EFFECTS OF HOUSEHOLD PROCESSING TECHNIQUES ON LEVELS OF SOME ANTINUTRITIONAL FACTORS AND MINERALS IN SOME NIGERIAN FOODS

BY

V I C T O R A M B R O S E M A I K A I

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of the requirements for the degree of
M.Sc. Biochemistry

DECLARATION

I hereby declare that this thesis has been written by me and it is a result of my research work.

It has not been presented in any previous work for the award of a higher degree at any other University. Information and excerpts from published and unpublished works of others have been specifically acknowledged in the text.

MAIKAI, VICTOR AMBROSE

CERTIFICATION

This Project thesis title "Effects of Household Processing Techniques on levels of some antinutritional factors and minerals in some Nigerian foods" by MAIKAI, VICTOR AMBROSE meets the regulation governing the award of the Degree of Master of Science (M.Sc) Biochemistry of Ahmadu Bello University, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to God and the family of Mr and Mrs Ambrose Maikai for their support, encouragement and assistance.

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To everyone, I say the Lord bless and keep you.

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ABSTRACT

Hydrogen cyanide, oxalate, phytate, tannin, calcium, copper, iron, magnesium, phosphorus and zinc content of forty locally consumed Nigerian foods were evaluated.

The foods were given different treatments including blanching, boiling, conversion to paste products, decortication, frying, roasting and soaking and changes in levels of the antinutritional factors and minerals simultaneously estimated.

Hydrogen cyanide was high in cassava and sorghum (19.83 and 5.26mg/kg respectively). Soluble oxalate was 36.66 mg/lOOg in spinach. Soybean and wheat had (78.70 and 48.86 mg/lOOg phytate respectively). Tannin was high in sorghum 148.35mg/100g. Calcium was high in baobab and spinach leaves (169.5 and 153.0mg/100g respectively) . Iron was high in boabab leaves (15.2mg/100g) while soybeans had 531.0mg/100g phosphorus. Zinc was 0.8mg/100g in sweet potato. Copper was generally low in the foods.

Blanching, boiling, conversion to paste products, decortication and soaking were effective in significantly ($P<0.05$) reducing the antinutritional factors and minerals. The phytate/mineral and oxalate/mineral ratios did not significantly ($P>0.05$) affect the bioavailability of calcium and magnesium, however iron and zinc bioavailability were significantly ($P<0.05$) affected.

CHAPTER ONE

INTRODUCTION

Available evidence (Feeney 1976, Schultz and Baldwin 1982; Hui 1992) indicates that plant survival is dependent on the intricate synthesis of a number of toxicants which protect the plants against microbial attack, insects and predators. Such commonly naturally occurring toxicants in plants include allergens, cyanogenic glycosides, haemagglutunins, oxalates, phytates, tannins and trypsin inhibitors.

Antinutritional factors elicit some pathological effects following their consumption (Conn 1973; Oke 1969; Liener 1980) in foods. Such effects include the allergic responses produced by allergens following the consumption of certain nuts. Other effects are the inhibition of cellular respiration by cyanogenic glycosides found in cassava (Montgomery 1980) and acute hemolytic anemia caused by vicine and convicine in java beans (Salunkhe and Wu 1977). Hypothyroidism and enlargement of the thyroid glands (Liener 1980) have also been associated with the consumption of thioglycosides in cabbage and related species, while phytoalexins in sweet potatoes have been shown to induce pulmonary edema, liver and kidney damage. Liener (1980) reported that protease inhibitors present in most leguminous plants especially beans result in abnormal growth and pancreatic hypertrophy. Oakenful et al, (1979) also reported that saponins promote agglutination of erythrocytes in vitro and mutagenic activity of cell cultures. Kumar and

Singh (1984) indicated that sorghum contain high tannin contents which have heen associated with liver necrosis and esophageal cancer. Apart from eliciting pathological conditions, antinutritional factors in foods have been linked with negative bioavailability of dietary minerals in foods (Davies and Nightingale, 1975; Oberleas, 1975; Rosenberg and Solomons 1982). Ackerman and Gebauer (1957) for instance, reported that in experimental animals, calcium and magnesium utilization was impaired following the consumption of foods high in oxalates. Tannins have been shown to form insoluble complexes with proteins and some divalent cations (Haslam, 1977; Hagerman and Butler, 1978) which could precipitate mineral deficiency diseases. Similarly, Oberleas (1973) reported that phytates chelate with minerals rendering them biologically unavailable from foods. It is well established (Saka 1993; Hui, 1992) that household processing techniques do not only improve pallatability and ensures availability of nutrients but also reduce the content of antinutritional factors (Pingle and Ramasastri, 1978; Fafunso and Maduagwu, 1983; Aalbersberg and Limaleru, 1991; Edem et al 1994).

In Nigeria most investigations that have been carried out on antinutritional factors have centered mainly on raw foods Eka, 1977; Chakraborty and Eka 1978). Since foods are not eaten raw but processed by either soaking, boiling, frying, roasting or cooking, it is necessary therefore to evaluate the effects of household processing techniques on the levels of antinutritional factors and minerals in

commonly consumed Nigerian staples.

The present study was therefore, prospectively designed to:

i. Assess the levels of some antinutritional factors and minerals in Nigerian raw foods and to comparatively evaluate the effects of household processing on levels of antinutritrional factors and minerals in such foods, and

ii. to comparatively evaluate the effects of household processing on levels of antinutritional factors and minerals in such foods, and

iii. to determine antinutritional-mineral ratios as an index of bioavailability of the minerals in the foods.

CHAPTER TWO

LITERATURE REVIEW

2.0 HOUSEHOLD PROCESSING TECHNIQUES

Available evidence indicates that household processing operations are adopted to improve palatability, digestibility, acceptability, enhancement of nutritive value of foods and preservation of foods (Kakade and Liener, 1975; Hui, 1992). Cooking can basically be classified into two operations:

i) Dry heat and

ii) Moist heat processing techniques (Baldwin and Cotterill, 1979; Brown and Cameron (1977).

Dry heat operations involves the use of dry heat in processes such as baking and roasting as in oven or closed vessels, grilling and broiling. While moist heat operations requires cooking the food in liquids at high temperatures. Examples of moist heat operations include:

(a) Boiling - Cooking at temperatures above 100°c in water.

(b) Frying - Cooking by partly or completely immersing of food in heated oil at high temperatures.

(c) Microwave - Cooking using radiation in an oven.

(d) Steaming - Cooking using steam directly or indirectly.

(e) Stewing and simmering - Cooking in water at temperatures below 100°c.

Other household food processing operations include,

blanching, decortication, dehydrating, drying, fermentation, milling and soaking. Most of this processing techniques have been shown to decrease the levels of nutrients and antinutritional factors (Kakade and Liener, 1975; Eastman, 1980; Prowie and Nakai, 1981; Essers, 1989; Rice et al 1990; Aug et al 1991) in foods.

2.1 NUTRITIONAL CHANGES OCCURRING IN HOUSEHOLD PROCESSING OF FOODS

Although processing has been reported to promote palatability and enhanced digestibility of foods, nutritional changes such as nutrient losses have been reported in household processing operations. Malik, 1967). Okwuraie, 1977) for instance have indicated that of all carbohydrates found in foods, starch is the most susceptible to heat treatment. Moist heat has been shown to cause starch grains to swell and ultimately rupture their envelopes (gelatinization). Kirk (1979) also revealed that monosaccharides, oligosaccharides and polysaccharides present in some foods may be lost during food processing by leaching. Malik (1967) also reported that prolonged or severe heating caramelises sugar resulting in a pleasant characteristic flavour and eventually charring.

Processing have equally been shown (Sinclair and Hollingsworth, 1969) to produce lipolytic oxidative rancidity in dietary lipids. Artman (1969) for instance showed that the configuration of lipids are altered during processing. Brown (1953) also demonstrated that repeated

frying of oils tend to increase the fatty acid content, decrease iodine number, lowered smoking and melting points, increased peroxide number and to promote polymerization and darkening of color. Dugan (1968) also reported that aldehydes formed by oxidation of unsaturated lipids react readily with free amino groups of protein to form products which alter the available amino acid patterns of proteins.

The effect of household processing operations on protein have also been reported, Kirk (1979) for instance reported that roasting of pure proteins at various temperatures (100° - 300°c) results in the destruction of essential amino acids such as tryptophan, methionine, cystine, basic and Bhydroxy amino acids. It has also been revealed that broiling muscle meat at 170°c for 45 minutes could result in 30% loss of vitamin B12. Selman (1968) reported that moist heat processing methods often resulted in the leaching of soluble nutrients especially the water soluble vitamins. Ogunmodede (1972) for instance, reported that traditional processing of Nigerian grains resulted in losses of more than 30% thiamine while 7.5% loss in thiamine was observed for vegetables handled in restaurants. Osifo (1971) reported losses of 62% and 69% in niacin and ribloflavin respectively during the processing of cereals to 'ogi'. Food processing has been shown to result in 37 - 70% loss in soluble mineral content during blanching of vegetable (Bengtsson, 1969). Osinubi et al (1985) reported a 49 - 65% loss in mineral content of cooked navy beans.

2.2 EFFECT OF HOUSEHOLD PROCESSING ON ANTINUTRITIONAL FACTORS

The effect of processing on the elimination of antinutritional factors following household operations have been fairly established. Many investigators, (Cooke and Maduagwa, 1978; Edem et al, 1994; Aalbersberg and Limaleru, 1991; Saka, 1993) have recorded that preliminary soaking, cooking, and sun drying reduced cyanide contents of foods by 50-97.4%. Soaking, dehulling and boiling have also been shown (Singh and Arora, 1978, Barroga et al 1985; Khokhar and Cauhan, 1986; Ogun et al, 1989; Edem et al 1994) to remove 80-100% tannin content of sal seed meal, mung bean seeds and cowpea. Fermentation, soaking and boiling has been reported to reduce phytic acid content of foods by 72-93% Oke (1967), Kakade and Liener (1975), Khokhar and Chauhan (1986), and Adewusi et al 1991), while Pingle and Ramasastri (1978) for instance have showed that soaking of vegetables and blanching leaches out 70-90% of total oxalates. Heat treatment has further been observed to reduce phytohemagglutinins of beans, and completely inhibit the action of trypsin inhibitors (Khokhar and Chauhan, 1986; Prowie and nakai, 1981).

2.3 ANTINUTRIENTS (Hydrocyanic acid, Oxalates, Phytic acid and Tannin)

HISTORY

Hydrogen cyanide was first detected in 1803 in plants (Kinsbury, 1964), while phytic acid was first

isolated from grains (Pfeffer, 1872) fore than a century ago. Oxalates was first elucidated as a systemic poison. Brown and Gettler, (1922) reported tannin as plant extracts used for tannin leather.

SOURCES

The food sources of the antinutritional factors are well established (Liener 1980). Cyanogenic glycosides is for instance predominantly found in cassava, legumes and some leafy vegetables (Oke, 1966; Conn, 1973) while Oxalates are found in appreciable amounts in spinach, cocoa, rhubarb and other leafy vegetables (Hagler and Herman, 1973; Liener, 1980). Reddy et al (1982) Nahapetian and Bassiri, (1977) indicated that phytic acid is the major storage form of phosphate and inositol in plant seeds. It is mainly found in legumes, oil seeds and cereal grains. Tannin is also widely distributed in many plants especially cereal grains.

PROPERTIES AND CHEMISTRY

Available evidence indicates (Montgomery, 1965) that hydrogencyanide exist as a colorless liquid which is soluble in water, alcohol and ether. The acid melts and boils at 14°c and 25.7°c respectively and has a density of 0.68g/ml at 20°c. The vapor is highly poisonous and flammable (fig. 1a). Oxalic acid (fig 1b) in its pure state exists as needle like cystals which efflorescence in air. It melts at 189.5°c and

at higher temperatures decomposes to carbondioxide, carbonmonoxide and water, Oxalic acid is an organic dicarboxylic acid that readily forms insoluble salts with calcium and magnesium, (fig 1c). Its' soluble salts are sodium, potassium and ammonium oxalate (fig 1d) the acid and its soluble salts are both corrosive and act as systemic poisons (Brown and Gettler, 1922). Myo-inositol or phytic acid (fig 2a) $C_6H_{18}O_{24}P_6$ has a molecular weight of 660. It is a highly charged compound with six phosphate groups extending from the central inositol ring. Phytates are excellent chelator of mineral ions (calcium, magnesium and

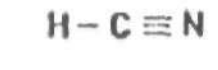


Fig 1a Hydrogen cyanide

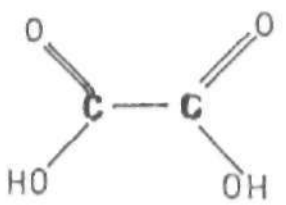


Fig 1b Oxalic acid

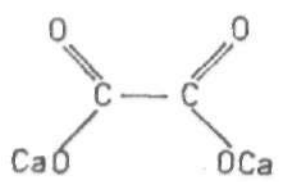


Fig 1c Calcium Oxalate

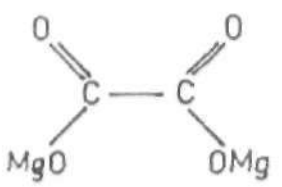


Fig 1c - Magnesium Oxalate

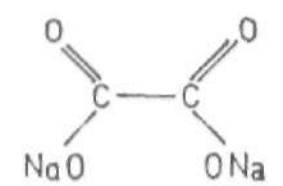
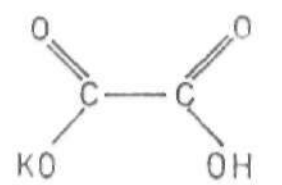


