THE EFFECT OF HOUSEHOLD PROCESSING ON THE THIAMINE, RIBOFLAVIN AND NIACIN CONTENT OF SOME LOCALLY CONSUMED NIGERIAN FOODS

BY

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DIGITIZED

DECLARATION

I hereby declare that this thesis is a record of my own research work and has not been submitted for the award of a degree at any other University. Information and excerpts from published and unpublished works of others have been acknowledged in the text.

MAC-INEGITE, JOSE OMOM

CERTIFICATION

This thesis entitled "The effect of Household processing on the thiamine, Riboflavin and Niacin content of some locally consumed Nigerian Foods" by Jose Cmom Mac-Inegite meets the regulations governing the award of the Degree of M.Sc. in Biochemistry of Ahmadu Bello University, and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This work is dedicated to the Divine

Creator who made this work to be possible

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ABSTRACT

Riboflavin, thiamine and Niacin content of 74 locally consumed Nigerian foods were evaluated. The effect of commonly adopted household processing techniques, such as blanching, decortication, frying, roasting and cooking on the thiamine, riboflavin, and Niacin content of Nigerian foods were also simultaneously quantified. Data obtained from present study was then utilised to evaluate the intakes of these vitamins in 60 apparently healthy university students.

Results obtained from present study revealed that mean Niacin, thiamine and riboflavin contents of Nigerian foods are 2.49±1.05, 0.33±0.14, and 0.21±0.12 mg/100g respectively. Legumes had significantly higher ($p<0.05$) content of the three vitamins. Vegetables also preferentially contained higher ($p<0.05$) vitamins than most foods when classified into their respective food groups. The thiamine, riboflavin, and Niacin losses following cooking for 60 minutes was 47.70±0.74, 40.30±0.69 and 15.25±2.449 respectively. Better retention were observed for foods that were converted to paste or roasted. Ripening appear to increase the concentration of the vitamins. It is suggested that microbial and chemical reactions occurring during ripening may account for these observations. The percentage losses for thiamine following blanching of

vegetables, was highest ($p<0.05$) in spinach while decortication of cowpea (legumes) produced 7.70±1.70 mean loss in thiamin.

The male subjects considered in present study had a mean thiamin, riboflavin, and Niacin intakes of 0.83±0.30, 0.56±0.28 and 13.54±1.20 mg/day respectively. The female subjects on the other hand had a mean thiamin, riboflavin and Niacin intakes of 0.56±0.29, 0.40±0.18, 10.29±1.50 mg/day respectively. These values fall below the recommended daily Dietary allowance of 1.20, 1.80 and 19.80 mg/day respectively for adult males by the WHO (1974). Similarly the WHO (1974) recommended Dietary allowances for adult females is 0.90, 1.30 and 14.50 mg/day of thiamin, riboflavin and Niacin respectively.

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Chapter 1

1.0 INTRODUCTION

In recent years, various techniques have been proposed and adopted for use in household operations and at industrial level for the processing of foods with the aim that the foods are ensured of nutrient and aesthetic conservations, improved palatability and a ready allowance for introduction of novel diets for the human populace. Such household processing techniques include, grilling, roasting, frying, braising and stewing (Baldwin and Cotterill, 1979).

Although conflicting evidence exist in the literature as to the need for processing of foods, accumulating reports (Manorama and Sarojini, 1982: Harris and Karmas, 1975) tend to support the need for a relative degree of food processing at the household level. Several investigators (Khan et al, 1979, Kirk, 1979: and Khan and Ghafoor, 1978) have shown that the nutritive value, palatability and texture of many foods can be increased by the thermal destruction of toxic proteins and peptides, enzymes, antivitamins and other natural toxicants in foods. Philips et al, (1981) also reported that cooking of legumes not only improves organoleptic properties but also increases nutritional quality. On the contrary other workers (Khan and Eggum, 1979: Harris and Von Loesecke, 1960) have produced evidence for decreased nutrient level during household processing. For instance, Khan and Eggum(1979) reported a decrease in the protein quality of foods processed at home or industrial level. Accord-

ing to Sgarbieri et al.(1972) and Kirk (1979), the decrease in protein quality is predominantly due to oxidative degradation of amino acids through the Maillard reaction involving the amino groups of proteins and reducing sugars or carbonyl groups of secondary degradation products from lipid oxidation. Kim, and Duwastien (1984) also reported loss of protein as a result of leaching in blanched beans.

According to High (1975) processing may alter the physical and chemical forms of fats and carbohydrates and change the isomerization of polyunsaturated fatty acids (pufas). Available evidence (Pikul et al 1984: Igene et al, 1980: Dawson and Schienhololz, 1976) showed that household processes such as cooking and refrigeration do promote oxidative rancidity of certain foods. Pearson et al. (1983) have equally reported that lipid oxidation products such as malonaldehyde is responsible for human cancer and heart diseases.

Kashani and Valadon (1983, 1984) also highlighted decreased total available carbohydrates during salting and roasting operations.

Accumulating evidence (Harris and Karmas 1975) also revealed that the water soluble vitamins are susceptible to damage during processing. Edijala (1980) for instance reported thiamine and riboflavin losses ranging from 41.7 - 66.10% and 41.2 - 52.9%, respectively during the cooking of six varieties of cowpeas. Other workers (Oguntona and Bender 1976, Selman and Rolfe 1980) attributed much of the vitamin losses to leaching into the cooking water. Cooking operations which involve the discarding of the broth will therefore result in great losses of these vita-

rins. According to Harris and Karmas (1975), vitamins are destroyed in foods during processing because they are sensitive to pH, light, oxygen, metal ions, moisture or water activity in the food.

Particular interest is focused on the effect of household processes on thiamine (vitamin B_1), riboflavin (vitamin B_2) and Niacin (vitamin B_3) in this dissertation because of the essential role of these water soluble vitamins in intermediary metabolism. It is well established that thiamine in its diphosphate form (TPP) is involved in oxidative decarboxylation reaction vital to the metabolism of carbohydrates. Other workers (Horwitt, 1972; Mayer and Gershoff, 1968; Goldsmith and Miller, 1967) have also identified riboflavin and niacin as constituents of coenzymes, flavin mononucleotide (FMN), and flavin adenine dinucleotide (FAD), and nicotinamide adenine dinucleotide (NAD) and nicotinamide ademine dinucleotide phosphate (NADP). These coenzymes are involved in the oxido-reduction reactions essential for cellular respiration and oxidative phosphorylation (Lopez et al, 1975).

Available evidence (Sauberlich et al, 1979) showed that the requirement for the three vitamins is related to Caloric and protein intakes. Olatunji et al, (1980) and (Thekorbnye and Ngyoddy 1985) for instance have reported that the habitual diets of the Nigerian populace is based on root and tuber staples which are predominantly high carbohydrate diets. Such diets will definitely precipitate increased requirements for thiamine and niacin which are involved in carbohydrate metabolism.

Furthermore, Beaten and McHenry (1964) also indicated increased requirement for niacin during low protein and tryptophan intakes. Various workers (Miller, 1985; Ihekoronye and Ngoddy 1985) have shown that appreciable quantities of protein and riboflavin are derived from foods of animal origin. In Nigeria where such foods are expensive and out of the reach of the generality of the populace, it is evident that B-complex vitamin deficiencies as a consequence of increased requirement arising from high caloric or suboptimal intakes from the diets may be prevalent amongst the Nigerian population.

Biochemical and clinical deficiency of these three vitamins have been reported (Candlish 1977) to result to nutritional disorders such as beriberi, Cheilosis (angular stomatitis) and pellagra. Existing mortality and morbidity statistics (FAO/WHO 1965) show that nutritional disorders attributable to deficiency of thiamine (vitamin B_1), riboflavin (vitamin B_2) niacin (vitamin B_3), and vitamin A occur widely in most developing countries. Current estimates by Ajayi and James (1984) on adolescents and pregnant women revealed a 30% prevalence of aribotlavinosis (biochemical vitamin B_2 deficiency) amongst these segments of the population.

However,there appears to be no direct data to substantiate the prevalence of thiamine, and niacin deficiency in Nigeria. Circumstantial evidences however, tend to suggest that most investigators have not focused direct attention on these water-soluble vitamins because of the lack of comprehensive information on the relative content of these vitamins in foods of the Nigerian diets. At present, there is scanty information on the thiamine

(vitamin B_1), riboflavin (vitamin B_2), and niacin (vitamin B_3) content of most Nigerian foods especially those consumed within the Northern part of the country.

This study was therefore conducted to evaluate the possible effect of household processing operations on the thiamine, riboflavin, and niacin content of some locally consumed Nigerian foods. The retention of the vitamins in foods after household handling operations shall also be studied. An attempt will also be made to determine the thiamine, riboflavin, and niacin intakes of a cross section of the Northern population with a view to assessing the adequacy of the vitamins in these subjects.

2.0 REVIEW OF LITERATURE

2.1 THERMAL PROCESSING - COOKING

In most developing countries, household processing techniques adopted for foods include blanching, roasting, decortication, cooking. Most of these food processing techniques can be more largely classified under heat treatment. Baldwin and Cotterill (1979) defined cooking procedures to involve:

(a) roasting or baking in a closed oven;

(b) broiling by exposure to direct heat;

(c) braising or heating in moisture;

(d) frying in either shallow or deep fat; and

(e) pressure cooking.

Rosenau (1979) defined blanching as a heat treatment used in the processing of vegetables with the principal aim of inactivating degradative enzymes and deaerate the product. Frying can also be referred to as cooking in boiling fat or oil. Frying may be classified based on deep fat frying or shallow fat frying.

According to Baldwin and Cotteril (1979) the most common temperature for roasting is about 163 ^{o}C while for braising the liquid in which the food is cooked is maintained at a temperature

of 35 - 99°C. It is well documented that [illegible] promote varying degrees of nutrient losses. [illegible] (Harris and Lovenberg, 1968), for instance, that [illegible] nutritive [illegible] Mills, [illegible] though thermal processing of [illegible] foods is important for producing a safe and palatable product, it can also result in the formation of [illegible] compounds. Dijkstra and Zhubik (1974), for instance, reported that mutagens such as benzo(a) pyrene are formed in [illegible] foods when subjected to [illegible] processing methods (broiling, grilling). Pensabene et al (1974) also reported the formation of [illegible] products when starch and secondary amines are heated together.

Nevertheless, cooking can be beneficial in obtaining the maximum nutritive value of certain foods. For instance, it has been reported (Fisher and Tappay, 1973; Liener, 1973; and Chandrasekhar et al, 1981) that the nutritive value of legumes could be improved by heat processing partly because of the destruction of trypsin inhibitors, hemagglutinin, and other toxic substances. According to Kakade et al, (1973) about 40% of the growth - depressing effect of unheated soybeans has been related to the presence of trypsin inhibitors, while the remainder is related to poor availability of undenaturated soybean proteins.

2.1.1 EFFECT OF HOUSEHOLD HEATING TECHNIQUES ON PROTEINS

Khan and Eggum (1979) and Ford (1973) have independently reported that heat processing damage to proteins can result from

destruction of amino acids by oxidation, loss of palatability, modification of some of the linkages between the amino acids so that the release is delayed during digestion, and formation of new linkages that are not hydrolysed during digestion. Kirk (1979) reported that during roasting of pure protein preparation at various temperatures (100 ^{o} to 300 ^{o}C) and times (0 to 20 minutes), tryptophan, methionine, cystine, basic and β-hydroxyamino acids are readily destroyed compared with acidic and neutral amino acids in pure casein and lysozyme preparations. According to Achinewhu (1981), the thermal degradation of protein is increased in carbohydrate containing foods. Hussein and Nouman (1978) also reported decrease in amino acid content of bean after cooking. Bjarnason and Carpenter (1970) on the other hand showed that poor nutritive quality of lysine in heated protein was due to the reaction of E-amino group of lysine with the amide group of asparagine and glutamine.

Doughty and Walker (1982) have documented the formation of lysino alanine (NE - (DL - 2 - amino - 2 - carboxyethyl) - L - lysine) during alkaline treatment of proteins. Sterberg et al, (1975) and De Groot et al, (1976) have also shown that lysinoalanine is formed in home-cooked and commercially prepared food. Lysinoalanine has been associated with decreased protein availability and is considered a factor in the reduction of the nutritional value of heated proteins. Elias et al (1979) observed 5 to 10% loss of protein for whole bean seeds during cooking with the solids in the cooking broth having a protein of 13 to 20% depending on the variety.

BROWNING REACTIONS

The Maillard reaction is characterised by a series of chemical phenomena involving non-enzymatic browning. This reaction has been shown (Johnes 1959; Clark and Cannenbaum 1973; Adrian, 1974; and Hurrell, 1977) to account for loss of the nutritional value of proteins following the interaction of free amino groups of proteins with reducing sugars or carbonyl groups of secondary degradation products from lipid oxidation. This is mainly as a result of loss of amino acids especially the limiting amino acids such as lysine.

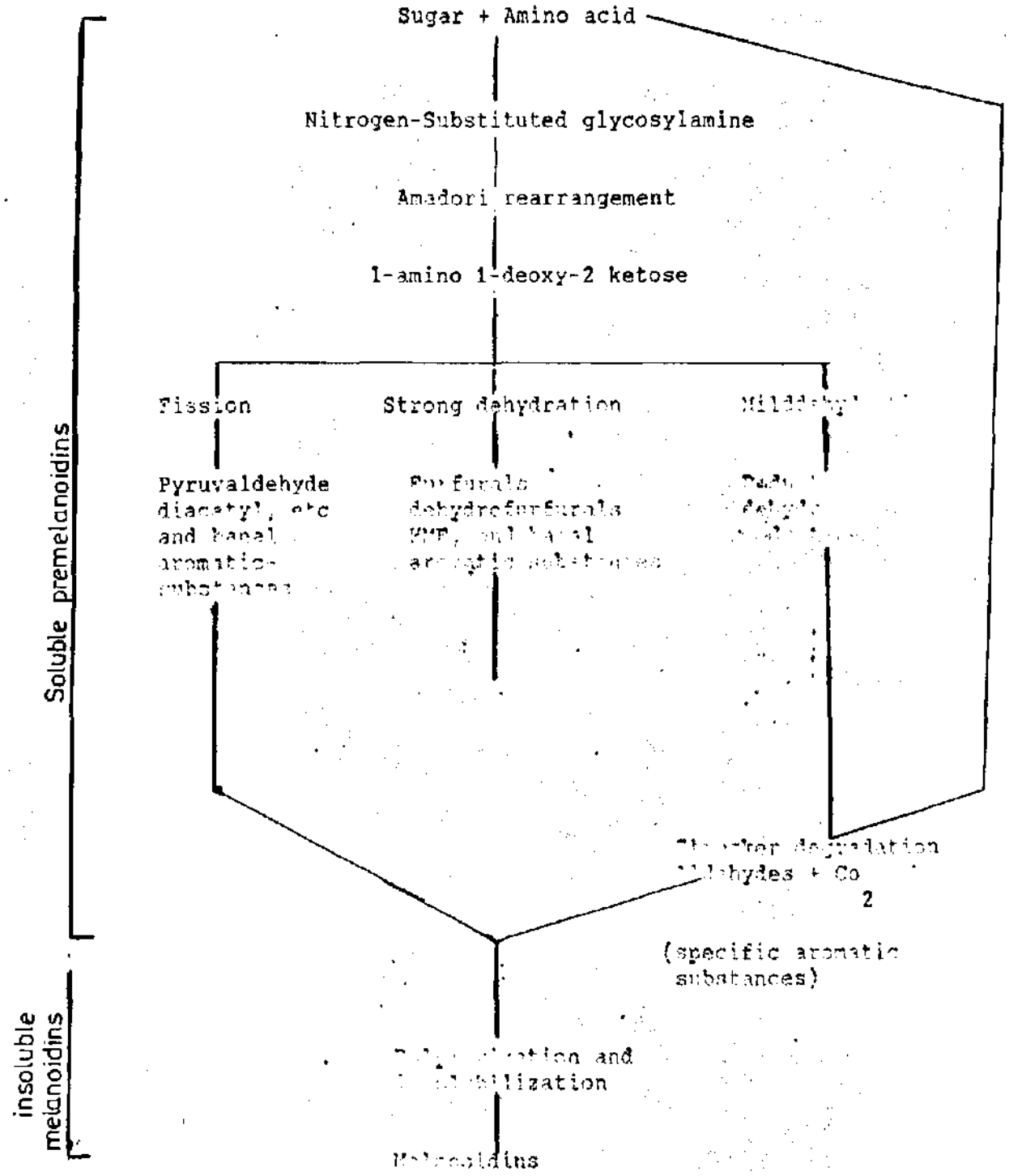
The biological consequences of the Maillard reaction fall under 3 categories:

(a) sugar and amino acid destruction, the resulting fall in protein quality being the most damaging.

(b) formation of detrimental substances of an antinutritional or toxic nature and

(c) formation of molecules with appetizing aromas, with consequent effect on psychosensorial and flavour levels.

A broad outline of the reaction as described by Adrian (1974) is given in fig. 1.0. Lea and Hannan (1950) reported that the initial stages of the Maillard reaction leads to the formation of colourless compounds, N-deoxyketosyl-amino acid derivatives. These have been shown to result in nutritional losses at room temperature even before the brown discoloration appears. Several investigators (Osner and Johnson, 1968; Linvingston et



Stages of the Maillard Reaction

[illegible] and Bourne et al.(1975) reported losses in nutritional value of proteins in the presence of carbohydrates. They observed that some protein-rich foods are severely reduced by roasting, baking and drying.

Other reports (Tarabo et al 1975; Johnson et al, 1977; 1979) indicate that fructose - phenylalanine, the amadori compound resulting when glucose reacts with phenylalanine is totally unavailable as a source of oral phenylalanine for chick growth because of slow absorption from the gut.

2.1.2 EFFECT OF HOUSEHOLD HEATING TECHNIQUE ON CARBOHYDRATES

Williams (1976) observed that although carbohydrates are generally regarded as less vulnerable to heat processing as certain labile nutrients such as vitamins they may be affected as well during processing, depending on the temperature and period of heating, moisture content, and pH of the solution. According to Kirk (1979) and Kon (1979) monosaccharides and some oligo- and polysaccharides may be lost during heat processing as a result of leaching. Hydroxymethyl furfural is considered as the most toxic compound formed during the heat processing of carbohydrates, especially simple sugars. El Nahru (1977) also reported significant decrease in carbohydrate content of beans subjected to cooking.

