NUTRIENT POTENTIAL OF WILD AND CULTIVATED EDIBLE MUSHROOMS AND THEIR POSSIBLE USE IN FORTIFYING SNACKS FOR PRE-SCHOOL AND SCHOOL CHILDREN

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DEDICATION

This work is dedicated to my family and the Almighty God.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABSTRACT

The study determined the nutrient composition of wild and cultivated edible mushrooms, and explored their use of cultivated *Pleurotus tuber-regium* in food-to-food fortification. Wild edible mushrooms (*Pleurotus tuber-regium, Pholiota mutabilis, Pleurotus ostreatus, Corprinus disseminates,* and *Peziza badioconfusa Korf*) were collected from different parts of the University of Nigeria, Nsukka (UNN) residential quarters and identified in the Department of Botany, UNN. Cultivated *Pleurotus tuber-regium* was collected from the Department of Botany, UNN. The wild and cultivated mushrooms were processed into flour and chemically analyzed using standard methods of analysis. Different proportions (20g, 40g and 60g) of the *Pleurotus tuber-regium* flour were incorporated into 600g of wheat flour, cocoyam paste and corn starch to produce composites. The composites were used to prepare the following snacks: wheat buns, cocoyam buns and *aged jollify*. Each of these snacks had their controls made without mushroom. Sensory evaluation of the snacks was conducted using 20 panelists (children aged 8-14 years). The evaluation was done in three days at the rate of one fortified food (snack) per day. A 9-point Hedonic scale of 9 (highest) to 1 (lowest) was used to evaluate the products. The nutrient composition of the snacks was calculated using available food composition Tables as well as the nutrient composition of the cultivated *Pleurotus* mushroom obtained in the study. The percentage increase in specific nutrients as a result of fortification was calculated. The ability of the most acceptable snacks in meeting some specific nutrient requirements of pre-school and school children was determined using recommended nutrient intakes (RENI) for energy, protein, vitamins and minerals. Data were analysed using one way analysis of variance (ANOVA). Significance was accepted at $p<0.05$, Duncan's new multiple range test was used to separate means.

The wild and cultivated mushrooms were high in protein (10.1 to 33.0% wet weight), but low in fat and crude fiber (<1% and <2% respectively). Calcium varied from 86.2 mg/100g to 372.3 mg/100g. All the wild and cultivated mushrooms contained good amounts of selenium from 11.3 µg/100g to 48.7 µg/100g, except *Pholiota mutabilis* which had 1.9µg/100g. Copper varied from 32.7 µg/100g to 199.4 µg/100g. Folic acid ranged between 1235.0 µg/100g and 2484.0 µg/100g, vitamin B_{12} from 1.85 mg/100g to 4.33 mg/100g and vitamin E from 16.28 mg/100g to 33.40 mg/100g. Thiamin varied between 0.04 mg/100g and 0.90 mg/100g, riboflavin from 0.13 mg/100g to 0.36 mg/100g and vitamin C, from 0.20 mg/100g to 9.7 mg/100g. There were no significant ($P>0.05$) differences in the organoleptic attributes of samples containing mushroom and those not containing mushroom except for texture of cocoyam buns fortified with 40g mushroom (CBM_{40}) which was significantly ($P<0.05$) different from the control. In wheat buns fortified with 60g mushroom flour (WBM_{60}), protein increased by over 20%, copper by over 700%, selenium by over 50%, folic acid by over 130% and vitamin E by over 230%. There were slight increases in calcium (19.6%), iron (2.8%), vitamin C (32.1%), thiamin (5.0%), riboflavin (16.7%) and niacin (5.3%) with addition of mushroom. For pre-school children (PSC), 100g of the wheat buns fortified with 60g mushroom (WMB_{60}) contributed 268.6% selenium, 180% folic acid, 563.6% vitamin B_{12} and 43.1% vitamin E of RNI. Wheat buns fortified with 60g mushroom (WBM_{60}), provided 66.5% and 42.9% of the recommended protein intakes of pre-school and school children, respectively. *Agidi jollof* fortified with 60g mushroom flour (AJM_{60}) had high increases in folic acid (374.7%), vitamin E (281.1%), vitamin B_{12} (77.8%) and selenium (61.1%) contents over the control. AJM_{60} furnished the following percentages of the requirements of pre-school children: Selenium (31.4%). folic acid (63.6%), vitamin B_{12} (90%) and vitamin E (31%). For school children, AJM_{60} furnished 26.9% selenium and 38.2% folic acid. Cocoyam buns fortified with 60g mushroom (CBM_{60}) had marked increases in selenium (91.5%), copper (104.4%), folic acid (714.9%), niacin (34.5%) and vitamin E (208.0%) over control. CBM_{60} contributed 24.4% of selenium, 47.3% of vitamin B_{12}, 96.0% of folic acid and 12.0% of vitamin E to the RNI of pre-school children. For school children, CBM_{60} provided 21.0% of selenium, 29.0% of vitamin B_{12}, 9.0% of vitamin E and 57.3% of folic acid. Wild or cultivated *Pleurotus tuber-regium* is indeed a highly nutritious food that can contribute to sustainable diets of various population groups. The fortified products could be promoted in place of empty-calorie and other fast foods that are almost replacing the traditional foods.

CHAPTER ONE
INTRODUCTION

1.0 Background of the Study

Food insecurity remains a significant international problem, with developing regions of the world enduring most of the burden. Food insecurity results in considerable health, social, psychological and behavioural consequences and is undeniably linked to poverty. Despite international commitment, the number of food insecure individuals remains unacceptably high (Bandies University, 2000). There is lack of sustainable physical and economic access to enough, safe, nutritious and socially acceptable food for a healthy and productive life all over the world, and in Nigeria in particular at national and household levels (Aliyu, 2005). In Nigeria, as in many developing countries, malnutrition is caused by many factors among which is the long standing moderate food shortage coupled with sub-optimal use of traditional food sources.

Traditional foods were defined by Kuhnlein and Recevour (1996) as food from a particular culture available from local resources and culturally acceptable as appropriate and desirable foods. Traditional plant foods have also been defined as those plants which are accepted by a community through customs, habit and tradition as appropriate and desirable foods. They are grown for food within the farming system in any particular locality or gathered in wild or semi wild condition. They can be divided into two groups: those consumed as traditional dietary staples and those consumed as components of accompanying relishes and sauces. They include a large variety of legumes, oils seeds, fruits and vegetables (FAO, 1995). Kuhnlein (2003) also reported that traditional foods contain a wealth of micronutrients that have been poorly described and reported in scientific literature. Understanding the micronutrient contents of species in our traditional food system would be an essential step towards the goal of building health promoting activities that could incorporate these foods into commonly used staples, thereby alleviating micronutrient malnutrition that constitute the most wide spread form of malnutrition in the world.

In Nigeria there are lots of cheap nutritious and readily available food crops (e.g. mushroom) which could be adequately processed and used as food fortificant to improve the already existing recipes such as porridges, snacks or even soups. Nutrition transition is taking place very much faster and in some cases with extreme rapidity (Reddy & Yusuf, 1998). The nutrition transition is marked by a shift from relatively monotonous diets based on indigenous staples towards more varied diets that include more preprocessed food, more food of animal origin, processed drinks and foods. This is inevitable consequence of urbanization. The effect of relatively dense diet and physical inactivity has increased the incidence of obesity and other diet related chronic diseases (Reddy & Yusuf., 1998).

Our locally available food sources of micronutrients should be given priority in order to achieve an improved nutrition which is one of the Millennium Development Goals. It was recognized by FAO (1995) that fortication of food could in certain situations be an essential component of food-based approach of eradicating micronutrient malnutrition. Food fortication is the public health policy of adding micronutrients to foodstuffs to ensure that minimum dietary requirement are met.

Fortification of food has been defined as the addition of one or more micronutrients to foodstuff (vitamins, protein or amino acids and minerals) whether or not it is normally contained in the food, for the pupose of preventing deficiency of one or more nutrients in specific population groups. Processed simple diets based on staple foods could be fortified by some traditional food sources that are very rich in important micronutrients. Dietary diversity especially from indigenous food sources appears to be one of the food-based approaches to meeting the nutrient requirement of the teaming population worldwide. Addition of micronutrient rich traditional food soruces to known recipes of staple foods could prevent large-scale deficiency disease.

Food fortification could be done to:

- replace losses that occur during manufacture, storage and handling of food to ensure nutritional equivalence in substitute.
- compensate for naturally occurring variations in nutrient levels.
- provide levels higher than those normally found in a food.
- provide a balanced intake of micronutrients in special cases (dietetic foods).

The FGN/UNICEF (2004) consultation group on food fortification considered various types of methods for forticiation.

i. Food to food
ii. Single nutrient to food
iii. Double or multiple fortification

(Nnanyelugo, 1999)

The mushroom is the visible fruiting body of a *fungus* which emerges from underground mycelium during certain seasons of the year. The mycelium usually hides under bark, ground, rotten wood and leaves. The mushrooms belong to the class *basidiomycetes* and subclass *Homobasidiomycetidoe*. Mushroom can be gathered in wild form or cultivated. The essential difference between the wild and cultivated mushroom is that the former bears their spores in groups of fours, while the latter usually bears their spores in twos (Atkins, 1996). Mushrroms are saprophytes and live on dead matters.

Edible mushrooms have high protein content and are excellent sources of fiber, B-complex vitamins, including riboflavin (B_2) biotin, folate, vitamin B_{12}, pro-vitamin D, vitamins E and K and a small amount of vitamin C (Qutila, 1999). Dubost (2005) also enumerated some minerals contained in the mushroom such as selenium, copper, potassium, phosphorus, zinc, manganese, iron, magnesium and calcium, all in variable amounts.

Today foods of fungal origin are consumed all over the world in vast quantities and commercial production is part of a rapidly growing industry. Fungi have excellent value nutritionally and are of great importance to vegetarians. Fungus has been influencing human affairs for thousands of years, whether as a direct food soruces, as a medicine or in a food process (Carlile & Watkinson, 1994). Mushroom being one of fungi origin with valuable micronutrients, need to be incorporated into our diet to help reduce the problem of micronutrient malnutrition (hidden hunger) and non communicable diseases.

Research suggest that mushroom may aid in the treatment of certain types of cancer, boost immune system and reduce the risk of coronary heart disease (CHD) like vegetables, muchrooms are a cholesterol free food. This is promising, as cholesterol is regarded as a risk factor of coronary heart disease and related conditions (Carlile & Watkinson, 1994). A study carried out by Fukushima (2000) reported that mushroom in *Basidiomycotina* had the ability to lower serum cholersterol concentration. Cheung (1998) also described mushroom as an ideal food for the prevention of artherosclerosis due to their high fiber content. This study concluded that inclusion of edible mushroom into the diet has a hypocholesteroldemic effect perhaps due to dietary fiber such as B-glucans which may increase intestinal mortality, reducing bile acid and cholesterol absorption. Unfortunately the use of mushroom as food has not been fully exploited.

The purpose of this study is to determine nutrient poterntials of traditional wild and cultivated edible mushrooms and their possible use in fortifying snacks for pre-school and school children.

1.1 Statement of the Problem

Micronutrient malnutrition or hidden hunger coupled with protein energy malnutrition (PEM) have remained a serious public health problem in many developing countries, including Nigeria (WHO, 1998). Micronutrient malnutrition occurs in the face of adequate energy and protein intake. Deficiencies in vitamin A, iron and iodine cause innumerable maternal and childhood deaths and leave millions of survivors blind or mentally retarded. Even less severe deficiencies impair intelligence and strength reducing working capacity, productivity and impending economic development (Laurian, Carl & Robert, 2007). Millions of people worldwide suffer from hunger and malnutrition. A major factor contributing to this international problem is food insecurity. In Nigeria two thirds of the population live below poverty line and household food security, quality of care, health services as well as environmental sanitation are inadequate. Numerous studies based on analysis of anthropometric data from chidlren in various parts of nigeria have shown high prevalence of household food insecurity and manultrition. The Nigerian Demographic and Health Survey (NDHS, 2008) revealed that 38% of chidlren under give years of age are stunted, an indication of chronic household food insecurity. This survey also found out that the proportion of underweight chidlren to be 29% which is attributable to transitory food insecurity. This is as a result of lack of knowledge of the nutritional adequacy of various traditional food resources (Agari, 1992). One of such food is the mushroom which is among the most neglected and underutilized foods in the Nigerian food system. The potential resources are good but, organizations, control and usage of these resources have been poor (Onyezili, 2005). Examples of such neglected plant foods include edible mushrooms. Consumption of mushroom has been negatively affected by misconceptions, superstitious belief, culture, religion, ignorance of their nutritional value and personal food preferences as well as deforestation, and flood (Agari, 1992). There is dearth of information on wild and cultivated edible mushroom in Nigeria. It has also been observed that mushroom have not been fully exploited in the alleviation of micronutrient malnutrition, hence this study. Nutrition transition which is marked by a shift from relatively monotonous diet based on indigenous staples towards more varied diet, is taking place vary much faster. It involves a shift towards preprocessed foods; more of animal origin, processed drinks and foods (Reddy & Yusuf, 1998). Traditional food sources are abandoned for more “modern” foods, when it is desirable to use the traditional foods to improve the more “modern” foods. Examples of such neglected plant foods include edible mushrooms. Consumption of mushroom has been negatively affected by misconceptions, superstitious belief, culture, religion, ignorance of their nutritional value and personal food preferences as well as deforestation, and flood (Agari, 1992). There is dearth of information on wild and cultivated edible mushroom in Nigeria. It has also been observed that mushroom have not been fully exploited in the alleviation of micronutrient malnutrition, hence this study.

1.2 General Objective

The general objective of this study was to identify and determine the nutrient potential of wild and cultivated edible mushrooms and evaluate their possible use as food fortificants.

1.3 Specific Objectives

The specific objectives were to:

i. harvest and identify wild edible mushrooms;
ii. determine the nutrient composition of the edible mushrooms;
iii. identify the photochemicals in the mushroom that would be used as food fortificant;
iv. incorporate mushroom flour into snacks in order to enrich their nutrient profile;
v. determine their nutrient composition as well as the organoloptic qualities of these enriched/fortified products; and
vi. determine their ability to met RNI of specific nutrients for pre-school and school children.

1.4 Significance of the study

Good nutrition is necessary to achieve a healthy active life, optimum educational performance and enhanced productivity. In order to achieve the Millennium Development Goals, it becomes necessary that our common staple and preprocessed foods be fortified with readily available cheap traditional foods that have been identified as good sources of essential micronutrients. Mushroom being one of such foods is cheap and affordable especially to consumers who dwell in the rural areas. The result of this study will provide the much needed information for different wild and cultivated edible mushrooms thereby enhancing the consumption of this valuable food and increased consumption will lead to increased cultivation/production and reduction in micronutrient malnutrition which is wide spread in Nigeria as well as other developing countries of the world. The result of this study will also be relevant to researchers who intend to conduct further research on mushroom. Dieticians, nutritionist and health educators will benefit from this study because this would provide information on the nutrient composition of edible mushrooms and the knowedge will help them to councel their clients appropriately.

CHAPTER TWO
LITERATURE REVIEW

2.1 Nutritional Problems in Nigeria

2.1.1 Protein-Energy Malnutrition(PEM)

Protein-Energy malnutrition is a condition resulting from regularly consuming insufficient amounts of energy and protein. The deficiency eventually results in body wasting, primarily of lean tissue, and an increased susceptibility to infections. In developing areas of the world, people often have diets low in energy and also in protein. This state of undernutrition stunts the growth of children and makes them more susceptible to disease throughout life (Torun & Chew, 1999). People who consume too little protein and food energy can go on to develop protein energy malnutrition (PEM), also referred to as Protein-Calorie Malnutrition (PCM). In its milder form, it is difficult to tell if the person with PEM is consuming too little energy or protein, or both, but if the nutrient deficiency especially for energy is quite severe, a deficiency disease called marasmus can results. Victims have little or no fat stores, little muscle mass, and poor strength. Death from infection is common. When an inadequate intake of nutrients, including protein, is combined with already existing disease, a form of malnutrition called kwashiorkor can develop. The children generally suffer from infections and exhibits edema, poor growth, weakness and an increased susceptibility to further illness (Torun & Chew, 1999).

Protein energy malnutrition can affect all age groups, but is more frequent among infants and young children. This is because ongoing growth increases nutritional requirements. In addition, persons in this age group often cannot obtain food by their own means. Infants who are weaned prematurely from the breast or who breastfeed for prolonged time without adequate complementary feeding become malnourished from a lack of adequate energy and protein intake. Older children usually have milder forms of protein energy malnutrition because they can cope better with social and food availability limitations (Torun & Chew, 1999). These two conditions form the tip of the iceberg with respect to states of undernutrition, and symptoms of these two conditions even can be present in the same person. There are still more than 150 million underweight pre-school children worldwide, and more than 200 million are stunted. This underweight and stunted is the tip of iceberg. Suboptimal growth may affect many more. Stunting is linked to mental impairment. At current rates of improvement about 1 billion children will be growing up by 2020 with impaired mental development (ACC/SCN, 2000).

2.1.2 Micronutrient Deficiency

Micronutrient malnutrition is the world's most prevalent and most devastating nutritional problem. More than two billion people worldwide are prevented from achieving their full potential because of micronutrient malnutrition (Laurian, Carl & Robert, 2007). Deficiencies in vitamin A, iron and iodine cause innumerable maternal and childhood deaths and leave millions of survivors blinded or mentally retarded. Even less severe deficiencies impair intelligence and strength reducing working capacity, productivity and impending economic development (Laurian *et al*., 2007).

The proportion of the population suffering from micronutrient deficiency and the resultant disease is at critical level. Low level of vitamin A have been associated with increase transmission of HIV from the mother to infant and with increase from HIV to AIDS and increase mortality from AIDS among infants (Laurian *et al*., 2007). Evidence is also emerging that deficiencies of the vitamins of B group, vitamin C, vitamin E, and selenium are also wide spread and needs to be addressed (Nutriview, 1997). Mild maternal zinc deficiency has been related to complications of labour and delivery, including placental abruptio and prolonged labour, premature rupture of membrane and the need for assisted or operative delivery. Also low calcium intake have been associated with hypertensive disorders and pre-eclampsia (WHO, 1998).

According to Bruce (2003) micronutrient deficiencies result in damage to DNA. He also pointed out that mitochondrial decay is accelerated by deficiencies in micronutrients such as iron and zinc. Bruce (2003) in his study also suggested that deficiencies for several vitamins, such as biotin, pantothenic acid and perhaps pyridoxine and riboflavin also contribute to mitochondrial decay and acceleration of aging. He also contended that there is the possibility of obesity resulting from shortage in consumption of fibre and micronutrient which inhibits satiety leading to a continuing cycle of overeating, and that an optimum intake of micronutrients could tune up metabolism and give a marked increase in health, particularly for the poor, elderly and obese at a little cost. The wide spread recognition of the importance of micronutrient deficiencies to global health and the potential to address such deficiencies relatively cheaply through fortification has led to several multilateral effort to support traditional interventions (Laurian *et al*., 2007).

2.1.3 Diet-related non-communicable diseases

Diet related chronic disease is a public health problem through out the world. Despite concerted effort to reduce poverty, improve nutrition, education and secure access to health foods, more than two billion people are sick or disabled and millions die prematurely each year as a result of chronic diet-related disease. The emerging global epidemic of non-communicable or chronic diet-related disease is no longer a problem restricted to affluent and industrialized countries. It is increasingly affecting low income countries and contributing to their existing burdens of under nutrition. Thus in low income societies, disease caused by caloric inadequacy and deficiency continue to persist, but now co-exist with the growing presence of diet-related chronic disease among adults; this is the double burden of malnutrition. Many of those chronic diet-related diseases are the result of changes in food system and life style that characterize the nutrition transition that accompanies economic development, increase mechanization, the urbanization of societies and the commercialization and now globalization of food systems. Diet-related chronic diseases take an enormous toll in lives (33 million premature deaths worldwide) and account for about 59% of premature deaths due to heart disease, stroke, cancer, diabetes and obesity, Diet-related chronic diseases account for at least 40% of all deaths in low income countries and represent an even greater proportion of loss of disability adjusted life years (DALYa); they constitute an immense and growing global health problem imposing additional economic and health burden on low income countries. People worldwide have a right to good quality, safe food based on sustainable food systems and renewable food resources, especially those derived from local and indigenous food species and harvest (ACC/SCN, 2000). Hence the aim of this study is to identify and determine the nutrient potential of wild and cultivated edible mushrooms and their possible use and in fortifying snacks for pre-school and school children

The changes also profoundly affect local systems production. Fewer farmers engage in subsistence agriculture in the classic sense. Most are increasingly oriented to markets for both income and food purchase (International Food Policy Research Institute, 2002). Market factors alter traditional cropping patterns in general, this results in erosion of the agricultural biodiversity represented by traditional crops and varieties, (Cannon, 2002). Commercial monocropping can offer economic benefits to rural populations and reduce food costs to consumers, but it has mixed impact on nutritional status, in part because of reduction in traditional dietary diversity (Dijkstra, 1997).

Changes in land use, including deforestations and appropriation of natural areas, diminish opportunities for gathering and hunting the essential wild components of many traditional food systems. Contamination from industrial and agricultural activities further undermines traditional and indigenous food systems and health. Sustainable development thus requires coupling investment in rural enterprise and infrastructure with sound resource management (Johns & Eyzaguirre, 2001).

2.2 Causes of Nutritional Probems

2.2.1 The Nutrition Transition

There are many reasons why the intake of micronutrients in the diet is inadequate. Food selection may be influenced by culture, religion, personal habit or preferences, convenience, medical disorders, appetite, ignorance or cost, extreme climatic conditions (e.g. droughts, flooding) can drastically limit the local production of nutrient rich foods. Armed conflicts and civil disturbances can also be a cause. Kuhnlein (2003) also reported that indigenous people were well aware of their food scarcity risk that they expressed their difficulties and frustrations in protecting their environment and livelihood. Kuhnlein (2003) further contended that developed and scientific communities do not usually understand the food resources that indigenous people know and use. Scientific and laboratory data for nutrient and other phytochemicals for a food system may be unknown for many species. This means that there is an urgent need to identify, determine and promote local food that are very rich sources of micronutrient to help curb the widespread of micronutrient malnutrition worldwide.

The rapid shift in nutrition transition is marked by a deviation from relatively traditional diets based on indigenous staples grains or starchy roots, locally grown legumes, other vegetables and fruits, and limited foods of animal origin, towards more varied diets that include more preprocessed foods, more foods of animals origin, more suggar and fat, especially in processed drinks and foods and often more alcohol (Kim, Moon & Popkins, 2000) the most immediate result of the combination of such relatively-dense diets with physically in-active lives, is a rapid icnrease in over weight and obesity.

There is rapid change in the traditional food system; lifestyles are also being influenced. In the transition to lifestyles which are more characteristic of Western industrial societies, countries that retain a strong traditional food system in which diet has recognized health, cultural, and ecological roles best avoid the often concomitant increase in chronic non communicable diseases (Stepp, Wyndham, & Zarger, 2000). Strong social marketing emphasizes the higher quality of traditional dishes based on interpretation that "a person should eat food produced in the land where he or she was born" (Wahlqvist & Wattanapepaiboon, 2002). Traditional systems often see food, medicine, and health as interrelated (Johns & Eyznguirre, 2001). Food have strong symbolic and religious value and is highly associated with cultural identity and social well being (Johns & Eyznguirre, 2001). The foods of indigenous peoples form part of rich knowledge system (Stepp *et al.,* 2000). They typically draw on indigenous resources and are associated with the land and environments from which they are obtained (Stepp *et al.,* 2000).

The fact that traditional food systems provide the inspiration for seminal insight into the relationship of diet and health underlines the theoretical value of their investigation (Wahlqvist & Wattanapepaiboon, 2002). For societies in transition, diets characterized by indigenous cereals, legumes, fruits and vegetables provide lower energy content and higher fibre than the highly processed foods and presumably reduce the risk of disease (Wahlqvist & Wattanapepaiboon, 2002).

Forces of globalization, commercialization, population increase, and urbanization change patterns of production and consumption and profoundly affect human diets (WHO, 2007). High-input, high-yield agriculture and long distance transport increase the availability and affordability of refined carbohydrates (wheat, rice, and sugar) and edible oils (Popkin, 2002). While making greater number of people secure in terms of energy, they also under pin the so-called nutrition transition and can undermine the self sufficiency and economic viability of local producers (Cannon, 2002). Edible oils, imported rice, and wheat also replace traditional cereals as the main energy sources in African countries (Kuhnlein, 2003). In addition, globalization of culture and commercial activities, promulgate a westernization of developing country food system and diets (Cannon, 2002). Bourne, Lambert, and Steyn (2002) reported that in South Africa, increased westernization of diets is occurring even in rural areas.

The food supplies and the diet of developing countries are in a state of rapid transition. This nutrition transition is accompanied by equally rapid changes in levels of physical activities and in the composition of humans (Barry, Horton, & Soowon, 2001). A demographic transition from rural societies with low life expectancy at birth and families with many children to urban societies with higher life expectancy at birth and fewer children has been well documented (Bangauris, & Watkins, 1996). According to Barry *et al*., (2001) there is a shift from endemic deficiency and infections disease mostly of early life to epidemic chronic disease, generally of later life. When population undergo massive, social and technological changes that includes increasing urbanization, their food supply and their diets change, consequently disease pattern also change.

Current evidence suggests that some diet related diseases become epidemic at a speed that is a function of the velocity of the demographic and nutritional transition and they emerge as epidemics in a predictable sequence. Increased urbanization and technological change lead to a shift from physically active to sedentary occupations, increase use of more labour saving devices at work and home and changes in income profits affects purchasing power towards processed foods (Lucas, Fewtre & Cole, 1999). The nutrition transition is marked by a shift from indigenous staple grains or starchy roots, locally grown legumes, vegetables and fruits, limited foods of animal origin, toward more varied diets that include more processed food, more foods of animal origin, more sugar and fat.

The consumption of this processed foods result to fetal and infant insults and related effects (Hoffman *et al*., 2000). McDade, Beck, Kuzawa, and Adair (2001) pointed out that these insult may also compromise immune function. According to Hoffman *et al*. (2000) a growing set of studies suggest that fetal and infant nutrition insults affects predisposition to cardiovascular disease, obesity, hypertension and adult-onset diabetes. Barry *et al*. (2001) reported that rapid urbanization results in the co-existence of micronutrient malnutrition and obesity within many households. High intake of processed food in urban diet greatly increases consumption of salt, a factor that is linked to hypertension.

Despite international commitment, the number of food insecure individuals remains unacceptably high (Bandeis Univeristy, 2000). There has been continued rapid growth in the world population and the number of individual below the poverty line has continued to swell. In 1999, the world population reached six billion. The United Nations estimated that the world population will exceed 8 billion people who live on less than one dollar a day, which is the internationally recognized standard for measuring poverty. There is a lack of sustainable physical and economic access to enough, safe, nutritious and socially acceptable food for a healthy and productive life all over the world. Dietary needs and food preferences for an active and health life cannot be met world wide (Aliyu, 2005).