Fig 1d Sodiun Oxalate



Potassium acid Oxalate

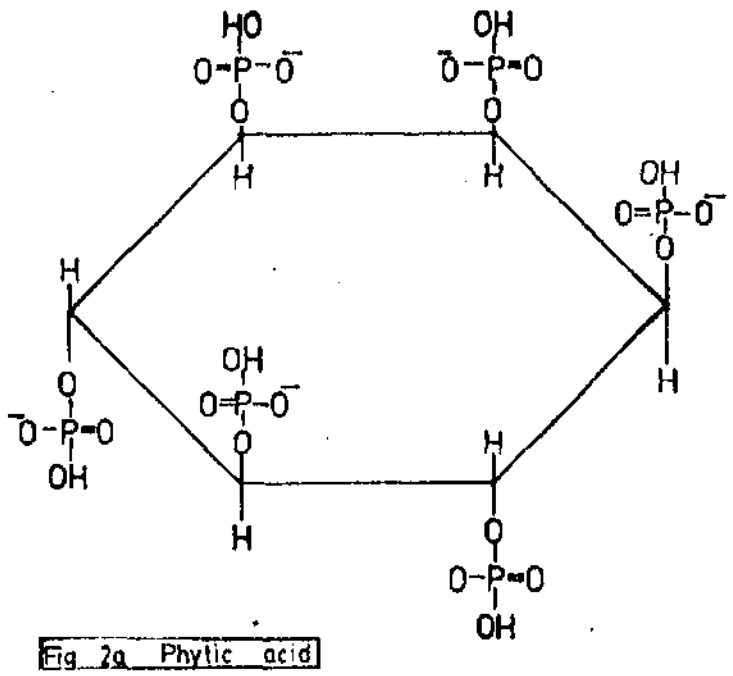


Fig 2a Phytic acid

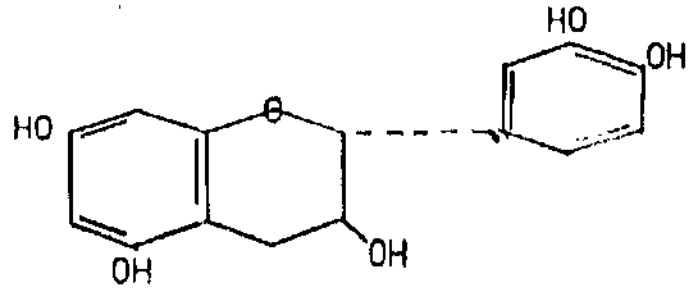


Fig 2b Catechin

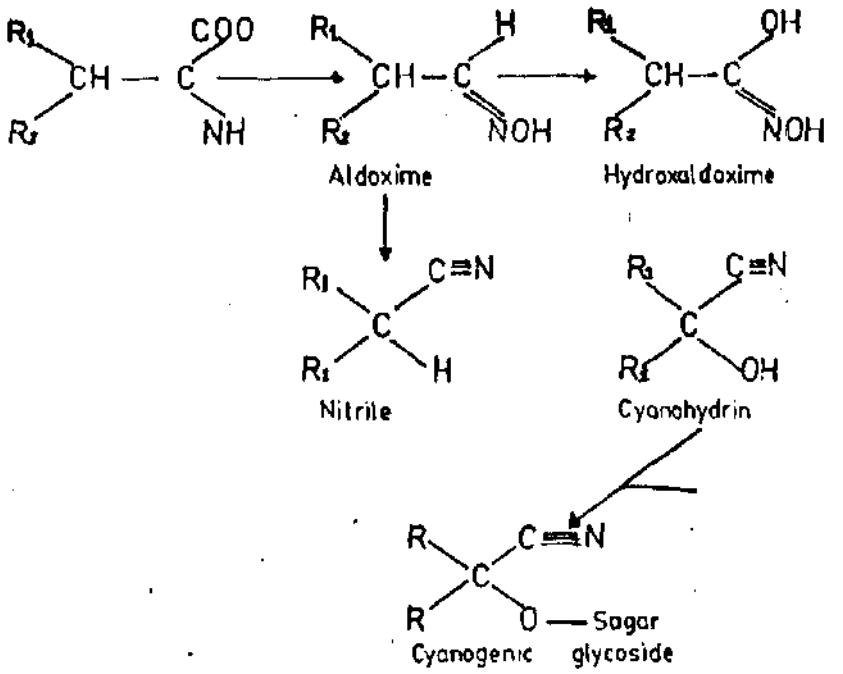


Fig 3a - Showing the biosynthesis of Cyanogenic glycoside

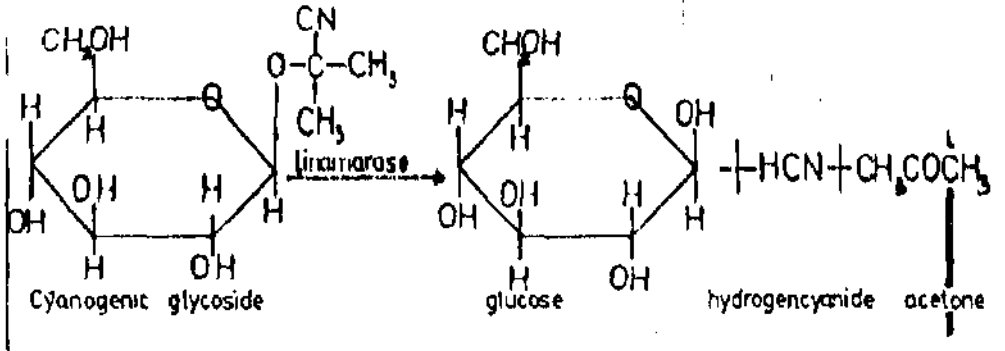


Fig 3b Showing biodegradation of Cyanogenic glycoside

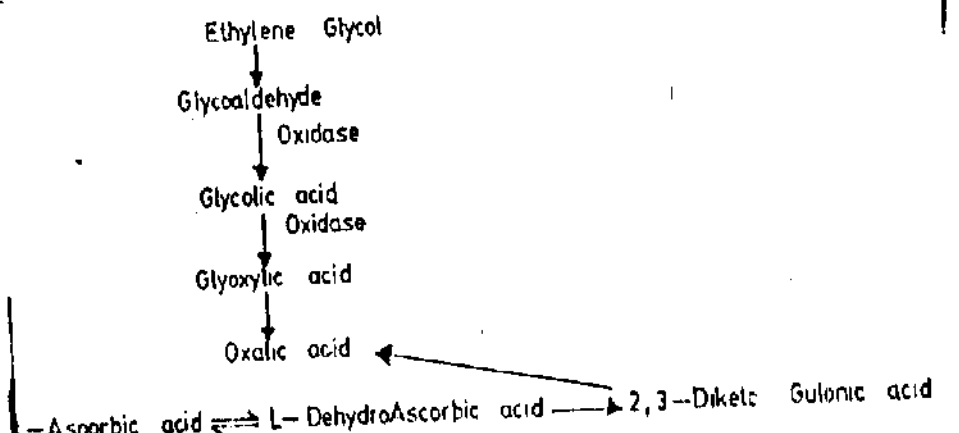
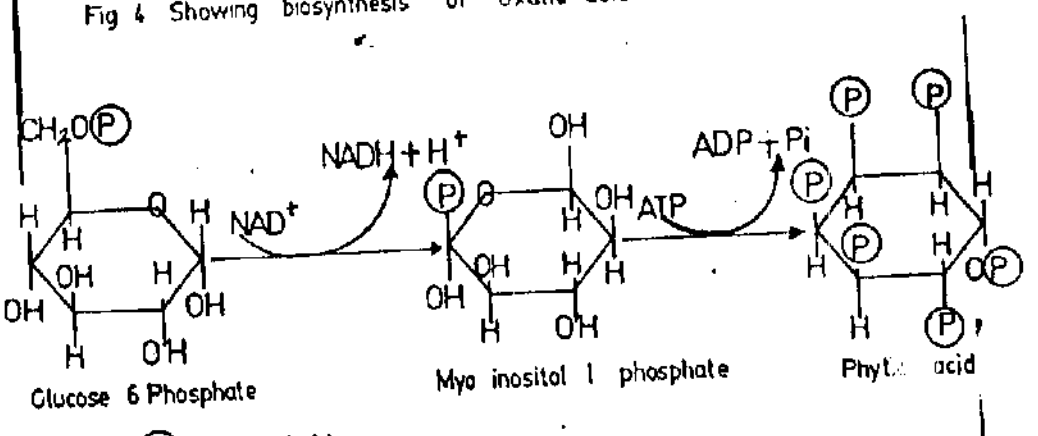


Fig 4 Showing biosynthesis of Oxalic acid



Ⓟ = OPO_3H_2

Fig 5 Showing biosynthesis of phytic acid

zinc). Tannins $(OH)_2C_6H_2COO.\ C_6H_2(OH)_2COOH$ (fig 2b) are yellowish amorphous powdery or flaky polyphenolic compounds with molecular weight between 500 and 3000 with melting point of 200°c. They exist in two forms the condensed proanthocyanidins and the hydrolysable forms (Haslam, 1977).

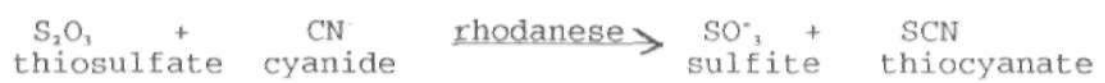
BIOSYNTHESIS AND DEGRADATION

The biosynthesis and degradation of various antinutritional factors are fairly established (Conn, 1973). Cyanogenic glycosides for instance are synthesized from amino acids (fig 3a) which are converted to cyanohydrins. Glucosides formation from cyanohydrins and subsequently catalysed by glucosyl transferases. Oyenuga, (1969) reported that Cyanogenic glucosides are degraded by linamarase to produce hydrocyanic acid, β-glucose and acetone (fig 3b). Hagler and Herman (1973) indicated that the synthesis of oxalic acid occurs via two biosynthetic pathway, the degradative pathway of protein or respiratory breakdown of carbohydrate (fig 4). Biosynthesis of phytic acid however, depends on cyclization of D-glucose (Maquenne, 1887; Cosgrove, 1966; Majumder et al 1972). The biosynthetic pathway begins from myoinositol-phosphate. Subsequently phosphate groups are derived from ATP and added concertedly to the complex through the catalytic action of the enzymes phosphoinositol kinase (fig 5). Biodegradation of phytate is initiated by phytases (Cosgrove, 1966; Loewus and Loewus, 1971). Biosynthesis of tannin is known to commence with the conversion of phenylalanine to cinnamic

acid. Haslam, (1977) reported that acetate units are further incorporated to produce catechins and tannins.

METABOLISM

The metabolism of the various antinutritional factors in monogastrics and ruminants is well documented (James, 1967). Kinsbury (1964) for instance reported that hydrogen cyanide is rapidly absorbed from the gastrointestinal tract, may produce fatal and nonfatal effects. Cyanogenic glycosides elicit their effect resulting in death by inhibition of cytochrome oxidase. Non fatal, inhibition of cellular respiration however can be reversed by the removal of hydrogen cyanide by metabolic detoxification. The biochemical principle for treatment of hydrogen cyanide poisoning is based on the principle that rhodanese catalyse the conversion of HCN to thiocyanate which is readily excreted.



James et al, (1970) also reported that oxalate in ruminants may be degraded by three mechanism. The antinutritional factor may be degraded by rumen bacteria or it may combine with calcium to form insoluble calcium oxalate which become unavailable for absorption it may also be absorbed from the rumen into the blood stream where it combines with calcium to produce hypocalcemia or interfere with other body processes. The insoluble calcium oxalate may cystallize in various tissues especially the kidneys and

rumen wall. Hagler and Herman (1973) reported also that ruminants can detoxify oxalates by converting it to carbonate and bicarbonate in the rumen. Since man lacks the enzyme phytase essential for hydrolysis of phytic acid, humans have limited capacity to hydrolyse it (Nelson, 1967; Reinhold, 1972; Rackis, 1974). Reichert et al (1980) and Osuntogun (1984) both independently observed that tannins combine with proteins, inhibiting enzymatic actions and absorption.

DOSAGES

The route of metabolism and lethal dose of the antinutritional factors have been defined (James et al, 1970). The lethal dose of hydogen cyanide for humans is between 0.5mg and 3.5mg/kg body weight (Montgomery, 1965) while Oke, (1969) reported a lethal dose of 2-5mg/kg body weight for soluble oxalate. Donnelly and Anthony (1969) observed that the tannin level required for rejection by grazing animals is 20mg/g of dry matter and above 2% to be lethal (Adewusi et al, 1991).

SYMPTOMS OF POISONING

The potency of cyanide poisoning has been shown to depend on the cyanogenic potential of the plant, the amount of free cyanide in the plant before ingestion, the size of the subject, and the speed of ingestion and release of cyanide during digestion. Notable symptoms of cyanogenic poisoning include, early stimulation of respiration,

dyspnea, gasping, paralysis, prostration, convulsion, coma and death (Montgomery, 1965; Harkness and Roth, 1975). Oxalic acid poisoning is characterized by rapid respiration, depression, weakness, coma and death (James, 1968). Elkin et al (1978) have attributed tannin toxicity to leg abnormality in chicks while Harrison and Mellanby (1939) reported that rickets and bone deformation may occur as a consequence of increase phytic acid consumption.

CLINICAL IMPLICATIONS

Existing reports (Montgomery, 1965; Herbert, 1979) indicate that cyanide ion exerts its effect by chelating with metal atoms particularly Fe, resulting in an inactivation of many Fe dependent enzymes especially the cytochrome oxidase required for oxidation reduction reactions. It also reacts with hemoglobin to form cyanohemoglobin. In ruminants ingestion of non letal quantities of cyanide, continually leads to iodine deficiency and goitrous condition due to conversion of cyanide to thiocyanate in the rumen (Conn, 1973). Hagler and Herman (1973) indicated that oxalate elicits its deleterious effect by complexing with various minerals such as calcium and magnesium thus limiting their bioavailability. Symptoms of oxalate poisoning includes hypocalcemia, tetany, defects in coagulation of blood. Chronic ingestion of oxalates could also result in renal fibrosis and failure (Hagler and Herman, (1973).

Phytic acid has been shown (Yoon et al, 1983; Thompson

and Yoon, 1984) to significantly reduce the rate of starch digestion as well as blood glucose response in normal volunteers. Jagadale et al (1976) associated the presence of tannin in ruminant feed to lower milk yield and a toxic degenerative changes in the intestine liver, spleen and kidney (Gupta et al, 1977) and mucus appearance in urine.

TREATMENT

Food processing has been shown (Khokhar and Chauhan, 1986; Edem et al 1994) to selectively eliminate the effect of antinutritional factors in foods. In extreme cases cyanide poisoning can be treated by sodium thiosulfate ($Na_2S_2O_3$) and sodium nitrite which are selectively administered as antedote. They exert their effect by complexing with hydrogen cyanide to produce the easily metabolisable form of the cyanide (thiocyanate) (Herber, 1979; Montgomery, 1965). Londer et al, (1989) have also reported that food processing produces inositol phosphates with lower degree of phosphorylation which did not chelate metal atoms.

MINERALS IN NUTRITION

Available evidence indicates that mineral elements are essential to life (Underwood, 1977; Shills et al, 1994). Minerals are classified into 'Macro' and 'Micro' elements to distinguish the mineral elements required in large or minute quantities. The 'Macro' elements include calcium, magnesium, and phosphorus while 'Micro' minerals include

copper, chromium, iron, iodine, manganese, potassium, selenium and zinc.

FOOD SOURCES OF MINERALS

Allen (1982) reported that milk and milk products and leafy vegetables were excellent sources of calcium. Avioli (1985) indicated phosphorus was widely distributed in food stuffs while Wallach (1988) reported that rich sources of magnesium existed in sea foods, soybeans, goundnuts and cereals. Whole grains, nuts, leafy vegetable and tea provide source of manganese (Keen, 1990). Heme iron found in animal foods and non heme iron mainly in plant foods such as cereals and green leafy vegetables have been reported (Gillooly et al, 1983; Shills et al 1994) to be rich sources of iron foods such as meat, liver, eggs and sea foods were good source of zinc (Hambidge et al 1986). Appreciable amounts of copper (Davis and Mertz, 1987) were reported in seafoods and legumes.

RECOMMENDED DAILY DIETARY ALLOWANCES

The table below shows the recommended daily allowances of minerals as recommended by food and nutrition board. National Academy of Sciences .

