GLYCAEMIC INDICES OF COMMONLY-CONSUMED MIXED MEALS 'AS EATEN' BY APPARENTLY HEALTHY YOUNG ADULTS IN SOUTHWESTERN NIGERIA

BY

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ABSTRACT

The GlycaemicIndex (GI) of foods is a widely recognised tool for the dietary management of chronic diseases, especially Type 2 Diabetes Mellitus, a metabolic disease associated with life threatening complications and reduction in quality of life. Existing dietary management uses information on GI of single foods but, data on GI of mixed meals 'as eaten' may be more useful.However,available data on GI of mixed meals are limited. This study was designed to determine the GI of commonly-consumed mixed meals 'as eaten' by apparently healthy young adults in southwestern, Nigeria.

This quasi-experimental study involved 120 volunteers screened for Fasting Blood Glucose (FBG), Proteinuria, Body Mass Index (BMI),haemoglobin and Blood Pressure (BP) after which 80 apparently healthy young adults were selected. Following a 10–12 hour overnight fast, each participant was made to consume 50g of glucose dissolved in 350ml of water.Fifty-two (52) mixed meals and Eighteen (18) single foods were identified as test mealsfrom theRoots and Tubers (RT), Cereals and Grains (CG) and Legumes food groups. For each test food, 8 participants were randomly selected and served a meal containing 50g available carbohydrate. Each participant served as his/her control with a day (wash-out) period allowed between meals. Capillary blood samples obtained by finger prick were used to determine blood glucose concentrations with aglucometer at 0, 30, 60, 90 and 120 minutes. Blood glucose curves were constructed to calculate the GI of test meals with values classified as high (70 – 100), intermediate (55 – 69) and low (< 55).Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$.

Participants age was 22.28±3.49 years, BMI 20.96±2.31 kg/m^2, FBG 84.74±6.59 mg/dL, haemoglobin 13.64±1.26 g/dl, and BP 112.19/72.45±11.55/8.75 mmHg. For the RT products: *eba*+*efoelegusi, fufu*+*ewedu* soup and *fufu*+*okra* souphad GI values of 74, 78 and 80, respectively. *Amala*+*eforiro* and *amala*+*okra* soup had a GI of 75 and 78. Same GI value (84) was obtained for *amala*+*efoelegusi*, pounded yam+*okra*, and boiled yam+fried egg. The CG: white rice+stew+fried plantain had GI of 74; while GI of 76 was obtained for white rice+stew+boiled beans and *ogi*+*moin-moin*. *Ogi*+*akara* had a GI of 77. The Legumes: boiled beans+stew, boiled beans+stew+ plantain and beans porridge had GI of 83, 84 and 85, respectively. The GI of *eba* (99) and *amala*(97) as single foods, was reduced to (74, 75), respectively when consumed with *efoelegusi* and *eforiro*. The GI values of *eba, amala,* whiterice, *ogi* as single foods were significantly higher than when eaten as mixed meals.However,*eba+efoelegusi*, white rice+friedplantain+stew, had the least GI of 74, while beans+*garri (soaked)*, *eba+ewedu* and*amala+ewedu*, had the highest GI of 93.

Commonly consumed mixed meals in southwestern Nigeria have high GlycaemicIndex. However, the more diversified the meals, the lower the glycaemicindex when compared to single foods. To improve the GlycaemicIndex of mixed meals, further evidence-based research on reduced varied mixed meals portion sizes "as eaten" is recommended.

Keywords: GlycaemicIndex, Blood glucose concentrations, Mixed meals, Single foods

Word count: 493

DEDICATION

This research work is dedicated to the allsufficient, covenant-keeping new dawn God who has kept and strengthened me throughout the thick and thin of life as combining the home front with career, business and academics was only by his supernatural grace, mercies and blessings.

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CERTIFICATION

I hereby certify that MRS. OGUNDELE, ABIMBOLA ENIOLA developed this study proposal and executed the various aspects of the study including data analysis and report writing in the Department of Human Nutrition, Faculty of Public Health, University of Ibadan under my supervision.

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ABBREVIATIONS AND ACRONYMS

ADA: American Dietetic Association

AGR: Abnormal Glucose Regulation

AOAC: Association of Official Analytical Chemist

ATP: Adenosine Tri Phosphate

ANOVA: Analysis of Variance

AUC: Area Under Curve

BMI: Body Mass Index

CDA: Canadian Diabetes Association

CHO: Carbohydrate

CVD: Cardiovascular Diseases

DFU: Diabetic Foot Ulcer

DM: Diabetes Mellitus

DSME: Diabetes Self-Management Education

FAO: Food and Agriculture Organization

FBG: Fasting Blood Glucose

FMOH: Federal Ministry of Health

GDM: Gestational Diabetes Mellitus

GI: GlycaemicIndex

ABBREVIATIONS AND ACRONYMS

GL: Glycaemic Load

GR: Glycaemic Response

HDL: High Density Lipoprotein

IDDM: Insulin Dependent Diabetes Mellitus

IDF: International Diabetes Federation

HbA1C: Glycated hemoglobin

Hr: hour

IGT: Impaired Glucose Tolerance

Kcal: Kilocalorie

kg/m^2: kilogram per meter square

LDL: Low Density Lipoprotein

LEA: Low Extremities Amputation

MDG: Millennium Development Goals

mg/dl: milligram per deciliter

mmol/L: millimole per liter

MODY: Maturity Onset Diabetes in Young

NBC: Nigerian Bottling Company

NCD: Non-Communicable Disease

NIDDM: Non-Insulin Dependent Diabetes Mellitus

OGTT: Oral Glucose Tolerance Test

PVD: Peripheral Vascular Disease

RBG: Random Blood Glucose

SMBG: Self-Monitoring of Blood Glucose

T1DM: Type 1 Diabetes Mellitus

T2DM: Type 2 Diabetes Mellitus

UN: United Nations

WDD: World Diabetes Day

WHO: World Health Organization

WHR: Waist Hip Ratio

CHAPTER ONE

INTRODUCTION

1.0Background to the Study

The World Health Organization (WHO,1999)defined Diabetes mellitus as a condition of metabolic disorder characterized by chronic hyperglycemias that results into long term damage/dysfunction and failure of various organs. It is a deadly metabolic disorder which results from an insufficient insulin production by the pancreas, with the subsequent impairment of glucose metabolism. Diabetes has also been defined by The United Nations (UN) as a chronic, debilitating, and costly disease linked with severe complications which pose severe risks for families, member states, and the entire world; and serious challenges to the achievement of the internationally agreed developmental goals(IDF, 2011).

Prevalence of Non-Communicable Diseases (NCDs) is swiftlygrowing worldwide, leading to increased morbidity and mortality. A report by the World Economic Forum (2011) shows that, 63% of all deaths worldwide currently stem from NCDs – mainlycancers, cardiovascular diseases, diabetes, and chronic respiratory diseases. About 60% of global burden of increase in NCDs is expected to occur in developing countries, and most of the associated mortality is obesity-related and attributable to type II diabetes mellitus (T2DM) and coronary heart disease (WHO/FAO, 2003). The International Diabetes Federation states that, diabetes affects at least 366 million people worldwide, and it is anticipated to reach 552 million by the year 2030, with 80% of all diabetes cases occurring in low- to middle-income countries (IDF, 2011).

A national survey in 1992 by the Non-communicable Disease Expert Committee of the Federal Ministry of Health (FMOH) reported that 2.2% of the population is either at high risk of developing diabetes or already have the condition and 90% of these people were above forty years of age (Akinkugbe, 1992). The incidences of diabetes are increasing with every new day with itsprevalence not only in the urban areas, but also amongst rural dwellers. The younger generationsare predisposed to diabetes because of increase urbanization which has caused bad lifestyle modification.To reduce the risk of developing the complications of diabetes mellitus, dietary and lifestyle modification are vital to control against elevations in blood glucose. The prevention of diabetes needs to be approached as a lifelong goal.

1.1GlycaemicIndex

In order to achieve better glycaemic control, dietary management is essential to reduce the risk of diabetes complications and to extend the life expectancy. A keyemphasis of nutritional management of diabetes is the improvement of glycaemic control by harmonizing food intake with endogenous and or exogenous insulin levels. Nutrition is of extreme importance in intensive diabetes management and has been defined as the keystone of care (Kalergis et al., 2005, Kouassi et al., 2009).

The concept of the glycaemicindex (GI) was introduced over 30 years ago, as a means of physiologically categorizingfood containing carbohydratesaccording to their effect on postprandial glycemia (Jenkins et al., 2002).The Glycaemicindex scientifically measures how a person's blood glucose levels changes while eating different types of carbohydrate foods in comparison with a reference food. Certain carbohydrate foods are rapidly digested releasing glucose into the blood stream whereas some carbohydrate foods are slowly digested releasing glucose slowly into the blood stream (Jenkins et al., 1994).

The Glycaemicindex (GI) was considered as a metric for the dietary management of type II diabetes (Brand-Miller, 2003). The glycaemicindex (GI) is a measure of how rapid blood glucose levels increase postprandially. It is defined as the incremental area under the glucose response curve following consumption of a 50 grams food portion relative to that produced by a 50 grams portion of a control food, either glucose or white bread (Wolever1993, Jenkins et al, 1981). Glucose which is the defining standard has a glycaemicindex of 100.It represents the impact of available carbohydrate (total carbohydrate minus fiber) in a food on a person's blood glucose level relative to consumption of a reference meal which is usually pure glucose (Jenkins et al., 2002).

Glucose or white bread is the standard reference food (Canadian Diabetes Association, 2008). The GlycaemicIndex (GI) is a scale that ranks carbohydrate-rich foods by how much they raise blood glucose levels compared to a standard food. Glycaemicindex is rated on 1 to 100. Food which raises the blood glucose level quickly after meal is known as high glycaemicindex food and is assigned a value of 70 and above whereas food which releases glucose slowly into the blood stream is known as low glycaemicindex and has a value of 55 and below (Brand-Miller *et al*., 1996).
According to this scale system, carbohydrate – containing foods are graded into three categories as High GI foods: GI values range is ≥ 70, Intermediate GI foods: GI values range between 55 – 69, Low GI foods: GI values range is < 55. This categorization depends on the rate at which blood sugar level rises, which in turn is related to the rate of digestion and absorption of sugars and starches available in that food (FAO/UN, 1998).

1.1.1 Glycaemic Load

GI can be convertedand applied as a tool called the Glycaemic load (GL) for managing diabetic patients (Jenkins et al, 2002). Since the GI is based on 50 grams of carbohydrate, an amount that does not always agree with the amount of carbohydrate usually eaten, the glycaemic load was developed. The Glycaemic load considers the serving size of a food portion, thereby offering a more realistic measure of a food's effect on blood glucose. It is determined by multiplying the GI of a food by the amount of carbohydrate per serving (the carbohydrate content) and dividing by 100 (Salmeron et al, 1997). The GI/GL concept has been developed to supplement information available on the chemical composition of foods given in food tables. The FAO/UN has endorsed the inclusion of this concept to guide food choices (FAO/UN, 1997). The glycaemicindex is about the quality of the carbohydrates not the quantity while the glycaemic load takes the quantity of available carbohydrates into account.

1.1.2Glycaemic Response

The effect of different foods on blood glucose levels over a period is known as the Glycaemic response. It has been discovered by researchers that some kinds of foods may raise blood glucose levels more quickly than other foods containing the same amount of carbohydrates. The glycaemic response of a food is a measure of the food's ability to elevate blood glucose. The glycaemic response is influenced by the amount of food eaten, its fat content, fiber content, and the way the food is prepared. An individual’s glycaemic response to a food or meal is determined by both the quality and quantity of carbohydrates (Sheard et al, 2004).

1.2 Problem Statement

Diabetes mellitus is a public health problem in Nigeria. It is a chronic disorder of carbohydrate metabolism whose prevalence is rising globally, including the rural Nigeria populations (Johnet al., 2005). Patients and the health systems suffer from the resulting heavy financial burden. Diabetes mellitus is the highest non-communicable disease cause of morbidity and mortality in Africa with its enormous complications imposing significant economic consequences on individuals, families, health systems and countries. This growing threat is increasingly afflicting the number of people, families and communities. The major cost drivers are outpatient care, hospitals and cost of insulins (WHO, 2009, WHO, 2016).

International Diabetes Federation (IDF, 2015) reports that every year there is a rise in the number of people living with this condition, which presents life-changing complications. Furthermore, aside the 415 million adults estimated to be currently having diabetes, about 318 million adults have impaired glucose intolerance, which makes them at high risk of developing diabetes in the future. An estimate of between 9.5 to 29.3 million people have been reported to be living with Diabetes in the Africa Region out of which three quarters of this estimate are said to be undiagnosed (IDF, 2015).In Nigeria,this figure is currently a little over a quarter million projected to triple by year 2030 (WHO, 2009). The progressive increase in the prevalence rates of Diabetes is associated with lifestyle changes; physical inactivity, overweight and obesity, poor diet and nutrition, pre-diabetes or impaired glucose tolerance (IGT), alcohol consumption, and cigarette smoking- which are potentially modifiable factors. There is also a recent suggested association between type 2 diabetes and high consumption of sugar sweetened beverages (IDF, 2017).Increasing urbanization, adoption of unhealthy western lifestyle with reduced physical activity, sedentary lifestyle and excessive intake of unhealthy foods contributes to obesity which is a risk factor for development of diabetes mellitus.

With the over 250 tribes having different culture and food types in Nigeria, the prevalence rateof diabetes has not been uniform; though the International Diabetes Federation reported 5.0% in the 2013 Diabetes Atlas (IDF, 2013).Serious complications and early death occur from poorly managed diabetes as individuals with diabetes have a higher risk of developing several disabling and life-threatening health problems. Diabetes results in disabling consequences such as blindness, kidney failure and lower limb amputation as consistently high blood glucose levels affects the heart and blood vessels, eyes, kidneys and nerves. These complications result in substantial economic loss to the diabetic, their families, health systems and national economies via direct medical costs and loss of work productivity and wages (WHO, 2016, IDF 2017).The prevalence of diabetes mellitus and its complications is rising in Nigeria presenting an immense public health burden with an increased prevalence rate of 2.2% reported from a national survey by Akinkugbe in 1997 to 5.0% in 2013(IDF, 2013).

However, evaluation of foods for GI is not in all sufficient. Integrating information about the glycaemicindex of mixed meals/foods for appropriate dietary management of Diabetes mellitus with its prevention is limited by scarcity of data more research is clearly needed. Furthermore, most previous works done on GI of Nigerian foods have providedinformation mainly on individual/single foods of which commonly consumed foods in southwestern Nigeria are usually not eaten as single foods but as mixed meals.Hence there still exists a dearth in knowledge of the glycaemicindex of mixed meals as eaten in Southwestern Nigeria.

1.3 Justification

The Glycaemicindex is currently used as a nutrition therapy tool as low glycaemicindex food reduce postprandial blood glucose levels preventing hyperglycemia and glycosuria. There is also enough evidence of long-term benefit to recommend using low glycaemicindex diets as a primary strategy in meal planning (ADA, 2008).GI has been transformed as a tool in planning diets for diabetic patients, prevention of diabetes, obesity, cardiovascular disease, and even certain cancers in the recent years (Brand Miller et al, 2003; Salmeron et al, 1997, Farhatet al, 2010). Enoughevidence exists to support the direct effect or association of low GI or glycaemic load (GL) diets in both the management and prevention of diabetes (Brand Miller et al, 2003; Salmeron et al, 1997). Conversely, consuming high GI foods is associated with an increased risk of type 2 diabetes mellitus (Salmeron et al, 1997) and coronary heart disease (Ford et al., 2001). In contrast a low GI diet has been reported to provide health benefits as epidemiological data indicate that a low GI diet prevents against the development of type 2 diabetes, coronary heart disease and metabolic syndrome (Wei et al, 2000, Wannamethee et al., 2002, Jenkins et al., 1982).

Currently, there ishigh interest in the role of low GI foods towards preventing and managing metabolic related diseases (Aston et al., 2008). However, paucity of information of GI and GL for many Western African traditional foods is still a major hinderance (Omoregie et al., 2008). This hereby justifies the need to evaluate and determine the GI of local mixed dishes to know those with low glycaemicindex that can be used in making diets for those prone to developing diabetes and the diabetic patients (Tanya et al., 1998). Identification and knowledge of the glycaemicIndex of some Nigerian mixed foods/meals will expand the variety of meals available for the dietary management of diabetes. This study will also provide recent data on the glycaemicindex of commonly consumed mixed meals as eaten in southwestern Nigeria and provide information on the impact of different combinations of dishes (especially soups) on the glycaemicindex of the mixed meals to effectively enable the use of glycaemicIndex in the management and prevention of DM.

It is still difficult to establish a connection between the Nigerian diet and diabetes prevalence since most existing data (on GI) are based on European foods or individual/single Nigerian staple foods, which are not fully representative of commonly consumed meals in Nigeria; hence the need for this study to determine the glycaemicindex of commonly consumed mixed meals as eaten by apparently healthy young adults in Nigeria.

1.4 Research Questions

1. What is the glycaemicindex of mixed meals commonly consumed in southwestern Nigeria?

2. What is the comparative glycaemicresponse of a mixed meal and that ofsingle staple foods?
3. Dosoups have any significant effect on the glycaemicindex of selected staples commonly consumed in southwestern Nigeria?
4. Is there any difference in the glycaemicindex of single foods and its mixed meals components?

1.5 Objectives of the study

1.5.1 General objective of the study

To determine the glycaemicIndex of commonly consumed mixed meals "as eaten" by apparently healthy young adults in Southwestern Nigeria.

1.5.2 Specific objectives

1. Identify the commonly consumed mixed meals as eaten in Southwestern Nigeria.
2. To determine the proximate content and available carbohydrates of these foods as cooked.
3. To determine the glycaemicindex and glycaemic load of commonly consumed foods (Single and Mixed meals) in apparently healthy participants.
4. To determine the association between the glycaemicindex of mixed meals and single foods that constitute the mixed meals.
5. To evaluate the effect of soups on the glycaemicindex of commonly consumed staples in Southwestern Nigeria.

1.6Research Hypothesis

The null hypothesis states that:

1. There is no relationship between the glycaemicindex of commonly consumed single foods and that of mixed meals as eaten by apparently healthy young adultsin Southwestern Nigeria.

2. The relationship between the glycaemicindex of commonly consumed single foods and that of mixed meals as eaten by apparently healthy young adults in Southwestern Nigeria is not an addition of themixed mealcomponents.

CHAPTER TWO

LITERATURE REVIEW

2.1Carbohydrateandglucose metabolism

Carbohydrate provides most ofthe dietary energy in the Nigerian diet. Oxidative metabolism is fueled by carbohydrate-dense foods which provides energy for the body and servesas vehicles for important micronutrients and phytochemicals. Dietary carbohydrate is vital to maintain glycaemic homeostasis and for gastrointestinal integrity and function. Unlike fat and protein, high levels of dietary carbohydrate, provided it is obtained from a variety of sources, is not associated with adverse health effects. Also, diets high in carbohydrate when compared with those high in fat, decrease the likelihood of developing obesity and its co-morbid conditions. An optimal diet should consist of at least 55% of total energy coming from carbohydrate obtained from a variety of food sources (FAO, 1998).

Glucose is a simple sugar with six carbon atoms and is the human body's key source of energy. It providesabout 3.75 kilocalories (16 kilojoules) of food energy per gram through aerobic respiration and is sometimes referred to as blood sugar and a common medical analyte measured in blood samples. Breakdown of carbohydrates (e.g. starch) yields mono- and disaccharides, most of which is glucose. Glucose is oxidized to eventually form carbon dioxide (CO_2) and water, which yields energy mostly in the form of ATP (AdenosineTriphosphate) through glycolysis and later in the reactions of the citric acid cycle and oxidative phosphorylation (Friedman, 1995).

The blood glucose level or blood sugar concentration is the amount of glucose (sugar) present in the blood of a human or animal. Naturally, the body tightly regulates blood glucose levels as a part of metabolic homeostasis. The concentration of glucose in the blood is regulated by insulin reaction and other mechanisms. In the morning glucose levels are usually lowest, before the first meal of the day (termed "the fasting level") andincrease after meals for an hour or two by a few millimolar. An indicator of a medical condition may be linked to blood sugar levels outside the normal range. A persistently high blood sugar level is referred to as hyperglycemia while low levels are referred to as hypoglycemia. The standard way of measuring blood glucose levels internationally, are in terms of a molar concentration, measured in mmol/L (millimoles per liter) or in mg/dL (milligrams per deciliter). For the measurement of glucose, since the molecular weight of glucose $C_6H_{12}O_6$ is 180, the difference between the two scales is a factor of 18, so that 1 mmol/L of glucose is equivalent to18 mg/dl [Danquah *et al*., 2015].