Lack of access to the means of supporting rural developmental is among the causative factors (FGN/WHO, 2004). Indeed, Nigeria exemplifies the paradox of a country which although boasts of one of the best resources endowments in Africa, recorded less progress in reducing under-five mortality than any country in sub-Sahara Africa since its independence in 1960 (UNICEF, 2000). Numerous studies based on analysis of anthropometric data from children in various parts of Nigeria have shown a high prevalence of household food insecurity and malnutrition. The Nigerian Demographic and Health Survey (NDHS, 2003) revealed that 38% of children under five years of age are stunted, an indication of chronic household food insecurity. This survey also found out that the proportion of underweight children to be 29% which is attributable to transitory food insecurity. There is food insecurity both at national and household levels in Nigeria because of lack of knwoeldge of nutritional adequacy of various traditional food soruces (Agari, 1992).

Accelerating epidemiological transition and concurrent shifts in diet, activities and body composition are universal trends, especially in middle and lower-income countries. The rapid shift in nutrition transition is marked by a deviation from relatively traditional diets based on indigenous staples grains or starchy roots, locally grown legumes, other vegetables and fruits, and limited foods of animal origin, towards more varied diets that include more preprocessed foods, more foods of animal origin, more sugar and fat, espcially in processed drinks and foods and often more alcohol (Kim, Moon, & Popkins, 2000). The most immediate result of the combination of such relatively-dense diets with physically in-active lives, is a rapid increase in over weight and obesity.

There is consequent epidemiological transition from a predominant of endemic deficiency and infectious disease often caused or exacerbated by poor nutrition to epidemic of chronic diet related diseases such as tooth decay, gastrointestinal disorders, obesity, adult onset diabetes, hypertensions, peripheral vascular diseases and stroke, hyperlipidemia, angina and ischemic heart diseases (HID) and certain cancers (Kim, *et al*., 2000).

2.2.2 Effect of HIV/AID on Nutrition

HIV/AID and Nutrition

In Africa, where more than 2.5 million people are living with HIV/AIDS, malnutrition and food insecurity are endemic. Today, nearly 40% of African children (5 years old) are stunted due to chronic nutritional deprivation (WHO, 2000).

AID has compromised or disrupted normal activity at a household, community and national level especially in Sub-Sahara Africa, because it takes it toll on the productive sector of the society. For production and food security of the family have been affected. The head of the household is often too debilitated and ill to continue to work and many communities are now struggling to cope with the smaller number of adult worker. The intellectual capital of many societies is also being badly eroded (Piwoz, 2000).

HIV infection increases energy requirements: HIV infection affects nutrition through increases in resting energy expenditure, reduction in food intake, nutrient mal-absorption and loss, and complex metabolic alterations that culminate in weight loss and wasting common in AIDS (Macalllan, 1999). The effect of HIV on nutrition begins early in the course of the disease, even before an individual may be aware that he or she is infected with the virus (Semba & Tung, 1999; Bogden, Kamp & Han, 2000). Asymptomatic HIV – positive individuals require 10% more energy, and symptomatic HIV positive individuals require 20% - 30% more energy than HIV – negative individuals of the same age, sex and physical activity level (WHO, 2003).

Metabolic complications of antiretroviral therapy: Active antiretroviral (ARV) improves nutritional status, independent of it's effects on viral suppression and immune status, although wasting still develop in some patients ARV side effects such as nausea and vomiting may affect adherence to therapy particularly in the first months of treatment (Chen, Westfall & Mugavera, 2003). Additional metabolic complications such as derangements in glucose and lipid metabolism, and lactic academia have been associated with the use of certain ARV drugs (Shevitz and Knox, 2001).

HIV exposure and infection exacerbates problems of child malnutrition: Children living with HIV or born into families affected by HIV are high risk group wit special needs. HIV positive women have higher incidence of preterm and low birth weight deliveries, and, as a result, HIV-exposed infants may start life with impaired nutrition (Coley, Msamanga, Smith & Fawzi, 2001). HIV-positive infants experience slower growth and are at greater risk of severe malnutrition (Kayila & Moura Machado, 2001).

Studies show that severe, malnutrition in HIV – positive children can be reversed with hospital and home-based-therapeutic feeding, though the time or recovery is longer than with uninfected children (Sadige, Ndejha & Ndekha, 2004).

HIV/AIDS and breast feeding: The risk of HIV transmission through breastfeeding is directly related to the health viral load, and immune status of their mothers. Infection occurs at an average rate of about 8.9 HIV transmissions per 100 child-years of breastfeeding (WHO, 2001) HIV-positive mothers are recommended to avoid breastfeeding if replacement feeding is feasible, affordable, and safe (WHO, 2001). In many resource – limited setting this cannot be assured, and many HIV-positive women initiate breastfeeding (Omari, Luo & Kankasa, 2003). For these women, exclusive breastfeeding and early cessation are recommended (WHO, 2001). Infants who are not breastfed of who stop breastfeeding early and do not have access to safe and nutritious replacement foods are at increased risk of malnutrition, diarrhea and other illnesses, and death (WHO, 2000).

HIV/AIDS and food security: Food security is the state in which all people have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life at all times (Bonnard, 2002). For insecurity and poverty may lead to high-risk sexual behaviours and migrating, increasing the risk of acquiring HIV infection (Loevinsohn & Gillespie, 2003) HIV/AIDS, in turn, significantly undermines a household ability to provide for basic needs. Livelihoods are diminished when HIV – infected adults cannot work and food production and/or earnings decrease. Healthy family members particularly women are often forced to stop work to care for sick family members particularly women are often forced to stop work to care for sick family members, further reducing income for food and other basic needs. Household labour constraints can cause reduction in cultivated area, shifts to less labour or each – intensive crops, and depletion of life stock (UNAIDS,1999).

Food insecure households frequently struggle to meet ordinary household needs without the added stress of HIV. Their capacity to absorb the costs associated with HIV – related illnesses, to provide enhanced nutritional support, and to participate in community program is severely restricted, and many find themselves in rapid down economic spiral. The spiral is made worse when disabled parents are unable to pass on practical crop and live stock knowledge and when children are withdrawn from school because of difficulty in paying school fees (Amdt & Wobst, 2002).

HIV/AIDS impacts entire community with rippling effect particularly in areas that are highly dependent on labour. For example, in rural Kenya, when HIV affects a relatively wealthy household and spending on health care increases, money to hire labourers declines. Poorer households become increasingly more vulnerable, for insecure, less able to send their children to school and less able to meet their children to school and to meet the own health needs. They can no longer find work because the wealth family cannot afford to hire them. Entire communities are weakened by HIV, not just individuals and traditional community safety nets are being stretched to their limit in highly affected areas (Ruth & Edith, 2000).

The socially constructed gender roles of men and women interact with biological roles to affect the nutrition status of the entire family and each gender. Because of the women cyclical loss of iron and their childbearing, their nutrition status is particularly vulnerable to deficiencies in diet, care, and health or sanitation services. Moreover, the nutrition status of newborn and infants is intimately linked with the nutrition status of the mother before, during and after pregnancy (Ruth & Edith, 2000).

Women typically have limited access to land, education, information, credit, technology, and decision making forums. They have the primary responsibility for child rearing and rely on developed social networks that act as an informal safety net for family in times of crisis. When involved in formal employment, the typical command lower remuneration rates than their male colleagues, even when they hold the same skills. Because of their triple burden of productive, reproductive, and social roles women tend to have less time to attend to their own needs, leisure related or otherwise. Poor female nutrition early in the life reduces learning potential, increases reproductive and material health risks, and lower productivity. This situation contributes women’s diminishing ability to gain access to other assets later in life and undermines attempts to eliminate gender inequalities. In essence women with poor nutrition are caught in a vicious circle of poverty and under nutrition (ACC/SCN, 1999).

Inequalities in access to and control of assets have severe consequences for women’s ability to provide food, care, and health and sanitation services to themselves, their husbands and their children, especially their female children. Women with less influence or power within the household and community will be unable to guarantee fair for distribution within the household. Any reduction in gender asymmetries benefits the entire family. Substantial evidence demonstrates that more equal access to and control over assets raises agricultural output, increases investment in children education, improves visits to health facilities for infants, raises household for security, and accelerates child growth and development (Ruth & Edith, 2002).

Improved women's status via improved nutrition status in childhood and during adolescence will enable women to stem the spread of HIV/AIDS has huge implications for the performance of the female labour pool (World Bank, 2001). Improvement in the nutrition status of adolescent females, and women make it more likely that the cultural constraints facing women will be reduced. They will become likely to stay in school and to learn more. They will become more empowered to make decisions in all spheres of activity including parenting (Ruth & Edith, 2002).

Gender inequality in access to and control of resources is not only unfair to women and children but also constitutes bad economics. It results in the misallocation of scarce resources, increased health care costs, lowered productivity and poor human development trends. Investment in the nutrition of women is an important short-term barometer in assessing expected returns to improving household nutrition and overall human development capability for a country. Improvements in nutrition status of female infants and children will translate into the improved human capital of the adolescence, the empowerment of their adulthood, and the development of their communities (World Bank, 2001).

2.2.3 Environmental Chnages

Rapid environmental changes are profoundly altering the relationship between humans and the ecosystem in which they live. These changes include overpopulation, loss of biological resources, ecosystem destruction associated with industrial and commercial development, climatic change, urbanization, modern agriculture employing pesticides and other inputs, and erosion of food crop diversity from years of genetic engineering focused on a few crop (Johns & Eyzoguire, 2001).

Such disruption in environment integrity can affect patterns of human health, disease, and nutritional status. Environmental degradation can lead to major nutrition-related health problems such as malnutrition, infectious disease, and contamination. When people have reduced access to and intake of crucial bioresources, they may suffer from protein energy malnutrition and micronutrient deficiencies. Diabetes and coronary heart disease that reflect reduced intake of nutrients and non-nutrients protecting health underscores the cost of increased reliance on processed foods or a narrow species based by industrial societies and urban populations. Major public health problems global importance such as tuberculosis, gastrointestinal diseases measles and respiratory disease all reflect the interaction of nutritional and environmental factors (Kuhnlein & Chan, 2000).

Environmental contamination from industrial and agricultural chemicals such as heavy metals, organchlorines, and radionuclotides may compromise people's nutritional status and health either directly or through changes in diet. Herbicides and pesticides eliminate uncultivated food sources from agro-ecosystems; other chemicals may make them unfit for consumption. Persistent Organic Pollution (POPs) transported in the atmosphere can have adverse effects on traditional food systems. Traditional values of conservation, encompassing relationships to land, spiritual dimensions, and concepts of health are fragile and vulnerable to modern forces of changes (John & Plablo, 2000).

2.3 Nutrition Intervention Programmes for Eradication of Malnutrition

2.3.1 Nutrition Education

Nutrition education provides nutritional services to the client/patients as prescribed by their physician, including nutrition assessment and councelling. It is any combination of nutritional strategies accompanied by environmental support designed to eradicate malnutrition. It provides children and adult of all ages with nutrition education materials on how to improve their nutrition. Nutrition and health education programmes in conjunction with dietary diversification can be organized to promote good nutrition hence reducing malnutrition. This option can be expensive requiring human resources which are not readily available throughout Nigeria. It is a long term programme which may take generations to show measurable effect (Blum, 1995).

The aim of each measure is to ensure adequate intake of nutrients in the long term. These programmes are particularly important during pregnancy, lactation and early childhood. The mothers realize that breast milk is a good source of the nutrient and exclusive breast feed up to six months. Mothers are encouraged to consume the appropriate foods, breast feed as long as possible and give infants and children foods rich in these nutrients (Nnanyelugo, 1999).

2.3.2 Dietary Supplementation

Oral supplementation (*Capsules/liquid distribution to target population*) is an effective means of solving problems of micronutrient deficiency in emergency situations to save lives due to the megadoses of micronutrient given at different age levels

(UNICEF, 1996). The control of micronutrient deficiency through oral supplementation has a short time frame. It is however very costly and has a very low sustainability. In many cases, large qualities of supplements are donated to countries. The governments concerned are responsible for their distribution (Nnanyelugo, 1999).

2.3.3 Dietary Diversification

Dietary diversity appears to be one of the food-based approaches to meeting the nutrient requirement of the teaming population worldwide, especially in the developing countries where nutrition transition is rapidly taking place. Dietary diversification usually includes a number of formal and informal channels to improve the production, distribution and consumption of food rich in the specific nutrients. The approach is long term. It may result in major changes as food production and alteration in dietary habits. However, bioavailability of nutrients is dependant on the type of diet, the method of food preparation, the absorptive capacity of the intestine and interrelationship with other nutrients. A handful of epidemiological studies underline the benefits of a varied diet, in increasing longevity and reducing the rates of chronic degenerative diseases and in improving nutritional quality and child growth in developing countries (Johns & Eyznguirre, 2006). The diversity of indigenous crops and wild plant and animal species available in most tropical countries, in addition to providing essential nutrients, presumably offers broad benefits to health (Ogle, Hung, & Tuyet, 2001). Considering the difficulty in precisely identifying optimal diets, a diverse diet, including legumes, fruits, vegetables and animal – source foods, provides an intrinsic buffer against the uncertainties of change and remains the preferred choice for human health (Third World Nutrition Programs, 2002).

Wild foods which are typically, understudied deserve particular attention both for basic characterization and for ecological agronomic and market research. Developing countries scientists with knowledge of local resources, customs, and cultural values will play a fundamental role in identifying sustainable approaches to diet (Wahlgvist & Wattanapepaiboon, 2002).

2..2.4 Fortification

Food fortification has been shown to be one of the methods of combating malnutrition across the varying socio cultural groups (World Bank, 1994). Fortification is the most accessible intervention method to increase nutrient intakes of a population without changing dietary and cultural habits provided that appropriate food is identified (Nnanyelugo, Ngwu, Asinobi, Uwaegbute, & Okeke, 1992; Sommer, 1993). Food fortification is highly sustainable fairly inexpensive and takes minimal time frame to achieve (Mora, 1995). Most developed countries have used several approaches in food fortification (Sommer, 1993). Fortification of foods with nutrient that have been shown to be insufficient in the daily diets has, to a large extent, been responsible for the elimination of vitamin and mineral deficiencies in developed countries such as Canada, Switzerland, Sweden, Japan, the UK and the U.S.A. (Lofti, Manner, Merx, & Ifeuvel, 1996).

Food fortification is a process of adding one or more nutrients (vitamins, proteins or amino acids, minerals), artificially to food to improve the quality of diets of a group, community or a population. It may be on a large scale controlled by government policy or commercial firms may fortify their products. Other terms such as enrichment, nutrification or restoration have been used interchangeable although each may imply a specific action. In this study mushroom flour is going to be used as the fortificant to fortify wheat flour, corn starch and cocoyam paste. The efficiency of fortification in addressing dietary deficiencies is unquestionable in developed countries and provides some consensus for its appropriate use in developing countries (FAO, 1995).

Interest in traditional industrial fortification of foods in developing countries has increased in recent years as NGOs have enlisted cooperation and support from the private sector. Such effects are timely in light of the growing consumption of processed and packaged foods (Regmi & Gethar, 2005). Consumption of wheat flour products is growing around the world, even where wheat is not a traditional food staple, (for example in Nigeria) opening new fortification opportunities at the milling stage. Political support for traditional fortification has recently been enhanced by three new promotion and coordination effort: Micronutrient initiative (based in Canada), Flour fortification initiative (based in Emorg University) and the Global Alliance for Improved Nutrition (GAIN, based in Geneva). Other important global actors include the Network for Sustained Elimination of Iodine Deficiency and the International zinc Nutrition Consultative Group. In addition efforts are underway to set regional standards for fortification. These were successfully concluded in Central America in the late 1990s (Bishai and Nilubola, 2002) and are currently underway for Southeast Asia under the leadership of the International Life Science Institute (ILSI)

In 2005, in Beijing, GAIN, together with the World Bank Institute (WBI), brought together 150 business leaders from all the global food supply chain to form a Business Alliance for Food Fortification, (BAFF), This forum produced a "Beijing Declaration on Food Fortification, "which expressed confidence in fortification as a proven means to reduce vitamin and mineral deficiencies and to improve nutrition levels among poor population. Coca-cola, Danone, and Unilever agreed to become the first co-chairs of BAFF, which requires annual reporting from member companies on progress towards increasing vitamin and mineral coverage of poor populations. (Laurian *et al.*, 2007)

The Flour Fortification Initiative provided an assessment of global progress through September 2007 and they report that 26% of the global wheat market is fortified, benefiting 1.8 billion people. Most wheat fortification efforts in the developing world are still preliminary or on a pilot with little sustained activity in Asia and Africa, where most of the micronutrient deficient population live. Shakar, Heaver and Lee (2006) report that consumption of iodized salt is not wide spread in either South Asia or Sub-Sahara Africa, even though this type of fortification is cheaper and easier to achieve. This, in spite of greater attention to fortification, its coverage remains low in the regions where micronutrient deficiencies are most important.

Food fortification programes in developing countries continue to face significant structural hurdles (Bishai & Nilubola, 2002). These include the low concentrated structure of the food industry, making private cooperation more difficult to achieve; hence price and market controls of many food staples are reduced, and the level of consumer awareness for effective demand of nutrients, which is necessary in the long run to sustain industrial motivation. These programs are still limited to reach the very poor, particularly those consuming rice or maize-based diets. Certain kinds of fortification may be impractical for some important food staples e.g. vitamin A (VA) fortification of milled rice, or may introduce off-colour or flavors (e.g. VA fortifications of white maize).

While industrial fortification efforts are becoming more wide spread in developing countries, such efforts are limited by the costs and by the imperfect coverage of the target population, particularly the poor and young children. Where mandatory, fortification cost is borne by food processors, such as flour millers, they may resist this imposition. Such mandates also may be impossible to enforce where food processing is carried out by many small and widely dispersed firms. Industrial fortification will only apply to marketed supplies and therefore may not reach those among the poor who obtain food outside of commercialized channels. Given this limitations it is clear that industrial fortification of food cannot provide a complete solution to the problem of micronutrient deficiencies in the medium term (Laurian *et.al*, 2007). Hence small scale fortification could be done even in homes using locally available good food sources of micronutrients as fortificants to enrich the processed foods which are about replacing our traditional food staples.

Examples of forms of fortification

(a) **Restoration**

- (i) Flour enrichment wih thiamin.
- (ii) Rice enrichment with vitamin C.
- (iii) Vitamins A and D to milk.
- (iv) Vitamins to breakfast cereals.
- (v) Ascorbic acid in fruit juices.

(b) **Enrichment of diet as a whole**

- (i) Addition of iodine to salt
- (ii) Vitamin D in evaporated or powdered milk
- (iii) Addition of calcium to flour.
- (iv) Addition of vitamin B_1 B_2, in US flour to higher levels than was originally present.

(c) **Use of substitute foods**

- (i) Margarine (substitute for butter) made from fats completely devoid of vitamin A and D is nutrified with the vitamins (3000IU vitamin A, 300 IU vitamin D).

(d) **Enrichment with amino acids**

- (i) Addition of lysine, which is the limiting amino acid in cereals (Nnanyelugo, 1999).

Choice of food vehicles and fortificants

Several food vehicles for various fortificants are available and their choice may differ from country to country as they are dependant on existing dietary practices. Salt, sugar, monosodium glutamate (MSG) and bouillon cubes, wheatflour, tea, milk, infant products, water, wheat products, vegetable oils, margarines, snacks and beverages, are some food vehicles used in various countries. Some of these have been used successfully in developing countries to reduce or eliminate malnutrition in these areas (Nelson, 1994; Lotfi, Manner, Merx & Huevel, 1996), some fortificants are proteins, amino acid, beta-carotene vitamins A D, E, thiamin (B_1) riboflavin (B_2) pyridoxine (B_6) vitamin C folic acid and vitamin B_{12}. Others are iron, calcium and iodine.

In making the selection the following characteristics of the food item should be considered.

- The food must be widely consumed by the population
- The consumption per capita will vary little from person to person and from day to day.
- The enrichment will not result in change in organoleptic properties.
- The cost and nature of food should make the process of fortification economically feasible on an industrial scale (Nnanyelugo, 1999).

2.4 Nutrition of Pre-school Children

2.4.1 Growth and development in pre-school and school children

The period that begins after infancy and lasts until puberty is often referred to as latent period of growth. Although physical growth may be less remarkable and proceed at a steadier pace than it did during the first year, those pre-school and school years are a time of significant growth in the social cognitive and emotional areas. Growth is generally steady and slow during the pre-school and school age years, but it can be erratic in individual children, with periods of no growth followed by growth spurts. These patterns usually parallel similar changes in appetite and food intake. For parents, periods of slow growth and poor appetite can cause anxiety, leading to mealtime struggles. The body proportion of young children change significantly after first year. Head growth is minimal, trunk growth slows substantially, and limbs lengthen considerably, all of which create more mature body proportions. Because of walking and increased physical activity, the legs strengthen, and the abdominal and back muscles strengthen to support the now erect children. These changes are gradual and subtle, occurring over the years (American Academic of Pediatrics, 2001).

The body composition of pre-school and school children remains relatively constant. Fat gradually decreases during the early childhood years, reaching a minimum between 4 and 6 years of age. Children then experience the adiposity rebound, or increase in body weight in preparation for the pubertal growth Spurt. Sex difference in body composition become increasingly apparent. Boys have more lean body mass per centimeter of height than girls. Females have a higher percentage of fat than males, even in preschool years, but these differences in lea body mass and fat do not become significant until adolescence (Whitake, 1998).

2.4.2 Nutritional problems in preschool and school children

Iron Deficiency Anaemia

Iron deficiency is one of the most common nutrient disorders of childhood, affecting approximately 9% of toddlers (Looker, 1997). Iron deficiency is less of a problem among older preschool and school children. Low income populations have incidence of iron deficiency, even in older children (Looker, 1997). Possible factors associated with iron deficiency, with or without anaemia includes parents educational level and access to medical care as well as dietary intake. In addition to growth and the increased physiological need for iron, dietary factors also play a role. For example, a 1-year-old child who continues to consume a large quantity of milk and exclude other foods may develop **milk anaemia.** Many young preschool children do not like meat, so most of their iron is consumed in the non-heme form which is absorbed less effectively. Infants with iron deficiency, with or without anaemia, tend to score lower on standardized tests of mental development and pay less attention to relevant information needed for problem-solving. Consuming good dietary sources of iron can help prevent iron deficiency anaemia. To enhance absorbability of non-heme iron sources, parents should be taught to increase the amount of ascorbic acid and meat, fish and poultry in their children diets (Halterman, 2001).

Dental Caries

Nutrition and eating habits are important factors affecting dental health. A optimal nutrient intake is needed to produce strong teeth and healthy gums. The composition of the diet and an individuals' eating habits (eg. Dietary carbohydrate intake, retentiveness of foods, eating frequency) are significant factors in the development of dental caries. Infant and young children who drink sweetened liquids from a bottle at bedtime or frequently are susceptible to early childhood caries and because children consume snack regularly those snacks that are least cryogenic (.e least likely to cause caries) should be encouraged. When protein foods such as cheese, nuts, and meat are eaten with more fermentable, sticky foods, they prevent the decrease in the plaque pH that usually accompanies ingestion of these foods and may help protect the teeth against caries (Powell, 1998).

Constipation

Young children who do not take enough of diets that include fruits and vegetables often develop constipation. Dietary intervention often include eating more dietary fibre and drinking more fluids, foods to emphasize for fibre are fruits, vegetables, whole grain breads, cereals and beans. The current daily fibre goal for children varies by age: 1-3 years 19g/day; 4-8 years, 25g/day; 9-13years, 31g/day for boys and 25g/day for girls. Accompanying fluid recommendation are 5 cups per day for toddlers ad about 8 cups per day for older children.

Allergies

Food allergies usually develop during infancy and childhood and one more likely when a child has a family history of allergies. Allergic responses most often include respiratory or gastro intestinal symptoms and skin reactions, but they may be more vague like fatigue lethargy, and behavioural changes (American Academy of Pediatrics, 2001).

2.4.3 Factors affecting food intake in preschool and school children

Numerous influences, some obvious and others subtle, determine the food intake and habits of children. Habits, like and dislike are established in the early years and are carried through to adulthood, when change is often met with resistance. The major influences on food intakes in the developing years include family environment, societal trend, the media, peer pressure and illness or diseases (Casey, 2001). .

Family Environment

For toddlers and preschool children, the family is the primary influence in the development of food habits. In young children's immediate environment, parents and older siblings are significant models. For attitude of parents can be strong predictors of food likes and dislikes and diet complexity in children of primary school age. Similarities between children's and their parent's food preferences are likely to reflect, genetic and environmental influences. In a recent report, school age children and adolescents who ate more dinners with their families consumed more fruits and vegetables, less fried food, and less soda, than those who rarely ate dinner with their families (Gilman, 2000).

Societal Trend

The increasing number of women with school age children employed outside the home has lead to children eating one or more meals at child care homes, day care centres or schools. Time constraints has also resulted to modification in food shopping and meal preparation to include more convenience or fast food (Murphy, 1998).

Media Messages

School-age children watch the television an average of 23 hours or more per week, whereas preschool children average about 27hours per week. One half of all commercials in children's programs advertise food primarily low in fibre and high in sugar, fat or sodium. Preschool children are generally unable to distinguish commercial messages from regular program, infact, they often pay more attention to the commercials, so they remember and request the advertised items (Borzekowski & Robinson, 2001).

Peer Influence

As children grow, their world expands and their social contacts become more important. Peer influence increases with age and affects food attitudes and choices. This may result in a sudden refusal of a food or request for a currently popular food. Decisions about weather to participate in school meals may be made more on the basis of friends' choices than on the menu. Such behaviours are developmentally typical, positive behavior, such as a willingness to try new foods can be reinforced. Parents need to set limits for undesirable influences but also need to be realistic, struggles over food are self-defeating.

Illness or Disease

Children who are ill usually have a decreased appetite and limited food intake. Acute viral or bacterial illnesses are often short-lived but may require an increase in fluids, protein or other nutrients. Chronic conditions such as asthma and cystic fibrosis may make it difficult to obtain sufficient nutrients for optimal growth. Children with these types of conditions are more likely to have behavior problems relating to food (Borzekowaski & Robinson, 2001).

2.4.4 Nutritional requirements of pre-school and school children

Children need more nutritious food in proportion to their size than to adults because of growth and development of bones. They may be at risk for malnutrition when they have poor appetite for a long period, eat a limited number of foods or dilute their diets significantly with nutrient-poor foods. The Recommended Nutrient Intakes (RNIs) are based on nutrient intakes needed for optimal health (Institution of Medicine, 2000). They include estimated average requirements (EARs), Recommended Dietary Allowances (RDAs), Adequate Intakes (AIs), and Tolerable Upper Intake levels (ULs). These reference intakes are meant to improve the long-term health of the population by reducing the risk of chronic disease and preventing nutritional deficiencies. Thus when intakes are less than the recommended level, it cannot be assumed that a particular child is inadequately nourished.

Energy

The energy needs of healthy children are determined on the basis of basal metabolism rate of growth and energy expenditure. Dietary energy must be sufficient to ensure growth and spare protein from being used for energy but not so excessive that obesity results. Suggested intake proportions of energy are 50% to 60% as carbohydrate, 25 to 35% as fat and 10% to 15% as protein. Energy intakes of healthy, growth children of the same age and sex vary depending on their activity level. A 9-year old boy and a 12½-year old girl approaching puberty have significantly different factors determining their energy needs even though they are in the same DRI age category. It is useful to determine energy requirement on an individual basis using energy per kilogram of weight or per centimeter of height (Goram, 2002).

