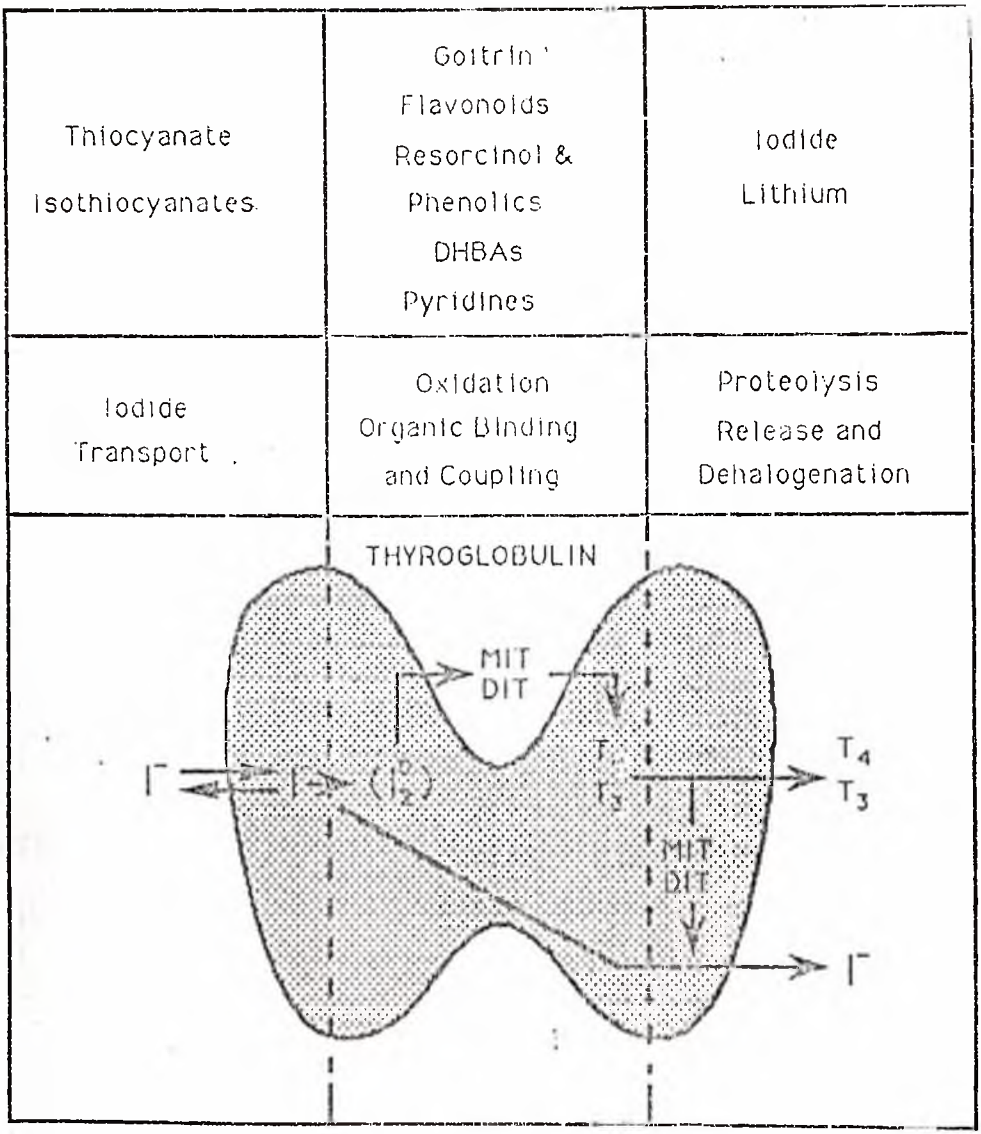

Fig.3 Naturally occurring goitrogens and their site of action in the thyroid gland. DHBAs = dihydroxibenzoic acids; I = iodide, MIT - monoiodotyrosine; DIT = diiodotyrosine; T3 = triiodothyronine; T4 = thyroxine. SOURCE : Gaitan 1990

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The isothiocyanates act on the thyroid mainly by their rapid conversion to thiocyanate. The naturally-occurring butyl, allyl, and methyl isothiocyanates do not inhibit the throidal peroxidase enzyme (Gaitan, 1986). However, isothiocyanates not only use the thiocyanate metabolic pathway but react also spontaneously with amino groups forming di-substituted thirourea - like antithyroid effect. Additive antithyroid effects of thiocyanate, isothiocyanate, and the thioglycoside "goitrin" occurs with combinations of these naturally - occurring goitrogens.

CLASS II:

The thiourea or thionamide - like goitrogens interfere with the processes of organification of iodine and coupling of iodotyrosines to form the active thyroid hormones, and their action usually cannot be antagonized by iodine. These goitrogens prevent the oxidation, of iodine by thyroid peroxidase (TPO) and impair covalent binding of iodine to thyroglobulin. In small amounts, they inhibit the formation of active thyroid hormones from iodotyrosine precursors. In larger quantities, formation of MIT and DIT is impaired. These types of compounds do not prevent transport of iodine into the thyroid gland, and pharmacological doses would be required to suppress iodine uptake.

The naturally-occurring thioglycoside L-5-Vinyl-2-thiooxazolidone, "goitrin" is representative of this category. Goitrin is unique in that it does not degrade like thioglycosides. Goitrin acts in vitro on the thyroidal peroxidase and 125I organification, and in vivo exerts a thionamide - like effect (Gaitan, 1986).

Flavonoids, which also belong to this category, are polyhydroxyphenols with a (6-C3-C6 structure (Cody et al, 1986). Flavonoid glycosides possess intrinsic antithyroid activity which is increased by conversion to flavonoid aglycones by o-methylation in the b-ring and by middle ring fission to phoroglucinol, resorcinol and other phenolic acids (Gaitan, 1990).

CLASS III

Agents in this group interfere with the processes of proteolysis and release of thyroid hormones. The most important representative of this group is iodine (Gaitan, 1986). An excess intake of iodine, arbitrarily defined as 2mg or more per day, inhibits the synthesis and release of thyroidal hormones and eventually produces "iodine goitre" and hypothyroidism. The recommneded dietary allowance for iodine is 150µg/day for both adult males and females who are not pregnant or lactating. An additional 25µg and 50µg are recommended during pregnancy and lactation respectively.

Lithium has also been shown to belong to this category (Gaitan, 1990). Goitre has developed in some mental patients as a result of treatment with high levels of Lithium.

Agents Acting Indirectly on the Thyroid

The thyroid hormones are excreted into the intestine in both free and conjugated forms, along with small amounts of their de-ionated metabolites. Glucuronide conjugation occurs mainly in the liver by the action of a UDP - glucuronyl transferase and sulfate conjugation mainly in the kidney by the action of a sulfate transferase. However, under normal circumstances little T4 and T3 are excreted in conjugated form.

The polycyclic aromatic hydrocarbons (PAH), 3 - methylcholanthrene (MCA) and 3, 4 - benzpyrene (BaP), accelerate T4 metabolism and excretion of T4 - glucuronide, but there is also indication that MCA interferes directly with the process of hormonal synthesis in the thyroid gland (Gaitan, 1986).

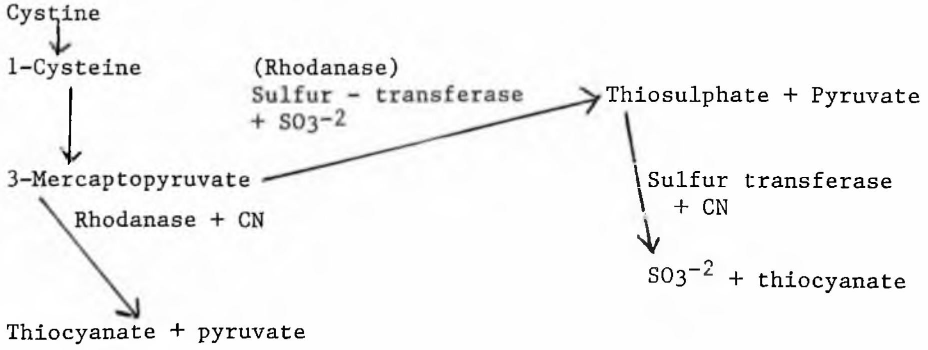
Flavonoids not only inhibit the thyroid peroxidase (TPO), but acting on iodothyronine, deiodinase enzymes, also the peripheral metabolism of thyroid hormones (Cody et al, 1986). Furthermore polymers of the flavonoid, phloretin, interact with TSH preventing its action at the follicular thyroid cell, thus, indicating that this class of compounds alters thyroid hormone economy in a complex manner (Gaitan, 1990).

Examples of Foods which Contain The Various Classes of Goitrogens

Sulfurated Organics

Studies have shown that staple foods in some third world countries such as cassava, maize, bamboo shoots, sweet potatoes, lima beans, and some millets may contain cyanogenic glucosides (thiocyanate precursors) capable of liberating large quantities of cyanide by hydrolysis. After their ingestion, these glucosides can be readily converted to thiocyanate (SCN) by a widespread tissue enzyme (Ermans, et al, 1980). In the human liver, cyanide is metabolized by the enzyme rhodanase in the presence of thiosulphate into thiocyanate, which is a goitrogen (see Fig. 4).

Fig 4: The Metabolic Disposal of Inorganic Cyanide



Source: Montgomery, 1973.

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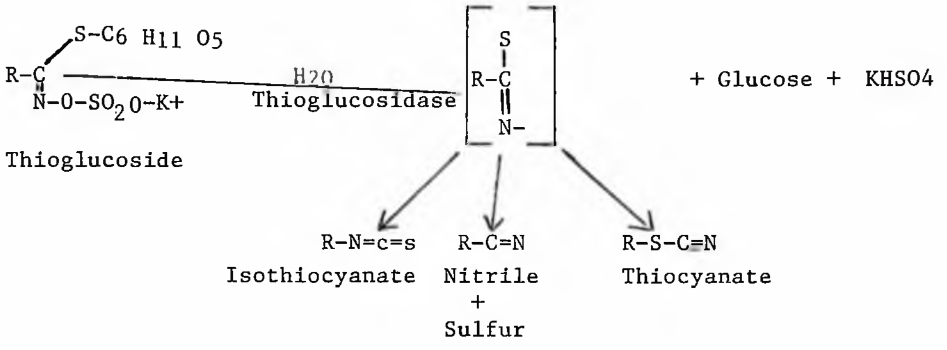
Thioglucosides undergo a loosen re-arrangement to form isothiocyanate derivatives and in some instances thiocyanate (Fig. 5). Therefore, the amount of thioyanate in the urine is a good indicator of the presence of thioglycosides in food.

Fig 5: Thioglycoside Chemistry



Source: Van Etten, 1973

Only under conditions of moderate to severe iodine deficiency is SCN a strong goitrogen.

During the past 30 years, thiocyanates and isothiocyanates have been shown as the principal goitrogens in cruciferae family, genus Brassica (Van Etten et al, 1973). The potent anti thyroid compound "goitrin" an aglucone from the thioglycoside progoitrin, was isolated from yellow turnips and from Brassica seeds (Gaitan, 1990).

The cyanogenic glucoside of cassava and lima beans is also known as Linamarin and considered as a beta glucoside of acetone cyanohydrin which is then split by hydroxynitrilelyase into HCN and acetone (Fig. 6).

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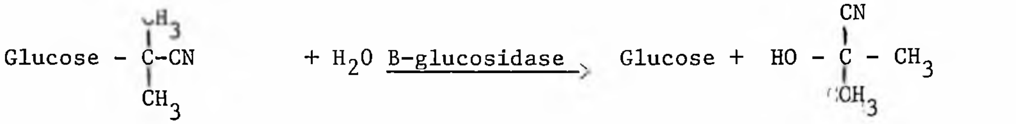
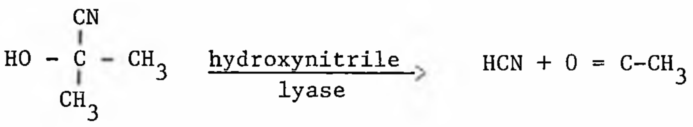
Figure 6: Linamarin and its hydrolysis products.



Acetone cyanohydrin

Linamarin



Acetone cyanohydrin Acetone

Scource : Montgomery, 1973

Both enzymes are in the plant tissues and are released when the cells are broken. No free HCN is readily ever present in these plants and vegetables until the glycosides are broken. Lima beans seed of different varieties may release 10-30mg HCN per 100g seed while fresh cassava releases 38mg per 100g. Cassava is however processed reducing the cyanide content to 1-6mg per 100g in different preparations. Consumption of unfermented cassava is suspected to contribute to the goitre problem in Eastern Nigeria (Ekpechi, 1973), and myxedematous endemic cretinism (1-7%) in a population of 1.5-20 million people in the northern part of Idjwi Island and Ubanga, Zaire (Matovinovic, 1983). Glycosides occur in the inedible portions of the foods mentioned, with the exception of cassava and therefore do not pose much threat. However, with cassava, the glycosides occur in the edible portion (Van Etten et al 1973).

Another form of goitrogen is known as goitrin. Its anti-thyroid effect cannot be counteracted by dietary iodine. These are derived from (R) 2-hydroxy-3-butenyl-glycosinolate present in cabbage, cauliflower, brussels sprouts, broccoli, kale, kohlrabi, turnips, rutabaga, rapeseed, mustard and crambe. These vegetables were shown to be high in thiocyanate, isothiocyanate and goitrin (Van Etten, 1973).

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Apart from the foods mentioned above, there have been several goitre endemias attributed to these sulfurated organics in foodstuffs (Delange et al, 1983). Two goitre endemias have been ascribed to the presence of these goitrogenic substances in milk. One was in Tasmania, where a seasonal variation in goitre prevalence in school children was noted in spite of adequate iodine intake, and in which an isothiocyanate, cheilorine, was suspected as the principal goitrogen (Clements, 1968). The other occurred in Finland, where goitrin present in cow's milk from the region of endemic goitre was considered as the causative factor. Rats fed for 1-2 years on milk produced in districts with endemic goitre developed thyroid glands almost twice as large as those in control rats given milk from non-goitrous districts (Gaitan, 1982). The concentration of 1,5, Vinyl-2-thio-oxazolidone (goitrin) in the range of 35-100μg/l in milk specimens from goitre districts, exceed the level necessary to explain the goitrogenic effect of this milk when fed to rats in long-term experiments. Thus, the authors concluded that goitrin might well be responsible, at least in part, for the goitre endemia in those areas of Finland. On the other hand, available data from the Tasmanian endemia failed to establish the goitrogenic properties of milk (Gaitan, 1982).

In Idjwi Island (Kivu Lake) and the Ubangi area in Central Africa, as many as 60% of the population are affected by goitre. Studies have shown that cassava, a staple food in these areas, has definite anti thyroid effects in humans and experimental animals. Thus daily consumption of some types of cassava in the presence of severe iodine deficiency, is thought to be the causative factor of endemic goitre and cretinism in these areas of Zaire (Delange et al, 1971).

The Effect of Mineral Elements In
The Incidence of Goitre

Cobalt and also manganese, have been reported to be necessary for the synthesis of the thyroid hormone in rats. The addition of physiological doses of colbat to a diet which was not naturally high in iodine or cobalt did not affect the weight of the gland, but caused definite histological changes, including an increase in the height of the epithelial cells and a decrease in the size of the follicles. It was concluded that the appearance of endemic disturbances of thyroid gland function in people inhabiting biogeochemical provinces with a low iodine and a low cobalt content depend not only on the level of Iodine and cobalt, but also the ratio of these elements in the environment. Other workers in the Soviet Union (Kovalsky,1970), have observed an inverse relationship between the cobalt levels in the foods, water, and soils in certain areas and the incidence of goitre in man and farm animals. A possible relationship between these warrants investigation in other areas and further critical examination of the suggestive cobalt iodine interaction in animals is desirable (Hegsted et al, 1976).

Fluoride:

The role of fluoride in goitrogenesis is controversial in both experimental as well as epidemiological studies (Koutras, 1980). It has been suggested as an etiological factor in South Africa, Tanzania, and Kenya. However, fluorosis and endemic goitre do not co-exist in Algeria or Nigeria.

Calcium:

The goitrogenic action of calcium, on the other hand, has been established under experimental conditions. Although epidemiological data are conflicting, this problem can be reconciled if one assumes that the goitrogenic effect of high calcium intake is unmasked only in presence of iodine deficiency. Some evidence of high calcium concentrations in water has been reported in Algeria, Egypt, Sudan and Zambia (Osman and Fattah, 1981).

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Disulfides:

Small aliphatic disulfides, the major component of onion and garlic have een shown to exert marked anti thyroid activity in the rat, and been incriminated y Abdou et al (1971) as a causative factor in Egypt. These foods, used argely in North African diets are consumed in both cooked and raw forms.

Disulfides are also present in high concentration (0.3-0.5g/L) in aqueous ffluents from coal - conversion processes. Disulfides have also been identified s water contaminants in the United States in water supplying a Columbian district ith endemic goitre (Gaitan, 1990). The most frequently isolated compounds n the United States are dimethyl, diethyl and diphenyl disulfides.

Iodine:

An excessive intake of iodine, arbitrarily defined as 2mg or more per day, nhibits proteolysis and release of thyroidal hormones and eventually produces iodide goitre" and hypothyroidism. Sustained ingestion of seaweeds (Kelp) ich in iodine causes "endemic coast goitre" as described among natives in okkaido, Japan (Suzuki, 1980). Suzuki reported that goitre prevalence in 8077 chool children in the coastal districts of Hidaka and on the island Rishiri s 9.0% and 2.6% respectively. In 3,400 school children in Sapporo, an inland own, it was only 1.3%. The population of seaweed fishermen of Hidaka (Hokkaido) d Rishiri consumed 10-50g of dry seaweed, mostly in soup while Kelp was not ncluded in the diet of the people of Sapporo, a town far from the coast. The dine content of several varieties of Kelp was between 0.8 and 4.5g/kg of the ied plant, about 60% of which was in the form of iodide. A bowl of seaweed up contained 80-200mg iodide, but the consumption was on an intermittent basis, pending on the surplus of Kelp unsold at the market place. Goitre was more equent in girls at puberty, and it was also more common in some families, ggesting a possible goitrogenic influence of additional factors.

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Lithium:

Studies in Venezuela documented higher lithium (Li^+) concentration in the water supply of a high incidence endemic goitre locality than in nearby non-endemic communities. Experimental observations indicated that Li^+ at those concentrations can be goitrogenic, but this effect is conditioned by dietary protein and iodine intake. It is accepted that Li^+ is goitrogenic, as demonstrated by development of goitre in Lithium-treated manic patients. Li^+ readily crosses the placenta with possible adverse effects on fetal thyroid function. Thus, an assessment of Li^+ intake should be part of studies on environmental goitrogenesis (Gaitan, 1990).

Flavonoids:

Flavonoids are polyhydroxy phenolic compounds that usually exist in plants as complex glycoside polymers. Following ingestion by mammals, flavonoid glycosides are hydrolyzed by intestinal microbial glycosidases to flavonoid aglycones which may be absorbed and undergo metabolism by mammalian tissues or be further metabolized by intestinal micro-organisms to undergo B-ring hydroxylation and middle ring fission with production of various metabolic compounds which include phenolic acid, phloroglucinol and gallic acid (Gaitan, 1988). Each metabolic step is characterized by marked increases in anti thyroid effects. For instance, flavonoid glycosides are 0.2 to 2 times as potent inhibitors of thyroid peroxidase (TPO) as propylthiouracil (PTU), while their corresponding aglycones are 0.5 to 14 times as potent, and the middle ring fission metabolite, phloroglucinol, 38 times more potent.

Flavonoids are important stable organic constituents of a wide variety of plants, including millet, sorghum, beans and groundnut etc. (Hulse, 1980). Epidemiological observations indicate that Pearl millet (Pennisetum americanum (L) Leeke) may be a factor contributing to the high incidence of goitre in rural areas of the semi-arid tropics, an ecological zone that almost circles the earth.

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Studies demonstrate that a diet comprised largely of millet is goitrogenic in the rat, and effect that is not overcome by high iodine intake. It suggests the activity of the type of goitrogen known as a goitrin. Heating and storage, akin to the manner in which millet is used as a food, increase the antithyroid activity of millet. Pennisetum millet is very rich in C-glycosyl flavones (C-GF). The C-GF glycosylvitexin, glycosyl rientin and vitexin, which constitute the largest proportion of the phenolic compounds in millet, all possess intrinsic antithyroid activity and appear, therefore, to be goitrogens in millet. Thiocyanate is also present in millet, and its antithyroid effects are additive to those of the C-GF (Gaitan, 1990). Thus, consumption of millet, together with iodine deficiency and various degrees of protein-calorie malnutrition, may contribute to the high incidence of goitre and attending morbidity in some areas of the semi-arid tropics.

Water Borne Goitrogens

Water borne goitrogens have also been known to cause goitre in parts of Latin America, Algeria, Sudan, and Egypt (Benmiloud, 1982). Polluted drinking water is common in these isolated areas. Bacteriological analyses done in these countries have revealed the presence of Clostridium perfringens and Escherichia Coli, both of which could be goitrogenic. They act either through production of myrosinase (Gaitan, 1980), which converts progoitrin into goitrin, or production of a substance that has an effect similar to that of T.S.H. (Benmiloud, 1982).