2.2The Endocrine Pancreas

The pancreas has two functional components: the exocrine pancreas which is in charge of digestion of foods through the release of enzymes into the pancreatic duct and the endocrine pancreas which is made up of small islands of cells known as Islets of Langerhans responsible for the release of the hormones insulin and glucagon, into the blood stream, for the homeostatic control of blood sugar (glucose) levels. There are no specific gross changes of the pancreas at the onset of type 2 diabetes mellitus (T2DM), while after a long period of the disease, there is a decrease from 1% to 40% of the total pancreatic weight. Histologically, at the onset of the disease the islet cell mass is normal, while in patients with long-standing type 2 diabetes, several morphological alterations can be detected (Franco et al., 2018).

2.2.1 The Regulatory Hormone – Insulin

The hormone that regulates the blood sugar level is known as Insulin. It is responsible for delivering energy in the form of both sugar and fat to the body cells. This hormone is excreted by the pancreas gland whenever food is eaten. The biggest impact with insulin secretion is caused by carbohydrates. The higher the GI of the carbohydrate, and the more of it is eaten results in the pumping out of more insulin by the pancreas. When there is too much Insulin in the bloodstream, a health problem called HYPERINSULINISM occurs. This condition also occurs when too many high glycaemic carbohydrates are eaten because there is always a surge in insulin levels beyond the body's need for cellular energy. In a person with type 2 diabetes or impaired glucose intolerance also called borderline diabetes, the body is longer able to uptake blood glucose into the cells. The body therefore usually produces enough, but at the same time cannot utilize the insulin efficiently. Consequently, the blood sugar stays too high.

The hormone insulin causes the body to store fat. Whenever the blood sugar levels surge, the excess sugar in the blood is converted into fat in the form of triglycerides and stored in the fat cells by Insulin which leads to weight gain. Consequently, when insulin levels are low, which is the situation whenever low glycaemicindex foods which bring about low glucose blood levels and low insulin levels are eaten; stored fat in the body are then used up as fuel hence the individual loses weight (Lucy et al, 2005).

2.2.2 The role of insulin and glucagon – glucose homeostasis

There is an obligatory requirement for glucose by the body, approaching 200g/dldetermined largely by the metabolic demands of the brain. Coma, seizure, or death may ensue if blood glucose concentration falls below 40mg/dl (2.2mmol/L).On the contrary, when blood glucose levels exceed about 180mg/dl (10.0mmol/L), it is associated with immediate (glycosuria and calorie loss) and long term (renal failure, retinopathy, atherosclerosis) consequences. For these reasons, there is a tightly regulated blood glucose concentrationby homeostatic regulatory systems. Insulin secretion is stimulated by hyperglycemia which in turn promotes the uptake of glucose by muscle and adipose tissue. Hypoglycemia also elicits secretion of glucagon, epinephrine, cortisol, and growth hormone, which are counter regulatory hormones that antagonize insulin action and restore normoglycemia (Ludwig, 2002, Cahill, 1970, Wilson et al., 1998).

Regulation of insulin and glucagon is compromised in type 1 or type 2 diabetes (Greenbaum et al., 2002; Shah et al., 2000). Most research have focused on the insulin-secreting β- cells because of the therapeutic benefits of insulin in diabetes (Benniger and Piston, 2014). Though studies by Pearson et al. (2016); Unger and Cherrington (2012) have nowadays proven that aberrant glucagon secretion from ά-cells exacerbates hyperglycemia in diabetes. Particularly, glucagon suppression by glucose and/or insulin becomes lost, and hyperglucagonemia persists at all glucose levels (Unger and Orci, 2010). It has even been proposed that hyperglucagonemia, rather than insulin deficiency is the primary driver of hyperglycemia (Fisher et al., 1996; Ramnanan et al., 2011). It has been repeatedly demonstrated that inhibition of glucagon action during diabetes can lead to restoration of euglycemia, even in the absence of insulin (Yu et al., 2008;Wang et al., 2010; Lee et al., 1998).

2.2.3 Insulin resistance

Beta cells are the cells that are normally stimulated to produce insulin when the glucose level rises. In this way, there is a system in the body by which the right amount of insulin is secreted for the right amount of glucose available. When glucose enters the cell, the blood glucose level decreases, and the beta cells stop secreting insulin. Insulin resistance is therefore a medical and biological term which means that the cells of the body don't properly respond to insulin. This means that they don't uptake glucose and fat efficiently. Whenever this occurs, the individual has too much insulin in the bloodstream which in turn leads to weight gain, metabolic syndrome and often type 2 diabetes (Lucy et al, 2005).In type 1 diabetes, the beta cells are destroyed by the immune system and no longer secrete insulin, however, type 2 diabetes is due to insulin resistance.

To overcome this resistance, the beta cells secrete more insulin, and glucose is eventually forced into the cells and maintained at normal limits at the expense of increased insulin secretion by the beta cells. With beta cell dysfunction, insulin secretion is impaired whereas with insulin resistance, insulin may still be secreted but insulin insensitivity manifests in target tissues. As the dysfunction of beta cell and insulin resistance worsens, hyperglycemia increases leading to the progression to type 2 diabetes. The postprandial glucose and insulin levels are physiological responses which, are directly related with the prevalence of chronic non-communicable diseases (NCDs) such as obesity, diabetes, cardiovascular diseases and hypertension (Pawlak et al.,2001; Jarvi et al, 1999; Sigal et al, 1997). When these responses are raised over a long period of time, insulin resistance may result, thus increasing the risk of developing these diseases (Wiseman et al, 1996; Byrnes et al, 1995).

2.3Overviewof diabetes mellitus

One of the important non-communicable diseases (NCDs), Diabetes, is rapidly attracting the attention of the international medical community, culminating in a United Nations political declaration on NCDs in September 2011 with follow-up meeting on Political

Declaration of the High-level meeting of the General Assembly on the Prevention and Control of NCDs in May 2013. [International Diabetes Federation, 2014; United Nations, 2011] Globally, the burden of diabetes is rapidly increasing. It is no longer a disease of mainly rich countries. The prevalence of this disease is rapidly increasing everywhere, most especially in the middle-income countries of the world (WHO, 2016). The International Diabetes Federation (IDF) Diabetes Atlas reports that, by end of 2013, there were 382 million (or 8.3% of adult world population) people worldwide with diabetes out of which80% live in low-and-middle-income countries; this number is estimated to reach 592 million in <25 years (by 2035). Currently, sub-Saharan Africa is estimated to have 20 million people with diabetes, about 62%are not diagnosed and the number is projected to reach 41.4 million by 2035 or an increase of 109.1%.

World Health Organization (WHO, 2016), has defined diabetes mellitus as a chronic progressive disease characterized by raised levels of blood glucose. It is a serious, chronic disease that occurs either when the insulin produced by the body cannot be effectively utilized by it or when the pancreas does not produce enough insulin – the hormone that regulates blood glucose. A public effect of uncontrolled diabetes is raised blood glucose (hyperglycemia) which over time may lead to serious damage to the blood vessels, heart, eyes, and nerves.

Prevalence of Non-Communicable Diseases (NCDs) is increasing rapidly worldwide, leading to increased morbidity and mortality. According to the report by World Economic Forum (2011), 63% of all deaths worldwide presently stem from NCDs – mainly cardiovascular diseases, diabetes, cancers, and chronic respiratory diseases. Approximately 60% of global burden of increase in NCDs is likely to occur in developing countries, and most of the associated mortality is obesity-related and attributable to coronary heart disease and type II diabetes mellitus (T2DM) (WHO/FAO, 2003).

According to the International Diabetes Federation, diabetes presently affects about half a billion adults, a total that is likely to exceed a half billion mark by 2045, 1 in 2 adults with diabetes is undiagnosed (212 million), 1 in 11 adults have diabetes, with two-thirds (279 million) of people with diabetes living in urban areas. two-thirds (327 million) of people with diabetes are of working age and over 1 million children and adolescents have type 1 diabetes (IDF, 2018).

2.3.1 Typesof diabetes

There are three foremost types of diabetes that are frequently recognized, and these are:

Classification	Characterization	Occurrence
Type 1 DM(T1DM) Formerly known as Insulin-Dependent diabetes mellitus (IDDM) or Juvenile-onset diabetes	• It's an autoimmune disease that stops the body from producing insulin. It is refered to as Latent Autoimmune disease in Adults (LADA • Beta cell destruction caused by auto immune response	• The onset is acute and develops over a period of a few days to weeks. It happens in children and young adults • About 5 to 10 percent of people with diabetes have type 1 and more than 95% develop the disease before the age of 25 with an equivalence occurrence in both sexes • In Nigeria it constitutes less than 3% of diabetic patients
Type 2 DM (T2DM) Formerly known as Non-Insulin Dependent diabetes mellitus (NIDMM) or Adult onset diabetes	• It's a metabolic syndrome characterized insulin resistance and insulin secretory defect that results from the body's inability to make effective use of the insulin produced.	• It's the most common type of diabetes associated with may preventable risk and causative factors such as hypertension, obesity, physical inactivity and poor diet. • More than 90% of all diabetes cases is T2DM • In Nigeria, it constitutes about 96% of the patients with DM
Gestational Diabetes Mellitus (GDM)	• It's associated to any degree of glucose intolerance with onset	• It is diagnosed usually in the second or third trimester of pregnancy

	or first recognition during pregnancy	• It usually disappears after pregnancy but women with GDM and their children have an increased risk of developing type 2 diabetes later in life. • A Nigerian reported GDM occurs in 2.98 per 1000 pregnancies while another stated that the incidence increased with maternal age
Other Specific Types of Diabetes	• It comprisesof diabetes due to various etiologies and includes persons with diseases of the exocrine pancreas such as pancreatitis, cystic fibrosis; persons with dysfunction associated with endocrinopathies (e.g. acromegaly), genetic defects of beta cells function (formerly called MODY – Maturity onset diabetes in young), or with defects of insulin action and drug or chemical induced diabetes	

(WDD, 2012, Chinenye et al, 2013, Oputa et al, 2012, ADA, 2018Wokoma et al, 2001, Ewenighi et al, 2013).

2.3.2 Diagnosisof diabetes mellitus

The presence of elevated plasma glucose with or without symptoms of diabetes mellitus or its complications is employed for the diagnosis of Diabetes mellitus

Criteria for the diagnosis of diabetes
FPG ≥ 126mg/dl (7.0 mmol/L). Fasting is defined as no caloric intake for at least 8 h.*
OR
2-h PG ≥ 200 mg/dL (11.1 mmol/L) during OGTT. The test should be performed as described by the WHO, using a glucose load containing the equivalent of 75 g anhydrous glucose dissolved in water. *
OR
HbA1C ≥ 6.5% (48 mmol/mol). The test should be performed in a laboratory using a method that is NGSP certified and standardized to the DCCT assay. *
OR
In a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glucose ≥ 200 mg/dL (11.1 mmol/L).

DCCT, Diabetes Control and Complications Trial; FPG, fasting plasma glucose; OGTT, oral glucose tolerance test; WHO, World Health Organization; 2-h PG, 2-h plasma glucose. *In the absence of unequivocal hyperglycemia, diagnosis requires two abnormal test results from the same sample or in two separate test samples (ADA, 2009, WHO, 1999, WHO 2011, ADA, 2018)

2.3.3 Diabetesguidelines

Irrespective of the type of diabetes in question, the goals of managing the patient are alike. The main goal of management is to have a blood glucose level of a person without diabetes. This is further explained in the table below:

Blood Glucose Goals – Desirable Blood Sugar Levels

Time of test	Person without Diabetes	Person with Diabetes
Fasting blood glucose	Less than 115mg/dl	80 to 120mg/dl
Before bedtime	Less than 120mg/dl	100 to 140mg/dl

Recommended Daily Food Portion

Daily Calories count	Carbohydrates	50% to 60%
	Protein	12% to 20%
	Fat	not more than 30%

(World Diabetes Day, 2012 – "Diabetes Education and Prevention")

2.3.4 Riskfactors of diabetes mellitus

The risk factors for type 1 diabetes are still unknown. Though, the risk of developing the disease slightly increases with having a family member with type 1 diabetes. Exposure to some environmental factors and viral infections have also been associated to the risk of developing type 1 diabetes. Type 2 diabetes has been linked with several risk factors which includes: physical inactivity, ethnicity, increasing age, high blood pressure, impaired glucose tolerance family history of diabetes, history of gestational diabetes overweight, poor nutrition during pregnancy and unhealthy diet. Nyenwe et al, 2003 reported that both Waist Hip Ratio (WHR) and Body Mass Index(BMI) were significantly higher in the diabetic subjects than in the normal subjects, also diabetic patients were significantly older than those with normal glucose tolerance occurring more frequently in people aged 50 years and above. The study stated further that subjects in the highest socioeconomic class showed significantly higher occurrence of type 2 diabetes when compared with the others. Also, diabetes was more prevalent in the Hausa-Fulani and Ibibio subjects than the other ethnic groups. The Prevalence of abnormal glucose Regulation (AGR) was two times higher among obese persons compared with participants who had a normal BMI. Obesity was significantly associated with having diabetes. Persons who had a higher dietary diversity score and who met the WHO minimum recommended physical activity level had a significantly lower likelihood of AGR (Mayega et al, 2013). In a 2012, cross sectional study, Soriguer et al., reported that the prevalence of obesity and abdominal obesity were significantly higher in all diabetes. The prevalence of a family history of diabetes was greater in all diabetes, Presence of diabetes mellitus was significantly associated with age, sex (less frequent in women), educational level (greater risk in persons without education (Soriguer et al, 2012). Sharp increases in the numbers of people developing diabetes have occurred due to changes in diet and physical activity which is related to rapid development and urbanization. Overweight pregnant women have been diagnosed with IGT, or pregnant women who have a family history of diabetes are all at increased risk of developing gestational diabetes mellitus (GDM). Additionally, with previous diagnosis of gestational diabetes or being of certain ethnic groups puts women at increased risk of developing GDM (IDF, 2018).Impaired glucose tolerance (IGT) is a category of higher than normal blood glucose, but lower than the threshold for diagnosing diabetes.

2.3.5 Signsand symptoms of diabetes mellitus

The classic symptoms of diabetes are polyuria (frequent urination), polydipsia (increased thirst), polyphagia (increased hunger) and weight loss (Vijan S., 2010). Most often people with type 2 diabetes do not have any symptoms. When symptoms occur, they are often ignored as they may not seem serious. Symptoms of Type 2 diabetes is usually not diagnosed until complications have occurred. In type 1 diabetes symptoms usually come on much more unexpectedly and are often severe. Common symptoms of diabetes include: Increased urination (sometimes as often as every hour), Excessive thirst and appetite, fatigue, nausea, unusual weight loss or gain, perhaps vomiting, blurred vision, frequent vaginal infections in women, In men, yeast infections, slow healing sores or cuts, dry mouth itching skin, especially in the groin or vaginal area (World Diabetes Day (WDD), 2012).

2.3.6 Complications of diabetes mellitus

Diabetes is a chronic disease characterized by hyperglycemia. The effect of hyperglycemia on the vascular system cannot be over emphasized as it is the main underlying cause of morbidity and mortality in DM patients. The effect of hyperglycemia on the vascular system are classified into two: Macrovascular complication (which includes peripheral arterial disease and coronary artery disease) and Microvascular complications (which includes Diabetic retinopathy, nephropathy and neuropathy). Complications of DM whether acute and chronic can be severe, debilitating and fatal. The longer the duration of the illness, the greater the possibility of an end organ complication. The problem of DM is attributable to complications which may be acute or chronic. Hyperglycaemic emergencies remain a major cause of concern in Nigerians with DM, accounting for 40% of all DM admissions with documented determinants of fatal outcomes being DM foot ulcers, hypokalemia and sepsis (Ogbera et al, 2007; Ogbera et al,2009). One complication of DM that is widely reported is foot ulceration with a prevalence rate of about 9.5%. Neuropathy is major risk factor for DM foot ulceration (and this is eminently preventable.In Nigeria, Diabetic nephropathy is assuming an increasing role as a cause of chronic kidney disease. It is one of the leading causes of chronic kidney disease in patients starting renal replacement therapy. DM nephropathy is associated with increased cardiovascular risk (Ogbera et al, 2006). Ogun et al, 2005 reported cardiovascular complications of DM such as Stroke, and peripheral disease at 11%. DM has been noted to account for 2.1% of cases of heart failure (Onwucheka, 2009).

A leading cause of blindness in people with DM is Diabetic retinopathy which accounts for 16.2% to 42.1% (Nwosu, 2000; Ashaye et al, 2008) of retinal diseases.A prominent clinical feature of hypogonadism is Erectile dysfunction which is usually associated with low testosterone levels. (Ogbera et al, 2009).Furthermore, asides diabetic retinopathy being a leading cause of adult blindness, diabetic subjects are six times more susceptible to cataracts and1.4 times more vulnerable to open- angle glaucoma (Tumosa, 2008; Mash et al, 2007).

Particularly in developing countries, the universal chronic killer status of DM originates not only from its direct systemic complications, but also indirectly from its linkageswith Communicable Diseases such as HIV/AIDS, TB, other Non-Communicable Diseases – chronic respiratory diseases, cardiovascular diseases, renal diseases, cancer – and other modifiable and non-modifiable risk factors including hypertension, obesity, physical inactivity,dyslipidemia,increasing age, poverty, ethnicity, urbanization, undernutrition, etc(Anon, 1990). Diabetes is a component causeof tuberculosis, pneumonias, and bacteremias(Kornum*et al*.,2008). It has also been reported to increase the risk of active tuberculosis by up to three times (Jeon et al, 2008). Of all medical admissions in South-South Nigeria, DM related admissions made up 15% with a case fatality rate of 16% and 10.4% of all hospital in-patients over a 10-year period, with case fatality of 17.2% (Unachukwu et al, 2008).The pattern is sustained in South East Nigeria, with DM, hypertension and HIV/AIDS being the commonest causes of admission and death in tertiary health institutions (Odenigbo, 2009; Osuafor et al, 2004).

The most common explanations for DM admission were hyperglycaemic emergencies 46% and diabetic foot ulcers (DFUs) 30% whereas DFUs and cerebrovascular disease have the highest case fatality rates of 28%and 25% respectively. The most prolonged duration of admission ranging from 15 – 122 days is associated with DFUs. Particularly worrisome in Nigeria and Africa, is the case of lower extremity amputation (LEA) resulting from DFUs (Awori et al., 2007; Ogbera et al, 2008). It is a major incapacitating complication of DM which results in long hospital stay and even longer rehabilitation, with huge financial consequences, often involving very poor people. Poor glycaemic control, infection, dyslipidemia and poor selfcare are traditional common risk factors for foot ulceration which leads to LEA in diabetic subjects. A Nigerian study shows that the Caregiver/Physician may contribute significantly to the risk for foot ulceration in Nigerian diabetics, and this may not be limited to Nigerian Physicians alone. Approximately 96.4% of diabetic subjects presents symptoms of peripheral neuropathy (PN) to a tertiary health facility and 97.3%without symptoms of PN had never had their feet observed by their Physicians (Oguejiofor et al, 2009).

Diabetes accounts for 3.8 million deaths annually and globally, a number similar in magnitude to the mortality attributed to HIV/AIDS (WHO, 2007) but the cause of death appear divergent in DM subjects between the developed Western nations and developing nations. The most significant cause of death in the diabetic population in Western countries, is cardiovascular disease (Winer, 2004; Cusicle et al, 2005). However, In Africa, the commonest causes of death in the same population are infection and acute metabolic complications, not cardiovascular or renal (Azevedo, 2008). In Nigeria, acute diabetic complications – hyperglycaemic hyperosmolar state, ketoacidosis, and hypoglycemia were the commonest causes of death in diabetic patients (Unachukwu et al, 2008).