Protein

The need of protein per kilogram of body weight decreases from approximately 1.1g in early childhood to 0.95g in late childhood. Although this amount of protein is approximately 5% to 6% of the energy RNI reported intakes from national surveys have shown that protein intake are considerably higher in the range of 10% to 16% (USDA, 2001). Children who are most likely to be at risk for inadequate protein intake are those on strict vegan diets, with multiple food allergies or who have limited food selections because of fad, diets behavoural problems, or inadequate access to food.

Daily Dietary Reference Intakes for Energy and Protein for Children

Energy

Age (yr)	***Males (kcal)***	***Female (kcal)***
1 – 2	1046	992
3 – 8	1742	1642
9 – 13	2279	2071

Protein

Age (yr)	***Grams***	***Gram (per kg)***
1 – 3	13	1.1
4 – 8	19	0.95
9 – 13	34	0.95

Source: Institution of Medicine, Food and Nutrition Board: *Dietary reference for energy and the micronutrients, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids,* Washington, D.C, 2002, National Academy

Minerals and Vitamins

Minerals and vitamins are necessary for normal growth and development. Insufficient intake can cause impaired growth and result in deficiency disease.

Children between 1 and 3 years of age are at high risk for iron deficiency anemia. The rapid growth period of infancy is marked by increase in hemoglobin and total iron mass. In addition, the diet may be rich in iron containing foods. Recommended intakes must factor in the absorption, rate and quantity of iron foods, especially those of plant origin (Trumbo, 2001).

Calcium

Calcium is needed for adequate mineralization and maintenance of growing bone in children. The RNI for calcium is higher for 9 to 18 years of age 1300mg of calcium per day, for 1 to 3 years olds, it is 500mg/day, for children 4 to 8 years, it is 800mg per day. Actual need depends on individual absorption rates and dietary factors such as quantity or protein, vitamin D, and phosphorus calcium intake has very little influence on the degree of urinary calcium excretion during periods of rapid growth, children need two to four times more calcium per kilograms than adults. Milk and dairy products are the primary sources of calcium, so children who consume no or limited amounts of these foods are at risk for poor bone mineralization (Trumbo, 2001).

Zinc

Zinc is essential for growth, a deficiency results in growth failure, poor appetite decrease taste acuity, and poor wound healing. An allowance of 3mg/day of zinc is recommended for 1 to 3 years-olds, 5mg/day for children 4 to 13 years of age (Trumbo, 2001). The best sources of zinc are meals and seafood, so some children who consume less of the seafood and meals may have zinc deficiency. Marginal zinc deficiency has been reported in preschool and school children from middle and low-income families (Roberts & Heyman, 2000). Diagnosis may be difficult because laboratory parameters including plasma, serum, erythrocyte, hair, and urine levels are of limited values in determining zinc deficiency. In some cases, a carefully controlled short-term trial of zinc supplementation may be the only conclusive way to diagnose a problem (Krebs and Hambidge, 1996).

Vitamin D

Vitamin D is needed for calcium absorption and deposition of calcium in the bones. Vitamin D is also formed from sunlight exposure on the skin, the amount required from dietary sources depends on non-dietary factors such as geographic location and time spent outside. Children living in tropical areas may need no dietary vitamin D or only 2.55µg (100IU) or less for optimal calcium, however in the tropical zones, some dietary sources is needed, the RNI is 5µg (200IU) for children. Vitamin D fortified milk and breakfast cereals are the primary source of this nutrient.

2.5 Mushrooms in Human Nutition

2.5.1 Use of fungi

Fungi have a profound influence on human affairs, and their use in food is a very ancient practice. Many fungi are of considerable medical significance, for thousands of years, Eastern cultures revered mushrooms as both food and medicine. Mushrooms or their extracts are made into a soup or tea, other fungi are used to modify food to make it more nutritious or palatable. Not only are fungi used as food, but they are also employed in food processes traced back to the times of the ancient Egyptians. Today food of fungal origin is consumed all over the world in vast quantities, and commercial production is part of rapidly growing industry. Ancient cultures believed edible fungi promoted healthiness and well being. Fungi are of excellent nutritional importance and deserve attention for their unique contributions to a healthy diet. (Carlile & Watkinson, 2002).

The word 'mushroom' is said to have been derived from the French word 'mausseron', a term that includes edible mushrooms as well as poisonous varieties. Today, the word referred only to edible fungi and is generally applied to the above ground portion (Jiskan, 2001). Mushrooms are saprophyte and belong to the class *basidiomycetes* and subclass *Homobasidiomyceudae.* The *Homobasidiomycetidae* is divided into two series: *Hymenomycetes* and the *Gasteromycetes*. The *Hymenomycetes* has two orders: The *polyperales* and *Agaricales*. Mushroom belong to the order *Agaricales* which bears a hymenium on gills of a fleshy basidiocarp. The *Agaricales* include mushroom and toadstools both of which bear their hymena on gills supported by a pileus. The pileus can be laterally attached as in *pleurotus* or centrally attached in the stip as in *Agaricus lentinus*. Toad stool is used typically to designate a *basidiocarp* that is poisonous to eat while mushrooms are used for edible ones (Chang & Miles, 2004). Mushroom are as mysteriously unique as they are delicious. Though often thought of as a vegetable and prepared like one, mushroom are actually a fungus, a special type of living organism that has no roots, leaves, flowers or seeds. While mushroom can be cultivated they can also be found growing wild in many regions of the world (Bobek, Galbavy & Ozdin, 1998).

Mushrooms have played an important role in the diet of many people for thousands of years. Ancient Egyptians hieroglyphics reveal that mushrooms were thought to bring immortality. Many later cultures believed that eating mushrooms could endow them with super-human strength, give them clairvoyance in locating lost objects. (Qutile, 1999).

2.5.2 Nutritional value of mushrooms

The nutritive value of any food is measured by the extent to which that food can satisfy human requirements of specific nutrients (Ene-Obong & Obizoba, 1996). Varying opinions have been expressed regarding the true nutritive value of edible mushrooms. Although mushrooms are a staple food in the diet of some cultures, edible mushrooms are usually considered for their flavour and condiment value. In the past authors have dismissed mushroom as a food of little nutritive value, some considering them devoid of nutrients. However, this naïve approach is simply inaccurate, as much as research conducted on mushroom suggests otherwise, showing mushrooms as a nutritionally sound food that are of even greater value to vegetarians (Ingold & Hudson, 1993). Mushrooms grow naturally in Nigeria during the early and late rainy seasons (Gbolangade, Sabowale & Adeyoye, 2006). They are usually found in forests, grasslands and damp rotton logs. *Pleurotus taber-regium* a tropical edible mushroom that produces the edible sclerotium or underground tuber as well as mushroom. *Pleurotus* are cultured on a wide variety of agroforestry products for the production of food, enzymes, and medicinal products (Andrew, Mirjan & Juru, 2007) several medicinal properties have been reported in extracts of *Pleurotus* species. They include antitumour properties attributable to their polysacchariches, antigenotoxic, bioantimutugenic activities (Fillipie & Umek, 2002), antiinflamatory activity, antilipidaemic, antihypertensive and antihyperglycaemic activities (HU *et al*., 2006). Antibacterial and antifungal activities (Ngai & Ng, 2006). There is also research evidence that extracts from medicinal mushrooms can function as immunomodulators (Jong, Birmingham & Pai, 1991).

Edible mushrooms are source of delicious food all over the world. They have a high nutritional value almost twice that of any vegetable or fruit. They are rich in vitamins B, E and D and mineral elements (Fasidi & Kadiri, 1990). Apart from their use as food, sufficient evidences suggest that many reduce cancer, heart disease, diabetes and viral infections (Oei, 1991).

Pleurotus taber-regium fruit body has been shown to be highly nutritive (Adejumo & Awosanya, 2004; Akindahunsi & Oyetayo, 2006). The protein content of *Pleurotus tuber-regium* compares well with that of several leguminous seeds and that implies that *Pleurotus tuber-regium* could serve as suitable meat substitute. Protein evaluation has shown that mushroom proteins have higher quality than that of green leafy vegetables (Chang, 1981). *Pleurotus tuber-regium* has 63.03g of carbohydrate (Ijeh, Okwujiako, Nwosu, & Nnodum, 2009), Akindahunsi and Oyetayo reported a carbohydrate yield of 56.2g/100g dry weight. A considerable fraction of this carbohydrate is contributed by oligosaccharides (Ijeh *et al.*, 2009). Several health benefits have been attributed to mushroom oligosaccharides including immunomodulatory effects which have been shown to be beneficial to individuals living with HIV (Jong *et al*, 1991). Akindahunsi and Oyetayo (2006) reported that *Pleurotus taber-regium* has a low fat and ash content. Ijeh *et al.*(2009) find out in previous studies that *Pleurotus tuber-regium* has a high crude fibre (10.86±0.56%) and indicated that the incorporation of *Pleurotus tuber-regium* in diet could aid bowel movement as well as reduce the incidence of colon cancers in its users. Epidemiological studies have found an association between high fibre diets and a lower incidence of cardiovascular diseases and large bowel cancers (Honda, Kai, & Ohi, 1999). Ijeh *et al*. (2009) analyzed *Pleurotus tuber-regium* and concluded that the fruit body of *Pleurotus tuber-regium* is rich in iron (5.02) and zinc, and that incorporation of 200g of *Pleurotus tuber-regium* will provide sufficient iron to meet the recommended nutrient intake (RNI) for school age children. Ijeh *et al*.(2009), also indicated from previous studies that the mushrooms are rich in alkaloids, saponins, flavonoids and oligosaccharide. That these alkaloid and saponins which could be toxic at high doses were found to occur in non-toxic doses and that dietary incorporation of *Pleurotus tuber-regium* at 5 and 10% levels resulted in a dose dependent increase in pancreatic weight and decreased in intestinal weights but had no significant effect on liver and kidney weights. Manjunathan and Kavigarasan had 12.5% of moisture for cultivated mushroom and 9.4% for the wild specie, 25.01% and 18.07% of protein for cultivated and wild *Pleurotus* respectively. Ragunathan and Swaminathan, (2003) obtained low fat concentration in three species of *Pleurotus* grown on various agro-wastes. That cultivated mushrooms would be a better energy source (338kcal) than the wildly obtained one (318kcal). (Fasidi & Ekuerre, 1993) and (Manzi, Gambelli, Marconi, Vivanti & Pizzoferrato, 1999) also reported that potassium was the most abundant mineral elements in mushrooms. Mushrooms are considered a good source of proteins. Vitamins, fats, carbohydrates, amino acids are present as well as water soluble vitamins and the essential minerals (Buigut, 2002). Mushrooms are good sources of vitamins like riboflavin, biotin and thiamin (Chang & Buswell, 1996). According to Shyam, Syed & Suresh (2010) *Pleurotus ostreatus* contain the following proximate vitamins and minerals moisture 88.4%, protein 24.66%, fat 2.82%, crude fibre 7.15%, total carbohydrate 53.20%, ash 6.70%, calcium 300mg/100g, phosphorus 1000mg/100g, Fe 14.35mg/100g, sodium (Na) 310mg/100g and potassium 2320mg/100g. *Pleurotus ostreatus* is a good source of B vitamins which help in breakdown of protein, fat and carbohydrate. It also has a higher folic acid contents which helps to protect against anaemia, diabetes and high blood pressure Bobek, Galbavy & Ginter(1998).

Moisture

According to Ene-Obong (1996) the moisture content of mushrooms is comparable to most leafy vegetables making mushroom a low energy dense food. According to Cooper (2001) moisture accounts for 90% of fresh weight, carbohydrates are the main component of mushrooms (average of 4.2%). Cooper (2001) also pointed out that mushroom contain glycogen and in their wall and many other carbohydrate such as glucans, chitosans, and mannans. Because mushroom cannot photosynthesize sugar, carbohydrates are present in lower proportion than vegetables such as carrots and sprouts and so provide only a fraction of the energy requirement. Mushroom contains an average of 85-125KJ, per 100g. This low energy value of mushroom enables it to be used in low calorie diets, and this makes it an ideal food for diabetes.

Protein

Ukoima, Ogbonnaya, Arikpo and Pepple (2009) studied some species of *Volvariella, velvacea*, 40.2% from *Pleurotus tuber-regium* and 30% from *Pleurotus sajorcaju*. Agricus bisporus contain protein between 24 to 44% (Jiskani, 2001). The protein content of mushroom vary widely from 13-37% per 100g dry matter. On dry weight basis these values are comparable to that of commonly consumed leafy vegetables. *Pleurotus tuber-regium* has been shown to contain about 13% crude protein (Ene-Obong & Carnovale, 1992) while *Pholiota* spp contain about 37.2% protein per 100g dry matter (Ndubuaku, 1993). *Cantharellus Gbarius* contain 3.5% and *Agaricus bisporus (portaballo*) 44% (Moore & Chiu, 2001). The protein values of mushroom is twice as that of asparagus and potatoes, four times that of tomatoes and six times that of oranges. The carbohydrate value varies which is equal to an apple. Mushroom protein is intermediate between that of animal and vegetsables (Kurtman, 1976) and is of superior quality because of the presence of all essential amino acids (Purkayastta & Nayak, 1981).

The value of amino acid in a given food indicates its protein quality. Adams & Moss (1995) observed in his study that mushroom have high protein content and that they contain all amino acids essential to human nutrition. Moore & Chiu (2001) found out however that every specie was limited in their availability of at least one essential amino acid. *Agaricus bisporus* has values highly comparable to whole egg protein. It was found that the most nutritive mushroom rank in potential nutritive value with those calculated for meat and milk, the only difference being relatively low content of certain amino acids namely isoleucine leucine, lysine and histidine. On the other hand, relative levels of lysine and tryptophan were significantly higher than those for legumes and vegetables (Adams & Moss, 1995).

Fat

Moore and Chiu (2001) reported that mushrooms are characteristically low in fat. Comprising 2-8% per 100g dry weight. They pointed out that this crude fat include all classes of lipid compounds; ranging from free fatty acids, glycerides, sterols, and phospholipids. Among the existing fatty acids, a high proportion are linoleic acid, found to be (23-74%) of total fatty acids. Sphingolipids, important in brain and nervous system, have also been identified but appear to represent only a small proportion of total glycolipids (Moore & Chiu, 2001).

It is becoming increasingly evident that mushroom play a significant role in the maintenance of optimum health. Like vegetables, mushrooms are cholesterol free foods. Fukushima (2000) found out that rats fed a diet of the mushroom fibre led to lowered serum total cholesterol and lowered very low density Lipoproteins (VLDL). Low density lipoproteins cholesterol concentrations are all thought to be artherogenic lipoproteins. Sugiyama, Sacki, Tanaka, Sakamoto and Ishiguro (1992) reported that extracts from the *Ninyotake* mushroom (*Polyporus confluens*) used to fed rats resulted in significant decrease of the plasma cholesterol level of the rats only by the ethyl acetate soluble fraction. When this fraction was further separated by silica gel chromotograph, two (2) major compounds comprising 45 and 28.5% of the ethyl acetale soluble fractions were obtained in a pure form. These include Grifolin (2-trans, trans-farn-esyl-5-methylresocinol). The addition of these two to a high cholesterol diet lowered blood plasma cholesterol levels significantly. Kabir, Yamaguchi and Kimura (1987) studied the effect of shitake (*Lentinies edodis*) and maitake (*Critola frondosa*) mushroom on blood pressure (RP) and plasma lipids of rats. Spontaneously hypertensive rats were fed a diet containing 5% mushroom powder and 0.5% Nacl solution as drinking water for 9 weeks. The dietary mushroom again decreased the blood pressure. However, Sugiyama & Sacki (1992) observed that *Nigyotake* mushroom unlike *shiitake* mushroom did not contain eritaadenin or evolve fatty acid level; rather it significantly increased fecal excretion of cholesterol and bile acid.

Fibre

Ogundana and Fagade (1981) indicated that mushroom is about 16.5% dry malter out of which 7.4% is crude fibre. Ene-Obong and Carnovale (1992) found that *Pleurotus tuber-reguim* contains 71.8% of total dietary fiber of which over 90% constitutes insoluble dietary fiber. This component helps to prevent constipation and consequent development of diverticulosis and other colonic diseases.

Vitamins

Mushrooms have been found to be a valuable source of vitamins. The fruit body of mushroom is an excellent source of B-complex vitamins including riboflavin (B_2) niacin, pantothenic acid, thiamin (B_1) biotin, folate and vitamin B_{12}. Mushrooms are one of the best plant-base sources of niacin. 100mg of fresh mushroom provide more than a quarter of the adult daily requirement of niacin. Mushrooms were found to contain 0.32-0.65mg per gram of B_{12} allowing just 3g of fresh mushroom to provide the RDA of this vitamin. Vegetarians may find this a useful way of getting this important nutrient. (Qutila, 1999).

Qutila (1999) found that ergocalciferol in mushroom increased serum 25-hydroxyvitamin D concentrations as effectively as did supplements, allowing mushroom to be reliably recommended as natural vitamin D source. Pro-vitamin D is present in some mushrooms particularly, shiitake, and can be converted to vitamin D by ultraviolet irradiation (sunlight). Vitamin A is uncommon although several mushrooms contain detectable amounts of pro-vitamin A measured as the B-carotene equivalent. Most cultivated mushrooms are believed to contain low amounts of the fat soluble vitamins, K and E, and only a small contributions to the daily requirement of vitamins C (Dubost, Beetman, Peterson, & Royse, 2005).

According to Ensminger, Ensminger, Kondale, and Robson (1983), raw *crimini* mushroom compose of the following nutrients: selenium 36.85g/100υg, riboflavin 0.62, thiamin 0.13mg/100υg, potassium 63.5mg/100g, magnesium 12.76mg/100g, iron 0.57mg/100g and dietary fibre 0.85g/100g.

Minerals

The mineral content of mushroom have been studied by some researchers Kawai *et al*. (1986) analyzed 24 species of wild edible mushrooms. The mineral contents varied widely. For example potassium (K) ranged from 1.1-5.3mg/100g, sodium (Na) 11-267mg; calcium (Ca) 5-342mg Magnesium 59-299mg; Phosphorus (P) 59-1938mg; Iron (Fe) 4.9-419mg; Copper (Cu) 0.2-23.2mg and zinc 0.4-16.3mg/100g.

Analysis of Oyster mushroom by Strmiskova, Strimska and Dubravieky (1992) showed that *Oyster* mushroom contain relatively low sodium (195mg/kg). The highest concentrated of micronutrient were Fe and Zn (90.3 and 67.5mg/1kg respectively). They showed that 40% of the sample exceeded the permitted cadmium (Cd) level 0.5mg/kg while lead (Pb), mercury Hg) and arsenic (As) did not exceed permitted levels of 5, 0.5 and 5mg/kg dry matter. Although the mushroom content of mushroom varies, it appear to be a good source of micronutrients in human nutrition; even though the bioavailability of these micronutrients need to be investigated. *Pleurotus* species contain high potassium to sodium ratio which makes mushroom an ideal food for patients with hypertension and heart disease (Purkayastha & Nayak, 1981). Chang (2004) also confirmed that some species of mushroom contain other minerals like selenium, copper manganese and iron.

For the past twenty years, phytonutrients found in mushroom have been the object of anti-cancer research. Most of this research have centered on carbohydrate-related parts of mushrooms, including their *Polysaccharide* and *beta-glucan* components. *Shiitake, Maiitake, Reishi* and *Crimini* mushrooms have been shown to have anticancer properties, as well. Adding these mushrooms to the diet may help protect against the development of breast cancer by preventing circulation levels of estrogen in the body from becoming excessive (Excessive estrogen, or hyperestrogenemia had been repeatedly linked to increased risk of breast cancer). This effect appears to be accomplished through inhibition of an enzyme in the body called aromatase (estrogen synthase) that is necessary for the production of estrogen (Bobek; Galbavy & Ozdin, 1998).

Selenium which is contained in crimini mushroom is needed for the proper function of the antioxidant system, which reduces the levels of damaging free radicals in the body. Selenium is a necessary co-factor of one of the body's most important internally produced antioxidant, *glutathione peroxidase*, and also works with vitamin E in numerous vital antioxidants systems through out the body. These powerful antioxidant actions make selenium, helpful not only against colon cancer by protecting colon cells from cancer – causing toxins, in decreasing asthma and arthritis symptoms and in the preventive of heart disease. In addition, selenium is involved in DNA repair. 466g of raw *crimini* mushrooms provide 52.6% of the daily value (DV) selenium. (http://www.naturopathic.org)

Copper is another mineral content in some mushroom species, copper is helpful in reducing the symptoms of rheumatoid arthritis. Copper along with manganese is an essential cofactor of a key oxidative enzyme called superoxide dismutase, which disarms free radicals produced within the mitochondria. Copper is also necessary for the activity of lysyl oxide, and enzyme involved in cross linking collagen and elastin, both of which provide the substance and flexibility in blood vessels, bones and joints. Low dietary intake of copper may also be associated with increased fecal free radical production and facal water alkaline phosphatase activity, risk factors for colon cancer. 466g of raw crimini mushrooms supply 35.5% of the DV for copper and 10.0% of the DV for manganese. Crimini mushrooms are also a good source of *iron* which is primarily used as part of hemoglobin. Hemoglobin synthesis also relies on copper. Without copper iron cannot be properly utilized in red blood cells. Two of these minerals are supplied in crimini mushrooms (Johns, Deasona, Masa & Cynthia, 2006). All the B complex vitamins contained in mushroom are necessary for carbohydrate, protein and lipid metabolism. Mushrooms were also found to be a very good source of zinc. Zinc effect many processes, it is a cofactor in a variety of enzymatic reactions. Zinc is necessary for an optimal sense of smell and taste, and has been shown to prevent the blood vessel damage that can occur in atheroselerosis and may help to reduce the painful inflammation of rheumatoid arthritis. A strong immune system depends on adequate zinc levels, so the zinc in mushroom may help also to prevent illnesses such as recurrent colds and ear infection, and even some of the serious infection seen in patients with advanced or long standing diabetes. 466g of crimini mushroom provide 10.4% of the daily value for zinc. Regular consumption of niacin-rich foods like crimini mushrooms also provide protection against Alzheimer's disease and age-related cognitive decline. L-ergothioneine, a powerful antioxidant, has been discovered in mushroom (American Chemical Society, 2005; Dubost, 2005 & Davis, 2003). Portabellas and crimini have the most L-ergothioneine, followed by white buttons, shiitake, maitake, oyster, and king oyster mushrooms (Dubost, 2005). L-ergothioneine is not destroyed when mushroom is cooked (Dubost, 2005)..

2.5.3 Species and varieties of edible mushrooms

Mushrooms are the edible portions of certain higher fungi, which emerge from the underground mycelium during certain times of the year. Botanically they constitute the fruit of the fungus.

There are several species and varieties of edible mushroom cultivated in the temperate, tropical and subtropical zones of the world. The most popular species in the temperate region are:

- *Agaricus bisporus* (a cultivated mushroom of commerce).

- *Agaricus bitorguis*.
- *Lentinus edodis* (Shiitake).
- *Auricularia polytricha* (the ear fungi).
- *Pleurotus ostreatus* (Oyster Mushroom).
- *Pleurotus sajor-cajunus*.

Volvariella volva cea (the padi straw mushroom).

- *Volvariella esculenta*

The following species have also received attention in Nigeria but there seem to be no published data.

- *Pleurotus tuber regium* (Okigbo, 1980; Nwokolo, 1986; Ene-Obong & Carnovale, 1992)

Chlorophyllum molytiditis
Psathyrella a *troubonata*
Termitomyces robustus
} Adewusi (*et al*., 1993).

- *Termitomyces striatus* (Zoberi, 1972; Adewusi *et al*., 1993)

- *Vovariella esculenta*
- *Volvariella bombycina*
- *Tricholoma lobayensis*
} Adewusi *et al*., (1993)
(Boot-lace) *Pholiota spp.*

In the Nsukka local Government Area of Enugu State, Ndubuaku (1993) identifies the following wild edible mushrooms.

Eru mgbafu –ani)
Eru nkpu
} *Termitomyces spp.*

Eru ata
Eru ebere (kpakum)
} *Volvariella spp.*

Eru Ogazi
Eru akiru
Eru nti
} *Agaricus spp.*

(Eru-ike-gwu-eze) *Pholiota spp.*

Cultivated species

Agaricus Biporus (button mushroom). This is the most commonly cultivated in Britain, it varies in colour from creamy white to light brown and in sizes from small (button) to jumbo. They are pleasingly mild and woody. Their flavour intensifies when cooked. They were first cultivated on prepared horse manure in seventeenth century in France, and in caves that provided the ideal stable environment in terms of temperature and humidly. Today they are cultivated in rich compost in purpose-built mushroom houses where heat and humidity are carefully controlled. It is one of the most technically advanced horticultural industries today(Dubost, Beetman, Peterson & Roys, 2005).

Lentiaula edodles (Shiitake Mushrooms)

They have been commercially cultivated since their original importation into Europe from Japan around 1940. They are widely available in supermarkets as well as in Asian markets. They are best cultivated on artificial logs. Shiitake has a medium brown colour with a distinctive, thick umbrella-shaped cap, and offer a rich, distinctly earthy flavour and chewy texture. After Agaricus, shiitake is the second most cultivated mushroom in the world. Health food store oriented and up scale restaurants are all targets for this specialty mushroom (Chang, 2004).

Pleurotus spp (Oyster mushroom)

The Oyster mushroom is grown mainly in central Europe. A soft brown colour, it is a large mushroom with a shape comparable to that of an Oyster shell. Oyster mushrooms have a delicate, mild flavour and velvety texture (Strmiskova, Strmiska & Dubravicky, 1992).

Volvariella Volvacea (*Paddy Straw Mushroom*)

It is so called because the substrate is a compost of rice straw. It has been cultivated for 2000 years in China and South-east Asia. It is a unique mushroom with a long, slender stem and tiny cap, grown mainly in Japan, and *pholiota nameko* cultivated in China and Taiwan (Bobek *et al*., 1998).

Truffle mushroom

The truffle mushroom belongs to the order *Tuberales* with an underground fruiting body, usually round and pitted. Truffles have been collected for at least 360 years. The most highly produced is the black truffle. It's tantalizing taste and aroma are so intense that it is used as flavouring instead of a separate dish (Bobek, Galbavy & Ozdin, 1998).

2.5.4 Cultivation and Harvesting

The cultivation of mushrooms in Europe has been going on for nearly 300years. It began in the underground cave of Paris in the time of Louis XIV and flourished until the mid-twentieth century. Mushrooms are now being produced in over eighty countries around the world. In 1945, the British Mushroom Grower's Association (MGA) was born and total production was estimated at some 450 tones. Today annual production is estimated at over six million tones. Britain is the fourth largest producers being surpassed only by the U.S.A. France and Taiwan, http://ww.mushroomcouncil.com/preparation/prep.html.

In various countries in Asia, up to eighty distinct varieties of wild fungi are offered for sale in the markets. In Britain, the public are much more apprehensive when it comes to buying wild mushroom. Even so, it is perhaps remarkable that success on a large scale has been achieved with the commercial production of a very few (Carlile & Watkinson, 1994).

Harvesting of mushrooms

- Do not harvest mushroom that grow near chemically contaminated sites, because mushroom contract toxic substances from the environment within their tissues.

It is particularly important to avoid areas near:

- Highways and expressways – investigations have shown that there are elevated lead levels in the soil within 300 meters of areas used by motor vehicles. Mushrooms concentrate this heavy metal to a greater degree than do other plants.
- Large cultivated areas – these are usually treated with various posticides.
- Chemical industries.
- Garbage dump and incinerator.