MINERALS	INFANT	CHILDREN	MALES	FEMALES (mg)
Calcium	450	800	800	800
Phosphorus	400	800	800	800
Magnesium	70	250	350	280
Iron	15	10	10	15
Zinc	5	10	15	12
Manganese	15	30	30	30
Copper	2	5	5	5
Iodine	-	-	0.15	0.15

Recommended dietary allowances of essential minerals for healthy humans.

METABOLISM OF THE MINERALS

The metabolic pathway for most essential minerals have been ascertained (Norman, 1990; Bronner 1988). Available evidence (Norman, 1990) indicate that about 25-50% of 800mg of daily calcium intake is absorbed. 99% of such calcium absorbed is located in bones and teeth. Norman (1990) revealed that calcium absorption by the intestine or the reabsorption by the kidney and calcium turn over in the bone are intricately regulated by various calcium regulating hormones. Calcium absorption is enhanced by amino acids such as lysine and arginine, vitamin D and lactose Norman 1990). Other investigations Allen, 1982; Recker, 1985) have reported that cocoa, spinach and other high oxalate, phytate foods inhibit the intestinal absorptive efficiency for calcium. Avioli (1985) indicated that 60-70% dietary phosphorus is absorbed as free phosphate. While Farus

(1985) noted that phosphorus absorption in humans is related liearly to phosphorus intake over the range of (4 to 30mg/kg) per day. Available evidence (Farus, 1985) revealed that Cellular and molecular mechanism for intestinal absorption of phosphorus is not well understood. The homeostatic mechanism of magnesium is however, similar to that of calcium (Hardwick et al 1991). The kidney cordinates the retention and excretion of magnesium in the body. Frieden (1984) indicated that absorption of manganese from the diet is about 5% and independent of diet. He revealed that manganese is absorbed throughout the small intestine where it competes with iron and cobalt binding sites. Keen, (1990) reported that calcium levels affect manganese metabolism by altering manganese absorption and retention. Its availability is also influenced by estrogens and adrenocortical hormones (Keen et al 1984). Hambidge et al (1986) reported that zinc is absorbed in the small intestine. Matseshe et al (1980) and Weigand (1983) have independently observed that following intake of food the intraluminal quantity of zinc increases to about 1.5 to 3 times the amount ingested at the distal duodenum, due to secretion of zinc containing digestive juices. Oberleas et al (1966) and Graf and Eaton (1984) also reported that zinc absorption is decreased by phytic acid resulting in the formation of insoluble zinc-phytate complex. Graf and Eaton (1984) revealed that the extent of absorption is influenced by amount of copper and other chemicals taken together, the dietary level of other metal ions, age of the animal and

organic substances. The metabolism of copper in the body has been established (Davis and Mertz, 1987). Dietary copper is absorbed into the body through the intestinal mucosa and transported via the portal blood to the liver where it is incorporated into the ceruloplasmin (Davis and Mertz, 1987; Linder, 1990). Ceruloplasmin, the transport protein for copper subsequently releases copper into the tissues. Sandstead, (1982) reported that phytate may impair the bioavailability of copper. Also calcium, cadminum, zinc, iron, lead, silver, molybdenum and sulfur affect copper absorption (Mason, 1979). Worwood, (1989) for instance reported the metabolism of iron is believed to occur via an intricate process involving the hemoglobin shunts. Increased iron absorption for instance, have been reported in iron deficiency anemic patients and absorption is known to be twice in children than adults (Cook and Skikne, 1989). Jacobs and Worwood (1980) indicated that the bioavailability of iron is enhanced by proteins, ascorbic acid, fructose and sorbitol. While bioavailability of iron is reduced by phytate, tannin, cobalt, zinc, copper and Manganese (Gillooly et al 1983). Iron is known to be poorly exreted by the body via feces and sweat and lost in women during menstrual cycle, parturition and breast feeding.

FUNCTIONS OF MINERALS

The biologic role of minerals in human nutrition have been extensively documented (Nordin, 1988; Jacob and Worwood, 1980; Howel and Gawthorne 1987). Calcium for

instance increases cell permeability and activates a number of enzymes such as lipases, adenosine triphosphate (ATP) and proteolytic enzymes. It also functions in the transmission of nerve impulses, muscle contraction and cellular adhesiveness (Nordin, 1988). Avioli (1985) reported that phosphorus is essential in intermediary metabolism as a cofactor in some enzymatic reactions. It also functions in oxidative phosphorylation via the synthesis of high energy compounds. Calcium and phosphorus both influence acid-base equilibrium in plasma and promote the development and maturation of bones (Avioli 1985). Magnesium is also involved in cellular oxidation and oxidative phosphorylation leading to ATP formation. Garfinkel and Garfinkel (1988) reported that magnesium activates various enzymatic processes especially pyruvate dehydrogenases, ketoglutarase dehydrogenase complex and alkaline phosphatase. Magnesium is also known to exert its influence on neuromuscular activity where low levels induce tetany (Wallach, 1988). Hambidge et al (1986) and Howel and Gawthorne (1987) have independently reported that copper and zinc are involved in cell and tissue growth. Zinc also functions as a cofactor for the enzyme carbonic anhydrase, alkaline phosphatase, alcohol, lactic and glutanic dehydrogenases. The role of copper in melanin formation, hemoglobin synthesis, bone and elastic tissue development and central vervous system have been established. Ceruloplasmin the main copper transport protein for instance facilitates the release of iron (III) Fe^{3+} prior to its incorporation into transferases.

Keen et al (1987) have also reported that manganese is a constituent of several metalloenzymes. Jacob and Worwood (1980). Fairbanks et al (1971) revealed that iron plays an important role in heme formation. In hemoglobin and myoglobin iron is stabilized in the ferrous state which it reversibly binds to oxygen thus functioning as an oxygen carrier in the blood and muscle respectively.

DEFICIENCES AND TOXICITIES OF MINERALS

The nutritional and clinical implications of mineral inadequacy from regular diets have been established (Keen and Gershwin, 1990; Mason, 1979; Jacobs and Worwood, 1980: Nordin 1988). "Primary deficiences" occur as a result of an inadequate intake of the mineral. A secondary or conditioned deficiency however, occur even if the dietary content of the essential nutrient in question is considered "adequate". Such conditioned deficiences could be due to genetic factors, drug interactions and nutritional interactions (Lonnerdal et al (1984). Toxicities are often classified into acute or chronic toxicities based on exposure to excesses of these elements. Bronner and Coburn (1981) and Sheikh et al (1990) reported that calcium metabolism often manifest as abnormalities of serum calcium, skeletal mineralization and certain neuromuscular disorders. Phosphorus has been shown to lead (Avioli 1985) to increase excretion of calcium and consequently to osteoporosis. Wallach (1988) reported that despite the low contents of dietary mangnesium, deficiences does not occur in humans

with healthy kidneys. Mills (1989) revealed that zinc deficiency for instance results in growth retardation in children, anorexia, hair loss, dermatitis, impaired immune function and skeletal abnormalities. Mcclaren (1981) reported that zinc poisoning results in vomitting and diarrhoea associated with toxic amounts of zinc. Howel and Gawthorne (1987) reported that copper defienciecy is rare in humans but in malnourished states, the symptoms include skeletal abnormalities, fractures and reproductive failure. Anemia is also promoted by the absence of ceruloplasmin the copper containing ferroxidase. Davis and Mertz (1987) reported that toxicity of copper could result in a hereditary disorder called Wilson's disease hepatolenticular degeneration. Keen (1990) reported that manganese deficiency in man precipitated mild dermatitis, slight reddening of hair and depressed vitamin K dependent clotting factor. Animal studies Keen, 1990) have showed manganese deficiency results in skeletal abnormalities, disturbed or depressed reproductive function and defects in lipid and carbohydrate metabolism. Toxicity of manganese has been associated with depressed growth, depressed appetite, impaired iron metabolism and nervous disorders. In humans the clinical manifestation of iron deficiency (Cook and Skikhe 1989) results in anemia and fatigue. In children anorexia, depressed growth and decreased resistance to infection are commonly observed. Toxicity of iron is low, due to the highly effective homeostatic mechanism. Iron over load has also been reported in some population groups

like the bantu tribes in South Africa who ingest as much as 100mg per day as a result of leaching from their pots.

BIOAVAILABILITY OF MINERALS

Greger (1988) defined bioavailability as "the usefulness of nutrients to life organisms". The presence of minerals in diets provides little assurance of its availability for absorption and utilization. Recent reviews of the bioavailability of minerals Solomons, 1982; Oberleas 1975; Rosenberg and Solomons, 1982; Allen, 1982; Graf and Eaton 1984) have pointed out that numerous dietary factors can affect the bioavailability of minerals.

These factors are thought to include inhibitory components, phytic acid, fiber, oxalates, and competitive minerals, the source of mineral (intrinsic or extrinsic), mineral-macronutrient interactions, food processing, food source, chemical nature of the compound, meal composition, nutritional and physiological status of subject.

INTERACTION OF ANTINUTRITIONAL FACTORS WITH MINERALS

Decrease bioavailability of minerals by chelation has been associated with presence of dietary components (Oberleas, 1975; Sandstead, 1982; Maga, 1982; Graf and Eaton, 1984). Phytic and oxalic acid have been shown to form stable complexes with Cu^{++}, Zn^{++}, Co^{++} Mg^{++} Fe^{++} and Ca^{++} (Oberleas 1973) the effectiveness with which the minerals are chelated depend upon the levels of these inhibitory

factors (Phytic and oxalic acid). Oberleas (1975), Couzy et al, 1993 reported that when dietary constituents and minerals are expressed as molar ratios could predict bioavailability of minerals. Couzy et al, (1993) reported that bioavailability of minerals could be predicted by using the x/y ratio. Where (x) is the inhibitory constituent and (y) the mineral.

CHAPTER THREE

3.0 CHEMICALS

All chemicals used were of analytical grade and supplied by the British Drug House (BDH) Chemicals Limited, Poole England. Vanillin and catechin were obtained from Hopkin and Williams England.

3.1 FOOD SAMPLING

Food samples were purchased from different parts of Northern Nigeria markets (Appendix I). The food samples (Appendix II) were then transported immediately to the Mary Hallaway Laboratory in Biochemistry Department in black cellophane bags. The foods were first freed from broken seeds, soil, dirt, dust and other foreign materials by hand picking. The foods were pooled together and representative samples obtained.

3.2 EXPERIMENTAL DESIGN

The effect of household processing techniques such as blanching, cooking, decortication, frying, soaking, roasting and conversion into paste products (moin-moin and tuwo) on the levels of hydrogen cyanide, oxalate, phytic, tannin contents and minerals was carried out using a standard size cooking stove.

3.2.1 PREPARATION OF VEGETABLES

Commonly consumed vegetables were cut into tiny shreds as locally prepared and blanched in boiling water (W/V) of 1:4 for 5 minutes. The aliquots six (6g) of the drained vegetable were dried in an oven at 60°C for 48 hours. The dried sample was milled in a blender and finely sieved. The fine powder was stored at 27°C in air tight container prior to assaying.

3.2.2 COOKING OF FOOD ITEMS (BOILING)

Thirty grams of each food samples to be assessed were added to 400-500ml of water in a cooking pot and cooked to required time (Appendix III). The cooked food was drained and dried to constant weight as previously described.

3.2.3 DECORTICATION OF COWPEAS

Seventy gram of dried grains were soaked in 350mls of water for 15 minutes at 27°C. The testa of the soaked cowpeas were carefully removed and dried to constant weight as described earlier.

3.2.4 FRYING OF FOODS

Representative portions of tubers, roots and plantain (30g) each were deep fried for 15 minutes by immersing them in hot/heated vegetable oil. Ten gram aliquots were taken and oven dried as previously described.

3.2.5 PREPARATION OF FOODS BY SOAKING

Some cereal grains fifty gram each were soaked for 15 and 12 hours in 500ml of water at room temperature. The grains were drained and dried as earlier described.

3.2.6 PREPARATION OF FOODS BY ROASTING

Representative food samples were roasted on hot glowing coal fire for 15 minutes. These were then oven dried as previously described.

3.2.7 PREPARATION OF PASTE PRODUCTS

Moin-moin and Tuwo were prepared using standard recipes (Appendix III)for their preparation. After cooking, the pastes were dried as earlier described and used for assaying.

3.2.8 PREPARATION OF SOUPS

The soups were all prepared using the standard recipes (Appendix II) for their preparation. After which 50g aliquots were taken and oven dried as described earlier.

3.3.0 ANALYTICAL METHODS

3.3.1 MOISTURE DETERMINATION

Moisture determination was conducted by the AOAC (1990) method.

PROCEDURE

The moisture content for the food samples were determined by weighing 5g of the food into a clean crucible which had been previously dried at 80°c and cooled in a desicator. The samples were dried to constant weight in the oven at 60°C. Duplicate determinations were made for each sample. The moisture content was calculated as follows:

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

3.3.2 DETERMINATION OF FREE CYANIDE CONTENT

Free cyanide was assayed by the method developed by (Ikediobi et al, (1980).

PROCEDURE

To aliquots of 0.2, 0.4, 0.6, 0.8, 1.0 and 1.20ml of standard solution in six test tubes were added 0.1M sodium phosphate buffer (pH 6.8) to bring the volume to 2ml and 4ml of alkaline picrate solution. The tubes and their contents were stopped and incubated in a water bath at 95°C for 5 minutes. Following cooling to room temperature, the absorbance of the deep orange color developed was measured at 490nm wavelength using a spectrophotmeter.

SAMPLE PREPARATION

Soluble cyanide was extracted from two grams of fresh ground sample with 15ml of 0.1M sodium phosphate buffer (pH 6.8) with a mechanical shaker for 30 minutes. The mixture was then centrifuged and the resulting supernatant liquid removed by filtering. The volume of the extract was measured.

To 0.40ml of the extract was added 1.6ml 0.1M sodium phosphate buffer to give a total volume of 2.0ml and 4ml of alkaline picrate solution. The tube were stopped and incubated in a water bath at 95°C for 5 minutes. The tube and its content was allowed to cool to room temperature and the absorbance of the deep orange solution was read in a spectrophotometer at 490nm. The absorbance of a blank sample containing a mixture of 2ml buffer and 4ml of alkaline picrate solution was simultaneously determined and % cyanide calculated thus:

% cyanide (dry weight) =

$$\frac{C(Ug/ml) \times \text{Extract volume(ml)}}{10^{4} \times \text{aliquot taken} \times \text{sample weight}}$$

C = Ug/ml CN^{-} from the graph.

3.3.3 DETERMINATION OF SOLUBLE OXALATE

Oxalate content was determined by titermetric method proposed by Dye (1956) as modified by Abaza et al (1968).