2.3.7 Prevalenceof diabetes mellitus in Nigeria

In Africa, Diabetes mellitus was considered aninfrequent medical condition at the beginning of the last century, but there is now evidence to demonstrate an increasing occurrence and prevalence of diabetes in these populations regarded as low and middle income (Kengne et al., 2005, Population Reference Bureau, 2008). Dr. Cook described DM as being an uncommon disorder in the African as far back as the beginning of the twentieth century. Though there is a convincing data to show an increasing occurrence and prevalence of DM in the continent. In Africa, the estimated prevalence of diabetes is 1% in rural areas, and between 5% to 7% in urban sub-Saharan Africa (Kengne*et al*, 2005). According to Ogbeira*et al*., 2014, the brief history of diabetes mellitus in the early nineties, stated that not much was known about DM in Nigeria and traditionally, people related DM to “curses” or “hexes” also diagnosis was made based on urinary or blood tests for glucose.

Achronic disorder that is not only assuming pandemic proportions worldwide but is also poised to affecting the developing countries of the world much more than their developed counterparts is Diabetes mellitus (DM). In developing countries such as Nigeria, it is a diverse group of metabolic disorders that is often accompanied with a high disease burden (Ogbera*et al*., 2014). Nigeria, which is one of the prominent black country for example has a population of 158 million people thus making it the most populous country in Africa which accounts for one sixth of Africa’s population. Nigeria has a cultural diversity with 398 documented ethnic groups and about 50% of Nigerians are urban dwellers(World Population Prospects, 2012). In most developing countries of the world,health care delivery is at best sub-optimal and this may be responsible for the dismal health indicator statistics such as increased maternal mortality and reduced life expectancy at birth. In Nigeria, health care provision is a concurrent responsibility of the three tiers of government. Also, private providers of health care also play a notable role in health care delivery. Despite having been inaugurated about two decades ago, health insurance is still taking tottering steps and payment for healthcare is largely "out of pocket". (Ogbera*et al*, 2014).

Studies have shown that there has been anadvanced increase in the prevalence of diabetes in Nigeria and the burden is anticipated to increase even further (Adeleye, et al., 2006). The World Health Organization states that, there are 1.71 million people living with diabetes in Nigeria and this figure is expected to reach 4.84 million by the year 2030 (WHO, 2009). In Nigeria, previous prevalence rate estimates of diabetes have been tagged at 2.5% compared to its 2.2% rate in 2003.The complications of diabetes impose significant economic consequences on individuals, health systems, families and countries. This threat is growing,with the number of people, families and communities afflicted increasing (WHO, 2009).

Over four decades from1960 to 2000, studies that were conducted showed generally low prevalence rates for diabetes in Nigeria (Kinnear, 1963; Osuntokun*et al*, 1971; Olatunbosun *et al*, 1998; Erasmus *et al*, 1989; Ohwovoriole*et al*, 1988). Two studies (Kinnear, 1963; Osuntokun*et al*, 1971) conducted in 1963 and 1971 reported prevalence of less than1% for diabetes in Nigeria. The incidenceand prevalence rate were still low at 0.8% to 2.8% in several studies (Olatunbosun et al, 1998; Erasmus et al, 1989; Ohwovoriole et al, 1988; Akinkugbe, 1997) that were conducted from 1988 to 1998 with most patients having non-insulin dependent diabetes (T2DM). These studies (Olatunbosun et al, 1998; Erasmus et al, 1989; Ohwovoriole et al, 1988] were limited to certain population groups in Nigeria except one (Akinkugbe, 1997) which was part of a national survey that evaluated the prevalence of non-communicable diseases in the entire Nigerian population.

In Port HarcourtNigeria, a study by Nyenwe et al., 2003, gave a crude prevalence rate of 6.8% (CI_/4.6_/9.0%), and standardized rate of 7.9% asthirty-four (34) out of five hundred and two (502) subjects had diabetes. The crude prevalence rates for males were

7.7 and 5.7% for females, respectively. From the 34 diabetic subjects seen, 14 (41.2%) of them were not previously known to have diabetes; 83.7% of these were asymptomatic. There is a relatively high prevalence of type 2 diabetes in Port Harcourt. This may be explained by changing lifestyle associated with industrialization. A significant proportion of the diabetic subjects are undiagnosed and asymptomatic.

Also, in 2008, Dahiru et al conducted a study on the prevalence of diabetes in a semi-urban communityDakace near Zaria in Nigeria which showed that out of 199 subjects recruited for the study the overall prevalence of diabetes was 2.0% with five participants (2.5%) having impaired fasting glucose (IFG). Amongst the diabetics, one was overweight (BMI = 27.43kg/m2) and one was obese (BMI = 31.55kg/m2), while among those with impaired fasting glucose two were overweight. Forty-three subjects (21.6%) were overweight and 15(7.5%) were obese.

Unadike et al., (2009) in a study conducted in Uyo, Nigeria reported that the Knowledge and awareness of certain aspects of diabetes among adolescents is poor; however, adequate health education had a positive impact on their knowledge and awareness. Chijioke et al., 2010 in a study conducted in Ilorin reported that Type 2 DM is a common cause of morbidity and mortality in Nigeria. Overall,the mortality rate was 32.5% with mean age at diagnosis and death being 53.43 + 15.07 and 57.07 + 14.29 respectively. Systemic hypertension was present in 50% of the study population with male and female rate of 55% and 43% respectively, Mortality rates were highest in those that presented with hypoglycemia, stroke and diabetic foot syndrome. Ignorance, poor hygiene, infections, lack of foot care and inadequate glycaemic/blood pressure control were the contributory factors to the high mortality.

Chinenye et al., 2012 conducted a multicenter study on the Profile of Nigerians with Diabetes mellitus and reported that most diabetes patients in Nigeria have suboptimal glycaemic control, have chronic complications of Diabetes Mellitus and are hypertensive. This study also reported that in Nigeria, the incidence of diabetes ranges between 0.65 in rural Mangu village to 11.0% in urban Lagos. To reduce diabetes-related morbidity and mortality, an improved quality of care and treatment to target is recommended.

Recently, so much attention is being given to Communicable diseases like Tuberculosis Malaria and HIV, at the detriment of the emerging epidemic of Non-Communicable disease like hypertension, heart disease and Diabetes. Over 30% of our elite populations including decision-makers are Diabetic. Moreover, meaningful treatment cannot be afforded by most of the Nigerian Diabetic population; with over 80% of the healthy populations being ignorant about Diabetes (Akogu, 2009).

According to World health assembly, 2013, the adult population aged 20–79-year-old in Nigeria located in sub-Saharan Africa, was reported to have an estimated 3.9 million people living with diabetes - the highest number - extrapolated at a prevalence of 4.99%). A pointer to Diabetes being a disease of 'affluence' was proven by some Studies conducted in Nigeria which indicated that the diabetes prevalence ranged from 0.8%among adults in rural highland occupants to over 7% in urban Lagos with an averagenational prevalence of 2.2%. (Olatunbosun et al, 1998).

Currently, prevalence of DM in Nigeria is not known but guestimates may likely be in the region of 8% - 10%. Out of the four classes of DM, three types are commonly recognized in our setting and these are type 1 DM, Type 2DM and gestational diabetes (Ogbeira et al, 2014). Of the three types of DM, Type 2DM is the commonly documented form of DM and it accounts for about 90% - 95% of all cases of DM in most endocrine clinics (Ogbeira et al, 2014). The prevalence ofT1DM is not known but there are sketchy reports from documented prevalence rates which are all hospital based and various endocrine centersthat range from 0.1/1000 to 3.1/1000 (Ugege et al, 2013; Adeleke et al, 2010)

Lifestyle changes; overweight and obesity, physical inactivity/sedentary lifestyle, alcohol consumption and excessive intake of calories, dietary changes and cigarette smoking- which are factors that are potentially modifiable have all being associated with the progressive increase in the prevalence rates of Diabetes. With over 250 tribes and different culture and food values, in Nigeria the prevalence values have not been uniform although the International Diabetes Federation reported 5.0% in its Diabetes Atlas of 2013 (IDF, 2013).

2.3.8 Management of diabetes mellitus

To effectively manage diabetesmellitus involves careful long-term monitoring and effective early treatment of diabetic complications. This can only be achieved by the patient being able to control and maintain their blood glucose level within a healthful and ideal range. This can be done by a combination of insulin therapy, exercise and diet (ADA, 2012). Management of persons with DM incorporates both non-pharmacological and pharmacological components. These components of care are routinely offered to persons with DM although most centers tend to underemphasize the non-pharmacological aspect paying utmost attention to the dietary aspect (Ogbera et al, 2014).

2.3.8.1 Drug Management

In Nigeria, treatment of DM has always involved the administration of insulin and oral hypoglycaemic agents in conjunction with dietary counselling and lifestyle modification. These includes the use of:

- A) Insulin: is usually given subcutaneously either by an insulin pump or byinjections. There are several types of insulin characterized by the time of onset of action and duration of action.

- B) Insulin sensitizers: These include Biguanides and Thiozolidinediones (TZD). Biguanides such as metformin (glucophage) is the most commonly used agent for type 2 diabetes in children, teenegers and adults.

- C) Alphaglucosidaseinhibitors are “diabetes pills” that do not have a direct effect on insulin but acts by slowing the digestion of starch in the small intestine.

- D) Incretin Mimetics: Incretins are also insulin secretagogues. These agents may also cause a decrease in gastric motility (Chatterjee et al, 2015).

2.3.8.2 Non-Drug Management

Diabetes Self -Management Education (DSME, Self - Monitoring of Blood Glucose (SMBG) and Foot care and Exercise are the key essentials for the non-drug management of DM. These entails education of the patient and families to initiate effective selfcare; self- monitoring of Blood Glucose (SMBG) to allow for patients to assess their individual response to therapy and evaluate whether glycaemic targets are being achieved. The care of the foot is also vital as foot complications are the cause of prolonged hospitalization and deaths.Physical exercise helps to prevent type 2 diabetes and improve metabolic control and blood circulation via use up of blood glucose and burning of fat. Exercise is known to reduce the risk of developing cardiovascular disease in DM and to impart glycaemic control positively (Chatterjee et al, 2015). The American Diabetes Association has recommended a component of comprehensive DM care to include a yearly laboratory evaluation for lipid profile, serum creatinine, liver function test, and calculated glomerular filtration rate, test for spot albumin excretion and thyroid stimulating hormone in persons with dyslipidaemia, T1DM, and women over 50 years of age (ADA, 2014).

2.3.8.3 Dietary Management

Dietary management is a vital cornerstone modality in the achievement of good glycaemic control in DM. The main target of Dietary management of DM is to improve the overall health by achieving and maintaining optimal nutritional status, attaining good glycaemic control and prevention of acute and long-term complications of DM. People with DM don't have a standardized diet and their dietary requirements are often influenced by, socio economic status, cultural beliefs and religious beliefs. Currently, the general recommendation is that carbohydrates should provide between 45%-65% of the daily caloric intake, fat should be 25%-35% of total daily calories and protein 15%-20% should be of total daily calories (Franz et al, 2010).

There are the erroneous beliefs amongst many people in Nigeria that DM results from consumption of carbohydrates hence the popular view that people with DM should either completely avoid carbohydrates or at best take minimal quantities. The resulting sequelae of these wrong notions thus includes the intake of monotonous meals which are deemed "safe" for people with DM. One of such meals that are commonly prescribed by well-known non- healthcare professionals and uninformed medical personnel include unripe plantain and beans. Abioye-Kuteyi*et al*,2005 study on dietary knowledge and practices in persons with T2DM, reported that about half of the Study subjects ate a monotonous diet of mainly plantain and did not necessarily attain good glycaemic control. These erroneous beliefs concerning dietary requirements in DM also influences the stance of patients when faced with the occurrence of iatrogenic hypoglycemia. Some patients with DM have been noted to absolutely refuse simple sugars in the management of this life-threatening acute complication of DM. There are varying Nigerian reports (Abioye-Kuteyi, 2005; Ntui et al, 2006) that note that adherence to dietary advice is often poor amongst people with DM. Dietary management as an aspect of DM care is seen as the turf of the nutritionists and as a result, quite several physicians have a poor know how on dietary counselling. Recent studies have shown that the consistent consumption of diets containing high – GI foods relates to an increased risk of type 2 diabetes mellitus (Salmeron et al, 1997) and coronary heart disease (Ford, 2001). On the other hand, including low GI foods in diet, improves blood glucose controls, prolong endurance during physical activity, reduce serum triglycerides, and improve insulin sensitivity (Brand et al., 1992, Jenkins et al., 1981, Thomas et al, 1991, Bymes et al., 1995, Brand-Miller et al., 2003).

2.4Glycaemicindex and Health

Health problems associated with high blood glucose such as obesity, metabolic syndrome, diabetes mellitus is due to high glycaemicindex foods. Clinical trials have therefore shown that low glycaemic diets improve glycaemic control in diabetes, increase insulin sensitivity; reduce food intake and body weight (Juntmen*et al*., 2003). It has also been suggested by prospective studies that low glycaemicindex diets may lessen the risk of diabetes, metabolic syndrome cardiovascular disease and possibly some type of cancer (Liu *et al*., 2000, Salmeron *et al*; 1997).

The concept of glycaemicindex (GI) (Feskens et al, 2006) was established to assistpatients with diabetes to control blood glucose when it was apparent that consuming high GI food was linked with an increased risk of type 2 diabetes mellitus (type 2 DM) (Willett et al, 2002; Thorbun et al, 1987). From dietary interventions and epidemiological studies, it has been suggested that a low-GI diet is useful for blood glucose control and consuming foods with a high GI or glycaemic load (GL) is hypothesized to contribute to insulin resistance, which is related with an increased risk of obesity, cardiovascular disease, some cancers and DM(Brand et al, 1990; Neuhouser et al, 2006; Ma et al, 2006). There exists an independent correlation between both dietary GI and GL with several metabolic risk factors in subjects whose dietary GI and GL were primarily determined based on the GI of predominant carbohydrate foods such as white rice (Murakami et al, 2006). It is therefore evident that GI is an aspect of diet of potential importance in the treatment and prevention of chronic diseases. It is also particularly important in the understanding and dietary control of diabetes.

2.4.1 Measurement of GlycaemicIndex

Valid scientific methods must be used to measure the GI values of foods. Mere looking at the food's composition or the nutritional information panel on food packaging cannot be used to predict or estimate the GI value of a food. Early testing of the glycaemic effect was a bit inconsistent, but methods for determining the glycaemic of a food have become standardized. Foods are tested on groups of eight to ten people who consume a standard serving of a carbohydrate in 10 to 15 minutes with blood samples taken every 30 minutes for the next hour. At another time, the volunteers do the same test as above, but this time with pure glucose, because glucose provides the baseline for the glycaemicindex. The result is analyzed giving a value for the food tested based on the value compared to 100. The glycaemicindex of any carbohydrate is an average of the effect on the individuals tested. The real change in blood sugar levels of a specific carbohydrate varies by person, but the variations follow the pattern established by the index. In other words, it's reliable (Lucy et al., 2005).

Accordingto the international standard method, however, feeding 10 or more healthy people a portion of the food containing 50 grams of digestible (available) carbohydrate and then measuring the effect on their blood glucose levels over the next two hours is also used to determine the GI value of a food. For each person, the area under their two-hour blood glucose response curve for this food is then measured. The same 10 people on another occasion consume an equal-carbohydrate portion of the sugar glucose (the reference food) and their two-hour blood glucose response is also measured. Then the GI value for the test food is calculated for each person by dividing their glucose AUC for the test food by their glucose AUC for the reference food. The average GI value for the 10 people is the final GI value for the test food (GlycaemicIndex Foundation, 2017)

Foods with a high GI score contain rapidly digested carbohydrate, which produces a large rapid rise and fall in the level of blood glucose. On the other hand, foods with a low GI score contain slowly digested carbohydrate, which produces a gradual, relatively low rise in the level of blood glucose.

$GI = (iAUC_{test\ food}/iAUC_{glucose}) \times 100$

Preferably, the GI should be expressed relative to glucose, however, other reference foods (e.g., white bread) can be used for practical reasons if their preparation has been standardized and they have been calibrated against glucose (Brouns et al, 2005).

According to FAO, 1998 method, GI is calculated geometrically as the incremental area under the blood glucose response curve of a 50g Carbohydrate portion of the test food expressed as a percent of the same amount of carbohydrate from a standard food taken by the same subject. The GI values obtained will then be adjusted relative to glucose.

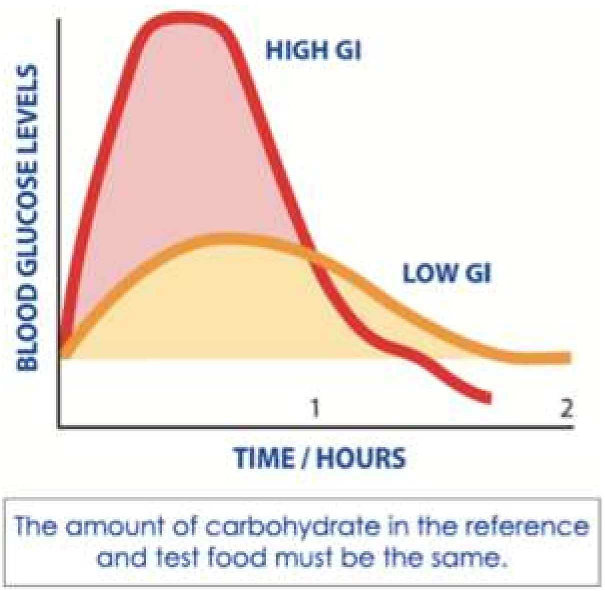
2.4.2 The Glycaemicindexfood guide and categorization

The glycaemicindex (GI) is a scale that ranks from 0 - 100 a carbohydrate-containing food or drink by how muchit raises blood glucose levels after it is eaten or drank. It measures how a carbohydrate-containing food raises blood glucose which is related to how quickly a carbohydrate containing food is broken down into glucose. The ranking of foods is based on how they compare to a reference food - either glucose or white bread (ADA, 2013). A high GI food increases blood glucose higher and faster than a low GI food. Three GI categories exists:

Green = Go
Low GI (55 or less) Choose Most Often
Yellow = Caution
Medium GI (56 to 69) Choose Less Often
Red = Stop and think
High GI (70 or more) Choose Least Often
Swapping of foods in the high GI category can be done with foods in the medium and/or low GI categoryto lower GI. (CAD, 2013). The glycaemicindex's ranking system is only

for carbohydrates and not for proteins or fats. Carbohydrate is a vital part of our diets, but not all carbohydrate foods are equal. There is a slower digestion, absorption and metabolism of carbohydrates with a low GI value (55 or less) which in turn causes a lower and slower rise in blood glucose and, therefore usually, insulin levels. Meat, poultry and fish do not have a GI because they do not contain carbohydrate.

The GI is not an eating program, but it is critical for following a healthy eating program. It is just a method of measuring the impact of carbohydrates in the body (Lucy et al., 2005).



2.4.3 Glycaemicload and categorization

The calculation of the amount of carbohydrate of a carbohydrate food factored by the glycaemicindex of the food is referred to as the Glycaemic Load. When a food with high glycaemic load is eaten for a long period of time as in months and years, the body cells become resistant to the insulin or insulin resistant. This therefore requires more and more insulin to be produced to deliver sugar and fat to the cells for Energy (Lucy et al 2005). The Glycaemic load for each food will be determined by the method of Salmeron et al, 1997. This will be calculated by taking the percentage of the food's carbohydrate content in a typical serving and multiplying it by its glycaemicindex values (Atkinson et al, 2008). GL values are classified as low (≤ 10), medium (> 10 to < 20) or high (≥ 20).

2.4.4Factors that influence and impact on the GI of foods

There are several factors that affectthe GI of a food. These includes food preparation/processing (for example grinding, blending, cooking, drying, puffing, extrusion, canning), the nature of carbohydrate mainly the starch, the ratio of amylose to amylopectin, the degree of hydration (method of cooking), the food particle size, the food form, protein – starch interaction,the fiber content of foods, antinutrients, acidity of foods, and time/day of food consumption and chemical composition of foods) (Wolevers and Bolognesi, 1996, Louise and Pamela, 2016).

In addition, other dietary factors that affect nutrient digestibility or insulin secretion, such as fat or protein content, also influence the GI of a food.Carbohydrate products have been reported to produce different glycaemic values depending on their chemical structure, particle size, amount and type of dietary fibre, fats, protein, antinutrients and food processing which may explain the variation among the carbohydrate staples (Jenkins et al., 2002).