- They should be cut with a knife at the base of the stipe for easy identification.
- When hunting mushroom do not disturb the top layers of the humus that covers the forest floor. This will damage any mycelium that may be there.
- Discard any overripe specimens, those that have been eaten by insects or show any sign of decay. These tend to have higher concentration of natural toxins.
- Use a wicker basket to carry harvested mushroom to avoid easy breakage.

- Do not carry them upside down to avoid dirt getting into the lamellae.

Identification – never eat mushroom until they have been identified as edible. (Moore & Chiu, 2001).

Cooking - Cook mushroom for at least five minutes to destroy harmful substances which usually disappear with heat and never eat mushroom raw (Chang & Hayes, 1978).

2.5.5 Consumption pattern of wild edible mushroom in Nigeria

Mushrooms grow naturally in Nigeria during the early and late rainy seasons. They are usually found in forests, grasslands, damp cotton logs, etc. *Pleurotus tuber-regiuum* (Sclerotia producing mushroom) is a tropical edible mushroom that produces the edible sclerotium or underground tuber as well as mushroom. *Pleurotus* are cultured on a wide variety of agroforestry products for the production of feed, enzymes and medical products (Andrew, Mirjan, Juru, 2007).

There is probably no scientific data on the consumption pattern of wild edible mushrooms in Nigeria. Information from personal communication however, revealed that mushrooms are normally used in preparing traditional dishes in Nigeria. They are basically used because of their flavour and aroma and in most parts where mushroom are eaten they are regarded as delicacies.

Ndubuaku (1993) made an attempt to study the consumption pattern of mushroom in Nsukka local government area of Enugu State Nigeria; he came up with the following results.

Consumption of mushroom	% response
Pleurotus tuber-regium (Osu)	97.5
Termitomyces spp (eru-abia)	88.5
Volvariella spp. (eru-ebere)	87.5
Pholiata spp. (eru-mgbatuan)	51.1
Aganicus compestris (eru-ogazi)	45

The most popular mushroom is the *pleurotus tuber-regium.* This mushroom is usually ground and mixed with melon seed to prepare soup. It is used as an extender, a pair alternative for melon seed.

In many parts of tropical Africa, the sclerotium is milled with melon or ground seeds in a ratio 1:3 seasoned and then moist mixed molded into parts for cooking or baking, and serves as a vegetable meat substitute (Nwokolo, 1987).

2.5.6 Phytochemicals

Phytochemicals are chemical components in plant food, they are biologically active and act as natural defense systems for their host plants protecting the plants from infections and microbial invasions and providing color aroma and flavor. More than two thousand plants are considered phytochemicals, such as flavonoids, carotenoids and anthocyanins. Dietary sources of phytochemicals include fruits, vegetables, legumes, whole grains, nuts, seeds, fungi, herbs, and spices (Craig, 1997). Phytochemicals are the subject of intense scientific research focusing on the prevention or treatment of chronic diseases such as cancer and heart disease. As protection against cancer plant-based chemical detoxify drugs, toxins, carcinogens, and mutagens. These phytochemicals have overlapping and complementary mechanisms such as neutralizing free radicals, inhibiting enzymes that activate carcinogens and inducing enzymes that detoxify carcinogens (Lampe, 1999).

Phytochemicals act as blocking and suppressing agents, thereby reducing the risk of cancer. Blocking agents prevent the active carcinogen or tumor promoter from reaching the target tissue by several mechanisms. Phytochemicals reduce the risk of coronary heart diseases by protecting low density lipoprotein (LDL) cholosterole from oxidation, reducing the synthesis or absorption of cholesterol, and affecting blood pressure and clotting (Craig, 1999).

Phytochemicals are grouped into classes on the basis of their similar protective functions and individual physical and chemical characteristics. The major classes of phytochemicals include the terpenes, phenols and thiols.

Terpenes are the largest classes of phytonutrients, found in a wide variety of plants foods and act as powerful antioxidants. Carotenoids comprise one subclass of terpenes. There are more than 600 naturally occurring, carotinoids, they are yellow, orange and red plant pigments and the most prevalent carotinoids include α–carotene, β-carotene, β-cryptoxanthins lycopene, lutein and zeaxanthin. Fruit and vegetables that contain carotenoids include apricots, papayas, sweet potatoes, mangoes, corn, pumpkins, carrots, tomatoes, parsley, oranges, pink grape fruit and spinach. Processed tomato products such as spaghetti sauce, have carotenoids with the highest availability (Holden, 1999)l lycopen, a carotenoid in tomatoes, has been called one of the most effective biologic singlet oxygen quenchers, it is two times as powerful as β-carotene in the destruction of free radicals. Limonoid are another subclass of terpenes found in citrus fruits such as grapes and orange juice. They are chemopreventive agents that has been identified to induce enzymes in the liver's phase I and II enzyme detoxification system.

Phenols

Phenols are phytochemicals that protect plants from oxidative damage, they include the subclass flavonoids. More than 500 flavonoids, are the blue, blue red, and violet plant pigments. Flavonoids scavenge free radicals compounds, such as superoxide anion and singlet oxygen and sequester metal ions. Anthocyanins are phytochemicals in the flavoroid family that give the bluish-red pigments to barberries, cherries, grape cranberries, currants, red cabbage and raspberries. Isoflavones are a phenol subclass found in beans and other legumes, especially soybeans risk of heart disease. And elevated serum cholesterol level, associated with heart disease, can be significantly lowered by consuming soy protein (Potter, 1998).

Thiols

Thiol is sulfur – containing phytochemicals found in cruciferous vegetables such as broccoli, cauliflower, Brussels sprouts, kale and cabbage. Cruciferous vegetables contain subclass of thiols called dithiolthiones, indoles, and isothiocyanates. These organosulfuric compounds up-regulatie enzymes involved in the detoxification of carcinogens and other foreign compounds and (Talaya and Faley, 2001).

CHAPTER THREE
MATERIALS AND METHODS

3.1 Sample Collection

The different species *(Pholiota mutabilis, Pleurotus ostreatus, Pleurotus tuber-regium, Corprinus disseminatus and Peziza basidioconfusa korf)* of wild edible mushrooms were collected from different parts of University of Nigeria, Nsukka (UNN) residential quarters. Cultivated mushrooms were collected from the Department of Botany, UNN. The wild mushroom species harvested were identified in the some department. Cocoyam, maize and wheat flour were bought from Ogige market Nsukka

Harvested and Identified Mushrooms

Botanical Name	**Igbo Name**	**Where collected**
Wild Pleurotus tuber-regium	"Talutalu"	No. 632 Odim Street, UNN
Cultivated Pleurotus tuber-regium	"Talutalu"	Department of Botany, UNN
Philiota mutabilis	"Ibere"	No. 8 Mbanefo Street, UNN
Corprinus disseminatus	"Onye kam ete"	No. 3 Mbanefo Street, UNN
Pleurotus ostreatus	"Dadarida"	No. 2 Ezenwaeze close, UNN
Peziza bacidioconfusa korf	"Ero ntikita"	No. 359 Margaret Cartwright, UNN

Source: *Wild mushrooms grow in the bush, while cultivated mushroom are grown atificially at homes with different substrates such sclerotia and other agro wastes.*

Each sample was sorted out carefully, dirts and sands were removed. Five gram (5g) of each sample was set apart for determination of actual moisture contents of the mushrooms. The rest were washed, dried in a hot air oven at 55^0C – 60^0C and milled into mushroom flour with milling machine. Dry flour was packaged in sample bottles and stored away in a freezer for further laboratory analysis. Below are plates of some mushroom samples and flow charts showing the process of mushroom flour, cocoyam paste and corn starch preparation.

Plate 1: Wild mushroom (*Corprinus disseminatus)*

Plate 2: Cultivated mushroom (*Pleurotus tuber-regium)*

Plate 3: ***Philiota mutabilis***

Plate 4: Wild ***Pleurotus ostreatus***

Plate 5: Wild *Pleurotus tuber-regium*

Mushroom
↓
Sorted to remove impurities
↓
Washed in clean tap water
↓
Air oven dried ($55^0C – 60^0C$) for 24 hours
↓
Milled
↓
Mushroom flour

Fig. 1: Flow chart of mushroom flour preparation

Cocoyam
↓
Peeled
↓
Washed with clean tap water
↓
Cut into pieces
↓
Grated
↓
Cocoyam paste

Fig. 2: Flow chart of Cocoyam paste preparation

Dry corn
↓
Sorted to remove impurities
↓
Soaked for 24hrs in a clean water
↓
Milled
↓
Sieved with (70mm mesh size)
↓
Corn starch

Fig. 3: Flow chart of Corn starch preparation

All the samples were chemically analyzed for proximate, minerals and vitamin compositions. The mushroom sample (cultivated *Pleuotus tuber-regium)* used as food fortificant was analysed for the presence of phytochemicals.

Laboratory Analysis

3.2 Proximate Analysis

3.2.1 Moisture

The moisture contents of freshly harvested mushrooms were determined using the hot-air oven method (AOAC, 2000). The crucibles were washed and dried in the oven at 100^{o}C for about 30 minutes and cooled in desiccators for about 5 minutes. Five grams of each sample was put in a hot air oven at about 100^{o}C for 24 hours. The dishes containing the sample were removed from the oven, cooled in desiccators to prevent re-absorption of moisture, weighed and put back in the oven for further drying. This was repeated until constant weights were obtained. The differences in weight of the dishes and the samples before and after drying were the total moisture contents of the samples.

The percentage moisture content was calculated from the weight loss of each sample.

Calculation

A = Wt of dish + sample before drying.

B = Wt of dish + sample after drying

Y = Total number of grams of sample used

C = Weight of moisture (A-B)

% Moisture = C/Y x 100/1

Residual Moisture: The residual moisture in the dry mushroom flour was determined using the method described above. The value was used to calculate the water conversion factor used to obtain the value of the mushroom on fresh weight basis (wet weight).

Water conversion factor (WCF) =

$$\frac{100 - moisture\ of\ sample?}{100 - moisture\ of\ sample\ in\ food\ composition\ table}$$

FAO(1968)

3.2.2 Crude Protein Determination

The Micro-Kjeldal method as described by Pearson (1976) was used.

Digestion

About 0.5g of each sample was weighed out into the Kjeldal digestion flask. Then, 2g of anhydrous sodium sulphate and 0.5g of cupric sulphate were added into the flask followed by 10ml of concentrated sulpuric acid. The samples were allowed to digest until a clear green solution is obtained. The digest was made up to 100ml with distilled water and shaken thoroughly.

Distillation

About 10ml of each of digested sample was transferred into a conical flask and 5ml of 1% boric mixed indicator was added and the flask placed under the condenser. Then, 10ml of 60% sodium hydroxide was added through the funnel. Owing to the presence of ammonia in the sample the boric acid indicator changed from purple to green, and this indicated the presence of protein. The green coloured sample was titrated against 0.01N hydrochloric acid in the burette to the end point (where the greenish sample turned purple). The titre value was used in calculating the crude protein.

Calculation

The titre was calculated by subtracting the initial burette reading. The dilution factor was calculated by dividing the total volume 100ml by 5ml since 5ml was taken for titration at a time.

$$\text{c/o Nitrogen} = \frac{Titre\ X\ N + dfMWN\ X\ 100}{Wt\ of\ sample\ in\ mg}$$

Where

N = normality of acid = 0.01

Df = dilution factor = 20 (obtained by dividing 100ml by 5ml)

Wt of sample in mg = 200mg (i.e 2g x 1000mg)

MWN = Molecular weight of Nitrogen = 14.01

% protein = % Nitrogen x 6.25

3.2.3 Fat Determination

Soxhlet extraction method was used as described by Pearson (1976). To determine the fat contents of the samples.

An extraction flask was thoroughly washed and dried in hot oven for 30mins. And was placed in desiccators to cool. About 2g of the sample was weighed and transferred into a rolled ashlet filter paper and placed inside the extractor. The timble was placed into soxhlet extractor. About ¾ of the extractor flask was filled with 50ml of petroleum ether and connected to the soxhlet and in turn to the condenser. The heater was switched on and the temperature not exceeding the boiling point of the petroleum ether was used. This was allowed to run for 3-6 hrs and the either was removed at the end before the timble was removed.

The oil that collected in the flask was dried at 100^{o}C in an oven. Then the extracted oil was weighed. The difference in the weight of the empty flask and the flask with the oil gives the oil content of the sample.

Calculation

A = weight of oil and flask

B = weight of flask

Weight of oil (C) = A-B

Y = weight of sample

% of fat = C/Y x 100/1

3.2.4 Ash Determination

The ash determination was done using Analytical Chemists (AOAC, 2000) method. The crucibles were washed, thoroughly dried in hot oven at 100^{o}C. Cooled in desiccators and weighed.

About 0.2g of each sample was weighed into the crucibles and put in the furnace. Heating was gradually started until temperature of 600^{o}C was reached. The temperature was maintained for 6 hours. The furnace was switched off and the temperature was allowed to drop before the crucibles were removed.

The crucibles were then placed inside desiccators and cooled. After a while, they were weighed and then the percentage ash was calculated thus.

A = wt of empty dish

B = wt of sample

C = wt of sample after ashing

D = wt of dish

Wt of ash (D) = C-A

% of ash = D/13 x 100/1

3.2.5 Determination of Crude fibre

The determination was done using (AOAC, 2000) method. About 2g of each sample was put into a 500ml boiling flask. Then 100ml of 1.25% dilute sulphuric acid (H_2S04) was added into the flask and digested for about 30 minutes. The flask was removed and the content was filtered using a bucknar flask carrying a white calico cloth filtered to a vacuum pump. The filtered residue was washed with hot water several times and returned into the same flask using a spatula. About 100ml of 1.25% of NaOH was measured and added into the flask and digested again for 30minutes. Filtration was done as before under a vacuum pump. The residue was washed several times with cold water, rinsed with hot water severally rinsed again with 1% HCL to neutralize any trace of alkaline. It was rinsed with methylated spirit, to remove any traces of oil in the residue. The residue was put into a weighed crucible and placed in an oven to dry for about 30 minutes. The crucible with its content was placed into desiccators to cool. The crucible and its content were weighed and recorded. The crucibles with its content were transferred into a muffled furnace and were allowed to ash for 2hours. After ashing completely, it was cooled in desiccators before the crucible plus the ash was weighed.

Calculation Result

Having known the weight of empty crucible and weight of the crucible plus ash, weight of

Fibre = wt of residue-wt of ash

$$\% \text{ fibre} = \frac{wt\, of\ fibre\, X\, 100/1}{wt\, of\ sample}$$

3.2.6 Determination of carbohydrate

Carbohydrate contents of the mushroom samples were obtained by difference. That is, 100% minus values of moisture, protein, fat, ash and crude fibre.

3.2.7 Estimation of Energy Value

The energy value was calculated from protein, fat and carbohydrate values using Atwater conversion factors (FAO, 1985). Fat, protein and carbohydrate supply 9, 4, and 4 kcal per gram, respectively.

3.2.8 Mineral

These were determined using American Public Health Association (APHA) (1976) method. About 1g of each of the previously ashed sample dissolved in a minimum amount (5ml) of concentrated hydrochloric acid (HCL) and warm distilled water. The diluted sample was filtered and adjusted to a known volume. The filtrate was neutralized with ammonium hydroxide (NH_4OH) and adjusted to a known volume. The filtrate was then analyzed for iron, calcium, magnesium, selenium, potassium, and copper by atomic absorption spectrophotometer.

3.2.9 Vitamins

The vitamins were determined by UV spectrophotometric method as described by (Pearson, 1976).

Vitamin C

1g of the sample was weighed into a test tube. It was marsarated with 20ml of 0.4% oxalic acid and filtered.

9ml of Indophenol reagent was added. Absorbance was measured at 520nm.

Vitamins B_{12}

1g of the sample was weighed into a test tube and was marsarated with 50ml of distilled water and filtered.

2ml of the filtrate was prepetted. pH was adjusted between 9.5-10.0 with 10% sodium hydroxide (NaoH). 0.1g of sodium cynide was added and allowed to stand for 5hours. 1g of sodium sulfate was added and pH adjusted between 11-11.5. 2 ml of Benzole Alcohol extract was added 3 times and 3ml of chloroform and 3ml of distilled water was added and shook for 2minutes.

The aqeous layer was discarded. 10ml of distilled water was added to the organic layer. 5ml of the solution was measured, into a test tube and 1ml of 2% sodium cynide solution was added. pH was adjusted between 5.6 using 12.5% potassium dihydrogen phosphate. Absorbance was measured at 582nm.

Vitamin E

1g of the sample was weighed into a test tube. It was marsarated with 20ml of ethanol and filtered. 1ml of the filterate was pipetted. 1ml of 0.2% ferric chloride in ethanol and 1ml of 0.5% of dipyridyl were added. It was diluted to 5ml with distilled water.

Absorbance was measured at 520nm.

Folic Acid

1g of the sample was weighted and massarated with 50ml of 0.1NaOH.

Heated for 30mins at 40^0C.

Cooled at room temperature and filtered.

Made up to 100ml with distilled water and absorbance was measured at 265nm.

Thiamin (Vitamin B_1)

1g of the sample was weighed into a test tube and marsarated with 50ml of distilled water and filtered. 2ml of the filterate was pipetted and 2ml of reagent solution (10% NaOH and 1% potassium ferrocynide (9:1) were added. 15ml of isobutyl alcohol was added and shook vigorously for 2 minitues. The isobutyl layer was collected and dried by passing through anhydrous sodium sulfate (spatular tip). It was shook and absorbance was measured at 367nm against isobutyl alcohol.

Riboflavin (Vitamin B_2)

1g of the sample was weighted into a test tube and marsarated with 50ml of distilled water and filtered. 1.5ml of the filterate was pipetted and 6.5ml of the distilled water was added. 2ml of dennigees reagent solution was added. After 15mins. Absorbance was measured at 525nm.

Niacin (Vitamin B_3)

1g of the sample was weighed into a test tube and marsarated with 50ml of distilled water. It was filtered. The filterate was pipetted and 6.5ml of distilled water was added.

0.5ml of 1.5 ammonia, 1ml of cynogen bromit, and 1ml of sulpharillic acid were added. It was shook vigorously. 0.5ml of conc. HCL was added. Absorbance was measured at 430nm.

3.2.10 Phytochemistry of edible mushroom (*Pleurotus tuber- regium*)

Test for Alkaloid

Extraction was done with 5% sulphuric acid in 50% ethanol. Solution was heated for about 5mins to eliminate protein. Prick red colour, indicated the presence of Alkaloid (Harbourne, 1984).

Test for Glycosides.

Diluited sulphuric acid was added to the sample and heated for 15mins. It was diluted with 20% hydrogen oxide of fehlings solution (equal vol of A+B mixed together) were added and heated for 5mins. Colour changed blue to green and indicated he presence of glucosides (Harbourne, 1984).

Test for Flavonoids

Extraction was done with ethyl acetate for about 3mins. Solution was heated for 1 min and diluted ammonia was added. Colour changed from colourless to yellow indicated the presence of flavonoids (Harbourne, 1984).

Test for Resins

Extraction was done with ethanol for about 2 mins. Solution was boiled for 1min. Some drops of the filtrate was added to water in a beaker, white precipitate was formed, which indicated the presence of resins (Harbourne, 1984).

Test for Steroids and Terpenoids

1gram of sample solution was placed in a test tube and boiled for sometime (it was not allowed to boil off). It was allowed to cool and was filtered. Equal volume of distilled water was added to the filtrate and poured into a separating funnel and extracted with chloroform (chloroform of equal volume was added).

The lower layer was collected and divided into two and put into two separate test tubes for both steroid and terpenoids tests.

Steroid: Concentrated sulphuric acid was added to the solution in one test tube and a reddish-brown interface was obtained which indicated the presence of steroids.

Terpenoids: The sample for terpenoid in the test tube was evaporated to dryness and concentrated suphuric acid was added. A reddish-brown interface appeared which indicated the presence of terpenoids (Trease & Evans, 1996).

Test for Tannins

A little quantity of the sample was collected into a test tube and 2-3 drops of ferric chloride was added. It produced a bluish green colour which indicated the presence of tannins (Harbourne, 1984).

Test for Saponins

A little quantity of the liquid was colleted into a test tube and 2-3 drops of febric acid was added and shook vigorously, it produced persistent foam, which indicated the presence of saponins (Harbourne, 1984).

3.2.11 Choice of Mushroom flour for fortification

Pleurotus tuber-regium flour was chosen among the mushroom flours for food-to-food fortification based on its high protein content, availability in large quantity because it can always be cultivated. It was also chosen because most cultures in Nigeria accept sclerotia (*osu*) from which it was cultivated as traditional edible food and this eliminates the phobia people have for mushrooms.

3.2.12 Pilot Study

Several pilot studies were carried out to form a composite using varying weights of the mushroom and the three selected foods; wheat flour, cocoyam past and corn starch. After several trials, 600g of each staple food was chosen as a result of the pilot study conducted which showed that the texture of the mixture with 600g gave the best blend.

3.2.13 Fortification/Composite Flour Preparation

Food to food fortification was done by incorporating varying weights of mushroom flour such as 20g, 40g, and 60g into 600g of grated cocoyam, wheat flour and corn meal respectively. In addition, the recipes for the buns contained the same amount of the following ingredients: onions, fat, fresh pepper, baking powder, nutmeg, sugar, salt and vegetable oil for deep frying. These were used to prepare snacks, yield and oil absorbed were determined. The receipe for *Agidi jollof* also contained the same amount of the following ingredients, pepper, onions, crayfish, salt, vegetable oil and water.

The composite were used to prepare snacks and *Agidi jollof*.

3.2.14 Recipe for cocoyam buns fortified with edible mushroom flour

Ingredient	Control	Recipe 1	Recipe 2	Recipe 3
Crated cocoyam (g)	600	600	600	600
Mushroom (g)	-	20	40	60
Sugar (g)	40	40	40	40
Baking powder (g)	10	10	10	10
Nutmeg (g)	10	10	10	10
Onions (g)	10	10	10	10
Fat (g)	5	5	5	5
Pepper (g)	30	30	30	30
Salt (g)	10	10	10	10
Total yield	900	1000	1020	1050
Unit yield	36	36	41	42

Methods of Preparation

1. Measure all ingredients
2. Grate cocoyam paste and keep aside
3. Cream sugar and fat for about 15 minutes to a soft consistency and set aside.
4. Blend onion and pepper and fry in oil with low heat.
5. Put the cocoyam paste in a bowl and add nutmeg, salt to taste, fried onions with pepper, creamed sugar with fat and baking powder. Mix thoroughly with a wooden spoon to get a smooth mixture.
6. Deep fry and serve as snack

This recipe for cocoyam buns was standardized after several pilot studies and the above method of preparation was adopted for all the products developed.

Cocoyam buns fortified with edible mushroom flour

Cocoyam buns without edible mushroom flour

Plate 6: Cocoyam buns

3.2.15 Recipe for Wheat buns fortified with edible mushroom flour

Ingredient	**Control**	**Recipe 1**	**Recipe 2**	**Recipe 3**
Wheat flour (g)	600	600	600	600
Mushroom (g)	-	20	40	60
Sugar (g)	40	40	40	40
Baking powder (g)	10	10	10	10
Nutmeg (g)	10	10	10	10
Fat (g)	10	10	10	10
Water	150	150	150	150
Salt (g)	30	30	30	30
Total yield	980	1000	1025	1050
Unit yield	39	40	41	42

Methods of Preparation

1. Weigh all ingredients
2. sieve flour, nutmeg and salt separately
3. Rub in fat and sugar into the dry ingredients.
4. Add water gradually and mix with a wooden spoon to avoid lumps.
5. Deep fry with moderate heat and serve as snacks or meal.

The above method of preparation were adopted for all the products developed.

Wheat buns fortified with edible mushroom flour

WBM_0 Wheat buns without edible mushroom flour (control)

Plate 7: Wheat buns

3.2.16 Recipe for *Agidi jollof* fortified with edible mushroom flour

Ingredient	Control	Recipe 1	Recipe 2	Recipe 3
Maize (g)	600	600	600	600
Mushroom (g)	-	20	40	60
Pepper (g)	15	15	15	15
Onions (g)	100	100	100	100
Crayfish (g)	100	100	100	100
Salt (g)	10	10	10	10
Maggi cube (g)	5	5	5	5
Vegetable oil (g)	90	90	90	90
Water (g)	1200	1200	1200	1200
Total yield	1620	1680	1710	1740
Unit yield	81	84	85	87

Methods of Preparation

1. Measure all ingredients
2. Blend onions, pepper and crayfish together and fry with a little oil, add salt to taste.
3. Hydrate the corn starch with a little water from the measured quantity. Put the remaining water to boil.
4. Add the hydrated corn starch into the boiling water and stir for about 15mins.
5. Add the fried ingredients to the corn starch and stir vigorously with wooden spoon for another 5min.
6. Wrap in a waterproof and serve as snacks.

The above method of preparation was adopted for all the products developed and the source of the above recipe was obtained from a personal interview with *Agidi jollof* dealers in Ogige market Nsukka. After several pilot studies the above recipe was standardized.

Agidi jollof fortified with edible mushroom flour

AJM_0 *Agidi jollof* without edible mushroom flour (control)

Plate 8: *Agidi jollof*

3.2.17 Sensory Evaluation

The sensory evaluation of the snacks prepared with the composite flours were determined and the control snacks were cocoyam buns, wheat buns and agidi jellof prepared without addition of the mushroom flour. A food attitude rating form was given to 20 volunteer judges (young children 8-14 years of age). The consent of their parents were obtained with a written informed consent form in which they indicated their willingness for their children's participation. The evaluation was done in three days. Each fortified staple food (maize, cocoyam and wheat) was evaluated in a day. The children came in batches and were seated apart from each other to avoid collaboration in scoring. They were instructed on the use of the food attitude rating forms and the importance of independence in judging the products. The products were served in small flat plates. A glass of water was given to each child to rinse the mouth in order to avoid carry over effect from the preceeding products. They evaluated the product using a nine point hedonic scale where 9 was the highest and 1 the lowest.

The degree to which the product was liked was expressed as like extremely (9 points), like very much (8 points), like moderately (7 points), like slightly (6 points), neither like nor dislike (5 points), dislike slightly (4 points), dislike moderately (3 points), dislike very much (2 points), dislike extremely (1 point).

3.2.18 Nutrient composition of snack

Proximate composition of the snacks containing 60g of *pleurotes* mushroom flours in 600g of cocoyam, wheat and maize meal were calculated using available food composition tables Platts (1985); Oguntona and Akinyele (1995); Pennington and Church (1980). Nutrient composition values obtained in this study for *pleurotus* flour were used in the computation.

The ability of the most acceptable snack in meeting some specific nutrient requirements of pre-school and school children were determined using the FAO/WHO (2002) recommended nutrient intake (RNI) for vitamins and minerals and the FAO/WHO/UNU (1985) for protein and energy.

3.2.19 Data Analysis

Mean and standard deviation of triplicate determinations were calculated for the nutrients of the mushrooms analyzed and for the organoleptic attributes scores of the snacks. The percentage increases in specific nutrient as a result of fortification was calculated. One way analysis of variance (ANOVA) was used to determine the differences in organoleptic attributes of the fortified snacks and control.

CHAPTER FOUR

RESULTS

Table 4.1a shows proximate composition of edible mushrooms per 100g on wet weight basis.