PROCEDURE

Soluble oxalate was determined by weighing two grams of the dry sample into a 250ml conical flask containing 200ml

distilled water. The flask was heated in water bath at 90°C for 5 hours. Subsequently it was cooled and diluted to volume and filtered. To fifty (50)ml aliquot of the extract was added 20ml 6M hydrochloric acid and evaporated to half its volume and then filtered. The brown precipitate formed was washed several times with warm distilled water. To the filterate was added 3 drops of methyl red indicator and concentrated ammonia until solution turned faint yellow. The resultant solution was then heated on a hot plate at 90°C with 10ml of 5% (w/v) calcium chloride to precipitate the oxalate. The resulting solution was kept overnight and subsequently filtered. The precipitate was washed with distilled water several times. The funnel containing the filter paper and precipitate was placed back into the original beaker in which the precipitate had formed. A hole was made in the bottom of the filter paper with a glass rod and the precipitate washed into the beaker using hot 25% (V/V) sulfuric acid solution and diluted to 125 ml. It was warmed to 90°C and titrated while hot with 0.05N potassium permanganate solution and near the end point the filter paper used was added to the solution and the titration completed.

$$CaC_2O_4 + H_2SO_4 \dashrightarrow Ca\ SO_4 + H_2C_2O_4$$

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \dashrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Calculation: $1Cm^3$ of 0.05N $KMnO_4$ = 2.2mg Oxalate.

3.3.4 DETERMINATION OF PHYTIC ACID

Phytate phosphorus was determined by the colorimetric method of Stewart (1974). The phytin present in the sample dissolved in the acidified extract. Phytic acid was then isolated as iron phytate. It was recovered, digested and estimated as phytate phosporus.

PROCEDURE

Five standard solutions were prepared by transfering each volume of the stock solution of 2ppm phosphorus into a 100ml volumetric flask and made up to mark with distilled water. The standard solutions were 20, 30, 40, 50, and 60ml thereby giving concentrations of 0.4, 0.6, 0.8, 1.0 and 1.2 ppm phosphorus respectively.

Two grams of the sample was extracted with 100ml 0.5M hydrochloric acid in a mechanical shaker for 3 hours. It was then filtered and 15ml of the filterate neutralised with 0.5M sodium hydroxide solution. The solution was made weakly acidic with few drops of 0.17M hydrochloric acid and diluted to 50ml with distilled water. Ten mls of the solution were taken in a test tube and 4ml of 0.25% ferric chloride solution added. The resulting mixture was heated for 15 minutes in a water bath, cooled and centrifuged. The supernatant was discarded and the residue washed with 0.5M hydrochloric acid and 0.17M hydrochloric acid respectively. It was recentrifuged and supernatant discarded after which 2 ml of distilled water was added and the mixture heated for 5 minutes in a water bath. Subsequently, 2ml of 0.5M sodium

hydroxide solution was added, the mixture was heated and filtered into a 100ml Kjeldahl flask. The residue was washed with distilled water and the washings added to the flask. To the filterate 0.5ml of concentrated sulfuric acid was added followed by the addition of 1ml per chloric acid and 5ml concentrated nitric acid. The flask was swirled gently and digested slowly for 15 minutes in a fume cupboard. After the flask was cooled, the contents of the flask were transferred to a 50ml volumetric flask and diluted to mark with distilled water.

Ten ml of the solution was pipetted into a 50ml volumetric flask and diluted to 2/3 full with distilled water. To it were added 2ml ammonium molybdate-sulfuric acid reagent and then shaken, followed by the addition of 2ml stannous chloride reagent and the volume made to mark with distilled water. Absorbance was taken at 700nm using spectrophotometer with 10ml of distilled water treated as for sample preparation taken as the blank.

Phytate phosphorus was calculated thus:

$$\text{Phytate phosphorus} = \frac{C(mg) \times 3.75}{\text{Sample weight (mg)}}$$

C(mg)=milligram phytate phosphorus from calibration curve.

3.3.5 DETERMINATION OF TANNIN

Tannin was determined by the Vanillin-Hcl procedure which was based on an acid catalysed addition of vanillin to flavonols and their polymers as well as addition to other

polyphenolic compounds such as dihydrochalcone and flavones. These reactions are determined colorimetrically at 500nm (Earp et al 1981).

PROCEDURE

Standards were prepared by pipetting out 0.2, 0.4, 0.6, 0.8 and 1ml of catechin stock solution into seperate tubes and their volumes made to 10ml with methanol. This was done specifically to obtain a calibration curve. The pipetted standard gave concentrations of 0.02, 0.04, 0.06, 0.08 and 0.10 mg/ml of catechin respectively.

To five hundred gram of the sample dispensed into centrifuge tubes were added 10ml of 1% HCl in methanol respectively and shaken for 10 minutes at 10,000g and the supernatant transferred into a 125ml volumetric flask. To the residue in each tube, another 5ml of 1% HCI in methanol was added and shaken as done earlier. The supernatant was added to the first extract in a 25ml volumetric flask. The volume was made to mark with 1% HCl-methanol reagent. The contents thoroughly shaken to ensure proper mixing.

To estimate the tannin content, 1ml aliquots of the extract were pipetted into a test tube and 5ml of vanillin-HCl reagent were added to the samples and standard preparations. Individual sample blanks were prepared by adding 5ml of 4% HCl in methanol to 1ml of the sample extract. The absorbance of the sample and their respective blanks as well as the standard catechin of different

concentrations were determined at 500nm using a spectronic 20 spectrophotometer.

Concentrations of catechin samples were determined on the standard curve by extrapolation. Catechin equivalent (CE) was determined as follows:

% catechin Equivalent =

$$\frac{\text{Catechin (mg/ml) x volume made up x 100}}{\text{vol. of extract taken x sample wt}}$$

Catechin (mg/ml) from graph.

3.3.6 DETERMINATION OF MINERAL ELEMENTS

WET DIGESTION OF SAMPLE

The method employed was that of the (AOAC 1990) which uses nitric and perchloric acids as the decomposition reagents for organic matter. These acids have the advantage of not producing insoluble sulfates which absorb a considerable proportion of trace metals.

Calcium, copper, iron, manganese, magnesium and zinc were determined by atomic absorption spectrophotometry (Osborne and Voogt, 1978) method. The solutions obtained from the wet digestion were prepared for calcium, magnesium and manganese determination by diluting (according to the procedure in the manual of Schimadzu AA 650 instrument) in the ratio 1:40 with 0.10% (w/v) lanthanum chloride to overcome any interference from phosphates.

The concentrations of zinc, copper, and iron was determined by diluting the sample digest in the ratio 1:20 with distilled deionized water.

The samples were subsequently aspirated into the atomic

absorption spectrophotometer (Schimadzu AA 650) using air-acetylene flame and the appropriate lamp for determination of each element.

Phosphorus was determined as phosphate by vanado molybdate spectrophoteric method (Pearson 1976). The stable orange-yellow colored complex of vanadimolybdi-phosphoric acid ($H_3PO_4.VO_3.HMO_3.nH_2O$) formed was determined at 440nm using a spectrophotometer.

3.3.7 STATISTICAL ANALYSIS

Duncan's multiple range test were run to separate significantly different means.

CHAPTER FOUR

RESULTS AND DISCUSSION

Levels of some antinutritional factors and minerals in some unprocessed Nigerian foods

The levels of antinutritional factors and minerals in cereals, legumes, leafy vegetables, vegetables, Root and tubers, oil seed and condiments are presented in Table 1.

Cassava and sorghum contained the highest levels of hydrogen cyanide (19.83, and 5.36 mg/kg respectively). Chakraborty and Eka (1978) reported hydrogen cyanide levels in cassava to be 93.96 mg/kg. Though similar, the differences in values could be due to method of analysis, variety, soil and environment. Generally, the hydrogen cyanide level of the foods were below toxic levels of 0.5-3.5mg/kg (Montgomery, 1980) body weight. The foods are considered safe for consumption since most foods are processed before consumption which ultimately reduces or eliminates the hydrogen cyanide content of foods. Oke, (1969), Chakraborty and Eka, (1978) reported that leafy vegetables (Spinach, water leaf, and baobab leaves) had soluble oxalate (5.61, 1.76 and 2.26mg/100g respectively). In this work, soluble oxalate was highest in spinach 36.66mg/100g and cocoyam 12.60mg/100g. Oke, (1969) reported that soluble oxalate is toxic at 2-5mg/kg body weight, high consumption of spinach could provide some risk. Spinach which provides cheap and rich sources of minerals especially calcium and iron could be affected by oxalate content as a

result of complexing action. However, since spinach is blanched, oxalate levels are reduced thereby making spinach a good nutritional source of minerals. Soyabean, wheat, and rice had highest levels of

phytic acid (98.70,48.86 and 47.80mg/100g respectively). Similarly, (Chakraborty and Eka, 1978) reported that (sorghum, wheat, groundnut and soyabean had (150.94, 114.49, 151.47 and 124.0mg/100g respectively). The results of the present study are different from those of (Chakraborty and Eka 1978). Nigerians mainly depend on cereal and legume grains for caloric and protein needs. Though toxic levels have not been reported, high phytic levels in foods might significantly ($P<0.05$) reduce bioavailability of minerals.

Tannin levels were highest in sorghum millet and (148.33 and 114.80mg/100g respectively). High tannin contents of cereals prevents bird predation and provides resistance to insects (Schultz and Baldwin, 1982). From nutritional view, cereals are cheapest sources of calories and some minerals. Tannins have been implicated in the complexing of proteins and mineral (iron) reducing their bioavailability.

Calcium level was high in leafy green vegetables, Baobab, spinach, and soya beans (169.5, 120.0mg/100g respectively). Baobab leaves, red pepper, and millet showed high level of iron (15.2, 11.6 and 10.5mg/100g respectively). Cereals showed a high levels of magnesium ranging from 166.5-191.5 mg/100g. Legumes (soyabean and groundnut) showed high phosphorus levels of 531.0 and

462.0mg/100g respectively. These foods provide cheap source of this important minerals which are essential for metabolic processes. Seet potato (white) had zinc content of 0.8mg/100g. Manganese was high in leafy green vegetables, bitter leaves 68.2mg/100g and 55.2mg/100g in baobab leaves. Again, since vegetables are readily available and cheap they provide mineral sources.

TABLE 1
LEVELS OF SOME ANTINUTRIONAL FACTORS AND MINERALS IN SOME UNPROCESSED NIGERIAN FOODS

FOOD ITEM	MOISTURE (%)	HYDROCYANIC ACID	SOLUBLE OXALATE	PHYTTIC ACID	TANNIN	CALCIU.	IRON	MAGNESIUM	PHOSPHORUS	ZINC	COPPER	MANGANESE
CEREALS												
WHEAT	11.30 ±0.30	2.60 ±0.52	2.30 ±0.45	46.86 ±0.40	9.63 ±0.65	28.0±2.10	3.0±1.26	116.5±0.51	348.0±0.20	0.5±0.25	0.2±0.36	13.8±1.20
WHOLE MAIZE (YELLOW)	7.00 ±0.20	3.66 ±0.32	2.25 ±0.35	31.30 ±0.30	53.23 ±0.25	10.0±1.80	1.4±0.35	166.5±1.21	442.5±0.90	0.5±0.30	0.1±0.51	12.5±0.70
WHOLE MILLET	20.00 ±0.20	3.03 ±0.15	2.46 ±0.46	38.13 ±0.20	114.80 ±0.52	14.0±0.46	10.5±0.30	191.5±0.15	366.5±1.27	0.5±0.12	0.5±1.21	9.5±1.27
WHOLE SORGHUM	6.10 ±0.14	5.26 ±0.25	3.03 ±0.15	40.33 ±0.51	148.33 ±0.41	34.5±0.81	9.0±1.20	15.5±0.41	196.0±0.96	0.5±0.05	0.5±0.05	11.0±0.15
RICE	7.10 ±0.14	ND	2.36 ±0.47	47.86 ±0.35	6.83 ±0.35	18.5±0.72	0.5±0.14	110.0±0.30	232.0±0.51	0.5±0.48	0.1±0.48	11.5±0.05
FRUITS												
RIPED SWEET ORANGE	89.93 ±0.41	ND	ND	2.06 ±0.20	ND	41.2±3.52	1.0±0.39	14.0±0.12	43.0±1.33	0	0.1±0.27	3.0±0.05
BIG GARDEN EGG	89.13 ±0.15	1.56 ±0.49	5.13 ±0.15	2.23 ±0.20	30.23 ±0.58	90.0±1.56	8.5±0.82	46.0±0.15	156.0±2.11	-	0.1±0.05	3.5±1.21
GUAVA	72.80 ±0.20	ND	2.66 ±0.32	8.90 ±0.36	2.93 ±0.30	19.2±0.32	1.5±2.10	19.5±2.36	61.5±0.86	-	0.1±0.71	3.8±0.39
LEGUMES & NUTS												
BIG WHITE BEANS	7.06 ±0.11	2.43 ±0.32	1.76 ±0.25	28.36 ±0.40	59.60 ±0.40	122.0±1.13	7.0±0.06	118.5±0.10	358.0±0.10	0.7±0.30	0.9±0.17	7.0±0.05
BROWN BEANS	5.90 ±0.10	2.00 ±0.25	2.56 ±0.49	25.60 ±0.20	71.60 ±0.55	131.0±3.12	7.5±0.12	118.0±2.00	362.0±0.05	0.2±0.41	0.9±0.58	7.0±0.15
GROUND NUT	7.30 ±0.26	ND	3.20 ±0.46	40.00 ±0.20	51.70 ±0.43	40.5±0.50	6.9±0.84	26.5±1.00	462.0±1.21	-	0.2±0.50	7.0±0.32
SMALL WHITE BEANS	4.10 ±0.10	ND	ND	8.13 ±0.15	20.56 ±0.49	99.0±0.05	6.3±0.90	98.2±0.33	331.0±0.84	-	0.7±0.37	4.1±0.40
SOYBEANS	5.03 ±0.05	1.03 ±0.25	2.50 ±0.35	98.70 ±0.32	46.30 ±0.41	120.0±1.12	7.5±1.20	17.5±0.60	531.0±1.12	-	0.9±0.22	14.5±0.15
LEAFY VEGETABLES												
BAOBAB LEAVES	91.20 ±0.43	1.43 ±0.40	3.30 ±0.15	5.00 ±0.25	12.33 ±0.35	169.5±0.90	15.2±1.27	33.5±2.10	237.0±0.05	0.1±0.05	0.3±0.02	55.2±1.27
BITTER LEAVES	85.30 ±0.17	1.80 ±0.35	2.30 ±0.26	3.86 ±0.35	19.36 ±0.40	120.0±1.80	3.1±0.15	19.5±0.78	339.0±0.28	-	0.8±0.15	68.2±0.21
CABBAGE LEAVES	93.10 ±0.10	0.80 ±0.41	2.00 ±0.20	5.20 ±0.10	9.90 ±0.75	26.2±0.35	3.0±0.05	14.0±1.20	131.0±0.73	0.2±0.27	0.2±0.22	49.0±0.05
FLUTED PUMPKIN LEAVES	88.90 ±0.10	2.52 ±0.35	1.80 ±0.40	4.70 ±0.11	10.00 ±0.32	25.1±0.11	1.4±0.18	16.2±0.05	138.2±0.58	0.1±0.02	0.1±0.27	51.2±0.48
LETTUCE LEAVES	91.40 ±0.21	2.30 ±0.47	2.50 ±0.43	6.20 ±0.05	11.20 ±0.36	40.2±0.35	1.8±1.50	15.2±3.10	124.8±2.48	0.2±0.33	0.6±0.05	41.5±2.12
SPINACH LEAVES	94.83 ±0.72	0.90 ±0.25	36.66 ±0.15	8.10 ±0.37	18.60 ±0.50	153.0±0.30	2.7±0.90	12.8±0.23	45.6±1.39	0.6±0.15	0.2±0.72	24.8±0.84