Food processing methods at high temperature and high-pressureextrusion technology, can increase the degree of starch gelatinization, resulting in quick digestion and a high GI (Louise and Pamela, 2016). Jimoh et al (2008) also reported thatheating, boiling and cooking results in the alteration of the physical properties of carbohydrate through gelatinization and retrogradation thereby increasing the starch availability to amylase. The swelling and softening of the starch molecules in food takes place in the cooking process. This speed up the rate of digestion giving rise to higher levels of blood glucose, thus having the effect of raising the GI of that food. High amylose starches tend to have lower GI as they are digested slowly than amylopectin-rich starches (Louise and Pamela, 2016).

The GI of foods can also be lowered with several ingredients such as soluble fiber which delays the digestion of carbohydrate and its absorption from the gut by increasing the viscosity of the intestinal contents and stomach,and forming a protective layer incorporating readily digestible carbohydrates. Adding a protein to a carbohydrate food increases the amount of insulin secreted causing the blood glucose levels to be affected. This results in the formation of a protective network around the carbohydrate molecule thereby preventing the action of glycolytic enzymes (Louise and Pamela, 2016).

Like fats and proteins, acid also slows down gastric emptying; which is the process by which food exits the stomach and enters the duodenum. By slowing down gastric emptying the food matter is absorbed more slowly by the body which reduces blood glucose levels. The more acid in a food, the lower the GI of that food. Other factors such as antinutrients which includes phytates may also delay a food's absorption and thus lower the GI.The riper a fruit or vegetable is, the higher the GI (Siddhartha, 2011).
However, potatoes irrespective of variety, cooking method or maturity have been reported to have exceptionally high GI values (Soh and Brand-Miller, 1999). Chewing have been shown to reduce the particle size of foods and facilitate mixture with salivary amylase, thereby reducing digestion time of carbohydrates (Omoregie and Osagie, 2008).

The metabolic state of subjects can also influence postprandial glucose concentrations and thus the GI. For instance, the glycaemic response measured as blood glucose AUC in people with impaired glucose tolerance and diabetes is increased compared with healthy individuals. However, GI is the AUC in response to a test food relative to that of a reference food and given that each person acts as his/her own control the GI of a food should not differ in those with and without abnormalities of glucose metabolism. The testing of GI has been conducted, and values published in international tables, using normoglycaemic individuals as well as those with impaired glucose tolerance (Foster-Powell et al., 2002). However, despite broadly comparable results, there has been a recommendation by Brouns et al. (2005)to use people with normal glucose tolerance for the determination of GI because variability in glycaemic response is greater in people with impaired glucose tolerance or diabetes.

An argument that GI is a property of food is to use a test food referenced to a standard, rather than a characteristic of the individual consuming the food. The intra- and inter-individual differences observed in GI and GL which are apparent even when measured under standardized conditions may be further exaggerated by differing physical and chemical nature of apparently similar food products. For instance, gelatinization and retrogradation which is a process of rendering starches water soluble; and a realignment of starch molecules during cooling and storage; the starch type; and dietary fiber, are all factors with potential glycaemic-modifying effects(Wolever, 1990).

2.4.5 GlycaemicIndex in Health and Diseases

A leading cause of cardiovascular disease is Type 2 diabetes, with a global prevalence of 10%(WHO, 2012). The capacity that foods containing carbohydrates have on increasing blood glucose in an individual's diet has been considered to contribute to the development of type 2 diabetes (Sheard et al, 2004). An increase glucose intolerance and risk of eventual type 2 diabetes has been proposedto be associated withfoodsthat havehigh glycaemicindex (GI) or glycaemic load (GL) that cause higher postprandial blood glucose and insulin concentrations (Jenkins et al, 1981). (Greenwood et al, 2013).

Previously, it was widely held that the amount of carbohydrates a food contains determines mainly the blood glucose response to different diets. This resulted consequently in traditional diabetes diet plans in which the amount of foods allowed were based on their carbohydrate contents (Eleazu et al, 2016). However, the concept of glycaemicindex (GI) which classifies the blood glucose-raising potential of carbohydrate foods relative to glucose or white bread has shown that foods with similar carbohydrate contents did not usually have the same impact on blood glucose levels (Pamela et al, 1994; Hoebler et al, 2000; Dona et al, 2010; Kati et al, 2010; Kwon et al, 2006)

These days, GI has been transformed by its popularizers from a potentially valuable tool in planning diets for diabetic patients to a key factorin the prevention and management of diabetes, prevention of dyslipidemia, cardiovascular diseases and even certain types of cancers (Omoregie et al, 2008). Although several studies as seen in Pamela et al, 1994; Hoebler et al, 2000; Dona et al, 2010; Kati et al, 2010; Kwon et al, 2006 have proposed the concept of low GIs and GL foods be applied in the prevention and management of type2 diabetes, the American Diabetes Association is still very much hesitant in embracing this concept as a useful tool for management of type 2 diabetes due to the challenges associated with this concept.

Based on human *in vivo* chemical trials, a numerical classification of the Glycaemicindex has been designed to quantify the relative blood glucose response to foods drinks, nutraceuticals, pharmaceuticals and any edible agents (Freeman and Lyons, 2008). The glycaemicindex ranks foods on how they affect blood glucose levels (Foster-Powell et al., 2002). The development of obesity, diabetes mellitus, cardiovascular disease (CVD) and cancerhas been reported to be linked to high G.I foods, with regards to the treatment of these diseases. Also established is the physiological effects of the glycaemicindex and the importance of these effects in preventing and treating diabetes, cardiovascular disease and obesity (Ludwig, 2002).

In Africa, limited studies have been conducted with regards to the GI of local foods which are quite diverse from those of the western world. For the diabetic patients in Africa to benefit from the new concept of dietary management of diabetes, it is imperative to determine the GI of local cuisine with the goal of recognizing those with low glycaemicindex that can be used in formulating diets for the diabetic subjects (Tanya et al., 1998).

Glycaemicindex studies in foods have been shown to be important. It's practical use in nutrition provides basis for the choice of appropriate diabetic diet of low glycaemic food materials, desirable for blood glucose control, use of foods with low GI for both gastric surgery patients who suffer hypoglycemia and patients with carbohydrate induced hyper-lipidemia, patients with reduced absorptive capacity and it also provides data to supplement result obtained from chemical analysis of food items (Jenkins, 1984).

It has been shown to be a marker of some beneficial effects of grains, legumes and some vegetables (Trout et al., 1993). A low carbohydrate diet to reduce weight for those with or at risk of type 2 diabetes has been recommended by The American Diabetes Association (ADA)(Bantle and Wylie, 2008). Ingesting a low GI diet that is rich in fibre is one of the ways of achieving low plasma glucose excursion. GI factor is a ranking of foods based on their overall effect on blood glucose levels. It echoes the quality of the effect of the glucose released into the circulatory system (Jenkens et al., 1981). Low GI foods, such as legumes, provide a slower, more consistent source of glucose to the bloodstream, thereby stimulating less insulin release than high GI foods, such as white bread (Thomas et al., 2007; Mann et al., 1980). A reported literature has also revealed the association between high GI diets and increased risk of chronic diseases through sustained hyper-insulinemia and hyper-glycemia (Mann et., 1980; Wolever et al., 1994). The benefit of consuming of low GI diets in the reduction of insulin response and improvement ofglycaemic and lipid concentrations in persons with diabetes mellitus and healthy controls alike has been described in previous literature (Little, 2003; Omoregie and Osagie, 2008; Jenkins, 2002)

Glycaemicindex was conceived as a tool for the dietary management of type2 diabetes (Brand-Miller, 2003). The evidence of glycaemicindex as a nutrition therapy intervention for diabetics was reviewed by the ADAwho also gave an acknowledgement that low glycaemicindex may reduce post-prandial glucose level with assertion that there are sufficient long-term benefits to recommend using low glycaemicindex diet as a primary strategy in meal planning (Asp,1996)

Low glycaemicindex diets are vital in the management of hyperglycemia and hyperinsulinemia. This is due to the fact that they are more effective per unit of energy than most other foods in inducing satiety, thereby suggesting these foods have a potential role in dietary strategies to avoid and treat diabetes and obesity (Anderson et al., 1999; Oboh et al., 2010).

Other reports also support the above reports of GI in relation to postprandial glucose, chronic complications etc. A decrease in postprandial glucose and insulin response, improvement in serum lipid concentrations, decrease in total fat mass and reduced risk of colon cancer in adults is linked with a lower GI diet (Davis et al., 2004). However, when a high GI meal is consumed, it can lead to an exaggerated postprandial peak in the blood glucose (Dong et al., 2006), which in turn resultsto diabetes-related complications, including strokes, heart disease, kidney disease, obesity, blindness, amputations, erectile dysfunction, mortality (Gonzalez et al., 2011) and cancer (Augustin et al., 2001). Irreversible diabetes results from high blood glucose levels and excessive insulin secretion that are thought to contribute to the loss of the insulin secreting function of the pancreatic beta-cells also known as beta cell exhaustion (Linus Pauling Institute, 2010). Knowledge of the GI value of available local food aids patients with diabetes to choose from less expensive healthy foods, and to improve diet quality without undue financial burden (Nnansel et al., 2015).

The development of obesity, diabetes mellitus, cardiovascular disease (CVD), and cancer has been reported to be associated with the intake of high carbohydrate foods, while intake of low carbohydrate foods has been revealed to play a positive role in the treatment of these diseases (Ludwig, 2002).

Epidemiological studies have proved that high intake of carbohydrate with high glycaemicindex produce greater insulin resistance and thus greater risk of Type II diabetes than the intake of low GI carbohydrates does. High dietary glycaemic loads have related to an increased risk of developing type 2 diabetes in various large prospective studies. Increased blood glucose and insulin concentrations, high dietary glycaemic loads are associated with increased serum triglyceride concentrations and decreased HDL concentrations; both are risk factors for cardiovascular disease. In Addition, high GI and glycaemic load of overall diet relate to greater risk of coronary heart disease in both men and women. Animal models have also shown that high GI foods promote insulin resistance, fat synthesis and the risk of hypertension and obesity. Replacing high GI carbohydrates with a low glycaemicindex forms has been suggested as an evidence from medium term studies to improve both blood sugar and blood lipid levels in people with diabetes (Brand-miller, 1994), in addition to reducing hypoglycaemic episodes (Willet, 2002)

Also, in addition, low GI foods improve satiety and thereby may aid in the control of weight. Therefore, to suitably manage diabetes mellitus, it is vital to identify the range of foods that are appropriate through the GI classification of foods. (Asinobi et al., 2016). Results from dual studies show that dietary glycaemicindex and Glycaemic load may be positively correlated to risk of gall bladder disease, however, this needs to be further determined through more clinical and epidemiological research (Linus Pauling Institute, 2010). A healthy low GI diet has been proven through research toaid people with diabetes (type 1 and type 2) manage their blood glucose levels, blood cholesterol levels and reduce insulin resistance– which is vital for lowering the risk of long term diabetes related complications. Recently, aCochrane reviewby Thomas et al (2009), reported that diets with low GI may help people with diabetes reduce their HbA1c by 0.5%. This will assist to decrease the risk of common diabetic complications by ~20%. It’s not surprising therefore that all of the evidence based recommendations for the diabetes management from the major diabetes organizations around the world (the Canadian Diabetes Association, AmericanDiabetes Association; and Diabetes UK for example) now advise people with type 1 and type 2 diabetes to use the GI or GL as part of their nutritional management (GlycaemicIndex Foundation, 2017). Around the world, studies have also shown that following a GI diet significantly helps people with type 1 and type 2 diabetes improve their blood glucose levels.

2.5 Commonly consumed foods eaten in Nigeria

The diversity and exciting nature of Nigerian foods cannot be overemphasized as they are often unrefined natural foods rich in carbohydrate, dietary fibers, and anextensive range of highly nutritious and vitamin rich combination. Literally inexhaustible is the list of foods eaten in Nigeria. This can be attributed to the Nigeria being, the most populous country in Africa, with about 160,000,000 inhabitants (population of 160 million) and over 500 totally different ethnic groups and languages, all reflecting different cultures which cuts across diverse natural geographical zones that includes the Sahara desert, the Green Savanna, the thick tropical rain forest, with different soil tendencies and properties. With this broad overview, it is easy to see how diverse the staple across the vast region called Nigeria could be. (African Women Culture, 2011): Nigerian foods "Retrieved on September15, 2017 from http://africanwomenculture.blogspot.com")

The diverse ethnic groups (over 250) in Nigeriaare accommodated under three main ethnic regions Igbo (in the East), Yoruba (in the West) and Hausa-Fulani (in the North). Subsistence food crops in Africa are mainly produced from a variety of plant foods such as maize, rice, sorghum, millet, yam, cassava, cocoyam and legumes. These are more commonly and widely consumed in Nigeria and other developing countries than in the developed world. They are relatively available, affordable and acceptable with an appreciable contribution to the nutrient intake (energy, protein, fat, vitamins and minerals) of the less developed world (Udenta et al, 2014).Foods that have high consumption frequencies of more than 3 times a week are known as commonly consumed foodsaspeople are dependent on these foods as their main meals(breakfast, lunch, and supper). These are primarily plant-based, though animal-based protein sources such as meats contribute more protein and several nutrients such as zinc, vitamin B_{12}, phosphorus, and iron. Plant-based protein foods, nevertheless, can make realistic contributions to intakes of magnesium, vitamin E, beta-carotene and phytochemicals(Phillips et al., 2015).Meals, routinely eaten in such quantities that constitutes a main portion of a standard diet are referred to as staple meals - supplying a large fraction of the needs for energy-rich materials and a significant proportion of the intake of other nutrients. Staple foods differ from place to place. They are cheap, readily available and supply one or more of the three organic macronutrients needed for survival and health and may be eaten as often as every day or every meal. Most staple plant foods are derivatives either from cereals; such as wheat, barley, rye, maize, rice, starchy tubers, or root vegetables; such as potatoes, yams, taro, cassava and cowpea; a major food legume in tropical Africa.For most staples, the primary source of nutrition is plant materials with high contents of carbohydrates (FAO, 2010).

Commonly consumed foods may differ from household to household. Despite this, a food consumption survey will certainly reveal the same trend of foods consumed with variant frequencies. People tend to consume what is available, affordable, and has ease of preparation. Availability may affect what is consumed at any given time as well as the quantity of food consumed. (Ayogu et al., 2017). Some of these cooked ready-to eat foods which serve as main meals with consumption frequency of 3 or more times a week includes:

Jollof:this is a word used to define 1 or 2 foods cooked together in which the ingredients and main food are cooked together in a pot. This term is mainly applied to rice and rice and beans.

Soup: is the food made by boiling solid ingredients in liquid until the flavors are extracted, forming a broth. The broth is usually thickened with soup thickeners and eaten with foods commonly called fufu.

Fufu: is solid food made from fermented cassava;

Garri (fried form of cassava); yam; cocoyam; and maize, rice, and wheat flours.

Stew and sauce are made just like soups but without thickeners. The ingredients may be fried in oil. They are eaten with staple foods (potato, yam, cocoyam, rice, plantain) that are cooked plain with or without salt.

Dish: is the ready-to-eat food that can be consumed on its own without a complement.

Meal: is a dish consumed at certain established time of the day. There are 3 meals a day (breakfast, lunch, and supper; the heaviest is called dinner). However, in-between meals are allowed for children and other vulnerable persons such as pregnant mothers and convalescents. Foods are cooked ready-to-eat dishes or individual foods. Soups, sauce, and stew are not normally consumed by themselves but with staples (Ayogu et al., 2017).

Most of the commonly eaten foods in every part of Nigeria according to the literatures reviewed are rice, beans, yam (or other forms of root and tuber like sweet potato and tuber products like garri, tapioca etc.), bread, and plantain.

2.6 Commonly Consumed Mixed Meals "As Eaten" In South West Nigeria

The list of foods eaten in Nigeria is literally inexhaustible. Nigeria is one of the world's most ethnically diverse countries, being the most populous country in Africa, with about 197,000,000 inhabitants (population of 197 million) (www.worldometers.info//). Nigeria's food regime is based essentially on two foods: grains, which provide 46% of calories and 52% of proteins consumed, and root and tubers, which provide 20% of calories and 8% of proteins consumed (Mitaut, 2011). The driest northernmost regions in Nigeria supports the cultivation of livestock and cereals, such as wheat, rice, maize, millet, and guinea-corn. The wetter middle-belt regions support the cultivation of legumes and livestock, while the southern, typically tropical regions of the country support the cultivation of tree crops as well as tubers and roots but relatively little livestock production (Alade, 1985). The people of the South West, predominantly the Yoruba, are arguably some of the most diverse eaters in Nigeria who generally do not eat single or individual meals; rather they eat mixed meals, consisting of two or more individual meals.

From literature review, foods commonly eaten in South west Nigeria were identified based on three main food groups – roots and tubers, cereals and grains, and the legumes. These are the foods that have high consumption frequencies of more than 3 times a week of which people are dependent on as their main meals consumed at certain established time of the day as either breakfast, lunch or dinner (Ayogu et al, 2017). These commonly consumed foods or traditional diets are mainly plant based with little contribution made by meat and its products. These includes Eight food products from the roots and tubers (*Eba, fufu, lafun*, boiled yam, *AmalaIsu*, pounded yam, yam pottage, fried yam), ten food products from the cereals and grains (boiled white rice, jollof rice, fried rice, *Eko/Agidi, Ogi/Pap*, bread, Semovita, wheat flour) and four food products from the legumes (boiled beans, *akara*, *moinmoin*, beans porridge). While the ingredients in traditional plates vary from region to region, most meals in south west Nigerian is generally characterized by a rich mix of starchy foods which serves as the main meal and these includes staple foods such as cassava, yam, maize, rice, wheat generally accompanied by a soup and or stew. Soups and stews are a very essential part of the meals in South western Nigeria and is prepared with various types of vegetables based on availability, preference and culture. The quickest, easiest and most commonly consumed soups are *Ewedu* soup, *Eforiro, Efoelegusi* and Okra soup. A total of 65 mixed meals across the three main food groups identified to be commonly consumed in Southwestern Nigeria were included in this study.

2.7 Review of glycaemicindex of commonly consumed foods in Nigeria

Staple mixed meals are meals that are frequently consumed in such quantities that constitutes a dominant portion of a standard diet in a population. This supplies a large fraction of the needs for energy and a significant proportion of the intake of other nutrients needs. Most people in Nigeria live on a diet based on one or more of the following staples which includes rice, wheat, maize (corn), millet, sorghum, roots and tubers (yams, cassava, potatoes) and animal products such as meat, milk, eggs and fish (UN/FAO, 2016). Carbohydrate food sources form the greatest percentage (50 – 60%) of the daily diet for different segments of the population (WHO, 2003) In Nigeria, starchy staples (cereals, roots/tubers) and legumes constitute the major part of the traditional diets (up to 70% and 25%, respectively) (Maziya-Dixon et al, 2004, Udentaet al, 2014). These starchy staples (maize, rice, sorghum, millet, yam, cassava, cocoayam and plantain) are utilized in many different forms for preparation of various dishes. Their nutritional importance is that they provide most of the energy, contain high carbohydrate, low protein and appreciable amount of minerals and vitamins, especially the B-complex vitamins. They form the base and usually constitute the major ingredients in the traditional dishes. Some dishes are light and serve as breakfast. Others are solid and frequently made palatable in combination with a variety of legumes and by the addition of palm oil, vegetables and fruits, a range of spices, various sauces and fish/meats. They serve as main meals and eaten later in the day (Udenta et al, 2014).

Nigeria is blessed with varieties of dishes which provide adequate nutrition for the body, integrating information about glycaemicindex of these foods into Nigerian diet is however limited by lack of data (Okafor et al., 2011). Most indigenous available staple foodsin Nigeria, are based on starchy foods that are high in glycaemicindex (GI) (Asinobi et al., 2016). According to Okafor et al.(2011), the staples that were studied were Rice, Yam, Plantain, Sweet potato, Beans (the foods were prepared by boiling) and Bread and these staples after analysis were seen to have relatively medium GI ranging from 56-62 with boiled rice being the lowest with value of 56, boiled yam and plantain- 58, Boiled sweet potato and boiled beans -62, The observed variation could be attributed to fiber, amylase and amount per serving.