The moisture content of the mushrooms varied from 17.3 – 60.6%, wild and cultivated *Pleurotus tuber-regium* had 17.3% and 18.7%, respectively, wild *Pleurotus ostreatus* had 49.1%, wild *Pholiota mutabilis* had 60.6%, wild *Corprinus disseminatus* and wild *Peziza badioconfusa korf* had 46.6% and 45.5%. respectively. Protein ranged between 10.1 – 33.8g/100g. Wild *Pleurotus tuber-regium* had 31.7g/1100g, cultivated *Pleurotus tuber-regium* had 31.2g/100g, wild *Pholiota mutabilis*had 10.1g/100g, wild *Corprinus disseminatus* had 12.8g/100g) and wild *Peziza badioconfusa korf* had 13.9g/100g. Fat contents were relatively low. It ranged between 0.1 – 0.6g/100g, wild *Pleurotus tuber-regium* contained 0.5g/100g, cultivated *Pleurotus tuber-regium* had 0.6g/100g, wild *Pleurotus ostreatus* had 0.4g/100g, wild *Pholiota mutabilis* contained 0.2g/100g, wild *Corprinus disseminatus* had 0.1g/100g and wild *Peziza badioconfusa korf* had 0.2g/100g. Fibre ranged between 0.5g/100g – 1.3g/100g, wild *Pleurotus tuber-regium* had 1.3g/100g, cultivated *Pleurotus tuber-regium* had 0.5g/100g, wild *Pleurotus ostreatus* had 0.8g/100g, wild *Pholiota mutabilis* had 0.6g/100g, wild *Corprinus disseminatus* and wild *Peziza badioconfusa korf*had 0.6g/100g and 0.7g/100g, respectively. Ash had values that ranged 2.5 – 5.1g/100g, wild *Pleurotus tuber-regium* had 5.1g/100g, cultivated *Pleurotus tuber-regium* had 4.4g/100g, wild *Pleurotus ostreatus* had 2.9g/100g, wild *Pholiota mutabilis*had 2.5g/100g, wild *Corprinus disseminatus*contained 3.1g/100g and wild *Peziza badioconfusa korf* had 2.9g/100g. Carbohydrate varied from 26.1 – 44g/100g, wild and cultivated *Pleurotus tuber-regium* had 44.2g/100g and 42.5/100g, wild *Pleurotus ostreatus* had 33.9g/100g, wild *Pholiota mutabilis* had 26.1g/100g, wild *Corprinus disseminatus* contained 36.7/100g and wild *Peziza badioconfusa korf* had 36.7g/100g. Energy ranged between 146.3 – 308.0kcal/100g, wild and cultivated *Pleurotus tuber-regium* had 304.4kcal and 308.9kcal/100g respectively, wild *Pleurotus ostreatus* had 188.0kcal/100g, wild *Pholiota mutabilis* and *Corprinus disseminatus* had 146.3kcal/100g and 238.3kcal/100g, respectively. *Peziza badioconfusa korf* contained 147.0kcal/100g.

Table 4.1a: Proximate composition of edible mushrooms (per 100g) on wet weight basis

Nutrients	Wild *Pleurotus tuber- regium*	Cultivated *Pleurotus tuber-regium*	Wild *Pleurotus ostreatus*	Wild *Pholiota mutabilis*	Wild *Corprinus disseminatus*	Wild *Peziza badioconfusa korf*
Moisture %	17.3±0.25	18.7±0.07	49.1±0.07	60.6±1.22	46.6±0.1	45.5±1.00
Protein (g)	31.7±0.07	33.8±0.00	13.2±0.00	10.1±0.21	12.8±0.07	13.4±0.00
Fat (g)	0.5±0.07	0.6±0.00	0.4±0.07	0.2±0.07	0.1±0.20	0.2±0.00
Fibre (g)	1.3±0.20	0.5±0.07	0.8±0.00	0.6±0.07	0.6±0.20	0.6±0.23
Ash (g)	5.1±0.01	4.4±0.20	2.9±0.90	2.5±0.10	3.1±0.07	2.1±0.30
Carbohydrate (g)	44.2±0.30	42.5±0.28	33.0±0.22	26.1±0.17	36.7±0.10	36.8±0.25
Energy (kcal)	304.4±1.60	308..9±2.52	188..0±1.50	146..3±2.13	238..3±1.42	147..0±1.00
Energy (KJ)	1308.8	1307.1	800.2	622.8	1013.5	860.8

Means ± standard deviations of three determinations

Table 4.1b shows proximate composition of edible mushrooms per 100g on dry weight basis.

The moisture content of the mushrooms varied from 8.2 – 10.6%, wild *Pleurotus tuber-regium* had 10.6%, cultivated *Pleurotus tuber-regium* had 12.0%, wild *Pleurotus ostreatus* had 8.6%, wild *Pholiota mutabilis* and wild *Corprinus disseminatus* had 9.7% and 8.2% respectively. Wild *Peziza badioconfusa korf* had 9.3%. Protein values on dry weight basis ranged between 22.0 – 35.8g/100g. Wild *Pleurotus tuber-regium* had 34.2g/1100g, cultivated *Pleurotus tuber-regium* contained 35.8g/100g, wild *Pleurotus ostreatus*, wild *Pholiota mutabilis*, wild *Corprinus disseminatus* and wild *Peziza badioconfusa korf* had 24.1g/100g, 23.2g/100g, 22.0g/100g and 23.1g/100g. Fat ranged between 0.1 – 0.7g/100g, wild and cultivated *Pleurotus tuber-regium* had 0.5d/100g and 0.7g/100g respectively. Wild *Pleurotus ostreatus* had 0.6g/100g, wild *Pholiota mutabilis* had 0.4g/100g, wild *Corprinus disseminatus* had 0.1g/100g and wild *Peziza badioconfusa korf* had 0.4g/100g. Fibre had valued that values from 0.5g/100g – 1.4g/100g, wild and cultivated *Pleurotus tuber-regium* had 1.4g/100g and 0.5g/100g respectively, wild *Pleurotus ostreatus* contained 1.4g/100g, wild *Pholiota mutabilis* had 1.3g/100g, wild *Corprinus disseminatus* had 1.0g/100g and wild *Peziza badioconfusa korf* contained 1.1g/100g. Ash ranged between 4.8 – 5.7g/100g, wild *Pleurotus tuber-regium* had 5.5g/100g, cultivated *Pleurotus tuber-regium* had 4.8g/100g, wild *Pleurotus ostreatus* had 5.2g/100g, wild *Pholiota mutabilis* had 5.7g/100g, wild *Corprinus disseminatus* contained 5.4g/100g and wild *Peziza badioconfusa korf* had 4.8g/100g. Carbohydrate values of the mushrooms on dry weight basis also varied from 46.21 – 63.3g/100g, wild and cultivated *Pleurotus tuber-regium* had 47.2g/100g and 46.2g/100g respectively. Wild *Pleurotus ostreatus* had 59.2g/100g, wild *Pholiota mutabilis* and wild *Corprinus disseminatus* contained 59.8g/100g and 65.3g/100g, respectively. Wild *Peziza badioconfusa korf* had 61.1g/100g. Energy values of the mushrooms ranged between 332.1 – 341kcal/100g. Wild and cultivated *Pleurotus tuber-regium* contained 332.1kcal and 334.2kcal/100g respectively, wild *Pleurotus ostreatus* had 337.7kcal/100g, wild *Pholiota mutabilis* had 335.0kcal/100g, wild *Corprinus disseminatus* had 341.2kcal/100g and *Peziza badioconfusa korf* had 340.6kcal/100g.

Table 4.1b: Proximate composition of edible mushrooms (per 100g) on dry weight basis

	Wild *Pleurotus tuber- regium*	**Cultivated *Pleurotus tuber-regium***	**Wild *Pleurotus ostreatus***	**Wild *Pholiota mutabilis***	**Wild *Corprinus disseminatus***	**Wild *Peziza badioconfusa korf***
Moisture %	10.6±0.25	12.0±0.07	8.6±0.10	9.7±1.22	8.2±0.42	9.3±1.00
Protein (g)	34.2±0.07	35.8±0.00	24.1±0.07	23.2±0.21	22.0±0.07	23.1±0.00
Fat (g)	0.5±0.07	0.7±0.00	0.6±0.07	0.4±0.07	0.1±0.20	0.4±0.00
Fibre (g)	1.4±0.20	0.5±0.07	1.4±0.00	1.3±0.07	1.0±0.20	1.1±0.23
Ash (g)	5.5±0.10	4.8±0.20	5.2±0.90	5.7±0.10	5.4±0.07	4.8±0.30
Carbohydrate (g)	47.7±0.30	46.2±0.30	59.2±0.40	59.8±0.40	63.3±0.10	61.1±0.41
Energy (kcal)	332..5±1.41	334.2±1.20	337.4±1.80	335..0±1.47	341..2±1.23	340..6±1.64
Energy (KJ)	1410.3	1416.2	1348.3	1425.8	1453.8	1446.2

Means ± standard deviations of three determinations

Table 4.2a shows mineral composition of edible mushrooms per 100g on wet weight basis.

The calcium content of the mushrooms varied from 86.2 – 370mg/100g, wild *and* cultivated *Pleurotus tuber-regium* had 370mg/100g and 227.5mg/100g respectively, wild *Pleurotus ostreatus* contained 200.4mg/100g, wild *Pholiota mutabilis had 134.6mg/100g,* wild *Corprinus disseminatus* had 198.1mg/100g and wild *Peziza badioconfusa korf* contained 86.2mg/100g. Iron ranged from 0.2 – 3.0mg/100g. Wild and cultivated *Pleurotus tuber-regium* had 1.1mg/100g, wild *Pleurotus ostreatus* had 0.7mg/100g, and wild *Pholiota mutabilis* contained 0.4g/1100g, Wild *Corprinus disseminatus* and wild *Peziza badioconfusa korf* had 1.3mg/100g and 0.2g/100g, respectively. Selenium ranged between 1.9 – 40.8µg /100g. Wild and cultivated *Pleurotus tuber-regium* had 19.7µg/100g and 40.8µg/100g respectively. Wild *Pleurotus ostreatus* contained 11.5µg/100g and 3.0g/100g, respectively, wild *Pholiota mutabilis* had 1.9µg/100g, wild *Corprinus disseminatus* had 20.9µg/100g and wild *Peziza badioconfusa korf* had 29.2µg/100g. Potassium varied from 10.0 – 24.1mg/100g. Wild and cultivated *Pleurotus tuber-regium* had 21.2mg/100g and 19.9mg/100g, respectively. Wild *Pleurotus ostreatus* had 13.2mg/100g, wild *Pholiota mutabilis* had 13.2mg/100g, wild *Corprinus disseminatus* had 11.6mg/100g and wild *Peziza badioconfusa korf* contained 10.0mg/100g. Magnesium ranged between 27.7 – 66.2mg/100g. Wild and cultivated *Pleurotus tuber-regium* had 66.2mg/100g and 62.2mg/100g respectively. Wild *Pleurotus ostreatus* had 37.0mg/100g, wild *Pholiota mutabilis* contained 27.7mg/100g, wild *Corprinus disseminatus* had 43.1mg/100g and wild *Peziza badioconfusa* had 42,8mg/100g. Copper ranged from 32.9 – 199.4 µg/100g. Wild and cultivated *Pleurotus tuber-regium* contained 120µg/100g and 199.4µg/100g, wild *Pleurotus ostreatus* had 78.4µg/100g, wild *Pholiota mutabilis* had 53.0µg/100g, wild *Corprinus disseminatus* had 32.9µg/100g and wild *Peziza badioconfusa korf* had 97.9µg/100g.

Table 4.2a: **Mineral composition of edible mushrooms (per 100g) on wet weights basis**

Minerals	**Wild *Pleurotus tuber- regium***	**Cultivated *Pleurotus tuber-regium***	**Wild *Pleurotus ostreatus***	**Wild *Pholiota mutabilis***	**Wild *Corprinus disseminatus***	**Wild *Peziza badioconfusa korf***
Calcium (mg)	370.3±2.60	227.5±0.20	200.4±16.30	134.6±6.10	198.1±1.00	86.2±4.00
Iron (mg)	1.1±0.70	3.2±0.10	0.7±0.00	0.4±1.70	1.3±0.70	0.2±0.10
Selenium (µg)	19.7±0.70	40.8±0.80	11.5±0.70	1.9±0.70	20.9±2.12	29.2±0.70
Potassium (mg)	21.2±6.60	24.1±0.80	19.9±2.10	13.2±1.00	11.6±1.00	10.0±1.20
Magnesium (mg)	66.2±1.00	62.3±1.53	37.0±0.60	27.7±1.53	43.1±0.60	42.8±0.60
Copper (µg)	120.4±1.00	199.4±0.60	78.4±0.00	53.0±0.60	32.9±0.60	97.9±0.60

Means ± standard deviations of three determinations

Table 4.2b shows mineral composition of edible mushrooms per 100g on dry weight basis.

The calcium content of the mushrooms varied from 143.7 – 402mg/100g, wild and cultivated *Pleurotus tuber-regium* contained 402.0mg/100g and 246.2mg/100g respectively, wild *Pleurotus ostreatus* had 358.0mg/100g, wild *Pholiota mutabilis* had 306.6mg/100g, wild *Corprinus disseminatus* had 341mg/100g and wild *Peziza badioconfusa korf* contained 143.7mg/100g. Iron ranged from 0.3 – 3.2mg/100g. Wild *Pleurotus tuber-regium* had 1.2mg/100g, cultivated *Pleurotus tuber-regium* contained 3.0mg/100g, wild *Pleurotus ostreatus* had 1.2mg/100g and wild *Pholiota mutabilis* had 0.8mg/100g, Wild *Corprinus disseminatus* and wild *Peziza badioconfusa korf* contained 2.3mg/100g and 0.3mg/100g, respectively. Selenium ranged between 4.5 – 48.7µg/100g). Wild and cultivated *Pleurotus tuber-regium* had 21.4µg/100g and 44.3µg/100g respectively. Wild *Pleurotus ostreatus* had 4.5µg/100g and wild *Pholiota mutabilis* contained 20.5µg/100g, wild *Corprinus disseminatus* had 36.2µg/100g and wild *Peziza badioconfusa korf* contained 16.7µg/100g. Potassium varied from 16.7 – 35.7mg/100g. Wild *Pleurotus tuber-regium* had 23.0mg/100g, cultivated *Pleurotus tuber-regium* had 26.3mg/100g, Wild *Pleurotus ostreatus* contained 35.7mg/100g while wild *Pholiota mutabilis* had 30.0mg/100g, wild *Corprinus disseminatus* contained 20.0mg/100g and wild *Peziza badioconfusa korf* had 16.7mg/100g. Magnesium ranged between 63.7 – 74.3mg/100g. Wild *Pleurotus tuber-regium* had 72.0mg/100g, and cultivated *Pleurotus tuber-regium* contained 67.7mg/100g of magnesium. Wild *Pleurotus ostreatus* had 66.0mg/100g, wild *Pholiota mutabilis* had 63.7mg/100g, and wild *Corprinus disseminatus* had 74.3mg/100g. Wild *Peziza badioconfusa* contained 71.3mg/100g of magnesium. Copper ranged from 56.7 – 216.7µg/100g. Wild and cultivated *Pleurotus tuber-regium* had 130.0µg/100g and 216.7µg/100g, respectively. Wild *Pleurotus ostreatus* had 140.0µg/100g, and wild *Pholiota mutabilis* had 120.3µg/100g, wild *Corprinus disseminatus* contained 56.7µg/100g and wild *Peziza badioconfusa korf* had 163.3µg/100g.

Table 4.2b: **Mineral composition of edible mushrooms (per 100g) on dry weights basis**

Minerals	**Wild *Pleurotus tuber- regium***	**Cultivated *Pleurotus tuber-regium***	**Wild *Pleurotus ostreatus***	**Wild *Pholiota mutabilis***	**Wild *Corprinus disseminatus***	**Wild *Peziza badioconfusa korf***
Calcium (mg)	402.0±2.60	246.2±0.20	358.0±16.30	306.6±6.10	341.0±1.00	143.7±4.00
Iron (mg)	1.2±0.70	3.2±0.10	1.2±0.00	0.8±1.70	2.3±0.70	0.3±0.10
Selenium (µg)	21.4±0.70	44.3±0.80	20.5±0.70	4.5±0.70	36.2±2.12	48.7±0.70
Potassium (mg)	23.0±2.60	26.3±0.80	35.7±2.10	30.0±1.00	20.0±1.00	16.7±1.70
Magnesium (mg)	72.0±1.00	67.7±1.53	66.0±0.60	63.7±1.53	74.3±0.60	71.3±0.60
Copper (µg)	130.0±1.00	216.7±0.60	140.0±0.00	120.3±0.60	56.7±0.60	163.3±0.60

Means ± standard deviations of three determinations

Table 4.3a shows vitamin composition of edible mushrooms per 100g on wet weight basis.

Vitamin C content of the mushroom ranged between 0.2 – 9.70mg/100g. Wild and cultivated *Pleurotus tuber-regium* had 3.02mg/100g and 9.70mg/100g, respectively. Wild *Pleurotus ostreatus* had 1.9mg/100g, wild *Pholiota mutabilis* contained 17.6mg/100g, wild *Corprinus disseminatus* had 1.25mg/100g and wild *Peziza badioconfusa korf* had 0.02mg/100g. Folic acid varried from 1235 – 2438.00µg/100g. Wild and cultivated *Pleurotus tuber-regium* contained 2300.00µg/100g and 2484µg/100g, respectively. Wild *Pleurotus ostreatus*, wild *Pholiota mutabilis* and wild *Corprinus disseminatus* had 1456.00µg/100g, 1936.00µg/100g and 1235µg/100g. Wild *Peziza badioconfusa korf* had 2040.00µg/100g. Thiamin ranged from 0.04 – 0.32mg/100g. Wild and cultivated *Pleurotus tuber-regium* contained 0.09mg/100g and 0.09mg/100g, respectively. Wild *Pleurotus ostreatus* had 0.11mg/100g, wild *Pholiota mutabilis* had 0.04mg/100g, wild *Corprinus disseminatus* had 20.19mg/100g and wild *Peziza badioconfusa korf* had 0.32mg/100g. Riboflavin varied from 0.13 – 0.35mg/100g, wild and cultivated *Pleurotus tuber-regium* had 0.21mg/100g and 0.18mg/100g, respectively, wild *Pleurotus ostreatus,* wild *Pholiota mutabilis,* wild *Corprinus disseminatus* and wild *Peziza badioconfusa korf* contained 0.22mg/100g, 0.13mg/100g, 0.29mg/100g, and 0.36mg/100g. Niacin varied from 0.32 – 0.86mg/100g. Wild and cultivated *Pleurotus tuber-regium* had 0.86mg/100g, respectively. Wild *Pleurotus ostreatus* had 0.39mg/100g, wild *Pholiota mutabilis* had 0.36mg/100g, wild *Corprinus disseminatus* had 0.37mg/100g and wild *Peziza badioconfusa korf* had 0.32mg/100g. Vitamin B_{12} ranged between 1.85 – 4.23mg/100g. 4.23mg/100g of vitamin B12 were present in both wild and cultivated *Pleurotus tuber-regium*. Wild *Pleurotus ostreatus* had 2.02mg/100g, wild *Pholiota mutabilis* contained 1.85mg/100g, wild *Corprinus disseminatus* had 2.50mg/100g and wild *Peziza badioconfusa korf* had 22.2mg/100g. Vitamin E had values that ranged from 16.23–33.40(mg)αTE/100g, Wild and cultivated *Pleurotus tuber-regium* contained 33.4(mg)αTE/100g and 28.52mg(αTE/100g), respectively. Wild *Pleurotus ostreatus* had 21.6(mg)αTE/100g, wild *Pholiota mutabilis* had 16.2(mg)αTE/100g, wild *Corprinus disseminatus* had 21.68(mg)αTE/100g and wild *Peziza badioconfusa korf* contained 25.20(mg)αTE/100g.

Table 4.3a: Vitamin composition of edible mushrooms (per 100g) on wet weights basis

Mineral and Vitamins	Wild *Pleurotus tuber- regium*	Cultivated *Pleurotus tuber-regium*	Wild *Pleurotus ostreatus*	Wild *Pholiota mutabilis*	Wild *Corprinus disseminatus*	Wild *Peziza badioconfusa korf*
Vitamin C (mg)	3.02±0.20	9.70±0.10	1.90±0.35	1.76±1.13	1.24±0.07	0.20±0.07
Folic Acid (µg)	2300.00±0.12	2480.00±0.70	1456.00±0.0	1936.00±0.21	1235.00±0.07	2040.00±0.12
Thiamine (mg)	0.09±0.00	0.90±0.00	0.11±0.00	0.04±0.00	0.19±0.07	0.32±0.07
Riboflavin (mg)	0.21±0.07	0.18±0.00	0.22±0.07	0.13±0.10	0.29±0.10	0.36±0.07
Niacin (mg)	0.86. ±0.07	0.86±0.07	0.39±0.10	0.36±0.07	0.37±0.07	0.32±0.07
Vitamin B_{12} (mg)	4.23±0.10	4.23±0.07	2.02±0.20	1.85±0.07	2.50±0.07	2.22±0.16
Vitamin E (mg) αTE	33.40±0.70	28.52±1.00	21.61±0.00	16.28±1.00	16.63±1.60	25.20±1.00

Means ± standard deviations of three determinations

Table 4.3b shows vitamin composition of edible mushrooms per 100g on dry weight basis.

Vitamin C content of the mushroom ranged between 0.33 – 10.50mg/100g. Wild and cultivated *Pleurotus tuber-regium* had 3.14mg/100g and 10.50mg/100g, respectively. Wild *Pleurotus ostreatus* had 3.40mg/100g, wild *Pholiota mutabilis,* wild *Corprinus disseminatus* and wild *Peziza badioconfusa korf* had 4.00mg/100g, 2.13mg/100g and 0.33mg. Folic acid varied from 1230.00 – 4400.00µg/100g. Wild and cultivated *Pleurotus tuber-regium* contained 2500.00µg/100g and 2700.00µg/100g, respectively. Wild *Pleurotus ostreatus* had 2600.00µg/100g, wild *Pholiota mutabilis* contained 4400.00µg/100g, wild *Corprinus disseminatus* had 2130.00µg/100g, and wild *Peziza badioconfusa korf* contained 3440.00µg/100g. Thiamin ranged from 0.10 – 0.53mg/100g. Wild and cultivated *Pleurotus tuber-regium* contained 0.10mg/100g and 1.11mg/100g, respectively. Wild *Pleurotus ostreatus* had 0.20mg/100g, wild *Pholiota mutabilis* contained 0.10mg/100g, wild *Corprinus disseminatus* had 0.33mg/100g and wild *Peziza badioconfusa korf* contained 0.6mg/100g. Riboflavin varied from 0.20 – 0.60mg/100g, wild and cultivated *Pleurotus tuber-regium* had 0.23mg/100g and 0.20mg/100g, respectively, wild *Pleurotus ostreatus,* 0.40mg/100g, wild *Pholiota mutabilis* had 0.30mg/100g, wild *Corprinus disseminatus* and wild *Peziza badioconfusa korf* had 0.5mg/100g and 0.60mg/100g. Niacin varied from 0.53 – 0.93mg/100g. Wild and cultivated *Pleurotus tuber-regium* contained 0.93mg/100g, respectively. Wild *Pleurotus ostreatus* and wild *Pholiota mutabilis* contained 0.70mg/100g and 0.83mg/100g, respectively. Wild *Corprinus disseminatus* had 0.64mg/100g and wild *Peziza badioconfusa korf* had 0.53mg/100g. Vitamin B_{12} ranged between 3.60–4.70mg/100g. Wild *Pleurotus tuber-regium* had 4.70mg/100g and cultivated *Pleurotus tuber-regium* had 4.60mg/100g, respectively. Wild *Pleurotus ostreatus* contained 3.60mg/100g, wild *Pholiota mutabilis* had 4.20mg/100g, wild *Corprinus disseminatus* had 4.30mg/100g and wild *Peziza badioconfusa korf* had 3.70mg/100g. Vitamin E had values that ranged from 31.00 – 4.20(mg)αTE/100g, wild and cultivated *Pleurotus tuber-regium* had 36.30mg(αTE/100g) and 31.00(mg)αTE/100g, respectively. Wild *Pleurotus ostreatus* contained 38.60mg(αTE/100g), wild *Pholiota mutabilis* had 37.00(mg)αTE/100g, wild *Corprinus disseminatus* contained 37.30(mg)αTE/100g and wild *Peziza badioconfusa korf* had 42.00(mg)αTE/100g.

Table 4.3b: Vitamin composition of edible mushrooms (per 100g) on dry weights basis

	Wild *Pleurotus tuber- regium*	**Cultivated *Pleurotus tuber-regium***	**Wild *Pleurotus ostreatus***	**Wild *Pholiota mutabilis***	**Wild *Corprinus disseminatus***	**Wild *Peziza badioconfusa korf***
Vitamin C (mg)	3.14±0.20	10.50±0.10	3.40±0.33	4.00±1.13	2.13±0.07	0.33±0.07
Folic Acid (μg)	2500.00±0.12	2700.00±0.07	2600.00±0.07	4400.00±0.21	2130.00±0.07	3400.00±0.12
Thiamine (mg)	0.10±0.00	0.10±0.00	0.20±0.00	0.10±0.00	0.33±0.07	0.53±0.07
Riboflavin (mg)	0.23±0.07	0.20±0.00	0.40±0.07	0.30±0.10	0.50±0.10	0.60±0.07
Niacin (mg)	0.93±0.07	0.93±0.09	0.70±0.10	0.83±0.07	0.64±0.07	0.53±0.07
Vitamin B_{12} (mg)	4.70±0.10	4.60±0.09	3.60±0.20	4.20±0.07	4.30±0.07	3.70±0.16
Vitamin E (mg) αTE	36.30±0.70	31.00±1.00	38.60±0.00	37.00±1.00	37.30±1.60	42.00±1.00

Means ± standard deviations of three determinations

Table 4.4 shows the phytochemicals present in the cultivated edible mushroom (*Pleurotus tuber-regium*). Flavonoids, steroids, saponis and resins were abundantly present. Terpenoid was moderately present. Alkaloid and glycosides were present in small quantity while tannins was absent.

Table 4.4: Phytochemical present in edible mushroom flour (*Pleurotus tuber-regium*)

Secondary metabolite	Relative abundance
Alkaloids	+
Flavonoids	+++
Glycosides	+
Steroids	+++
Saponins	+++
Tannins	-
Terpenoids	++
Resins	+++

- = *absent*, + = *present in small quantity*, ++ = *moderately present*, +++ = *abundantly present*

Table 4.5 Shows Energy and proximate composition of wheat buns fortified with cultivated mushrooms (*Pleurotus tuber-regium)* (per 100g as consumed)

Moisture and fat content decreased with about 7.0% and 6.1% respectively after fortification while protein and carbohydrate increased moderately by over 20%. Percentage increase in energy was very minimal (about 4%).