2.1.3 EFFECT OF HOUSEHOLD HEATING ON LIPIDS

Heat processing or cooking may cause lipolytic, oxidative rancidity, polymeric or other degradative mechanisms of lipids

which result into modification of both the physical and biological properties of the lipid. It has been shown (Artman 1969) that fats or oils used in restaurants, and homes are subject to decreased unsaturation, slight increases in peroxides, conjugation of double bonds, and formation of polymers because of their intermittent use. Studies carried out by Dugan (1968) confirmed the presence of both toxic and carcinogenic compounds such as N-nitrosopyrolidine and N-nitrosamines in oxidised and thermally abused lipids. Numerous researchers (Carpenter et al, 1963; Crawford et al, 1967) have reported that the addition of abused lipids to foods is antagonistic to thiamine, riboflavin, proteins, vitamin A and tocopherol. Kaunitz et al, (1955) and Carpenter et al, (1963) also observed that the reactions of oxidised lipids and their secondary reaction products with proteins result in cross-linking between proteins as well as destruction of lysine and the sulfur- containing amino acids. Malonaldehyde, a secondary product of lipid oxidation has been shown (Pearson et al, 1983) to be a principal factor in protein cross-linking reaction by the formation of Schiff bases with lysine and other free amino groups in the protein.

2.2 EFFECT OF HOUSEHOLD PROCESSING ON VITAMINS

Processing techniques that accompany household operations and industrial production of various foods have been observed (Cain, 1967; Schroeder, 1971; and Finglas and Faulks, 1984) to facilitate significant losses in vitamin levels of such processed foods. The vitamins mostly affected are the water-soluble.

Indigenous investigators (Ogunmodede, 1972; Eka and Nobb, 1976) and Edijala 1980) have revealed that household processing operations do result into great losses of vitamins in some Nigerian foods. Ogunmodede (1972) for instance observed that traditional processing of Nigerian grains resulted into losses of up to 20% in thiamine and riboflavin.

2.2.1 EFFECT OF COOKING ON VITAMINS

Edijala (1980) reported high losses of thiamine and riboflavin ranging from 41.7 - 60.2% and 38.9 - 52.0%, respectively during cooking of 6 varieties of cowpeas. Augustin (1981) also in his own investigation observed that during cooking, beans retained more than 70% water soluble vitamins. According to Clarke (1982), great losses of nutrients occur when rice is prepared by cooking and rejecting of excess water. Law (1970) also reported losses of thiamine up to 75% in restaurant handling of vegetables. Other investigators (Priestley, 1979; Olmedilla-brad et al, 1983) reported considerable losses of 7.7 and 13% of thiamine and riboflavin respectively during the cooking of eggs.

Earlier investigations (Roy and Rao 1963) have shown that the alkalinity of the cooking water has effect on losses of thiamine in rice during cooking. Roy and Rao (1963) observed that there was no loss in thiamine of rice subjected to boiling in distilled water while 8 - 10% and 36%, respectively was lost in cooking with tap water and well water. Hein and Hutchings (1971), on the other hand, reported that during cooking of meat, there was little loss of niacin; Up to one half may be lost in

the fats, the losses being greater in broiling or frying than in frying. Lang (1970) also reported losses of 19% and 43% niacin respectively in boiled and baked potatoes. However, Harris and Karmas (1975) reported that heating of cereal grains especially under alkaline condition generally leads to increase in the niacin content.

Some household processing methods such as preparation of "moin-moin", "akara" have been shown (Akinyele 1980, Idigbe, 1980) to enhance the retention of thiamine, riboflavin and niacin. However, one conflicting report (Osifo 1971) revealed losses of 62 and 69% of niacin and riboflavin respectively during the preparation of "ogi".

2.2.2 EFFECT OF BLANCHING ON VITAMINS

Blanching is usually performed by dipping the products into boiling water or steam for two to five minutes depending on the type and size of the pieces. Baloch et al, (1977) and Steinbuch (1980) have independently shown that processing operations such as blanching, post-blanching treatment and dehydration are responsible for losses of vitamins and other nutrients in foods. Several other workers (Lund,1975: Thompson,1982: Selman and Rolfe, 1980: and Nieo et al,1990) have reported great losses of vitamins during the blanching of vegetables.

According to Rosenau (1979) and Alzamora et al, (1985) the losses in nutrients especially water - soluble vitamins during blanching are caused primarily by leaching, oxidation, and thermal destruction. Dietrich et al,(1970) and Lopez and Baganis

(1971) have shown that the loss of water soluble vitamins and minerals during the blanching process is in the order of decreasing losses, hot water > steam > microwave. Gibbs (1977) reported that the loss of water-soluble vitamins during blanching may range from 0 to 60% as a result of leaching and thermal destruction. Awoth et al, (1980) for instance showed that okra blanched at 70 mins in water at 98°C and that blanched 5 min steam retained 54 and 63%, respectively, of the initial ascorbic acid content.

Although blanching causes destruction and loss of nutrients, failure to reach the required time-temperature conditions for a product results in only partial inactivation of enzymes thereby resulting in nutrient losses during processing that exceed those incurred by blanching.

2.2.3 EFFECT OF HOUSEHOLD PRESERVATION ON VITAMINS

Sulfites are often used as preservative both at home and in industrial processes. Oguntona and Bender (1976) reported the splitting of thiamine into inactive thiazole and pyrimidine sulphonic acid during sulfite treatment of potatoes. They also observed that sulfite soaking of potatoes doubled the loss caused by frying for 5 min. Potatoes cooked in water for 20 min samples soaked in sulfite. Mapson and Wagner (1961) in their own study observed 25% loss of thiamine after sulfite treatment of potatoes, and 35.0 - 40.0% overall loss on subsequent cooking. Hermus (1970) also reported losses of thiamine in minced meat up

[illegible] from the use of sulphur dioxide as preservative.

2.2.4 EFFECT OF HOUSEHOLD FERMENTATION ON VITAMINS

Fermentation processes as commonly adopted in household operations have been shown (Hamad and Fields,1979) to improve and enhance the niacin content of cereal grains because of the release of bound niacin. Similarly, Zamora and Fields, (1979) reported an increase in riboflavin when cowpeas underwent natural fermentation.

2.2.5 EFFECT OF LIGHT ON VITAMINS

The effect of light on the retention of riboflavin in foods has been documented (Bender 1978a). Stephens and Chaintain, (1959) reported losses of 17% riboflavin in bread rolls exposed to light for 24 hours, while losses reduced to 13% and 2% respectively on wrapping in amber and orange plastic. The lumiflavin formed during the photolysis of riboflavin has been reported (Bender 1978b) to destroy vitamin C in milk.

Available evidence (Wagner - Jauregg 1972) shows that thiamine, and niacin are insensitive to photo-oxidation.

2.3 INTERACTION OF VITAMINS WITH OTHER ANTI NUTRITIONAL FACTORS IN FOODS

Existing reports (Weswig et al 1946, Sealock and Goodland, 1944; and Fujita, 1954) indicate that most foods contain antinutritional factors that might inhibit the absorption of essential

nutrients. Antagonists which interfere with the function of vitamins have also been observed (IRM 1984). Thiaminases, enzymes which are present in small concentrations in vegetables and animal food products have been shown (Wilson 1973, Muller et al. 1975, and Chang and Hilker 1976) to be capable of degrading thiamine into biologically inactive products. Thiamine has also been reported (Joslyn and Leichter, 1966) to be decomposed by thermostable factors in ferns which have been identified as both nitrogenous and flavonoid. According to Liu et al. (1967) losses of thiamine in experimental diets for laboratory animals occur during storage at room temperature primarily because of catalytic effect of salt mixtures.

McIntire and Frost, (1944) have also reported that s and ? amino acids decrease the rate of thiamine destruction. Dwivedi and Arnold, (1973) similarly demonstrated that proteins protect thiamine from destruction, although there are conflicting reports regarding the protective mechanisms of proteins on thiamine. Dwivedi and Arnold (1973) reported that SH groups of albumin have protective role in preventing thiamine destruction.

Weswig et al, (1946) reported the existence of antithiamine substances in plant materials. Chang and Hilker (1976) have identified some of the antithiamine factors as phenols and flavonoids. Rungruangsak et al, (1977) studied the interaction of thiamine with caffeic acid and other phenol derivatives and concluded that the polyphenolic compounds with orthoxy groups have a marked antithiamine effect whereas those with para and meta hydroxy substituent showed medium and no effect respectively. Chang and Hilker (1976) also observed that the antithiamine

acidity of tea appeared to be related to its tannin content. Mosiatelonaki et al (1977) have shown that these tannins are present in tea, fruits and vegetables commonly consumed by people in various parts of the world. They also demonstrated that thiamine react with tannic acid to form modified thiamine derivatives. Priestley (1979) reported that thiamine participate in a Maillard-type of reaction with glucose. IFT (1984) also reported the binding of ovoflavoprotein with riboflavin in eggs.

Candlish (1977) and Wojtoiak (1975) have also independently reported that the unavailable form of niacin is bound to polysaccharide and peptides in a complex niacytin, which is not hydrolysed by the gastrointestinal tract (G.I.T).

2.4 OCCURRENCE

Particular attention has been focused on the vitamins, thiamine, riboflavin and niacin in present study because of their essentiality in human nutrition. Available evidence (Geervani and Theophilus 1980, Steyn-Parva and Monfoort 1963) indicate that the three vitamins are widespread in foods. Excellent sources of thiamine include lean meat, yeast, eggs, whole careals, legumes and nuts. Lamden (1972) reported the occurrence of free, mono, di- and triphosphoric esters, and mono-, and disulfide of thiamine with the diphosphate ester predominating as a protein complex with carboxylase in most foods.

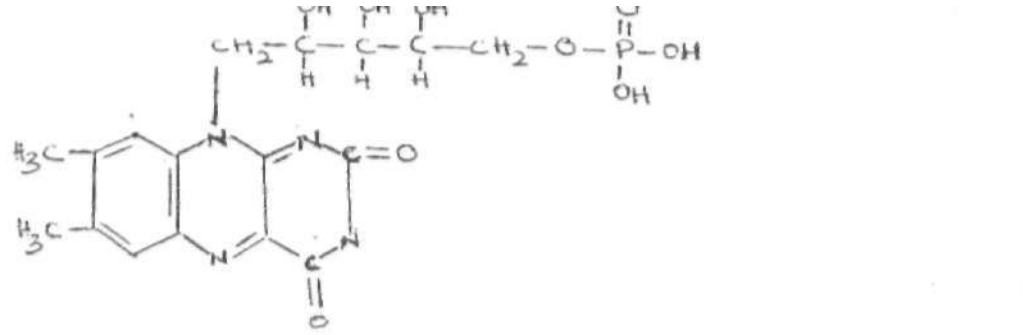
Riboflavin exist in nature either as free riboflavin, flavin mononucleotide (FMN) or flavin adenine dinucleotide (FAD) (fig 2.0). Wagner and Folkers (1964) reported the existence of free riboflavin in whey, urine and retina. Hartman and Dryden (1965,

1971) also reported the existence of 65 to 95% of free riboflavin in cow's milk. Good sources of riboflavin include beef muscle, poultry, eggs, tomatoes, yeast and vegetables.

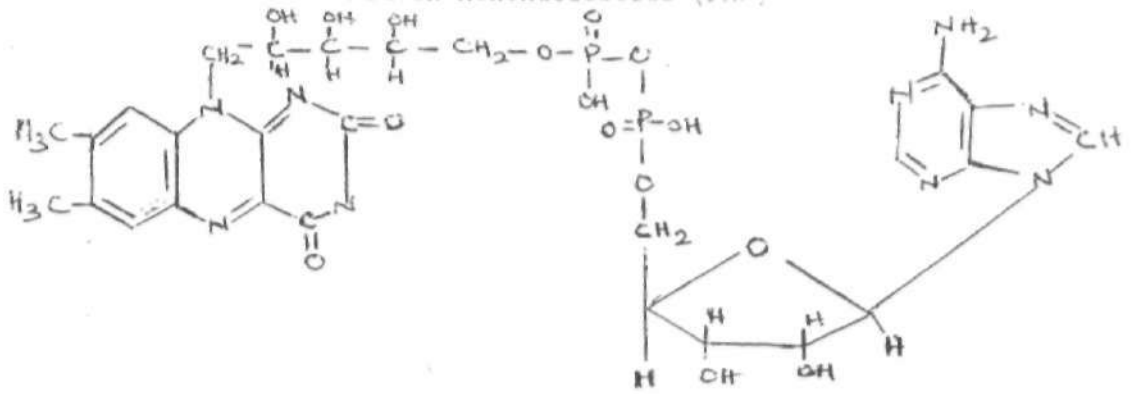
Niacin is found in tissues largely in the form of niacinamide as a constituent of two coenzymes, nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). (fig 2.0). Harris and Karmas (1975) have reported the existence of unavailable form of niacin in many cereal grains, which is liberated during heating. Excellent dietary sources of niacin include, liver, kidney, lean meat, wheat, peanuts, yeast, legumes, poultry and leafy plants.

2.5 CHEMISTRY AND PROPERTIES

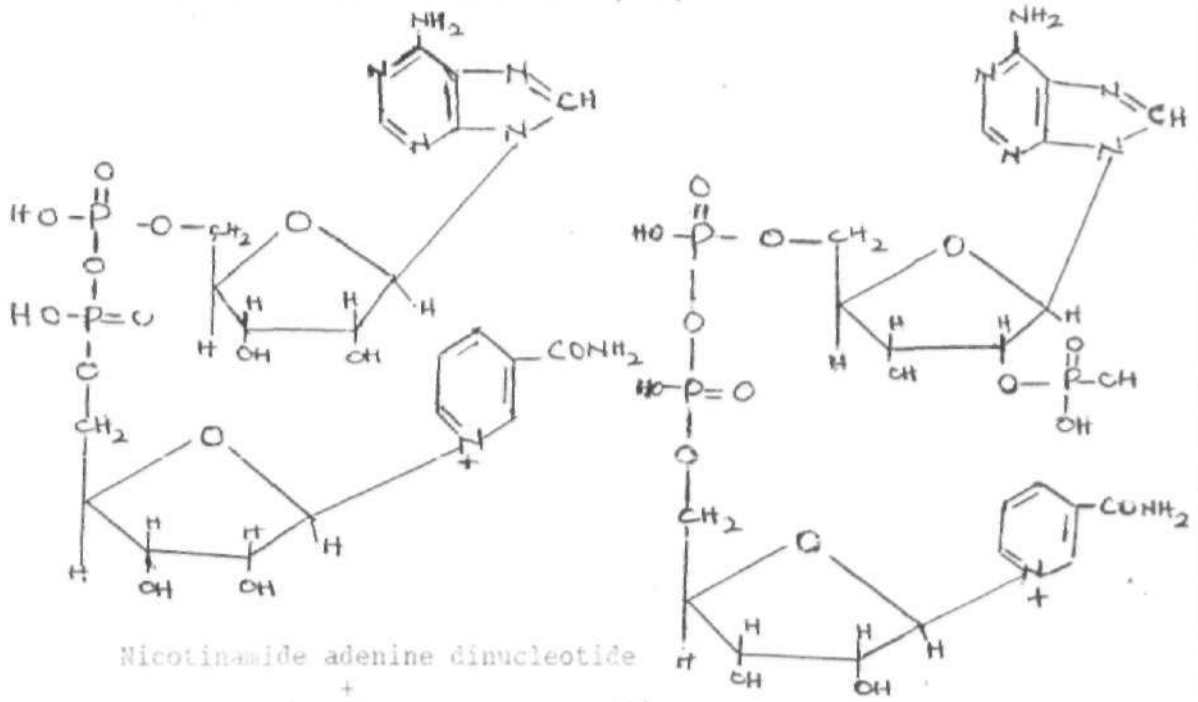
The chemistry and properties of the three water soluble vitamins, thiamine, riboflavin and niacin (fig 3.0) have been elucidated. Riboflavin naturally exist as a yellowish green fluorescent compound while pure isolates of thiamine and niacin are white crystalline solids. Harris and Karmas (1975) showed that riboflavin and thiamine are readily decomposed by heat under alkaline conditions, while niacin is stable to boiling in neutral, acid or alkaline solutions. Other workers (Bender



Flavin Mononucleotide (FMN)



Flavin adenine dinucleotide (FAD)



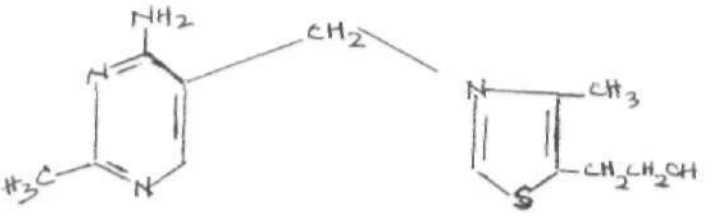
Nicotinamide adenine dinucleotide

(NAD^+)

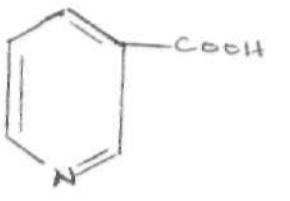
Nicotinamide adenine
dinucleotide Phosphate

$(NADP^+)$

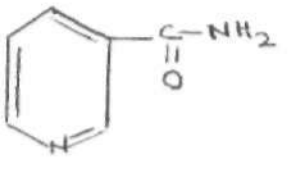
Fig. 2.0 Structures of (a) FMN, (b) FAD, (c) NAD, and (d) $NADP^+$



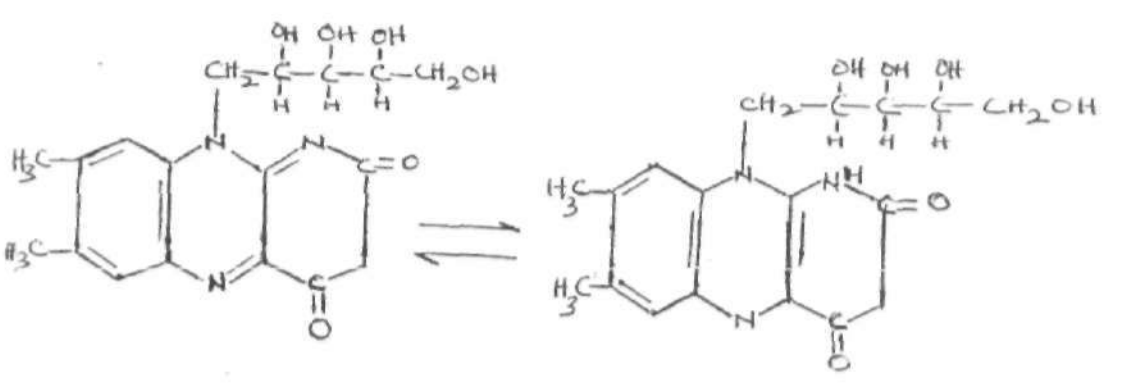
(a) Thiamine



(b) Nicotinic acid



(c) Nicotinamide



(Oxidized state) (reduced state)

(d) Riboflavin

Fig 3.0 Structure of (a) thiamine, (b) and (c) Niacin and (d)Riboflavin.