Carbohydrate foods have been seen to produce different glycaemic values depending on their chemical structure, particle size, amounts and types of dietary fiber, protein, antinutrients and food processing which may explain the variation among the carbohydrate staples (Jenkins et al., 2002). Legumes have been reported to produce relatively low glycaemic response in both healthy individuals and in diabetics due to their components particularly the soluble dietary fiber and the nature of the starch (Oboh et al., 2010). However, in Okafor et al., (2011) study, a rather high level of GI which contradicts earlier reports of Oboh et al.,2010 was observed in GI value of boiled beans; and this may be explained by the amount of beans served, molecular weight and length of amylase present in the beans as well as degree of retrogradation. Okafor et al. (2011) further stated in their study that equal amount of dietary fiber should be served alongside these staples to further reduce their GI values and no particular food has a definitive GI because the GI is dependent on the history of the processing, storing, ripening, cutting and cooking of the food. Based on the universal classification of glycaemicindex of food (Trout et al., 1993), the results gotten from this study showed that the glycaemicindex for Nigerian staple meals were moderately low for plantain and beans vegetable stews and high for other starchy staples vegetable stews. This could be a result of the ratio of Amylose to Amylopectin present in the cooked starch staple meals, which has been shown to be responsible for the slow release of glucose from starch (Brand-miller et al.,1992). Considering the diverse inexhaustible list of Nigeria foods, it is crucial to determine the glycaemicindex of Nigerian foods to expand the varieties of meal available for prevention and dietary management of type 2 diabetes in Nigeria.

CHAPTER THREE

METHODOLOGY

3.1 Study Design

This is aquassi-experimental study set out to determine the glycaemicindex of commonly consumed mixed meals "as eaten" by apparently healthy young adults in Southwestern Nigeria.

3.2 Study Location

This study was carried out at the Department of Human Nutrition, Faculty of Public Health, College of Medicine, University of Ibadan. The institution, occupying over 1,032 hectares of land, is in Ibadan North Local Government Area. The university was founded on 17 November 1948. The University was originally instituted as an external college of the University of London (then it was called the University College, Ibadan). The institution presently has 13 faculties and 12 halls of residence. Nine out of the halls are for undergraduates. Obafemi Awolowo Hall accommodate both male and female students, so also Alexander Brown Hall. The total population of undergraduate students accommodated in the halls of residence is 4187 for male students' and 2732 for female students' (Planning unit, University of Ibadan 2011)

3.3 Study Population

The study population consisted of both undergraduate and postgraduate students, male and female of the College of Medicine, University of Ibadan who are non-diabetic, non-obese and non-hypertensive. For this study, meals were not formulated rather, an assessment of the participants' glycaemic response to normal meals as eaten in the Nigerian culture was evaluated.

Inclusion criteria

1. Apparently healthy
2. Participants were within age 17 to 35 years old.
3. Participants were male or female undergraduate or postgraduate students with normal BMI (18.5 – 24.99kg/m^2) and normal fasting blood glucose levels (< 126mg/dl)
4. No history of medication or any disease
5. All signed informed consent forms

Exclusion criteria

1. Participants who are less than 17 and above 35 years old

2. Subjects with special diets as a result of a medical condition, those with active gastro-intestinal or metabolic disease (e.g. celiac disease), smokers, females on their menstrual period, and those with a first-degree family history of Diabetes mellitus.

3. Individuals who did not consent to participate.

3.4 Sample Size Determination

The sample size for this study was determined using (Kasiulevicius et al., 2006) sample size formula below:

$$n = \frac{Z^2 \alpha 2P(1-P)}{e2}$$

where n is

n= required sample size (minimal)

$Z^2_{\alpha/2}$ = standard normal deviate corresponding to 95% confidence level set at 1.96

P=prevalence of diabetes in Nigeria (2.5%) - WHO, 2003

e=level of error tolerance set at 5%

$$n = \frac{1.96^2(0.025)(1-0.025)}{(0.05)^2}$$

n=37.455

n=37

Adjusting the sample size for 10% attrition

$$n_f = \frac{n}{1-NR}$$

Where n_f= Adjusted sample size due to attrition

NR= 10% non-response rate

$$n_f = \frac{37}{1-10\%}$$

n_f = 41.11

n_f = 41

In order to increase the sample size for the study, a design effect of 1.5 will be used to multiply the calculated sample size

n_f= 1.5 x 41

n_f= 62 participants

3.4.1 Sampling Technique

A purposive sampling technique was used to select the consenting male and female respondents for the study.

3.5 Study Participants

Out of the 120 participants that were screened for the study, 80 apparently healthy young adults (53 females and 27 males) between ages 17 and 35 from the University of Ibadan, were selectedto participate after giving informed consent.

3.6Method and Instrument for Data Collection

Quantitative method was used for data collection. The researcher with four trained Research Assistants collected the data for this study. This included information on:

1. Demographic characteristics (sex, age).
2. Anthropometric data/measurements (weight and height).
3. Clinical data/measurements(Urinalysis, Fasting blood Glucose (FBG), Blood pressure, and Hemoglobin test).

3.6.1 Tools for Data Collection:

1. Urinalysis test kit.
2. Hana Bathroom scale for weight measurements
3. Stadiometer for height measurements
4. Mission Hb® Hemocue meter for hemoglobin test
5. Omron Automatic Blood pressure monitor for blood pressure measurements
6. Accucheck® Active Glucometer and strips for blood glucose measurement

3.6.2 Measurements

1. Weight:

Method: Weight were measured using an analogue HANA bathroom scale and readings taken to the nearest 0.1kg. Each subject stood erect on the scale with light clothing and without shoes. The scale reading was allowed to return to zero before the next subject is asked to stand on it. An object with a known weight was used to validate the scale readings before the measurements began.

2. Height:

Method**:** Height was measured to the nearest 0.1cm using a stadiometer. Participants stood erect with bare foot and eyes directed straight ahead with the back and head against the stadiometer pole, after which the head gauge was moved down to the head to take the reading. This was done twice and the average height reading recorded.

3. **Blood Pressure Measurements:**

Method:Blood pressure measurements were taken using a conventional mercury-in-glass sphygmomanometer (Omron). Readings were taken on the left mid-upper arm rested on a table, with the subject in a sitting position on a chair with feet flat on the floor. Blood pressure recordings was made after each participant had rested for about 15 minutes. This measurement was repeated twice in a non-consecutive manner. Hypertension was classified according to the seventh report of the Joint National Committee on prevention, detection, evaluation and treatment of Hypertension (JNC 7) withthe reading criteria for blood pressure given as 120/80mmHg (Chobanian et al, 2003).

4. **Urinalysis measurement**:

Method: The lid from the urine samples were removed after ensuring it is mixed, then the urine test strip (Mission Expert Urinalysis Reagent strips REF U034-111 Lot URS6120037 Expiry 2019-01)was removed from the container while also ensuring the test patches were not contaminated.This was then inserted fully into the urine samples while tapping off the excess. The test strip was held against the result scale on the container by comparing the color of thetest patches against the scale on the container. The resultfor the presence or absence of glucose, protein, ketones and blood was recorded.

5. **Blood Hemoglobin:**

Method:Mission Hb®Hemocue meter and test strips(SN 195A0011DC8 manufactured by ACON Laboratories Inc. USA) was used to determine the hemoglobin values of the participants. The code chip was inserted into the meter to set up until it was ready for use. Thenblood samples obtained by finger-prick using hypodermic sterile needle was placed on the already inserted test strip when the blood drop signal flashes. The result on the hemocue meter screen was read after 15 seconds.

6. **Blood Glucose Measurements:**

Method:Blood glucose measurements were taken using an Accucheck® Active Glucometer which consists of 10 Accu check Softclix lancets, 10 Accu check Active test strips, Carry case,Quick start guide and User's manual (SR: GB09292013, SR: GU 01753524, SR: GB 09915253, SR: GU 01753545). The code chip for each test strip was inserted into the meter to set up for use.

Readings were taken with the subject in a sitting position on a chair with feet flat on the floor. Blood samples was obtained by finger-prick using hypodermic needle or lancets. Each blood sample was thereafter placed on a test strip inserted into the calibrated glucometer (Accu-check®) when the blood drop signal beeps. Record the direct readings after 15 seconds based on glucose oxidase assay method. Fasting Blood Glucose test (FBG) was conducted to assess the blood glucose level of the subjects to determine if subjects were apparently healthy or diabetic.

Diabetes mellitus was diagnosed based on ADA, 2018 Classification and diagnosis of Diabetes Mellitus, which recommends the diagnosis of diabetes based on otherwise raised values on two occasions of glucose readings of either:

1. A fasting plasma glucose of ≥ 7.0mmol/l (≥ 126mg/dl) or a
2. Casual (Random) plasma glucose of ≥ 11.1mmol/l (≥ 200mg/dl) or 2-Hour plasma glucose of ≥ 11.1mmol/l (≥ 200mg/l) during a standard 75gm oral glucose tolerance test (OGTT) is diagnostic.

3.6.3 Calculation of Glycaemic Index:

The GI was calculated using the method described by FAO/WHO (FAO/WHO, 1998) as the area under the blood glucose response curve of a 50g carbohydrate portion of the test food expressed as a percent of the response to the same amount of carbohydrate from glucose- the standard food taken by the same subject.

1. The area under the blood glucose response curve was calculated geometrically by applying the trapezoid rule (Brouns et al, 2005). The GI values were classified as high (70 – 100), intermediate (55 – 69) or low (< 55).

2. The Glycaemic load for each food was determined by the method of Salmeron et al, 1997.This was calculated by taking the percentage of the food's carbohydrate content in a typical serving and multiplying it by its glycaemicindex values (Atkinson et al, 2008). GL values were classified as low (0 - 10), medium (11 to 19) or high (≥ 20).

3.7 Test Foods and Preparation

Commonly consumed staples per food group and the form in which they are eaten in southwestern, Nigeria were identified from a review of literatures (Better life cook book, 1992, Sanusi et al, 2009, Sanusi et al, 2012, HETAN, 1993,andAnegbu, 2013 from http://allnigerianfoods.com)

Table 3.1. shows the identified commonly consumed foods as eaten in southwestern Nigeria. This has been grouped into three main food groups that includes the starchy roots and tubers group comprising of yam and cassava products, the cereals and grains groups comprising of rice, maize and wheat and the legumes group comprising of beans. The food products and food forms in which the meals are consumed from each of the three-main food groups identified have also been categorized from literature review.

Table 3.1 Commonly consumed foods in Southwestern Nigeria

Food group	Food products	Form consumed
Roots and Tubers	**Cassava and its products**	
	Eba/Garri cooked, Fufu, Cassava flour (AmalaLafun)	Consumed with Draw soups such as: Ewedu, Ogbonno, Okro. Consumed with Vegetable soups such as: Soko, Tete, Egusi and Ugwu leaves
	Yam – boiled	Yam-boiled and a. fried egg b. Beans porridge c. stew
	Yam flour (AmalaIsu) Yam – Pounded	Yam flour (AmalaIsu) and Yam-pounded with: a. Draw soups such as: Ewedu, Ogbonno, Okro. b. Consumed with Vegetable soups such as: Soko, Tete, Egusi and Ugwu leaves
	Yam Pottage	Yam Pottage
Cereals and Grains	Rice and its products	
	White Rice – boiled	White rice is usually consumed with a. stew b. stew and boiled beans or moinmoin c. stew and boiled egg, fried plantain
	Jollof rice	Jollof and Fried rice is usually consumed with fried plantain or moinmoin

	Fried Rice	
	Maize and its products	
	Ogi/Pap Eko/Agidi	Ogi/Pap and Eko/Agidi is usually consumed with: a. Bean cake (Akara), b. Moinmoin c. Vegetable soup

Compiled from (Better life cook book, 1992, Sanusi et al, 2009, Sanusi et al, 2012, HETAN, 1993,and Anegbu, 2013 from http://allnigerianfoods.com).

Table 3.1 b Commonly consumed Foods in Southwestern Nigeria (continuation)

Food group	Food products	Form consumed
Cereals and Grains continued	Wheat and its products	Forms Consumed
	Bread	Bread is consumed with a. fried egg b. akara c. moinmoin d. beans porridge.
	Semovita Semolina Wheat flour	Semovita, Semolina and Wheat flour is usually consumed with: Draw soups such as: Ewedu, Ogbonno, Okro and vegetable soups such as: Soko, Tete, Egusi and ugwu leaves
Legumes	Beans and its products	
	Boiled beans	Boiled beans is usually consumed with white rice and stew
	Moinmoin Akara	Moinmoin and akara are usually consumed with a) Ogi/Pap b) Eko/Agidi c) Bread
	Beans porridge	Beans porridge is usually consumed with a) Plantain b) Bread c) Ogi/Pap

Compiled from (Better life cook book, 1992, Sanusi et al, 2009, Sanusi et al, 2012, HETAN, 1993,and Anegbu, 2013 from http://allnigerianfoods.com).

The recipe for each food was measured with the aid of an SF-400 electronic weighing scale and selected commonly consumed mixed meals were prepared in the Kitchen unit of the Department of Human Nutrition, University of Ibadan. The ingredients for these test meals were together purchased from Bodija Market in Ibadan. The ingredients and preparation methods used was according to the Nigerian Cookery Book (Anegbu, 2013), Better life cookbook (1992).The weight of foods and ingredients used are described in Appendix 3.

According to the common cooking practices in Nigeria, the single foods and mixed meals were prepared as described below:

Food Preparation and cooking methods

1. Eba/Garri cooked: Dry fine grains of fermented cassava were reconstituted in hot water and stirred to get a semi-solid paste
2. Fufu: Fermented cassava paste was added to boiling water, stirred and cooked until a solid paste was obtained.
3. Lafun (Cassava flour): Dry powder was added to boiling water and stirred until a semi-solid paste was derived.
4. Yam – boiled: The yam was peeled, sliced and cooked until softened with salt added to taste
5. AmalaIsu (Yam flour): Dry powder was added to boiling water and stirred until a solid paste was derived
6. Yam – Pounded: Raw yam was peeled, sliced and cooked until it was soft, and was pounded in a mortar with a pestle to a smooth dough
7. Yam Pottage: Raw yam was peeled, cut into small pieces and cooked until soft after which grinded fresh pepper, onions, palm oil, maggi and salt were added to taste. The mixture was stirred until the right consistency and texture was obtained.
8. Plantain (boiled): Plantain was cut into water and cooked in water with salt added to taste.
9. White rice – boiled: Raw grains of rice were washed and cooked until soft with salt added to taste

10. Ogi/Pap – Semi – solid yellow maize paste was mixed with water in a bowl. Hot boiling water was then added while stirring continuously until cooked to the desired thickness and consistency.
11. Semovita – Flour was added to boiling water and stirred until a thick and consistent paste was obtained with cooking for additional 2 – 3 minutes
12. Wheat flour – Flour was added to boiling water and stirred until a thick and consistent paste was obtained with cooking for additional 2 – 3 minutes
13. Bread – Foodco bread was purchased from Foodco supermarket and bakery.
14. Beans boiled- Whole beans were rinsed with water and cooked by boiling in water until tender with salt added to taste.
15. Beans porridge – Whole beans were rinsed with water and cooked by boiling in water until tender with salt, onions, pepper and palm oil added to taste.
16. *Akara* (Beans cake) – Whole beans were soaked, washed and dehulled with water after which pepper and onions were added before being wet milled to a consistent paste. Salt was added to the beans paste and fried into small balls until it had a golden brown colourwith vegetable oil.
17. *Moinmoin* – Whole beans were soaked, washed and dehulled with water. Fresh pepper and onions were added to the dehulled seed and grinded into a consistent paste. Thereafter, the paste was poured in a bowl, then vegetable oil, seasonings and salt were added to taste and enhance texture. The mixture was stirred, and some little water added. This was then wrapped with leaves and steamed to cook.
18. *Ewedu* soup –Fresh *Ewedu* leaves were sorted, washed and transferred into a cooking pot with water in it. It was then allowed to cook slightly with salt and locust beans (*Iru*) added to taste after which it was mashed or pounded with a cooking broom into very tiny bits to desired thickness and consistency.
19. Okra soup – Okra leaves were sorted, washed and sliced after which it was cooked with salt and locust beans (*Iru*) added to taste.
20. *Efo – riro* – The green spinach leaves were sorted, shredded into tiny bits, washed and steamed. Freshly grinded pepper and onions were fried in palm oil with seasonings (maggi), locust beans, salt and smoked fish added to the sauce to taste.

Thereafter, the steamed green spinach was added into the pepper sauce, stirred together and allowed to simmer for few minutes.

21. *Efo-elegusi* – Grinded melon seeds is dissolved with water into slurry paste in a bowl. Palm oil is the added into the cooking pot with onions, freshly grinded pepper, seasonings (maggi), locust beans (Iru), smoked fish and salt. This was allowed to fry and simmer for some minutes after which the melon paste was added into the mixture and allowed to be cooked. The soup was then stirred together and allowed to simmer until it was ready.
22. Stew – Freshly grinded pepper, tomatoes and onions was boiled until cooked. This was then fried in vegetable oil with boiled meat stock, meat, salt and other seasoning (maggi, curry, thyme) added to taste.

3.8 Proximate Analysis:

Test food samples were analyzed chemically according to the official methods of analysis described by the Association of Official Analytical Chemist (A.O.A.C., 18^{th} Edition, 2005). Available carbohydrate was calculated by difference. Samples were analyzed based on fresh matter. Moisture was determined by oven drying, Protein content by Kjeldahl method and the fat was measured gravimetrically by Soxhlet extraction method. All analysis was carried out in triplicate.

i. Crude Protein Determination (AOAC Official Method 988.05)

The crude protein in the sample were determined by the routine semi-micro Kjeldahl, procedure/technique. This consists of three techniques of analysis namely Digestion, Distillation and Titration.

Apparatus: Analytical Balance (Mettler Toledo, USA Model No: H6752S, T1217), Digestion tubes (Durham Borosilicate glass UK), Digestion Block Heaters (Tecator HB, Germany. Model No: BD40, Serial No: T2597), 50ml Burette, 5ml Pipette, 10ml Pipette, 10ml Measuring Cylinder, 100ml beakers, Fume Cupboard (Gallenkamp, UK. Model No: G51289, Serial No: 2526L).

Reagents: Concentrated 95 – 98%H_2SO_4, 0.01NHCL, 40% (w/v) NaOH, 2% boric acid solution, methyl red – bromocresol green mixed indicator, Kjeldahl Catalyst tablet.

Digestion

0.5g of each finely ground dried sample was weighed carefully into the Kjeldahl digestion tubes to ensure that all sample materials got to the bottom of the tubes. To this were added 1 Kjeldahl catalyst tablet and 10ml of Conc. 95-98%H_2SO_4. These were set in the appropriate hole of the Digestion Block Heaters in a fume cupboard. The digestion was left on for 4 hours, after which a clear colourless solution was left in the tube. The digest was cooled and carefully transferred into 100ml volumetric flask, thoroughly rinsing the digestion tube with distilled water and the flask was made up to mark with distilled water.

Distillation

The distillation was done with Markham Distillation Apparatus which allows volatile substances such as ammonia to be steam distilled with complete collection of the distillate. The apparatus was steamed out for about ten minutes. The steam generator is then removed from the heat source to all the developing vacuum to remove condensed water. The steam generator is then placed on the heat source (i.e. heating mantle) and each component of the apparatus was fixed up appropriately.

Determination: 5ml portion of the digest above was pipetted into the body of the apparatus via the small funnel aperture. To this was added 5ml of 40% (w/v) NaOH through the same opening with the 5ml pipette.The mixture was steam-distilled for 2 minutes into a 50ml conical flask containing 10ml of 2% Boric Acid plus mixed indicator solution placed at the receiving tip of the condenser. The Boric Acid plus indicator solution changes colour from red to green showing that all the ammonia liberated have been trapped.

Titration

The green colour solution obtained was then titrated against 0.01N HCl contained in a 50ml Burette. At the end point or equivalent point, the green colour turns to wine colour which indicates that all the Nitrogen trapped as Ammonium Borate $[(NH_4)_2BO_3]$ have been removed as Ammonium chloride (NH_4Cl).