In bacteriological studies of some villages in Greece, the drinking water in villages with high prevalence of goitre was polluted with E. Coli and Coli-like substances significantly more often than water from non-goitrous localities (Malamos et al, 1971). A similar relationship had been demonstrated previously by Vought et al (1967) in Richmond Country, Virginia, U.S.A., where goitre exists despite adequate iodine supplementation. Vought et al (1974) also showed antithyroid activity in culture of E-Coli isolated from a polluted

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system in an area of high endemia. A class I-type anti thyroid activity reflected as reduced uptake of ^{131}I by the rat thyroid was present in the $5x10^4$ to $10x10^4$ molecular weight fraction of the cell-free extract of the E-Coli. More recent studies (Koutras, 1980, Gaitan, 1980) in endemic and non-endemic areas of Greece showed that concentrations of both E. Coli antibodies and Ig G were higher in the goitrous population than in the non-goitrous population of the endemic area, and that IgG concentrations were higher in the endemic area, where drinking water was subject to pollution, than in the non-endemic area, which had a non-polluted water supply.

Previous epidemiological studies have shown a significant statistical correlation ($p< 0.005$ to $p< 0.0005$) between goitre prevalence and rock types in watersheds supplying 37 localities in Western Colombia. This correlation accounted for 57% of the variation in goitre prevalence, and it was hypothesized that bacterial contamination of water supplies could be one factor involved in the remaining 43%. Therefore, bacteriological studies were performed to incorporate this variable into the statistical model in 34 of the 37 localities previously surveyed (Gaitan et al, 1980). Only two variables demonstrated significant relationships with goitre prevalence. The overall concentration of bacteria in the pipeline system (associated with increased goitre prevalance ($p< 0.005$) and K. pneumoniae in the water source (associated with decreased goitre prevalence, $p< 0.001$). A model fitted with the geological ($p< 0.005$) and bacteriological variables ($p< 0.005$) accounted for 80% of the variability in goitre prevalence.

Phtalates are ubiquitous in their distribution have been frequently identified as water pollutants (Gaitan, 1986). Dibutyl and dioctyl have been repeatedly isolated from the goitrogenic well water supplying the high endemic goitre district of Candelaria Town in Western Columbia (Gaitan, 1983). Phtalate esters were also found in water supplies from the coal - rich Appalachian goitre area of eastern Kentucky in the United States and from other goitre localities in Western Columbia (Gaitan, 1983). Commonly, phtalates result from industrial pollution or artificial contamination, but phtalates also occur naturally in plants, shale, crude oil, petroleum and as emission from coal - liquefaction plants (Gaitan, 1986).

PAHs (Polycyclic Aromatic Hydrocarbons) have been found repeatedly in food, domestic water supplies, and in industrial and municipal waste effluents. They also occur naturally in coal, soils, ground water and surface water, and in their sediments and biota. One of the most potent of the carcinogenic PAH compounds, 3,4, benzpyrene (BAP), is widely distributed and as in the case of other PAHs, is not efficiently removed by conventional water treatment processes (Gaitan, 1990).

The PAH carcinogens, BAP and 3 - methylcolanthrene (MCA), accelerate T4, metabolism and excretion of T4 glucuronide, resulting in decreased serum T4 concentrations, activation of pituitary-thyrotropin-thyroid axis and eventually in goitre formation (Gaitan, 1990).

2.6 Nutritional Status and Goitre

Nutrition may also play a role in goitrogenesis (i.e development of goitre), through protein-energy malnutrition and Vitamin A deficiency. These may have secondary effects on iodine nutritional status.

Protein-energy malnutrition, occurring as marasmus, kwarshiorkor, marasmic-kwarshiorkor, or adult protein malnutrition, is commonly found in less developed countries with goitre endemias. Iodine malabsorption may be associated with protein-energy malnutrition (PEM) and thus contribute to endemic goitre (Ingenbleek and Beckers, 1973), particularly where iodine intake is limited. PEM may also interfere with iodide uptake by the thyroid (Gaitan et al, 1983), and with thyroglobulin formation (Ingenbleek and Devisscher, 1979). On the other hand, very severe P.E.M. in some areas with extremely low iodine intakes may impair the ability to develop goitre with a resultant mild prevalence rate for this condition (Delange, 1986).

Another nutritional factor that may be involved in the goitrogenic action of cassava in humans is the protein-energy intake, since the endogenous conversion of cyanide (HCN) into SCN, thiocyanate requires sulfur amino acids. Experiments with pigs have indicated that protein deficiency protects against the anti thyroid action of cassava by reducing the quantity of SCN arising from HCN. It has also been shown experimentally that the presence of protein energy deficiency impaires the development of goitre due to a goitrogenic diet (Delange et al, 1982).

Low blood retinol levels, an indicator of Vitamin A status, are correlated with higher goitre incidence (Ingenbleek et al, 1979). Studies in Senegal have shown that concomittant Vitamin A deficiency (ie. presence of Vitamin A deficiency as a secondary factor) increases the severity of iodine deficiency (Ingenbleek et al, 1986). The mechanism suggested for this is that decreased retinol could reduce thyroid hormone synthesis by defective glycosylation of thyroglobulin and its subsequent iodation.

2.7 Consequences of Iodine Deficiency Disorders

Direct complications of endemic goitre are mechanical complications which are pressure symptoms. These are either from the trachea or from the esophagus. From the trachea, there is respiratory difficulty, progressing to dyspnoea (difficult or laboured breathing) and in rare cases to death from suffocation. X-rays show deviation of the trachea and narrowing of its lumen. From the esophagus, there may be difficulty in swallowing (Dunn, 1990, Koutras, 1990b).

Hypothyroidism - means that the body does not receive enough thyroid hormone. Hypothyroidism is detected by low levels of serum T4, relatively normal T3 and increased TSH Levels. Hypothyroidism produces sluggishness,

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sleepiness, dry skin, cold intolerance, and constipation. In neonates, hypothyroidism results in mental retardation and impaired growth. It may contribute to endemic cretinism and other associated disorders (Dunn, 1990).

Endemic Cretinism

Endemic cretinism occurs only in areas of severe endemic goitre, and its pathogenesis is not well understood. However, the condition is defined by three major features according to the Pan American Health Organization.

(1) Epidemiology: It is associated with endemic goitre and severe iodine deficiency.

(2) Clinical Manifestations: These comprise mental deficiency together with either;

  (a) A predominant neurological syndrome including defects of hearing and speech, squint, and characteristic disorders of stance and gait of varying degrees or;

  (b) Predominant hypothyroidism and stunted growth.

Although in some regions, one of the two types may predominate, in others a combination of the two syndromes will occur.

(3) Prevention: In areas where adequate correction of iodine deficiency has been achieved, endemic cretinism has been prevented (Delange, 1990).

There are three forms of endemic cretinism. These are:

  (a) Nervous or Neurological endemic cretinism

  (b) Mixed nervous - Myxedematous

  (c) Myxedematous cretinism

Neurological Endemic Cretinism

This is the commonest form of endemic cretinism. Its symptoms include principally impairment of intellectual function, of hearing and speech and of motoricity. Total deafness is accompanied by total mutism.

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The two main features of the motor disorder are proximal spasticity and regidity, both more marked in the lower extremities. The proximal spasticity is manifested by increased knee jerks and adductor jerks. Standing posture and gait are characterized by adductor thightness, partial flexion at hips and knees, occassionally wide-based; in severest cases, walking or even standing is impossible (Delange,1990).

The prevalence of goitre in these cretins is as high as in the non cretinous population of the area and they are clinically euthyroid. However, these individuals have higher serum TSH levels and lower levels of serum T4 and thyroidal uptake of radio-iodine than do non cretinous clinically euthyroid adults from the same endemic area.

Myxedematous endemic Cretinism

These cretins show less retardation than the neurological cretins and are often capable of performing simple manual tasks. All exhibit major clinical symptoms of longstanding hypothyroidism, dwarfism, myxedema, dry skin, sparseness of hair and nails, retarded sexual development, and retarded maturation of body proportions.

The prevalence of goitre in the myxedematous cretins is much lower than in the non cretinous population (Matovonic, 1983).

(3) Mixed Neurological and Myxedematous

This is characterized by dominant neurological disorders or dominant hypothyroidism in the same individual.

Reproductive Failure

Women in severely iodine deficient areas have more miscarriages, still births, and other problems of pregnancy and reproduction than do iodine - sufficient women. Continued miscarriages and fetal wastage decrease the fertility of a population and endanger the health of women (Dunn, 1990).

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Childhood Mortality

Iodine deficiency kills children. Their defenses against infections and other nutritional problems are lower than those of children in iodine-sufficient areas.

Socio-Economic Retardation

Iodine deficiency also affects the socio-economic development of a community in two ways. First, the people are mentally slower and less vigorous. They are harder to educate and harder to motivate, and thus they are less productive in their work. Scarce community resources may have to be diverted to support such persons.

Secondly, in most of these areas, agriculture is the most important economic activity and domestic animals suffer from iodine deficiency in much the same way that people do. Thus domestic animals will be smaller and produce less meat, eggs and wool. They also have more abortions and are frequently sterile (Dunn et al, 1990).

2.8 IODINE DEFICIENCY IN AFRICA AND GHANA

A look at a map of Africa (Fig.7) shows that with the exception of a few Sahelian countries such as Mauritania and Niger and a few West African coastal countries such as Benin, Gabon and Togo, goitre endemia is present everywhere. The incidence of goitre varies among countries and regions within the same country (Table 2) severe endemias are found in Zaire and some of its neighbours, e.g. Angola, Chad, and Rwanda. Similarly, 20% (4 million) of the population of Algeria has a goitre incidence varying from 10-80%. Morocco has a smaller endemic area, but the incidence of goitre is quite high (Benmiloud et al, 1982).

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Fig. 7 Distribution of endemic goitre in Africa.

SOURCE : Benmiloud et al, 1982

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Table 2: Incidence of Goitre in Africa

Maximum Percentage	Affected Countries
< 90	Zaire, Angola, Chad, Uganda, Sudan
< 80	Kenya, Sierra Leone, Algeria, Morocco, Tanzania, Mali, Upper Volta (Burkina Faso)
< 60	Zambia, Egypt, Tunisia, Nigeria, Guinea
< 50	Malagasy Republic, Central Africa Republic Senegal, Gambia
< 40	Rwanda, Zimbabwe

Source: Benmiloud et al, 1982

Although the areas involved are frequently found in the highlands or mountains, this is not always the case. In Senegal, Egypt, Zaire, and Algeria goitrous areas can also be found at low altitudes. Although normally occurring inland, endemia can also be found on the seashore in Algeria, Tanzania, Sudan and Senegal.

Iodine Deficiency in Ghana

Figure 8 shows the endemic goitre areas in Ghana. In Ghana, endemic goitre has been reported from several places including Axim, (a coastal town), Brong-Ahafo, Mampong in Ashanti and the Upper Region (Baddoo, 1974). High incidences of goitre were reported from Sandema, Nandom and Bawku in the Upper Region. At a clinic in Zebilla, 25% of women in attendance had goitre. These goitres were reported to have started with the first pregnancy, receded between the pregnancies and recurred during subsequent pregnancies. In a 1961/62 National Nutrition Survey of Ghana, the nutrition of adults in the Northern and Upper Regions of Ghana was studied. In each of three towns - Binduri, Yarogo and Jirapa, goitre was found to be endemic. In each place, percentage of goitres were higher among women than men (National Food and Nutrition Board, Ghana 1961).

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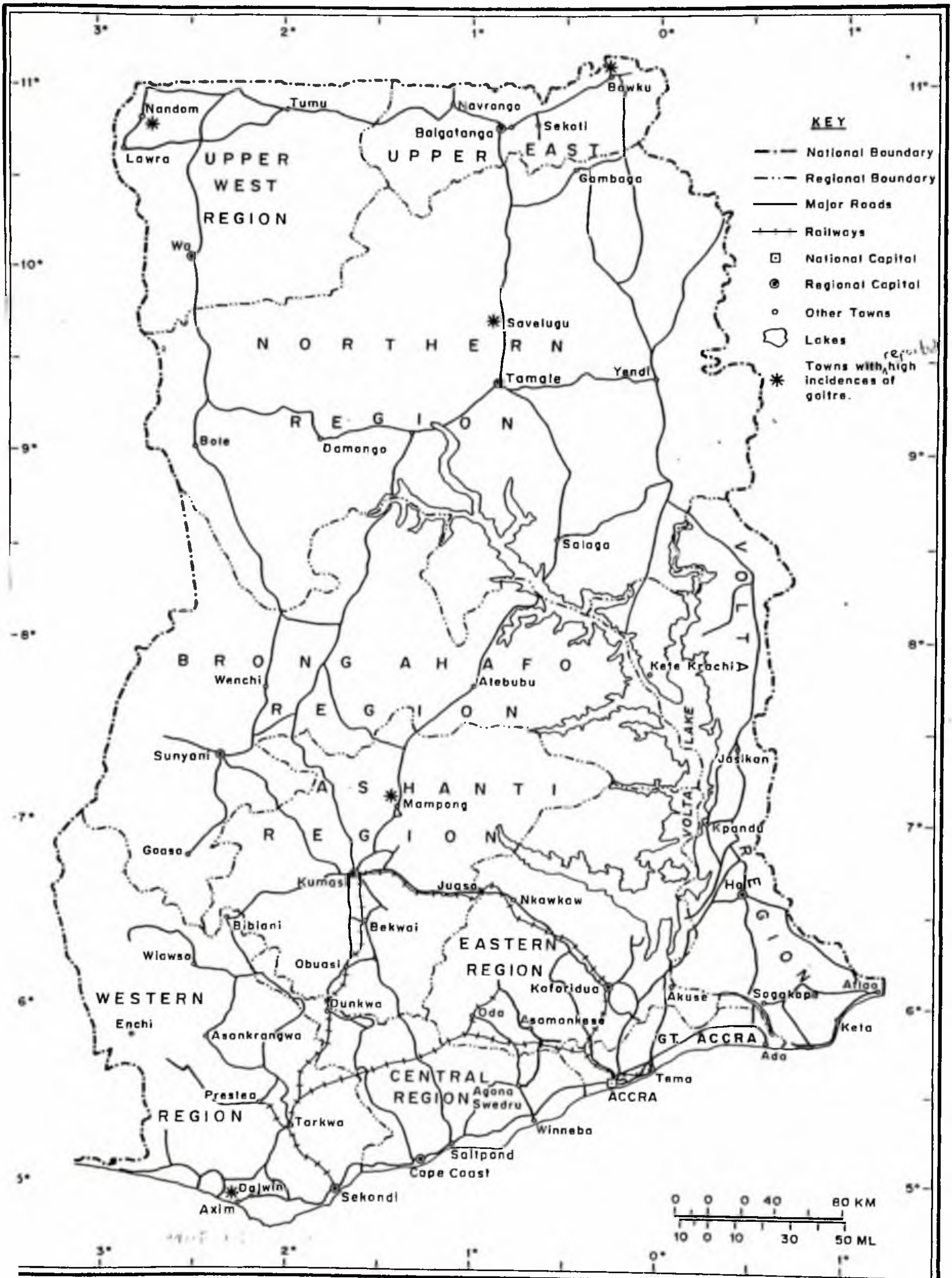
Fig. 8. MAP OF GHANA SHOWING THE MAJOR ROAD NETWORK AND THE RAILWAY SYSTEM



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Incidences of goitre have been reported recently in the Volta Region. Kokofu in Ashanti and more areas of the Northern Savannah of Ghana (Asibey Berko, 1990).

2.9 Summary

Although the primodial role of iodine deficiency as environmental determinant in the development of endemic goitre and attending morbidity is firmly established, there is epidemiological and experimental evidence indicating that concomitant exposure to other naturally-occurring antithyroid agents, magnify the size of the goitre endemia and may affect as well as the clinical expression of the associated disorders. Furthermore, supplementation of iodine not always results in complete eradication of goitre leaving in some well defined instances, clusters or geographical "pockets" where the condition remains endemic.

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CHAPTER THREE

MATERIALS AND METHODS

3.1 Geographic Areas of Study

The research was conducted in three areas of Ghana. These were Axim in the South-Western, Sekoti in the Upper-Eastern and Accra, in the Greater Accra Region. These towns especially Axim and Sekoti were selected based on prior knowledge that goitre is prevelent in these areas (Asibey-Berko, 1990, 1991, Commey, 1972).

Axim (Appendix 1) is a coastal town and originally a fishing village. It lies close to the sea on flat and undulating sandy land at an altitude of 0-5ft above sea level with an annual average rainfall of 151.77mm. Axim being the district capital of the Nzema East area, is the principal administrative, educational and health centre for the whole district. According to the chief (personal communication), over 90% of the male population are engaged in fishing and farming, while the majority of the female population are involved in coconut oil production. The main produce food crop is cassava.

Sekoti (Appendix II) is about 36km from the district and regional capital of Upper East, Bolgatanga on the Bolgatanga-Bawku road. It comprises seven villages, at an altitude of 820-960ft above sea level. The average annual rainfall is about 79.63mm. Their settlements consist of households which are scattered over a large area and widely separated from each other. The houses are built with earth consisting of round hut with a conical roof arranged in circles within an enclosing wall to form a compound household. Apart from the people, the household contains a poultry yard, a grain store and a piece of land where cattle and goats are kept for the night.

The main occupation of the population is farming and rearing of cattles and goats, as well as guinea fowls and chickens. The crops grown in the area include rice, millet, guinea corn, beans and groundnuts.

Sekoti has a Health Centre which is opened once a week to cater for the

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health needs of the people and those of the surrounding villages.

Accra (Appendix III) is the country's political and administrative capital and also the headquarters of numerous institutions and organizations. It is the educational, commercial and entertainment centre for the country. It is a major industrial centre, it produces a wider range of medical facilities than any other town in the country. It is a major communication centre and offers more opportunities for employment than any other urban settlement in the country. Accra is at an altitude of about 50-250ft and has an average annual rainfall of 56.73mm.

3.2 The Subjects

The subjects involved in the study were Primary/Junior Secondary School students aged between 10 and 14 years inclusive. School children were used because they congregate in one place and are easily accessible. They also are representative of the current state of iodine deficiency, and are a major priority group for prompt correction of iodine deficiency (Dunn, 1990). The age group was limited to 10-14 years because it has been found that the goitre is palpable at this time, when growth rate is very rapid.

In each of the study areas, a minimum of 200 (two hundred) subjects were surveyed. Four schools were randomly selected and 50 pupils in each school selected using systematic random sampling (FAO, 1990) to take part in the goitre/cretinism survey and anthropometry. However, in Sekoti, there were only two schools, one primary and the other Primary/Junior Secondary school. The population for the 10-14 years group did not reach the two hundred needed for the goitre/cretinism survey.

Therefore, children from the community were also randomly selected to make up the number.

A sub-sample of 14 pupils in each school were further systematically randomly sampled for urinary thiocyanate, urinary iodine, the "24-hour dietary recall" and the food habits of the students.

3.3 Epidemiological Data

Goitre Survey:

A recommended modification (Hetzel, 1988) of the technique suggested by Perez et al (1960) was used for the goitre survey.

Physical Examination of the Subject

The detection of goitre was done by palpation. The children were examined while standing with the head and neck in a vertical position. The thyroid area was examined and without delay the tips of the four fingers from both hands were used simultaneously to examine very gently the full extent of the lobes of the isthmus. The children were asked to relax the neck muscles by throwing their heads slightly backwards.

Since the thyroid follows the movements of the larnyx during swallowing, the children were given a glass of water to swallow to differentiate the goitre from other neck masses.

Classification of the Goitre Size (Appendix IV)

Delange et al (1986) recommend the following classification of thyroid size:

Size:

Stage 0 : No goitre

State IA : Goitre detectable by palpation and not visible even when the neck is fully extended. Thyroid lobes larger than ends of thumbs.

Stage IB : Goitre palpable and visible only when the neck is fully extended. This stage also includes nodular glands, even if not goitrous.

Stage 2 : Goitre visible with the neck in normal position, palpation is not needed for diagnosis.

Stage 3 : Very large goitre that can be recognized at about 10 meters.

Cretinism Survey

A questionnaire (Appendix V) was used to determine the cretinism rate. The presence of mental retardation were looked and inquired about. Defects of hearing, speech, presence of squint, disorders of stance and gait were recorded.

Anthropometric Data

(a) Weight

The subject without any footwear and in light clothes was made to stand on the centre of the Seltzer bathroom scale, looking straight ahead with arms hanging on the sides. The weight was then taken in kilograms.

(b) Height

The height of the subjects were measured with a microtoise. The subjects, without shoes, were made to stand straight against a wall and the height measured with a microtoise in centimetres.

Urinary Iodine Excretion

Urinary iodine excretion was determined using the method of Sandell and Kolthoff (1937) as described by Karmarkar et al (1986).

Casual urine samples were collected into 25-30ml **sterile** bottles and preserved with 0.1ml Acetic acid per 25ml urine. The urines were stored frozen as soon as possible and subjected to dry ashing for two hours at 600°C, in the presence of potassium carbonate. Iodide present in the ash was measured by Ceric arsenite system using Schimazu 120 spectrophotometer.

(a) Water for Analysis

Double distilled de-ionized water was collected from Noguchi Memorial Institute for Medical Research and de-ionized water from Chemistry Department of the University of Ghana to prepare any reagents needed in the urinary iodine assay.

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(b) Cleaning of Glassware

All glassware used were washed and first boiled in 5N Conc. HNO_3 for two hours and soaked overnight. The glassware were then first rinsed four times with tapwater, once with distilled water, twice with deionized water and finally with double distilled deionized water. Drying was carried out in air oven.

Measurement of Concentration of Iodine

In studies on iodine, some authors have used the iodine in μg/creatinine in g ratio on spot samples and very rarely on 24-hour specimens. However, other studies have shown that the iodine status was much better reflected by μg iodine/dl concentration than by the iodine/creatinine ratio (Bourdoux, 1988). Therefore, it is suggested that iodine concentrations in spot sample expressed as microgram iodine per 100ml urine instead of the iodine/creatinine ratio should be used for assessing the iodine nutritional status (Dunn, 1990).