1978a, Lachoy (1960) reported that thiamine and riboflavin are relatively stable to heat under acidic conditions. Wagner-Jauragg (1972) also reported the conversion of riboflavin to lumiflavin and lumichrome during photolysis under alkaline and acid or neutral conditions respectively, while thiamine and niacin are insensitive to photo oxidation..

2.6 FUNCTIONS

The functions of the three vitamins in intermediary metabolism have been defined. Available evidence (Henderson and Schenker, 1976: Itokawa, 1977) shows that thiamine in its biologically active thiamine pyrophosphate (diphosphothiamine, cocarboxylase) functions principally in carbohydrate metabolism as a coenzyme in such reactions as the decarboxylation of a-keto acids, particularly of pyruvate and a-ketoglutarate. Horecker and Smyrniotic (1953) and Racker et al, (1953) have also reported independently of the involvement of thiamine pyrophosphate as a coenzyme for transketolase in the pentose phosphate pathway of glucose metabolism.

Mayer and Gershoff (1968) and Peskin et al (1967) have observed in separate reports that thiamine is essential for normal growth, appetite, digestion, gastro intestinal tonus and nerve activity because of its involvement in the synthesis of acetylcholine. According to Barchi (1976) and Dakshinamurti (1977), thiamine in its phosphoric ester form is involved in the function of excitable membrane by the activation and inactivation of the sodium transport.

Various investigators (Mayer and Gershoff 1968, Horwitt 1971, Hartman and Dryden 1974) have reported that riboflavin has a metabolic function as a constituent of two coenzymes, FMN and FAD. These coenzymes function as components of enzyme [illegible] active compounds called flavoproteins, and are involved in the respiratory chain and oxidative phosphorylation by functioning as proton and electron carriers. FMN is the coenzyme for several enzymes such as cytochrome C-reductase, L-amino acid oxidase, glycolic acid oxidase and Wachurg's yellow enzyme. FAD is a coenzyme for diaphorase, xanthiane oxidase, D amino acid oxidase, and glycine oxidase. As a constituent of these enzymes riboflavin is involved in the enzymatic oxidation of glucose, fatty acids and purines. Sure[illegible] and Brisbett (1975) have shown that riboflavin is a fundamental constituent of animal tissues including man, and therefore essential for growth and normal health. Mayer and Gershoff (1963) on the other hand have suggested a role in visual mechanism of the retina for riboflavin. Other investigators (Bhat and Gopolan 1974a, 1974b, and Gallender and Gallender, 1979) observed that riboflavin added to the diets of rats prevents the occurrence of cataracts. Lavate and Sreenivasan (1959) also reported that riboflavin is essential in maintaining the integrity of the nervous tissue.

Other investigators (Myer, 1966; Goldsmith and Miller, 1967) have documented that niacin exert important metabolic functions in intermediary metabolism as a constituent of two coenzymes, NAD and NADP which are necessary for cellular oxidations. Niacin has also been shown (Mayer and Gershoff 1968) to be essential for

growth and development in the young. Yeh (1975) observed that niacin inhibit ketogenesis by blocking the conversion of AcetylCo A to acetate.

2.7 DEFICIENCY

Suboptimal intakes of most water-soluble vitamins have been shown (Candlish 1977) to precipitate a state of deficiency. Presently, the etiological factors precipitating such nutritional disorders, the symptoms and diagnosis of biochemical and clinical forms of deficiency of the three vitamins have been clearly documented.

Inadequacy of thiamine for instance has been shown (Latham, 1970; McGraw and Metcalf, 1975) to cause a nutritional disorder known as beriberi. According to the FAO/WHO (1965) report, clinical signs of thiamine deficiency recorded in nutrition surveys include absence of knee jerks, the presence of calf tenderness, anorexia, inanition (weight loss), cardiomegaly, bradycardia and neuromuscular disturbances (Cataxia and convulsions) (Jelliffee, 1966; Gubler, 1976). Meyer and Gershoff (1968) also reported retarded growth, anorexia, neuron degeneration, convulsions, hyperesthesia, anesthesia and gastro intestinal disturbances in thiamine deficiency in man. Other reports (McCandless and Schenker, 1968; Dakshinamurti, 1977) indicate that thiamine deficiency interrupts the propagation of nerve impulses via acetylcholine. Dancis and Levitz, (1972) and Patal and Owen, (1976) have independently reported that thiamine deficiency may be an etiological factor in the incidence of the maple

[illegible] which is caused by absence of or [illegible] of the branched-chain α-keto acid dehydrogenase [illegible].

According to Sebrell and Butler (1976), a clinical syndrome, cheilosis (lesions of the lips in the angles of the mouth) is one of the early prominent symptoms in experimentally induced riboflavin deficiency. Other symptoms of riboflavin deficiency include magenta tongue, atropic lingual papillae, angular paperilitis (angular blepharitis), scrotal (or Vulval) dermatosis, epidermal atrophy and cornea vascularization and greasy scaling especially of nasolabial folds (Jelliffe, 1966; Mayer and Gershoff, 1968). Baker and Frank (1968) also reported an impairment in erythrocyte formation in animals and man during riboflavin deficiency. Thurnham and his co-workers (1978) also produced experimental evidence to indicate that riboflavin deficiency results to anemia. Hoppel and Tandler (1975, 1976) have equally reported that aribоflavinosis results in rapid impairment of oxidative metabolism.

Poor intakes of niacin have been reported (Gopalan and Jaya Rao, 1975; Pfeiffer and Bacchi 1975) to result into the metabolic disorder called pellagra. Pellagra which is also associated with tryptophan deficiency can lead to psychosis with delusions and hallucinations if it is untreated (Goodhart and Shils, 1980; Harper and Gaus 1986). Jelliffe (1966) identified the symptoms of niacin deficiency to include pellagrous dermatosis, scarlet and raw tongue, atropic lingual papillae, tongue fissuring and malar and supra orbital pigmentation. Pellagra has been classi-

cally recognized as a disease predominant amongst cereal consuming population groups. According to Gopalan and Jaya Rao (1975) the disease accounts for about 1% of admission to General Hospitals and 3 - 10% of admissions to mental institution in endemic areas.

2.8 NUTRITIONAL REQUIREMENTS

Sauberlich et al, (1979) have provided experimental evidence to indicate that the requirement of thiamine, riboflavin, and niacin is related to caloric intake. The requirement of these vitamins in humans is usually expressed as milligrams per 1000 Kcal ingested.

FAO/WHO (1974) recommended 0.4, 0.6, and 7 mg/1000 Kcal for thiamine, riboflavin and niacin, respectively. The Food and Nutrition Board (FNB 1980) of the National Research Council - National academy of Science recommended 0.5, 0.6 and 7 mg/1000 Kcal for thiamine, riboflavin and niacin respectively. According to the FAO/WHO, the reference man will require 3200 Kcal daily. Using the FNB, NRC - NAS recommended Dietary allowances, males 19 to 22 years of age and consuming 3000 Kcal would require 1.5, 1.7 and 19 mg/day of thiamine, riboflavin and niacin, respectively. The FNB (1980) recommended Dietary allowances for females 19 to 22 years of age is 1.5, 1.2 and 14 mg/day of thiamine, riboflavin and niacin respectively. Available evidence from experimental studies with adults and infants (Reinhold et al, 1944, FAO/WHO 1965) indicate that the thiamine requirement is related to the dietary ratio of carbohydrates to fat. According to AMA (1951)

and Bourne and Kidder, (1953) increased proportion of calories derived from non carbohydrate sources will decrease thiamine requirement. It is also suspected that increase in calorie requirements accompanying increased physical activity may lead to a corresponding increase in the absolute requirement of thiamine. Other workers (Goldsmith and Unglaub, 1960; Goldsmith, 1964; Wohl and Goodhart, 1964) have reported increased requirement for thiamine during disease states such as polyneuritis, chronic alcoholism, pernicious vomiting of pregnancy. Bourne and Kidder (1953) and Goldsmith (1964) have also reported increased requirement for thiamine during hyper metabolic states such as fever, hyperthyroidism, leukemia and hyper adrenalism.

According to FAO/WHO (1965), the requirement for riboflavin appears to be related to body size since Calorie requirements are adjusted to body size. Accumulated evidence (Horwitt 1972) from experimental animals suggest that excess carbohydrates may reduce the requirement for riboflavin while excess fat increases the need for the vitamin, although no comparable data for man showing the effects of altering the ratio of carbohydrate to fat on riboflavin requirement has been confirmed. Wohl and Goodhart (1964) reported increased requirement for riboflavin during pregnancy and lactation. Bower and Brown (1980) also observed that the human body has an increased need for riboflavin during pregnancy, lactation and periods of growth. Earlier reports (Czackes and Guggenhein, 1946; Kaunitz et al, 1954) also showed that the requirement for riboflavin is dependent on the protein intakes.

Hill and Goodhart (1964) and Pearson and Mathews (1964) also reported increased requirement for niacin in low protein and tryptophan intakes. Animal experiments by Bogdan and Fyfe Tao, (1972) have also indicated that certain amino acid imbalances may increase the requirement for niacin or may interfere in its formation from tryptophan.

2.9 ASSESSMENT OF NUTRITIONAL STATUS

Early nutritional deficiency of essential nutrients at the tissue level is detected by biochemical tests. These tests measure changes in the supply of a nutrient or detect biochemical changes reflecting metabolic alterations consequent to nutritional effects. For the assessment of status of vitamins in humans, one of several methods may be used. These could involve the use of dietary methodologies or biochemical measurements. The biochemical measurements include:

(a) Measurement of blood level of the vitamin.

(b) Measurement of the urinary excretion of the vitamin.

(c) Measurement of changes in enzyme activity in the blood, and

(d) Measurement of metabolites of the vitamin in urine or blood.

According to Pearson (1962) the most practical approach to the assessment of nutritional status in regard to thiamine, riboflavin and niacin is by measurement of urinary excretion or urinary excretion after a test dose of the vitamin. The WHO (1963) Expert committee on the medical assessment of nutritional status also suggested the use of the urinary excretion test for

the assessment of the nutritional status of children, riboflavin and niacin during field surveys. The suggested guide for the interpretation of the urinary excretion data by the Interdepartmental committee on Nutrition for National Development (ICNND 1963) is shown in Table 1.

Horwitt et al. (1950) reported that individuals with urinary riboflavin excretion of 40 to 70 µg riboflavin/24hrs to [illegible] signs of ariboflavinosis within 4 to 6 months.

Ziporin et al, (1965a) criticised the use of urinary excretion levels for determination of thiamine status because it is influenced by renal factors, recent dietary intakes, bacterial action and other factors not related to dietary intake. Other workers (Blanchaer and Cameron, 1948: Caster et al, 1948: Vgtcikova, 1957) reported various factors such as age, physical state and physical exercise to influence the amount of thiamine excreted in the urine.

Brin (1962) and Sauberlich (1967) also reported from animal and human studies that the red blood cell transketolase activity is a sensitive index for thiamine nutritional status. However, Bamji (1970) observed that conditions such as disease of the liver and gastrointestinal tract (GIT) have profound effect on the activity of the enzyme. MarKhanen and Kalliomaki (1966) also observed that the activity of the enzyme is decreased following thiamine deficiency. In order to differentiate between the enzyme lesion caused by thiamine deficiency and those from non specific causes, Brin (1962) suggested an in-vitro test

TABLE 1

Suggested Guide to Interpretation of Urinary Vitamin Data

of Young Adult Males

	"Low"	Deficiency
Niacin		
N' methyl Nicotinamide (mg/6 hrs)	0.3 - 0.59	< 0.3
mg/gm Creatinine	0.5 - 1.59	< 0.5
Riboflavin		
ug/6 hr	10 - 29	< 10
ug/g Creatinine	27 - 79	< 27
Thiamine		
ug/6hr	10 - 24	< 10
ug/g Creatinine	27 - 65	< 27

From ICNND (1963)

consisting of stimulation of enzyme activity in the presence of saturating amounts of thiamine pyrophosphate (the "TPP effect"). The "TPP effect" rather than the actual enzyme is claimed to be a true measure of thiamine nutritional status (Chong and Ho, 1970). According to the ICNND (1963) guideline, a "TPP effect" of > 25% is indicative of thiamine deficiency. Tiporin et al, (1967b) also suggested the use of measurement of metabolites of thiamine in urine which is an index of the amount of thiamine taken from the tissue stores and utilised for metabolic needs. The criteria presently used in assessing thiamine adequacy are shown in table 2.

According to Tillotson and Sauberlich (1971) and Tillotson and Baker (1972), urinary riboflavin will vary with time of sampling as will the creatinine to which it is referenced. Tucker et al, (1960) also observed that urinary riboflavin is influenced by physical activity, nitrogen-balance, temperature, sleep and stress. Glatzle et al, (1968) and Beutler (1969 have therefore suggested the use of erythrocyte glutathione reductase (EGR) as a measurement of the nutritional status of riboflavin in man. This is preferred to other methods of analysis because it estimates protein-bound riboflavin which is not markedly affected by normal dietary riboflavin intakes. Sauberlich et al, (1972) have adopted the EGR for the assessment of the nutritional status of high school population with satisfactory result. Beutler (1969) reported the requirement of FAD as a Coenzyme for EGR. The FAD is a tightly bound prosthetic group of EGR whose activity

TABLE 2

Criteria for Thiamine Nutritional Adequacy

	Adequacy Grouping			
	Below Adequate		Adequate	
Criterion	Deficiency	Low	Acceptable	High
Dietary Thiamine intake mg/1000Kcal	<0.2	0.2-0.29	0.30-0.40	>0.5
Proportion of RDA	<0.5 RDA	<0.75 RDA	0.75-1.0RDA	>RDA
Biochemical Urine excretion	<27	27 - 65	66 - 120	>120
ug/g creatinine Redblood cells	>25	15 - 24	< 15	
Thiamine diphosphate effect % stimulation				

From Brin (1976).

Reduction of Absorbance with added FAD/10min
-- x AC.
Reduction of Absorbance without FAD/10min

Tillotson and Sauberlich (1971) have shown the percentage stimulation (AC) of the rat EGR in the presence of FAD to be a sensitive parameter for the measurement of riboflavin nutritional status of the rat. Tillotson and Baker (1972) have also confirmed from their study that the EGR is a sensitive measure of riboflavin nutritional status in man.

It is difficult to estimate the niacin status in humans since tryptophan may also serve as its precursor. The two primary metabolites of niacin in man excreted in the urine are N'-methylnicotinamide (N'MN) and its pyridone derivative. Goldsmith et al, (1955) observed that consumption of large quantities of niacin and tryptophan in the diet results into increase in the quantity of the pyridone excreted even though the excretions of N'MN are in the normal range. It has been generally accepted that under normal conditions, the pyridone/N'MN ratio may be at least 2. However, available evidence (Leklem et al, 1975) showed that this ratio will be markedly reduced in oral contraceptive users deficient in vitamin B6. Brown et al, (1965) also found N'MN excretion slightly increased and 2-pyridone slightly de-

[illegible] subjects deficient in niacin [illegible] et al. (1965) reported that the tryptophan saturation could be a good index of niacin status in man.

Gnanalingam et al. (1972) observed that [illegible] are not increased during acute calorie restrictions and fasting, as niacin appears to be synthesized during protein catabolism. They suggested that increased NAMN excretions may be due to the synthesis of niacin from tryptophan liberated during protein catabolism as well as the subsequent utilisation of niacin stored in the catabolized tissue.

Chapter 3

3.0 MATERIALS AND METHODS

3.1 CHEMICALS

All chemicals used were of analytical grade and supplied by the British Drug House (BDH) chemicals Ltd., Poole England and Williams, Chadwell Heath, Essex, England.

3.2 FOOD SAMPLING:

Food samples were purchased from local markets in Zaria, Kaduna, and other parts of the country. Foods were classified into ten groups. The representative food samples were obtained in the normal form in which they are sold in the market and transported to the laboratory in black cellophane bags.

3.2.1 PREPARATION OF FOOD SAMPLES:

Part of the food samples (10g) were kept for moisture determination while the remainder were dried to constant weight in an oven at 60 C for 48 hrs. The dried food samples were pulverised in a blender and sieved with a fine local sieve. The fine powder was stored in air tight fitting containers until required for assay.

3.2.2 EXPERIMENTAL DESIGN

The raw food samples served as the controls. Nigerian foods selected from 10 food groups were used for vitamin assay. The effect of currently adopted household processing techniques such as blanching, fermentation, frying, roasting, cooking and conversion into paste products ("Moin-moin" and "Ewwo") on the thiamine, riboflavin and niacin content of the foods were estimated. Cooking was done with just sufficient amount of water on a normal size gas cooker. The effect of ripening on five varieties of fruits was also investigated.

SOAKED COWPEAS:

The dry cowpea grains about 30 g were soaked for 6 hrs. in 200 ml of tap water at room temperature. The soaked grains were drained and dried as earlier described and aliquots (6 g) used for vitamin assay.

DECORTICATION OF COWPEAS

Seventy grams of dry grains were soaked in five times their own weight of water for 6 hrs. The testa of the soaked grains were carefully removed and dried to constant weight as earlier described. The powder of the pulverised grains was used for vitamin assay.

PREPARATION OF "MOIN-MOIN"

About 150 g of the wet decorticated grains were milled in a blender with an equal volume of water to produce a thick slurry. The blender was rinsed with 50 ml of tap water and added to the homogenate. Hot water was then added to the homogenate to give a cowpea to water ratio (W/V) of 1:1.5. The smooth homogenate was then distributed into "Santana" nylon bags, tied and placed in a cooking pot. A little water was added to immerse (but not submerged) the "Santana" nylon bags and covered tightly with paper. After cooking for 35 mins, the "santana" nylon bags were removed and allowed to cool. The paste formed (20g) was dried as earlier described and used for vitamin determination.

PREPARATION OF OTHER PASTE PRODUCTS - "TUWO"

About 500g each of dehulled and undehulled grains of maize, sorghum and millet were milled into fine powder.