Table 4.5: Energy and proximate composition of wheat buns fortified with cultivated *Pleurotus tuber-regium flour* (per 100g as consumed)

Nutrient	**Wheat buns control (WBM_o)**	**Fortified wheat buns (WBM_{60})**	**Percentage Increase**
Moisture %	11.4	10.6	
Protein (g)	8.4	10.3	22.6%
Fat(g)	14.7	13.8	
Crude fiber(g)	0.7	0.8	1.4%
Carbohydrate(g)	11.4	13.8	21.0%
Energy (kcal)	211.6	220.2	4.1%
Energy (KJ)	811.6	918.5	4.8%

WBM_o – Wheat buns without mushroom flour
WBM_{60} – Wheat buns fortified with 60g mushroom flour

Table 4.6 shows the mineral and vitamin composition of wheat buns fortified with cultivated mushrooms (*Pleurotus tuber-regium*) (per 100g as consumed)

There were marked increases in copper (>700%), selenium (>50%), folic acid (130%), vitamin B_{12} (>300) and vitamin E (>200%). There were slight increases in calcium (19.5%), Iron (2.8%), vitamin C (32.1%), Thiamin (5.0%), Riboflavin (16.7%) and Niacin (5.3%.

Table 4.6: Mineral and vitamin composition of wheat buns fortified with cultivated *Pleurotus tuber-regium* (per 100g as consumed)

Mineral and Vitamins	Wheat buns control (WBM_o)	Fortified wheat buns (WBM_{60})	Percentage Increase
Calcium (mg)	65.2	77.9	19.5%
Iron (mg)	2.11	2.17	2.8%
Selenium (µg)	32.9	49.7	51.1%
Copper (µg)	1.6	13.4	725.0%
Vitamin C (mg)	1.8	2.5	32.1%
Folic acid (µg)	136.4	324.8	138.1%
Thiamin (mg)	2.10	2.20	5.0%
Riboflavin (mg)	0.06	0.07	16.7%
Vitamin B_{12}(mg)	0.00	3.13	313.0%
Vitamin E(mg)αTE	0.85	2.8	240.0%
Niacin (mg)	1.31	1.38	5.3%

WBM_o – Wheat buns without mushroom flour
WBM_{60} – Wheat buns fortified with 60g mushroom flour

Table 4.7 shows contribution of wheat buns fortified with cultivated mushrooms (*Pleurotus tuber-regium)* per 100g as consumed to mineral and vitamin intakes of pre-school (2-5years) and school children (6-10years).

For pre-school children 100g of wheat buns fortified with mushroom (*Pleurotus tuber-regium*) can contribute over 260% of selenium, more than 550% of vitamin B_{12}, over 400% of thiamine and folic acid over 180% of the requirements. It can contribute about 53.6% of iron and more than a third of vitamin E requirement for pre-school children. It can only provide 20% niacin and 14.2% calcium requirements of pre-school children.

For school children it provided over 360% of vitamin B_{12} and over or more than 250% of selenium and thiamin. It contributed over 100% of folic acid and can also provided more than or a third of iron and vitamin E requirements. Only 8.2% calcium 8.2%, 3.6% of copper, 8.5% of riboflavin and 11.7% of niacin requirements were met by wheat bun fortified with cultivated *Pleurotus tuber-regium* flour

Table 4.7: Table 4.7: Contributed of fortified wheat buns to mineral and vitamin intakes of pre-school (PSC) and school children (SC)

Mineral & Vitamins	aPre-school children RNI (2-5yrs)	aSchool children RNI (6-10yrs)	Wheat buns control (WBM_0)	aPre-school children RNI percentage met	aSchool children RNI percentage met	Fortified wheat buns (WBM_{60})	aPre-school children RNI percentage met	aSchool children RNI percentage met
Calcium (mg)	500-600mg/day	600-1300µg/day	65.2	11.9%	6.9%	77.9	14.2%	8.2%
Iron (mg)	3.9-4.2mg/day	4.2-5.9mg/day	2.11	52.1%	41.8%	2.17	53.6%	43.0%
Selenium (µg)	18.5mg/day	21.5µg/day	32.9	177.8%	153.0%	49.7	268.6%	231.1%
Copper (µg)	200-220µg/day	340-400µg/day	1.6	0.8%	0.4%	13.4	6.4%	3.6%
Folic acid (µg)	160-200µg/day	200-400µg/day	136.4	75.5%	45.5%	324.8	180.4%	108.2%
Thiamin (mg)	0.5-0.6/day	0.6-1.1mg/day	2.10	382.0%	247.1%	2.2	400%	258.8%
Riboflavin (mg)	0.5-0.6mg/day	0.6-1.0mg/day	0.06	10.9%	7.5%	0.07	12.7%	8.8%
Niacin (mg)	6-8mg/day	8-16mg/day	1.31	18.7%	10.9%	1.4	20.0%	11.7%
Vitamin B_{12}(mg)	0.5-0.6mg/day	0.6-1.1mg/day	0.00	0.0%	0.0%	3.1	563.6%	364.5%
Vitamin E (mg)αTE	6-7mg (αTE)/day	7-11mg(αTE)/day	0.9	13.8%	10.0%	2.8	43.1%	31.1%

a: Source: FAO/WHO/RNI (2002)
RNI: Recommended Nutrient Intake
WBM_0: Wheat buns without mushroom flour
WBM_{60}: Wheat buns fortified with 60g mushroom (cultivated Pleurotus tuber-regium) flour

Table 4.8 shows contribution of wheat buns fortified with cultivated mushrooms (*Pleurotus tuber-regium*) to the protein and energy intakes of pre-school (2-5 years) and school children (6-10 years).

For pre-school children 100g of wheat buns fortified with cultivated mushroom flour can provide over 60% of daily requirement for protein and over or more than 14% for energy. For school children it can provide over 40% of daily protein requirement and only about 10% of energy requirement.

Table 4.8: Contribution of fortified wheat buns to protein and energy intakes of Pre-School and School children

Protein and energy	**aPre-school children (2-5yrs)**	**aSchool children RNI (6-10yrs)**	**Wheat buns control (WBM_0)**	**aPre-school children RNI percentage met**	**aSchool children RNI percentage met**	**Fortified wheat buns (WBM_{60})**	**aPre-school children RNI percentage met**	**aSchool children RNI percentage met**
Protein	15.5g/day	24g/day	8.4	54.1%	35.1%	10.3	66.5%	42.9%
Energy (Kcal)	1550kcal/day	2100kcal/day	211..6	13.6%	10.1%	220.2	14.2%	10.5%
Energy (KJ)	6500kj/day	8800kj/day	811.1	12.5%	9.2%	910.5	14.0%	10.3%

a: Source: FAO/WHO/RNI (2002)
RNI: Recommended Nutrient Intake
WBM_o – Wheat buns without mushroom (Pleurotus) flour
WBM_{60} – Wheat buns fortified with 60g mushroom (Pleurotus) flour

Table 4.9 shows energy and proximate composition of *Agidi jollof* fortified with cultivated *Pleurotus tuber-regium* (per 100g) as consumed.

Moisture increased by 0.5% after fortification. Protein increased by >20%, Crude fiber by 14.2% and energy by 3.8%KJ. Carbohydrate increased slightly by 3.8% while fat decreased by 2.1%.

Table 4.9: Energy and proximate composition of *Agidi jollof* fortified with 60g cultivated *Pleurotus tuber-regium* flour (per 100g as consumed)

Nutrients	Agidi jollof control (AJM_o)	Agidi jollof fortified (AJM_{60})	Percentage increase
Moisture %	20.6	20.7	0.5%
Protein (g)	6.3	7.9	25.4%
Fat (g)	9.5	9.3	
Crude fiber (g)	0.7	0.8	14.2%
Carbohydrate (g)	36.8	38.2	3.8%
Energy (Kcal)	259.6	269.4	3.8%
Energy (KJ)	1084.2	1127.8	4.0%

AJM_o – Agidi jollof without mushroom (Pleurotus) flour
AJM_{60} – Agidi jollof fortified with 60g mushroom (Pleurotus) flour

Table 4.10 shows mineral and vitamin composition of *Agidi jollof* fortified with cultivated *Pleurotus tuber-regium* flour (per 100g as consumed).

There were marked increases in calcium (43.0%) selenium (61.1%), folic acid (>350%)) vitamin B_{12} (77.8%) and vitamin E (281.1%). There were fair increases in vitamin C (25.5%) copper (16.1%) and iron (5.9%). There was no increase observed in thiamin and riboflavin.

Table 4.10: Mineral and vitamin composition of *Agidi jollof* fortified with cultivated *Pleurotus tuber-regium* flour (per 100g as consumed)

Minerals and vitamins	Agidi jollof(control) AJM_o	Fortified Agidi jollof AJM_{60}	Percentage increase
Calcium (mg)	17.8	28.4	43.0%
Iron (mg)	1.7	1.8	(5.9%)
Selenium (μg)	3.6	5.8	61.1%
Copper (μg)	56.5	65.6	16.1%
Vitamin C (mg)	1.85	2.32	25.4%
Folic acid (μg)	24.13	114.54	374.7%
Thiamin (mg)	1.6	1.60	0.0%
Riboflavin (mg)	0.08	0.08	0.0%
Niacin (mg)	0.92	1.01	9.8%
Vitamin B_{12} (mg)	0.27	0.48	77.8%
Vitamin E (mg)αTE	0.52	2.02	281.1%

AJM_o – Agidi jollof without mushroom flour
AJM_{60} – Agidi jollof fortified with 60g mushroom flour (Pleurotus tuber-regium)

Table 4.11 shows contribution of *Agidi jollof* fortified with mushroom (cultivated *Pleurotus tuber-regium)* flour (Per 100g as consumed) to the mineral and vitamin intakes of pre-school (2-5 years) and school children (6-10years).

For pre-school children 100g of *Agidi jollof* fortified with mushroom (*Pleurotus tuber-regium)* contributed about 200% of the thiamin, 90% of vitamin B_{12} and about 64% of the folic acid. It contributed over 44% of the iron and about a third of the selenium and vitamin E requirements. The contribution to riboflavin and niacin was only about 14%, while it was only 9% for calcium. For school children, it furnished 200% of thiamin, 55% of B_{12}, 20% of vitamin E, 27% of selenium, 31% of iron and 38.2% of folic acid requirements. Its contribution to iron 36%, riboflavin (10%) and niacin (8.4%) were minimal.

Table 4.11: Contribution of *Agidi jollof* fortified with mushroom to the mineral and vitamin intakes of pre-school and school children

Mineral and Vitamin	aPre-school children (2-5yrs)	aSchool children RNI (6-10yrs)	Agidi jollof control (AJM_0)	aPre-school children RNI percentage met	aSchool children RNI percentage met	Fortified Agidi jollof (AJM_{60})	aPre-school children RNI percentage met	aSchool children RNI percentage met
Calcium (mg)	500-600mg/day	600-1300mg/day	16.9	3.1%	1.8%	28.4	9.2%	3.0%
Iron (mg)	3.9-4.2mg/day	4.2-5.9mg/day	1.7	41.9%	33.7%	1.8	44.4%	(36.0%
Selenium (µg)	18.5mg/day	21.5µg/day	3.6	19.5%	16.7%	5.8	31.4%	26.9%
Copper (µg)	200-220µg/day	340-400µg/day	56.5	26.9%	17.7%	65.6	31.2%	17.7%
Folic acid (µg)	160-200µg/day	200-400µg/day	24.13	13.4%	8.0%	114.54	63.6%	38.2%
Thiamin (mg)	0.5-0.6/day	0.6-1.1mg/day	1.60	290.9%	188.2%	1.60	290.9%	168.2%
Riboflavin (mg)	0.5-0.6mg/day	0.6-1.0mg/day	0.08	14.5%	10.0%	0.08	14.5%	10.0%
Niacin (mg)	6-8mg/day	8-16mg/day	0.92	13.1%	7.7%	1.01	14.4%	8.4%
Vitamin B_{12} (mg)	0.5-0.6mg/day	0.6-1.2mg/day	0.27	49.0%	30.0%	0.5	90.0%	55.0%
Vitamin E (mg)αTE	6-7(mg)αTE/day	7-11(mg) αTE/day	0.53	8.2%	5.8%	2.02	31.0%	(20%

a: Source: FAO/WHO/RNI (2002)
RNI: Recommended Nutrient Intake
AJM_o – Agidi jollof without mushroom flour
AJM_{60} – Agidi jollof fortified with 60g mushroom flour (Pleurotus tuber-regium)

Table 4.12 shows contributions of *Agidi jollof* fortified with cultivated mushroom *(Pleurotus tuber-regium)* flour to the protein and energy intakes of pre-school (2-5years) and school children (6-10years).

For pre-school children 100g of *Agidi jollof* fortified with *Pleurotus tuber-regium* flour contributed 50% of protein requirement but only a fair percentage of the energy requirement about 17% per day. For school children it provided over a third (32.9%) of the protein requirement. It also furnish about 12.8% of energy per day.

Table 4.12: Contributions of *Agidi jollof* fortified with cultivated mushroom *(Pleurotus tuber-regium)* flour to the protein and energy intakes of pre-school and school children.

Nutrients	aPre-school children (2-5yrs)	aSchool children RNI (6-10yrs)	Agidi Jollof control (AJM_0)	aPre-school children RNI percentage met	aSchool children RNI percentage met	Fortified Agidi Jollof(AJM_{60})	aPre-school children RNI percentage met	aSchool children RNI percentage met
Protein	15.5g/day	24g/day	6.3	40.0%	26.3%	7.9	50.1%	32.9%
Energy (Kcal)	1550kcal/day	2100kcal/day	259.6	16.7%	12.4%	269.4	17.4%	12.8%
Energy (KJ)	6500kj/day	8800kj/day	1084.2	16.7%	12.6%	1127.8	17.4%	13.1%

a: Source: FAO/WHO/UNU (1985) Energy and Protein Requirement
RNI: Recommended Nutrient Intake
AJM_o – Agidi jollof without mushroom flour
AJM_{60} – Agidi jollof fortified with 60g mushroom flour (Pleurotus tuber-regium)

Table 4.13 shows the energy and proximate composition of cocoyam buns fortified with cultivated *Pleurotus tuber-regium* flour (per 100g as consumed).

There were slight decreases in the moisture and fiber content of the snack. Protein increased by 89.3%; fat by >20% and carbohydrate decreased by 6.5% while energy increased 21.5%.

Table: 4.13: Energy and proximate composition of cocoyam buns fortified with cultivated *Plurotus tuber-reguim* flour (Per 100g as consumed)

Nutrients	Cocoyam buns control (CBM_o)	Fortified cocoyam buns (CBM_{60})	Percentage increase
Moisture %	40.8	35.5	
Protein (g)	1.97	3.73	89.3%
Fat (g)	24.5	29.5	20.3%
Crude fiber(g)	0.79	0.71	
Carbohydrate (g)	31.0	29.0	
Energy (kcal)	330.0	401.0	21.5%
Energy (KJ)	1378	1676.0	21.6%

CBM_o – cocoyam buns without mushroom flour
CBM_{60} – Cocoyam buns fortified with 60g mushroom flour (Pleurotus tuber-regium)

Table 4.14 shows mineral and vitamin composition of cocoyam snacks (buns) fortified with cultivated *Pleurotus tuber-regium* flour (per 100g as consumed).

There were marked increase in selenium content (91.5%), copper (104.4%), folic acid (>700%), niacin (34.8%), vitamin B_{12} (26.0%) and vitamin E (>200%). There were fair increase in calcium (3.5%) and slight decrease in thiamin and riboflavin contents of the snacks.

Table 4.14: Mineral and vitamin composition of the fortified cocoyam buns

Minerals and vitamins	Cocoyam buns control (CBM_0)	Fortified cocoyam buns (CBM_{60})	Percentage Increase
Calcium (mg)	84.73	84.76	3.5%
Iron (mg)	2.16	2.03	
Selenium (μg)	2.36	4.52	91.5%
Copper (μg)	10.38	21.22	104.4%
Folic acid (μg)	21.10	171.95	714.9%
Thiamin (mg)	0.21	0.18	
Riboflavin (mg)	0.31	0.12	34.8%
Niacin (mg)	0.66	0.89	
Vitamin B_{12} (mg)	0.0	0.26	26.0%
Vitamin E (mg)αTE	0.25	0.77	208.0%

CBM_0 – Cocoyam buns without mushroom
*CBM_{60} – Cocoyam buns fortified with 60g mushroom flour (*cultivated *Pleurotus tuber-regium).*

Table 4.15 shows contribution of cocoyam buns fortified with cultivated mushrooms (*Pleurotus tuber-regium*) to the mineral and vitamin intakes of pre-school (2-5 years) and school children (6-10 years).

For pre-school children 100g of cocoyam buns fortified with *pleurotus* flour can contribute over a third of the iron, thiamin, vitamin B_{12}. 96% of folic acid and over one fifth of iron (24%), riboflavin (22%) selenium 50.1% requirements. For school children it provided about a third or more of selenium (40.2%), a fifth of thiamin(21.2%), selenium (21%), vitamin B_{12} (29%) and (57.3%) of folic acid requirement. Calcium, copper, niacin and vitamin E were less than 10%.

Table 4.15: Contribution of cocoyam buns fortified with cultivated *Pleurotus tuber-regium* flour to the mineral and vitamin intakes of pre-school and school children.

Mineral and Vitamin	aPre-school children (2-5yrs)	aSchool children RNI (6-10yrs)	Cocoyam buns control (WBM_0)	aPre-school children RNI percentage met	aSchool children RNI percentage met	Fortified cocoyam buns (WBM_{60})	aPre-school children RNI percentage met	aSchool children RNI percentage met
Calcium (mg)	500-600mg/day	600-1300µg/day	84.73	15.4%	(8.9%	84.76	15.4%	9.0%
Selenium (µg)	18.5mg/day	21.5µg/day	2.36	53.3%	42.7%	2.03	50.1%	40.2%
Iron (mg)	3.9-4.2mg/day	4.2-5.9mg/day	2.16	12.8%	11.0%	4.52	24.4%	21.0%
Copper (µg)	200-220µg/day	340-400µg/day	10.38	4.9%	2.8%	21.22	10.1%	5.7%
Folic acid (µg)	160-200µg/day	200-400µg/day	21.10	11.7%	17.0%	171.95	96.0%	57.3%
Thiamin (mg)	0.5-0.6/day	0.6-1.1mg/day	0.21	58.2%	24.7%	0.18	32.7%	21.2%
Riboflavin (mg)	0.5-0.6mg/day	0.6-1.0mg/day	0.31	56.3%	38.7%	0.12	22.0%	15.0%
Niacin (mg)	6-8mg/day	8-16mg/day	0.66	9.4%	5.5%	0.89	12.7%	7.4%
Vitamin B_{12} (mg)	0.5-0.6mg/day	0.6-1.2mg/day	0.00	0.00%	0.00%	0.26	47.3%	29.0%
Vitamin E (mg)αTE	6-7(mg)αTE/day	7-11(mg)αTE/day	0.25	3.8%	2.8%	0.77	12.0%	9.0%

a: Source: FAO/WHO/RNI (2002)
RNI: Recommended Nutrient Intake
CBM_0 – Cocoyam buns without mushroom
CBM_{60} – Cocoyam buns fortified with 60g mushroom flour (cultivated *Pleurotus tuber-regium).*

Table 4.16 shows contribution of cocoyam snack fortified with cultivated mushroom (*Pleurotus tuber-regium*) flour to the protein and energy intakes of preschool and school children.

For pre-school children 100g of cocoyam buns fortified with cultivated mushroom (*pleurotus)* can provide over 20% of daily protein requirement and over 25% of energy requirements. For school child, it will provide more than 15% of daily protein requirement and above 19% of the daily energy requirement.

Table 4.16: Contribution of cocoyam buns fortified with cultivated *Pleurotus tuber-requim* flour (per 100g to the protein and energy intakes of the pre-school and school children

Nutrient	aPre-school children (2-5yrs)	aSchool children RNI (6-10yrs)	Cocoyam buns control (CBM_0)	aPre-school children RNI percentage met	aSchool children RNI percentage met	Fortified cocoyam buns (CBM_{60})	aPre-school children RNI percentage met	aSchool children RNI percentage met
Protein	15.5g/day	24g/day	1.97	12.7%	8.2%	3.73	24.1%	15.5%
Energy (Kcal)	1550kcal/day	2100kcal/day	330	21.3%	15.7%	401.0	25.9%	19.1%
Energy (KJ)	6500kj/day	8800kj/day	137.8	21.2%	15.7%	167.6	25.8%	19.1%

a: Source: FAO/WHO/RNI (1985) Energy and Protein Requirement
RNI: Recommended Nutrient Intake
CBM_0 – Cocoyam buns without mushroom
*CBM_{60} – Cocoyam buns fortified with 60g mushroom flour (*cultivated *Pleurotus tuber-regium).*

Table 4.17 shows the means ± standard deviations of the sensory evaluation scores of wheat buns, *Agidi jollof* and cocoyam buns fortified with different levels of edible mushroom flour.

There were no significant (P>0.05) differences in the organoleptic attributes of the control wheat buns and those fortified with the different levels of edible mushroom flours. Their degrees of likeness (slightly to moderately liked were statistically similar even though the control had slightly higher scores in almost all the attributes except for the colour).

For *Agidi jollof* the colour, texture, flavour and the general acceptability were statistically (P<0.05) similar for the control as well as the fortified products. However the *Agidi jollof* fortified with 60g of mushroom flour had equal or higher scores for all the attributes and compares favourably with the control. The degree of likeness for both the control and *Agidi jollof* fortified with 60g mushroom flour was rated as like slightly, while the products fortified with 20g and 40g, ranged from neither liked nor disliked to liked slightly.

The colour, flavour and the general acceptability of the buns were not statistically different (P>0.05). The colour rated between 6.80 – 7.45 which denoted liked slightly and liked moderately. The flavour was rated between 6.85 - 7.95 which signifies between liked slightly and liked moderately. The general acceptability ranged between 6.30 - 7.55 scores which refer to like moderately.

There were significant (P<0.05) different in the texture of the cocoyam buns. Cocoyam buns fortified with 60g of mushroom flour had a significant higher score (7.55, liked moderately than the control (6.40) slightly liked), and cocoyam buns fortified with 20g mushroom flour (5.70 neither liked nor disliked).

Table 4.17: Organoleptic properties of wheat buns fortified with edible mushroom flours (*Pleurotus tuber-regium*)

	Colour	Texture	Flavour	General Acceptability
Wheat buns (control) (WBM_{0})	$7.35^{a}\pm1.35$	$7.20^{a}\pm1.77$	$7.65^{a}\pm1.09$	$6.80^{a}\pm1.85$
Wheat buns (WBM_{20})	$7.55^{a}\pm1.88$	$6.60^{a}\pm2.04$	$7.55^{a}\pm1.28$	$6.70^{a}\pm1.84$
Wheat buns (WBM_{40})	$7.30^{a}\pm2.27$	$6.60^{a}\pm2.16$	$6.95^{a}\pm2.67$	$6.70^{a}\pm2.06$
Wheat buns (WBM_{60})	$7.10^{a}\pm1.59$	$6.55^{a}\pm2.09$	$7.00^{a}\pm2.05$	$6.60^{a}\pm2.09$
LSD(0.05)	1.13	1.18	1.27	1.23
Agidi jellof				
Agidi jellof (control) (AJM_{0})	$6.05^{a}\pm2.91$	$6.20^{a}\pm1.28$	$6.75^{a}\pm1.86$	$5.65^{a}\pm2.01$
Agidi jellof (AJM_{20})	$5.50^{a}\pm2.69$	$5.60^{a}\pm2.52$	$6.50^{a}\pm2.07$	$4.95^{a}\pm2.65$
Agidi jellof (AJM_{40})	$5.55^{a}\pm2.40$	$5.35^{a}\pm1.93$	$6.20^{a}\pm2.26$	$5.70^{a}\pm2.18$
Agidi jellof (AJM_{60})	$6.30^{a}\pm2.45$	$6.60^{a}\pm1.96$	$6.75^{a}\pm2.40$	$6.75^{a}\pm2.18$
LSD(0.05)	1.64	1.24	1.35	1.46
Cocoyam buns				
Cocoyam buns (control) (COM_{0})	$7.45^{a}\pm1.67$	$6.40^{bc}\pm2.30$	$7.20^{a}\pm1.54$	$6.30^{a}\pm2.47$
Cocoyam buns (COM_{20})	$6.92^{a}\pm1.67$	$6.75^{ab}\pm1.45$	$6.85^{a}\pm2.01$	$6.70^{a}\pm1.78$
Cocoyam buns (COM_{40})	$6.80^{a}\pm1.28$	$5.70^{c}\pm1.42$	$6.90^{a}\pm1.62$	$6.30^{a}\pm1.66$
Cocoyam buns (COM_{60})	$7.40^{a}\pm1.60$	$7.55^{a}\pm0.95$	$7.95^{a}\pm0.95$	$7.55^{a}\pm1.47$
LSD(0.05)	0.98	1.01	0.99	1.18

a – c values with different superscript letters on the same column for specific products are statistically different ($P<0.05$)

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS OF RESULTS

5.1 Nutritional Value of Edible Mushrooms

The nutritive value of any food is measured by the extent to which that food can satisfy the human requirements of specific nutrient (Ene-Obong and Obizoba, 1996). Varying opinions were expressed regarding the nutritive value of edible mushrooms. In the past many dismissed mushroom as a food of little nutritive value, research conducted on mushrooms suggested otherwise. They observed that mushroom is nutritionally healthy and safe food that are of even greater value to vegetarians. Although mushrooms are staple food in the diet of some cultures, edible mushrooms are usually considered for their flavour and condiment value (Ingold & Hudson, 1993).

Results from this study showed that the moisture contents of most of the mushrooms on wet weight (ww) basis were high except for wild and cultivated *Pleurotus tuber-regium*. The moisture contents of the mushrooms wet weight (ww) were comparable with most leafy vegetables, making fresh mushrooms low energy dense food. Water is the macronutrient needed in the largest quantity. It is needed for regulation of body process: temperature, transportation of nutrients and excretion of waste products from the body. The moisture value on wet weight of *Pleurotus ostreatus* was lower than the value obtained by Shyam, Syed, Suresh and Mirza (2010). This may result from the differences in the state of maturity of the mushrooms. On dry weight (dw) basis the moisture values obtained in this work were close to the value reported by Chi and Liv (2008). The moisture content of the *Pleurotu speicies* (cultivated *Pleurotus*) and wild *Pleurotus* compares well with values reported by Manjunathan and Kavlyarasa (2011). The lower moisture content observed on dry weight basis of the mushrooms suggests higher concentrations of the nutrients and this implies that mushroom when consumed in their dry state, maximum amount of nutrient could be obtained. It also suggests that dry mushroom flours could be used to fortify food products as investigated in this study.

The protein values observed in the mushrooms were relatively high. On wet weight basis the protein contents compared well with the protein reported for most cereals, while on dry weight basis the protein contents compare well with protein values for several leguminous seeds, meat and milk product. This implies that mushroom flours could serve as a suitable meat and milk substitutes for vegetarians and low income households.

The protein values of these mushrooms also confirms why the *Sclerotia* ("osu") from which *Pleurotus tuber-regium* is cultivated is used traditionally as meat substitute in Alayi in Bende local government area of Abia State, Nigeria. Mushroom protein is intermediate between that of animal and vegetables (Kurtzman, 1976) and is of superior quality because it contains all the essential amino acids (Purkayatha & Nayak, 1981). The protein levels of the mushrooms studied were close to values reported by Aleto and Aladetimi (1995). The slight different could also result from the differences in the soil from which the *scloretia* was grown. The present study indicates a much protein yield than values reported by Ijeh, Okwujiako, Nwosu and Nnodim (2009) for cultivated *Pleurotus tuber-regium*. This variation could result from differences in the method of analysis or from different mediums of cultivation of the mushrooms. The protein content of *Pholiota specie* on dry weight basis in this study was lower than that reported by Ndubaku (1993). Protein is needed for the building of worn out tissues, enzymes, hormones and other structures in the body. Protein evaluation has shown that mushroom proteins have a higher quality than most green leafy vegetables and may contribute substantially to the total protein intake when combined with other foods as concentrate (Jiskani, 2001).