While subjects will vary in the concentration of their urinary iodine depending upon how much liquid they have been drinking, this variation will tend to even out among samples from many subjects. For this reason, it is recommended that samples be obtained from at least 40 subjects to determine the mean concentration of urinary iodine in a given region (Dunn, 1990, Bourdoux, 1988).

Thus in the study, iodine concentration was measured as microgram per 100ml urine. The concentration of each samples was calculated by using regression equation. In each batch of analysis, several standards were prepared including a quality control sample and the absorbances used for the regression equation. All analyses were done in duplicates.

Ashing of Samples

The dried urine samples in the test-tube were ashed at 600°C for two hours. During this period the furnace door was opened for 15 seconds at approximately 30 minutes intervals to renew the air in the furnace.

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Sample used for Quality Control

The quality control sample was prepared from a pupil's urine in Accra. The concentration of iodine in the urine was measured using the method by Karmarkar (1986). The urine was then divided into small (0.5ml) quantities and stored frozen.

The purpose of the Quality control was to ensure that reliable and acceptable results were obtained from the assays. The repeated analysis of the control should give results within the "acceptable limits of error".

Percent Recovery Experiment

A recovery experiment was done to check the accuracy of the method by Karmarkar (1986). In the experiment, a test sample was prepared by adding a standard solution of the analyte to an aliquot of a urine sample. A baseline sample was prepared by similarly adding solvent to a second aliquot of the urine sample. The two samples were then analyzed by the test method. The difference between the measured values of the two samples gave the amount recovered (Westgard, 1978). It is recommended that the volume of standard added to original sample should not be more than ten percent and that this be carried out by adding 0.1ml of standard to 1.0ml of a patient sample (Westgard, 1978).

A. Sample Preparation for Percent Recovery Experiment

A known concentration of standard Potassium Iodate was added to the aliquot of the same urine as follows:

Sample (1) = baseline sample consisted of 1ml of urine +0.1ml water.

(2) = 1ml of urine + 0.1ml $1\mu gI_2/dL$

(3) = 1ml of urine + 0.1ml $25\mu gI_2/dL$

(4) = 1ml of urine + 0.1ml $50\mu gI_2/dL$

B. Formulae for Calculating for Percent Recovery Experiment

$$\text{Conc. Added} = \text{Standard Conc.} \times \frac{\text{ml Standard}}{\text{ml urine} + \text{ml Standard}}$$

$$\text{Conc. Recovered} = \text{Conc. Measured}_{(test)} - \text{Conc. Measured}_{(baseline)}.$$

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$$\text{Recovery} = \frac{\text{Conc. Recovered}}{\text{Conc. Added}} \times 100\%$$

The recovery of iodine was found to range from 83.3% to 95.59%. The sensitivity of the assay was found to be less than 1μg/dL. Intra-assay coefficients of variation were from 0.19 to 1.5%.

Classification of Severity of Iodine Deficiency

The severity of iodine deficiency was classified as follows:

Grade I : Mild iodine deficiency:
There is an average of more than 5μg/dL in the urine. The thyroid hormone supply is adequate for normal physical and mental development.

Grade II : Moderate iodine deficiency, the average urinary excretion is between 2.0-3.5μg/dL. The secretion of thyroid hormones may not be adequate and these individuals are at risk of developing hypothyroidism but not overt cretinism.

Grade III : Severe iodine deficiency:
The average urinary iodine excretion is less than 2.0μg/dL. The population is at serious risk of cretinism (Dunn, 1990, Matovinovic, 1973).

Urinary Thiocyanate (SCN)

This was measured according to the procedure of Aldridge (1945). The concentration of urinary SCN was measured in mg/dL. Determinations were done in duplicates.

Dietary Assessment (Appendix VI)

The nutrient intake of the subjects were assessed using the "24-hour dietary recall". The subjects were asked to recall everything that they had eaten within the last 24-hours including breakfast, lunch, dinner and foods consumed in between meals, both in and outside the home. The subjects were asked

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to estimate the amount or size of food portions, using food portions obtainable from cooked vendors as reference. Samples of these foods were obtained from the place of purchase and weighed. The foods consumed were converted into the quantitative data of energy, protein and other nutrients using Food Composition Tables. The intakes were compared with FAO/WHO recommended daily intakes of nutrients (FAO/WHO, 1974, 1985).

A questionnaire (Appendix VII) was also used for a listing of staples, vegetables, seaweeds, and fish eaten by the people. Samples of the staples and fruits eaten in the Upper East Region, in particular Sekoti, were collected into polythene bags, stored and used for goitrogen analyses - that is HCN.

3.5 Determination of Cyanide Content of Food

The alkaline titration method by A.O.A.C. (1975) was used. About 20g of samples were used and determination done in duplicates. The cyanide content was expressed as mg HCN/Kg fresh weight.

3.6 Bacterial Analysis of Water

250ml of water was collected into sterile bottles from each source of drinking water at each locality for bacterial analysis. To reduce multiplication of bacteria, the samples were immediately placed on ice and refrigerated as soon as possible. The bacterial analyses were done at the Reference Laboratory at Korle Bu Teaching Hospital, Accra.

3.7 Statistical Analyses of Data

1. Anthropometric data were analysed using the National Centre for Health Statistics, U.S.A. recommended by W.H.O. for height and weight reference median value for age group 10-14 years.

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2. Dietary intake were analysed by the use of the FAO Food Composition tables for Africa (1968) together with published information by Watson (1971) Ankrah and Dovlo (1973) and Eyeson and Ankrah (1975).

3. Analysis of variance (ANOVA) was used to compare the means of the various variables in the three areas of study.

4. Walker-Ducan Adaptive procedure was used to compare the means where ANOVA was found to be significant.

5. The logistic multiple regression model was used to explore the possible relationship between the response variable (goitre) and the explanatory variables. This model was used because the outcome variable (goitre) is discrete taking on two or more possible values. That is the outcome variable is binary dichotomous.

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CHAPTER FOUR

R E S U L T S

.1 Epidemiological Data - Goitre and Cretinism Prevalence

The prevalences of goitre, and cretinism are compared in Tables 3 and 4.

TABLE 3 : PERCENT DISTRIBUTION OF GOITRE BY GRADE IN THE STUDY AREAS (NUMBER OF SUBJECTS IN PARENTHESIS)

	SURVEY AREA			TOTAL
	Sekoti	Axim	Accra	
Total No. Examined	249	220	210	679
% 1A	16.9 (42)	13.2 (29)	15.7 (33)	15.3 (104)
% 1B	37.3 (93)	3.2 (7)	4.8 (10)	16.2 (110)
% 2	2.0 (5)	0.9 (2)	0.0 (0)	1.0 (7)
% 3	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
% Visible goitre (grade 2-3)	2.0 (5)	0.9 (2)	0.0 (0)	1.0 (7)
% Total goitre (grade 1 -3)	56.2 (140)	17.3 (38)	20.5 (43)	32.5 (221)
% Normal (grade 0)	43.8 (109)	82.7 (182)	79.5 (167)	67.5 (458)
Distance from the Sea.	610km	100m	200m	
Altitude Above Sea Level.	820-960ft	0-50ft	50-250ft	

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TABLE 4 : PERCENT DISTRIBUTION OF GOITRE BY GRADE AMONG MALES IN THE STUDY AREA (NUMBER OF PUPILS IN PARENTHESIS)

	SURVEY AREA			TOTAL
	Sekoti	Axim	Accra	
Total No. Examined	159	113	99	371
% 1A	16.3 (26)	8.0 (9)	14.2 (16)	13.8 (51)
% 1B	32.1 (51)	0.9 (1)	1.0 (1)	14.3 (53)
% 2	1.3 (2)	0.0 (0)	0.0 (0)	0.5 (2)
% 3	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
% Visible goitre (grade 2-3)	1.3 (2)	0.0 (0)	0.0 (0)	0.5 (2)
% Total goitre (grade 1-3)	49.7 (79)	8.8 (10)	17.2 (17)	28.6 (106)
% Normal	50.3 (80)	91.4 (103)	82.8 (82)	71.4 (265)

Goitre examinations were performed on 679 school children aged between ten and fourteen years inclusive. There were 371 males and 308 females. Overall goitre for both sexes was 32.5%. Goitre was found more prevalent in females (37.3%) (table 5) than in males (28.6%) (table 4).

There were marked differences in goitre prevalences among the school children from different areas (Chi-square trend p<0.001). The mean prevalence of goitre was 17.3% in Axim, 20.5% in Accra and 56.2% in Sekoti where 2.0% of the children population studied had visible goitre (grade 2). Among the schools within each area, total goitre prevelance ranged from 8.2% to 21.6 in Axim, 16.4 to 27.6% in Accra and 50.4 to 64.0% in Sekoti (Appendix IX).

Endemic cretinism was not found in any of the areas studied. This may be probably due to the fact that parents will not normally send such children to the school. In fact in the community such persons are normally hidden (personal observations in Sekoti). (Table 3).

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Tables 4 and 5 show the percentage distribution of goitre by goitre grade and sex : ' › . Goitre grade 1A and 1B are known as invisible goitre, while goitre grade 2-3 are collectively called visible goitres. Total goitre is defined as the sum of invisible and visible goitres.

TABLE 5 : PERCENT DISTRIBUTION OF GOITRE BY GRADE AMONG FEMALES IN THE STUDY AREA (NUMBER OF PUPILS IN PARENTHESIS)

	SURVEY AREA			TOTAL
	Sekoti	Axim	Accra	
Total No. Examined	90	107	111	308
% 1A	17.8 (16)	18.7 (20)	15.3 (17)	17.2 (53)
% 1B	46.7 (42)	5.6 (6)	8.1 (9)	18.5 (57)
% 2	3.3 (3)	1.9 (2)	0.0 (0)	1.6 (5)
% 3	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
% Visible goitre (grade 2-3)	3.3 (3)	1.9 (2)	0.0 (0)	1.6 (5)
% Total goitre (grade 1-3)	67.8 (61)	26.2 (28)	23.4 (26)	37.3 (115)
% Normal	32.2 (29)	73.8 (79)	76.6 (85)	62.7 (193)

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Most goitre were classified as goitre Grade 1 with 1B predominating. In both Axim and Accra, goitre Grade 1A was more prevalent compared with goitre Grade 1B in Sekoti.

4.2 Anthropometric Data - Protein Energy Malnutrition Incidence

The nutritional status of the children assessed by means of body measurements of weights and heights compared with the U.S. National Centre for Health Statistics (NCHS) is shown in Table 6.

Table 6: Percentage Protein-Energy Malnutrition Among 10-14yrs School Children in the Study Areas (Number of Children in Parenthesis)

Weight For Height (Wasting)

Survey Area	Sex	No. Examined	% Moderately wasted (60-80%) Median		% Severely wasted <60% median		Total wasting <80% median	
Sekoti	Males	152	21.7	(33)	0	(0)	21.7	(33)
	Females	86	33.7	(29)	1.2	(1)	34.8	(30)
	Combined	238	26.1	(62)	0.4	(1)	26.5	(63)
Axim	Males	113	0	(0)	0	(0)	0	(0)
	Females	107	0	(0)	0	(0)	0	(0)
	Combined	220	0	(0)	0	(0)	0	(0)
Accra	Males	90	1.1	(1)	0	(0)	1.1	(1)
	Females	108	2.8	(3)	0	(0)	2.8	(3)
	Combined	198	2.0	(4)	0	(0)	2.0	(4)

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Wasting, defined as a low weight-for-height (<-2SD from the reference median value or <80% Median value) is an indication for acute (rather than chronic) malnutrition. Wasting was most frequent in Sekoti where 26.5% of the children studied were total wasted, while 26.1% were severely wasted. In Accra, only 2.0% of the children were found total wasted while no wasting was found among Axim's school children. Among the schools within each area, percent total wasting ranged from 15.2 to 25.0% in males in Sekoti while total wasting in the females ranged from 23.2% to 37.7%. In Accra only 3 out of 22 boys or 13.6% in Osu were wasted. One out of 22 boys in Madina was wasted. While wasting was not found among children in Nima Primary/JSS or Mamprobi (Appendix X).

HEIGHT-FOR-AGE (STUNTING)

TABLE 7 : PERCENTAGE PROTEIN-ENERGY MALNUTRITION AMONG 10-14 YEARS SCHOOL CHILDREN IN THE STUDY AREA (NUMBER OF CHILDREN IN PARENTHESIS)

Survey Area	Sex	No Examined	% Moderately Stunted 90-80% median value	% Severely Stunted <80% Median value	% Total Stunted <90% median value
Sekoti	Males	152	19.7 (30)	0 (0)	19.7 (30)
	Females	86	9.3 (8)	3.5 (3)	12.8 (11)
	Combined	238	16.0 (38)	1.3 (3)	17.2 (41)
Axim	Males	113	23.0 (26)	6.2 (7)	29.2 (33)
	Females	107	17.8 (19)	3.7 (4)	21.5 (23)
	Combined	220	20.5 (45)	5.0 (11)	25.5 (56)
Accra	Males	90	3.3 (3)	2.2 (2)	5.6 (5)
	Females	108	1.8 (2)	0.0 (0)	1.8 (2)
	Combined	198	2.5 (5)	1.0 (2)	3.5 (7)
Total	Males	355	16.6 (59)	2.5 (9)	19.1 (68)
	Females	301	9.6 (29)	2.3 (7)	12.0 (36)
	Combined	656	13.4 (88)	2.4 (16)	15.8 (104)

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Stunting due to chronic malnutrition (defined as <-2SD or <90% of median Height-for-age) was found highest among Axim School children, where 25.5% of the children studied were stunted. In Sekoti, 17.2% of the children were stunted compared with 3.5% in Accra. Among the schools within each area of study, Appendix XI shows that stunting ranged from 11.5 to 23.7% among males in Sekoti compared with 0-16.4% in females. In Axim, stunting ranged from 20.0 to 31.3% in males while 3.8 - 28.1% were found in females. In Accra, stunting in males ranged from 0- 13.6% as compared with 0-4.5% in females. The differences observed in degrees of stunting among males and females were highly significant (Chi-squared trend $p<0.05$).

The development with age of weight and height in the three areas of study is shown in Tables 8 and 9 and figures 9-12. Weight in both females and males were systematically lower in Sekoti and Axim than in Accra (Fig. 9 and 10). Analysis of variance showed significant differences($p<0.05$) in mean weight for age at all ages with the exception of the ten and eleven year olds in males. Mean height (Table 9 and Fig. 11 and 12) was also lower in Sekoti and Axim than in Accra in both males and females. All differences were also significant at $p<0.05$ by Analysis of variance at ages 11-14 in males and all the ages in females.

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Fig 9. Comparison of Median Body Weight as a function of Age in Males in Sekoti, Axim, and Accra

LEGEND

—·—·— SEKOTI

— — — AXIM

——— ACCRA

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Fig. 10. Comparison of Median Body Weight as a function of Age in Females in Sekoti, Axim, and Accra

LEGEND

—·—·— SEKOTI

— — — AXIM

——— ACCRA

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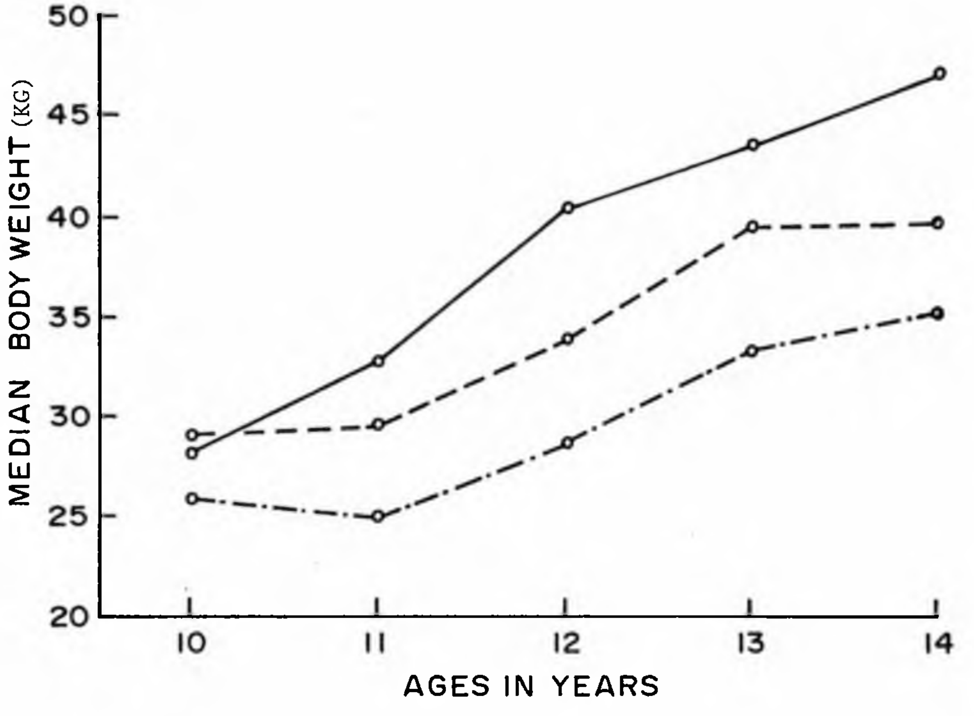

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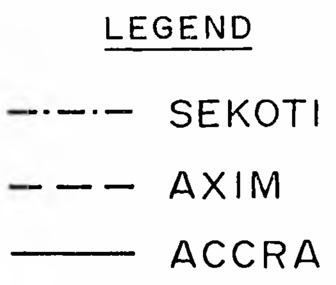
Fig 11. Comparison of Median Body Height as a function of Age in Males in Sekoti, Axim, and Accra.



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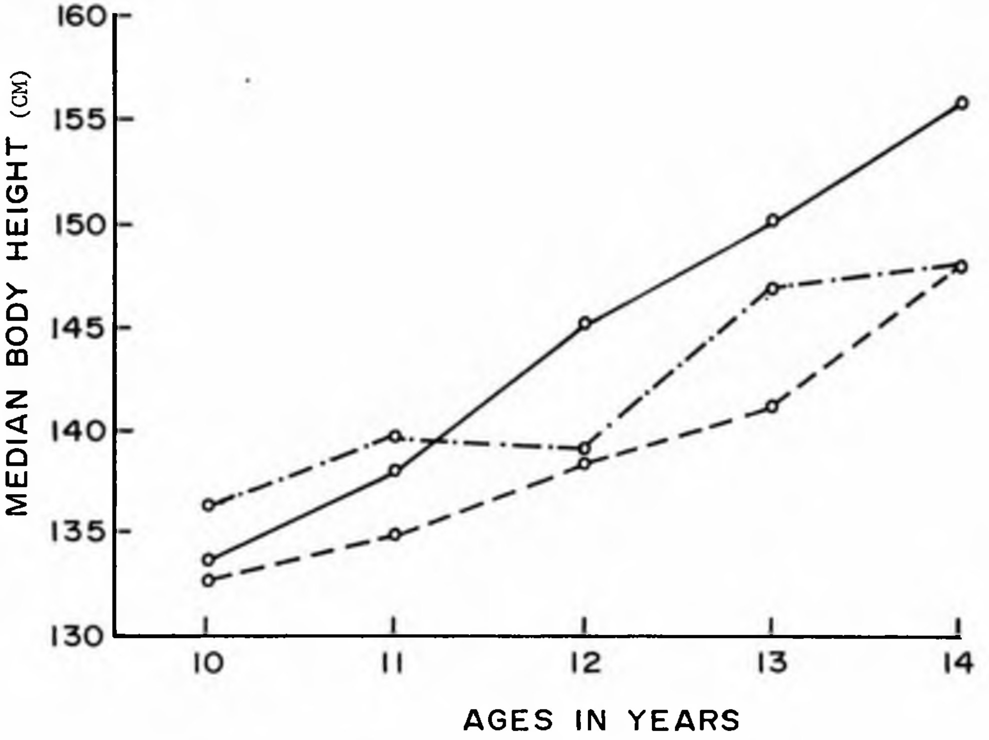

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Fig 12. Comparison of Median Body Height as a function of Age in Females in Sekoti, Axim, and Accra.

LEGEND

—·—·— SEKOTI

— — — AXIM

——— ACCRA

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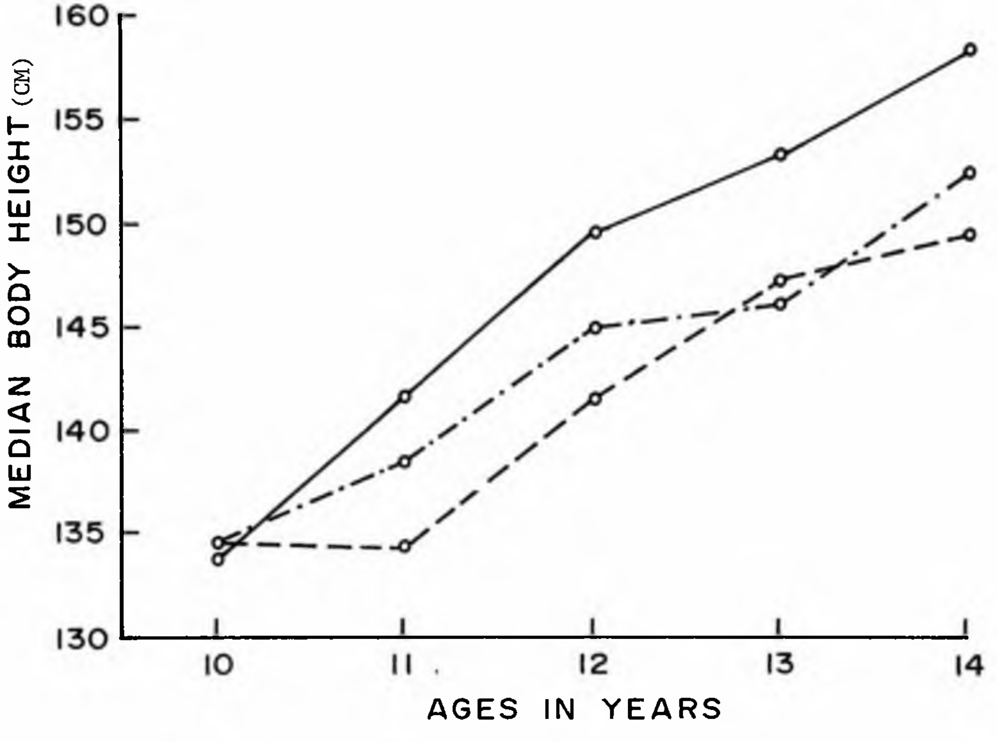

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Table 8: Mean Weight of Children 10-14years According to age and (sex separate) (Number of children in parenthesis)

(a) Males

AGE (Years)	SEKOTI	AXIM	ACCRA
10	26.85 ± 3.38(43) [1*]	27.2 ± 4.02(12)	27.50 ± 2.46(17)
11	28.29 ± 4.21(29)	29.23 ± 4.32(24)	29.71 ± 4.90(21)
12	29.19 ± 3.36(26)	31.73 ± 4.64(28)	34.03 ± 2.09(17)
13	31.17 ± 4.83(24)	33.27 ± 4.81(22)	38.06 ± 8.16(18)
14	33.79 ± 3.66(29)	38.13 ± 6.46(27)	41.76 ± 5.99(17)

1.* Mean Weight in kg. ± S.D.