The percentage nitrogen in this analysis was calculated using the formula:

% N = Titre value x Atomic mass of Nitrogen x Normality of HCl used x 4

or % N = Titre value x Normality/Molarity of HCl used x Atomic mass of

N x Volume of flask containing the digest x 100

Weight of sample digested in milligram x Vol. of digest for steam distillation. The crude protein content is determined by multiplying percentage Nitrogen by a constant factor of 6.25 i.e. % CP = % N x 6.25.

ii. **Crude Fat or Ether Extract Determination (AOAC Official Method 2003.06)**

Apparatus: Soxhlet apparatus (Gallenkamp UK. Model No: G421HT, Serial No:2314SL) and accessories, oven, desiccator and analytical balance (Mettler Toledo, USA Model No: H6752S, T1217). **Reagents:** Petroleum spirit or Ether (40° – 60°C b.pt).

Determination: 1gm of each dried sample was weighed into fat free extraction thimble and pug lightly with cotton wool. The thimble was placed in the extractor and fitted up with reflux condenser and a 250ml soxhlet flask which has been previously dried in the oven, cooled in the desiccator and weighed. The soxhlet flask is then filled to $^3/_4$ of its volume with petroleum ether (b.pt. 40º – 60ºC), and the soxhlet flask. Extractor plus condenser set was placed on the heater. The heater was put on for six hours with constant running water from the tap for condensation of ether vapour. The set is constantly watched for ether leaks and the heat source is adjusted appropriately for the ether to boil gently. The Ether is left to siphon over several times say over at least 10 – 12 times until it is short of siphoning. It is after this is noticed that any ether content of the extractor is carefully drained into the ether stock bottle. The thimble containing sample is then removed and dried on a clock glass on the bench top. The extractor, flask and condenser is replaced and the distillation continues until the flask is practically dry. The flask which now contains the fat or oil is detached, its exterior cleaned and dried to a constant weight in the oven. If the initial weight of dry soxhlet flask is Wo and the final weight of oven dried flask + oil/fat is W_1, percentage fat/oil is obtained by the formula:

$$\frac{W_1 - W_0}{wt.of\ sample\ taken}\ x\ 100$$

iii. **Dry Matter and Moisture Determination (AOAC Official Method 967.08)**

Apparatus: Oven, crucibles, desiccator and balance.

Reagents: Silica gel, grease.

Determination: 2g of the sample was weighed into a previously weighed crucible. The crucible plus sample taken was then transferred into the oven set at 100°C to dry to a constant weight for 24 hours overnight. At the end of the 24 hours, the crucible plus sample was removed from the oven and transferred to desiccator, cooled for ten minutes and weighed.

If the weight of empty crucible is Wo

weight of crucible plus sample is W_1

weight of crucible plus oven-dried sample W_3

$$\% \text{ Moisture} = \frac{W_1 - W_3}{\text{W1} - \text{Wo}} \; x\ 100$$

$$(\%DM)\%Dry\ Matter = \frac{W_3 - W_0}{W_1 - W_0} \; x\ 100$$

or % Moisture = 100 – % DM.

iv. **Determination of Ash (AOAC Official Method 942.05)**

Apparatus: Porcelain Crucibles, a Dessicator, Analytical Balance (Mettler Toledo, USA Model No: H6752S, T1217) and a Furnace (Gallenkamp UK, Model No: F2457, Serial No: T5378G).

Determination: 2.0gm of the sample were weighed into a porcelain crucible. This was transferred into the muffle furnace set at 550ºC and left for about 4 hours. About this time, it had turned to white ash. The crucible and its content were cooled to about 100ºC in air, then room temperature in a desiccator and weighed. This was done in duplicate. The percentage ash was calculated from the formula below:

$$Ash\ content = \frac{Weight\ of\ ash}{Original\ weight\ of\ sample} \; x\ 100$$

v. Fibre Determination (AOAC 958.06)

Apparatus: Heating mantle, crucibles, furnace (Gallenkamp UK, Model No: F2457, Serial No: T5378G), sieve cloth, fibre flask, funnel, analytical weighing balance (Mettler Toledo, USA Model No: H6752S, T1217), a desiccator.

Reagents: 0.255N H_2SO_4, 0.313N NaOH and Acetone.

Determination: 2.0gm of the sample was accurately into the fibre flask and 100ml of 0.255N H_2SO_4 added. The mixture was heated under reflux for 1 hour with the heating mantle. The hot mixture was filtered through a fibre sieve cloth. The filtrate obtained was thrown off and the residue was returned to the fibre flask to which 100ml of (0.313N NaOH) was added and heated under reflux for another 1 hour. The mixture was filtered through a fibre sieve cloth and 10ml of acetone added to dissolve any organic constituent. The residue was washed with about 50ml hot water on the sieve cloth before it was finally transferred into the crucible. The crucible and the residue were oven-dried at 105ºC overnight to drive off moisture. The oven-dried crucible containing the residue was cooled in a dessicator and later weighed to obtain the weight W_1. The crucible with weight W_1 was transferred to the muffle furnace for Ashing at 550°C for 4 hours.

The crucible containing white or grey ash (free of carbonaceous material) was cooled in the desiccator and weight to obtain W_2. The difference $W_1 - W_2$ gives the weight of fibre. The percentage fibre was obtained by the formula:

$$\% \, Fibre = \frac{W_1 - W_2}{weight \ of \ sample} \ x \ 100$$

vi. Nitrogen-Free Extract (NFE) Determination

The NFE determined by difference. This was done by subtracting SUM of (Moisture % + % Crude Protein + % Ether Extract + % Crude Fibre + % Ash) from 100 i.e. (100 – (% M + % CP + % EE + % CF + % Ash).

3.9 Test Procedure and Feeding Experiments

Following a 10 – 12 hours overnight fast, study participants on one occasion consumed 50g of glucose dissolved in 350ml water and blood glucose measurements was taken with the aid of an Accucheck glucometer.On subsequent occasions the number of which was dependent on the 52 mixed meals and 18 single meals commonly consumed, the fasting blood sample of participants was firstly collected and portions of prepared meals containing 50g available carbohydrate were weighed on electronic scales to the nearest gram on the morning of the test and served to each participant. A set of eight participants each from the pool of Eighty (80) apparently healthy participants were administered either a single or mixed meal portion containing 50g available carbohydrate.Participants in a seated position were instructed to consume all the test meals served between 10 -15 minutesin the nutritional research laboratory during the study period.50g available carbohydrate for each test food sample was calculated from the results of the proximate analysis and the measured portion of the food was served to the participantswith a sachet of water.

For each test meal consumed, the selected eighty (80) participants stood as their own control. Participants were asked to remain seated during each session for the duration of the test. Blood samples was obtained by finger-prick using sterile hypodermic needle or lancets) before eating the test meals (0 min) and at 30, 60, 90, and 120 minutes intervals after consumption of the meals. Each capillary blood sample was thereafter placed on a test strip which was then inserted into a calibrated Glucometer (Accu-check ®) which gave direct readings after 15 seconds based on glucose oxidase assay method.The procedure for the determination of glycaemic responses of participants was as described by Wolever, (1993).

Weight of Foods and Ingredients Used is in Appendix 3

3.10 Quality Control:

Participants were admonished to adhere to research protocols such as observing the 10 – 12 hours overnight fast and remaining seated during the duration of the test to reduce inter and intra within variations.

Instruments used for this study such as the glucometer, weighing scales were calibrated daily. Research assistants/data collectors were trained on test and data collection procedures. Immediate and accurate recording of data was ensured by assigning each researcher to one specific aspect of test and data collection.

Validation: Some Blood samples were also taken, stored in labeled batches and analyzed for blood glucose using classical laboratory analysis method. (Appendix 6).

3.11 Calculation of Glycaemicindex and Glycaemicload

The GI was calculated using the method described by FAO/WHO (FAO/WHO, 1998) as the area under the blood glucose response curve of a 50g carbohydrate portion of the test food expressed as a percent of the response to the same amount of carbohydrate from a standard food taken by the same subject. The area under the blood glucose response curve will be calculated geometrically by applying the trapezoid rule (Brouns et al, 2005). The GI values are classified as high (70 – 100), intermediate (55 – 69) or low (< 55).

The Glycaemic load for each food was determined by the method of Salmeron et al, 1997. This was calculated by taking the percentage of the food's carbohydrate content in a typical serving and multiplying it by its glycaemicindex values (Atkinson et al, 2008). GL values were classified as low (≤ 10), medium (> 10 to < 20) or high (≥ 20).

3.12 Statistical Analysis

Data Analysis was done using SPSS (version 20.0) for windows and MS Excel was used for statistical analysis of data obtained. Descriptive statistics such as frequencies, mean ± standard deviation (SD) was also used to summarize and present the results for GI and AUC (Area under the curve). Analysis of Variance (ANOVA)was used to test for difference in means of frequencies and correlations was used for comparisons of quantitative data for categorical variables at $p<0.05$.

3.13 Consent and Ethical Approval

Informed consent was obtained from all study participants and ethical approval for this study was obtained from The Joint University of Ibadan and University College hospital (UI/UCH) Ethics Review Committee. This is attached in Appendix 8.

CHAPTER FOUR

RESULTS

4.1: **Proximate Composition of Commonly Consumed Cassava Products**: Table 4.1 shows the protein content of food prepared from cassava products ranges from 0.29g – 0.75g/100g edible portion. The highest protein content of 0.75g is observed in *AmalaLafun* while *Fufu* has the lowest protein content of 0.29g. The moisture content of the cassava products ranges from 69.29% to 74.93%. The fat content varied from 0.07g/100g in *Eba white* to 0.16g/100g in *fufu.* The crude fibre values ranged between 0.15g/100g in *AmalaLafun* to 0.96g in *Eba white*.The ash, carbohydrate and energy values varied between 0.78g -1.05g, 22.96g – 29.25g and 93.65kcal – 119.60kcal respectively.

4.2**Proximate Composition of Commonly Consumed Yam Products**: Table 4.2 shows that protein content of food prepared from yam products ranges from 0.38g – 1.32g/100g edible portion. The highest protein content of 1.32g is observed in Yam - boiled while Yam flour - *Amala* has the lowest protein content of 0.38g. The fat content varied from 0.08g/100g in Yam - boiled to 3.21g/100g in Yam Pottage. The crude fibre values ranged between 0.26g/100g in Yam flour - *Amala* to 0.51g in Yam – boiled. The ash, moisture, carbohydrate and energy values varied between 0.84g -1.47g, 70.77% in Yam boiled – 77.82% in Yam flour – *Amala*, 20.53g – 26.22g and 85.14kcal – 120.72kcal respectively.

4.3Proximate Composition of Commonly Consumed Plantain Products: Table 4.3 shows the highest protein content of 1.30g is observed in Plantain - fried in veg oil while Plantain unripe -boiled has the lowest protein content of 0.92g. The fat content varied from 0.50g/100g in *Plantain* unripe -boiled to 13.85g/100g in Plantain - fried in veg oil. The crude fibre values ranged between 0.18g/100g in Plantain - fried in veg oil to 5.60g in Plantain unripe -boiled. The ash content was 0.40g in Plantain unripe -boiled and 1.37g for Plantain - fried in veg oil. The moisture, carbohydrate and energy values varied between 47.85% -61.53%, 31.04g/100g – 35.44g/100g and 132.37kcal – 271.65kcal respectively.

Table 4.1. Proximate Composition of Commonly Consumed Cassava Products (g/per 100g Edible portion)

Sample Description	Protein (g)	Fat (g)	Crude Fibre (g)	Ash (g)	Moisture (%)	CHO (g)	Energy (Kcal)
Eba white	0.31 ± 0.04	0.07 ± 0.02	0.96 ± 0.02	0.78 ± 0.04	74.93 ± 0.75	22.96 ± 0.78	93.65 ± 3.21
Fufu	0.29 ± 0.02	0.16 ± 0.01	0.22 ± 0.01	0.78 ± 0.03	69.29 ± 0.54	29.25 ± 0.52	119.60 ± 2.09
AmalaLafun	0.75 ± 0.02	0.09 ± 0.01	0.15 ± 0.01	1.05 ± 0.02	73.53 ± 0.08	24.43 ± 0.06	101.56 ± 0.25

*CHO – Carbohydrate: expressed as the difference between the total weight of the food samples and the addition in grams of protein, fat, crude fibre, ash, and moisture

Table 4.2 Proximate Composition of Commonly Consumed Yam Products (per 100g Edible portion)

Sample Description	Protein (g)	Fat (g)	Crude Fibre (g)	Ash (g)	Moisture (%)	CHO (g)	Energy (Kcal/g)
Yam - Boiled	1.32 ± 0.05	0.08 ± 0.02	0.51 ± 0.02	1.10 ± 0.04	70.77 ± 0.24	26.22 ± 0.23	110.91 ± 0.79
Yam Pottage	1.20 ± 0.07	3.21 ± 0.14	0.35 ± 0.01	1.47 ± 0.01	72.02 ± 0.81	21.75 ± 0.74	120.72 ± 3.96
Pounded Yam	1.07 ± 0.03	0.28 ± 0.04	0.29 ± 0.02	1.03 ± 0.19	75.15 ± 0.17	22.18 ± 0.34	95.49 ± 1.22
Yam flour (Amala)	0.38 ± 0.05	0.16 ± 0.03	0.26 ± 0.02	0.84 ± 0.07	77.82 ± 0.79	20.53 ± 0.79	85.14 ± 3.24

*CHO – Carbohydrate: expressed as the difference between the total weight of the food samples and the addition in grams of protein, fat, crude fibre, ash, and moisture

Table 4.3 Proximate Composition of Commonly Consumed Plantain Products (per 100g Edible portion)

Sample Description	Protein (g)	Fat (g)	Crude Fibre (g)	Ash (g)	Moisture (%)	CHO (g)	Energy (Kcal/g)
Plantain - unripe boiled	0.92 ± 0.03	0.50 ± 0.22	5.60 ± 0.33	0.40 ± 0.16	61.53 ± 0.21	31.04 ± 0.54	132.37 ± 0.61
Plantain - fried in veg oil	1.30 ± 0.05	13.85 ± 0.01	0.18 ± 0.01	1.37 ± 0.02	47.85 ± 0.02	35.44 ± 0.02	271.65 ± 0.18

*CHO – Carbohydrate: expressed as the difference between the total weight of the food samples and the addition in grams of protein, fat, crude fibre, ash, and moisture

4.4**Proximate Composition of Commonly Consumed Cereals and Grains Products:** Table 4.4. shows the protein content of food prepared from cereals and grains products ranges from 2.40g – 8.83g/100g edible portion. The highest protein content value of 8.83g is in Ogi-yellow while Semovita has the least protein content of 2.40g. The fat content varied from 0.25g/100g in White rice - boiled to 4.04g/100g in Ogi yellow. The crude fibre values ranged between 0.19g/100g in Semovita to 8.24g in Ogi yellow. The ash values ranged from 1.03g – 2.08g/100g, moisture content from 10.12% in raw ogi yellow to 65.38% in white rice boiled. The carbohydrate and energy values varied between 22.09g in wheat - 67.75g in raw ogi yellow and, 131.40kcal – 342.62kcal respectively.

4.5. Proximate Composition of Commonly Consumed Legumes and Legume Products Table 4.5. shows the protein content of commonly consumed legume products with values ranging between 6.50g to 12.07g. The highest protein content of 12.07g is in *Akara* while the least protein content is in *Moinmoin*. The fat content varied from 0.49g/100g in boiled beans to 8.30g/100g in *Akara.* The crude fibre values ranged between 0.87g/100g in *Akara* to 1.45g in beans porridge. The ash content values ranged between 1.72g – 2.45g. The highest moisture content of 72.45% is seen in *Moinmoin* while the lowest moisture content of 52.55g is seen in *Akara*. The carbohydrate content varied between 15.73g in moinmoin to 23.76g in Akara. The least energy values of 111.27kcal was observed in *Moinmoin*while *Akara*had the highest energy value of 218.03g/100g edible portion.

Table 4.4. Proximate Composition of Commonly Consumed Cereals and Grains Products (per 100g Edible portion)

Sample Description	Protein (g)	Fat (g)	Crude Fibre (g)	Ash (g)	Moisture (%)	CHO (g)	Energy (Kcal/g)
White rice – boiled	2.88 ± 0.04	0.25 ± 0.02	1.03 ± 0.04	1.05 ± 0.02	65.38 ± 0.20	29.41 ± 0.22	131.40 ± 0.76
Jollof rice	2.79 ± 0.03	2.77 ± 0.02	0.40 ± 0.01	1.71 ± 0.02	64.89 ± 0.43	27.43 ± 0.41	145.84 ± 1.96
Fried Rice	2.64 ± 0.02	3.30 ± 0.02	1.17 ± 0.01	1.49 ± 0.01	59.03 ± 0.02	32.37 ± 0.05	169.71 ± 0.11
Ogi' yellow	8.83 ± 0.02	4.04 ± 0.01	8.24 ± 0.04	1.03 ± 0.01	10.12 ± 0.03	67.75 ± 0.03	342.62 ± 0.10
Semovita	2.40 ± 0.07	0.84 ± 0.01	0.19 ± 0.02	2.08 ± 0.02	59.80 ± 0.02	34.69 ± 0.05	155.94 ± 0.07
Wheat	8.42 ± 0.03	3.09 ± 0.02	1.71 ±0.02	1.57 ± 0.02	63.12 ± 0.05	22.09 ± 0.04	149.85 ± 0.07

*CHO – Carbohydrate: expressed as the difference between the total weight of the food samples and the addition in grams of protein, fat, crude fibre, ash, and moisture

Table 4.5. Proximate Composition of Commonly Consumed Legumes and Legume Products (per 100g Edible portion)

Sample Description	Protein (g)	Fat (g)	Crude Fibre (g)	Ash (g)	Moisture (%)	CHO (g)	Energy (Kcal/g)
Boiled Beans	10.79 ± 0.02	0.49 ± 0.02	1.17 ± 0.01	1.99 ± 0.03	64.06 ± 0.02	21.50 ± 0.08	133.54 ± 0.08
Beans Porridge	7.38 ± 0.05	4.48 ± 0.02	1.45 ± 0.02	2.26 ± 0.06	62.07 ± 0.15	22.36 ± 0.13	159.26 ± 0.63
"Moinmoin"	6.50 ± 0.03	2.48 ± 0.03	1.12 ± 0.01	1.72 ± 0.03	72.45 ± 0.07	15.73 ± 0.04	111.27 ± 0.26
"Akara"	12.07 ± 0.07	8.30 ± 0.25	0.87 ± 0.02	2.45 ± 0.06	52.55 ± 0.26	23.76 ± 0.03	218.03 ± 2.40

*CHO – Carbohydrate: expressed as the difference between the total weight of the food samples and the addition in grams of protein, fat, crude fibre, ash, and moisture

4.6**Foods and Portion size containing 50g available Carbohydrates** Table 4.6. shows the equivalent weight of food samples containing 50g available carbohydrate served to each study participants. This portion size was derived from the result of proximate analysis of available carbohydrate in 100g edible portion with values ranging between 67.75g in raw ogi yellow to 317.66 in *moinmoin* prepared with vegetable oil.

Table 4.6a Foods and Portion size containing 50g available Carbohydrates

Food	Equivalent weight/portion size containing 50g available carbohydrate (g)
Cassava Products	
AmalaLafun	205
Eba	217.77
Fufu	170.94
Yam Products	
Boiled yam	190.69
Yam pottage	229.78
Amala	243.55
Pounded yam	225.42
Plantain Products	
Unripe plantain	161.29
Unripe plantain + stew	161.29

Table 4.6b Foods and Portion size containing 50g available Carbohydrates

Food	Equivalent weight/portion size containing 50g available carbohydrate (g)
Cereal Products	
Wheat	226.35
Semovita	144.18
Ogi yellow (raw)	67.75
Boiled rice	170.01
Jollof rice	182.28
Fried rice	154.46
Bread(FoodCo)	97.5
Legume Products	
Boiled beans	232.34
Akara (veg oil)	210.53
***Moinmoin* (veg oil)**	317.66
Beans porridge	223.33

4.7. Soups and stew with their corresponding portion sizes: Table 4.7. shows the measured weight of a single serving spoon for the various soups and stew served as accompaniment to the main staple food for each participant. A uniform serving weight for each of the soups with various staple food was maintained to reduce variability within the staple meals. The highest serving weight of 60g was observed in *Eforiro* while the least serving weight of 41.5g was in *Okro* (plain).

Table 4.7 Soups and stew with their corresponding portion sizes (in grams)

Soups	Weight of a single Serving (g)*
Ewedu	55.9
Eforiro	60
Efoelegusi	55.6
Okro (plain)	41.5
Stew	45

*Equal amounts of soups and stew were served with accompanying staples

4.8.Serving proportion for composite and mixed dishes Table 4.8. represents the weight combination of the mixed meals served to each participant with proportioning done as eaten in the Nigerian diet.