For preparation of "tuwo" product, about 60g of fine powder was mixed with 150 ml of cold water to produce a slurry in a cooking pot. The homogenate was cooked for 15 minutes while stirring and hot water was added intermittently to produce the desired consistency. The paste product - "Tuwo" was then dried as earlier described and used for vitamin assay.

COOKING OF FOOD ITEMS

The raw food items (20 - 30g) were added to cold water (400 - 500ml) in a cooking pot and cooked for the required time interval. Food aliquot (5g) were removed intermittently at 30 and 45 minutes interval until cooked at 60 minutes. The cooked items were dried to constant weight as earlier described and used for vitamin assay.

FRYING OF FOOD ITEMS

Food items (15g) such as ripe plantain, root and tubers, and a few vegetables were fried for 15 minutes by completely immersing them in groundnut oil. The food aliquots (5g) were treated as earlier described and stored for vitamin assay.

BLANCHING OF VEGETABLES

Three varieties of commonly consumed vegetables were cut into tiny shreds as locally consumed and blanched in boiled water (W/V) of 1:4 for 5 minutes. The aliquots (6g) of the drained vegetables were treated as earlier described and used for vitamin assay.

ROASTING OF FOOD ITEMS

Aliquots (10 - 20g) of four food samples (Yam, Groundnut, Fresh Corn and Benni Seed) were roasted in fire until it was "done". The food aliquots were dried to constant weight as earlier described and used for vitamin assay.

RIPENING

Five varieties of unripe fruits were harvested at source and divided into two groups. One group was kept in the dark in a cupboard for one week to allow for ripening. The other group was processed immediately for vitamin assay. Aliquots (10g) of ripeened fruits were also treated as earlier described and used

3.3. ANALYTICAL METHODS

3.3.1 MOISTURE DETERMINATION:

The moisture content of the food samples was determined by weighing 5g of the food into a petri-dish which had been previously dried at 60 ^{o}C and cooled in a desiccator (Oyeleke 1984). The samples were dried in the oven at 60 ^{o}C until a constant weight was obtained. Duplicate determinations were made for each sample. The moisture content was then calculated as follows:

$$\text{Moisture (\%)} = \frac{\text{Loss in Weight due to drying}}{\text{Weight of sample taken}} \times 100\%$$

3.3.2 THIAMINE DETERMINATION:

Thiamine was estimated by the procedure of the AOAC (1980) according to the modifications of Edwin (1979).

EXTRACTION OF THIAMINE

Thiamine was extracted by heating 1g of food sample with 10ml of 0.1NHCl in 25 ml test tubes for 30 minutes in a boiling water bath. The tubes were thoroughly mixed and optimum acidity determined at the end of digestion by bromocresol green indicator. The food extracts were left to cool at room temperature and 1 ml of freshly prepared 6% Taka diastase in 2.5M sodium acetate solution added. The pH was subsequently adjusted to 4.5 with HCl using bromocresol green as indicator. The mixture was then incubated for 12 hrs. (overnight) at room temperature.

Following incubation, the mixture was centrifuged at 3000g for 5 mins, and the clear supernatant transferred to a 25 ml test tube. The residue was re-extracted twice with 4 ml. of 0.1N HCl and centrifuged at 3000g for 5 mins. The extracts were combined and made up to the 25 ml mark with distilled deionized water.

PURIFICATION:

One millilitre of the dephosphorylated extract was pipetted directly to 1g of fuller's earth in a stoppered test tube with caution avoiding the sides of the tube (Winton and Winton 1945). After mixing by shaking, the tubes were filled with nearly boiling distilled deionized water, and allowed to stand. After all the Fuller's earth particles have settled, the supernatant was decanted off, and the washing was repeated twice.

FORMATION OF THIOCHROME:

To 1g of the Fuller's earth residue was added 0.30ml 1% mercuric chloride solution and 2 ml of 30% sodium hydroxide solution. The contents were properly mixed and an aliquot of isobutanol (5ml.) was added. The tubes were shaken for 2 mins. and subsequently centrifuged at 3000g for 5 mins. The clear isobutanol extracts of thiochrome were used for fluorimetric determination of thiamine (Appendix 1).

3.3.3 DETERMINATION OF RIBOFLAVIN

Riboflavin estimation was evaluated by fluorimetric procedure proposed by Osborn and VOOgt (1978).

EXTRACTION OF RIBOFLAVIN

Riboflavin was extracted from the food samples (2g) by acid hydrolysis with 20ml of 0.2 N HCl for 1 hr in a boiling water bath. The pH of the extract was adjusted to 6.0 - 6.5 by drop-wise addition of 40% sodium hydroxide. Corresponding drops of 1NHCl was later added to adjust the pH to 4.5. The resulting extract was diluted to the 25ml. mark with distilled deionized water and filtered through a Whatman No. 1 filter paper.

DECOLORIZATION OF THE EXTRACT:

To two test tubes containing 4 ml aliquots of the sample extract were added 4 ml distilled deionized water and 4 ml dilute

standard riboflavin (0.1 ug/ml), respectively. Glacial acetic acid (0.4 ml) and 0.2 ml 3% potassium permanganate solution ($KMnO_4$) were then added consecutively to the contents of the tube. After 2 minutes, 0.2 ml of 3% hydrogen peroxide (H_2O_2) was added and the fluorescence taken immediately.

MEASUREMENT OF FLUORESCENCE:

The fluorescence of the extract was measured at excitation wavelengths of 440 nm and emission wavelength of 525nm. The riboflavin content of the food sample was calculated thus:

Weight (g) of sample = W

Volume (ml) of extract = 25

Aliquot (ml) taken for decolorising = 4

Reading of sample = S

Reading of Standard (0.4ug) = T.

Riboflavin mg/100g sample

$$= \frac{S}{T} \times \frac{0.25}{W}$$

3.3.4 DETERMINATION OF NIACIN:

The AOAC (1980) procedure was adopted in the estimation of niacin.

PREPARATION OF SAMPLES AND STANDARDS

Niacin in non cereal was extracted by acid hydrolysis of food sample (3.0g) with 20ml of 1N H_2SO_4 in 25ml test tube for 1 hr. in a boiling water bath. The pH of the supernatant was subsequently adjusted to 4.5 with 20% NaOH using bromcresol green as indicator. The content of the tubes was then made up to the 25 ml mark with distilled water and filtered through Whatman No. 1 filter paper. To 3.4g $(NH_4)_2SO_4$ in a 25ml stoppered test tubes was added 9.0 ml of sample filtrate. The content was made up to 10ml with distilled water. The solution was shaken vigorously until the $(NH_4)_2SO_4$ dissolved. The filtrate obtained (1ml) was used for colorimetric determination of niacin. Working standard (3.2 ug/ml) was prepared by adding 8.0ml of working solution II to 3.4g $(NH_4)_2SO_4$ in a test tube and made up to 10ml with distilled water.

Niacin in cereals was extracted by alkaline hydrolysis of food sample (5g) by heating with 1.5g $Ca(OH)_2$ in a boiling water bath for 2 hrs. In this case, the supernatant of the extract was placed in icebath for 15 mins. before the addition of $(NH_4)_2SO_4$ (8g). The niacin content of the cereal samples was obtained from the standard curve (Appendix 2).

COLOUR DEVELOPMENT (NON CEREALS)

Niacin content of non cereal foods was determined colorimetrically by setting up 4 tubes as follows:

	Standard Blank	Standard Solution	Sample Blank	Sample Solution
Standard solution (3.2ug/ml)	1.0 ml	1.0 ml	-	-
Sample Solution	-	-	1.0 ml	1.0 ml
Distilled water	5.0 ml	-	5.0 ml	-
dil NH_4OH	0.5 ml	0.5ml	0.5 ml	0.5 ml
CNBr Solution	-	5.0 ml	-	5.0 ml
10% sulfanilic acid	2.0 ml	2.0 ml	2.0 ml	2.0 ml
dil Hcl	0.5 ml	-	0.5 ml	-
Distilled water	-	0.5 ml	-	0.5 ml

The absorbance was read at 440 nm and the niacin content was calculated as:

mg Niacin/100g food sample =

$$\frac{\text{A unknown}}{\text{A standard}} \times \frac{0.32}{\text{g sample}} \times 25 \text{ (dilution factor)}$$

3.4 DIETARY DATA:

Dietary data from 60 apparently healthy students (18 females and 42 males) of the Ahmadu Bello University, Zaria were collected by a 3 day dietary record. The students were taken from different ethnic groups in Nigeria. Their diets comprised largely of cereals, root and tubers, fruits and vegetables. The anthropometric data of the student is shown in table 3.

TABLE 3

Anthropometric Data of Subjects

	n	Age(years)	Height(cm)	Weight (kg)
Male	42	23.3 + 2.4	168.1 + 12.7	57.0 + 8.7
Female	18	20.9 + 1.4	156.4 + 12.5	56.6 + 9.6

4.0 RESULTS AND DISCUSSION

4.1 VITAMIN CONTENT OF RAW FOOD SAMPLES

The thiamine (vitamin B_1), riboflavin (vitamin B_2), and Niacin (vitamin B_3) content of 74 locally consumed Nigerian foods are shown in table 4.

The data revealed that the vitamin B_1, vitamin B_2, and vitamin B_3 levels of the foods ranged from 0.07 - 1.0, 0.01 - 0.47 and 0.04 - 8.96 mg/100g (on dry weight basis) respectively. Trace amounts of thiamine were observed in "Burukutu", a cereal based alcoholic beverage while the highest concentration of thiamine was found in the big white beans variety (Vigna sinensis Var. Unguiculata). The lowest niacin levels in foods was found in Palm oil (Elaeis guineansis) while the highest level was found in tomato. On the other hand pineapple (Ananas sativa) had the least riboflavin concentration compared to high values of the vitamin observed in "Kunu", a non alcoholic cereal based beverage. The high riboflavin level found in "Kunu" may not be unrelated to the inherently high microflora found in "Kunu" and other alcoholic beverages like palm wine (Okafor 1978). Zamora and Fields (1979) in a previous study have attributed the high concentration of riboflavin in fermented cowpeas to the presence of yeast which is excellent source of most water-soluble vitamins.

TABLE 4

Thiamine, Riboflavin and Niacin Content, of Selected Food items

FOOD ITEM	Moisture (%)	Thiamin mg/100g dry weight	Riboflavin mg/100g dry weight	Niacin mg/100g dry weight
Root and Tubers				
Yam (raw)	69.00±0.71	0.17±0.01	0.05±0.01	1.40±0.10
Cassava (raw)	56.90±0.46	0.12±0.01	0.05±0.01	1.40±0.20
White sweet Potato (raw)	54.00±0.67	0.58±0.04	0.16±0.05	1.62±0.03
Red sweet Potato (raw)	67.60±1.13	0.65±0.10	0.22±0.03	1.81±0.06
Coco yam (raw)	54.00±0.14	0.17±0.03	0.14±0.01	1.39±0.01
Irish Potato (raw)	62.00±0.79	0.18±0.05	0.15±0.02	3.05±0.31
Cocoyam	78.40±0.28	0.05±0.01	0.04±0.02	0.29±0.12

TABLE 4 (Continued)

FOOD ITEM	Moisture (%)	Thiamin mg/100g dry weight	Riboflavin mg/100g dry weight	Niacin mg/100g dry weight
Legumes and Nuts				
Groundnut (raw)	6.20±0.32	0.70±0.08	0.10±0.02	6.10±0.80
Brown Beans (raw)	6.40±0.28	0.95±0.95	0.21±0.10	3.81±0.25
Big White Beans (raw)	6.00±0.20	1.00±0.01	0.20±0.08	3.01±0.05
Small White Beans (raw)	4.40±0.16	0.83±0.04	0.21±0.04	0.50±0.10
Soya Beans (raw)	4.40±0.10	0.58±0.02	0.18±0.02	2.86±0.60
Cereals				
Whole millet	21.00±0.27	0.40±0.02	0.16±0.05	1.90±0.24
Whole maize	6.60±0.10	0.29±0.06	0.11±0.01	2.50±0.15
Whole sorghum)	6.60±0.20	0.32±0.01	0.15±0.06	4.00±0.32
Rice	8.20±0.16	0.33±0.05	0.09±0.01	2.50±0.08
Wheat flour	5.00±0.20	0.22±0.04	0.08±0.04	2.90±0.77
Dehulled Sorghum	6.60±0.21	0.48±0.16	0.19±0.10	2.70±1.10
Dehulled maize	6.80±0.10	0.20±0.05	0.17±0.07	2.00±0.16

TABLE 4 (Continued)

FOOD ITEM	Moisture (%)	Thiamin mg/100g dry weight	Riboflavin mg/100g dry weight	Niacin mg/100g dry weight
Snacks				
Akara	48.90±0.70	0.15±0.08	0.14±0.10	4.63±1.20
Wena	60.80±0.15	0.15±0.02	0.15±0.02	0.50±0.03
Buns	21.40±0.01	0.12±0.04	0.05±0.01	1.14±0.08
KuliKuli	2.00±0.28	0.13±0.10	0.18±0.03	3.43±0.03
Cake	20.70±0.42	0.18±0.09	0.10±0.05	1.60±0.10
Fried Coconut	6.20±1.40	0.12±0.02	0.14±0.01	1.56±0.06
Oils, Oilseeds and Condiments				
Melon (raw)	1.60±0.28	0.13±0.01	0.10±0.01	1.34±0.04
Benniseed (raw)	2.70±0.14	0.66±0.01	0.44±0.02	2.00±0.01
Coconut (raw)	52.40±1.00	0.20±0.02	0.19±0.01	2.00±0.05

TABLE 4 (Continued)

FOOD ITEM	Moisture (%)	Thiamin mg/100g dry weight	Riboflavin mg/100g dry weight	Niacin mg/100g dry weight
Cottonseed	5.00±0.16	0.34±0.05	0.35±0.10	2.00±010
Palm Oil	-	0.10±0.02	-	0.04±0.04
Groundnut oil	-	0.05±0.01	0.07±0.01	2.23±0.03
Maggi	3.20+0.10	0.07±0.01	0.04±0.01	2.00+0.08
Locust bean	14.60+0.18	0.70±0.03	0.20±0.06	1.34+0.04
Cottonseed oil	-	0.05±0.01	0.06±0.01	0.05±0.02
Beverages				
Burukutu	-	0.07±0.01	0.06±0.02	1.87±0.07
Pito	-	0.10±0.02	0.10±0.05	2.36±0.05
Kunu	-	0.23±0.06	0.62±0.10	1.43±0.01

TABLE 4 (Continued)

FOOD ITEM	Moisture (%)	Thiamin mg/100g dry weight	Riboflavin mg/100g dry weight	Niacin mg/100g dry weight
Vegetables				
Carrots (Raw)	80.00±0.88	0.33±0.07	0.06±0.01	3.05±0.14
Tomatoes (Raw)	93.60±0.12	0.63±0.11	0.40±0.06	8.96±0.15
Onions (Raw)	89.80±0.10	0.32±0.04	0.38±0.09	2.00±0.05
Spinach (Raw)	79.00±0.15	0.32±0.01	0.25±0.01	2.90±0.04
Okra (Raw)	85.80±0.20	0.37±0.15	0.38±0.10	4.06±0.10
Bitter leaves (Raw)	80.80±0.23	0.56±0.07	0.47±0.08	2.67±0.09
Fluted pumpkin (Raw)	85.50±0.12	0.35±0.01	0.43±0.05	2.31±0.02

TABLE 4 (Continued)

FOOD ITEM	Moisture (%)	Thiamin mg/100g dry weight	Riboflavin mg/100g dry weight	Niacin mg/100g dry weight
Fruits				
Unripe sweet orange	84.00±0.20	0.20±0.03	0.02±0.03	0.82±0.13
Unripe mango pulp	82.60±0.31	0.18±0.01	0.16±0.01	1.14±0.04
Unripe Guava	66.00±0.17	0.20±0.05	0.36±0.08	2.59±0.06
Unripe Lemon orange	88.80±0.10	0.17±0.08	0.15±0.10	3.38±0.17
Unripe Pineapple	80.00±0.07	0.17±0.08	0.09±0.01	0.57±0.05
Ripe Plantain (Raw)	63.20±0.10	0.22±0.10	0.20±0.05	1.91±0.08
Ripe Orange	86.40±0.01	0.32±0.09	0.04±0.01	1.34±0.01
Ripe Guava	70.50±0.42	0.25±0.10	0.33±0.09	3.53±0.09
Orange juice	-	0.07±0.01	-	0.29±0.04
Ripe Mango	78.40±0.14	0.35±0.10	0.20±0.02	1.93±0.10
Ripe Lemon Orange	88.60±0.20	0.30±0.30	0.21±0.03	2.50±0.04
Ripe Pineapple	82.00±0.04	0.32±0.01	0.01±0.01	0.67±0.01

TABLE 4 (Continued)

FOOD ITEM	Moisture (%)	Thiamin mg/100g dry weight	Riboflavin mg/100g dry weight	Niacin mg/100g dry weight
Lime Juice	-	-	-	-
Dates	7.60±1.20	0.17±0.05	0.09±0.02	4.67±0.04
"Aya"	41.90±0.50	0.15±0.01	0.08±0.03	1.56±0.02
Banana	72.30±0.14	-	-	3.22±0.07
Garden egg	92.00±0.42	0.15±0.04	0.16±0.01	1.34±0.01
Sugar Cane juice	-	0·24± 0·01	0·04± 0·03	2·23± 0·02
Meat and Meat Products				
Egg (Raw)	74.40±0.45	0.56±0.07	0.27±0.06	1.34±0.08
Beef Liver (Raw)	77.00±0.08	0.53±0.03	0.47±0.01	6.68±0.01
Goat meat (Raw)	71.40±1.60	0.38±0.01	0.46±0.02	2.23±0.02
Beef Kedney	82.60±1.21	0.48±0.09	0.45±0.01	5.34±0.16
Meat Pie	50.80±0.65	0.51±0.02	0.44±0.02	1.56±0.01

TABLE 4 (Continued)

FOOD ITEM	Moisture (%)	Thiamin mg/100g dry weight	Riboflavin mg/100g dry weight	Niacin mg/100g dry weight
Beef	75.20±2.10	0.37±0.06	0.31±0.02	3.56±0.10
Suya	43.20±1.50	0.27±0.02	0.40±0.03	2.23±0.05
Squash egg	55.20±0.14	0.35±0.04	0.22±0.01	2.45±0.07
Milk and Milk Products				
Ice cream	-	0.56±0.09	0.04±0.01	1.78±0.08
Peak milk	-	0.07±0.01	0.37±0.02	2.00±0.01
Lahda Skimmed Milk	1.00±0.01	0.28±0.01	0.46±0.07	2.23±0.01
Yoghurt	-	0.07±0.03	0.07±0.05	1.78±0.06
Lolly Pop	-	0.03±0.02	0.02±0.01	2.27±0.01

The vitamins B_1, B_2 and B_3 of the foods when classified into various food groups are presented in table 4.0. Data obtained revealed that plant food sources such as legumes, vegetables and cereals are also good sources of vitamins B1 and B3 in the Nigerian diet while vegetables, milk and milk products appear to contribute significantly to riboflavin derived from Nigerian foods. Although the contribution from milk and milk products towards niacin content of Nigerian foods may appear to be relatively low, ample evidence (Hartman and Dryden 1965) exist to ascertain a high degree of bioavailability of nicotinic acid from milk relative to cereals where niacin may exist in bound forms. Hartman and Dryden (1974) for instance showed that the milk protein is an excellent source of tryptophan, a precursor of niacin. As observed by Adrian (1975) the efficiency of nicotinic acid and tryptophan depends on the protein quality of the ration.