(b) Females

AGE (Years)	SEKOTI	AXIM	ACCRA
10	25.81 ± 4.06(31)	28.95 ± 4.18(23)	28.14 ± 3.74(22)
11	24.90 ± 4.00(15)	29.58 ± 5.80(20)	32.75 ± 4.76(18)
12	28.71 ± 4.41(17)	33.91 ± 4.80(22)	40.45 ± 9.19(28)
13	33.33 ± 7.21(12)	39.50 ± 5.91(20)	43.64 ± 7.06(18)
14	35.23 ± 4.00(11)	39.61 ± 4.91(22)	47.16 ± 7.5(22)

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Table 9: Mean Height of Children 10-14 Years According to Age (sex separate)

(Number of children in parenthesis)

(a) Males

AGE (Years)	SEKOTI	AXIM	ACCRA
10	136.36 ± 6.59(43)[1*]	132.58 ± 6.26(12)	133.59 ± 5.30(17)
11	139.65 ± 6.78(29)	134.92 ± 6.15(24)	137.95 ± 5.49(21)
12	139.07 ± 6.04(26)	138.39 ± 6.72(28)	145.19 ± 5.46(17)
13	146.87 ± 8.43(24)	141.19 ± 6.76(22)	50.29 ± 9.35(18)
14	148.02 ± 7.70(29)	148.00 ± 8.50(27)	155.89 ± 7.92(17)

1.* Mean Height in cm ± S.D

(b) Females

AGE (YEARS)	SEKOTI	AXIM	ACCRA
10	134.48 ± 8.24(31)	134.67 ± 7.52(23)	133.77 ± 6.01(22)
11	138.45 ± 7.33(15)	134.39 ± 6.98(20)	141.58 ± 6.51(18)
12	144.92 ± 5.83(17)	141.55 ± 5.8(22)	149.61 ± 4.74(28)
13	146.15 ± 7.60(12)	147.31 ± 7.22(20)	153.37 ± 5.18(18)
14	152.49 ± 6.42(11)	149.45 ± 6.38(22)	158.39 ± 3.88(22)

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4.3: Biochemical Studies - Urinary Iodine, Iodine-thiocyanate Ratios and thiocyanate

Urinary iodine and thiocyanate excretion determinations were made on specimens from 157 pupils. 43 pupils in Sekoti, 59 in Axim and 55 in Accra. The severity of iodine deficiency would be classified as in Table 10.

Table 10: I.D.D. Severity and the Need for Correction

Stage	Clinical Features			Typical goitre prevalence	Mean urinary iodine (ug I/dl)	Need for correction
	goitre	Hypo-thyrodism	cretinism			
1 Mild	+	0	0	10-30%	3.5-5.0	Important
II Moderate	+ +	+	0	20-50	2.0-3.5	Urgent
III Severe	+ + +	+ + +	+ +	30-100	< 2.0	Clinical

0 = absent; +, + + and + + + = present with + + + being most severe.

Source : Dunn, 1990

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TABLE 11 : COMPARISON OF THE URINARY IODINE, THIOCYANATE, AND I/SCN RATIO LEVELS IN SEKOTI, AXIM, AND ACCRA (MEAN ± S.E.M NUMBER OF CHILDREN ARE SHOWN IN PARENTHESIS)

	SEKOTI (43)	AXIM (59)	ACCRA (55)
% Total Goitre	56.2	17.3	20.5
Urinary Concen-tration I (μg/dL)	22.93 ± 2.13	46.93 ± 2.25	20.48 ± 0.76
SCN (mg/dL)	1.84 ± 0.16	3.30 ± 0.55	1.13 ± 0.12
Urinary ratio a* I/SCN (μg/mg)	21.36 ± 5.92	42.15 ± 9.89	29.06 ± 3.39

a* I/SCN ratio > 7 : Normal

< 3 : Goitre Appearance

< 2 : Goitre and Hyperendemia

The differences between the urinary iodine concentrations in Axim, Accra and Sekoti were highly significant ($p<0.001$) by ANOVA. Axim had 2.3 times and 2.0 times higher urinary iodine concentration than Accra and Sekoti respectively. The distribution of urinary iodine concentrations is shown in Fig. 13. The mean urinary iodine in Sekoti was 22.93 ± 2.13μg/dL, a level far higher than would be expected in a place with dietary iodine deficiency. In Accra, the mean urinary iodine level was 20.48 ± 0.76 with a range of 6.35 - 28.89μg/dL. No pupils were found below 5μg/dL or excretion level indicating iodine deficiency.

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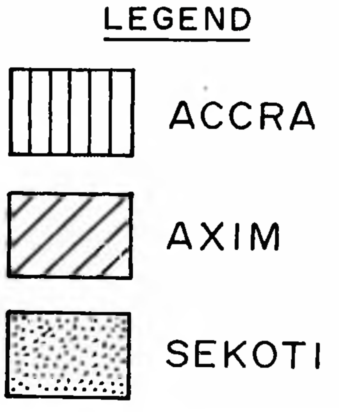
Fig 13. The distribution of Urinary iodine excretion (µg/dL) in Sekoti, Axim, and Accra.



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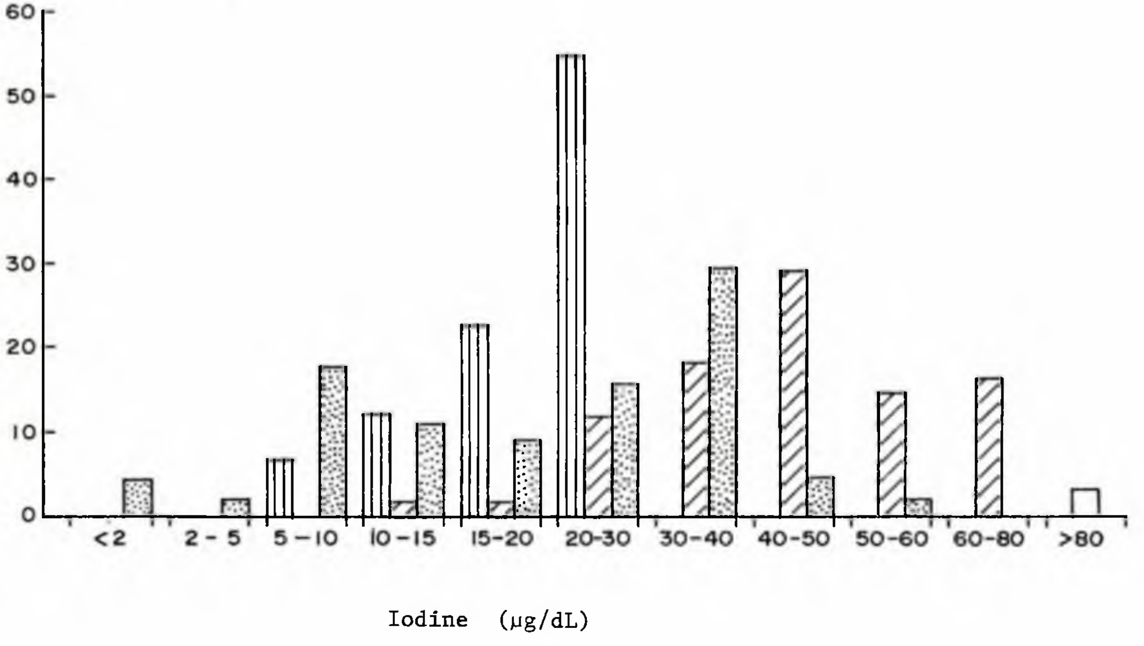

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In Axim, the mean urinary excretion was 46.92 ± 2.25μg/dL. The range of values were 14-84μg/dL. No persons were also found to be below 5μg/dL. Among the schools within each area (Apprendix XII), it was observed that the differences in iodine concentrations were not statistically significant.

The urinary SCN in Axim was 1.8 and 2.9 times higher than in Sekoti and Accra (See Fig.14). All differences for the urinary SCN were highly significant at $p<0.001$ by ANOVA. Accra had the lowest SCN with a mean of 1.13 ± 0.12, followed by Sekoti 1.84 ± 0.16 and Axim 3.30 ± 0.55mg/dL. Despite the high SCN excretion in Axim, and because of its high urinary iodine excretions, the I/SCN ratio was also high with a mean of 42.15 ± 9.89. In Accra, the mean I/SCN ratio was 29.06 ± 3.92, followed by Sekoti 21.36 ± 5.92. Although there was a progressive decrease in I/SCN ratio in the areas, these ratios were not statistically significant ($p>0.05$ by ANOVA).

The distribution of the urinary iodine/thiocyanate ratio is shown in Fig.15. In Axim, 6.78% of the children were found to be below I/SCN of 3, the point where goitre develops as a result of dietary goitrogens, thiocyanate, compared with 11.65% in Sekoti and no pupils for Accra.

Table 12 compares the mean urinary iodine, SCN and I/SCN ratios among pupils with goitre and those without goitre in each area. The result for the urinary iodine showed no significantly different from each other in Axim schools. However, in Sekoti, the mean difference between goitre and no goitre pupils was highly significant at $p<0.001$, while those in Accra were also significant at $p<0.01$. Appendix XIII compares the urinary iodine excretion among children with goitre and those without goitre in the various schools.

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Fig 14. Comparison of Urinary Thiocyanate (mg/dL) in Axim, Sekoti and Accra.

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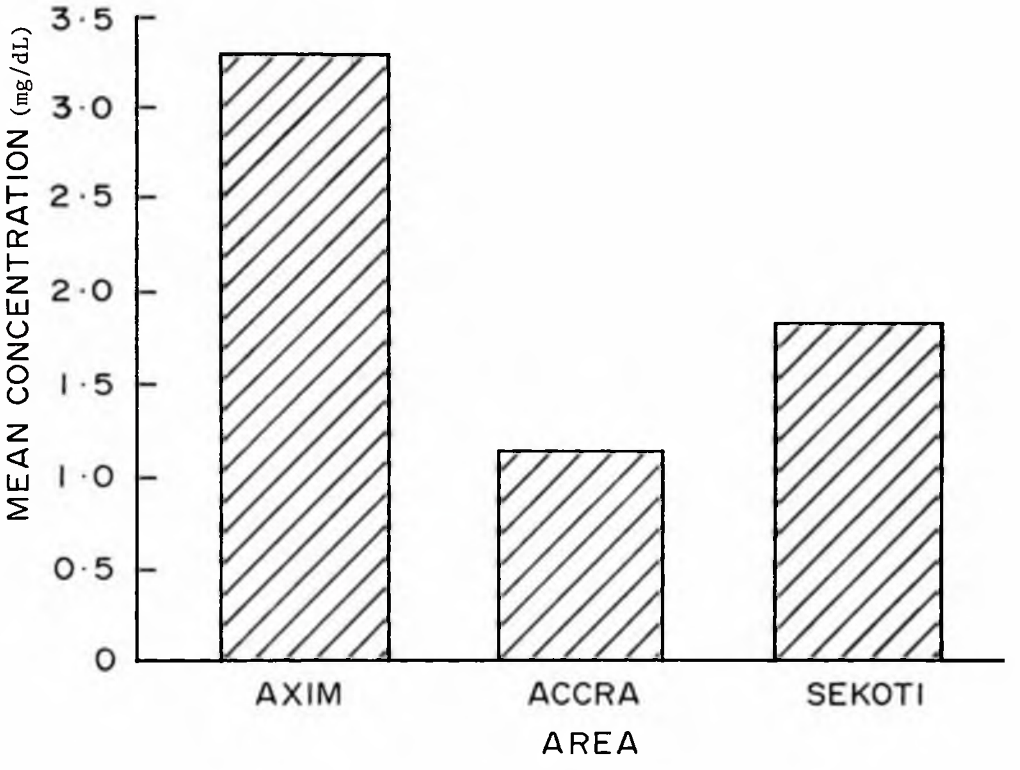

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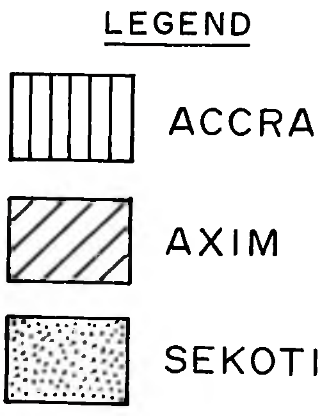
Fig 15. Comparison of Urinary I/SCN Ratio ($\mu g/mg$) in Accra, Axim, and Sekoti.



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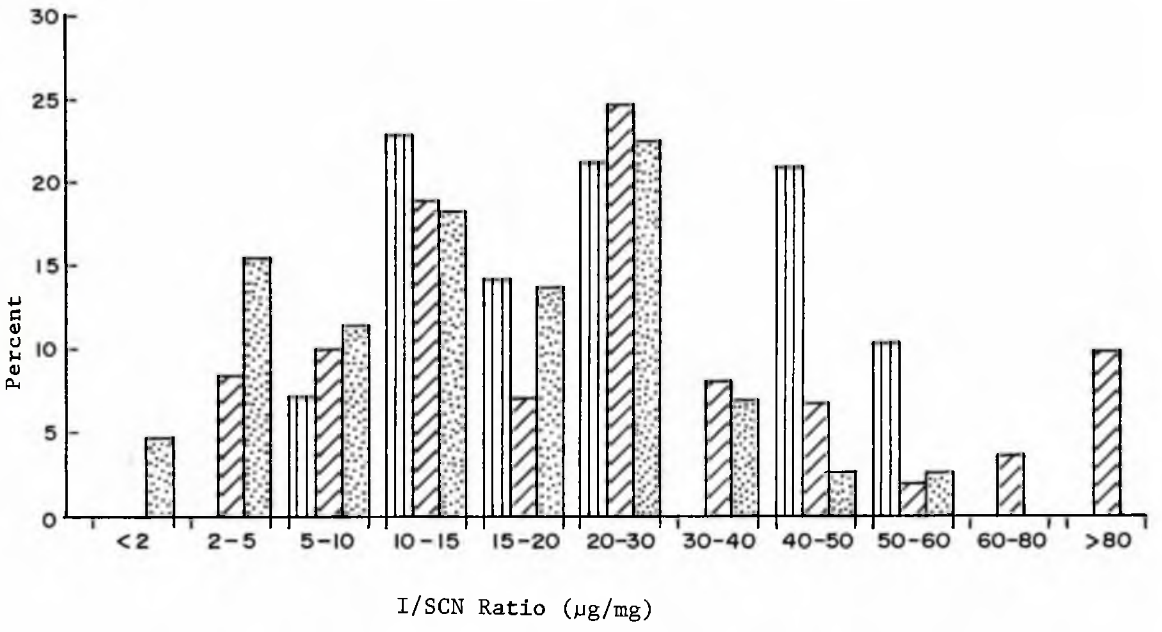

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TABLE 12 : COMPARISON OF URINARY IODINE, SCN, AND I/SCN RATIO AMONG CHILDREN WITH GOITRE AND THOSE WITHOUT GOITRE FROM SEKOTI, AXIM AND ACCRA (MEAN ± S.E.M., NUMBER OF CHILDREN IN PARENTHESES)

	SEKOTI		AXIM		ACCRA	
	Goitre (23)	No Goitre (13)	Goitre (25)	No Goitre (34)	Goitre (24)	No Goitre (31)
Urinary Concentration I(µg/dL)	18.95 ± 2.94	23.51 ± 3.35	47.80 ± 3.70	46.27 ± 2.82	21.42± 1.14	19.76±1.02
SCN (µg/dL)	1.75 ± 0.26	1.80 ± 0.20	3.92 ± 0.80	2.85 ± 0.78	1.46± 0.19	0.78±0.09
Urinary Ratio I/SCN (µg/mg)	14.10 ± 2.70	16.01 ± 2.20	26.81 ± 7.67	38.53 ± 6.16	20.52± 2.95	31.95±3.39

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In all the areas, the mean I/SCN ratios among pupils with goitre and those without goitre, were not significantly different from each other. The SCN excretion in Sekoti and Axim was not significantly different from each other. However, in Accra those with goitre and without goitre, the SCN excretion was statistically different ($p<0.01$).

Fig. 16 shows the association between the urinary I/SCN ratio and the prevalence of goitre in the three areas of study. It is shown that the increase in prevalence of goitre is inversely correlated to the progressive decrease of the urinary I/SCN ratio ($r = -0.75$ $p<0.01$) used as an index of the balance between the dietary supplies of iodine and thiocyanate, goitrogens.

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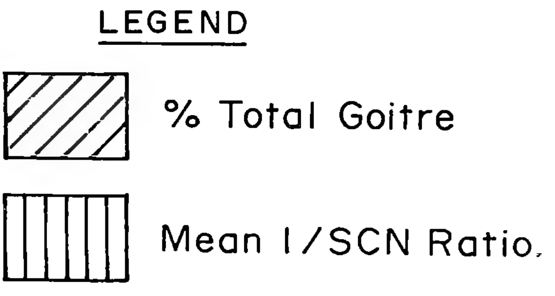
Fig 16. The Relationship between the Urinary I/SCN Ratio and the prevalence of Goitre.



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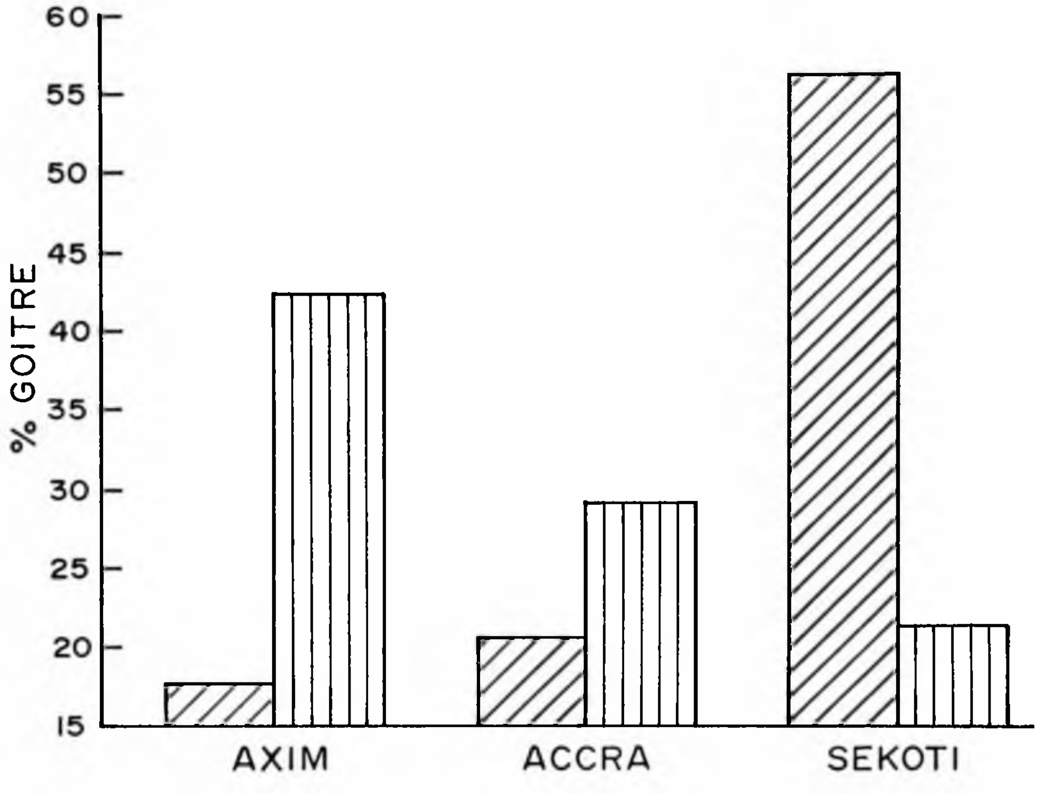

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4.4 Analysis of Nutrients Intake

The nutrient intakes of protein, energy and Vitamin A of one hundred and forty-two (142) pupils were assessed by the 24-hour dietary recall method. The percentage Recommended Dietary Allowance (RDA) met for each individual was calculated using the FAO/WHO recommended nutrient intakes (1974, 1985) for age and sex. The net protein utilization (NPU) for protein in a mixed diet was taken as 70% (FAO/WHO, 1985).