TABLE 1 CONT'D

OIL SEEDS, SPICES & CONDIMENTS	MOISTURE(%)	HYDROCYANIC ACID	SOLUBLE OXALATE	PHYTIC ACID	TANNIN	CALCIUM	IRON	MAGNESIUM	PHOSPHORUS	ZINC	COPPER	MANGANESE
BENNISEED	2.00 ±0.11	ND	6.30 ±0.37	11.90 ±0.23	9.86 ±0.35	58.2±0.37	0.9±0.05	28.0±0.05	80.1±0.05	-	0.1±0.15	7.0±0.10
MELON SEED	1.80 ±0.12	2.20 ±0.30	8.10 ±0.45	10.00 ±0.10	12.00 ±0.20	46.1±0.32	6.3±0.25	19.6±0.25	101.0±0.22	0.2±0.39	0.2±0.78	28.2±0.65
COTTON SEED	5.90 ±0.10	2.70 ±0.15	2.30 ±0.37	8.20 ±0.05	11.90 ±0.10	168.0±0.51	0.4±0.50	11.2±0.50	435.7±0.39	0.5±0.35	0.2±0.69	42.2±0.27
GINGER	58.00 ±0.05	ND	1.20 ±0.25	6.90 ±0.20	38.20 ±0.20	12.5±0.33	0.2±0.77	8.1±0.77	48.0±0.42	0.5±0.20	0.5±3.00	31.1±1.20
LOCUST BEAN	10.30 ±0.17	4.40 ±0.45	2.50 ±0.32	5.40 ±0.28	20.70 ±0.68	50.7±2.11	1.1±0.10	23.9±0.10	218.5±0.69	0.1±0.05	0.5±0.70	47.2±1.00
ONION	92.95 ±0.30	ND	1.10 ±0.10	2.30 ±0.20	9.50 ±0.41	4.3±0.80	0.1±0.62	6.1±0.62	11.6±0.50	-	0.5±0.10	23.0±0.65
RED PEPPER	71.06 ±0.49	2.40 ±0.40	10.40 ±0.37	8.10 ±0.47	5.50 ±0.73	72.5±0.11	11.6±0.71	16.5±0.71	232.9±0.60	0.1±0.27	2.1±0.20	13.0±0.70
ROOTS & TUBERS												
CARROT	82.10 ±0.17	ND	3.40 ±0.45	6.50 ±0.20	22.90 ±0.56	65.5±2.31	2.0±0.70	14.5±0.70	119.0±0.42	0.2±0.71	0.5±0.10	65.0±0.85
CASSAVA	58.56 ±0.40	19.83 ±0.35	2.96 ±0.15	3.96 ±0.55	10.53 ±0.50	18.5±0.72	1.1±0.42	8.2±0.42	29.5±0.17	0.1±0.62	0.2±0.50	12.5±0.20
COCOYAM	52.96 ±0.15	5.00 ±0.15	12.60 ±0.51	7.90 ±0.51	38.00 ±0.51	15.2±1.20	0.8±0.33	15.1±0.33	34.2±0.15	0.7±1.00	0.7±0.36	32.0±0.73
IRISH POTATO	64.50 ±0.50	ND	2.80 ±0.35	8.10 ±0.20	9.00 ±0.10	15.1±2.00	1.8±1.00	10.5±1.00	48.0±0.36	0.18±0.30	1.0±1.32	28.2±0.10
RED SWEET POTATO	55.66 ±1.15	ND	3.70 ±0.26	13.10 ±0.32	20.10 ±0.05	16.5±0.10	1.0±2.00	18.2±2.00	35.8±0.72	0.5±0.10	0.2±0.15	28.2±1.00
WHITE SWEET POTATO	54.90 ±0.10	ND	3.00 ±0.50	10.20 ±0.26	20.20 ±0.10	17.2±0.88	0.8±-.05	19.0±0.05	30.0±0.85	0.8±0.80	0.8±0.90	28.2±0.32
YAM	68.13 ±0.11	3.50 ±0.45	5.30 ±0.41	11.76 ±0.25	32.10 ±0.26	20.0±0.15	0.4±0.36	15.6±0.36	48.5±2.10	0.4±0.39	1.0±1.00	34.0±0.14
VEGETABLES												
TOMATOES	94.33 ±0.41	2.20 ±0.30	8.60 ±0.49	5.30 ±0.35	17.10 ±0.36	16.8±0.50	0.7±0.38	23.5±0.38	51.0±0.10	0.2±0.48	0.2±0.10	46.2±0.88
UNRIPED PLANTAIN	68.30 ±0.42	2.80 ±0.30	3.00 ±0.25	7.10 ±0.15	8.90 ±0.65	15.2±1.20	1.0±0.72	31.0±0.72	30.4±0.15	0.6±2.10	0.2±0.33	45.2±0.33
RIPED PLANTAIN	62.30 ±0.43	ND	ND	6.30 ±0.26	2.00 ±0.30	13.6±0,05	1.2±0.10	38.0±0.10	46.5±0.03	0.1±2.10	0.2±0.05	46.8±0.69
UNRIPED BANANA	73.18 ±0.23	3.00 ±0.15	1.20 ±0.40	4.20 ±0.05	8.20 ±0.55	8.8±0.09	0.8±0.63	10.0±0.63	45.5±1.90	0.3±0.66	0.2±0.18	31.2±0.42
RIPED BANANA	76.06 ±0.11	ND	ND	2.60 ±0.60	1.10 ±0.10	9.2±1.12	1.1±0.40	17.5±0.40	48.2±0.45	0.1±1.18	0.2±0.90	39.0±0.10
OKRA	82.73 ±0.23	1.13 ±0.32*	4.70 ±0.50	3.96 ±0.35	8.90 ±0.86	76.2±2.13	0.4±0.37	15.3±0.37	51.2±0.42	0.2±0.18	0.4±0.11	24.0±0.12

Values are averages of Triplicate determinations expressed on dry matter basis as mg/100 with standard deviations.

1 Hydrogen cyanide values are expressed as (mg 1kg). * Mn expressed as (µg/100g)

ND = Non detectable

Effect of cooking on some selected foods

The effect of cooking on levels of antinutritional factors and minerals in some selected foods are presented on Table 2.

Cooking (Appendix II) significantly ($P<0.05$) reduced or eliminated hydrogen cyanide contents in most of the foods, cassava had 80% reduction. This can be compared to (Essers, 1989) reported losses of 98.1% and 99.2% of hydrocyanic content in cassava leaves cooked for 30 and 90 minutes respectively. Hydrocyanic acid is a heat labile compound, at higher temperatures and longer cooking time it is completely eliminated. Soluble oxalate was significantly ($P<0.05$) reduced in sweet potatoes and yam (41.57%). The results compare favourably to that of to (Edem et al 1994) who reported 72.4% losses in oxalate of cooked canophor seed. The losses could result due to leaching into cooking water. Foods legumes with longer cooking time showed significant ($P<0.05$) losses in phytic acid. Most of the foods showed significant ($P<0.05$) losses in their tannin content ranging from 26-68%. Tan et al (1984) reported that cooking effectively reduce tannins as they are water soluble. Reduction/elimination of this antinutritional factors enhances the nutritional value of foods. The minerals were significantly ($P<0.05$) reduced in foods with longer cooking time (25-100%) where their cooking water was discarded.

TABLE 2

EFFECT OF COOKING ON LEVELS OF SOME ANTINUTRITIONAL FACTORS AND MINERALS IN SOME NIGERIAN FOODS

	Moisture (%)	HCN	Soluble Oxalate	Phytic	Tannin	Ca	Fe	Mg	P	Zn	Cu	Mn
CEREALS												
RICE	76.20±0.63	-	2.18b±1.18	25.30b±0.09	2.30b±0.09	15.3b±0.70	0.3b±0.17	95.8a±0.33	142.1±1.20	0.1b±0.05	0.1a±0.76	9.6b±0.90
LOSS (%)		-	(8)	(47)		(17)	(40)	(13)	(39)	(80)	(0)	(16)
LEGUMES & NUTS												
BIG WHITE BEANS	73.00±0.64	NDb	NDb	NDb	28.70b±0.17	50.3b±0.18	3.9b±1.43	54.5b±1.00	108.6±0.70	0.3b±0.60	0.1a±0.69	2.5b±0.09
LOSS (%)		(100)	(100)	(68)	(52)	(59)	(44)	(55)	(70)	(57)	(0)	(64)
BROWN BEANS	75.90±0.10	NDb	NDb	9.07b±0.66	28.22b±0.17	54.2b±0.16	4.4b±0.17	54.8b±0.20	98.0b±0.60	-	Ndb	2.7b±1.00
LOSS (%)		(100)	(100)	(65)	(60)	(59)	(41)	(54)	(73)	-	(100)	(61)
GROUNDNUT	36.60±0.60	NDb	2.80b±0.21	38.20a±3.20	50.80b±0.70	37.2a±2.19	5.8b±0.32	186.0a±0.2 1	435.0±0.81	-	0.1b±0.26	6.8a±0.21
LOSS (%)		(100)	(12)	(4)	(21)	(8)	(10)	(8)	(6)	-	(50)	(3)
SMALL WHITE BEANS	70.10±1.20	-	NDb	4.30b±1.78	8.35b±0.08	45.1b±2.19	3.2b±1.00	48.8a±1.00	112.0±0.30	-	Ndb	2.8b±1.09
LOSS (%)		-	(100)	(47)	(59)	(54)	(49)	(50)	(66)	-	(100)	(32)
ROOTS AND TUBERS												
CASSAVA	60.55±0.15	4.00±0.96	NDb	3.80a±1.82	5.00b±1.20	15.8a±1.20	1.8a±0.15	4.9b±1.20	20.8b±0.75	-	Ndb	11.0a±0.18
LOSS (%)		(80)	(100)	(100)	(53)	(15)	(0)	(30)	(29)	-	(100)	(12)
COCOYAM	63.10±0.10	ND	11.20a±0.81	7.20a±0.32	29.00b±1.12	12.0b±1.10	0.8a±0.33	7.8b±0.18	22.3b±0.76	0.4b±0.90	0.1b±0.86	27.2a±0.15
LOSS (%)		(100)	(11)	(9)	(23)	(21)	(0)	(48)	(35)	(43)	(86)	(15)
IRISH POTATO	69.95±0.90	-	2.00b±0.30	2.50a±0.33	4.10b±1.21	12.5b±0.07	1.8a±1.20	8.3b±1.60	31.3b±1.00	-	0.2b±0.15	23.9b±0.25
LOSS (%)		-	(29)	(2)	(49)	(18)	(0)	(21)	(35)	-	(80)	(16)
RED SWEET POTATO	63.44±0.82	-	1.60b±1.40	11.80a±1.12	9.20b±0.05	14.0a±0.02	0.8b±0.52	12.7b±0.80	35.0b±0.76	0.2b±1.90	Ndb	26.2a±1.00
LOSS (%)		-	(57)	(10)	(54)	(15)	(20)	(33)	(46)	(60)	(100)	(7)
WHITE SWEET POTATO	59.35±0.13	-	1.80b±0.11	8.20b±0.32	9.00b±1.00	14.0a±0.02	0.9a±0.08	10.7b±2.00	39.2b±1.00	0.3b±1.30	Ndb	24.5a±1.00
LOSS (%)		-	(40)	(20)	(55)	(15)	(13)	(33)	(44)	(63)	(100)	(13)
YAM	68.15±0.51	NDb	3.14b±0.72	10.96a±0.16	15.0b±0.60	14.0b±1.00	0.5b±0.09	10.0b±0.01	32.0b±1.60	0.1b±1.10	Ndb	30.8a±0.05
LOSS (%)		(100)	(41)	(7)	(53)	(30)	(25)	(36)	(34)	(75)	(100)	(9)
SOUPS												
EGUSI	75.50±0.42	ND	16.00±0.21	8.25b±0.76	8.50b±0.27	15.8a±1.20	1.1a±2.10	18.0a±1.20	100.2±0.80	0.3b±0.05	Ndb	19.6b±0.05
LOSS (%)		(100)	*(26)	(18)	(26)	(2)	(15)	(8)	(1)	(50)	(100)	(30)
KUKA	93.00±0.50	ND	2.81a±0.49	4.80b±0.88	12.10a±0.80	158.2a±1.00	4.9a±0.87	33.0a±1.10	36.2a±1.00	0.1a±0.05	0.2b±0.07	53.0a±0.80
LOSS (%)		(100)	(15)	(4)	(2)	(7)	(6)	(1)	(2)	(0)	(67)	(4)
OKRA FRESH	92.10±0.12	NDb	4.00a±0.71	3.80a±0.21	8.00b±0.21	24.9a±0.69	0.4a±0.36	14.0a±0.30	39.3b±0.88	0.2a±0.16	1.0a±1.00	23.0a±0.72
LOSS (%)		(100)	(15)	(4)	(10)	(2)	(8)	(8)	(23)	(0)	(0)	(4)
STEW	85.80±0.80	NDb	6.22b±1.20	4.50a±0.30	13.20b±1.00	15.5a±0.36	20.8a±0.10	20.8a±0.40	39.9a±1.40	0.2a±2.00	NDb	38.5b±1.00
LOSS (%)		(100)	(28)	(15)	(22)	(8)	(11)	(11)	(22)	(0)	(100)	(17)

Values are averages of triplicate determination expressed on dry matter basis as mg/100g
Figures in parenthesis represent loss during the treatment, as percentage of control values.
a Values are not significantly (P >0.05) different from control values
b Values with different following letters are significantly different from control values (P<0.05).
1 Nutrient contents values expressed in (mg/kg) Mn as Mg/100g

Effect of frying on some selected food:

The effect of frying on levels of antinutritional factors and minerals on some selected foods is shown on Table 3.

Frying did not significantly (>0.05) reduce (2-13%) phytic acid, tannin, soluble oxalate and minerals of most of the foods. This could result due to cooking medium (fat) where the minerals and antinutritional factors are not soluble enough to leach out. However, there was significant ($P<0.05$) losses of soluble oxalate, and tannin in legumes. This compares with (Ogun et al, 1989) losses in processed cowpeas. Soaking and decortication could be attributed to this losses.