Ogunmodede and Oyenuga,(1969) however, assayed the thiamine (vitamin B_1), riboflavin (vitamin B_2) and niacin (vitamin B_3) content of 30 varieties of cowpeas. Their data showed considerable variation of vitamin content between the different varieties of cowpeas. The mean values of vitamins B_1, B_2 and B_3 obtained in this study is however consistent with the findings of Ogunmodede and Oyenuga, (1969) and Edijala (1980). The mean values of thiamin and niacin in soya bean obtained in this study is also similar to the levels reported following analysis of 21 soybean varieties in India (Panday and Narayan, 1978).

Although the mean value for thiamine and niacin of a local variety of rice obtained in this study appeared to be lower ($p<0.05$) than those reported by Malakar and Banerjee (1959), the

riboflavin values were similar. The variation might be due to differences in variety and other environmental factors.

4.2 EFFECT OF COOKING ON THIAMIN, RIBOFLAVIN AND NIACIN

Various cooking time intervals are adopted in present study to identify possible effects of cooking on vitamin retention and to obtain conditions suitable for household operations.

Table 6 - 8 and appendices 3 - 5 show the mean values of thiamine, riboflavin, and niacin and their percentage retention during cooking at atmospheric pressure at varying time intervals of 30, 45 and 60 minutes. The average retention of vitamins B_1, B_2 and B_3 in different foods during cooking as a function of time is also presented in Fig 4.0 - 6.0 respectively.

Data showed that cooking results to substantial losses of all the vitamins especially vitamins B_1 and B_2. Thiamine retention for instance ranged from 65.0 - 88.24, 50.53 - 77.27 and 38.46 - 60.61% respectively during cooking for 30, 45 and 60 minutes interval. Highest losses were evident in niacin for root and tubers. This may be attributable to the fact that the niacin from these sources are readily available and therefore be leached out easily during cooking.

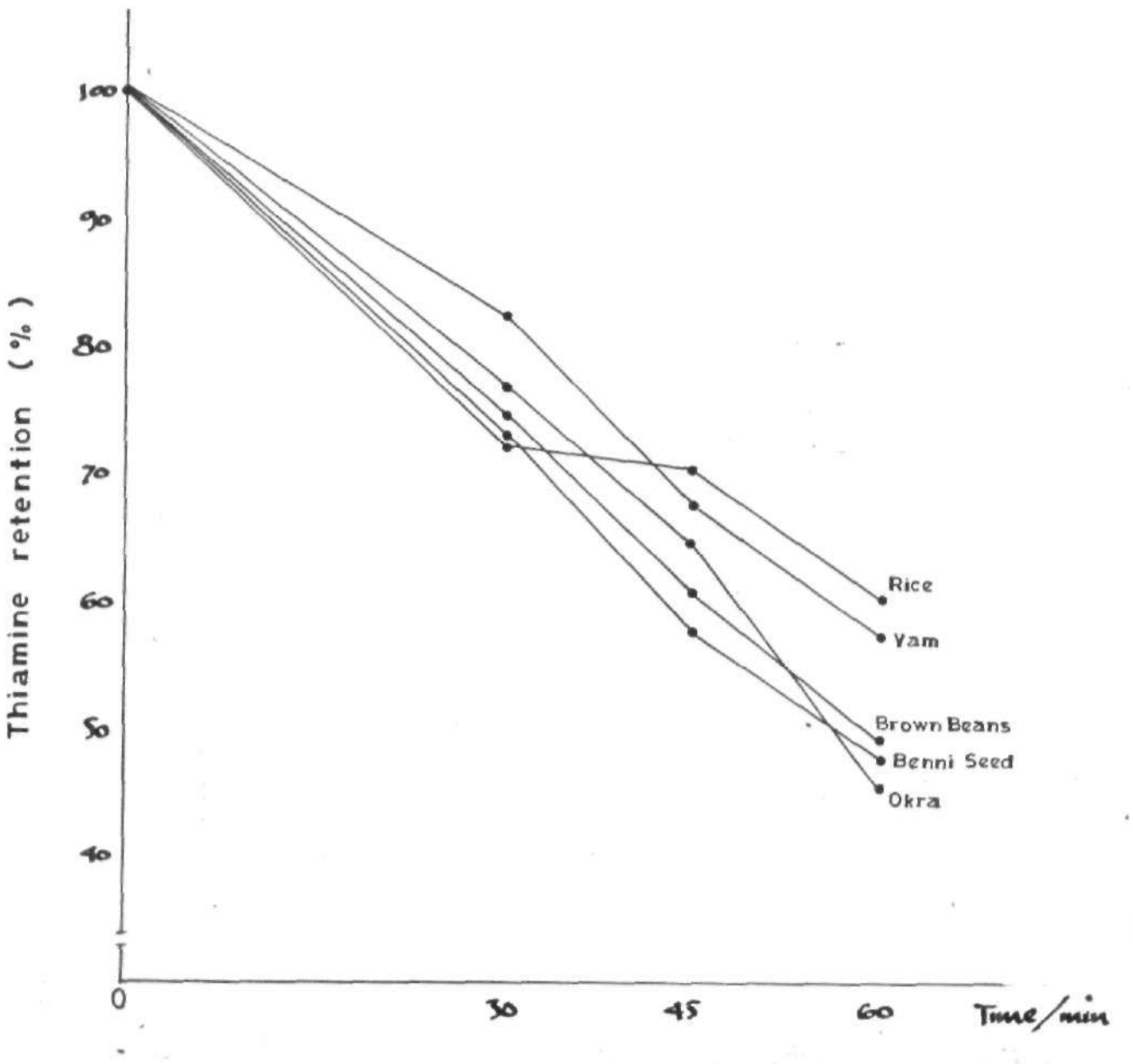


Fig. 4.0. Variation in Thiamine retention with cooking time .

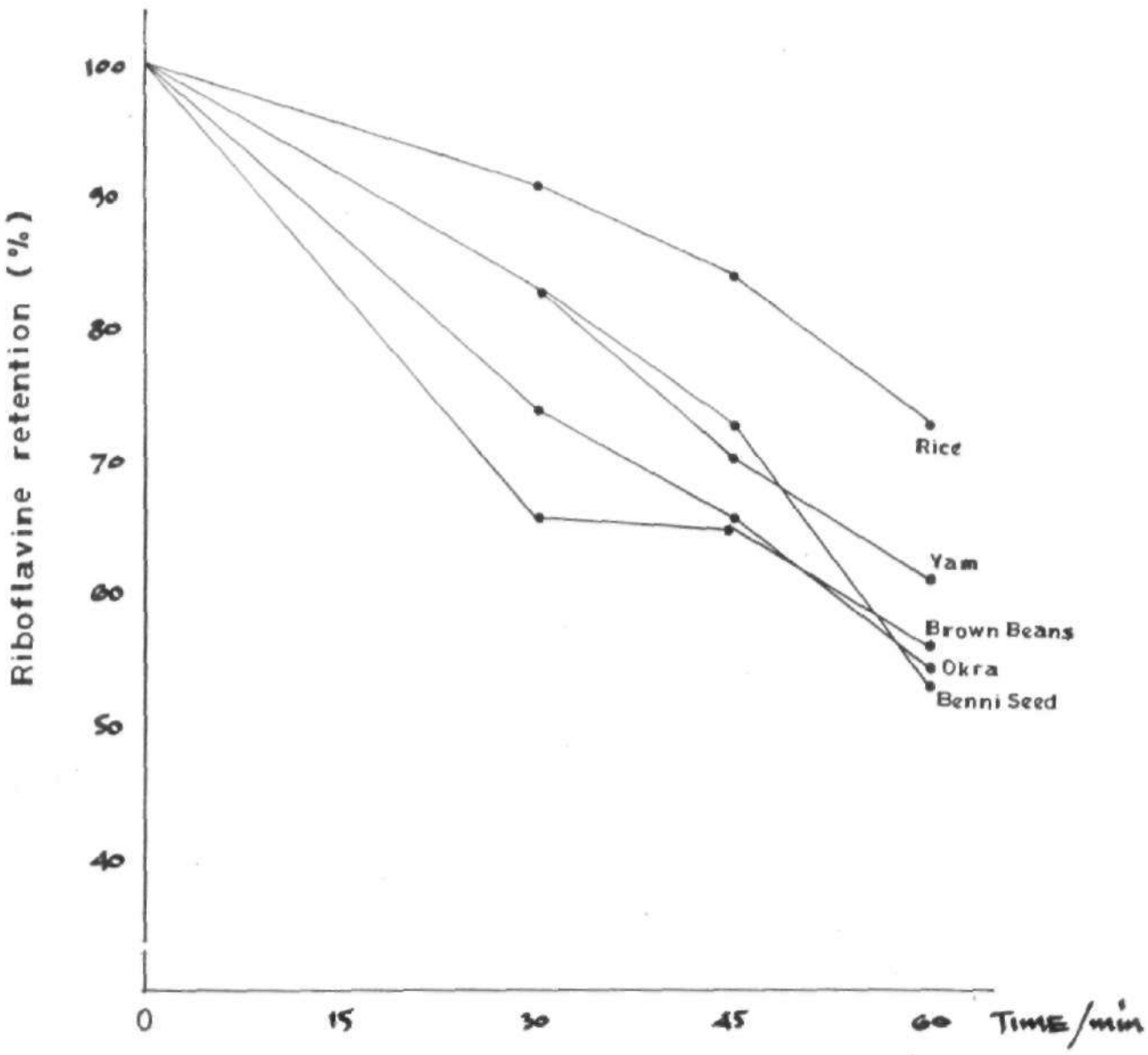


Fig. 5.0. Variation in Riboflavine retention with cooking time .

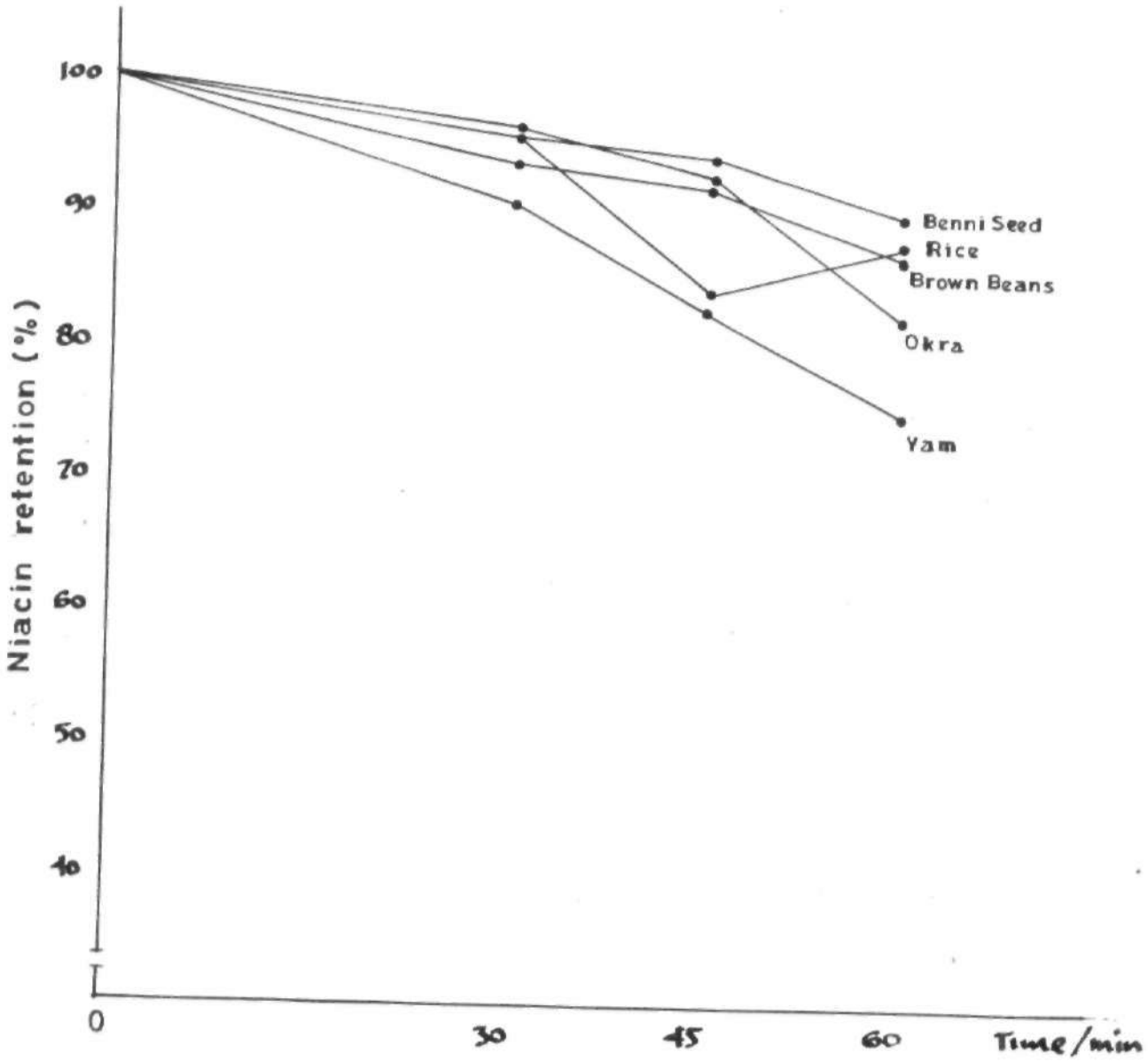


Fig. 6.0. Variation in Niacin retention with cooking time .

TABLE 5

Effect of Cooking at Atmospheric Pressure on Thiamine, Riboflavin and Niacin Content of Locally Consumed Nigerian Foods

Cooking Time (min)	Moisture (%)	Thiamin mg/100g dry weight	Retention (%)	Riboflavin mg/100g dry weight	Retention (%)	Niacin mg/100g dry weight
0	69.00±0.71	0.17±0.03		0.05±0.01		1.40±0.08
30	68.00±0.57	0.15±0.03	88.24	0.04±0.01	80.0	1.28±0.01
45	68.60±0.28	0.12±0.01	70.59	0.03±0.02	60.0	1.18±0.11
60	65.00±0.28	0.10±0.02	58.82	0.03±0.01	60.00	1.01±0.02
0	56.90±0.46	0.12±0.010		0.05±0.01		1.40±0.07
30	63.00±0.85	0.10±0.03	83.33	0.04±0.02	80.0	1.33±0.02
45	69.00±0.14	0.08±0.01	66.33	0.035±0.01	70.0	1.31±0.01
60	67.40±0.10	0.07±0.01	58.33	0.032±0.01	64.0	1.18±0.06

Table 6 (continued)

Food item	Cooking time (min)	Moisture (%)	Thiamin mg/100g dry weight	Ribo-flavin (%)	mg/100g dry weight	Niacin (%)	mg/100g dry weight
Fresh dwarf beans	0	54.00±0.67	0.59±0.06		0.16±0.07		1.62±0.02
	30	57.00±0.20	0.45±0.03	77.59	0.13±0.03	81.25	1.56±0.10
	45	58.20±0.28	0.37±0.12	63.79	0.11±0.01	68.75	1.30±0.03
	60	59.00±0.82	0.32±0.08	55.17	0.090±0.01	56.25	1.26±0.06
Fresh runner beans	0	67.60±1.13	0.65±0.01		0.22±0.10	1.81	1.81±0.01
	30	74.50±0.42	0.56±0.03	86.15	0.19±0.02	86.36	1.64±0.04
	45	75.40±0.25	0.48±0.01	73.85	0.17±0.06	77.27	1.56±0.01
	60	69.00±0.15	0.39±0.03	56.92	0.15±0.02	68.18	1.45±0.04
Frozen peas	0	54.00±0.14	0.17±0.060	0.14	0.014±0.05	0.64	1.39±0.05
	30	64.00±0.10	0.14±0.02	82.33	0.12±0.01	86.71	1.24±0.01
	45	68.00±0.12	0.11±0.01	64.71	0.10±0.03	71.43	1.12±0.09
	60	63.00±0.13	0.10±0.040	58.82	0.09±0.01	64.20	1.10±0.07

TABLE 5 (Contd.)