Table 13-14 and Fig. 17 show the mean nutrient intake of the subjects aged 10-14 years in comparison with FAO/WHO, 1985 recommended intakes. For sample calculation of Energy and protein requirement, see Appendix XX. Energy requirement in all the areas studied were not met. Accra and Sekoti met 74.00 ± 2.58% and 73.71 ± 2.43% respectively compared with Axim which only met 63.97 ± 3.55%. The mean difference of energy among the areas was highly significant ($p<0.001$ by ANOVA). However, between Sekoti and Accra, the percentage requirement met for energy was not statistically significant ($p<0.05$). Mean protein intakes for all the areas were above the RDA. Accra met 123.88 ± 6.46%, Sekoti 119.00 ± 7.71% and Axim 109.87 ± 4.58%. The differences observed in the areas for protein were significant at ($p<0.05$).

Mean Vitamin A (Fig. 17) intakes were not satisfied by the children in Sekoti. The overall percentage requirement met was 80.86 ± 13.54% in Sekoti compared with 1460.44 ± 227.87% in Accra and 1988.68 ± 252.36% in Axim. The males in Sekoti however, met 107.89% of the Vitamin A requirement while females satisfied only 55.52%.

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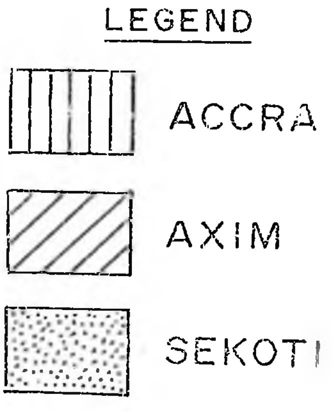
Fig 17 : Comparison of the Mean percentage Recommended Dietary Allowance (RDA) Met for Calories, Protein, and Vitamin A in Sekoti, Axim, and Accra.



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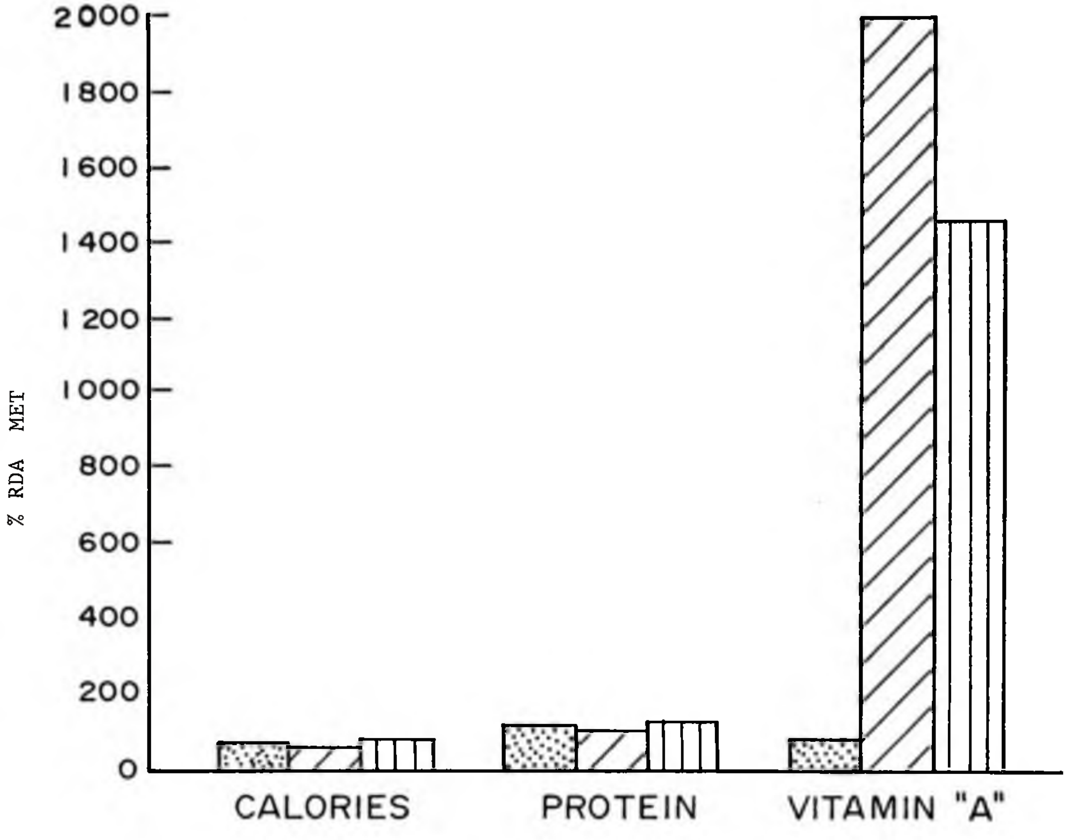

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TABLE 13 : PERCENTAGE REQUIREMENT MET OF ENERGY, PROTEIN, AND VITAMIN A IN 24-HOUR DIETARY RECALL AGE GROUP 10-14 YEARS (MEAN ± S.E.M)

Survey Area	Sex	N	% RDA Energy	% RDA Protein	% RDA Vitamin A	% Calories from Millet	% Calories from Cassava
Sekoti	Males	19	73.53 ± 2.82	120.37 ± 11.74	107.89 ± 25.78	63.82 ± 3.50	Not much consumed
	Females	16	73.93 ± 4.23	117.38 ± 9.83	55.52 ± 11.97	61.85 ± 3.39	-do-
	Combined	35	73.71 ± 2.43	119.00 ± 7.71	80.86 ± 13.54	62.92 ± 2.43	-do-
Axim	Males	29	65.55 ± 4.19	111.06 ± 5.95	2188.92 ± 333.21	Not much consumed	33.93 ± 3.84
	Females	28	63.97 ± 3.55	106.48 ± 0.40	1777.01 ± 28.56	-do-	29.67 ± 0.25
	Combined	57	64.77 ± 2.56	109.87 ± 4.58	1988.68 ± 252.36	-do-	31.84 ± 2.68
Accra	Males	25	70.46 ± 3.64	124.13 ± 0.87	1246.47 ± 151.06	-do-	17.49 ± 2.71
	Females	25	77.62 ± 3.44	125.62 ± 8.00	1674.42 ± 331.59	-do-	23.39 ± 3.40
	Combined	50	74.00 ± 2.58	123.88 ± 6.46	1460.44 ± 227.87	-do-	19.61 ± 2.30

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Millet the staple food in Sekoti in particular and in the Upper East region in general contributed 62.92 ± 2.43% of total calories in Sekoti. Whereas cassava was more eaten in Axim (31.84 ± 2.68%) compared with Accra (19.61 ± 2.30%).

When analysing the data on the basis of the presence of pupils with goitre and those without goitre (Table 14), no significant differences were observed for the percentage of RDA satisfied for energy, protein and Vitamin A among the areas. However, among Axim schools, the percentage requirement for protein was significant ($p<0.05$).

4.5: Food Habits

The data collected from the school children in Sekoti, Axim and Accra were expressed as percentage of the people questioned who had eaten a given food for at least once in the past week. Quantities were not estimated. The results for the main food items are shown in Table 15.

In Sekoti, Millet was by far the food of choice (100%). The children had millet in the form of tuo zaafi and "millet gari". Groundnuts consumption was also high. However, the groundnut eaten were those sundried in the shell. The skins are not removed before eating. Sea-fish was also consumed by the children. However, the contribution of seafish to the diet in the form of protein was very small. The seafish most eaten is the anchovies (popular known as Keta Schoolboys) and in very small quantities. Cassava leaves, cabbage and lettuce were not popular in this area. Only 20.97% of the children had eaten cassava products such as gari.

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TABLE 14A : PERCENTAGE REQUIREMENT MET OF ENERGY, PROTEIN, AND VITAMIN A IN 24 - HOUR DIETARY RECALL AMONG PUPILS WITH GOITRE AGE GROUP 10 - 14 YEARS (MEAN ± S.E.M)

Survey Area	Sex	N	% RDA Energy	% RDA Protein	% RDA Vitamin A	% Calories from Millet	% Calories from Cassava
Sekoti	Males	10	74.25 ± 3.96	122.13 ± 15.58	128.03 ± 46.59	64.86 ± 4.41	Not much consumed
	Females	12	73.01 ± 4.89	112.34 ± 12.04	41.51 ± 12.38	62.12 ± 4.28	-do-
	Combined	22	73.61 ± 3.18	116.79 ± 9.69	80.84 ± 20.26	63.37 ± 2.34	-do-
Axim	Males	7	71.43 ± 9.13	124.23 ± 10.31	1923.50 ± 678.97	Not much consumed	34.16 ± 6.89
	Females	17	69.03 ± 3.80	116.59 ± 7.30	1708.59 ± 480.96	-do-	33.07 ± 4.45
	Combined	24	69.73 ± 4.06	119.03 ± 5.83	1771.28 ± 384.12	-do-	33.39 ± 3.71
Accra	Males	9	67.81 ± 5.52	114.39 ± 19.46	1582.29 ± 621.86	-do-	29.70 ± 4.96
	Females	13	73.26 ± 4.56	123.09 ± 11.99	1227.82 ± 392.50	-do-	23.09 ± 4.69
	Combined	22	71.03 ± 5.04	119.00 ± 10.84	1372.83 ± 349.94	-do-	25.93 ± 3.39

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TABLE 14B : PERCENTAGE REQUIREMENT MET OF ENERGY, PROTEIN, AND VITAMIN A IN 24 - HOUR DIETARY RECALL AMONG PUPILS WITHOUT GOITRE AGE CROUP 10 - 14 YEARS (MEAN ± S.E.M)

Survey Area	Sex	N	% RDA Energy	% RDA Protein	% RDA Vitamin A	% Calories from Millet	% Calories from Cassava
Sekoti	Males	9	72.73 ± 4.25	118.41 ± 18.73	84.81 ± 12.26	62.67 ± 5.79	Not much consumed
	Females	4	76.47 ± 9.60	132.48 ± 15.59	97.53 ± 19.59	61.06 ± 5.20	-do-
	Combined	13	73.88 ± 8.87	122.74 ± 12.10	88.72 ± 10.62	62.18 ± 3.85	-do-
Axim	Males	22	63.67 ± 4.48	106.87 ± 8.25	2273.37 ± 401.67	Not much consumed	33.22 ± 5.70
	Females	11	56.14 ± 5.01	90.41 ± 8.72	1882.73 ± 680.24	-do-	24.39 ± 5.72
	Combined	33	61.17 ± 3.27	89.96 ± 5.74	2143.16 ± 353.47	-do-	30.71 ± 5.70
Accra	Males	16	71.97 ± 4.97	129.61 ± 12.58	1057.57 ± 331.00	-do-	10.62 ± 3.06
	Females	12	82.41 ± 5.18	128.46 ± 10.62	2158.22 ± 521.70	-do-	23.72 ± 4.71
	Combined	28	76.44 ± 5.24	129.12 ± 8.23	999.00 ± 304.64	-do-	16.23 ± 2.78

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Table 15: Percentage of children questioned Who had consumed the principal food items At least once in the past week (Number of children in parenthesis)

n Food Item	SEKOTI 62	AXIM 167	ACCRA 50
Millet	100.00 (62)	3.0 (5)	82.00 (41)
Cassava	20.97 (13)	99.40 (166)	100.00 (50)
Cabbage	0.0 (0)	* -	30.00 (15)
Sea Fish	100.00 (62)	100.00 (167)	100.00 (50)
Groundnuts	100.00 (62)	81.44 (136)	100.00 (50)
Maize	* -	98.20 (164)	* -
Lettuce	0.0 (0)	* -	40.00 (20)
Cassava Leaves	0.0 (0)	0 (0)	0.0 (0)
Bamboo Shoots	* -	0.0 (0)	* -

* - Data not collected

In Axim, cassava and seafish were the most popular foodstuffs compared to Sekoti. 99.40% and 100% of the school children questioned had consumed cassava and seafish respectively in the past week. Cassava products such as fufu, akyeke, and gari were highly consumed by the children. Millet consumption was much lower consumed almost by a negligible part of the children surveyed. Groundnuts consumption was also high. It is eaten in the form of roasted groundnuts and groundnut soup with the skin removed. Here, also, cassava leaves and bamboo shoots did not form part of the diet. Sea weeds, a potential source of goitre were also not eaten by the people.

In Accra, millet products such as porridge was consumed by 82.00% of the children in the past week. Cassava, seafish and groundnuts were also popular. 30% and 40% of the children had consumed cabbage and lettuce respectively in the past week. However, cassava leaves were not consumed.

4.6 Cyanide Content of Selected Foods

The cyanide content of selected foods are shown in Table 16, and compared with cyanaide toxicity in Table 17. Among the cassava products studied from Accra, gari had the highest cyanide value, but still innocuous (ie. harmless).

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Table 16: Cyanide Content of Selected foods from Accra

FOOD ITEM	CYANIDE CONTENT mg HCN/kg SAMPLE
Gari	34.02
Cooked Kokonte	10.26
Boiled Cassava	27.54
Cassava Fufu	18.36
Raw groundnuts with Skin	8.64
Boiled groundnuts in a Shell	7.02
Roasted Groundnuts	7.02
Banku	10.80

Table 17: Definition of HCN Toxicity

	HCN CONTENT/kg FRESH PEELED ROOTS
Innocuous (ie. harmless)	less than 50mg
Moderately poisonous	80-100mg
Dangerously poisonous	over 100mg

Source: De Bruijn (1971), Bolhuis (1954), and Coursey (1979)

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TABLE 18 : CYNIDE CONTENT OF FRUITS AND VEGETABLES IN SEKOTI

FOOD ITEM	CYANIDE CONTENT mg HCN/kg SAMPLE
Millet (Raw)	9.85
Sorghum (Raw)	30.78
Bean Leaves (Sun Dried)	9.72
Belisi (Sun Dried)	Trace
Bra (Sun Dried)	1.35
Kona (Fresh)	0.0
Nkpagra (Fresh)	0.0
Pusa (Fresh)	0.0
Tokara (Baobab Leaves) (Sun Dried)	76.41

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Table 18 shows the cyanide content of the various fruits and vegetables eaten by the people in Sekoti during both dry and rainy seasons. In the dry season, these fruits and vegetables are eaten in the dried form. Other fruits and vegetables are eaten by the people in Sekoti, but at the time of the survey, these other fruits and vegetables were not available (not in season). Only tokara leaves (Baobab leaves) could be considered to be moderately poisonous. The cyanide content for the sun dried tokara leaves was measured to be 76.41mg HCN/kg.

The cassava products from Axim were not analysized due to the time constrain, and lack of chemical reagents.

4.7: Sources of Water

The sources of water used in the three areas of study are shown in Table 19.

Table 19: Percentage of children using the following Source of water for drinking (Number of children in parenthesis)

n WATER SOURCE	SEKOTI 63		AXIM 167		ACCRA 50	
Pipe Borne	0.0	(0)	37.72	(63)	100.00	(50)
Bore Hole	98.31	(58)	0.0	(0)	0	(0)
Well	55.93	(33)	66.47	(111)	0	(0)
River/Stream	11.86	(7)	0	(0)	0	(0)
Pond/Dam	1.69	(1)	0	(0)	0	(0)
Underground Water	1.69	(1)	0	(0)	0	(0)
Rain Water	-		100.0	(167)	-	

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In Sekoti, the major sources of water are bore hole, well, and stream. In Axim the major source of drinking water is well even though there is a pipe-borne water. In Accra, pipe-borne water is the major source of drinking water.

4.8: Microbiological Studies of the Water Samples

Table 20: Bacterial Analysis of Water In Accra Samples

TYPE OF WATER	LOCATION	BACTERIAL COUNT/mL of water	PRESUMPTIVE Coliform count/dL	ECOLI count/dL
Pipe Borne	Madina	$1.9x10^2$	17	17
Pipe Borne	Madina	26	0	0
Pipe Borne	Madina	13	3	0
Pond a*	Madina	$6x10^3$	Over 1800	550
Pipe Borne	Nima	$2.4x10^3$	0	0
Pipe Borne	Mamprobi	$4.7x10^3$	0	0
Pipe Borne	Chorkor	$5.9x10^3$	160	30
Pipe Borne	Mamprobi	$4.7x10^3$	90	5
Pipe Borne	Osu-R.E.	$7.5x10^4$	8	0
Pipe Borne	Osu-R.E.	$2.0x10^4$	0	0

a* used only when there is water shortage due to closure of pipe-borne water.

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Table 21: Bacterial Analysis of Water in Axim Samples

TYPE OF WATER	BACTERIAL COUNT/mL	PRESUMPTIVE COLIFORM COUNT/dL	E. COLI COUNT/dL
Pipe Borne	3.8×10^5	> 1800	3
Well	9.0×10^2	550	550
Stream a*	6.5x10	> 1800	> 1800
$Well_2$	7.8×10^4	> 1800	1600
$Well_3$	1.3×10^5	> 1800	11
$Well_4$	2.2×10^3	> 1800	225

a* used only for washing and bathing. However, when there is water shortage, it is used for drinking.

Table 22: Bacterial Analysis of Water in Sekoti Samples

TYPE OF WATER	LOCATION	BACTERIA
Pond	Kpagrabong	Klebsiella, Edwardsiella
Bore hole	Naboko	Klebsiella
Well	Daasang	Klebsiella, Proteus, Pseudomonas
Stream	Kugrin	Klebsiella, Proteus

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TABLE 23 : MICROBIOLOGICAL STANDARDS FOR WATER

ORGANISM	UNIT	CUIDELINE VALUE
A. Piped Water Supplies		
A.1 Treated Water Entering Distribution System		
Faecal Coliforms	Number/100mL	0
Coliform Organisms	Number/100mL	0
A.2 Untreated Water Entering the Distribution System		
Faecal Coliforms	Number/100mL	0
Coliform Organisms	Number/100mL	0
Coliform Organisms in an occasional Sample		3
A.3 Water in the Distribution System		
Faecal Coliforms	Number/100mL	0
Coliform Organisms	Number/100mL	0
B. Unpiped Water Supplies		
Faecal Coliforms	Number/100mL	0
Coliform Organisms	Number/100mL	10

SOURCE : W.H.O., Guidelines for Drinking Water Quality, Vol.1, Recommendations; Geneva, 1984.

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MICROBIOLOGICAL STANDARDS FOR WATER, AND MISCELLANEOUS FOODS

W A T E R

FOR DRINKING TAP WATER

I.E. CHLORINATED WATER SUPPLY

CATEGORIES

Table 24

Test For Organisms Their Numbers and Toxins	Suitable for Human Consumption	Unsuitable for Human Consumption
Viable Bacteria Count	10^2/100mL	Above 10^2/100mL
Presumptive Coliform Count	Nil/100mL	One or above/100mL
E. Coli Count	Nil/100mL	"
Pathogenic Microbes	Nil	"
Strept. Faecalis	Nil/100mL	"
Anaerobic Spore-Formers	Nil/100mL	"
Aerobic " "	10^2/100mL	Above 10^2/100mL
Toxins " "	Nil	Positive

NON CHLORINATED PIPED DRINKING WATER SUPPLIES

Table 24a

Test for Organisms Their Numbers and Toxins	Suitable for Human Consumption	Unsuitable for Human Consuption
Viable Bacteria Count	10^2/mL	Above 10^2/mL
Presumptive Coliform Count	0-2/100mL	One or 2/100mL
E. Coli Count	Nil	One or above/100mL
Pathogenic Microbes	Nil	"
Strept. Faecalis	Nil	"
Anerobic Spore Formers	Nil	"
Aerobic " "	10^2/100mL	"
Toxins " "	Nil	10^2/100mL

SOURCE : Korle Bu Teaching Hospital, Reference Laboratory, Korle Bu, Accra.

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GRADES OF NON-CHLORINATED PIPED WATER

Table 24b

	GRADE	PRESUMPTIVE COLIFORM COUNT/100mL	E. COLI COUNT/ 100mL
Class 1	Excellent	0	0
Class 2	Satisfactory	1-3	0
Class 3	Suspicious	Greater than 0,1 or more	0,1 or More

SOURCE : Korle Bu Teaching Hospital, Reference Laboratory, Korle Bu, Accra.

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Bacterial analysis of the sampled water are shown in Tables 20-22 and compared with W.H.O. Microbiological Standards for drinking water quality in Table 23 and Korle-bu Reference Laboratory Standards (Table 24).

In Sekoti, due to the long-storage period, it was not possible to quantify the bacteria. However, some bacteria were isolated and identified, by the Bacteriology Unit at Noguchi Memorial Institute for Medical Research.

In Axim (Table 21) and Accra (Table 20) all the water samples collected were declared microbiologically unsactisfactory by the Medical Officer due to the high bacterial count and the presence of coliforms and E. coli at Public Health and Reference Laboratory at Korle-bu Teaching Hospital.

4.9 DATA ANALYSIS

To try to explain the factors for the prevalance of goitre among the school children in the three areas, a multiple regression analysis using the logistic model was used to investigate the relationship of goitre with the various variables described.

With this model the proportion of children with goitre from each school is the dependent variable and the possible causative variables are independent variables. The independent variables were the mean urinary iodine excretion, the mean I/SCN ratio, percentage weight-for-height and percentage height-for-age as indices of protein energy malnutrition, the mean percentage RDA met for protein, energy, vitamin A; and percentage calories from millet, and cassava, and the number of times cabbage was eaten.

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A stepwise regression was used to select the variables in order of importance, testing for the significance of the coefficient of each variable while adjusting for the effects of the other variables. The results of the analysis are given in Table 25. The urinary iodine/SCN ratio, percentage requirement met for vitamin A and chronic malnutrition showed significant relationships with goitre, while the rest of the variables did not show a significant relationship with goitre prevalence. This model with five variables accounts for 90% of the variability in goitre prevalence. The number of times cabbage was eaten is negatively correlated with goitre prevalence. This is contrary to what has been observed (Matovinovic, 1983, Van Etten, 1973) because, the number of people eating cabbage was very small, compared with those children, who did not eat it.