TABLE 3

EFFECT OF FRYING ON LEVELS OF SOME ANTINUTRITIONAL FACTORS AND MINERALS IN SOME NIGERIAN FOODS

FOOD ITEM	MOISTURE	HCN	SOLUBLE OXALATE	PHYTIC ACID	TANNIN	Ca	Fe	Mg	P	Zn	Cu	Mn*
ROOTS AND TUBERS												
IRISH POTATO	15.53±0.05	-	2.00B±0.30	6.50±1.00	8.90±3.18	12.0b±0.42	1.6a±1.50	0.0a±1.50	47.5±1.00	-	NDb	26.2a±0.22
LOSS (%)		-	(29)	(20)	(1)	(21)	(11)	(5)	(1)	-	(100)	(7)
RED SWEET POTATO	20.50±0.80	-	3.20±1.00	12.50a±0.50	9.20A±1.10	10.2a±0.28	1.0a±0.64	18.0a±0.46	2.48±0.11	0.3b±1.27	NDb	24.0a±0.21
LOSS (%)		-	(14)	(5)	(5)	(8)	(0)	(1)	(31)	(40)	(100)	(15)
WHITE SWEET	20.40±0.11	-	2.42B±3.00	9.80a±0.20	19.72A±0.27	15.8a±0.07	0.7a±1.12	17.6a±0.32	19.0±0.17	0.6b±0.50	NDb	24.2a±0.31
LOSS (%)		-	(19)	(4)	(2)	(8)	(13)	(7)	(37)	(25)	(100)	(14)
YAM	58.10±0.05	-	4.80a±0.92	11.20a±0.23	30.33A±1.60	19.2a±1.14	0.3b±0.49	15.0a±0.16	27.0b±0.08	0.2b±0.50	NDb	32.8a±0.20
LOSS (%)			(9)	(5)	(6)	(4)	(25)	(4)	(44)	(50)	(100)	(4)
LEGUMES												
BIG WHITE BEANS "PASTE"	60.20±0.48	NDb	NDb	26.43a±1.00	NDb	110.0a±1.00	2.0a±0.44	96.3b±0.71	152.0b±0.90	0.5b±0.11	0.18±0.05	5.9b±0.10
LOSS (%)		(100)	(100)	(7)	(100)	(10)	(8)	(19)	(58)	(61)	(0)	(16)
BROWN BEANS "PASTE"	60.03±0.30	NDb	1.00b±1.66	68.80a±1.80	NDb	119.6a±0.32	16.0a±0.27	97.1a±0.15	157.2b±1.00	-	0.1a±0.10	5.8b±0.13
LOSS (%)		(100)	(61)	(4)	(100)	(9)	(7)*	(10)	(57)	-	(0)	(17)
SMALL WHITE BEANS "PASTE"	59.90±0.20	-	NDb	17.50a±0.31	NDb	88.5a±1.15	0.2a±1.20	87.5±2.00	128.0b±1.20	-	0.1a±0.05	2.6b±0.12
LOSS (%)		-	(100)	(3)	(100)	(11)	(33)	(11)	(61)	-	(0)	(37)
VEGETABLE												
PLANTAIN	63.00±0.71	-	ND	5.30b±0.21	NDb	11.8a±0.39	1.2a±0.57	35.4a±0.81	30.3a±0.11	-	0.1b±0.05	42.8a±0.17
LOSS (%)		-	(100)	(16)	(100)	(13)	(0)	(7)	(5)	-	(50)	(9)

Values are averages of triplicate determinations expressed on dry matter basis as mg/100g. Figures in parenthesis represent loss during the treatment as percentage of control values.

a Values are not significantly ($P>0.05$) different from control values

a Values with different following letters are significantly different from control values ($P<0.05$)

ND = non detectable

1 HCN values expressed as (mg/kg), *MN values expressed as (µg/100g)

Effect of roasting on some selected foods

The effect of roasting was evaluated on some selected foods. It is presented on Table 4.

Significant ($P<0.05$) losses in hydrogen cyanide content (100%) of the foods were noted. However, soluble oxalate, phytic acid, tannin and the minerals were not (3-14%) significantly ($P>0.05$) reduced. The non reduction is attributed to the processing method where there was no leaching of the nutrients.

TABLE 4

EFFECT OF ROASTING LEVELS OF SOME ANTINUTRITIONAL FACTORS AND MINERALS IN SOME NIGERIAN FOODS

FOOT ITEM	MOISTURE (%)	HCN	SOLUBLE OXALATE	PHYTIC ACID	TANNIN	Ca	Fe	Mg	P	Zn	Cu	Mn*
CEREALS												
FRESH CORN	55.20±0.05	NDb	1.82b±0.11	30.20±0.05	48.33±0.37	7.8b±0.21	0.9b±1.36	46.0a±0.17	328.0±0.10	0.3b±1.20	0.1a±0.05	11.3a±1.70
LOSS (%)		(100)	(19)	(4)	(9)	(22)	(36)	(12)	(26)	(40)	(0)	(10)
LEGUMES												
GROUNDNUT	10.33±0.23	NDb	3.00±0.49	39.30±0.49	48.90±0.39	35.0±0.46	4.9b±1.25	120.0±1.00	412.0±1.20	-	0.2a±0.71	6.5a±1.20
LOSS (%)		(100)	(6)	(2)	(5)	(14)	(29)	(5)	(11)	-	(0)	(7)
SOYBEAN	3.20±0.18	NDb	NDb	87.60±0.17	38.10±1.00	112.0±1.00	6.2b±0.15	125.2±1.00	427.4±1.00	-	0.1a±0.07	12.3±1.11
LOSS (%)		(100)	(100)	(11)	(18)	(7)	(17)	(15)	(20)	-	(0)	(15)
OIL SEED												
BENISEED	3.30±0.30	ND	5.82±0.30	11.00±1.20	9.20±0.16	50.9±0.61	1.2b±0.72	23.4±0.36	70.7±0.28	-	0.1a±0.52	5.3b±0.48
LOSS (%)		(100)	(8)	(8)	(7)	(13)	(33)	(16)	(12)	-	(0)	(24)
ROOTS & TINERS												
CASSAVA	52.00±1.00	ND	2.20±0.31	3.28±0.20	10.20±0.90	15.0±2.00	0.8a±0.71	7.9a±0.80	28.2±1.00	0.1a±0.20	0.1b±1.00	12.0a±0.05
LOSS (%)		(100)	(25)	(17)	(3)	(19)	(27)	(4)	(4)	(0)	(50)	(4)
COCOYAM	46.30±0.50	1.00b±0.01	12.00±1.11	6.82±0.11	37.80±2.40	10.5b±1.10	0.7a±2.13	11.8±0.11	31.2±1.00	0.5b±0.24	0.6a±0.12	29.0±1.00
LOSS (%)		(80)	(5)	(14	(1)	(31)	(12)	(22)	(9)	(29)	(14)	(9)
YAM	58.10±0.20	ND	4.00a±0.20	9.80±0.12	30.23±1.00	18.7±0.71	0.4a±0.15	13.7±0.05	35.8±0.12	0.3b±0.50	1.0a±0.15	33.8±0.16
LOSS (%)		(100)	(25)	(17)	(6)	(7)	(0)	(12)	(26)	(25)	(0)	(1)

Values are averages of triplicate determinations expressed on dry matter basis as mg/100g. Figures in parenthesis represent loss during the treatment As percentage control values.

a Values are not significantly (P>0.05) different from control values.

b Value with different following letters are significantly different from control values (P>0.05).

1 Hydrogen cyanide values expressed as (mg/kg), * Mn as (mg/100g)

ND - non detectable.

Effect of Blanching in some selected foods

Table 5 reveals the data on the effect of blanching in some selected foods.

Blanching is commonly employed to ensure improved storage properties of leafy vegetables. Hydrogen cyanide, soluble oxalate, tannin and most minerals had significant ($P<0.05$) losses during blanching (23-51%). This results could be compared to (Selman, 1986; Bengstsson, 1966) reported that blanching promoted losses up to 40% antinutritional factors and minerals that were water soluble. The state of the vegetable, amount of cooking water and cooking time could all influence the losses.

TABLE 5

EFFECT OF BLANCHING ON LEVELS OF SOME ANTINUTRITIONAL FACTORS AND MINERALS IN SOME NIGERIAN FOODS

Food ITEM	MOISTURE(%)	HCN	SOLUBLE OXALATE	PHYTIC ACID	TANNIN	Ca	Fe	Mg	P	Zn	Cu	Mn*
LEAFY VEGETABLE												
SPINACH	91.80±0.17	-	28.36±0.05[a]	7.90±2.20	16.60±0.18 [a]	153.8±1.00 [a]	1.9±1.00 [a]	10.0±0.20 [a]	38.7±1.30 [a]	0.5±1.30 [a]	ND [a]	19.4±1.11
LOSS (%)		-	(23)	(2)	(11)	(1)	(30)	(22)	(15)	(17)	(100)	(22)
BITTER LEAVES	80.20±0.15	ND	2.00±1.36	3.80±1.20	12.56±0.30 [b]	108.8±0.11 [a]	2.0±0.21 [b]	17.8±0.30 [a]	228.6±1.21 [b]	-	ND [a]	43.8±0.33 [b]
LOSS (%)		(100)	(13)	(2)	(35)	(10)	(35)	(9)	(32)	-	(100)	(36)
FLUTED PUMPKIN LEAVES	85.90±0.27	ND	1.20±1.20	3.60±2.30	7.20±0.20 [b]	22.5±0.72 [a]	1.0±0.18 [a]	14.9±2.11 [a]	123.4±0.05 [a]	-	ND [a]	43.0 ±1.42
LOSS (%)		(100)	(33)	(23)	(28)	(10)	(29)	(8)	(11)	-	(100)	(16)

Values are averages of duplicate determinations expressed on dry matter basis as mg/100g. Figures in parenthesis represent loss during the treatment as percentage of control values.

[a] values are not significantly (P>0.05) different from control values

[b] value with different following letters are significantly different from control values (P<0.05).

Hydrogen cyanide values are expressed as (Mg/kg). * Mn as µg/100g

ND = non detectable

Effect of Decortication on some selected foods

The effect of decortication on levels of antinutritional factors and minerals of some selected foods is presented on Table 6.

Decortification significantly ($P<0.05$) reduced/eliminated tannin contents of the foods. The result compare to Bakshy et al, 1978; Ogun et al, (1989) who reported a complete elimination of tannin in decorticated cowpeas. Losses could be attributed to the fact that tannins are mainly found in the seed coat. There was no significant ($P<0.05$) losses in soluble oxalate phytic acid and minerals due to the processing method. Decortication which removes tannin enhances the nutritional value of the foods.

TABLE 6

EFFECT OF DECORTICATION ON LEVELS OF SOME ANTINUTRITIONAL FACTORS AND MINERALS IN SOME NIGERIAN FOODS

FOOD ITEM	MOISTURE(%)	HCN	SOL. OXA.	PHYTIC ACID	TANNIN	Ca	Fe	Mg	P	Zn	Cu	Mn *
LEGUMES AND NUTS												
BIG WHITE BEANS	57.00±0.66	2.20±0.06 [b]	1.20±0.07 [b]	27.72±0.23 [b]	ND [b]	119.5±0.33 [b]	6.1±0.12 [b]	112.9±0.14 [b]	308.0±0.03 [b]	0.6±1.00 [b]	ND [b]	5.6±2.13 [b]
LOSS (%)		(50)	(32)	(2)	(100)	(2)	(13)	(5)	(14)	(14)	(100)	(20)
BROWN BEANS	56.90±1.23	2.20±0.05 [b]	2.00±0.88 [b]	22.06±0.42 [b]	ND [b]	128.7±0.18 [b]	7.2±0.93 [b]	107.8±1.40 [b]	331.3±0.02 [b]	ND [b]	ND [b]	6.0±0.08 [b]
LOSS (%)		(63)	(22)	(14)	(100)	(2)	(14)	(9)	(8)	(100) [b]	(100)	(14)
GROUNDNUT	49.00±0.62	2.60±0.33 [b]	3.00±1.12 [b]	38.90±1.20 [b]	ND [b]	38.1±0.15 [b]	5.8±0.87 [b]	106.0±1.30 [b]	440.0±0.13 [b]	-	0.2±0.11 [b]	6.5±2.11 [b]
LOSS (%)		(35)	(6)	(3)	(100)	(6)	(16)	(16)	(5)	-	(0)	(7)
SMALL WITHE BEANS	53.63±0.05	-	ND [b]	7.13±2.10 [b]	ND [b]	88.5±0.15 [b]	5.3±0.71 [b]	86.6±0.52 [b]	318.1±0.52 [b]	-	ND [b]	4.0±0.81 [b]
LOSS (%)		-	(100)	(12)	(100)	(11)	(16)	(12)	(4)	-	(100)	(2)
SOYBOANS	56.10±1.20	3.00±0.71 [b]	2.12±2.00 [b]	97.63±3.20 [b]	ND [b]	116.0±0.66 [b]	6.4±1.20 [b]	117.3±0.58 [b]	500.5±0.57 [b]	-	0.1±0.08 [b]	14.2±0.92 [b]
LOSS (%)		(50)	(15)	(1)	(100)	(3)	(15)	(20)	(6)	-	(0)	(2)

Values are averages of duplicate determinations expressed on dry matter basis as mg/100g. Figures in parenthesis represent loss during treatment as percentage of control values

[a] Values are not significantly (P>0.05) different from control values
[b] values with different following letters are significantly different from control values (P<0.05)

* HCN values are expressed as (mg/kg), *Mn as (mg/100g)
ND = non detectable

Effect of soaking at room temperature on some selected foods

The effect of soaking at room temperature on some selected foods at various time interval is presented on Table 7.

Soaking of cereals and soybean for 12 hours significantly ($P<0.05$) reduced the contents of hydrogen cyanide, tannins, phytic acid soluble oxalate and minerals. The result compares to those of previous investigators (Singh and Arora, 1978; Lolas and Markakis, 1975) who reported significant losses in antinutritional factors after soaking. The obvious decrease in phytate, tannin and soluble oxalate during soaking can be attributed to leaching of phytate, oxalate tannate ions and soluble minerals into soaking water under the influence of concentration gradient. Absorped water may also activate enzymes resulting in hydrolysis hence losses. Soaking, an integral part of traditional processing offers dual advantage of saving energy cost by shortening cooking time as well as rendering the grains nutritionally superior. High mineral losses due to leaching suggest a need for fortication of foods especially baby foods.