Table 4.8a Serving proportion for composite and mixed dishes

Food	Weight (g)	Available carbohydrate
Fried Egg (1 medium size)	55.5g	....
Bread	78	40g
Akara	42.1	10g
Bread	58	30g
Moinmoin	127.1	20g
Bread	38.9	20g
Beans porridge	134	30g
Boiled beans	46.5	10g
Boiled rice	136	40g
Boiled rice	102.1	30g
Boiled beans	46.5	10g
Plantain	20	10g

Table 4.8b Serving proportion for composite and mixed dishes cont'd

Food	Weight (g)	Available carbohydrate
Boiled egg	45.3	
Boiled rice	135	40g
Plantain	20	10g
Boiled beans	185.9	40g
Plantain	20	10g
Jollof rice	145.8	40g
Plantain	20	10g
Jollof rice	145.8	40g
Moinmoin	63.6	10g
fried rice	123.6	40g
Moinmoin	63.6	10g
Fried rice	123.6	40g

4.9.Demographic and Clinical measurements of participants:

Table 4.9. represents a summary of the demographic and clinical characteristics of participants of this study. More females participated in this study and the mean age of all participants was 22.28. The mean BMI, fasting blood glucose, systolic and diastolic blood pressure and hemoglobin values is 20.96, 84.74mg/dl, 112.19mmHg, 72.45mmHg and 13.64g/dl respectively. The age, FBG and hemoglobin values were statistically significant at $p < 0.05$ for male and female participants.

Table 4.9 Demographic and Clinical measurements of participants

Characteristics	Female	Male	p-value
Number of Participants	53	27	
Mean Age(years)	21.3 ± 2.78	24.18 ± 4.02	0.017
Mean BMI(kg/m^2)	20.84 ± 2.57	20.79 ± 2.60	0.401
Mean Fasting Blood Glucose(mg/dl)	85.21 ± 8.15	84.07 ± 5.41	0.007
Mean Systolic Blood Pressure(mmHg)	109.71 ± 9.93	116.63 ± 11.60	0.963
Mean Diastolic Blood Pressure(mmHg)	72.68 ± 8.45	73.04 ± 9.12	0.587
Mean Hemoglobin(g/dl)	12.2 ± 0.92	14.78 ± 1.06	0.025

4.10. GlycaemicIndex of Cassava products (*Eba*) (Single and Mixed meals): Table 4.10 shows the glycaemicindex of cassava-based products – *Eba* and forms in which it is consumed as a mixed meal. It shows that *Eba* consumed with 'Efoelegusi' soup had the lowest GI of 74, while the highest GI of *Eba* meal was observed when consumed with 'Ewedu' with a GI value of 93. The GI value for*Eba* as a single meal compared with its mixed meal forms was statistically significant at $p < 0.05$.

4.11.Glycaemicindex of Cassava products (*Fufu*) (Single and Mixed meals)

Table 4.11 shows the glycaemicindex of cassava-based products – Fufu and forms in which it is consumed as a mixed meal. It shows that Fufu consumed with 'Efoewedu' soup had the lowest GI of 78, while the highest GI value of 83 for Fufu meal was observed when was consumed with 'Efoelegusi'. The GI value for*Fufu* as a single meal compared with its mixed meal forms was not statistically significant at $p < 0.05$.

4.12. Glycaemicindex of Cassava products (*Amala*-Lafun) (Single and Mixed meals)

Table 4.12 shows the glycaemicindex of cassava-based products – Lafun and forms in which it is consumed as a mixed meal. It shows that Lafun consumed with 'okro' soup had the lowest GI of 84. Lafun consumed with 'Efoelegusi and 'Eforiro' soup had the same highest GI of 90. Association between the GI of Lafun as a single meal and its mixed meal forms was not significant at $p < 0.05$.

4.13. Glycaemicindex of Yam and Yam products- Boiled yam (Single and Mixed meals):

Table 4.13 shows the glycaemicindex of Yam-based products – Boiled Yam and forms in which it is consumed as a mixed meal. It shows that Boiled Yam consumed with fried egg had the lowest GI of 84, and yam pottage had the highest GI of 88. The GI value forboiled yam as a single meal compared with its mixed meal forms was not statistically significant at $p < 0.05$.

Starchy Roots and Tubers and their mixed meals

Table 4.10Glycaemicindex of Cassava products (*Eba*) (Single and Mixed meals)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Eba	218	99^{c}	3.5	High	
Eba and Ewedu	274	93^{bc}	2.3	High	
Eba and Egusi	274	74^{a}	4.3	High	0.000
Eba and Okro	260	82^{a}	2.6	High	
Eba and Efo-Riro	278	84^{ab}	3.5	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$).*SEM – Standard Error of Mean

Table 4.11Glycaemicindex of Cassava products (*Fufu*) (Single and Mixed meals)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Fufu	171	88^{b}	2.7	High	
Fufu and Ewedu	227	78^{a}	1.94	High	
Fufu and Egusi	227	83^{ab}	1.7	High	0.091
Fufu and Okro	212	80^{a}	2.8	High	
Fufu and Efo-riro	231	81^{ab}	3.2	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Table 4.12Glycaemicindex of Cassava products (*Amala*-Lafun) (Single and Mixed meals)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Lafun	205	97^{b}	3.2	High	
Lafun and Ewedu	260.9	86^{ab}	2.3	High	
Lafun and Egusi	260.6	90^{ab}	3.2	High	0.112
Lafun and Okro	246.5	84^{a}	4.0	High	
Lafun and Efo-riro	265	90^{ab}	2.7	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Table 4.13. Glycaemicindex of Yam and Yam products (Single and Mixed meals)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Boiled Yam	191	94[a]	4.6	High	
Boiled Yam and stew	236	85[a]	4.1	High	0.349
Boiled Yam and Fried Egg	246	84[a]	2.10	High	
Yam Pottage	230	88[a]	4.98	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

4.14Glycaemicindex of Yam products (*Amala*) (Single and Mixed meals):

Table 4.14 shows the glycaemicindex of Yam-based products – Amala and forms in which it is consumed as a mixed meal. It shows that Amala consumed with 'Eforiro' soup had the least GI of 75. The highest GI value of 93 was derived when *Amala* was eaten with Ewedu soup. Association between the GI of *Amala* as a single meal and its mixed meal forms was significant at $p < 0.05$.

4.15. Glycaemicindex of Yam products (Pounded Yam) (Single and Mixed meals)

Table 4.15 shows the glycaemicindex of Yam-based products – Pounded Yam and forms in which it is consumed as a mixed meal. It shows that Pounded yam consumed with 'okro' soup had the least GI of 84, while the highest GI value of 89 was derived when Pounded Yam was eaten with Eforiro soup. Association between the GI of pounded yam as a single meal and its mixed meal forms was not significant at $p < 0.05$.

4.16. Glycaemicindex of Plantain and Plantain products (Single and Mixed meals):

Table 4.17 shows the glycaemicindex of Plantain and Plantain products in the form which it is consumed as a mixed meal. It shows that Unripe plantain consumed alone had a high GI of 89 and when Unripe plantain was consumed with stew, a high GI value of 88 was also elicited. The GI value forunripe plantain as a single meal compared with its mixed meal forms was not statistically significant at $p< 0.05$.

Table 4.14. GlycaemicIndex of Yam products (*Amala*) (Single and Mixed meals)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Amala	244	97^{b}	2.8	High	
Amala and Ewedu	299	93^{b}	3.2	High	0.000
Amala and Egusi	299	84^{a}	3.7	High	
Amala and Okro	285	78^{a}	2.7	High	
Amala and Efo-riro	304	75^{a}	3.1	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Table 4.15. Glycaemicindex of Yam products (Pounded Yam) (Single and Mixed meals)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Pounded Yam	225	94^a	4.3	High	
Pounded Yam and Ewedu	281	88^a	4.3	High	
Pounded Yam and Egusi	281	87^a	4.8	High	0.487
Pounded Yam and Okro	267	84^a	3.2	High	
Pounded Yam and Efo-riro	285	89^a	2.4	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Table 4.16. Glycaemicindex of Plantain and Plantain products (Single and Mixed meals)

Food	Portion Size(grams)	Mean	SEM	Category	p-value
Unripe Plantain	161	89^{a}	3.9	High	
Unripe Plantain with Stew	206	88^{a}	3.4	High	1.791

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

4.17Glycaemicindex of Semovita products (Single and Mixed meals):

Table 4.17 shows the glycaemicindex of Cereal-based products – Semovita and forms in which it is consumed as a mixed meal. It shows that Semovita consumed with 'ewedu' and 'eforiro soup had the same least GI of 81and Semovita consumed with 'Efoelegusihad the highest GI of 88. The GI value forSemovita as a single meal compared with its mixed meal forms was not statistically significant at $p < 0.05$.

4.18. Glycaemicindex of Wheat products (Single and Mixed meals):

Table 4.18 shows the glycaemicindex of Cereal-based products – Wheat and forms in which it is consumed as a mixed meal. It shows that Wheat consumed with 'Eforiro' had the least GI of 79 while wheat consumed with "EfoElegusi" had the highest GI value of 90. The GI value forWheat as a single meal compared with its mixed meal forms was not statistically significant at $p < 0.05$.

4.19. Glycaemicindex of Bread-based meals (Single and mixed dishes): Table 4.19 shows the glycaemicindex of Cereal-based products – White bread and forms in which it is consumed as a mixed meal. It shows that Bread consumed with 'moinmoin' had the least GI of 78 and bread consumed with Akara had the highest GI of 93. The GI value forBread as a single meal compared with its mixed meal forms was not statistically significant at $p < 0.05$.

Cereals and Cereal products

Table 4.17Glycaemicindex of Semovita products (Single and Mixed meals)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Semovita	144	90^{a}	3.2	High	
Semovita and *Ewedu*	200	81^{a}	1.9	High	
Semovita and *Egusi*	200	88^{a}	2.7	High	0.127
Semovita and *Okra*	186	83^{a}	3.4	High	
Semovita and *Efo-riro*	204	81^{a}	1.8	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Table 4.18.Glycaemicindex of Wheat products (Single and Mixed meals)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Wheat	226	93^{b}	3.1	High	…….
Wheat and Ewedu	282	87^{ab}	3.4	High	0.127
Wheat and Egusi	282	90^{ab}	3.9	High	…….
Wheat and Okra	268	86^{ab}	3.8	High	
Wheat and Efo-riro	286	79^{a}	2.6	High	…….

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Table 4.19. Glycaemicindex of Bread-based meals (Single and mixed dishes)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
White bread	98	88^{ab}	3.0	High	
Bread and Egg	143	81^{ab}	3.9	High	
Bread and *Akara*	120	93^{b}	4.4	High	0.094
Bread and *Moin-Moin*	185	78^{a}	4.5	High	
Bread and Beans	173	81^{ab}	2.9	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

4.20. Glycaemicindex of Rice-based products: Boiled white rice (Single and Mixed dishes):

Table 4.20 shows the glycaemicindex of Cereal-based products – Rice and forms in which it is consumed as a mixed meal. It shows that boiled white rice eaten with fried plantain and stew had the lowest GI of 74, while boiled rice eaten with fried plantain, boiled beans, boiled egg and stew had the highest GI of 84. The GI value for boiled whiterice as a single meal compared with its mixed meal forms was statistically significant at $p < 0.05$.

Table 4.20a shows the glycaemic of Cereal-based products – Fried Rice and forms in which it is consumed as a mixed meal. It shows that fried rice eaten with fried plantain and meat had the lowest GI of 78. The same highest GI value of 88 was observed when fried rice was eaten with meat and it was consumed with moin-moin and meat. The GI value forfried rice as a single meal compared with its mixed meal forms was not statistically significant at $p < 0.05$.

Table 4.20b shows the glycaemic of Cereal-based products – Jollof Rice and forms in which it is consumed as a mixed meal. It shows that jollof rice eaten with meat had the lowest GI of 79 while the highest GI of 87 was derived when Jollof rice was eaten with fried plantain and meat. The GI value forJollof rice as a single meal compared with its mixed meal forms was not statistically significant at $p < 0.05$.

Table 4.20. Glycaemicindex of Rice-based products (Single and Mixed dishes)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
White rice	170	93^{b}	2.1	High	
Boiled rice and stew	215	83^{a}	1.4	High	
Boiled rice, Fried Plantain and Stew	201	74^{a}	1.8	High	0.003
Boiled rice, boiled beans and stew	228	76^{a}	3.2	High	
Boiled rice, fried plantain, boiled beans, egg, stew	259	84^{a}	4.1	High	
Boiled Rice, Boiled beans, Fried Plantain, Stew and meat	214	82^{a}	4.3	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Table 4.20a Continuation of Glycaemicindex of Rice products (Single and Mixed dishes)

Food	Portion Size(grams)	Mean GI	SE	Category	p-value
Fried rice and meat	154	88[a]	3.6	High	
Fried rice, fried plantain, meat	144	78[a]	3.2	High	0.246
Fried rice, Moinmoin and meat	219.8	88[a]	5.6	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Table 4.20b Continuation of Glycaemicindex of Rice products (Single and Mixed dishes)

Food	Portion Size(grams)	Mean GI	SEM	Category	p-value
Jollof rice and meat	182	79^{a}	2.6	High	
Jollof rice, plantain, meat	166	87^{a}	5.3	High	0.310
Jollof rice, Moinmoin, meat	209	80^{a}	2.5	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

4.21Glycaemicindex of Maize products (Single and Mixed dishes)

Table 4.21 shows the glycaemicindex of Cereal-based products – Maize and forms in which it is consumed as a mixed meal. It shows *Ogi*yellow eaten with moinmoin had the least GI of 76 while the highest GI of 92 was derived when *Ogi* yellow was consumed as a single meal. The GI value for*Ogi* yellow as a single meal compared with its mixed meal forms was statistically significant at $p < 0.05$.

Table 4.21.Glycaemicindex of Maize products (Single and Mixed dishes)

Food	Portion Size (grams)	Mean GI	SEM	Category	p-value
Ogi and Akara	211	77[a]	2.6	High	
Ogi and MoinMoin	318	76[a]	1.2	High	0.000
Beans and *Ogi*	232	79[a]	1.55	High	
Ogi yellow	240	92[b]	2.2	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

4.22. Glycaemicindex of Beans and Beans products (Single foods)

Table 4.22 shows the glycaemicindex of Legume-based products – Beans and forms in which it is consumed as a single meal. *Moinmoin* consumed as a single meal had the highest GI of 94 while boiled beans and *Akara* had a tied GI value of 91. The least GI of 85 was observed in beans porridge. There is no significant difference at $p < 0.05$ for these single beans' meals.

Legumes and Legumes products

Table 4.22.Glycaemicindex of Beans and Beans products (Single foods)

Food	Portion Size(grams)	Mean GI	SE	Category	p-value
Boiled Beans	232	91^{a}	3.3	High	
Akara	211	91^{a}	3.3	High	0.281
Moin-Moin	318	94^{a}	3.5	High	
Beans Porridge	223	85^{a}	3.0	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

4.23. GlycaemicIndex of Beans and Beans products (Mixed meals):

Table 4.23 shows the glycaemicIndex of Legume-based products – Beans and forms in which it is consumed as a mixed meal. Boiled beans, fried plantain and stew has the least GI value of 84, while the highest GI value was observed when Beans porridge was consumed with garri soaked in water with a GI value of 96. There is no significant difference at $p < 0.05$ for these mixed beans meals.

Table 4.23.GlycaemicIndex of Beans and Beans products (Mixed meals)

Food	Portion Size (grams)	Mean GI	SEM	Category	p-value
Boiled Beans and Stew	278	88^{ab}	1.4	High	
Boiled beans, fried plantain and stew	251	84^{a}	3.02	High	0.086
Beans and garri	235	86^{a}	3.3	High	
Beans + Garri and Water	235	96^{b}	3.4	High	

Note: All values are expressed as mean ± SEM of eight values. Values with different letters on the same column are significantly different ($p < 0.05$). *SEM – Standard Error of Mean

Figure 4.1 illustrates the effect of equal portions of *Ewedu* soup served with each staple food. The highest reducing effect on the GI of the main staple food is observed when *Ewedu* is eaten with Fufu with a GI of 78, this is next to *Ewedu* eaten with Semovita having a GI of 81 and then *Ewedu* eaten with Wheat with a GI of 86. A GI of 87 and 88 was derived for *Ewedu* consumed with Wheat and Pounded yam. However, the least reducing GI effect of *Ewedu* soup on staples, was observed when the soup was eaten with*Amala* and*Eba* with the same GI of 93.

Figure 4.2 illustrates the effect of equal portions of *Efoelegusi* soup served with each staple food. The highest reducing effect on the GI of the main staple food is observed when *Efoelegusi* is eaten with *Eba* with a GI of 74, this is next to *Efoelegusi* and *Fufu* with a GI of 83 and then *Efoelegusi* eaten with *Amala* with a GI of 84. A GI of 87 and 88 was derived for *Efoelegusi* consumed with Pounded yam and Semovita. However, the least reducing effect of *Efoelegusi* soup on staples, was observed when the soup was eaten with *Lafun* and Wheat with the same GI of 90.

Figure 4.3 illustrates the effect of equal portions of *Okra* soup served with each staple food. The highest reducing effect on the GI of the main staple food is observed when Okra is eaten with *Amala* with a GI of 78, this is next to Okra and Fufu with a GI of 80 and then Okra eaten with *Eba* with a GI of 82. A GI of 83 and the same GI of 84 was derived for Okra consumed with Semovita, *Lafun* and Pounded Yam respectively. However, the least reducing effect of Okra soup on staples, was observed when the soup was eaten with Wheat with a GI of 86.

Figure 4.4 illustrates the effect of equal portions of *Eforiro* soup served with each staple food. The highest reducing effect on the GI of the main staple food is observed when *Eforiro* is eaten with *Amala* with a GI of 75, this is next to *Eforiro* and Wheat with a GI of 79 and then *Eforiro* eaten with *Fufu* and Semovita with a GI of 81. A GI of 84 and 89 was derived for *Eforiro* consumed with *Eba* and Pounded Yam respectively. However, the least reducing effect of *Eforiro* soup on staples, was observed when the *eforiro* was eaten with *Lafun* with a GI of 90.