In univariate analysis, when the other variables are ignored, percentage calories from millet was correlated highly significantly with goitre prevalence ($r = 0.75$, $t < 0.001$), and percentage of calories from cassava was also correlated highly with goitre ($r = 0.64$) grade 1A, since most of the children observed in Accra and Axim had goitre size 1A.

However, percentage calories from cassava and millet did not demonstrate a significant relationship with goitre in the presence of other variables. This may be due to the fact that the percentage calories from millet and cassava are related to the percentage requirement met for energy whose contribution was minimal to the goitre.

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RELATIONSHIP OF GOITRE PREVALENCE WITH URINARY IODINE/THIOCYANATE RATIO (I/SCN), % RDA MET FOR VITAMIN A, AND CHRONIC MALNUTRITION IN ELEVEN (11) SCHOOLS OF THE THREE AREAS OF STUDY

Table 25 :

VARIABLE	COEFFICIENT	t(9 d.f)	P
Constant	4.843		
I/SCN Ratio	-0.098	-4.115	<0.015
% RDA Met for Protein	-0.002	-2.490	<0.06 (NS)*
% RDA Met for Vitamin A	-0.001	-3.147	<0.035
Moderate and Severe Chronic Malnutrition	6.364	3.165	<0.034
Number of Times Cabbage was Eaten	-2.847	-2.321	<0.08 (NS)

Multiple R = 0.949

R^2 = 0.901

R = 6.095 $p<0.05$

a* NS = Not Significant at $p = 0.05$

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CHAPTER 5: DISCUSSIONS

The findings of this survey confirm the existence of marked regional variations in the prevalence of goitre, protein-energy malnutrition, dietary habits of the children, and the urinary iodine excretion levels in Accra, Sekoti and Axim.

According to Dunn, 1990, total goitre prevalence of 30-100% along with mean urinary iodine level of less than 2.0μg/dl in an area is considered severe endemia. While a total goitre prevalence of 10-30% along with mean urinary iodine level of between 3.5 - 5.0μg/dl is considered mild. (Table 10). Based on goitre prevalence alone, Sekoti could be considered severe endemic area since 56.2% of the 249 children examined had goitre mostly grade 1B. On the other hand, the goitre prevalence of the two urban costal areas of Accra (20.5%) and Axim (17.3%) may be considered mild with mostly grade 1A.

However, the mean urinary iodine levels in all the areas were highly in excess of the 5μg/dl defined to be an indication of iodine deficiency. The mean urinary iodine level in Axim (46.9μg/dl) was significantly ($p<0.001$) higher than Accra (20.48μg/dl) and Sekoti (22.93μg/dl) where the dietary iodine supplies are very similar.

Moreover, pupils found to have goitre in all the areas were also excreting iodine levels (Accra 21.42μg/dl , Axim 47.80μg/dl and Sekoti 18.95μg/dl) far higher than would be expected in people with dietary iodine deficiency. This clearly shows that the pupils may be getting enough dietary iodine, but some goitrogens present in the food or water may be competing or interfering with iodine for the

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formation of thyroid hormones by the thyroid gland and causing the goitre. Examples of such goitrogens are thiocyanate (SCN) found in cassava (which inhibits the trapping of iodide by the thyroid) flavonoids, found in millet, (interfere with the processes of organification and coupling of iodotyrosines to form the active thyroid hormones (Gaitan, 1990) and micro organisms such as E. Coli and C. Perfringens found in polluted drinking water, produce substances which have similar effect to that of T.S.H. (Benmiloud, 1982).

The high prevalence of goitre observed in Sekoti, is in agreement with previous reports by W.H.O., 1958 and Davey, 1974. However, urinary iodine level was not determined at that time. There is still no available data on urinary iodine levels in the country. Therefore the urinary iodine concentrations measured in the three areas cannot be compared with data in this country. However, the urinary iodine excretion levels of the children in the areas studied compares with the 1971 survey of 7785 school children age 10-15 from four states in the United States of America (Michigan, Kenturcky, Texas, and Georgia). There, it was found that the range of iodine supply was 98-2293µg/day according to three urine samples taken at weekly intervals. There was no difference in iodine consumption between children with or without goitre. Similarly, Gaitan et al, 1978 also found the mean urinary iodine excretion values of 163-205µg/day in five localities in the Cauca Valley (a goitrous area) in Western Colombia among school children.

The high urinary iodine excretion level found in Axim (46.9µg/dl) could be explained by the relative proximity of the ocean and by a frequent consumption of seafish. For about 90% of the male population, fishing is their main occupation (According to the Chief of Axim).

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Also at the time of the survey in Axim, fish was in season and the price of the fish was very low. The overall normal iodine intake observed in Sekoti (22.93μg/dL) may be partially explained by the consumption of seafish (dried Anchovies) and also it could be possible that the soil is not deficient in iodine. However, more information or research needs to be done in this area to confirm the findings. Dietary iodine determinations need to be done. The urinary iodine concentration in Accra (20.48μg/dL) was not statistically different from Sekoti (22.93μg/dL). This is probably because even though Accra is on the cost, at the time of the survey in Accra, fish was very expensive and probably the children did not consume much. The parents of the children in Accra have more choice of protein in the form of meat.

The data clearly show that neither the high prevalence of goitre observed in Sekoti nor the relatively low incidences in Accra and Axim can be explained by differences in the dietary iodine supply. Though there could be persons whose dietary patterns make them relatively iodine deficient, especially in Sekoti where very few pupils (4.7%) were found to be excreting iodine level less than 2μg/dL. It may be concluded that the endemia of the areas of study may be contributed to environmental goitrogens either in the food or water.

The ratio of the urinary excretion of iodine and thiocyanate (I/SCN) was used in the study as an index of the exposure to dietary goitrogens, in this case, thiocyanate. Where the iodine intake is normal, the I/SCN ratio is higher than 7. Endemic goitre is not found as long as this ratio is higher than 3-4. But goitre appears when this ratio reduces to about 3. Goitre becomes hyperendemia and complicated by cretinism only when it is lower than 2. (Gaitan, et al, 1982). Gaitan and co-workers, 1982, have shown that when the iodine supply is higher than 60μg/day, goitre is not abnormally prevalent even in the presence of a high SCN supply (Ermans et al, 1980). This may explain why Axim which had the highest SCN supply (3.30 ± 0.55mg/dL) and highest iodine supply (46.9μg/dL) had a low goitre prevalence.

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As a consequence to the high iodine excretion in all the areas, the I/SCN ratios were normal, that is above 7, despite the progressive decrease of the I/SCN ratio from Axim (42.1μg/mg) to Sekoti (21.4μg/mg) (Table 13 and Fig. 16). Also the I/SCN ratio was not statistically different (ANOVA, $p>0.05$) in all the three areas. This suggests that the exposure to thiocyanate, a goitrogen, or the ratio between the iodine and thiocyanate supplies are statistically the same in the three areas. Therefore, the differences in the incidence of goitre in the study areas cannot be attributed to foods containing the goitrogen, thiocyanate. But the the possibility of some other goitrogens in the food whose antithyroid effect cannot be overcome by high iodine intake, which were not determined in the present study, may be contributing to the high incidence of goitre seen in Sekoti, cannot be ruled out. Although there may be persons identified in this survey whose thyroid enlargement is a result of deficient iodine intake or low iodine, high goitrogen (thiocyanate) overload, especially in Axim and Sekoti where 6.78% and 22.65% of the children respectively were found to be below the I/SCN ratio of 2μg/mg. The increased goitre prevalence in the presence of low iodine/SCN ratio agrees with the findings of other investigators (Delange et al 1971, 1978 and Bourdoux et al, 1982).

According to the food habits and the 24-hour dietary recall survey, millet and sorghum constitutes the major staple food in Sekoti. The dietary survey showed that the proportion of energy derived from millet and sorghum is between 58-67% of the daily calories. In a univariate analysis, percent calories from millet was positive ($r = 0.75$) and highly significantly ($p<0.01$) correlated with goitre prevalence. Thus the possibility of some goitrogen in

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millet, other than thiocyanate contributing to the high goitre incidence in Sekoti can therefore not be ruled out. It could suggest the activity of goitrins (i.e goitrogens whose antithyroid effect is not reversed by high iodine intake). An example of such a goitrogen is flavonoids, organic constituents in millet, sorghum, beans and in the skin of groundnuts (Hulse, 1980). Penninsetum millet, the type of millet grown in Northern and Upper Region of Ghana (Saka 1991 Nyankpala Agric. Station), is very rich in C-glycosyl flavones glucosyl vitexin, glucosyl orientin and vitexin. These compounds are known to possess intrinsic antithyroid activity, whose effect cannot be overcome by high iodine intake. Millet and sorghum also contain thiocyanate, an inhibitor of both thyroid iodide transport and organic binding (Class I type of inhibitor goitrogen), whose antithyroid effects are additive to those of the C-GF (Gaitan, 1990). This may help to explain the high incidence of goitre prevalence in the North (Sekoti) despite the same degree of thiocyanate exposure in all the areas. This effect of millet is supported by other epidemiological studies (Gaitan et al, 1989; Osman and Fatah, 1981). Osman and Fatah, 1981 found goitre was more prevalent in rural villages of the Darfur Province in Sudan, where as much as 74% of dietary energy was derived from millet, than in an urban area, where millet provided only 37% of the calories. This finding was confirmed by Elton et al 1985, who also demonstrated that as judged from urinary iodine excretion, the degree of deficiency was nearly identical in the two regions. (56µg I/g creatinine in urban compared with 46µg I/g creatinine in rural area).

The deleterious effects of protein and calorie deficiencies on thyroid function have been documented by several researchers (Gomez et al 1955, Ingenbleek, 1986). In this study, it was observed that although

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the mean protein intakes in all the areas were adequate in comparison with the Recommended Dietary Allowance (RDA) published by FAO/WHO, 1985 (Table 13) the mean energy intakes were about 70% of the RDA, with the lowest requirement met in Axim (64%). Under insufficient energy intake, ingested protein cannot be fully utilized to maintain proper growth and as a result may lead to protein-energy malnutrition. In Sekoti also, the quality of the protein ingested may be poor since millet and sorghum contributed more than half of the total protein consumed and as a result may also contribute to protein-energy malnutrition (P.E.M.). PEM was found to be more critical in Sekoti as reflected by loss in weight and in Axim by delay in height growth. P.E.M. is known to reduce the thyroid trapping avidity for iodide, and alter the response of the endocrine organ to exogenous thyroid-stimulating hormone. These will lead to lower synthesis of thyroid hormones and may also contribute to increased goitre prevalence despite adequate iodine intake.

The high incidence of wasting (26.5%) in Sekoti, Upper East region and stunting (25.5%) in Axim in the Western region is supported by the findings of U.N.I.C.E.F. sponsored study in 1985. In this study, it was observed that wasting was especially serious in the Northern and Upper regions. While the more chronic problem of stunting was more common in Western and Ashanti region (Asibey-Berko, 1991, UNICEF, 1985). However, the combined effects were more serious in the Northern and Upper regions.

Nutritionally, the whole of the Northern Ghanaian savannah is beset with an overall lack of food during the months of February-July. According to studies, years ago, adults and children receive only about 60% of their calory and nutrient requirements at that time, leading to weight loss and growth failure (Davey, 1974). The present study found however, that the caloric intake was 73.7% which is still not enough to meet the demand of the physiological processes of the body as well as the daily activities of the children. The higher energy intake observed contrary to what has been observed may be explained by the fact that the survey was performed at the beginning of the hungry season when some food may still have been available. Mean vitamin A intake (86% of R.D.A.) was also very low compared with Accra (1460.44% of RDA and Axim 1988.68% of RDA) (See Fig 17). This confirms what has, for years, been known about Vitamin A deficiency in the Northern and Upper Regions (Davey, 1974). Vitamin A Deficiency is correlated highly with higher goitre incidence (Table 25). This observation agrees with the findings of other investigators (Ingenbleek et al, 1979 and 1986). The mechanism whereby poor nutritional standards especially Vitamin A deficiency might harm thyroid function regardless of iodine intake is that decreased retinol could reduce thyroid hormone synthesis by defective glycosylation of thyroglobulin and its subsequent iodation. Thus Vitamin A deficiency in Sekoti coupled with chronic malnutrition alongside the possible effects of goitrogens may account for the high goitre prevalence there.

The high chronic protein-energy malnutrition (stunting) in Axim may probably also contribute to the goitre seen there. Although chronic malnutrition in Axim may be due to frequent infections, or genetic variation in the height of the children, it may be probably due to a long period of inadequate nutrition in the past. Moreover, cassava is one of the major staple foods in Axim, forming about 31-35% of the daily caloric intake. Cassava contains very little protein

(1-2g/100g) and might well lead to chronic protein-energy malnutrition if consumed in isolation. Eventhough Axim has good access to fish, because they are by the sea, it is possible that the protein is not fully utilized for its purpose since the caloric intake (64% of RDA) does not meet the recommended dietary allowance. Studies by Ingenbleek, 1986 have shown that a high consumption of cassava is invariably characterised by very poor protein status (i.e. lower prealbumin and retinol blood concentration). However, it cannot be implied that Axim school children have lower retinol blood concentration unless the blood concentrations of retinol and prealbumin are determined.

Evidence supporting the fact that there might have been chronic undernutrition in Axim is the supplementary feeding programs currently being provided by the Catholic Relief Services, in the schools visited.

The children are fed with sorghum-fortified grits and wheat blend mixtures prepared in the form of porridge for the past eight years (Personal communication with the head teachers of the schools studied). The supplementary feeding could also explain why the children's weight as compared with the height of reference children of the same sex and age were within the normal range.

Mean Vitamin A intakes were however, very high in Axim and Accra, ranging from 41.5 to as high as 2188 of the RDA (Table 13). The high values were seen in these pupils who had consumed green leafy vegetables, palm oil and palm soup. While the pupils who did not eat any of these food have very little Vitamin A. The main type of Vitamin A in these foods were Beta-carotene which must be converted by the body into retinol before it can be properly utilized. The absorption of the beta-carotene is only about 20 to 25% (Carper, 1987). of quantity ingested.

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Although excess vitamin A intake is known to be dangerous since the excesses are stored in the fat, primarily, the liver, and can cause yellowing and liver damage, it is retinol not beta-carotene that produces toxic effects. Thus the high vitamin A intake observed in Accra and Axim may not be toxic since the more beta-carotene consumed, the lower the percentage absorbed (Carper, 1987).

Another possibility for the variation of goitre prevalance seen in the study which was not included in the multiple regression model was the role of polluted drinking water. A relationship between polluted drinking water and goitre prevalence rates has been reported (Gaitan 1973, 1980 and Gaitan et al, 1978), despite adequate iodine intake. The high bacterial count and the presence of fecal matter such as E. Coli and coliforms in Accra and Axim water samples (Tables 20/21) account for the variation of the goitre prevalence in the areas. In both Accra and Axim, because they are on the coast, the possibility of the people being exposed to marine pollutants mainly through the consumption of fish and other seafoods contaminated with sewage and ingesting pathogens such as E. Coli, cannot be ruled out, as a possible cause of the goitre. However, studies should be done to determine the extent to which man is exposed to marine pollutants and their effects on the health of the people.

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CHAPTER 6

SUMMARY AND RECOMMENDATIONS

(1) The goitre and cretinism survey show that based on goitre prevalence alone, Sekoti could be considered severe endemic goitre area while Axim and Accra were found to be mild.

(2) Protein-energy malnutrition was severe in Sekoti in terms of wasting and the combined effects of wasting and stunting. Stunting due to chronic malnutrition was found highest among Axim school children. This high incidence of stunting may probably explain the goitres seen.

(3) The dietary supply of iodine in Sekoti and Accra were not statistically different while Axim had high iodine intakes due to the higher consumption of fish. No statistical differences were observed in the iodine intake of the pupils with goitre and those without goitre. The mean urinary iodine level in all the areas were highly in excess of the 5µg/dL defined to be an indication of iodine deficiency, indicating that the endemia of the areas of study may be contributed to environmental goitrogens either in the food or water.

(4) The thiocyanate exposure as a measure of dietary goitrogens, in this case thiocyanate, was almost the same in the three areas. Even though Axim had the highest SCN overload in the urine due to high consumption of cassava. The urinary I/SCN ratio decreased progressively as goitre prevalence increased. However, I/SCN ratio in all the areas were higher than 3, the point below which goitre develops due to thiocyanate exposure. Therefore, the possibility of exposure to other types of goitrogen especially in the North, Sekoti, cannot be ruled out.

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(5) Mean Protein intakes were adequate and comparable to R.D.A. in all the areas. However, the quality of the protein may be poor especially in Sekoti where millet and sorghum contributed more than half to the total protein. Mean energy intakes in all the three areas were not met. Axim had the lowest (64%) while there was no statiscally difference (p >0.05) between the energy intakes in Accra (74%) and Sekoti (73.71%). The higher energy intake observed in Sekoti contrary to what has been observed, may be explained by the fact that the survey was performed at the beginning of the hungry season when some food may still have been available.

Mean Vitamin A intakes were remarkedly low in Sekoti compared with Accra and Axim where palm oil and fruits were eaten. This confirms what has, for years, been known about the Northern and Upper regions. Vitamin A deficiency in the North and Upper regions may contribute to the high incidence of goitre seen.

Based on the 24-hour dietary recall and food habits of the children, millet and sorghum contributed about 64% of the total daily caloric intake in Sekoti while cassava was the major factor in Axim (31.84%) and Accra (19.61%).

Millet especially, the type of millet eaten in the North and Upper regions is known to contain the goitrogens, C-glycosyl flavones and thiocyanate whose anti thyroid effects are additive and cannot be overcome by high iodine intake. Thus it may be possible that the goitrogenic effect of millet may account for the severe endemic goitre seen in that area.

(6) Vegetables such as cabbage, lettuce, and cassava leaves were not eaten in both Axim and Sekoti. However, few pupils were observed to have eaten cabbage and lettuce in Accra. Seaweeds were not eaten in any of the areas.

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(7) The major sources of drinking water were found to be well in Axim, bore-hole and well in Sekoti and pipe borne water in Accra.

Bacterial analysis of the water samples collected in some parts of Accra and Axim showed that the drinking water in both areas were microbiologically unsatisfactory due to high bacterial counts and the presence of coliforms and E. Coli.

(8) A multiple regression analysis revealed that about 90% of the variability in goitre prevalence could be attributed to a decrease in urinary iodine/SCN ratio below 3, low Vitamin A intakes and generalized malnutrition.

Conclusion

In the light of the epidemiological observations reported in this survey, it may be concluded that the endemic goitre in Axim, Sekoti, and Accra study areas of Ghana may not be due to nutritional iodine deficiency. But that environmental factors known as goitrogens may be the main factors underlying the endemia.

It may be added that there could be persons or populations whose dietary patterns make them relatively iodine deficient. For such persons iodine supplementation may be a dietary necessity.

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RECOMMEDNATIONS

(1) The results of measurements of plasma thyroid hormone levels have always been considered the most sensitive index of iodine deficiency (Gaitan, 1990). Therefore, it is recommended that the plasma thyroid hormones should be measured to confirm the findings.

(2) It has been shown that even with experienced workers, there can be up to 20% difference in the identification of goitre between observers (Maberly, 1990). Therefore, ultrasound should be used in the field if possible to either replace goitre grading or provide a standard to assist in training for grading.

(3) Other aetiological factors such as iodine, calcium, iron, lithium, disulfides concentrations in the water should be determined in the areas where goitre is prevalent. Such minerals are known to inhibit the proper utilization of iodine in the diet.

(4) Detailed analysis of bacterial contamination of water should be carried out. Goitrogens that contaminate the water are especially likely to be widely consumed since water is such an unbiquitous component of the diet.

(5) There should be nutrition education campaign in the areas, especially Sekoti on the dangers associated with the consumption of raw groundnuts with the skin and in Axim and Accra on high cyanide containing cassava. Nutrition education should also be given in the North concerning the dangers of consuming raw millet and of answering to the call of nature in the open without building communal toilets.

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(6) There is a need for general improvement in the environmental sanitation in the area as a means of reducing the bacterial contaminations of the water and improving the general nutrition status of the pupils by reducing incidence of infections such as malaria and diahorrea.

(7) Finally, in the Upper East region, especially Sekoti, very little marine fish is used in their diets owing to the high prices offered by the fish mongers. Special offer should be made to sell marine fish to these people at reasonable prices.