Food item	Cooking Time (min)	Moisture (%)	Thiamin mg/100g dry weight	Reten-tion (%)	Riboflavin mg/100g dry weight	Reten-tion (%)	Niacin mg/100g dry weight	Reten-tion (%)
Cereals Pulses	0	60.07±0.79	0.18±0.240		0.15±0.01		3.05±0.02	
	30	77.47±0.33	0.14±0.08	77.78	0.12±0.06	66.67	2.57±0.08	84.26
	45	78.70±0.14	0.12±0.02	66.67	0.11±0.04	73.33	2.28±0.01	75.08
	60	78.51±0.45	0.10±0.01	55.56	0.10±0.01	66.67	1.81±0.07	59.34
Legumes and Tuber								
Potatoes	0	6.51±0.22	0.72±0.28	0.00	0.10±1.03		6.10±0.09	
	20	41.12±0.19	0.63±0.07	93.71	0.08±0.02	80.0	5.72±0.02	93.77
	45	41.00±0.79	0.51±0.01	72.86	0.07±0.05	71.0	5.52±0.10	90.56
	60	41.50±0.24	0.40±0.03	57.14	0.06±0.01	60.0	5.41±0.06	88.69
Bitter Gourd	0	6.63±0.23	0.95±0.09		0.20±0.03		3.81±0.09	
	20	63.12±0.22	0.56±0.16	58.95	0.17±0.02	90.95	3.59±0.05	94.23
	45	63.03±0.29	0.49±0.01	51.53	0.14±0.01	66.67	3.55±0.02	93.18
	60	63.37±0.70	0.42±0.04	42.11	0.11±0.06	52.39	3.30±0.01	86.61

			Thiamin mg/100g dry weight	Retention (%)	Riboflavin mg/100g dry weight	Retention (%)	Niacin mg/100g dry weight	Retention (%)
			1.00±0.02	-	0.23±0.23		3.01±0.04	
			0.46±0.07	45.0	0.14±0.01	70.0	2.92±0.09	97.01
			0.54±0.02	54.0	0.12±0.03	65.0	2.82±0.05	93.69
			0.45±0.01	45.0	0.12±0.04	55.0	2.67±0.01	88.70
							2.50±0.04	
			0.34±0.04	18.67	0.14±0.03	66.67	2.35±0.05	94.0
			0.32±0.02	43.84	0.12±0.10	57.14	2.29±0.03	91.60
			0.42±0.03	10.66	0.12±0.01	57.14	2.19±0.06	87.60

TABLE 3 (Continued)

Food item	Cooking time (min)	Moisture (%)	Thiamin mg/100g dry weight	Reten-tion (%)	Riboflavin mg/100g dry weight	Reten-tion (%)	Niacin mg/100g dry weight	Reten-tion (%)
Cereals:								
Rice	0	8.20±0.18	0.33±0.04		0.09±0.01		2.50±0.01	
	20	76.30±0.14	0.24±0.03	72.72	0.35±0.09	91.11	2.40±0.04	96.0
Oils, Oil seeds	45	77.60±0.05	0.25±0.01	75.75	0.34±0.04	84.84	2.10±0.03	84.0
Oil Cedtrients	60	80.40±0.57	0.20±0.040	60.61	0.31±0.01	79.33	2.20±0.06	88.0
Maize	0	5.60±0.28	0.13±0.02		0.10±0.06		1.14±0.01	
	15	69.50±0.11	0.05±0.02	38.46	0.07±0.01	70.0	1.20±0.02	99.55
	45	69.52±0.26	0.05±0.02	38.46	0.05±0.02	50.0	1.14±0.08	95.07
Pernicest	0	8.70±0.24	0.55±0.10		0.44±0.07		2.00±0.03	
	20	67.00±0.09	0.56±0.03	84.85	0.35±0.05	66.11	2.00±0.09	100.00
	45	70.00±0.05	0.51±0.03	77.27	0.33±0.11	75.00	2.00±0.01	100.00
	60	66.30±0.24	0.38±0.01	57.58	0.25±0.04	56.82	1.90±0.03	95.0

Generally, it appears that cooking at short time interval enhance the retention of the three vitamins (Appendices 3 - 5).

The retention of thiamine and riboflavin at 60 minutes of cooking in this study was in conformity with values reported by Edijala (1980). However, the losses of thiamine observed in this study were slightly lower ($p > 0.05$) than values reported by Pushpamma et al, (1982) and Villadevi et al, (1972). This variation could be due to differences in the cooking time.

Although values of vitamins B_1 and B_2 leached into the cooking water were not determined, these losses will be greatly reduced if the cooking water is consumed with the cooked foods. In Nigeria, it is a usual practice to consume the cooking water along with the foods especially in "boiled beans," "yam porridge", "cocoyam porridge" etc. Higher losses of thiamine were observed in melon and carrots. Retention was lowest when the food items were cooked for 60 minutes. The loss of thiamine was more in okra than the brownbeans and rice subjected to cooking especially for 60 minutes (fig 7.0).

Riboflavin retentions ranged from 66.67 - 91.11, 57.14 - 84.44 and 50.00 - 73.33% respectively at 30, 45 and 60 minutes interval of cooking. Higher losses of riboflavin were observed in beans and melon. The percentage loss of riboflavin was slightly higher ($P > 0.05$) in brownbean preparation than rice preparations subjected to cooking. This observation did not confirm the findings of Pushpamma et al, (1982) that cereal preparation have higher loss of riboflavin than legume preparations subjected to boiling and frying.

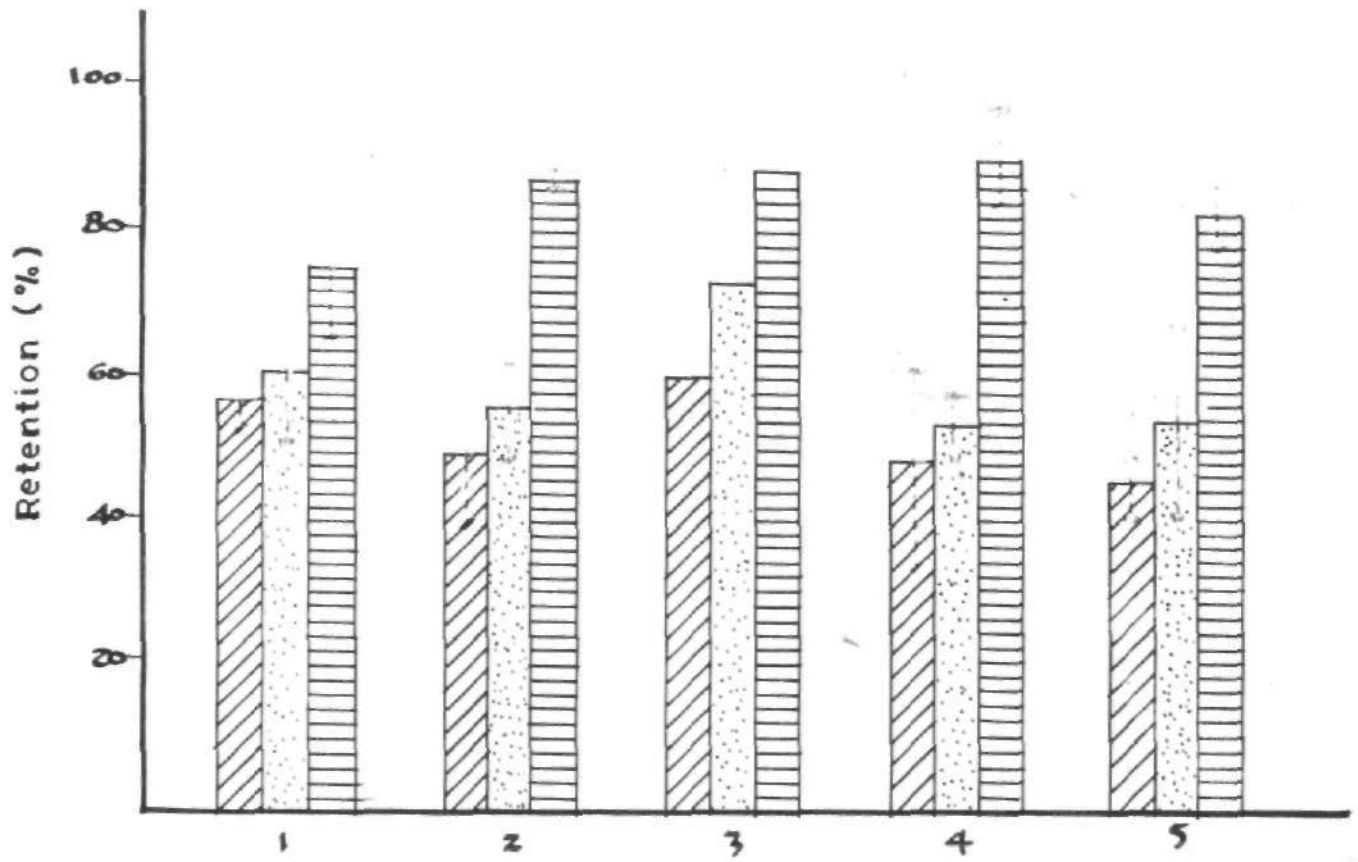


Fig. 7.0. Retention (%) of Thiamine, Riboflavin and Niacin during cooking for 60 minutes.

Retentions of niacin ranged from 84.26 - 100, 84.29 - 100 and 89.34 - 95.00% when subjected to cooking for 30, 45 and 60 minutes respectively. The loss ranged from 9.96 - 24.53%. The losses in niacin concentration of the foods were lowest than those obtained for thiamine and riboflavin. This observation is consistent with previous reports (Harris and Levenberg 1960).

4.3 EFFECT OF DECORTICATION ON THIAMIN, RIBOFLAVIN AND NIACIN

The mean thiamine, riboflavin and niacin content and percentage retention of three varieties of decorticated beans is presented in table 6.

Decortication of the three varieties of beans did not significantly ($P > 0.05$) affect the thiamine and riboflavin content of the two white varieties. Higher losses of the two vitamins are however observed for the brown variety. This observation is consistent with previous reports (Edijala 1980). Our present study did not validate the significant elevation in thiamine levels observed for the white varieties of beans by Edijala (1980).

TABLE 6

Effect of Decortication on Thiamin, Riboflavin, Niacin Content of Cowpeas

Food Type	Moisture (%)	Thiamine mg/100g dry weight	Retention (%)	Riboflavin mg/100g dry weight	Retention (%)	Niacin mg/100g dry weight	Retention (%)
Brown Beans	56.97±0.10	0.78±0.01	81.11	0.17±0.04	81.0	2.99±0.02	78.48
Big White Beans	56.80±0.12	0.96±0.03	96.00	0.19±0.02	95.0	2.42±0.03	87.40
Small White Beans	54.00±1.13	0.80±0.01	88.90	0.20±0.01	95.24	2.28±0.01	91.60
Means + S.D.	55.97±0.94	0.85±0.05	92.30±5.17	0.18±1.01	91.41±4.71	2.57±0.21	83.49±4.10

The mean riboflavin losses of 9.59% also observed in present study is significantly lower than the 24% reported by Edijala (1980) for most legumes. The variability in our results may be attributed to slight variations in methodology for assaying the vitamins and processing of the decorticated beans.

The niacin retention was also similar to that of thiamine and riboflavin with an average retention of 83.43%. The results suggest that there is high concentration of the vitamins especially niacin in the testa of the brown variety.

4.4 EFFECT OF SOAKING ON THIAMIN, RIBOFLAVIN AND NIACIN

Table 7 summarised the mean thiamine, riboflavin and niacin content and percentage retention of three varieties of beans soaked for 6 hrs at room temperature. Soya beans were soaked for 2 days as it is normally utilized in home preparation for soya milk.

Soaking of the three varieties of beans for 6 hrs did not significantly ($P > 0.05$) affect the thiamine, riboflavin and niacin content of the legume grains. The up to 14.74% thiamin losses observed for the brown variety is similar to the 13.5% reported by Edijala (1980) after 62 hrs of soaking. The high losses of thiamine, riboflavin and niacin for soya beans suggest that household processed soyamilk may need to be fortified with substantial amount of vitamins in order to enhance its use as an ideal diet for infant nutrition.

TABLE 7

Effect of Soaking at Room temperature on thiamine, riboflavin, and Niacin Content of legumes

FOOD TYPE	Soaking Time	Moisture (%)	Thiamine mg/100g dry weight	Retention (%)	Riboflavin mg/100gm dry weight	Retention (%)	Niacin mg/100gm dry weight	Retention (%)
Brown Beans	6 hrs	60.20±0.01	0.91±0.090	85.26	0.17±0.01	81.0	3.74±0.06	98.16
Small White Beans	6 hrs	55.80±0.16	0.86±0.020	103.61	0.15±0.03	71.43	2.35±0.01	94.0
Big White Beans	6 hrs	58.60±0.28	0.93±0.010	93.0	0.14±0.02	70.0	2.98±0.09	99,0
Soya Beans	2 days	60.00±0.80	0.32±0.040	55.17	0.11±0.040	61.11	1.62±0.20	56.64

4.5 EFFECT OF CONVERSION INTO PASTE PRODUCT ON THIAMIN, RIBOFLAVIN AND NIACIN CONTENT OF LEGUMES AND CEREALS

In various household preparation of Nigerian diet, most foods are processed into paste. In present study the mean thiamine, riboflavin, and niacin content and percentage retention of common paste food products - "moin-moin" and "tuwo" are presented in table 8.

The retention of thiamine in all the paste products ranged from 40.63 - 78.13%. Lowest retention of thiamine was observed in "tuwo" prepared from whole sorghum. Retention of thiamine in "moin-moin" for the three varieties of beans investigated ranged from 63.16 - 70.0% (mean = 65.67 $\pm$ 3.76). The highest retention of thiamine was obtained in the small white beans, while the brown variety gave the lowest retention. The mean retention of thiamine in "moin-moin" was 65.67% compared to the mean retention of 49.46% for the cooked whole grains at 60 minutes. This findings tend to indicate that vitamin retention in beans can be increased by conversion of legume foods into paste product.

Retention of thiamine in "tuwo"products ranged from 40.63 - 78.13%. From the data in table 8, it appeared thiamine is more concentrated in the testa of whole maize while in sorghum the vitamin is concentrated in the grain than the testa. The high retention observed in "tuwo" (dehulled sorghum) might be due to the removal of antinutritional factors in the bran during the dehulling process which would otherwise interfere with the stability of thiamine. The results also indicate that there was poor retention of thiamine in the preparation of "tuwo from dehulled maize", "tuwo from whole sorghum" and "tuwo from whole

TABLE 9

Effect of Conversion into Paste on thiamine, Riboflavin and Niacin Content of Legumes and Cereals

PASTE PRODUCTS (%)	Moisture (%)	Thiamine mg/100g dry weight	Retention (%)	Riboflavin mg/100m dry weight	Retention (%)	Niacin mg/100g dry weight	Retention
Brown Beans "Moin-moin"	72.00±0.14	0.60±0.01	63.16	0.17±0.06	81.0	2.94±0.140	77.17
Dry White Beans "Moin-moin"	71.10±0.10	0.70±0.90	70.0	0.18±0.030	90.0	2.38±0.040	79.07
Dried White Beans "Moin-moin"	72.0±0.20	0.53±0.02	63.86	0.19±0.05	90.48	2.10±0.060	84.0
Mean ± S.E.M	73.13±0.70	0.61±0.05	65.67±2.17	0.18±0.01	87.16±3.09	2.47±0.250	80.08±2.04
Dry whole millet	70.60±0.10	0.23±0.20	57.50	0.11±0.05	68.75	2.50±0.020	49.33
Dry whole maize	72.0±00.01	0.50±0.07	62.96	0.29±0.08	81.0	4.40±0.131	52.56
Dry dehulled maize	73.40±0.21	0.13±0.01	44.83	0.08±0.01	72.73	3.00±0.060	34.18
Dry whole sorghum	72.10±0.21	0.31±0.02	40.63	0.11±0.01	73.33	6.80±0.101	50.27
Dry dehulled sorghum	73.0±0.03	0.20±0.03	78.13	0.12±0.09	80.00	3.50±0.090	87.50

millet."

The retention of riboflavin in "moin-moin" for the three varieties of beans studied ranged from 81.0 - 90.48% (mean = 87.16 ± 5.34). The lowest retention of riboflavin was also observed in the brown variety. Compared with the "tuwo products", riboflavin retention ranged from 68.75 - 81.0%. The mean retention of riboflavin for "moin-moin" was 87.16% compared to the mean retention of 56.21% for the cooked white grains at 60 minutes. Similarly there was good retention of riboflavin in the preparation of "tuwo" products. Dehulling appeared to have little effect on riboflavin content of maize.

The retention of niacin in "moin-moin" ranged from 77.17 - 84.0% (mean = 80.08%) compared with the 87.90% retention in the cooked whole grain (appendix 5). In maize, dehulling appeared to decrease the niacin content as shown by the results of preparation of "tuwo" products. On the contrary, dehulling enhanced the niacin content of sorghum. There was also a poor retention of niacin in the preparation of "tuwo" whole sorghum. This result seem to suggest that during preparation of "tuwo"products most of the niacin in cereals may exist in the bound form. Consequently, the retention of the vitamin during preparation of "tuwo" products is poor when the retention of 49.33% in preparation of "tuwo" (whole millet) is compared to the retention of 88% during cooking for 60 mins. However, the preparation of "moin-moin" appeared to enhance better retention of thiamine, riboflavin and niacin compared to the preparation of "tuwo" products (fig 8).