Fat values in all the mushrooms studied were relatively low but enough to contribute to the palatability of the mushrooms. The fat values of the mushrooms in the present study were in agreement with values obtained by Moore and Chiu (2002) who observed that mushrooms are characteristically low in fat. Despite the low fat content of the mushrooms, it has been shown that the higher proportion of the existing fatty acids in mushrooms are linoleic acid which is 23 - 74% (Moore & Chiu, 2002). Moore and Chiu (2002) also pointed that sphingolipids which are important in brain and nervous system have also been identified in some mushroom species. In view of the low fat content, mushrooms could be of great nutritional benefit to those with diet-related non communicable disease, such as hypertension, diabetes, cardiovascular diseases, liver disease, hypercholesterolemia and obesity.

The highest fibre contents observed in the wild *Pleurotus tuber-regium* among the mushroom on both wet weight and dry weight basis indicates that the wild *Pleurotus tuber-regium* has higher fibre than other mushrooms analyzed and could contribute substantially to fibre values when used as food fortificant. The fibre content of *Pleurotus ostreatus* and *Pholiota mutabilis* were close to that of groundnut as reported by FAO (1968). Fukushina (2000) found out that rats feed on a diet of mushroom fibre led to lowered serum total cholesterol and lowered very low density lipo proteins (VLDL). Fibre is commonly known as roughage. Although the dietary fibre content of these mushrooms was not determined, it is very likely that mushrooms contained a reasonable amount of soluble dietary fibre hence the physiological effects. Studies have shown that soluble dietary fiber exert these physiological effects e.g. they are of good nutritional value and help to form softer bulky stools and speed up transit time through the digestive tract, hence protect against colon and rectal cancers (Ene-Obong, 2001).

The high values of ash observed in the mushrooms confirms the higher level of some mineral elements contained in them. The ash is the inorganic matter after combustion of foods. It constitutes the minerals contained in the food. These minerals determine the osmolarities of the many physiological processes in the body.

The low levels of the carbohydrate observed among the mushrooms especially on wet weight basis agrees with Cooper (2001) that the proportion of carbohydrate in mushrooms are low because mushrooms cannot photosynthesize. On dry weight basis, the levels of the carbohydrate were relatively higher than on wet weight basis and this could help to argument the energy values of some snacks when mushroom flour is used as food fortificant. In this study the carbohydrate content of cultivated *Pleurotus tuber-regium* on dry weight basis was lower than 63.03g/100g which Ijeh *et al*., (2009) reported in earlier study. This could result from the differences in the maturity of the mushrooms and in the method of processing. Ijeh *et al*., (2009) reported that a considerable fraction of this carbohydrate in cultivated *Pleurotus tuber-regium* was contributed by oligosaccharides and that several health benefits have been attributed to mushroom oligosaccharides including immunomodulatory effects which has been shown to be of great benefit to individuals living with HIV.

5.2 Mineral Composition

Mineral in diet are essential for metabolic reactions and healthy bone formation, transmission of nerve impulses, regulations of water and salt balance (Kalac & Svoboda, 2000). Calcium is used as structural component of bone and teeth and it represents 40% of all the minerals in the body (Wardlaw, Hamp & Disilvestra, 2004). The mineral contents of the six edible mushrooms analysed in this study varied with the different species. The range of calcium values observed in wild and cultivated *Pleurotus tuber-regium, Pleurotus ostreatus, Pholiota mutabilis* and *Corprinus disseminatus* on dry weight (dw) basis compared well with the range of calcium values obtained by other researchers (Shyam *et al.*, 2010). The value of calcium 341mg/100g on dry weight (dw) basis observed in *Corprinus disseminatus* is in line with the report Kawai, Sugahara, Matsuzawa, Sumiyashiki, Aoyagi and Hosogai (1986) that mushrooms contain 342mg/100g of calcium. The highest value (402mg/100g) of calcium observed in wild *Pleurotus tuber-regium* on dry weight basis implies that consumption of 100g of the flour can provide sufficient calcium to meet about 50% of the recommended nutrient intake (RNI = 700mg) for school age children. Meeting calcium needs has been associated with reduced risk of osteoporosis, hypertension, colon/breast cancers, kidney stones, premenstrual syndrome, lead exposure and obesity/over weight (Kalac and Svoboda, 2000). Dairy products are the major source of calcium but are not usually affordable to low income earners in the developing countries especially poor rural dwellers. Mushrooms are seasonal and can also be cultivated. They could be harvested, dried and stored for use as fortificants to enrich staple foods such as maize, cocoyam and other staple foods which are not rich in calcium.

The relatively low content of iron in the six edible mushrooms indicates that mushrooms are not very good source of iron. Cultivated *Pleurotus tuber-regium* had 3.2mg/100g which was less than 5.02mg/100g reported by other researchers (Ijeh etal., 2009). This could be due to the differences in maturity, methods of processing, analysis or location.

The presence of selenium in the mushrooms analysed confirm the earlier report by Chang & Buswell (1996) that mushrooms contain minerals like selenium, copper, manganese and iron. The range of values for selenium on wet weight observed in this study are close to that reported by Ensminger, Kondale, and Robson (1983) who observed that raw *Crimini* mushroom contain 36.45µg selenium per 100g mushroom. Selenium is needed for proper functioning of the antioxidant system (Glutathione peroxidase) which reduces the levels of damaging free radicals in the body. The highest value of selenium (44.27µg/100g) in cultivated *Pleurotus tuber-regium* on dry weight basis could be as a result of the substrate used for cultivation. This is an added advantage because this edible cultivated *Pleurotus tuber-regium* could be locally cultivated and used to fortify our local staples that have low selenium contents. The values of selenium observed in other mushrooms analysed suggest also that these mushrooms could make substrial contribution to intakes of population groups.

The copper contents of the six edible mushrooms were high and this suggests that these mushrooms could be used in treating some patients with debilitating illnesses such as cancer and rheumatoid arthritis. Copper is necessary for the proper functioning of iron. Copper also has a role in two of the three members of a family of enzymes known as superoxide dismutase. This family of enzyme eliminates free radicals known as superoxide (O^-_2). Copper is equally a part of cytochrome C oxidase which catalyzes the last step of electron transport chain. It is a part of lysoloxidase which is important in connective tissue formation (Wardlaw *et al.* , 2004). With this knowledge it implies that dietary incorporation of copper rich food is necessary for the proper functioning of these enzymes in the body. Consumption of 415g of cultivated *Pleurotus tuber-regium* (dw) will furnish the FAO/WHO RNI for an adult (900µg of copper daily).

The range of potassium in the mushrooms on dry weight basis is within the range (31-45mg/100g) reported by some researchers (Ukoima, Ogbonnaya, Arikpo & Pepple, 2009). Potassium in addition to fluid balance and nerve impulse transmission influences the contractibility of smooth, skeletal and cardiac muscles. Potassium is the major cation inside the cell. Intracellular fluid contains 95% of the potassium in the body (Preuss, 2001). The potassium contents of the mushroom were relatively low. However incorporation of 400g flour of *Pleurotus tuber-regium* into a snack can furnish 10% of FAO/WHO RNI of pre-school child, while incorporation of about 500g of *Pholiota mutabitis* flour into a pre-school snack will also furnish 10% of the FAO/WHO RNI. Low blood potassium is a life threatening problems. Symptoms often include a loss of appetite, muscle cramps, confusion, constipation and increased urinary excretion. Incorporation of these mushrooms flour into our local food staples can help alleviate the problems of potassium deficiency.

The value of magnesium in the mushrooms is relatively high indicating the potential for their use as a good source of magnesium. Magnesium has a vital role in a varying range of biochemical and physiological process. Most enzymes that utilize ATP requires magnesium, and it also contributes to DNA and RNA synthesis during cell proliferation. It is also important for nerve and heart function, as well as insulin release from the pancreas and ultimate insulin action on cells (Food and Nutrition Board, 1997). An adult female recommended nutrient intake for magnesium is 260mg/day (FAO/WHO, 2002). Hence dietary incorporation of 200µg of mushroom flour (*Pholiota mutabilis*) could supply about 50% of magnesium for an adult female. Other species analysed in this study could also contribute substantial amount of magnesium when used.

The high level of selenium and copper observed in this study will go a long way to combat the problem of free radicals in the body since they have antioxidant properties. The appreciable levels of other minerals observed, such as iron, calcium, potassium and magnesium will also help to reduce micronutrient deficiencies in our traditional diets if mushroom flour is incorporated to enrich them.

5.3 Vitamin Composition

The vitamin C contents of the mushrooms were low and this is in agreement with earlier report by Dubost, Beetman, Peterson and Royse (2005) that mushrooms are low in vitamin C. However, the little quantity of vitamin C can help the absorption of non-haem iron in the food when mushroom flour is added.

The folic acid levels in the mushrooms studied is in agreement with earlier report by Jiskani (2001) that mushrooms have high folic acid content. *Peziza badioconfusa kort* had exceptionally high folic acid content of 3400μg/100g and this suggests that adding this mushroom flour into our staple foods can help supply sufficient folic acid for daily requirement. The vitamin B_{12} present in these six edible mushrooms studied confirms what Igold (1993) stated that mushrooms would be of great benefit to vegetarians since no other plant food contains vitamin B_{12} except some mushrooms. All the B-complex vitamins functions as co-enzymes and participate in energy metabolism, hence addition of edible mushroom flour into the diet of patients with symptoms of dizziness resulting from hypoglycemia can help rapid release of energy. Addition of mushroom flour into the diets of those involved in energy requiring tasks can be of great benefit athletes and women in labour. The result of this study is also in line with the report of Ensminger *et al*., (1989) that mushrooms are excellent source of B-vitamins. Vitamin E, one of the fat soluble vitamins, was also present in the mushrooms. This confirms the earlier report by Ensminger *et al*., (1989) that mushrooms contain vitamin E that function primarily as an antioxidant. It implies that addition of edible mushroom flour into our diet can provide some amount of vitamin E sufficient to met the daily requirement.

5.4 Phytochemicals Screening of the Mushroom

Phytochemicals act as blocking or suppressing agents; they prevent active carcinogen or tumour promoter from reaching their target tissue by several mechanisms (Wardlaw *et al*., 2004). Hence, phytochemicals reduce the risk of cancer, prevents malignant expression of cells that have been exposed to cancer causing agents (Wardlaw *et al*., 2004).

The presence of some phytochemicals in the edible mushroom flour (*Pleurotus tuber-regium*) is an added advantage. The abundance of flavonoid, saponoid and steroids in the cultivated *Pleurotus tuber-regium* suggested that this mushroom flour when used as fortificant can function as scavenger to free radicals such as superoxide anion and singlet oxygen. These phytochemcials lower total blood cholesterol and low density lipo protein cholesterol (LDL-C) and increases high density lipoprotein cholesterol (Wardlaw *et al*., 2004) and help in the synthesis of protein. Glycosides are used to prepare drug for congestive cardiac failure (Wardlaw *et al*., 2004).

The moderate presence of terpenoids also implies that cultivated *Pleurotus tuber-regium* flour when added into our local staple foods can act as a detoxifyer of carcinogens by making them more water soluble for excretion from the body (Craig, Wood & Gull, 2004).

The absence of tannins in the cultivated *Pleurotus tuber-regium* is also an advantage, because protein complexes will not be formed and absorption of the little iron contained in the mushroom will not be hindered when these snacks are eaten.

5.5 Effect of of some Traditional Food Staples with Mushroom Flour

Food fortification has been shown to be one of the methods of combating malnutrition across the varying socio-cultural groups (Nnayelugo *et al*., 1992). Fortification is the most accessible intervention method to increase nutrient intakes of the population without changing dietary and cultural habits provided that appropriate food is identified (Sommer, 1993). Industrial fortification efforts are becoming widespread in developing countries; such efforts are limited by their continuing costs and by imperfect coverage of the target population, particularly the poor and young children. Industrial fortification will only apply to marketed supplies and therefore may not reach the poor who obtain food outside of commercialized channels. Given these limitations, it is clear that industrial fortification of food cannot provide a complete solution to the problem of micronutrient deficiencies in the medium term (Laurian *et al*., 2007). Therefore local fortification in the form of food to food forticication could go a long way in reducing micronutrient deficiencies in both rural and urban population.

Effect on incorporation of mushroom flour on weat buns

The slight decrease in moisture content of the snacks (wheat buns) could be as a result of the dry nature of the cultivated mushroom (*Pleutotus tuber-regium).* It could also result from the quantity of the mushroom incorporated into the wheat flour. The moderate percentage increases in the protein content of the snacks could be as a result of the combined low protein content of the wheat flour and other ingredients used in the preparation of the snack.

The marked increase in selenium, copper, folic acid, vitamin B_{12} and vitamin E suggests that *Pleurotus* could serve as a fortificant to complement some of our local staples that lack some important micronutrients. The percentage daily requirements met by these fortified snacks for pre-school and school children is an indication that these commonly consumed snacks made from wheat flour can be improved upon by using *Pleurotus* flour as a potential fortificant to reduce the problem of the nutrition transition and its resultant micronutrient malnutrition.

Effect on incorporation of mushroom flour on *Agidi jollof*

Most pre-school and school children consume this food as snacks in school, therefore the moderate and high increases in the protein and some micronutrients such as selenium, copper, iron, calcium and folic acid could improve the nutrient content of this commonly consumed snack. This will reduce the problem of eating empty calories and reduce the problem of macro and micro nutrient malnutrition. In view of the percentage requirements met by the fortified *agidi jollof*, school meals when fortified with *Pleurotus* flour could help to reduce micronutrient deficiencies among pre-school and school children.

Effect on incorporation of mushroom flour on Cocoyam buns

Cocoyam is always available in most of the rural areas in Nigeria and other African countries. It is either roasted or boiled and eaten with oil. In this study the cocoyam was fortified with cultivated *Pleurotus tuber-regium* and the significant increases in selenium, copper, vitamin E and folic acid when expressed as the percentage of the control strongly suggest apart from meeting nutrient requirements, this could help to combat the problem of free radicals; selenium and copper act as anti-oxidant component in the body. The increase in protein which was almost doubled could be as a result of the very low protein content of cocoyam and the high protein content of *Pleurotus.* The high fat content of the cocoyam buns could be as a result of the added fat in the recipe as well as fat absorbed by the buns during frying. The protein, carbohydrate and relatively high fat content will make that snack a good energy source for school children and pre-school children.

The percentages of the nutrients met by 100g of this snacks for pre-school and school children for vitamin and minerals suggest that cocoyam flour when fortified with *Pleurotus tuber-regium* flour has the potential of contributing substantially to meeting protein and micronutrient requirements of resource poor communities.

The fortified snacks showed a good percentage increase in both mineral and vitamins when expressed as a percentage of the control. Most of the fortified buns met over 50% of the FAO/WHO RNI for pre-school and school children. The progressive increase observed in the nutrient composition of the fortified snacks is an indication that some of our traditional food staples can be successfully fortified with edible mushroom flour in order to help combat micronutrient deficiencies and protein energy malnutrition that have remained a serious public health problem in many developing countries of the world including Nigeria. The result of this study can serve as a good source of information for people in the rural areas on the nutrient value of mushroom. Small scale fortification could be done in homes using edible mushroom flour as food fortificant. The fortification is economically feasible for both urban and rural dwellers. This fortification is timely in the light of growing consumption of processed and packaged foods (Remi & Gether, 2005). The result of this study will open a new fortification opportunities because of the fast growing consumption of wheat flour around the world especially in Nigeria were school children and adolescents depend solely on wheat products in the school.

5.6 Organoloptic properties of fortified products

The non-significant differences in colour could be attributed to the fact that *Pleurotus* flour is creamy white and so did not impact a significant colour change in the product. The more the amount of the *Pleurotus* the browner the snack. This could be due to the increase in the protein content that will encourage more. In terms of flavour, *Pleurotus* mushroom has a bland to mild flavour that will not make a significant change in the overall flavour of the product.

The texture difference could be attributed to the increased amount of *Pleurotus* flour which would have given the product the drier, crispier texture. It could also be that the panelists were not familiar with the new product in terms of texture.

The general acceptability of the snack were affected by their colour, flavour and texture. Among the snacks fortified with mushroom flour, wheat and cocoyam buns were highly accepted while maize meal (*Agidi jollof*) fortified with mushroom flour was poorly accepted by the panelists. This suggests that wheat buns could be substituted with fortified cocoyam buns.

Conclusion

Wild and cultivated mushrooms have significant role in ensuring sustainable diets for rural and urban dwellers in resource poor communities. Wild or cultivated *Pleurotus tuber-regium* is indeed a highly nutritious food that can contribute to sustainable diets of various population groups. It is not just rich in micro-nutrients, and macronutrients but also rich in phytochemicals. Products fortified with mushrooms could be used to fight macro and micro nutrient deficiencies in Nigeria and other African countries where cocoyam, maize and wheat are staples. The fortified products could be promoted in place of empty - calorie and other fast foods that are almost replacing our traditional foods.

Recommendations

- There is need to evaluate protein quality of these edible mushrooms. *Pleurotus* can be easily propagated within and around homes, there is therefore need to popularize and encourage its use as vegetable and flour, providing needed micronutrient and protein.
- Intense effort should be geared towards the husbandry of mushrooms, especially *Pleurotus tuber-regium*. People who are involved in small scale food-to-food fortifications should be educated on the nutritional potentials of edible mushrooms.
- The rural population who are more disposed to getting mushrooms should be educated through nutritional education on the benefit of edible mushrooms.
- People should be encouraged to cultivate mushrooms at home (*Pleurotus tuber-regium*) and use its flour to fortify some of our traditional foods that are low in some micronutrients.
- Mushroom flour could be readily produced and made available in the market as food fortificant.

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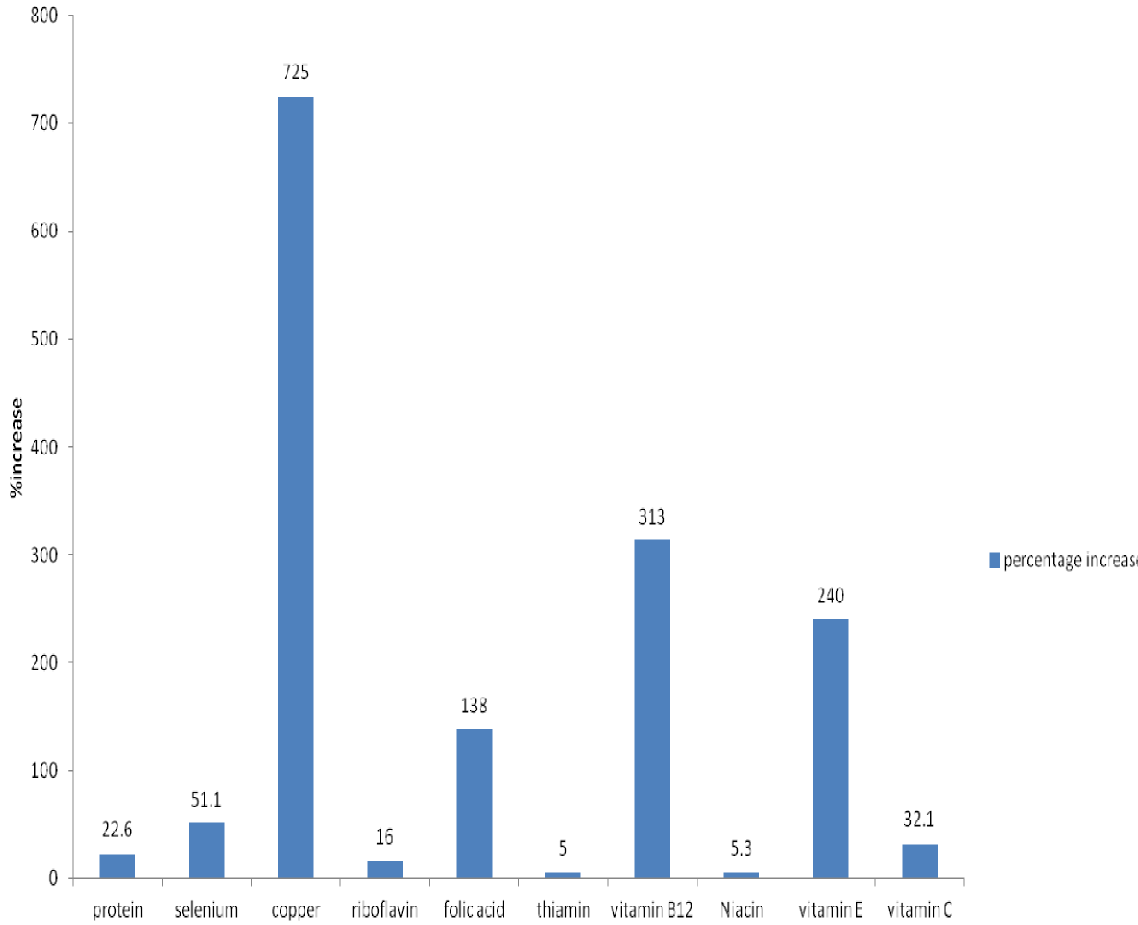
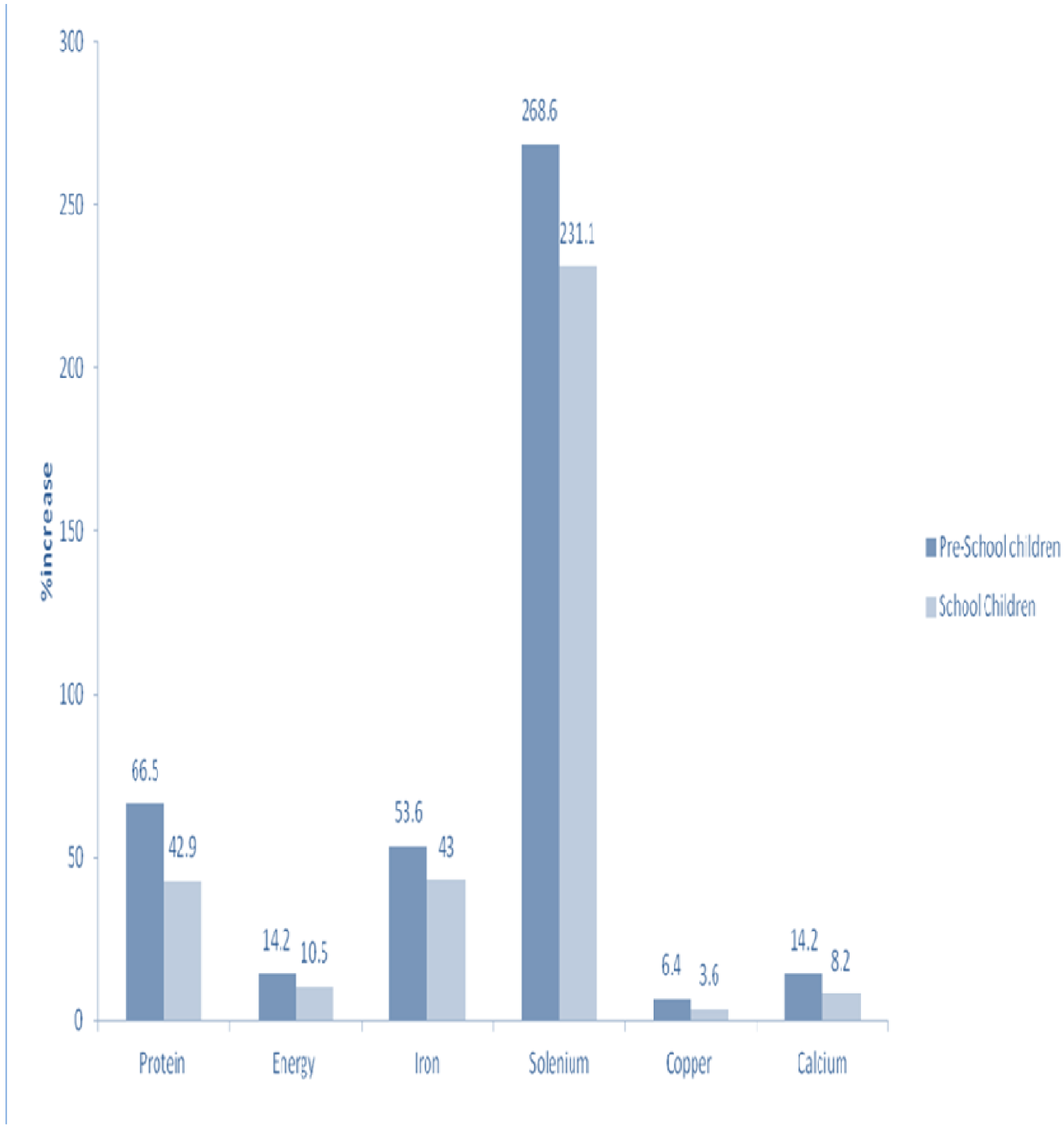
APPENDIX A



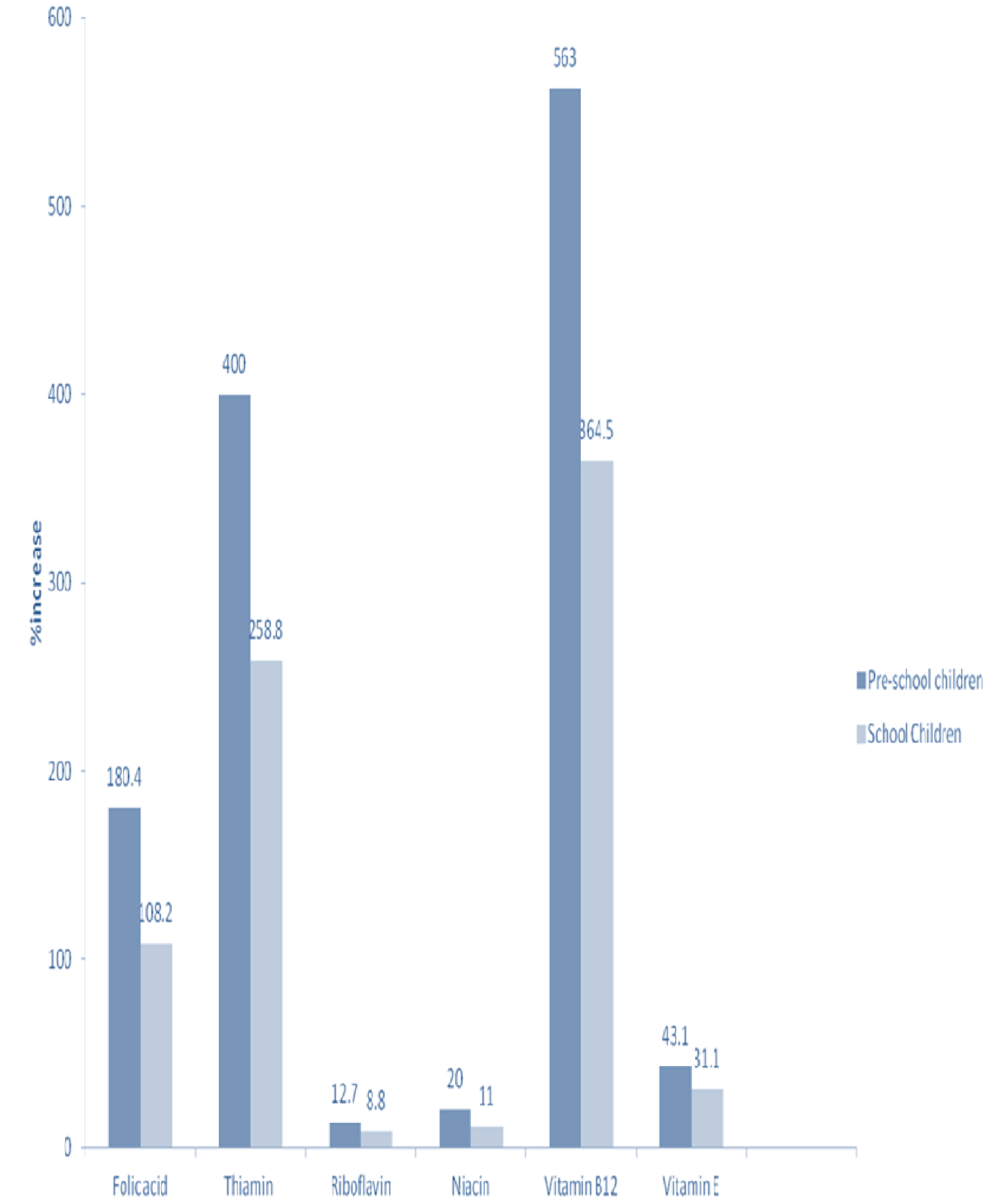
Percentage increases in specific nutrients as a result of fortification of wheat buns with *Pleurotus tuber-regium* flour