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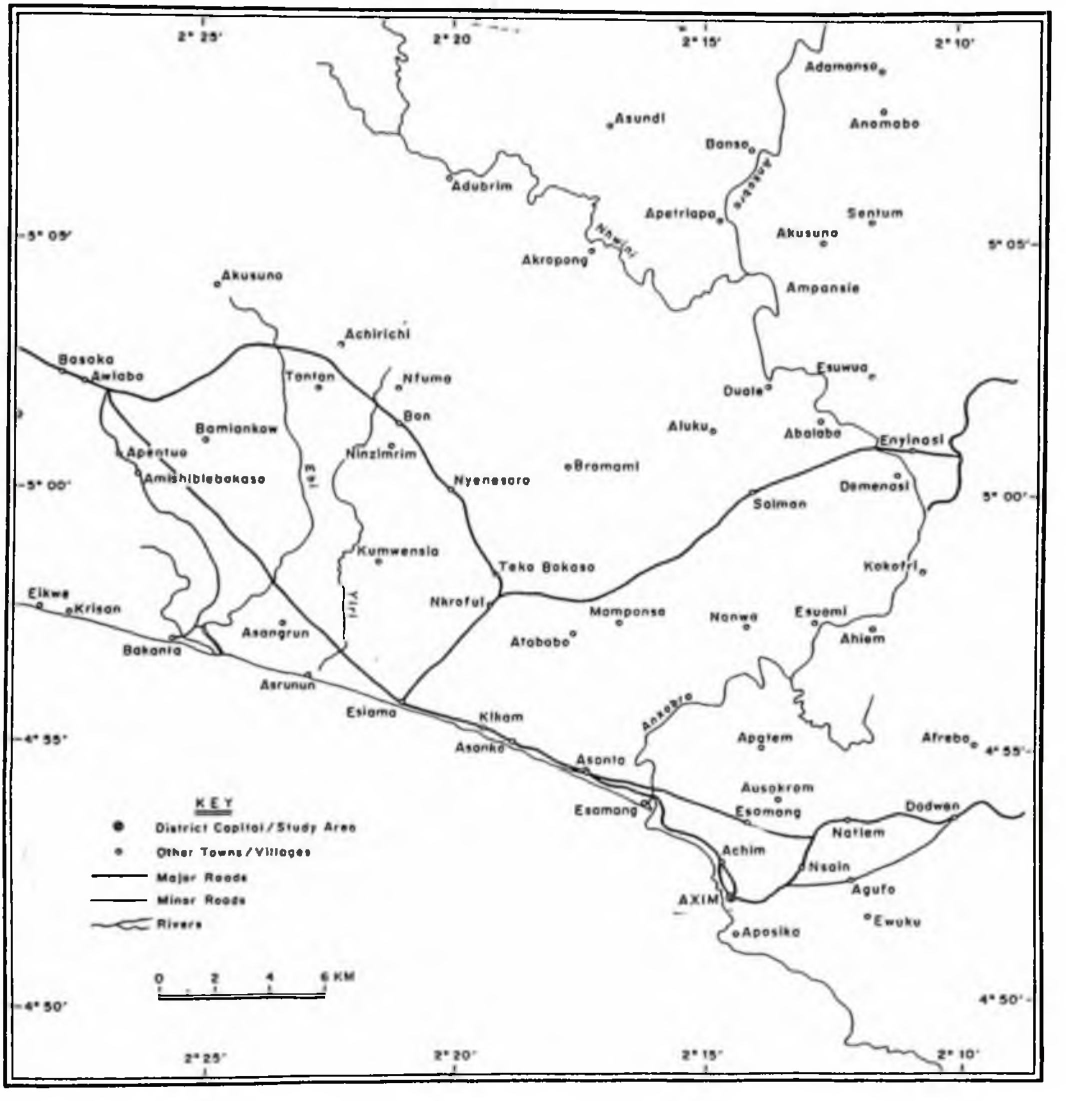
APPENDIX I

Fig. MAP SHOWING THE LOCATION OF THE STUDY AREA – AXIM, AND ITS ENVIRONS IN THE WESTERN REGION OF GHANA



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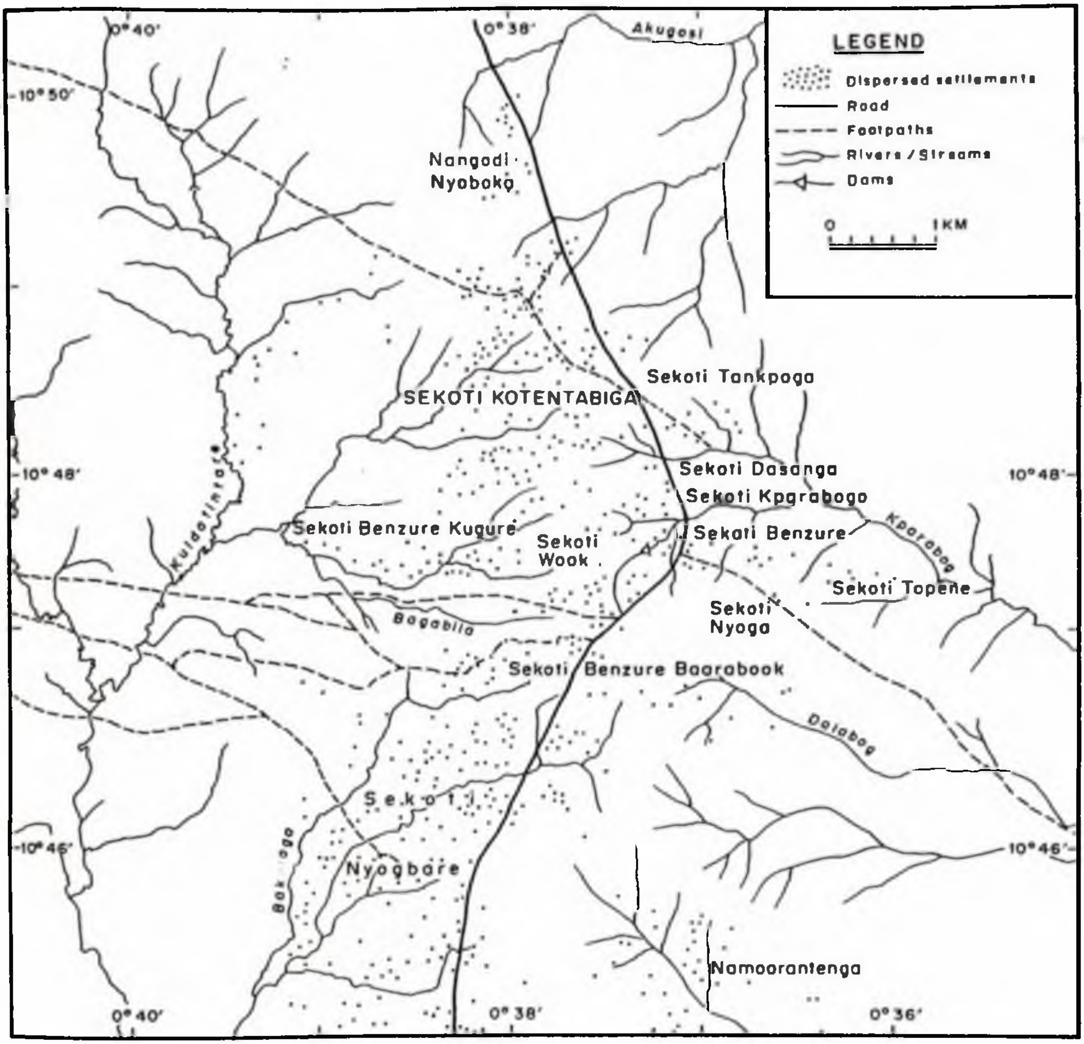
APPENDIX II

MAP OF SEKOTI



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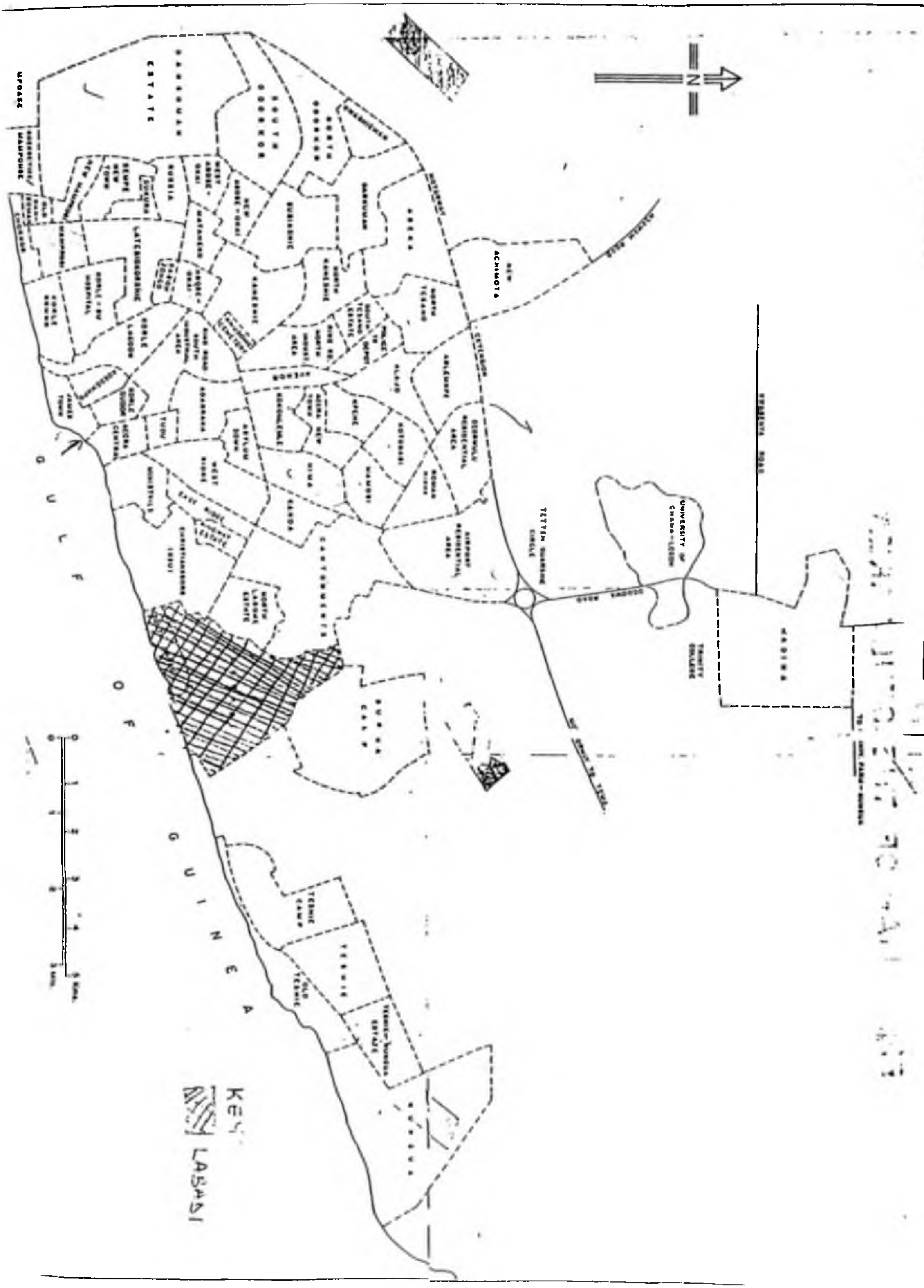
APPENDIX III

Fig. [redacted] 1

RESIDENTIAL AREAS OF ACCRA



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APPENDIX IV

DEPARTMENT OF NUTRITION AND FOOD SCIENCE
UNIVERSITY OF GHANA
LEGON

INVESTIGATION OF THE POSSIBLE ROLE OF GOITROGENS
IN THE DEVELOPMENT OF
IODINE DEFICIENCY DISORDERS IN GHANA

1. Survey of Endemic Goiter and Cretinism Prevalence

Subject's Name:..

Age:.........................

Serial No.:.........................Sex: /____/ Male /____/ Female

Examined at: (a) Home..................

Home Address:...

....

....

House No.:...

(b) School...

Name of School...

....

School Address...

....

....

....

School Block No.:...

Town............................Altitude above sea level.................

Years in locality:.....................Former Residence..................

Thyroid Sizes: /____/ 0 /____/ 1A /____/ 1B /____/ 2

/____/ 3 /____/ 4 /____/ A

Cretinism

Weight...........Kg Height...........cm

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APPENDIX V

Tick where applicable

Symptom	Present	Absent
1. Spasticity (tightness of muscles affecting gait)		
2. Slow speech		
3. Edema of eyelids		
4. Peripheral edema		
5. Edema of face		
6. Small physical size for age		
7. Slow movements		
8. Sparse eyebrows		
9. Coarse features		
10. Low hair-line		
11. Slow spreading vacuous smile		
12. Flat Planter arches		
13. Bone deformities		
14. Dry, Scaly skin		
15. Thickened Skin		
16. Full Puffy face		
17. Sparseness of hair		
18. Protuberant abdomen		
19. Poor Vision		
20. Poor hearing		
21. Deaf		
a) Partial		
b) Complete		
22. Convulsions		
23. Dizziness		
24. Mental retardation		
a) According to townsfolk		
b) According to Interviewer		
25. Mute		
26. Deaf and Mute		
27. In Area with Severe endemic goitre?		
28. Goitre		

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APPENDIX VI

IV. FOOD INTAKE (24 hour Dietary Recall)

Please name the foods you ate or drank all day yesterday.
Estimate quantities of each food item:

Name:...Sex:.................

Serial No:.................................. Age:...........................

Name of School:..

House No:..

Town:..

	Food Item	Quantity
Midnight (12.00 a.m.)		
Breakfast		
A.M. Snack		
Lunch		
P.M. Snack		
Supper		
Bedtime Snack		
Midnight (12.00)		

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APPENDIX VII

DIET HISTORY FORM

Name:.. Sex:....................

Serial No.:.................................... Age:....................

Name of School:...

House No.:.........................

Town:...

For the following list of foods, please indicate the number of times on the average you ate them per day (D), Week (W), Month (M), or Year (Y) whichever is appropriate.

Record the number of times eaten in the first column and circle the appropriate frequency in the second column. Estimate quantities of each food item in the last column.

e.g. If you eat cassava fufu 2 times per day, record as follows:-

No. of Times		Frequency	Quantity
Cassava Fufu	2	(D) W M Y	₵100/ each

If you never ate a food, put an (0) in No. of times.

	No. Of Times	Frequency	Quantity
1. Cassava			
Do you eat Cassava? Yes, No In what form do you take it?			
a. Boiled Cassava		D W M Y	
b. Cassava Fufu		D W M Y	
c. Cassava Kokonte		D W M Y	
d. Gari		D W M Y	
e. Other (Specify)..........			
2. Millet			
a. Masa (Cake)			
b. Porridge		D W M Y	

.../2

	No. of Times	Frequency	Quantity
2. Millet (Contd)			
c. Tuo Zaafi		D W M Y	
d. Flour ("Gari")		D W M Y	
e. Fula		D W M Y	
f. "Walisa" (Steamed Millet)		D W M Y	
g. Others (Specify).........			
3. Groundnuts			
a. Raw Groundnuts		D W M Y	
b. Boiled Groundnuts		D W M Y	
c. Roasted Groundnut		D W M Y	
d. Groundnut Paste		D W M Y	
e. Groundnut Soup		D W M Y	
f. Other (Specify)..........			
4. Any Hungry Season Vegetables/ Fruits? (Feb - July)			
a.		D W M Y	
b.		D W M Y	
c.		D W M Y	
d.		D W M Y	
e.		D W M Y	
f.		D W M Y	
g.		D W M Y	
5. Marine Fish			
a. Tuna		D W M Y	
b. Herrings		D W M Y	
c. Mackerel (Saman)		D W M Y	
d. Burrito (Boiboe)		D W M Y	
e. Other (Specify)..........		D W M Y	
6. Vegetables			
a. Cassava Leaves		D W M Y	
b. Cocoyam Leaves		D W M Y	
c. Bitter Leaves		D W M Y	
d. Sour Leaves		D W M Y	

.../3

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	No. Of Times	Frequency	Quantity
6. Vegetables (Contd)			
e. Bean Leaves		D W M Y	
f. Okro Leaves		D W M Y	
g. Garden Egg Leaves		D W M Y	
h. Cabbage		D W M Y	
i. Lettuce		D W M Y	
j. Other (Specify).........		D W M Y	
7. Seaweeds			
Are there some vegetables and leaves that are eaten from the sea?			
a.		D W M Y	
b.		D W M Y	
c.		D W M Y	
8. Milk			
a. Fresh Milk		D W M Y	
b. Sour Milk		D W M Y	
c. Other (Specify)..........			

WATER

Water Supply

1. Sources of water supply

Public tap /____/ Pond /____/ Bore-Hole /____/ River /____/

Other (Specify).................................

2. Storage of Water:

In Pot /____/ Drums /____/ Buckets /____/

Other (Specify).................................

3. How far is the water supply from house/school?..........................

4. How frequently does flooding occur here?..............................

....

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LATRINES*

5. What type of latrine do you use?

   Water Closet /___/ KVIP /___/ Pit /___/

   Other (Specify) ....

6. How do you take your bath?

   In buckets /___/ Shower /___/

   Other (Specify)..

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APPENDIX VIII

NATIONAL IDD PREVALENCE SURVEY : DRAFT CORE QUESTIONNAIRE

FORM NO --- FN

1. BASIC DATA

1.1 Interviewer's code ________ INT

1.2 Date of interview ________ DATE

1.3 District Name .... ________ DISTRICT

Code ________

1.4 EA Code .... ________ EA

1.5 Subject .... ________ SUBJECT

1. Child 2. Women

1.6 Name ....

1.7 Age .... ________ AGE

1.8 Sex .... ________ SEX

1. MALE 2. FEMALE SEX

1.9 Place of Interview .... ________

1.HOME 2.SCHOOL 3.OTHER PLACE

1.10 Region of Birth ________ BIRTH

1.11 Years lived in this Region ________ YEARS

1.12 Highest Educational level :
1. None
2. Primary
3. JSS/Middle/Technical
4. Secondary
5. Tetiary

1.13 Main Occupation :
1. Farmer
2. Trader
3. Unskilled manuel
4. Commercial manual OCC.
5. Clerical/Admin.
6. Professional/Execu.

2. DRINKING WATER

2.1 Main source of drinking water in the rainy season :
1. Piped water into house
2. Public Tap.
3. Borehole
4. Well
5. River/Stream DWRAINS
6. Pond/dam
7. Other:
8. Not known

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2.2 Main source of Drinking

1. Piped Water into Houses
2. Public Tap
3. Borehole
4. Well
5. River/stream DWDRY
6. Pond/dam
7. Other:
8. Not known

2.3 FLOODING

2.3.1 Do you have flooding here?

(1) Annually (2) 2 - 5 years, (3) Rarely, (4) Never FLOOD

3. ["I AM NOW GOING TO READ OUT A LIST OF VARIOUS FOODS AND THEN I WILL GO BACK OVER THEM ONE BY ONE TO ASK YOU HOW MANY TIMES YOU HAVE EATEN EACH OF THEM WITHIN THE PAST WEEK"]

3.1	Millet	1. 0x	2. 1x	3. 2-4x	4. 5-9x	5.10x	9. NK	MILLET
3.2	Cassava	1. 0x	2. 1x	3. 2-4x	4. 5-9x	5.10x	9. NK	CASSAVA
3.3	Maize	1. 0x	2. 1x	3. 2-4x	4. 5-9x	5.10x	9. NK	MAIZE
3.4	Bamboo Shoots	1. 0x	2. 1x	3. 2-4x	4. 5-9x	5.10x	9. NK	BAMBOO SHOOTS
3.5	Sea Fish	1. 0x	2. 1x	3. 2-4x	4. 5-9x	5.10x	9. NK	SEA FISH
3.6	Groundnuts	1. 0x	2. 1x	3. 2-4x	4. 5-9x	5.10x	9. NK	GROUNDNUTS

3.7 Have you eaten any food within the past week which contained?

3.8.1 Maggi (1) Yes (2) No

3.8.2 Junto (1) Yes (2) No

4. VITAMIN-A FOOD SOURCES: How many times have you eaten in past week?

		(1) 0x	(2) 1x	(3) 2-4x	(4) 5-9x	(5) 10x	(9) NK	
4.1	Cod-liver oil	1	2	3	4	5	9	CD. OIL
4.2	Carrots	1	2	3	4	5	9	CARROT
4.3	Pawpaw	1	2	3	4	5	9	PAWPAW
4.4	Margarine (Vit.A fortified)	1	2	3	4	5	9	MARGARINE
4.5	Liver	1	2	3	4	5	9	LIVER
4.6	Palm Oil	1	2	3	4	5	9	PALM OIL
4.7	Green Leaf Vegetables	1	2	3	4	5	9	GREEN VEG.
4.8	Sweet Potatoes (Red & Yellow)	1	2	3	4	5	9	SWEET POT.
4.9	Mangoes	1	2	3	4	5	9	MANGOES
4.9.1	Tomatoes	1	2	3	4	5	9	TOMATOES
4.9.2	Butter	1	2	3	4	5	9	BUTTER
4.9.3	Eggs (Yolk)	1	2	3	4	5	9	EGGS

5. VITAMIN A CLINICAL

5.1 Bitot Spot (1) Yes (2) No BITOT SPOT

5.2 Xerophthalmia (1) Yes (2) No XEROP

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6. PEM

6.1 Weight (kg) .... WT

6.2 Height (cm) .... HT

6.3 Edemn (1) Yes (2) No EDEMA

Which type of salt do you (Usually/Normally) use with food? SALT

1. Rock 4. Other ....
2. Sea 9. NK
4. Imported

7. GOITRE

7.1 What do you think is the most common cause of Goitre? GCAUSE

An illness

Spirtual

Born with it

Food Eaten

Iodine Deficiency

Other :

9. Not Known

7.2 Do you think it is a good or bad thing to have Goitre?

Good/Bad/Neither/ 9. NK

8. EXAMINATION FOR IODINE DEFICIENCY DISORDERS

8.1 Goitre Grade 00 : .... GGRADE

1A : ....

2B : ....

22 : ....

33 : ....

44 : ....