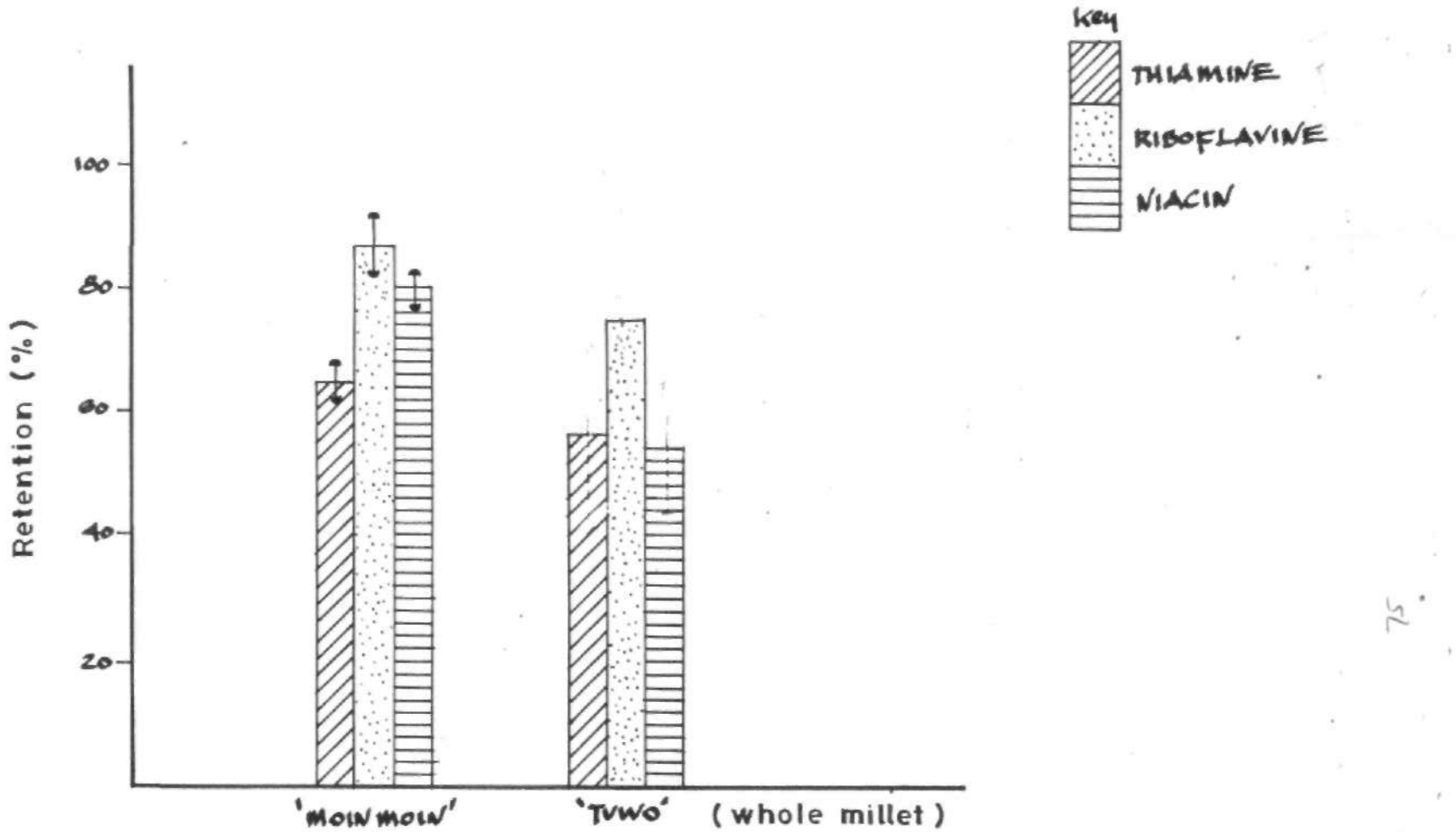


Fig. 8.0. Retention (%) of Thiamine, Riboflavine and Niacin during preparation of 'Moin Moin' and 'Tuwo' (whole millet)

Results of the traditional processing of beans into "moin-moin" in present study agreed with values reported by Edijala (1980) and Akinyele (1989). The mean retention of 92.30, 90.41 and 83% of vitamins B_1, B_2 and B_3 respectively in the decorticated grains compared to 65.67, 87.16 and 80.08% in "moin-moin" suggests that the losses in "moin-moin" were due mainly to decortication and thermal destruction as loss by leaching could not occur. Since decortication of the brown variety resulted into higher losses of thiamine, riboflavin and niacin, this variety may not be recommended for use in the preparation of "moin-moin".

4.6 EFFECT OF FRYING ON THIAMIN, RIBOFLAVIN AND NIACIN CONTENT OF COWPEAS

The mean thiamine, riboflavin, and niacin content and percentage retention of some food items fried in groundnut oil are presented in table 9.

Pushpamma (1982) observed that loss of thiamine and riboflavin was more in recipes prepared by deep fat frying method. In present study, the retention of 55.17 and 77.78% of thiamine and niacin respectively in white sweet potato when subjected to cooking for 60 minutes compared to retention of 62.78 and 86.02 of thiamine and niacin during frying is at variance with the observation of Pushpamma (1982). The retention of 50.00% in riboflavin during frying of white sweet potatocompared to the retention of 56.25% during cooking for 60 minutes however, appears to validate this assertion. The

[illegible]

[illegible] Content of [illegible]

[illegible]	Moisture (%)	Thiamin mg/100g dry weight	Retention (%)	Riboflavin mg/100g dry weight	Retention (%)	Niacin mg/100g dry weight	Retention
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.71±0.121	105.56
[illegible]	[illegible]	[illegible]	44.601	0.14±0.08	63.64	1.73±0.01	95.58
Yam	55.30±0.24	0.12±0.02	70.59	0.03±0.01	60.00	0.95±0.03	67.86
Irish Potato	55.80±1.14	0.10±0.06	55.46	0.06±0.01	40.00	2.29±0.11	75.08
Groundnut oil	-	0.93±0.01	60.00	0.03±0.20	- 42.86	[illegible]±0.11	89.69
Cottonseed oil	-	0.32±0.03	40.00	0.04±0.04	66.67	0.03±0.01	60.00
Palm oil	-	0.04±0.01	40.00		-	0.02±0.02	75.00
Onion	70.20±0.26	0.15±0.30	46.88	0.16±0.060	47.37	0.60±0.080	30.00
Coconut	6.20±0.90	0.12±0.04	60.00	0.14±0.080	73.68	1.56±0.021	78.00
Plantain	63.20±0.10	0.10±0.10	45.45	0.14±0.020	70.00	1.03±0.030	53.93

effect of frying on some other food items (fig 9.0) also support their reports. The high loss of riboflavin during frying compared to cooking might be due partly to the effect of oxidation consequent to exposure of foods to light and heat. The high losses of thiamine and niacin in root and tubers during cooking might be due mainly to leaching.

4.7 EFFECT OF BLANCHING ON THIAMIN, RIBOFLAVIN AND NIACIN CONTENT OF SOME VEGETABLES

The mean thiamine, riboflavin and niacin content and percentage retention of three blanched vegetables is given in table 10.

Retention of thiamine ranged from 37.5 - 65.7% (mean = 53.43+0.08%). Highest ($p < 0.05$) losses of thiamine was observed in spinach during blanching. The loss of riboflavin was also highest ($p < 0.05$) in spinach. Retention of riboflavin ranged from 48.0 - 85.11% (mean = 71.50+0.10%),

Like thiamine and riboflavin, niacin retention showed similar pattern with highest ($p < 0.05$) losses in spinach (fig. 10.0). Niacin retention ranged from 65.86 - 86.58% (mean = 79.40+0.21%).

The losses of thiamine, riboflavin and niacin observed in the three blanched vegetables in present study are in agreement with the findings of (Rice et al, 1990; Kirk, 1979; Selman and Rolfe, 1982). The considerably larger ($p<0.05$) losses observed in spinach in present study supports the findings of Fennema (1975, 1977). Blanching is an established household processing operation that is commonly employed to ensure improved storage properties for vegetables. Blanching is also used in the

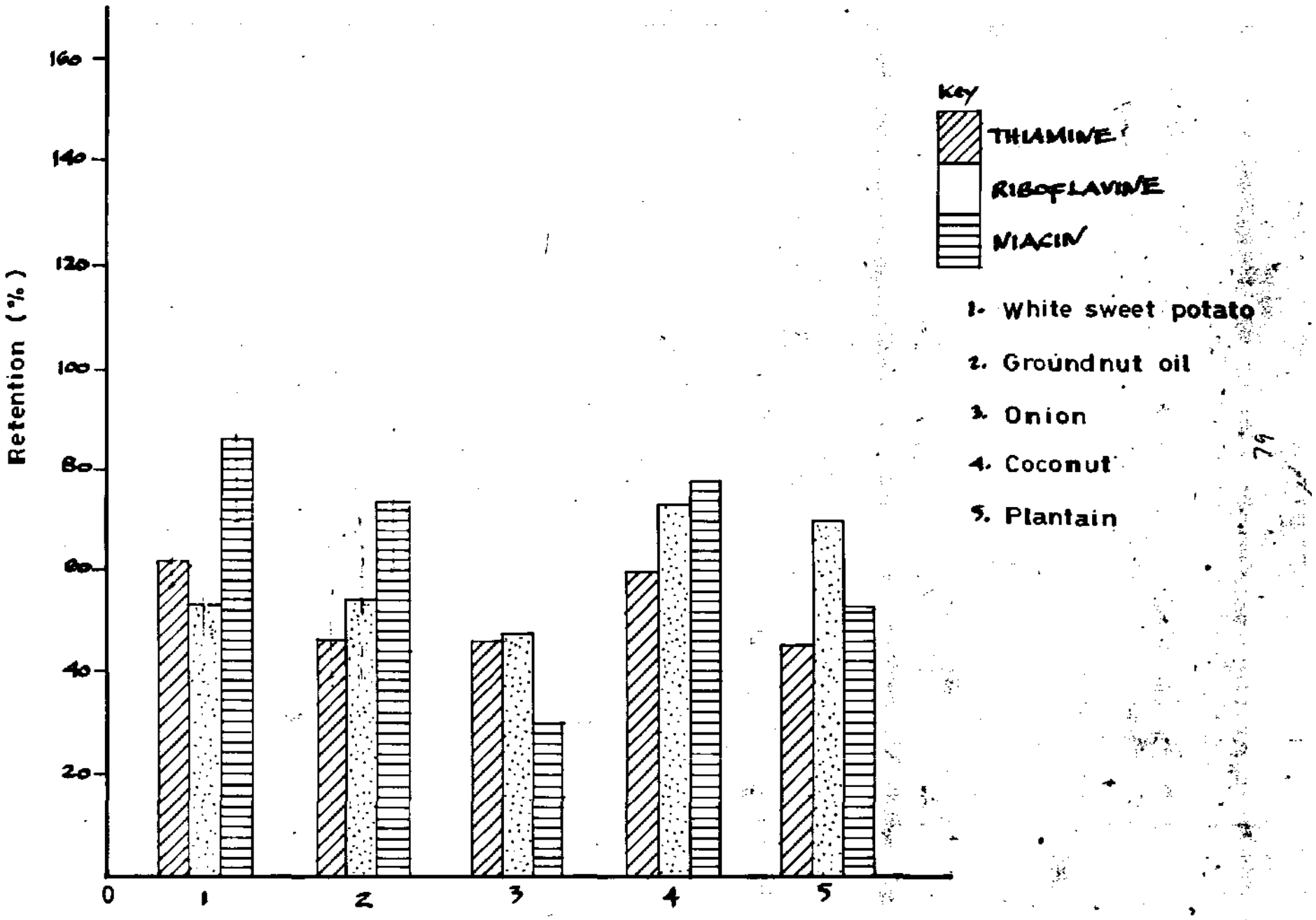


Fig. 9.0. Percentage Retention of Thiamine, Riboflavine and Niacin during frying .

TABLE 12

Effect of Blanching (5 min) on Thiamine, Riboflavin, and Niacin Content of some Vegetables

VEGETABLES	Moisture (%)	Thiamine mg/100g dry weight	Retention (%)	Riboflavin mg/100g dry weight	Retention (%)	Niacin mg/100g dry weight	Retention (%)
Fluted Pumpkin	87.20±0.11	0.33±0.04	65.71	0.35±0.01	31.40	2.00±0.04	86.58
Bitter leaves	82.00±0.05	0.32±0.01	97.14	0.40±0.01	35.11	1.03±0.01	85.77
Spinach	93.63±0.13	0.02±0.05	17.50	0.12±0.01	48.0	1.90±0.06	65.86

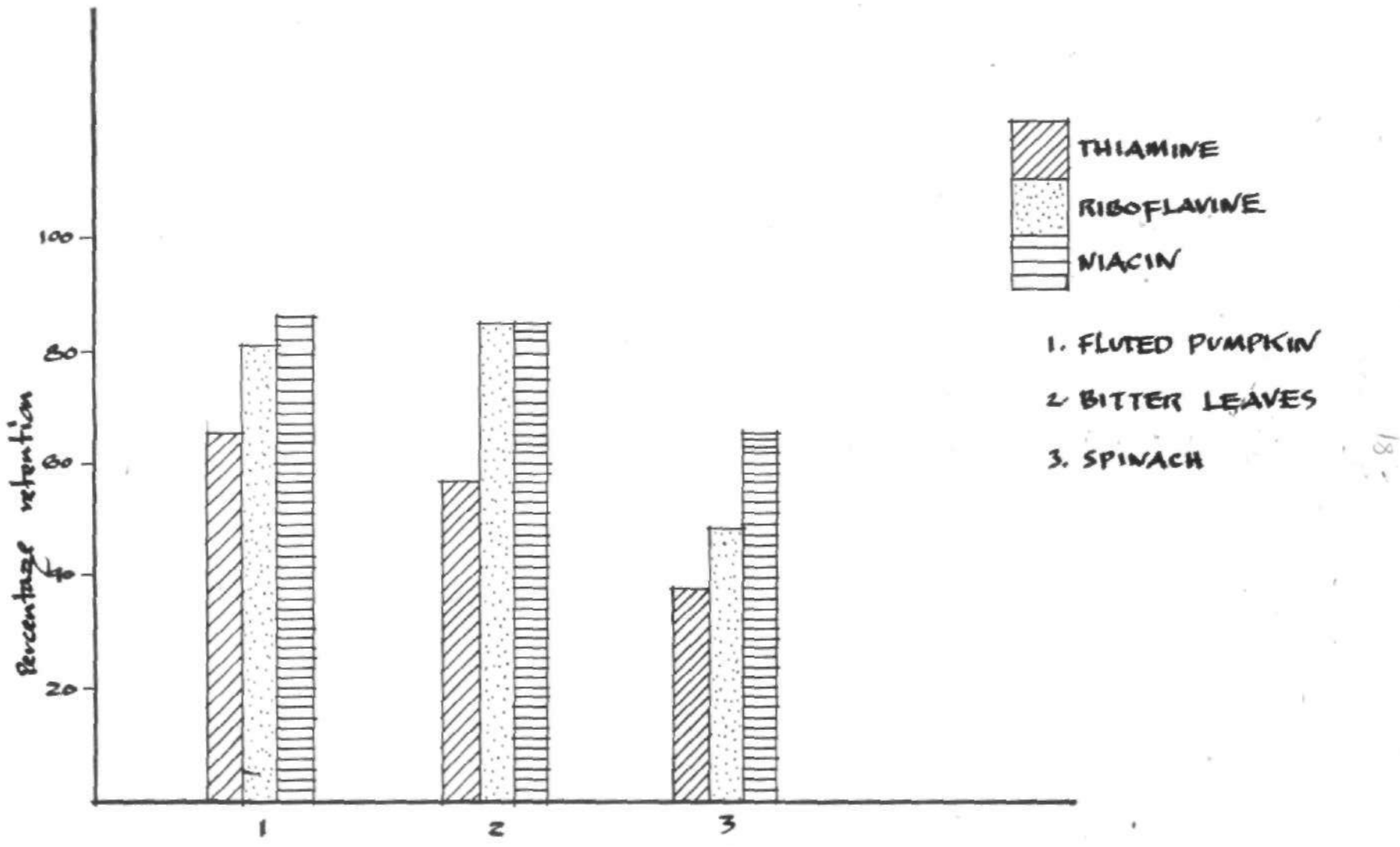


FIG 10.0 PERCENTAGE RETENTION OF THIAMINE, RIBOFLAVINE AND NIACIN IN FLUTED PUMPKIN BITTER LEAVES AND SPINACH DURING BLANCHING

production of potato chips to lower the reducing sugar content, which will otherwise cause darkening and bitter tasting products formed by the maillard reactions of sugars at the frying temperatures. The inevitable high losses of these water - soluble vitamin emphasizes the need for adequate vitamin supplementation of blanched vegetables.

4.8 EFFECT OF ROASTING ON THIAMIN, RIBOFLAVIN AND NIACIN CONTENT OF SOME SELECTED FOOD ITEMS

The mean vitamins B1, B2 and B3 [illegible] retention in [illegible] in table 11.

The retentions of vitamin B1, B2 and B3 [illegible] 54.59, 76.43, 60.18, 99.2, 162.6, 120.0% respectively for roasted foods evaluated. A detailed comparison of values of vitamin retention of the roasted foods with values for foods cooked at 60 minutes respectively revealed that household processing technique such as roasting enhance vitamin retention. This may possibly be due to the absence of leaching promoted by cooking for the water soluble vitamins. In Nigeria, it is a usual practice to roast foods for consumption in form of snacks. Data from present study therefore support the consumption of roasted foods in order to enhance bioavailability of the vitamins.

TABLE 11

Effect of Blanching on Thiamine, Riboflavin, and Niacin in some selected food items

FOOD ITEM	Moisture (%)	Thiamine mg/100g dry weight	Retention (%)	Riboflavin mg/100g dry weight	Retention (%)	Niacin mg/100g dry weight	Retention (%) FOOD ITEM
Yam	50.20±1.90	0.13±0.01	76.47	0.05±0.01	80.0	0.84±0.04	60.00
Groundnut	0.70±0.14	0.49±0.10	53.57	0.07±0.04	70.0	5.91±0.09	96.89
Fresh Corn	55.5±1.63	0.35±0.08	68.82	0.38±0.02	90.48	4.00±0.15	129.00
Benni seed	2.50±0.10	0.36±0.06	54.50	0.38±0.01	68.18	1.95±0.01	97.50

.op

4.9 EFFECT OF RIPENING ON THIAMIN, RIBOFLAVIN AND NIACIN CONTENT OF SELECTED FRUITS

The mean thiamine, riboflavin, and niacin content and percentage retention of five fruits during ripening is shown in table 12.

Increases ranging from 25.0 - 94.44% were observed in thiamine content of all the five fruits with the exception of 9.33% riboflavin decrease following ripening of Guava. There was also riboflavin increase of 11.11 - 65.0% for all four fruits.

A loss of 26.04% of niacin was also observed in Guava during ripening. The observed decrease of riboflavin and niacin in Guava and lemon orange might be due to the acidic content of these fruits. It has been postulated that the high acidic content of the fruits hinders microbial growth which may contribute significantly to elevation of water soluble vitamins. Available evidence (Kermasha et al, 1987) indicate that fruit development and maturation in plants are the results of large number of biochemical changes within the developing fruit. According to Kermasha et al, (1987) these changes affect the colour, texture and flavour of the harvested fruit.

Tadeo et al, (1988) reported increase in total free amino acid (TAA) of orange juice during ripening. Kermasha et al,(1987) also reported that the increase in acidity during development of the fruit could reflect an increase in the organic acid content. The general increase in thiamine, riboflavin and niacin might thus be partly due to microbial activity and enhanced stability

TABLE 12

Effect of Ripening on Thiamin, Riboflavin and Niacin content of some selected fruits

FRUITS	Moisture (%)	Thiamine mg/100g dry weight	Retention (%)	Riboflavin mg/100g dry weight	Retention (%)	Niacin mg/100g dry weight	Retention (%)
Sweet orange	84.40±0.01	0.32±0.06	+60.7	0.24±0.02	+65.0	1.34±0.07	+63.41
Mango pulp	78.40±0.14	0.35±0.02	+34.14	0.20±0.04	+25.0	1.93±1.01	+69.30
Guava	70.50±1.42	1.25±1.01	+25.0	0.33±0.13	- 9.33	3.53±0.13	+36.29
Local orange	88.62±0.28	0.30±0.12	+76.47	0.21±0.08	+40.0	2.50±0.04	-26.04
Pineapple	85.0±0.04	0.32±0.08	+88.24	0.10	+11.11	3.67±0.02	+17.54

content. Ketiku (1373) and Izonfuo and Omuaru, (1988) have equally reported increased concentration of amino acids during ripening in plantain. As observed by Watada (1986) ethylene produced endogenously by plants and their organs is capable of inducing physiological responses, including ripening, removal of tannin, and softening of the tissues.