APPENDIX B



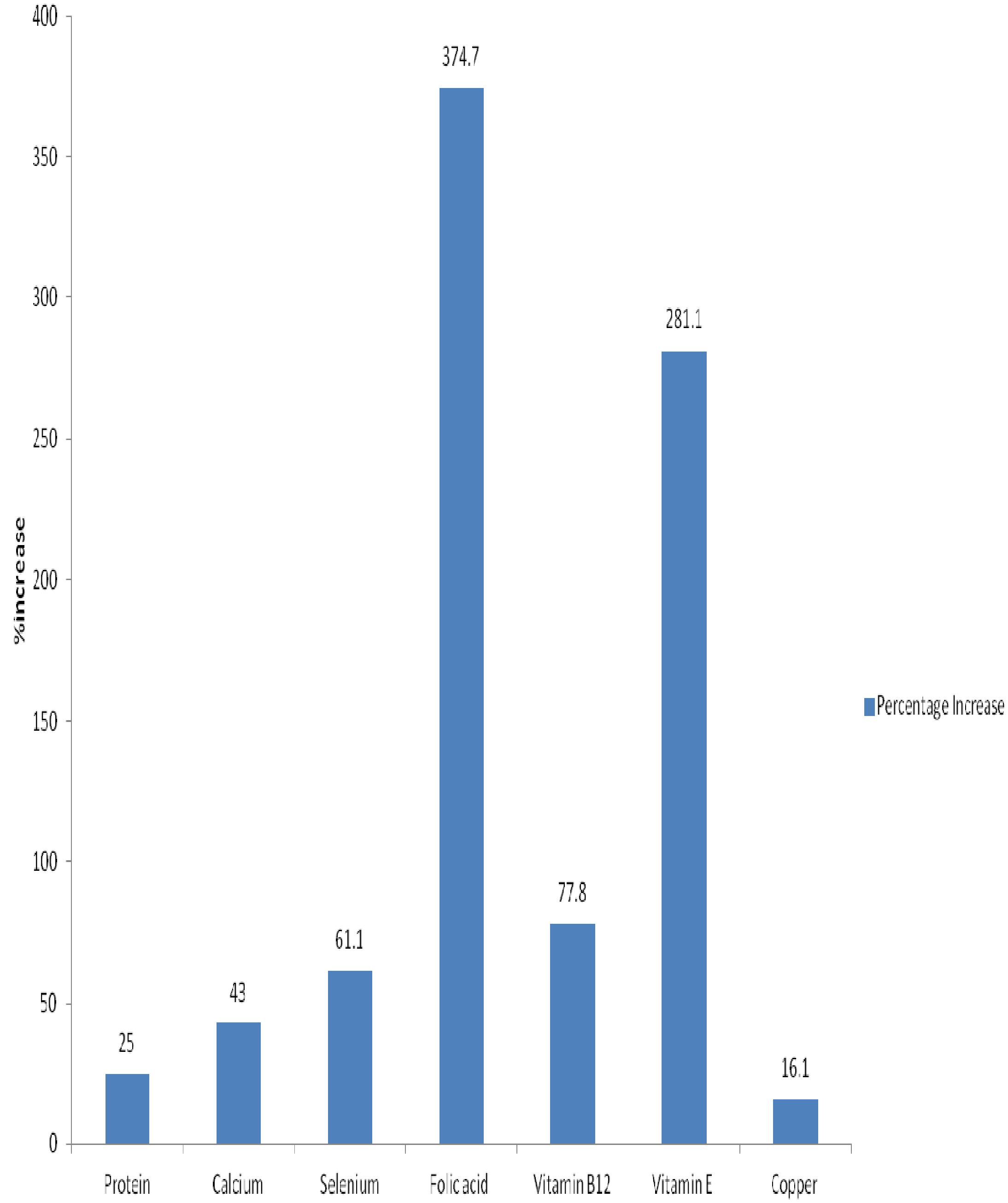
Contribution of wheat buns fortified with *Pleurotus tuber-regium* flour to protein, energy and some micronutrients intakes of pre-school (2-5 years) and school children (6-10 years)

APPENDIX C



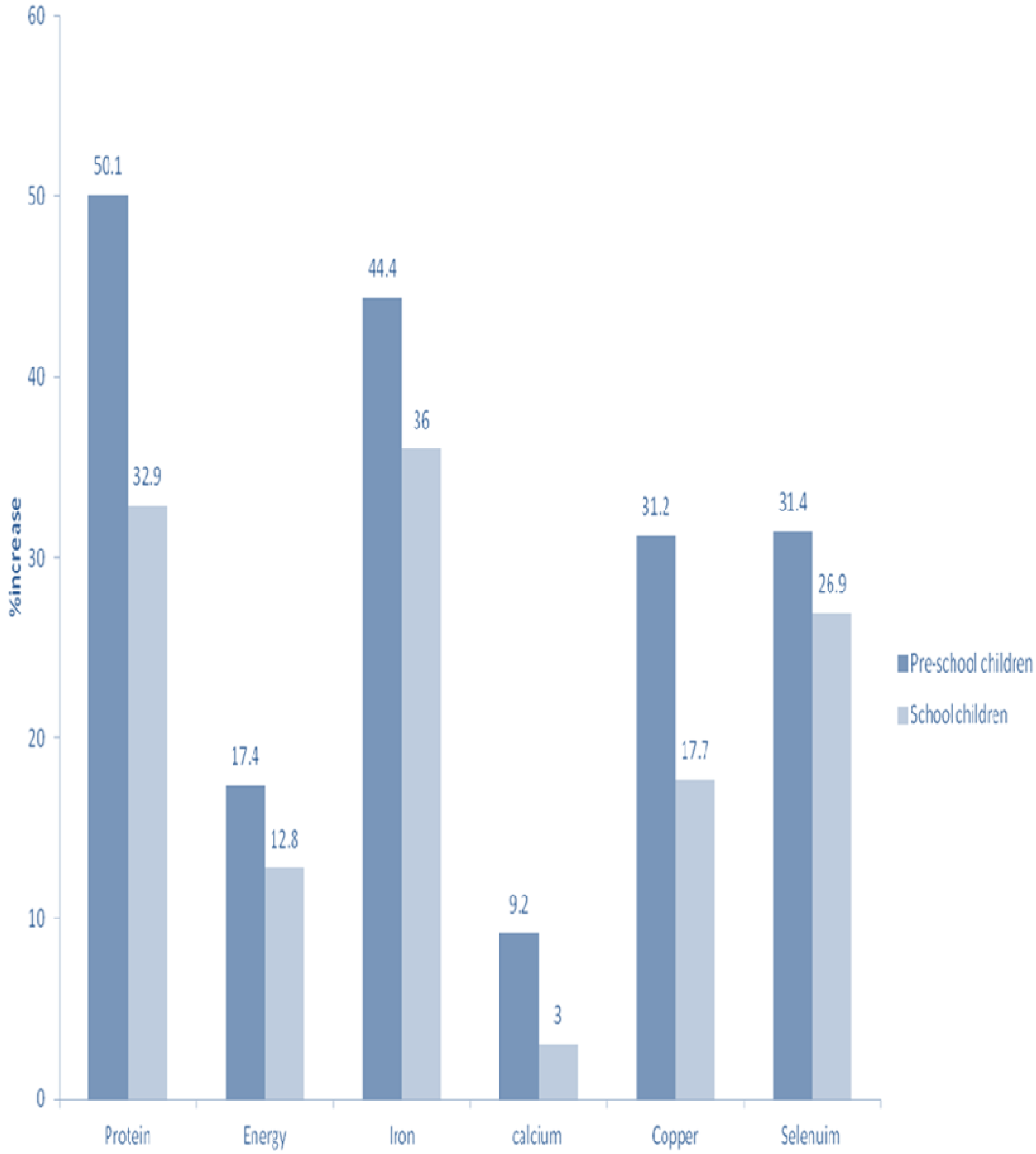
Contribution of wheat buns fortified with *Pleurotus tuber-regium* flour to vitamin of pre school (2-5 years) and school children (6-10 years)

APPENDIX D



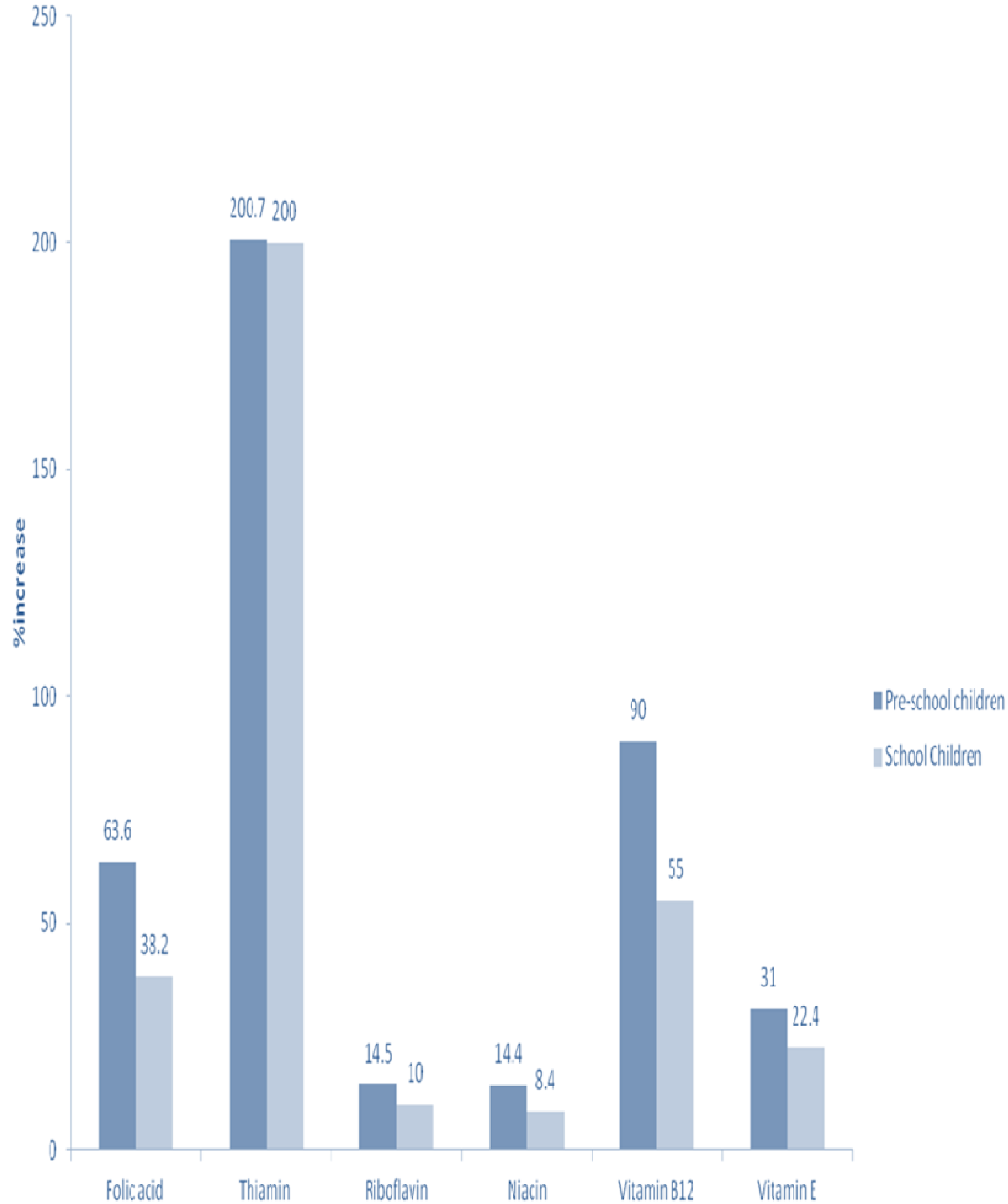
Percentage increases in specific Nutrients as a result of fortification of *Agidi jollof*

APPENDIX E



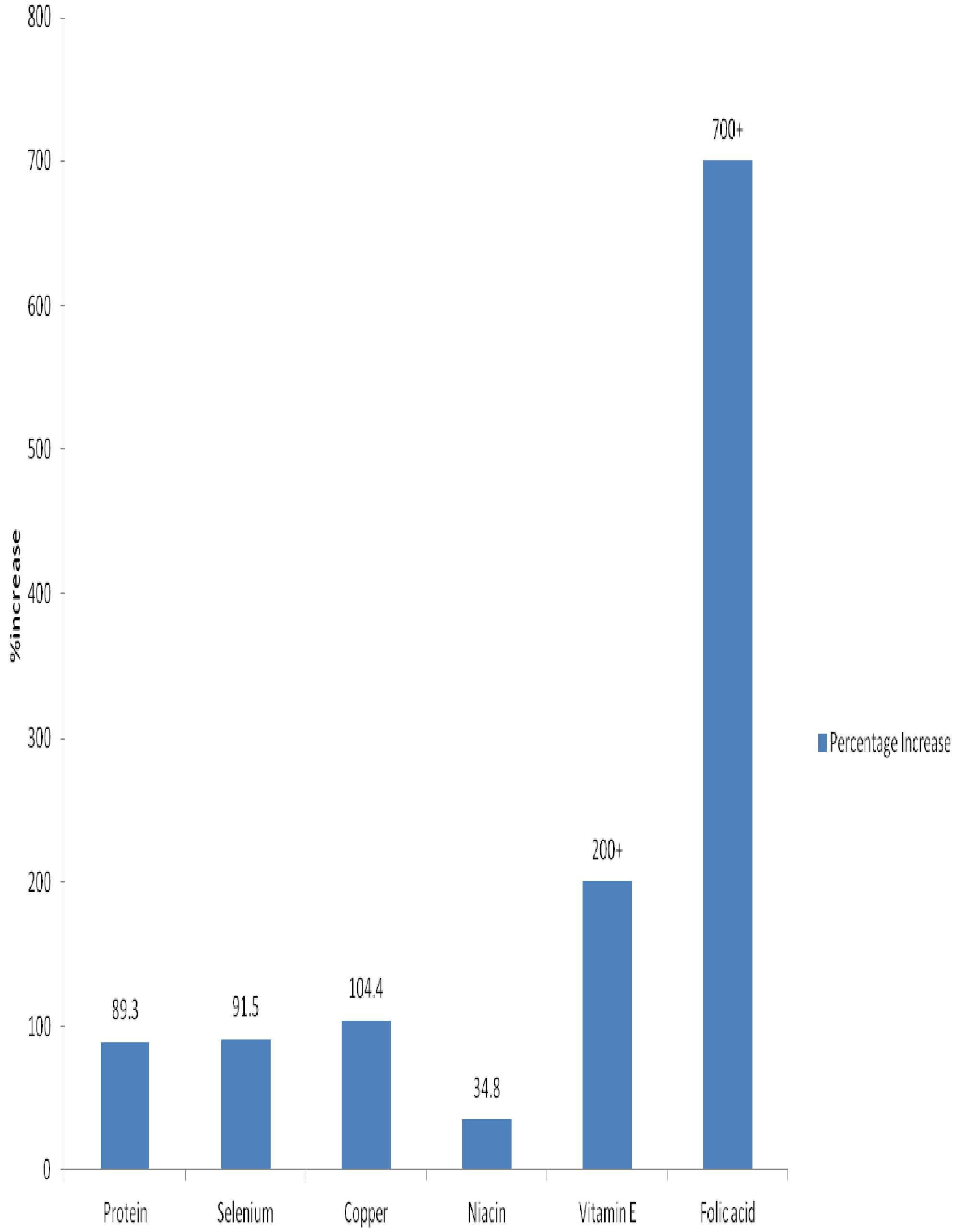
Contribution of *Agidi jollof* fortified with *Pleurotus tuber-regium* flour to protein, energy and some micronutrients intakes of pre-school (2-5 years) and school children (6-10 years)

APPENDIX F



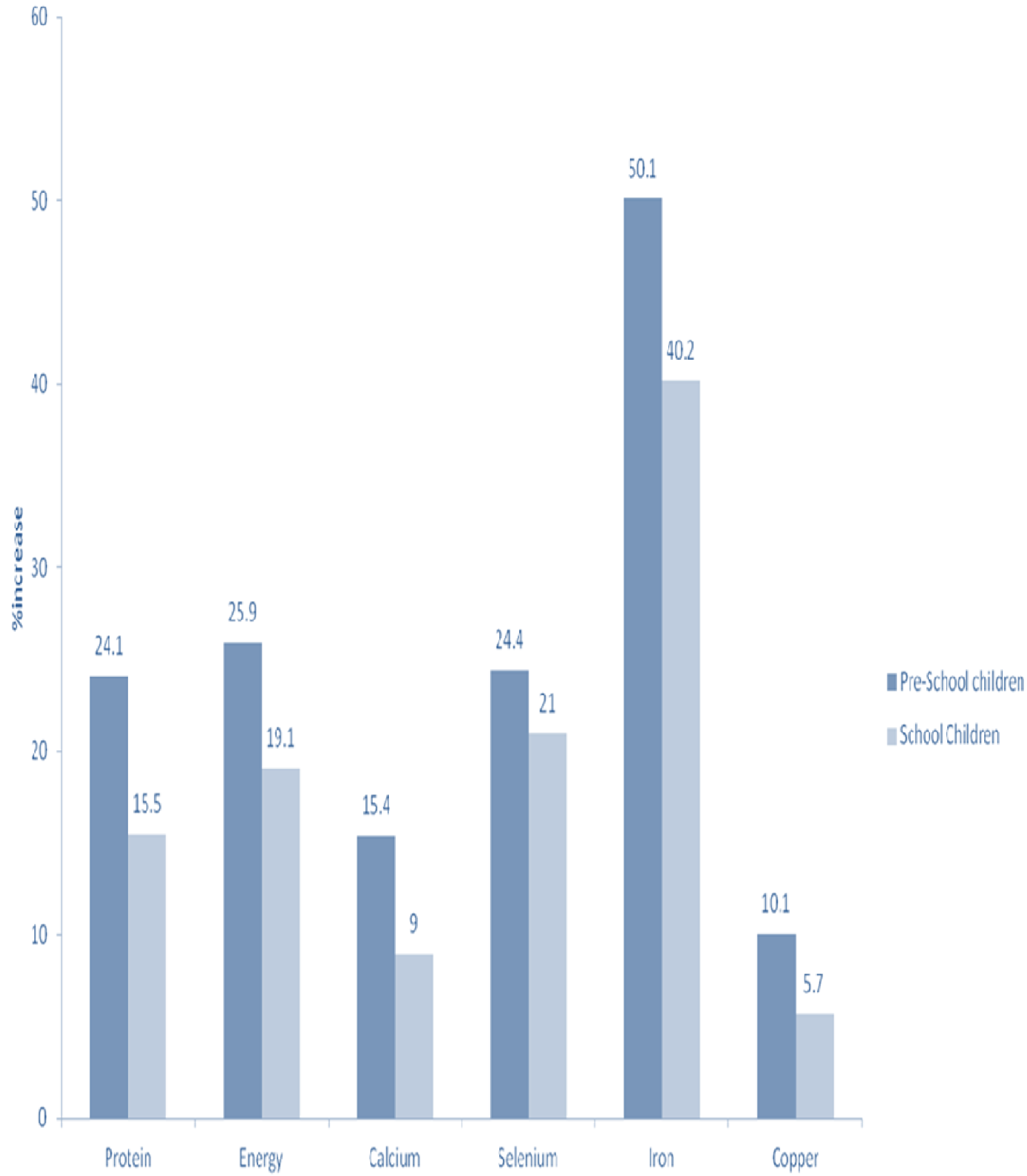
Contribution of *Agidi jollof* fortified with *Pleurotus tuber-regium* flour to vitamin intakes of pre-school (2-5 years) and school children (6-10 years)

APPENDIX G



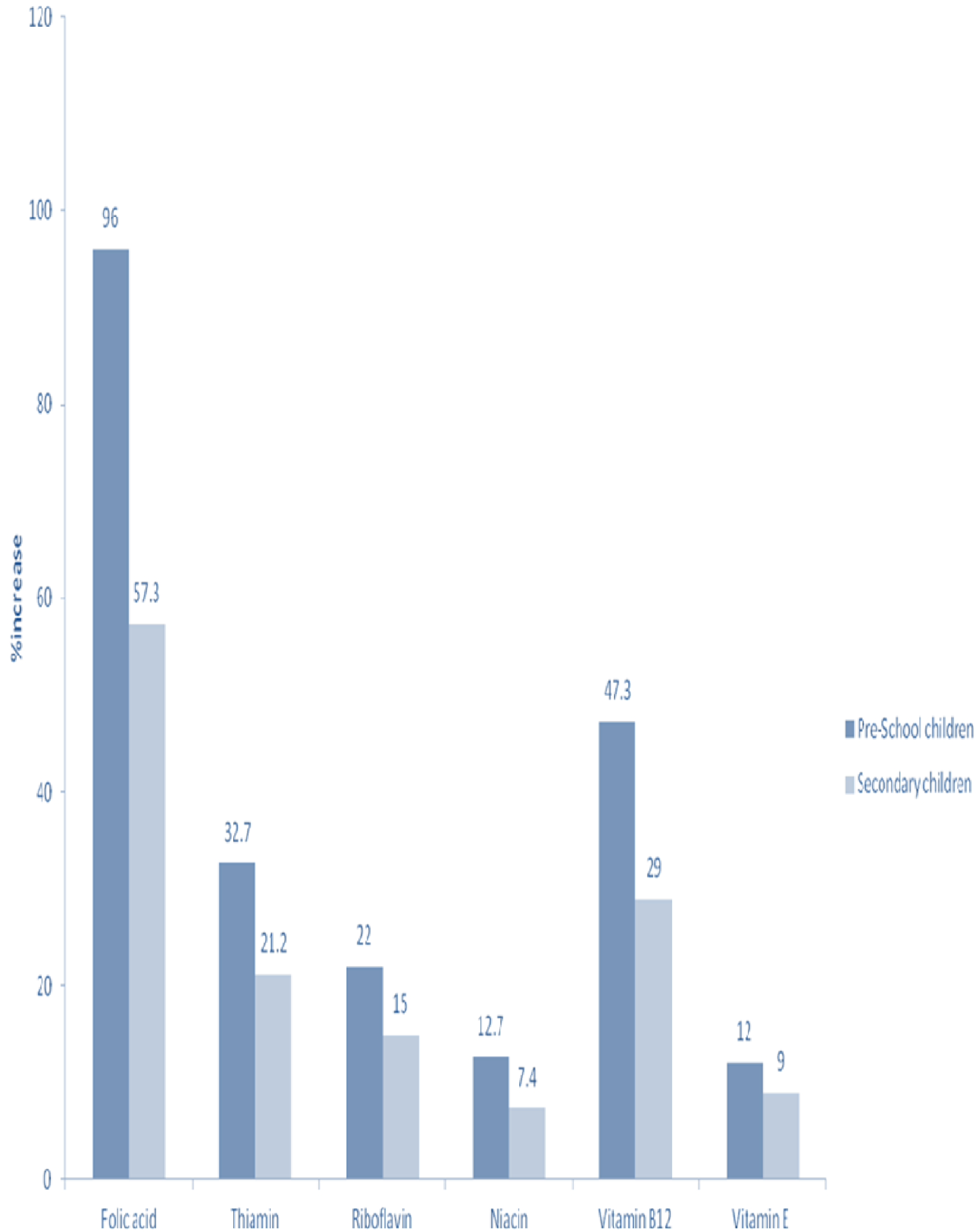
Percentage increases in specific nutrients as a result of fortification of cocoyam buns with *Pleurotus tuber-regium* flour

APPENDIX H



Contribution of cocoyam buns fortified with *Pleurotus tuber-regium* flour to protein, energy and some micronutrients intakes of pre-school (2-5 years) and school children (6-10 years)

APPENDIX I



Contribution of cocoyam buns fortified with *Pleurotus tuber-regium* flour to vitamin intakes of pre-school (2-5 years) and school children (6-10 years)

UNIVERSITY OF NIGERIA, NSUKKA, DEPARTMENT OF HOME SCIENCE, NUTRITION AND DIETETICS

Consent Form

I/we, …………………………………………….………………

give my/our consent for my child/children to participate in the sensory evaluation of the new developed snacks.

Sign:…………………………..
(Student)

Date: ……………………………….

Sign:…………………………..
(Parent(/Parents)

Date: ……………………………….

SENSORY EVALUATION DATA SHEET
UNIVERSITY OF NIGERIA, NSUKKA, DEPARTMENT OF HOME SCIENCE, NUTRITION AND DIETETICS

SENSORY EVALUATION OF SOME PRODUCTS PRODUCED FROM PROCESSED COCOYAM, WHEAT FLOUR, MAIZE, FORTIFIED WITH EDIBLE PROCESSED MUSHROOM FLOUR.

Evaluate each sample for colour, texture and flavor, indicate how much you like each sample by ticking the option that describes your feeling about it.

Products: Cocoyam buns, Wheat buns and *Agidi jollof*	**COLOUR**									**TEXTURE**									**FLAVOR**								
Sample codes	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
9 Like extremely																											
8 Like very much																											
7 Like moderately																											
6 Like slightly																											
5 Neither liked or dislike																											
4 Dislike slightly																											
3 Dislike moderately																											
2 Dislike very much																											
1 Dislike extremely																											

GENERAL ACCEPTABILITY RATING OF THE SAMPLE
(FOOD ATTITUDE AND RATING FORM-FARE)

Degree of acceptability		Sample codes								
9	I would eat this/these at e very opportunity	1	2	3	4	5	6	7	8	9
8	I would eat this/these often									
7	I would eat this/these occasionally									
6	I would eat this/these sparingly									
5	I would eat this/these when available									
4	I don't like this/these but manage it/them									
3	I would hardly ever eat this/these again									
2	I would eat this/these only if I were forced									
1	Ion no account would I eat this/these									