8.2 Goitre Nodules (1) Yes (2) No (8. NA) GNODULE

8.3 Cretinism Suspected (1) Yes (2) No [If yes, complete a Mental Assessment Form] CRETIN

8.4 Cretinism Verification Form ____________________ MAFN

____

9. CRETINISM VERIFICATION

9.1	Specify	Yes (1)	No (2)	
9.2	Reported Mentally Retarded	1	2	SPAS

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9.3	Deaf (Partial or Complete)	Yes (1)	No (2)	MNTR
9.4	Mute	1	2	DEAF
9.5	Impaired Articulation	1	2	MUTE
9.6	Stunted in Height	1	2	IART
9.7	Flat Plantar Aches	1	2	HT
9.8	Bone Deformities	1	2	PLANTAR
9.9	Dry Sealy Skin	1	2	BDEF
9.9.1	Thickened Skin	1	2	DSKIN
9.9.2	Spareseness of Hair	1	2	TSKIN
9.9.3	Slowness of Movement	1	2	HAIR
9.9.4	Protuberant Abdomen	1	2	SIMOVE
9.9.5	Unbilical Hernia	1	2	PABDO
9.9.6	Edema of Eyelid	1	2	EEDEMA
9.9.7	Exolphthaluria (Prominent Eyeballs)	1	2	EXTHAL

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APPENDIX IX : GOITRE PREVALENCE AMONG SCHOOLS AND AREAS OF STUDY (SEXES SEPARATE)

(NUMBER OF CHILDREN IN PARENTHESIS)

(a) Males

Survey Area		Location of Children	No Examined	% Normal	% Total Goitre
	1.	Sekoti Prim/JSS	69	39.1 (27)	60.9 (42)
Sekoti	2.	Nyobare School	22	45.5 (10)	54.5 (12)
	3.	Community	68	63.2 (43)	36.8 (25)
		Total	159	50.3 (80)	49.7 (79)
	1.	Anglican School	29	96.6 (28)	3.4 (1)
Axim	2.	Methodist School	25	100.0 (25)	0 (0)
	3.	Catholic School	32	87.5 (28)	12.5 (4)
	4.	Ahle Sule School	27	81.5 (22)	18.5 (5)
		Total	113	91.4 (103)	8.8 (10)
	1.	Mamprobi Prim/JSS	25	84.0 (21)	16.0 (4)
Accra	2.	Nima Prim/JSS	26	76.9 (20)	23.1 (6)
	3.	Osu R.E. Prim/JSS	22	77.3 (17)	22.7 (5)
	4.	Medina Prim/JSS	22	92.3 (24)	7.7 (2)
		Total	95	86.3 (82)	17.9 (17)

(b) Females

Survey Area		Location of Children	No. Examined	% Normal	% Total Goitre
	1.	Sekoti Prim/JSS	17	23.5 (4)	76.5 (13)
Sekoti	2.	Nyobare School	16	37.5 (5)	62.5 (10)
	3.	Community	57	33.3 (19)	66.7 (38)
		Total	90	32.2 (29)	67.8 (61)
	1.	Anglican School	32	87.5 (28)	12.5 (4)
Axim	2.	Methodist School	26	65.4 (17)	34.6 (9)
	3.	Catholic School	25	64.0 (16)	36.0 (9)
	4.	Ahle Sule School	24	75.0 (18)	25.0 (6)
		Total	107	73.8 (79)	26.2 (28)
	1.	Mamprobi Prim/JSS	25	80.0 (20)	20.0 (5)
Accra	2.	Nima Prim/JSS	32	68.8 (22)	31.2 (10)
	3.	Osu R.E. Prim/JSS	33	87.9 (29)	12.1 (4)
	4.	Medina Prim/JSS	21	66.7 (14)	33.3 (7)
		Total	111	76.6 (85)	23.4 (26)

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(c) Sexes Combined

Survey Area		Location of Children	No Examined	% Normal	% Total Goitre
	1.	Sekoti Prim/JSS	86	36.0 (31)	64.0 (55)
Sekoti	2.	Nyobare School	38	42.1 (16)	57.9 (22)
	3.	Community	125	49.6 (62)	50.4 (63)
		Total	249	43.8 (109)	56.2 (140)
	1.	Anglican School	61	91.8 (56)	8.2 (5)
Axim	2.	Methodist School	51	82.4 (42)	17.6 (9)
	3.	Catholic School	57	77.6 (44)	22.8 (13)
	4.	Ahle Sule School	51	78.4 (40)	21.6 (11)
		Total	220	82.7 (182)	17.3 (38)
	1.	Mamprobi Prim/JSS	50	82.0 (41)	18.0 (9)
Accra	2.	Nima Prim/JSS	58	72.4 (42)	27.6 (16)
	3.	Osu R.E. Prim/JSS	55	83.6 (46)	16.4 (9)
	4.	Medina Prim/JSS	47	80.9 (38)	19.1 (9)
		Total	210	79.5 (167)	20.5 (43)

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WEIGHT FOR HEIGHT (WASTING)

APPENDIX X : PERCENTAGE DISTRIBUTION OF PROTEIN-ENERGY MALNUTRITION AMONG 10-14 YRS. SCHOOL CHILDREN ACCORDING TO SCHOOL OF THE STUDY AREA (SEX SEPARATE)(NUMBER OF CHILDREDN IN PARENTHESIS)

MALES

Survey Area		Lacation of Children	No Examined	% Mildly Wasted	% Moderately Wasted	% Severely Wasted	% Normal	Total Wasted (Mod. + Sev.)
Sekoti	1.	Sekoti Prim/JSS	52	44.2 (23)	15.2 (8)	0 (0)	40.4 (21)	15.2 (8)
	2.	Nyobare Prim.	24	54.2 (13)	25.0 (6)	0 (0)	20.8 (5)	25.0 (6)
	3.	Community	76	32.9 (25)	25.0 (19)	0 (0)	42.1 (32)	25.0 (19)
		Total	152	40.1 (61)	21.7 (33)	0 (0)	38.2 (58)	21.7 (33)
Axim	1.	Anglican Prim/JSS	29	13.8 (4)	0 (0)	0 (0)	86.2 (25)	0 (0)
	2.	Catholic Prim/JSS	32	6.2 (2)	0 (0)	0 (0)	93.8 (30)	0 (0)
	3.	Methodist Prim/JSS	25	16.0 (4)	0 (0)	0 (0)	84.0 (21)	0 (0)
	4.	Ahle Sule Prim. School	27	25.9 (7)	0 (0)	0 (0)	74.1 (20)	0 (0)
		Total	113	15.0 (17)	0 (0)	0 (0)	85.0 (96)	0 (0)
Accra	1.	Mamprobi South Prim/JSS	20	15.0 (3)	0 (0)	0 (0)	85.0 (17)	0 (0)
	2.	Nima One Prim/JSS	26	34.6 (9)	0 (0)	0 (0)	65.4 (17)	0 (0)
	3.	Osu R.E. Prim/JSS	22	50.0 (11)	13.6 (3)	0 (0)	36.5 (8)	13.6 (3)
	4.	Madina Queen of Peace	22	36.4 (8)	4.5 (1)	0 (0)	59.1 (13)	4.5 (1)
		Total	90	34.5 (31)	4.4 (4)	0 (0)	61.1 (55)	4.4 (4)

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APPENDIX XI : PERCENTAGE DISTRIBUTION OF PROTEIN-ENERGY MALNUTRITION AMONG 10-14 YEARS SCHOOL CHILDREN ACCORDING TO SCHOOL OF THE STUDY AREA (SEX SEPARATE) (NUMBER OF CHILDREN IN PARENTHESIS)

HEIGHT-FOR-AGE (STUNTING)

MALES

Survey Area		Location of Children	No Examined	% Mildly Stunted	% Moderately Stunted	% Severely Stunted	% Normal	% Total Stunted (Mod. + Severe)
Sekoti	1.	Sekoti Prim/JSS	52	21.2 (11)	11.5 (6)	0 (0)	67.3 (35)	11.5 (6)
	2.	Nyobare Prim.	24	54.2 (13)	25.0 (6)	0 (0)	20.8 (5)	25.0 (6)
	3.	Community	76	31.6 (24)	23.7 (18)	0 (0)	44.7 (34)	23.7 (18)
		Total	152	31.6 (48)	19.7 (30)	0 (0)	48.7 (74)	19.7 (30)
Axim	1.	Anglican Prim/JSS	29	55.2 (16)	20.7 (6)	0 (0)	24.1 (7)	20.7 (6)
	2.	Catholic Prim/JSS	32	40.6 (13)	18.8 (6)	12.5 (4)	28.1 (9)	31.3 (10)
	3.	Methodist Prim/JSS	25	44.0 (11)	20.0 (5)	0 (0)	36.0 (9)	20.0 (5)
	4.	Ahle Sule Prim.	27	40.8 (11)	33.3 (9)	11.1 (3)	14.8 (4)	44.4 (12)
		Total	113	45.1 (51)	23.0 (26)	6.2 (7)	25.7 (29)	29.2 (33)
Accra	1.	Mamprobi South Prim/JSS	20	55.0 (11)	5.0 (1)	0 (0)	40.0 (8)	5.0 (1)
	2.	Nima One Prim/JSS	26	19.2 (5)	0 (0)	0 (0)	80.8 (21)	0 (0)
	3.	Osu R.E Prim/JSS	22	45.5 (10)	0 (0)	4.5 (1)	50.0 (11)	4.5 (1)
	4.	Madina Queen of Peace	22	13.6 (3)	9.1 (2)	4.5 (1)	72.7 (16)	13.6 (3)
		Total	90	32.2 (29)	3.3 (3)	2.2 (2)	62.2 (56)	5.6 (5)

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APPENDIX X : PERCENTAGE DISTRIBUTION OF PROTEIN-ENERGY MALNUTRITION AMONG 10-14 YEARS SCHOOL CHILDREN ACCORDING TO SCHOOL OF THE STUDY AREA (SEX SEPARATE) (NUMBER OF CHILDREN IN PARENTHESIS)

WEIGHT FOR HEIGHT (WASTING)

FEMALE

Survey Area		Location of Children	No Examined	% Mildly Wasted	% Moderately Wasted	% Severely Wasted	% Normal	% Total Wasting (Mod. + Severe)
Sekoti	1.	Sekoti Prim/JSS	13	53.8 (7)	15.4 (2)	7.7 (1)	23.1 (3)	23.1 (3)
	2.	Nyobare Prim	12	58.4 (7)	33.3 (4)	0 (0)	8.3 (1)	33.3 (4)
	3.	Community	61	34.4 (21)	37.7 (23)	0 (0)	27.9 (17)	37.7 (23)
		Total	86	40.7 (35)	33.7 (29)	1.2 (1)	24.4 (21)	34.9 (30)
Axim	1.	Anglican Prim/JSS	32	3.1 (1)	0 (0)	0 (0)	96.9 (31)	0 (0)
	2.	Catholic Prim/JSS	25	20.0 (5)	0 (0)	0 (0)	80.0 (20)	0 (0)
	3.	Methodist Prim/JSS	26	7.7 (2)	0 (0)	0 (0)	92.3 (24)	0 (0)
	4.	Ahle Sule Prim.	24	25.0 (6)	0 (0)	0 (0)	75.0 (18)	0 (0)
		Total	107	13.1 (14)	0 (0)	0 (0)	86.9 (93)	0 (0)
Accra	1.	Mamprobi South Prim/JSS	22	9.1 (2)	0 (0)	0 (0)	90.9 (20)	0 (0)
	2.	Nima One Prim/JSS	28	14.3 (4)	0 (0)	0 (0)	85.7 (24)	0 (0)
	3.	Osu R.E. Prim/JSS	33	24.2 (8)	0 (0)	0 (0)	75.7 (25)	0 (0)
	4.	Madina Queen of Peace	25	36.7 (9)	12.0 (3)	0 (0)	52.0 (13)	12.0 (3)
		Total	108	21.3 (23)	2.8 (3)	0 (0)	75.9 (82)	2.8 (3)

APPENDIX XI : PERCENTAGE DISTRIBUTION OF PROTEIN-ENERGY MALNUTRITION AMONG 10-14 YEARS SCHOOL CHILDREN ACCORDING TO SCHOOL OF THE STUDY AREA (SEX SEPARATE) (NUMBER OF CHILDREN IN PARENTHESIS)

HEIGHT-FOR-AGE (STUNTING)

FEMALES

Survey Area		Location of Children	No Examined	% Mildly Stunted	% Moderately Stunted	% Severely Stunted	% Normal	% Total Stunted (Mod. + Severe)
Sekoti	1.	Sekoti Prim/JSS	13	7.7 (1)	0 (0)	7.7 (1)	84.6 (11)	7.7 (1)
	2.	Nyobare Prim.	12	16.7 (2)	0 (0)	0 (0)	83.3 (10)	0 (0)
	3.	Community	61	26.2 (16)	13.1 (8)	3.3 (2)	57.4 (35)	16.4 (10)
		Total	86	22.1 (19)	9.3 (8)	3.5 (3)	65.1 (56)	12.8 (11)
Axim	1.	Anglican Prim/JSS	32	37.5 (12)	21.9 (7)	6.2 (2)	34.4 (11)	28.1 (9)
	2.	Catholic Prim/JSS	25	20.0 (5)	12.0 (3)	0 (0)	68.0 (17)	12.0 (3)
	3.	Methodist Prim/JSS	26	46.2 (12)	0 (0)	3.8 (1)	50.0 (13)	3.8 (1)
	4.	Ahle Sule Prim	24	33.3 (8)	37.5 (9)	4.2 (1)	25.0 (6)	41.7 (10)
		Total	107	34.6 (37)	17.8 (19)	3.7 (4)	43.9 (47)	21.5 (23)
Accra	1.	Mamprobi South Prim/JSS	22	22.7 (5)	4.5 (1)	0 (0)	72.7 (16)	4.5 (1)
	2.	Nima One Prim/JSS	28	10.7 (3)	0 (0)	0 (0)	89.3 (25)	0 (0)
	3.	Osu R.E. Prim/JSS	33	15.2 (5)	0 (0)	0 (0)	84.8 (28)	0 (0)
	4.	Madina Queen of Peace	25	24.0 (6)	4.0 (1)	0 (0)	72.0 (18)	4.0 (1)
		Total	108	17.6 (18)	1.8 (2)	0 (0)	80.5 (87)	1.8 (2)

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APPENDIX XII : COMPARISON OF BIOCHEMICAL DATA ACCORDING TO SCHOOLS AND AREA OF STUDY

(Mean ± S.E.M. Number of Children in Parenthesis)

Survey Area		Location of Children	No Examined	Urinary I Excretion (μg/dL)	Urinary I/SCN Ratios (μg/mg)
	1.	Sekoti Prim/JSS	11	19.92 ± 3.66	17.27 ± 3.59
Sekoti	2.	Nyobare School	6	18.45 ± 5.54	18.47 ± 6.05
	3.	Community	19	21.56 ± 3.38	12.82 ± 2.04
	4.	Missing Label Sample	7	34.88 ± 4.13	19.97 ± 4.04
		Total	43	22.93 ± 2.13	21.36 ± 5.92
	1.	Anglican School	13	45.94 ± 4.13	53.60 ± 7.02
Axim	2.	Catholic School	12	44.93 ± 5.00	33.80 ± 7.22
	3.	Methodist School	18	53.99 ± 4.60	46.90 ± 4.21
	4.	Ahle Sule School	16	41.24 ± 4.54	35.07 ± 7.25
		Total	59	46.92 ± 2.25	42.15 ± 9.89
	1.	Mamprobi Prim/JSS	14	22.89 ± 1.34	23.53 ± 3.78
Accra	2.	Nima Prim/JSS	13	20.17 ± 1.47	22.31 ± 5.60
	3.	Osu R.E. Prim/JSS	14	19.57 ± 1.51	33.42 ± 3.51
	4.	Medina Prim/JSS	14	19.29 ± 1.69	26.37 ± 5.60
		Total	55	20.48 ± 0.76	29.06 ± 3.39

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APPENDIX XIII : COMPARISON OF URINARY IODINE EXCRETION AMONG CHILDREN WITH GOITRE AND THOSE WITHOUT GOITRE FROM AREAS OF STUDY (Mean ± S.E.M. NUMBERS OF CHILDREN IN PARENTHESIS)

Survey Area		Location of Children	No Examined	Urinary I Excretion (μg/dL) with Goitre	Urinary I Excretion (μg/dL) without Goitre
Sekoti	1.	Sekoti Prim/JSS	11	18.00 ± 4.73 (8)	25.09 ± 3.97 (3)
	2.	Nyobare School	6	21.84 ± 6.11 (5)	7.05 (1)
	3.	Community	19	18.30 ± 5.69 (10)	24.78 ± 4.37 (9)
Axim	1.	Anglican School	13	39.79 ± 5.82 (5)	49.79 ± 4.91 (8)
	2.	Catholic School	12	49.91 ± 5.92 (6)	39.94 ± 4.84 (6)
	3.	Methodis School	16	54.50 ±10.67 (5)	52.06 ± 5.42 (11)
	4.	Ahle Sule School	16	42.34 ± 6.41 (8)	40.14 ± 6.83 (8)
Accra	1.	Mamprobi Prim/JSS	14	24.48 ± 1.59 (7)	21.27 ± 2.08 (7)
	2.	Nima Prim/JSS	13	20.69 ± 2.18 (7)	19.58 ± 2.18 (6)
	3.	Osu R.E. Prim/JSS	14	21.82 ± 1.39 (5)	18.91 ± 2.23 (9)
	4.	Medina Prim/JSS	14	17.26 ± 4.21 (5)	19.42 ± 2.46 (9)

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APPENDIX XIX : PERCENTAGE REQUIREMENT MET OF ENERGY, PROTEIN, AND VITAMIN A IN 24-HOUR DIETARY RECALL ACCORDING TO SCHOOLS AND AREA AGE GROUP 10-14 YEARS (SEXES COMBINED) (MEAN ± S.E.M.)

Survey Area	Location of Children	N	% RDA Energy	% RDA Protein	% RDA Vitamin A	% Calories from Millet	% Calories from Cassava
Sekoti	Sekoti Prim/JSS School	11	75.39 ± 4.10	97.58 ± 4.10	82.60 ± 44.90	58.54 ± 5.10	No much consumed
	Nyobare School	6	64.97 ± 6.00	107.17 ± 20.30	74.50 ± 15.20	67.18 ± 6.40	-do-
	Community Children	18	75.60 ± 5.10	119.61 ± 10.51	87.55 ± 12.20	64.17 ± 2.88	-do-
Axim	Anglican School	13	72.73 ± 7.19	127.83 ± 13.41	1994.30 ± 587.22	Not much Consumed	34.50 ± 5.93
	Catholic School	12	58.57 ± 4.60	106.30 ± 9.50	2591.04 ± 550.52	-do-	26.18 ± 4.19
	Mathodist School	16	58.30 ± 3.97	100.40 ± 5.80	1718.18 ± 469.50	-do-	20.70 ± 4.21
	Ahle Sunna School	16	69.44 ± 4.10	103.65 ± 5.80	1798.20 ± 462.70	-do-	45.60 ± 4.75
Accra	Mamprobi South Prim/JSS	14	86.14 ± 4.38	150.82 ± 12.85	1685.07 ± 472.22	-do-	24.12 ± 3.90
	Nima 1 Prim/JSS	13	69.70 ± 4.35	109.42 ± 12.33	1557.57 ± 397.67	-do-	19.12 ± 4.30
	Osu RE	13	72.23 ± 5.17	126.34 ± 11.27	963.07 ± 425.39	-do-	16.54 ± 4.71
	Madina Queen of Peace	10	64.92 ± 4.89	101.75 ± 10.19	1666.29 ± 481.60	-do-	22.04 ± 6.20

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APPENDIX XX

SAMPLE CALCULATION OF ENERGY AND PROTEIN REQUIREMENT OF CHILDREN AGED 10-14 YEARS

Energy Requirement

Males

The energy needs of children aged 10-18 years was determined on the basis of Basal Metabolic Rate (BMR), based on mean actual body weight in kilogram. The predicted BMR equation is (17.5W + 651) kcal/day, where W = body weight in kg. (FAO/WHO, 1985)

(a) For 10-12 year old, weight, 34.5Kg,

Energy Requirement = 1.75 (17.5W + 651)

= 1.75 (17.5 x 34.5 + 651)

= 2200 kcal/day.

(b) For 12-14 years, weight 44Kg,

Energy Requirement = 1.68 (17.5W + 651) kcal/day.

= 1.68 (17.5 x 44 + 651)

= 2387.28 kcal/day

= 2400 kcal/day.

Females

The energy requirement of females, aged 10-18 years, the BMR = 12.2W + 746.

(a) For 10-12, weight = 36Kg,

Energy Requirement = 1.64 (12.2 x 36 + 746) kcal/day

= 1945.73

= 1950.00 kcal/day

(b) 12-14 years, W = 46.5Kg,

Energy Requirement = 1.59 (12.2 x 46.5 + 745)

= 2100.00 kcal/day

Protein Requirement

The protein intake was adjusted for the Net Protein Utilization (NPU) values of the diet. The NPU of the reference protein which may be egg or milk is 100%. When the source of protein is a mixed diet as eaten in developing countries, the NPU may be taken as 60-70 percent (FAO/WHO, 1985). For this study, the NPU has been taken as 70 percent. Therefore, corrected protein intake = Mean actual intake x 0.70.

∴ Actual Protein Intake for:

(1) aged 10-14 years male = 1g/kg body weight

(2) aged 10-12 years female = 1g/kg body weight

(3) aged 12-14 years female = 0.95g/kg body weight

Source : FAO/WHO. 1985.

Males

∴ For a male, aged 10-12 years, weight = 34.5Kg

(1) Protein Requirement = $\frac{1g}{kg}$ x 34.5Kg = 34.5g

(2) For 12-14 years, weight = 44Kg.

∴ Protein Requirement = $\frac{1g}{kg}$ x 44kg = 44.0g

Females

(1) For a Female, aged 10-12 years, weight = 36kg

∴ Protein Requirement = 1g x 36kg = 36g

(2) For a Female, aged 12-14 years, weight = 46.5kg

∴ Protein Requirement = $\frac{0.95g}{kg}$ x 46.5kg

= 44g.