Watada (1986) reported 16% increase in vitamin C (ascorbic acid) of tomatoes treated with ethylene for 24 hrs. Giri et al (1980) also reported increase in vitamin C during ripening in five varieties of papaya. Although there is paucity of information on the effect of ripening on thiamine, riboflavin, and niacin, the observed increases in present study appeared to be consistent with the reported increase in vitamin C during ripening.

4.10 ESTIMATED VITAMIN INTAKES

The estimated mean intakes of vitamins B_1, B_2 and B_3 obtained from dietary data of 3-day record of the subjects considered in present study were 0.83 ± 0.30, 0.50 ± 0.28 and 13.54 ± 1.20 mg/day respectively for adults male. The female subjects similarly had a mean thiamin, riboflavin and niacin intakes of 0.56±0.29, 0.40±0.18 and 10.29±1.50 mg/day respectively.

The estimated intakes appeared to fall below the level recommended by the WHO (1974). The observed suboptimal intakes of the students for all nutrients may not be unrelated to the general economic recession facing the country. The reality of

the current Structural Adjustment Programme (SAP) in Nigeria shows that most families cannot afford adequate diets. In view of the suboptimal intakes observed in present study, it appears there may be a high prevalence of water-soluble vitamin deficiency in this population group.

Chapter 5

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

Data from present study revealed that legumes provide appreciable amounts of thiamine, riboflavin, and niacin in the Nigerian diet. Unfortunately legumes which are excellent plant sources of the vitamins are becoming increasingly expensive and almost unavailable to the teaming population. The high losses of the vitamins observed during cooking attest to the need for fortification of most Nigerian processed foods with vitamins.

Although vegetables appeared to provide appreciable amounts of riboflavin, their relative high moisture content limit their utilisation as a potent source of vitamin for the Nigerian population. Sauberlich et al, (1979) reported that the requirement of thiamine (vitamin B_1), riboflavin (vitamin B_2), and niacin (vitamin B_3) is related to caloric intakes. Beaton and McHenry,(1964) also reported increased requirement for niacin during low protein intakes, although calorie and protein intakes of subjects are not evaluated in present study. According to Ihekoronye and Ngoddy (1985) and Sauberlich et al, (1979), the bulk of the diet of low income group in developing countries is composed largely of cereal grains or starchy root and tubers because animal products representing protein of high quality are either too expensive or simply unavailable. It appears therefore

that the poor intakes available to this population group may further be affected by poor calorie and protein intakes of the populace. The easy accessibility of Hausa/Fulani population groups to milk and milk products suggests that their riboflavin intakes may be better than population groups in southern Nigeria who consumed predominantly starchy based staples.

5.2 CONCLUSIONS

In present study, the following assertions can be deduced:

(a) The thiamine, riboflavin and niacin content of most Nigerian foods ranged from 0.07 to 1.00, 0.01 to 0.47, and 0.04 to 8.96 mg/100g respectively.

(b) Legumes and vegetables appear to significantly contribute to thiamine, riboflavin and niacin concentrations, derived from Nigerian foods.

(c) Cooking techniques significantly promote losses of the vitamins to the tune of 47.70+3.74%, 40.30+2.64%, and 15.25+2.44% for thiamine, riboflavin, and niacin respectively.

(d) Conversion of predominant root and tuber based staples and legumes (Cowpea in particular) into paste, produced better retentions of the vitamins in foods.

(e) Ripening appears to promote increased concentration of all the three vitamins in fruits relative to the unripe fruits.

(f) Blanching techniques employed for vegetables resulted to significant losses in the vitamins. The ascending order in degree of retention are 53.45% for thiamine < 71.50% for riboflavin < 79.40% for niacin.

Application of food composition table to actual food intakes consumed by a selected group of Nigerian population revealed that male subjects consumed 69.17%, 32.22%, and 76.35% of thiamine, riboflavin, and niacin respectively relative to established recommended dietary allowances while female subjects consumed 62.22%, 30.76% and 70.96% of thiamin, riboflavin and Niacin respectively.

5.3 RECOMMENDATIONS

In the light of the findings obtained from the study, the following recommendations are hereby proposed.

(a) In view of serious vitamin losses observed following cooking at various time intervals, it is recommended that foods should be consumed with their broth.

(b) It is recommended that an optimum cooking time of 30 mins be adopted for vegetables considering the high losses of vitamins observed in cooking vegetables.

(c) It is also recommended that most cereal and legume based foods should be preferentially processed into their paste (especially cowpea into "moin-moin") to enhance retention of the 3 vitamins.

It is suggested from present studies that suboptimal intakes of the 3 vitamins may indicate a high degree of biochemical vitamin deficiency in the Nigerian population. It is hereby stressed that there is a need for the evaluation of the status of these student population by other biochemical indices which are more reflective of nutritional status.

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APPENDIX 1 Determination of Standard Curve for thiamine:

The fluorescence of the isobutanol extract was measured at excitation wavelength of 365 nm and emission wavelength of 436 nm. A plot of flurescence against thiamine in ug/ml was made. From the straight line of best fit, the concentration, C, corresponding to the fluorescence of the sample was obtained.

Thamine (ug/ml)	0.00	0.10	0.50	1.00	1.50
1% Mercuric chloride	0.30ml	0.30ml	0.30ml	0.30ml	0.30ml
Isobutanol	5.0ml	5.0ml	5.0ml	5.0ml	5.0ml
Deionized Distilled Water	3.70ml	3.60ml	3.20ml	2.70ml	2.20ml
Fluorescence	0.00	10.00	33.00	65.00	100.00

mg thiamine/100g sample =

$$\frac{C}{10xg\ sample} \times 8.3 \text{ (dilution factor)}$$

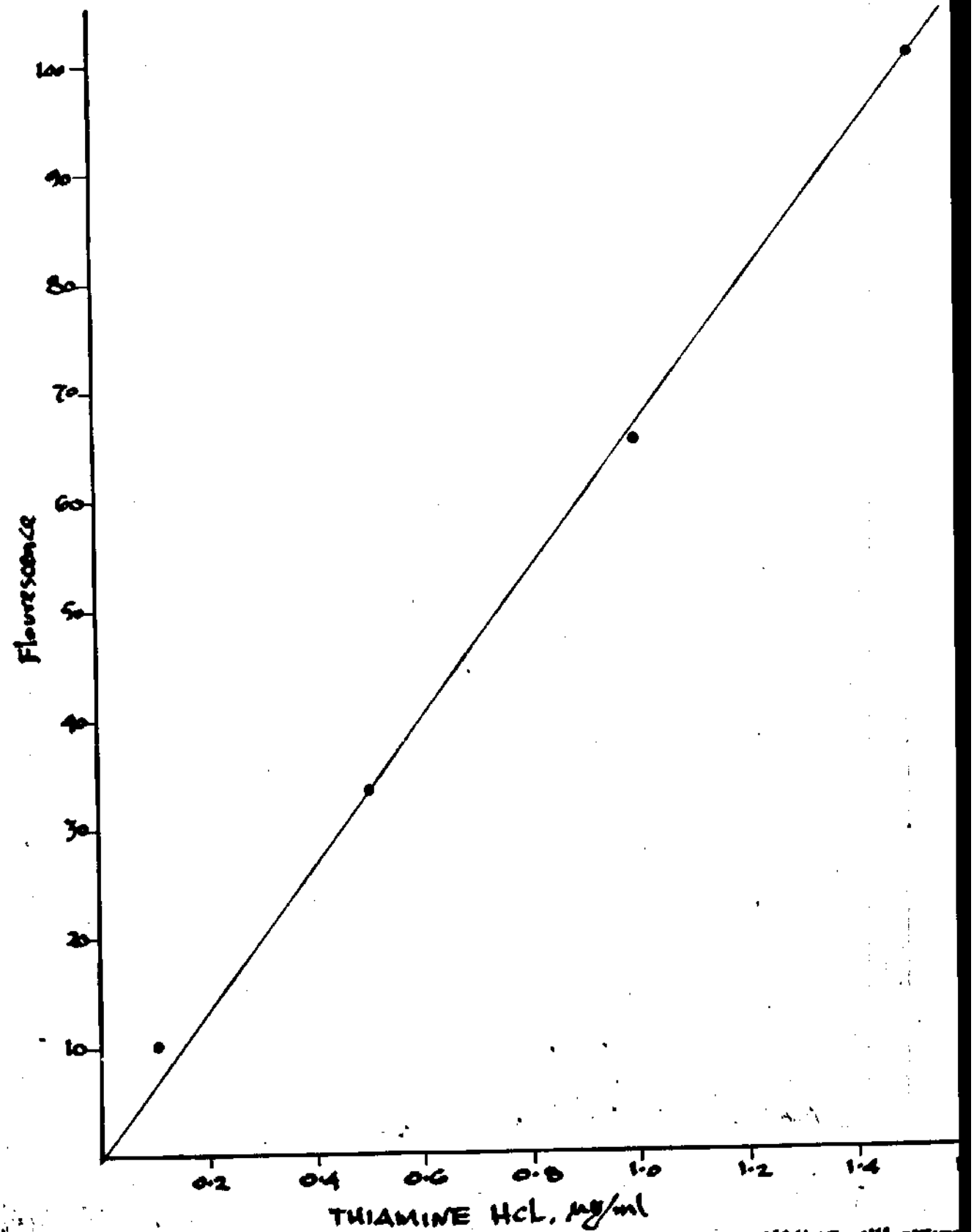


FIG 1.0A STANDARD CURVE FOR THIAMINE HYDROCHLORIDE

Determination of Standard Curve for Niacin.

The spectrophotometer was set to OA at 470 nm with standard blank and the absorbance of all other tubes were taken 12 - 15 min. after addition of 1ml. 55% sulfanilic acid.

A plot of Absorbance (A) of standard minus that of reagent blank against niacin in ug/ml was made as shown below. From the straight line of best fit, the ceoncentration, C, corresponding to Absorbance of sample corrected for sample blank and reagent blank was obtained.

Reagent Bank	1	2	3	4	5	6
Nicotinic acid (10 ug/ml	0.00	0.00	5.0ml	10.0ml	15.0ml	20.0ml	25.0ml
Cold CNBR	10.0ml	10.0ml	10.0ml	10.0ml	10.0ml	10.0ml	10.0ml
55% Sulfanilic acid	1.0ml	1.0ml	1.0ml	1.0ml	1.0ml	1.0ml	1.0ml
OD	0.012	0.012	0.027	0.042	0.058	0.072	0.087
OD-Reagent Blank OD		0.00	0.015	0.030	0.046	0.06	0.075
Concentration of Niacin (ug/ml)		0.00	2.5	5.0	7.5	10.0	12.5

$$\text{mg Niacin/100g sample} = \frac{C}{10xg\ \text{sample}} \times 20\ \text{(dilution factor)}$$

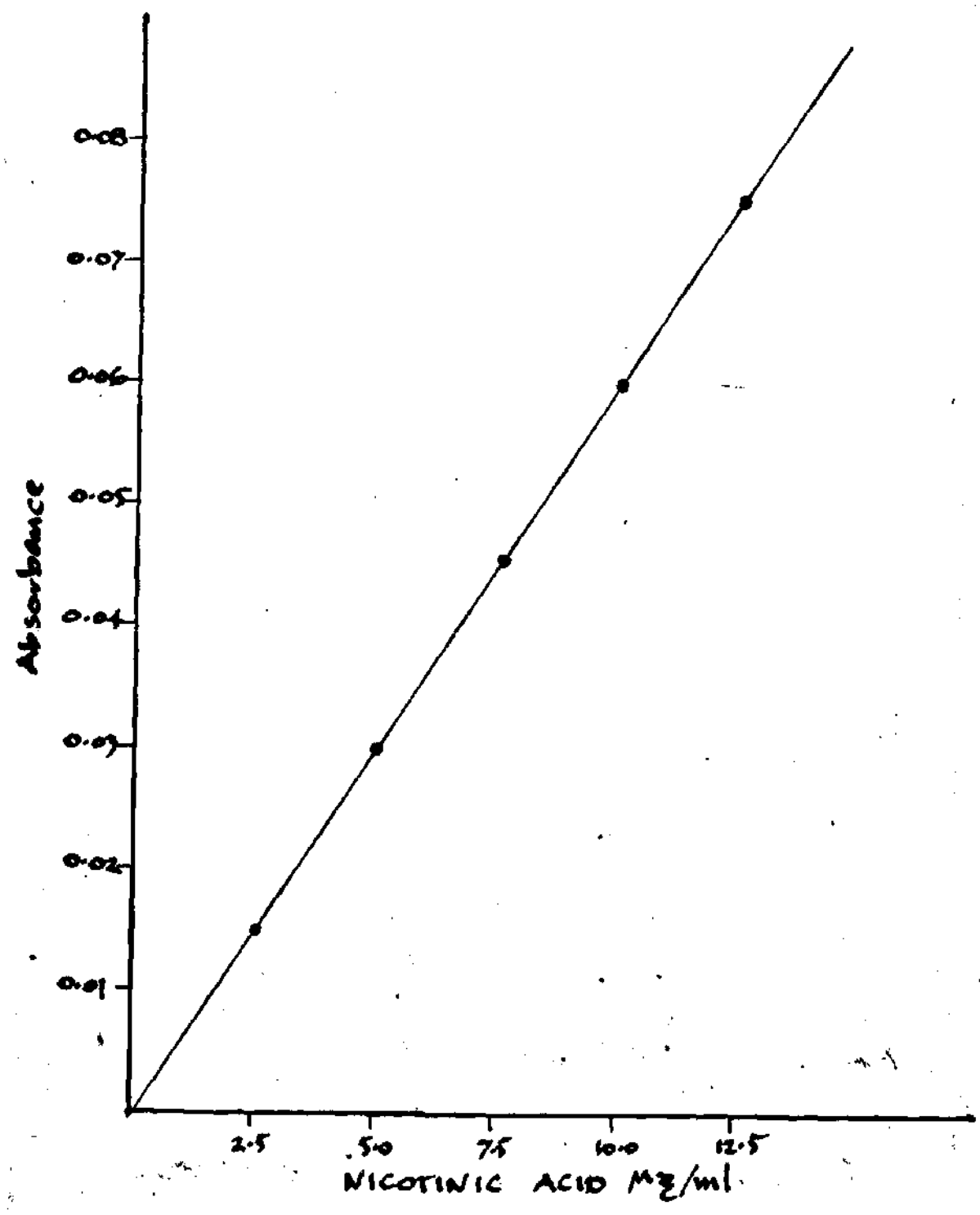


FIG 2.0a STANDARD CURVE FOR NICOTINIC ACID

APPENDIX 3

PERCENTAGE RETENTION OF THIAMINE IN SOME SELECTED FOOD ITEMS DURING COOKING

FOOD ITEM	COOKING TIME (MIN)			
	0	30	45	60
Root and Tubers:				
Yam	100	88.24	70.59	58.82
Cassava	100	83.33	66.33	58.33
White Sweet Potato	100	77.59	63.79	55.17
Red Sweet Potato	100	86.15	73.85	58.46
Irish Potato	100	77.78	66.67	55.56
Cocoyam	100	82.35	64.71	58.82
Legumes & Nuts:				
Groundnut	100	85.71	72.86	57.14
Brown Beans	100	80.95	50.53	42.11
White Big Beans	100	65.0	56.00	48.0
White Small Beans	100	68.67	63.86	50.60
Cereals - Rice	100	72.72	70.75	60.61
Oil seeds:				
Melon	100	61.54	38.46	38.46
Benni seed	100	84.85	77.27	57.58

FOOD ITEM	COOKING TIME (MIN)			
	0	30	45	60
Vegetables:				
Carrots	100	75.76	66.67	39.39
Tomatoes	100	80.95	76.19	50.79
Okra	100	72.97	59.46	43.24
Onion	100	78.13	56.25	50.0

APPENDIX 4

PERCENTAGE RETENTION OF RIBOFLAVINE IN SOME SELECTED FOOD ITEMS DURING COOKING

FOOD ITEM	COOKING TIME (MIN) 0	30	45	60
Root and Tubers:				
Yam	100	80.0	60.0	60.0
Cassava	100	80.0	70.0	64.0
White Sweet Potato	100	81.25	68.75	56.25
Red Sweet Potato	100	86.36	77.27	68.18
Irish Potato	100	86.67	73.33	53.33
Cocoyam	100	85.71	71.43	64.20
Legumes & Nuts:				
Groundnut	100	80.0	71.0	60.0
Brown Beans	100	47.62	66.67	52.38
White Big Beans	100	70.0	65.0	55.33
White Small Beans	100	66.67	57.14	57.14
Cereals - Rice	100	91.11	84.44	73.33
Oil seeds:				
Melon	100	80.0	70.0	50.0
Benni seed	100	86.36	75.0	56.82

FOOD ITEM	COOKING TIME (MIN)			
	0	30	45	60
Vegetables:				
Carrots	100	75.00	66.67	53.33
Tomatoes	100	85.0	75.0	67.5
Okra	100	65.79	52.63	52.63
Onion	100	73.68	68.42	44.74

APPENDIX 5

PERCENTAGE RETENTION OF NIACIN IN SOME SELECTED FOOD ITEMS DURING COOKING

FOOD ITEM	COOKING TIME (MIN) 0	30	45	60
Root and Tubers:				
Yam	100	91.43	84.29	72.14
Cassava	100	95.0	93.57	84.29
White Sweet Potato	100	96.30	80.25	77.78
Red Sweet Potato	100	90.61	82.87	80.11
Irish Potato	100	84.26	75.08	59.34
Cocoyam	100	89.21	80.58	79.14
Legumes & Nuts:				
Groundnut	100	93.77	90.66	88.69
Brown Beans	100	94.23	93.18	86.61
White Big Beans	100	97.01	93.69	88.70
White Small Beans	100	94.0	91.60	87.60
Cereals - Rice	100	96.0	84.0	88.0
Oil seeds:				
Melon	100	92.54	89.55	85.07
Benni seed	100	100.00	100.00	95.00

FOOD ITEM	COOKING TIME (MIN)			
	0	30	45	60
Vegetables:				
Carrots	100	97.70	95.08	87.54
Tomatoes	100	95.98	89.62	87.28
Okra	100	97.78	97.29	74.63
Onion	100	95.50	90.50	80.0