TABLE 7

EFFECT OF SOAKING AT ROOM TEMPERATURE ON LEVELS OF SOME ANTINUTRITIONAL FACTORS AND MINERALS IN SOME NIGERIAN FOODS

FOOD ITEM	Moisture (%)	Hydrogen Cyanide	Soluble Oxalate	Phytic Acid	Tannin	Ca	Fe	Mg	P	Zn	Cu	Mn *
CEREALS												
WHOLE MAIZE	64.10±0.20	1.00±0.85 [a]	2.10±0.19 [a]	8.70±0.39 [a]	11.20±0.27 [a]	4.2±0.27 [a]	0.6±0.05 [a]	73.3±0.29 [a]	135.0±1.00 [a]	-	ND [a]	11.3±0.7 [a]
LOSS (%)		(73)	(7)	(72)	(78)	(58)	(57)	(56)	(69)	-	(100)	(10)
WHOLE MILLET	58.36±2.00	2.10±0.38 [a]	3.50±0.62 [a]	15.23±0.52 [a]	43.60±0.11 [a]	3.7±0.11 [a]	3.4±0.19 [a]	78.2±1.09 [a]	151.0±0.20 [a]	-	0.5±1.70 [a]	8.0±2.00 [a]
LOSS (%)		(31)	(18)	(60)	(62)	(73)	(67)	(59)	(59)	-	(0)	(16)
WHOLE SORGHUM	60.83±0.71	1.20±0.17 [a]	2.02±0.59 [a]	16.26±0.49 [a]	52.06±0.33 [a]	6.4±0.33 [a]	4.7±1.15 [a]	43.9±1.00 [a]	83.0±0.38 [a]	-	ND [a]	10.2±0.69 [a]
LOSS (%)		(77)	(33)	(59)	(65)	(81)	(48)	(62)	(58)	-	(100)	(7)
LEGUMES												
BIG WHITE BEANS	60.66±0.80	1.50±1.90 [a]	1.40±0.36 [a]	20.00±1.00 [a]	58.93±1.00 [a]	118.5±1.00 [a]	6.8±1.25 [a]	102.0±0.26 [a]	346.5±1.20 [a]	0.3±0.06 [a]	0.1±0.05 [a]	6.8±2.13 [a]
LOSS (%)		(66)	(20)	(1)	(1)	(3)	(3)	(14)	(3)	(57)	(0)	(3)
BROWN BEANS	58.55±0.80	3.70±0.36 [a]	2.20±0.08 [a]	24.50±0.26 [a]	68.13±0.26 [a]	120.8±1.18 [a]	6.4±1.23 [a]	106.7±0.67 [a]	350.2±1.20 [a]	0.1±0.08 [a]	ND [a]	6.5±1.00 [a]
LOSS (%)		(38)	(14)	(4)	(5)	(8)	(14)	(10)	(3)	(50)	(100)	(7)
SMALL WHITE BEANS	56.33±0.19	-	ND [a]	7.26±3.00 [a]	17.00±3.00 [a]	90.8±0.13 [a]	5.8±0.30 [a]	86.3±0.20 [a]	307.9±0.30 [a]	-	ND [a]	3.8±1.70 [a]
LOSS (%)		-	(100)	(11)	(17)	(8)	(8)	(12)	(7)	-	(100)	(7)
SOYBEANS	59.63±1.22	1.60±1.26 [a]	1.60±0.13 [a]	20.43±0.28 [a]	18.80±0.28 [a]	48.8±0.71 [b]	4.3±0.25 [a]	78.9±1.20 [a]	221.4±1.20 [a]	-	ND [a]	12.0±0.73 [a]
LOSS (%)		(73)	(36)	(79)	(59)	(58)	(42)	(47)	(58)	-	(100)	(17)

Values are averages of duplicate determinations expressed on dry matter basis as mg/100g. Figures in parenthesis represent loss during treatment as percentage of control values.

[a] values not significantly (P>0.05) different from control values
[b] values with different following letters are significantly different from control values (P<0.05).
Hydrogen cyanide values expressed as (mg/kg), *Mn as (µg/100g)
ND = non detectable

Effect of conversion to paste products of some selected foods

Cereal and legume grains are mostly processed into paste products before consumption. The effect of conversion to paste products is presented on Table 8.

Significant ($P<0.05$) losses were noted in hydrogen cyanide, 55-73% in oxalate, 35-55% in phytic acid, 56-77% in tannin and 18-60% in some minerals. Ogun et al (1989), similarly reported 98-100% losses of tannin in moin-moin. Losses could be attributed to the processing methods such as decortication, milling, cooking etc. Conversion to paste products though significantly reduces tannin, hydrogen cyanide acid and some minerals it enhances also the retention of minerals in processing to paste product such as tuwo and moin-moin.

TABLE 8

EFFECT OF CONVERSION TO PASTE PRODUCTS ON LEVELS OF SOME ANTINUTRITIONAL FACTORS AND MINERALS IN SOME NIGERIAN FOODS

FOOD ITEM	MOISTURE(%)	HYDROGEN CYANIDE	SOLUBLE OXALATE	PHYTIC ACID	TANNIN	CALCIUM	IRON	MAGNESIUM	PHOSPHORUS	ZINC	Cu	Mn *
CEREALS												
WHOLE MAIZE "TUWO"	[illegible]	ND^{b}	0.60±1.3^{b}	21.40±0.30^{b}	20.00±2.17^{b}	7.6±0.12^{b}	4.8±0.57^{b}	145.3±0.06^{b}	228.9±2.06^{b}	2.3±0.04^{b}	1.0±0.22^{a}	8.2±0.16^{b}
LOSS (%)		(100)	(73)	(28)	(42)	(22)	(9)	(13)	(48)	(40)	(0)^{a}	(34)
WHOLE MILLET "TUWO"	73.20±0.17	ND^{b}	2.40±0.32^{b}	24.80±1.16^{b}	48.20±0.09^{b}	11.5±0.27^{b}	8.9±0.39^{b}	150.9±1.71^{b}	238.6±0.07^{b}	0.4±0.22^{b}	ND^{b}	4.3±0.15^{b}
LOSS (%)		(100)	(44)	(35)	(58)	(18)	(15)	(2)	(35)	[illegible]	(100)	(57)
WHOLE SORGHUM "TUWO"	[illegible]	ND^{b}	1.90±1.26^{b}	29.20±0.80^{a}	42.00±1.11^{b}	30.70±0.30^{b}	8.9±0.57^{b}	103.2±1.20^{b}	[illegible]	[illegible]	ND^{b}	4.8±0.90^{b}
LOSS (%)		(100)	(37)	(28)	[illegible]	(11)	(1)	(11)	[illegible]	[illegible]	[illegible]	(11)
WHOLE MAIZE "OGI"	[illegible]	ND^{b}	0.60±0.2^{b}	[illegible]	30.00±2.70^{b}	[illegible]	2.6±1.15^{b}	123.1±2.20^{b}	[illegible]	0.1±0.00^{b}	ND^{b}	6.2±0.08^{b}
LOSS (%)		(100)	(84)	[illegible]	(44)	[illegible]	(5)	(38)	(36)	(80)	(100)	(50)
DEHULLED MILLET "FURA"	73.90±0.06	ND^{b}	2.38±0.37^{b}	[illegible]	ND^{b}	12.8±0.56^{b}	8.6±0.07^{b}	148.2±0.30^{b}	232.2±1.90^{b}	2.3±0.25^{b}	[illegible]	3.0±1.50^{b}
LOSS (%)		(100)	(37)	(2)	(100)	(4)	(8)	(4)	(35)	(42)	(0)	(60)
DEHULLED MAIZE "TUWO"	76.16±0.22	ND^{b}	0.80±0.40^{b}	18.50±0.81^{b}	ND^{b}	5.0±0.66^{b}	0.9±1.20^{b}	9.2±5.00^{b}	257.4±1.00^{b}	0.1±0.05^{b}	ND^{b}	5.9±1.51^{b}
LOSS (%)		(100)	(63)	(35)	(100)	(20)	(2)	(41)	(36)	(80)	(100)	(42)
DEHULLED MILLET "OGI"	83.00±0.15	ND^{b}	1.10±0.31^{b}	21.90±0.71^{b}	ND^{b}	11.1±1.70^{b}	5.5±0.31^{b}	135.2±0.12^{b}	247±0.00^{b}	-	ND^{b}	5.2±0.40^{b}
LOSS (%)		(100)	(71)	(41)	(100)	(21)	(39)	(17)	(31)	-	(100)	(42)
RICE "TUWO"	75.10±0.21	-	1.20±0.36^{b}	43.00±2.66^{a}	3.01±2.43^{b}	41.2±0.92^{b}	0.3±2.00^{b}	7.2±1.00^{b}	139.5±0.58	0.3±0.32^{b}	ND^{b}	6.5±0.05^{b}
LOSS (%)		-	(49)	(10)	(56)	(23)	(4)	(28)	(40)	(40)	(100)	(26)
LEGUMES												
BIG WHITE BEANS "MOIN-MOIN"	69.03±0.1	ND^{b}	ND^{b}	23.30±1.2^{b}	ND^{b}	8.8±2.16^{b}	1.8±0.08^{b}	116.0±0.30^{b}	274.1±0.59^{b}	0.4±0.34^{b}	ND^{b}	5.0±1.00^{b}
LOSS (%)		(100)	(100)	(18)	(100)	(28)	(10)	(14)	(27)	(43)	(100)	(29)
BROWN BEANS "MOIN-MOIN"	[illegible]	ND^{b}	ND^{b}	22.70±2.04^{b}	ND^{b}	[illegible]	6.0±1.20^{b}	105.9±1.02^{b}	[illegible]	[illegible]	ND^{b}	4.8±0.88^{b}
LOSS (%)		(100)	(100)	(19)	(100)	(15)	(20)	[illegible]	(19)	(50)	(100)	(31)
SMALL WHITE BEANS "MOIN-MOIN"	82.06±0.05	-	ND^{b}	8.70±7.18^{a}	ND^{b}	80.4±0.80^{b}	5.0±0.25^{b}	90.2±1.30^{b}	214.5±0.12^{b}	-	ND^{b}	3.3±0.22^{b}
LOSS (%)		-	(100)	(15)	(100)	(18)	(21)	(12)	(37)	-	(100)	(20)
SOYBEAN "OGI"	81.00±0.34	ND^{b}	1.00±0.50^{b}	75.10±0.10	28.70±0.55^{b}	122.6±0.05^{b}	5.2±0.56^{b}	124.3±0.30^{b}	334.5±0.42^{b}	-	ND^{b}	2.5±1.32^{b}
LOSS (%)		(100)	(60)	(24)	(38)	(15)	(3)	(18)	(36)	-	(100)	(14)
ROOTS & TUBERS												
[illegible]	84.80±0.02	[illegible]	[illegible]	[illegible]	2.40±0.36^{b}	11.9±0.27^{b}	[illegible]	[illegible]	22.4±0.42^{b}	0.1±0.52^{a}	0.2±0.15^{b}	[illegible]
LOSS (%)		(70)	(9)	(55)	(77)	(30)	[illegible]	[illegible]	(31)	(0)	(0)	(34)
YAM POTTAGE	65.20±0.50	ND^{b}	3.80±2.01^{b}	4.10±0.28^{b}	27.90±0.30^{a}	15.9±1.00^{b}	0.3±2.00^{b}	12.7±1.26^{b}	18.7±0.11^{b}	0.3±0.89^{b}	0.5±1.12^{b}	27.8±0.13^{b}
LOSS (%)		(100)	(28)	(23)	(13)	(21)	(22)	(19)	(34)	(25)	(22)	(18)

Values are averages of duplicate determinations expressed on dry matter basis as mg/100g. Figures in parenthesis represent loss during treatment as percentage of control values. ^{a} values with different following letters are significantly different from control values (P<0.05)

4.9 The phytate-mineral (Ca,Mg,Zn) ratios of some selected foods.

The phytic, calcium, magnesium, zinc content and phytate-mineral ratio of 32 commonly consumed Nigerian foods are presented on Table 9.

The phytate contents of the foods ranged from 4.8 - 52.8mg/100g DM. According to previous reports Maga, 1982; Harland and Oberleas 1987), the data indicates that phytate is appreciable in cereal and leguminous base staples. The mean phytic acid intake of the foods is 20.99mg/100g. Available evidence indicates that phytic acid in foods promotes negative bioavailability of divalent ions such as zinc, copper, iron, magnesium and calcium, 1960; Erdman and Forbes, 1977; Harland et al, 1988).

Adopting a phytate/calcium ratio of >56.5 a phytate/magnesium ratio of >152.7 and a phytate/zinc ratio of >22.1 as indicative of negative bioavailability of the minerals from the foods as a consequence of their phytate levels (Oberleas, 1975), the data revealed that calcium and magnesium content are not significantly ($P>0.05$) affected by the phytate contents of the foods. On the contrary, zinc bioavailability from 29 out of the 32 foods evaluated appears to be impaired as a consequence of their phytate content.

TABLE 9
The Phytate, Calcium, Magnesium, Zinc and Phytate: Mineral ratios of selected Nigerian diets.

FOOD ITEM	MOISTURE (%)	PHYTIC ACID	CALCIUM	MAGNESIUMM	ZINC	PHY/Ca	PHY/Mg	PHY/Zn
RICE & STEW	88.20±0.11	58.00±0.11	33.8±2.10	108.2±0.71	0.5 ±0.36	0.82	0.25	20.12
WHITE COWPEA & STEW	78.10±1.20	16.10±1.20	68.3±0.82	63.2±1.30	08 ±2.20	0.23	0.25	20.12
BROWN COWPEA & STEW	82.10±0.82	18.00±0.82	63.1±2.90	62.0±1.20	0.3 ±0.43	0.28	0.29	60.00
DANWAKE 'COWPEA PROCESSED	69.20±0.58	22.10±2.30	67.2±0.74	132.0±1.30	0.2 ±2.60	0.32	0.16	110.5
GROUNDNUT	36.60±1.10	38.20±0.58	37.2±2.80	116.0±0.81	-	1.02	0.32	-
SMALL COWPEA & STEW	72.00±0.42	8.90±2.10	58.0±3.10	56.8±0.43	0.1 ±1.20	0.15	0.15	89.0
CASSAVA & STEW	51.50±0.62	17.20±0.22	25.2±0.71	30.9±0.52	0.1 ±0.33	0.68	0.55	172.0
COCOYAM & STEW	67.10±0.34	13.10±1.88	38.8±0.68	21.7±0.65	0.6 ±0.61	0.33	0.60	21.83
IRISH POTATO & STEW	58.20±0.20	11.50±3.20	19.6±0.52	16.4±0.73	0.2 ±1.20	0.58	0.70	57.5
RED SWEET POTATO & STEW	66.20±0.50	13.20±2.52	28.0±0.26	32.2±0.82	0.2 ±3.10	0.47	0.40	66.0
WHITE SWEET POTATO & STEW	62.80±0.02	15.10±1.58	30.3±3.20	36.2±0.40	0.1 ±0.87	0.50	0.41	151.0
YAM & STEW	68.30±0.58	18.20±2.00	32.2±3.10	28.2±3.10	0.3 ±1.20	0.56	0.64	60.66
EGUSI SOUP	75.50±0.43	11.20±0.67	20.3±0.83	26.10±1.20	0.3 ±1.38	0.55	0.42	37.33
KUKA SOUP	93.00±0.32	6.20±0.60	160.9±0.82	43.0±0.76	0.2 ±0.30	0.03	0.14	31.00
OKRA FRESH SOUP	92.10±0.22	4.80±0.92	89.2±1.20	33.6±2.10	02±0.73	0.05	0.14	24.00
STEW	85.80±0.42	8.70±0.45	53.5±3.10	46.7±1.12	0.3±1.10	0.16	0.18	29.00
FRIED IRISH POTATO	15.53±0.32	8.20±2.51	31.2±0.10	19.10±1.28	0.1±1.10	0.26	0.42	82.0
FRIED RED SWEET POTATO	20.50±0.92	18.20±3.52	28.1±0.72	32.1±3.10	0.1±0.31	0.64	0.56	182.0
WHITE SWEET POTATO	20.40±0.11	16.10±2.10	26.0±2.10	27.1±0.81	0.2±2.00	0.61	0.59	80.5
FRIED YAM	52.10±0.20	13.20±0.49	42.2±1.20	26.2±0.89	0.2±0.70	0.31	0.50	66.0
FRIED WHITE BEANS CAKE	60.20±0.82	40.40±3.32	150.7±0.56	131.2±2.20	0.2±1.72	0.26	0.30	202.0
FRIED BROWN BEANS CAKE	60.03±0.51	52.80±1.30	142.8±0.45	126.2±0.42	0.1±2.10	0.50	0.57	728.0
MAIZE MEAL & OKRA SOUP	76.20±0.38	32.40±0.86	92.2±0.52	138.0±0.62	0.3±0.66	0.35	0.23	108
MILLET MEAL & KUKA SOUP	70.80±0.52	35.10±0.72	170.2±1.82	171.2±0.72	0.4±1.32	0.20	0.20	87.75
SORGHUM MEAL & OKRA SOUP	71.30±0.45	33.10±0.48	100.2±3.60	122.3±0.36	0.4±0.72	0.33	0.27	82.75
MAIZE 'PAP'	89.26±0.50	19.10±0.72	9.9±2.10	103.1±0.52	0.2±0.82	1.92	0.18	95.5
MILLET PASTE 'FURA'	75.86±0.20	29.30±0.62	80.0±0.90	178.2±3.18	0.2±1.90	0.36	0.16	146.5
RICE MEAL & EGUSI SOUP	75.10±0.05	44.00±2.10	40.2±1.20	22.0±0.96	0.3±0.46	1.09	2.0	146.6
WHITE COWPEA 'STEAMED PASTE	68.03±0.32	29.13±1.73	96.2±2.10	122.0±0.21	0.4±0.90	0.23	72.82	72.82
BROWN COWPEA 'STEAMED PASTE	69.46±0.30	28.10±0.73	100.3±1.80	119.9±1.10	0.3±0.51	0.23	93.6	93.6
EBA & EGUSI SOUP	69.80±0.68	8.80±0.18	32.2±0.58	28.2±1.30	0.3±0.48	0.27	0.31	29.33
YAM POTTAGE	65.20±0.67	13.40±0.34	56.8±4.30	52.1±4.41	0.4±0.58	0.23	0.25	33.5

Each value is the average of triplicate dtermination with standard deviations.

4.10 The Oxalate-mineral (Ca, Mg, Fe) ratios of some selected foods

The oxalate, calcium, magnesium, iron content and oxalate-mineral ratios of 32 commonly consumed foods are presented on Table 10.

The soluble oxalate content of the foods ranged from 0.80-18.00mg/100g. Egusi soup had the highest oxalate content (18.00mg/100g). Though the oxalate contents of the foods fell within permissible levels, the mean oxalate intake of the foods was 5.76mg/100g. Oxalic acid is mainly reported to be high in leafy vegetables Oke, 1969, Eka, 1977; Kelsay and Prather 1983).

Kelsay and Prather (1983) reported that high oxalate foods could result in negative bioavailability of calcium, magnesium and iron. Adopting a oxalate/calcium ratio of >9.6, a oxalate/iron ratio >5.5 and a oxalate/magnesium ratio of >23.5 as indicative of negative bioavailability (Couzy et al, 1993 and Derache, 1990), the data revealed that the bioavailability of calcium and magnesium is not ($P>0.05$) significantly affected. However, oxalate had a significant ($P<0.05$) effect on bioavailability of iron in foods such as (Eba, yam pottage, rice, cocoyam, sweet potatoes and Egusi). Impairment of iron bioavailability of these foods appear likely due to oxalate content.

TABLE 10

THE OXALATE, CALCIUM, MAGNESIUM, IRON CONTENT AND OXALATE-MINERAL (Ca, Mg, Fe) RATIOS OF SOME COMMONLY CONSUMED NIGERIAN FOODS

FOOD ITEM	MOISTURE (%)	SOLUBLE OXALATE	CALCIUM	IRON	MAGNESIUM	OX/Ca	OX/Fe	OX/Mg
RICE & STEW	88.20±0.11	5.20±1.32	33.8±0.38	0.7±1.30	108.2±0.08	0.15	7.42	0.04
WHITE COWPEA & STEW	78.10±1.20	4.20±0.50	68.3±0.05	4.5±1.10	63.2±1.20	0.06	0.93	0.06
BROWN COWPEA & STEW	82.10±0.82	3.70±2.505.10±1.50	63.1±0.40	5.0±0.62	62.0±1.32	0.06	0.74	0.05
GROUNDNUT	36.60±1.10	2.10±1.10	37.2±2.00	5.8±1.32	116.0±1.32	0.07	0.48	0.02
SMALL COWPEA & STEW	72.00±0.42	2.50±0.90	58.0±0.30	5.2±0.49	56.8±0.80	0.03	0.40	0.03
CASSAVA & STEW	51.50±0.62	17.60±0.80	25.2±0.05	1.9±0.62	30.9±0.67	0.09	1.31	0.08
COCOYAM & STEW	67.10±0.34	4.30±0.60	38.8±0.38	1.2±2.00	21.7±0.08	0.45	14.66	0.81
IRISH POTATO & STEW	58.20±0.20	8.10±0.20	19.6±1.10	2.2±0.72	16.4±0.70	0.21	1.95	0.26
RED SWEET POTATO & STEW	66.20±0.50	7.20±1.30	28.0±4.00	1.0±2.80	32.2±2.10	0.28	8.10	0.25
WHITE SWEET POTATO & STEW	62.40±0.02	6.20±4.20	30.1±3.00	1.3±1.10	36.2±1.00	0.23	5.53	0.19
YAM & STEW	68.30±0.58	8.30±1.60	32.2±2.60	1.2±4.20	28.2±2.10	0.19	5.16	0.21
EGUSI SOUP	75.50±0.43	3.00±0.50	20.3±1.30	1.3±0.52	26.1±1.48	0.40	6.38	0.31
KUKA SOUP	93.00±0.32	6.10±0.50	160.9±0.60	5.2±2.52	43.0±2.13	0.01	0.57	0.06
OKRA FRESH SOUP	92.10±0.22	9.20±0.70	89.2±1.40	1.0±1.09	33.6±1.78	0.06	6.10	0.18
STEW	85.80±0.42	4.10±0.73	53.5±0.40	4.2±0.52	46.7±0.48	0.17	2.19	0.19
FRIED IRISH POTATO	15.53±0.32	5.20±1.26	31.2±2.42	1.8±2.70	19.1±3.30	0.13	2.27	0.21
FRIED RED SWEET POTATO	20.50±0.92	4.80±4.12	28.1±0.30	1.3±1.10	32.1±1.20	0.18	4.00	0.16
FRIED WHITE SWEET POTATO	20.40±0.11	6.20±0.72	26.0±1.00	1.0±0.88	27.1±0.70	0.18	4.80	0.17
FRIED YAM	52.10±0.20	6.20±0.81	42.2±2.10	0.7±0.70	26.2±2.10	0.14	8.85	0.23
FRIED WHITE BEANS CAKE	60.20±0.82	7.00±1.20	150.7±0.50	7.3±1.60	131.2±0.05	0.04	0.84	0.04
FRIED BROWN BEANS CAKE	60.03±0.51	8.20±1.00	142.8±0.10	12.0±2.00	126.2±1.70	0.04	0.58	0.05
MAIZE MEAL & OKRA SOUP	76.20±0.38	7.20±2.18	92.2±1.36	6.2±1.90	138.0±0.40	0.08	1.32	0.05
MILLET MEAL & KUKA SOUP	70.80±0.62	6.80±0.70	170.2±2.50	11.0±0.62	171.2±0.56	0.04	0.65	0.04
SORGHUM MEAL & OKRA SOUP	71.30±0.45	6.80±0.70	100.2±2.10	10.9±0.72	122.3±1.70	0.06	062	0.05
MAIZE 'PAP'	89.26±0.50	0.80±0.50	9.9±1.43	0.6±1.38	103.1±2.10	0.08	1.33	0.00
MILLET PASTE 'FURA'	75.86±0.20	2.30±0.96	80.8±2.20	6.9±3.48	178.2±1.60	0.02	0.34	0.01
RICE MEAL & EGUSI SOUP	75.10±0.05	6.30±0.48	40.2±0.82	1.0±2.82	22.0±3.12	0.15	6.30	0.28
WHITE COWPEA 'STEAMED' PASTE	60.03±0.32	3.72±1.36	96.2±1.20	5.9±2.72	122.0±1.30	0.40	003	0.63
BROWN COWPEA 'STEAMED PASTE'	69.46±0.30	5.12±0.92	100.3±0.42	6.5±2.11	119.9±4.20	0.30	0.05	0.78
EBA & EGUSI SOUP	69.80±0.68	7.20±0.52	32.2±3.20	1.2±0.38	28.2±1.72	0.22	6.00	0.25
YAM POTTAGE	65.20±0.67	7.80±1.20	56.8±0.82	0.8±2.10	52.10±2.31	0.13	9.75	0.14

Each Value is the average of triplicate determination with standard deviations.

CHAPTER FIVE

5.0 SUMMARY

Data obtained from this study revealed that hydrogen cyanide, soluble oxalate, phytic and tannin levels in the forty Nigerian foods examined were not high enough to pose any risk problem.

Traditional household processing techniques such as blanching, cooking, conversion to paste products, decortication and soaking resulted in significant reduction/elimination of the antinutritional factors and mineral elements. Other processing methods (frying and roasting) did not significantly ($P>0.05$) reduce the levels of antinutritional factors and minerals. The phyate-mineral and oxalate-mineral ratios of some selected foods did not affect the bioavailability of calcium and magnesium, however, zinc and iron contents of some foods were affected by the antinutritional factors.

It therefore, appears from this work that household processing reduces both the contents of antinutritional factors and minerals in foods.

5.1 CONCLUSION

In the present study the following can be deduced:

(a) The hydrogen cyanide, soluble oxalate, phytate and tannin content of the forty foods examined ranged from (1.10-19.83; 1.10-12.60; 2.30-98.70; 1.10-148.33mg/100g respectively).

(b) Calcium, phosphorus and iron were highest in legumes and leafy vegetables.

(c) Cooking significantly ($P<0.05$) promoted losses of hydrogen cyanide, soluble oxalate, phytate, tannin and minerals (20-100%).

(d) Conversion of cereal, legumes (cowpea and tuber staples into paste products significantly ($P<0.05$) reduced the antinutritional factors and some mineral to the tune of (16-100%).

(e) Blanching techniques employed for vegetables resulted in significant ($P<0.05$) losses in both antinutritional factors and minerals (15-58%).

(f) Frying and roasting of some foods did not significantly ($P>0.05$) reduce the contents of antinutritional factors and minerals.

(g) The phytate/mineral and oxalate/mineral ratios showed that phytate and oxalate did not affect calcium and magnesium bioavailability, however, the bioavailability of zinc and iron could be impaired as a result of the phytate and oxalate content of the foods.

5.2 RECOMMENDATIONS

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

(a) In view of the significant ($P<0.05$) mineral losses associated with losses of antinutritional factors observed following most household processing methods, it is recommended that some minerals (zinc and iron) be supplemented.

(b) Decortication of cereals and legumes should be

carried out since tannins are eliminated and minerals retained.

(c) It is highly recommended that food composition tables should include antinutritional factors content.

(d) It is also recommended that when mineral intakes of foods are determined, not only their relationship to Recommended Daily Allowance levels be considered but also levels of antinutritional factor contents.

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APPENDIX I

LIST OF MARKETS

Samaru main market

Zaria main market

Kaduna Central market

Gusau main market

Sokoto main market

Kano main market

Jos main market

Maiduguri main market.

APPENDIX II

LIST OF FOODS

CEREALS

Wheat

Whole maize (yellow)

Whole millet

Whole sorghum

Rice

FRUITS

Riped sweet orange

Big Garden egg

Guava

LEGUMES

Big white beans

Brown beans

Groundnut

Small white beans

Soybeans

LEAFY VEGETABLES

Baobab leaves

Bitter leaves

Cabbage leaves

Fluted pumpkin leaves

Lettuce leaves

Spinach leaves

OIL SEEDS, SPICES & CONDIMENTS

Melon seed

Cotton seed

Ginger

Locust bean

Red pepper

ROOTS & TUBERS

Carrot

Cassava

Cocoyam

Irish potato

Red sweet potato

White sweet potato

Yam.

VEGETABLES

Tomatoes

Unriped plantain

riped plantain

Unriped Banana

Riped Banana

Okra

APPENDIX III

STANDARD RECIPES USED

COOKED COWPEA: A (250ml) cup of cowpea was placed in boiling water and cooked till soft (60 mins). This was carried out on all cowpeas examined.

COOKED GROUNDNUT: Two (250ml) cups of fresh unshelled groundnut was placed in boiling water and cooked for 10 minutes.

COOKED RICE: A cup of rice was placed in boiling water, cooked till soft (40 mins).

COOKED TUBERS: A medium size yam, was peeled, cut into smaller sizes and placed in boiling water, cooked till soft. Same was done for irish potato, sweet potato, cocoyam and cassava.

PASTE PRODUCTS

MOIN - MOIN: Dehulled cowpea was blended. To some portions, tomato sauce, pepper, onion, salt and vegetable oil was added and mixed. Portions were taken in plastic wrappers and steamed in boiling water for 45 mins.

BEANS CAKE ("AKARA"): To the aforementioned blended portion of cowpea paste, it was whipped, and spoonfuls fried in vegetable oil till brown.

CORN MEAL ("TUWO")" Maize flour was dissolved in cold water to form a slurry. The slurry was poured into boiling water with constant stirring till a consistency was obtained. Boiled for 10 mins. and

more flour added with stirring to desired consistency and then Cooked for 10 mins. The same thing was done for millet and sorghum flours.

CASSAVA ("GARRI"): Garri was sprinkled into boiling water till the water was saturated, covered and stirred to consistency.

MILLET PASTE ("FURA"): Dehulled millet flour, spice was mixed with water into a paste, the paste was shaped into balls and placed in boiling water for 10 mins. The balls were pounded and reshaped back to balls this was coated with rice flour.

YAM POTTAGE: Two medium size yam was peeled, washed, cut into smaller sizes, placed in boiling water, tomato sauce, pepper, onion, salt and palm oil added. It was cooked till very soft and turned.

CORN STARCH ("PAPOGI"): Maize was soaked for 12 hours and in water, afterwards grounded, mixed with more water and seived. The starch was allowed to settle overnight and water poured off-leaving the starch below. Portions of the starch was mixed with water into a slurry and boiling water poured with stirring into desired consistency.

S O U P S

EGUSI: Grounded melon seeds were placed in boiling water, tomato sauce, onion, pepper, salt and palm oil were added and cooked for 45 mins. Chopped spinach leaves were added and steamed for 2 mins.

OKRA: Fresh green okra were chopped and placed in boiling water with salt, pepper, onion and palm oil added till cooked (20 mins.).

KUKA: Grounded dry Baobab leaves (powder) was slowly stirred into boiling water, salt and pepper were added and cooked for 20 mins.

STEW: Tomatoes, peppers (small and big), onion were blended, the slurry was boiled for 60 mins to evaporate off the water giving a thick paste. The paste was fried in vegetale oil for 20 mins.

APPENDIX IV

COOKING TIMES

RICE	40 minutes
GROUNDNUT	1 hour
CASSAVA	10 minutes
COCOYAM	20 minutes
SWEET POTATOES	20 minutes
IRISH POTATOES	15 minutes
YAM	20 minutes
EGUSI	45 minutes
KUKA	15 minutes
OKRA	15 minutes
STEW	1 hour 20 mins.