Soups Comparison with Common Staples

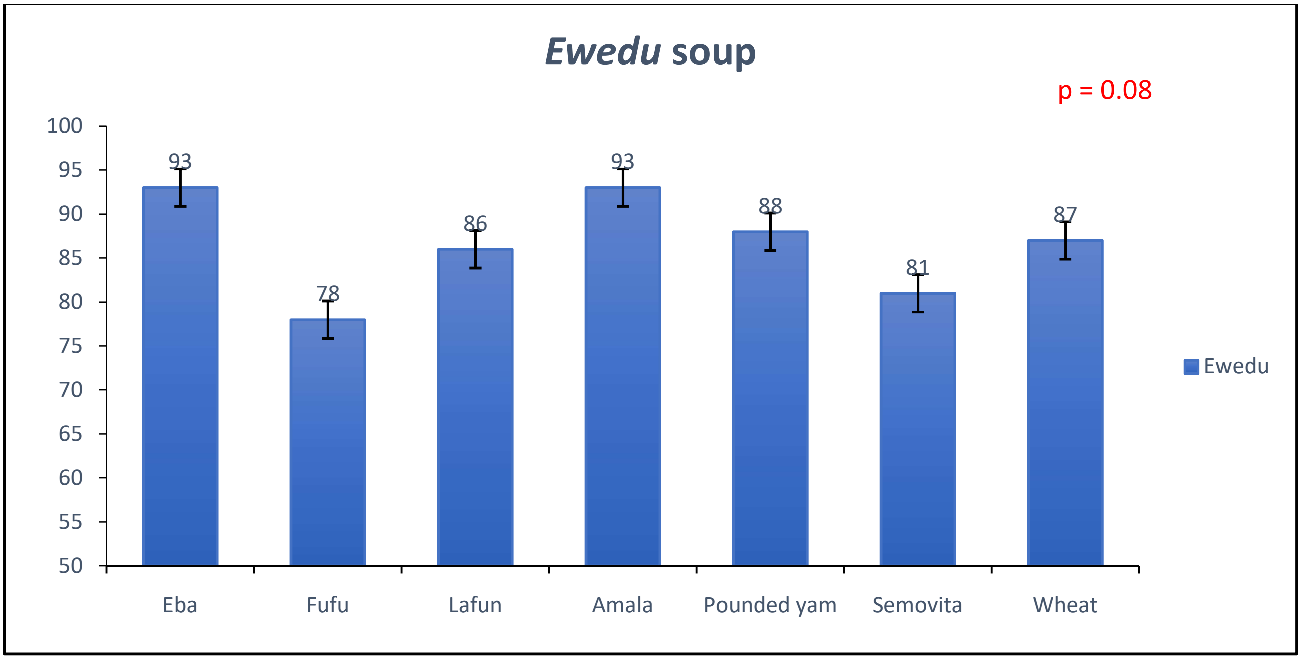


Figure 4.1.GlycaemicIndex of Commonly consumed staples with *Ewedu soup*

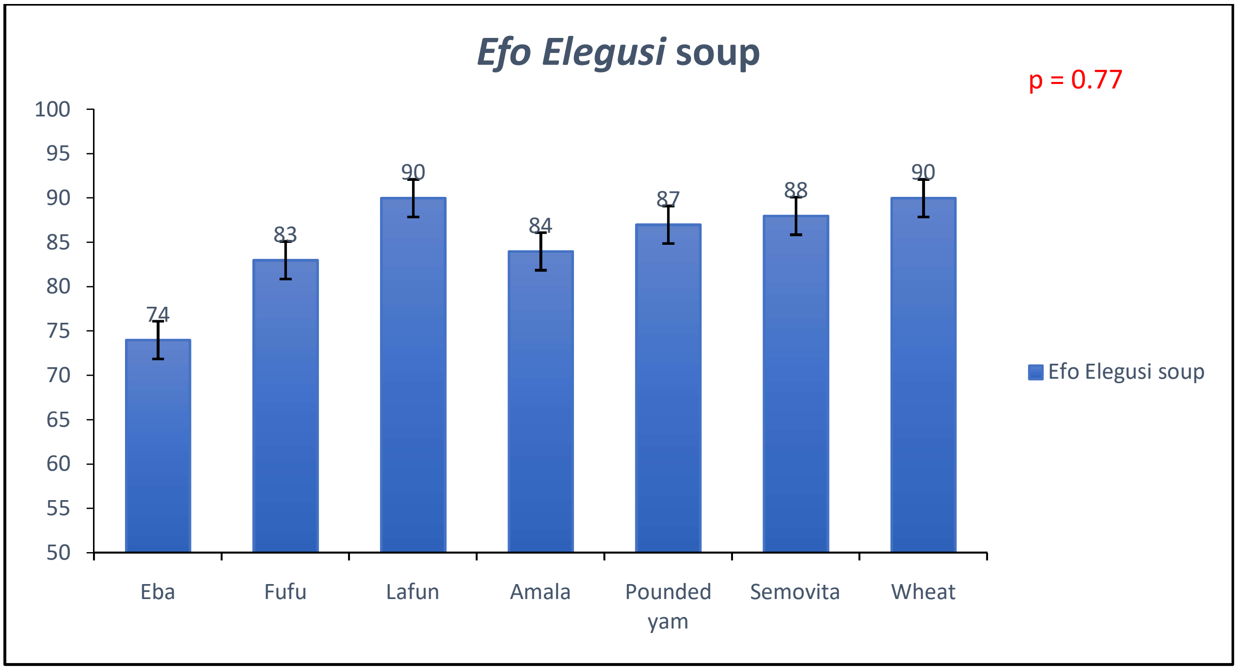


Figure 4.2.GlycaemicIndex of Commonly consumed staples with *Efo-elegusi*

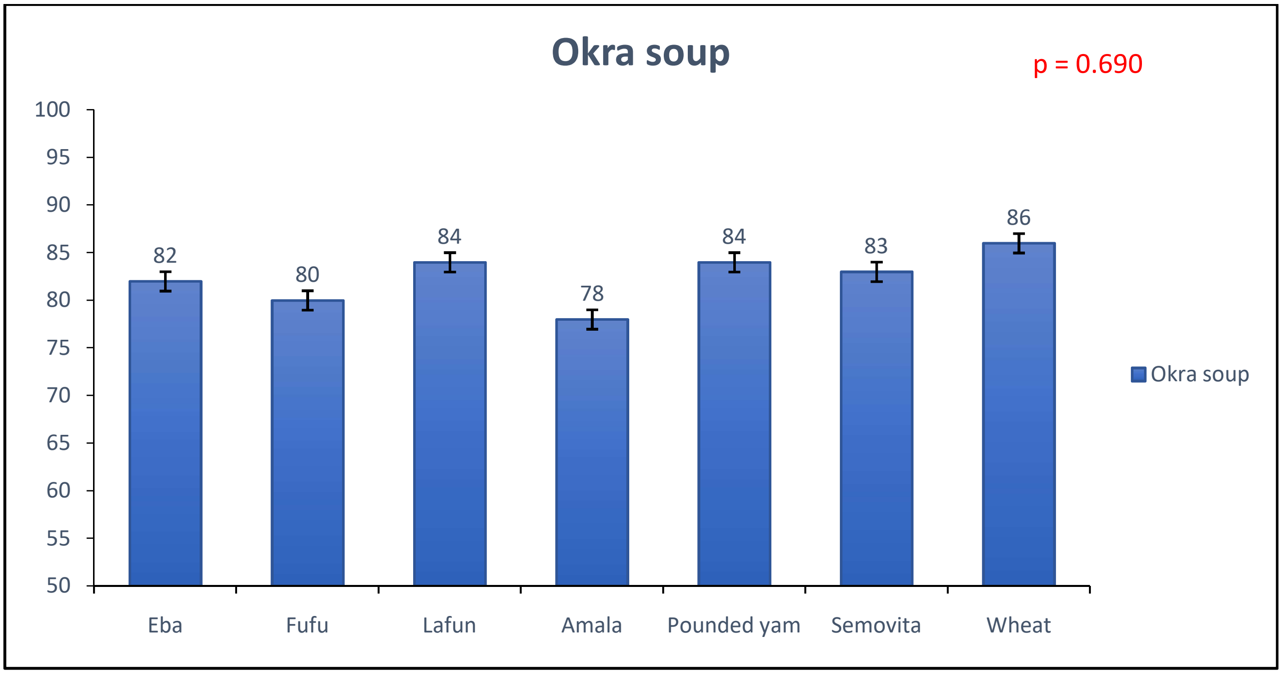


Figure 4.3GlycaemicIndex of Commonly consumed staples with *Okra*soup

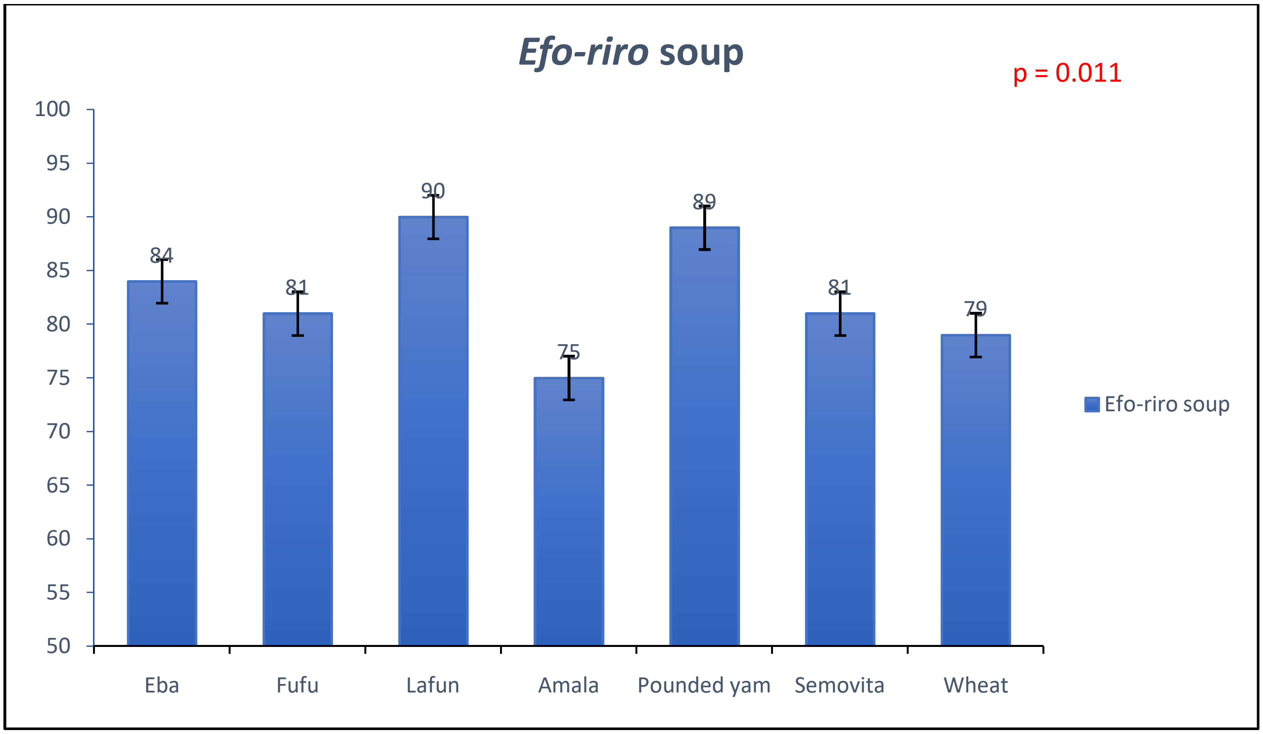


Figure 4.4.GlycaemicIndex of Commonly consumed staples with *Efo-riro*

Table 4.24, 4.24a and 4.24b, shows the glycaemic load of some foods included in this study. Medium glycaemicload values (GL) values were observed in *Moinmoin*: 15, Boiled beans and stew: 18, Beans Porridge: 19, Jollof rice and *moinmoin*: 19, *Ogi* yellow: 19, Boiled rice and stew: 19 and Yam Pottage: 19. Semovita, wheat, boiled yam, *Amala*, Unripe plantain, *Fufu, Eba, lafun*, bread with egg, bread with *moinmoin*, bread with beans and fried rice and *moinmoin* have high glycaemic load values.

Table 4.24. Glycaemicload of commonly consumed foods in Cereals, Root, Tuber and Legume groups

Food	Available CHO (g/100g of Food)	Experimental portion(g)/50g CHO	Mean GI	GL Mean	Category
Semovita	34.68	144	90	31	High
Wheat	22.12	226	93	21	High
Boiled Yam	26.22	191	94	25	High
Amala	20.53	244	97	20	High
Pounded Yam	22.18	225	94	21	High
Unripe Plantain	31.00	161	89	28	High
Fufu	29.25	171	88	26	High
Eba	22.96	218	99	23	High
Lafun	24.39	205	97	24	High

*CHO - Carbohydrate

Table 4.24a. Glycaemic Load of commonly consumed Foods in Cereals, Root, Tuber and Legume groups (continued)

Food	Available CHO (g/100g of Food)	Experimental portion(g)/50g CHO	Mean GI	GL Mean	Category
Bread and Egg	34.96	143	81	28	High
Bread and Akara	41.67	120	93	39	High
Bread and Moin-Moin	27.02	185	78	21	High
Bread and Beans	28.90	173	81	23	High
Jollof Rice and Moin-moin	23.92	209	80	19	Medium
Fried Rice and Moin-moin	26.74	187	88	24	High
Bread and Egg	34.96	143	81	28	High

*CHO - Carbohydrate

Table 4.24b. Glycaemicload of commonly consumed foods in Cereals, Root, Tuber and Legume groups (continued)

Food	Available CHO (g/100g of Food)	Experimental portion(g)/50g CHO	Mean GI	GL Mean	Category
Boiled Beans	21.51	233	91	20	High
Akara	23.75	211	91	22	High
Moin-Moin	15.74	318	94	15	Medium
Beans Porridge	22.39	223	85	19	Medium
Boiled Beans and Stew	21.65	231	83	18	Medium
Ogi Yellow	20.833	240	92	19	Medium
White Rice	29.41	170	93	27	High
Boiled Rice and Stew	23.26	215	83	19	Medium
Yam Pottage	21.75	230	88	19	Medium
White Bread	51	98	88	45	High

*CHO - Carbohydrate

CHAPTER FIVE
DISCUSSION, CONCLUSION, RECOMMENDATION

5.1 DISCUSSION

The glycaemicindex of commonly consumed mixed meals "as eaten" by apparently healthy young adults in Southwestern Nigeria was analyzed in this study.Dietary management of diabetes mellitus referred to as Medical Nutrition Therapy is crucial to achieving glycaemic control and reducing the rate of long-term complications of diabetes. Diet remains one of the treatment modalities common to people with diabetes.In cases of mild severity, it is all that is required to restore carbohydrate range to normal. The control of diet plays an integral role in any of the methods that is currently used in the management of diabetes which includes either Diet alone, Diet and Oral hypoglycaemic drugs, Diet and Insulin and artificial pancreas. (ADA, 2008).

5.1.1 Proximate Content and Available Carbohydrate of Individual Cooked Foods

The proximate analysis of the main staples consumed in South west, Nigeria was individually cooked and analyzed to determine the portion size of the food containing an equivalent of 50g available carbohydrate for each test meal form. The available carbohydrate was derived by "difference" by subtracting the total weight of the food from the addition of grams of protein, fat, ash and moisture content of the food. It refers to sugars and starches in the food that are digested and absorbed by the small intestine and which are glycogenic. Generally, foods analyzed in this study have high carbohydrate content with results ranging from 15.76g/100g in moinmoin prepared with vegetable oil to 67.75g in raw ogi yellow. For the roots and tubers (cassava and yam) group, the available carbohydrate ranged between 20.53g/100g in yam flour(amala) to 29.25g/100g in Fufu. Aside the high moisture content which varies from 69.29g/100g to 77.82g/100g, these crops contain mainly carbohydrates (largely starches) with very little protein and fats with values ranging from 0.29g/100g in fufu to 1.32g/100g in boiled yam for protein and 0.07g/100g in

Eba white to 3.21g/100g in yam pottage for fat respectively (FAO, 1994). The high fat content of yam pottage can be attributed to the red palm oil used during its preparation. The available carbohydrate values for Fufu, Boiled yam, Eba/garri, and pounded yam are close to values reported by Sanni et al, 1999, Kolawole et al, 2012, and Barbara et al, 2012). The proximity of values derived is associated with factors such as variation in specie, cooking/method of preparation, recipe used, and methods of analysis.The fiber content in the cassava and yam products ranged between 0.15g/100g in *Amalalafun* to 0.96g/100g in *Eba* white. Being a major starchy staple food, with high carbohydrate content, it can provide more than 25% of carbohydrate needed and 10% of the daily calorie intake for the body (Ayogu et al, 2017).

The proximate content of boiled unripe plantain and plantain fried in vegetable oil showed a high carbohydrate content of 31.04g/1009 and 35.44g/1009 respectively with moisture content of 61.53g/100g for unripe boiled plantain and 47.85g/100g for fried plantain. This is consistent with values reported bySanusi et al, 2017. The fibre content of boiled unripe plantain 5.60g/100g is higher than plantain fried in vegetable oil with values of 5.18g/100g which is similar to values obtained by Adamu et al, 2017, Asinobi et al, 2016).

In the cereal group, the available carbohydrate in the cereal group varied between 22.09g/100g in wheat amala to 67.75g/100g in raw Ogi yellow, moisture content ranged from 10.12g in raw Ogi yellow to 65.38g in boiled white rice, protein content was least in semovita with a value of 2.40g/100g and highest in raw Ogi yellow with a value of 8.83g/100g, the fat content of 0.25g/100g was least for boiled white rice and highest for raw ogi yellow with a value of 4.04, the fibre content ranged between 0.19g in semovita to 8.24g in raw ogi yellow. The carbohydrate, moisture, energy and protein values derived for boiled white rice and jollof rice agree with values reported in literature (Kolawole et al, 2012, Sanni et al, 1999, Afolabi et al, 2013, Oguntona et al, 1999, Sanusi et al, 2017).

For the legume products, akara prepared with vegetable oil had the highest available carbohydrate and protein values of 23.76g/100g and 12.07g/100g while moinmoin had the least value of 15.73g/100g and 6.50g/100g respectively. The fat content ranged between 0.49 in boiled beans to 8.30g/100g in akara while the least fibre content of 0.87g/100g was observed in akara and the highest fibre content of 1.45g/100g in beans porridge. The proximate values obtained for beans is close to values reported in previous studies (Sanni et al, 1999, Sanusi et al, 2017).

5.1.2 GlycaemicIndex of Commonly Consumed Mixed Meals

The findings from this study showed that mixed meals commonly consumed in Southwestern Nigeria ranging from the roots and tubers, cereals and grains and legumes food products are high glycaemicindex foods. This is consistent with the report of Asinobi et al,(2016) that most indigenous available staple foods in Nigeria, are based on starchy foods that are high in glycaemicindex (GI).Thiscan be attributed to the fact that these foods (roots, cereals, seeds and tubers) which are easily available and affordable containsstarch which is the most abundant carbohydrate in man's diet. The cereal grains contain as much as 70 percent of carbohydrate, whereas the dried seeds of leguminous plants average about 40 percent. Apart from their high-water content (70-80 percent), roots and tubers contain mainly carbohydrates (largely starches that account for 16-24 percent of their total weight) with very little protein and fat (0-2 percent each) (FAO, 1994).Overall, the cereals and the starchy roots and tubers group constitute the largest portion of the typical African diet;especially the latter, because of their limited contribution to the provision of an adequate diet. They are in fact usually consumed with the typical African sauce which is an extra-ordinary mixture of all sort of ingredients, including vegetables, tomatoes, peppers and spices, salt and maggi (monosodium glutamate) cubes, meats, mushroom, seed meals and several other condiments (Alade, 1985). The glycaemicindex of a specific food or meals is determined primarily by the nature of the carbohydrate consumed and by other dietary factors that affect nutrient digestibility or insulin secretion (Ludwig, 2002). Most whole grains in processed foods do not contain the intact whole grain kernel but have been milled into a fine particle size (thus higher GI) flour, with varying amounts of bran and germ reincorporated (Ludwig, 2018).

The glycaemicindex of cassava based mixed meal of "Eba" prepared from *GarriEgba*in this study was least in *Eba* consumed with *Efoelegusi*(melon seeds prepared with pumpkin(*ugwu*) leaves) with a GI of 74 and highest in *Eba*consumed with *Ewedu* soup with a GI of 93. The GI values of 82 and 84 was obtained when *Eba* was eaten with *Okro* and *Eforiro* soup (*Efo* green- Spinach) respectively. This is similar to GI values of 82.25 reported by Omoregie et al,(2008) though the particular type of soup used was not stated. The findings of Elizabeth, 2012 on the glycaemicindex of *Eba* prepared from two types of *garri (Egba and Ijebu)* served with vegetable soup also confirms a similar high GI value of 95.51 and 98.28. However, a slightly higher GI value of 101.4 was reported by Asinobi et al, 2016 for traditionally fortified staple meal of *garri (eba)* blended with bitter leave vegetable stew. The increase in surface area of the test meal because of blending supportsthe evidence that food form and particle size have a large effect on the physiologic properties of foods which in turn affects the GI value obtained for the test meal(Wolever et al, 1991). Elizabeth, (2012), reported similar high GI values of 92.88 and 88.90 for *Eba (Egbagarri)* and *Eba (Ijebu garri)* eaten with *Ogbonno* soup. The varietal differences of the type of garri and the effect of higher fermentation days on the garri has influence and impact on the GI of the food.Ogbuji et al, 2016, investigated the glycaemicindex of four different cassava products and reported a GI of 92 for *Eba (garri).*The differences in the GI values is possibly as a result of methodology of blood glucose analysis, variation in participants, processing and cooking methods and type of vegetable used. Also, the study by Ihediohanma, (2011) on the effect of fermentation on the GI of cassava granules from the same cassava specie showed that while the glycaemic carbohydrate increased with the length of fermentation, the dietary fiber decreased. The effect of fermentation therefore on the glycaemicindex of various cultivars and specie of garri can be associated with the varying high GI values of*Eba*.

The glycaemicindex of cassava based mixed meal of "Fufu" in this study was lowest in *Fufu* consumed with *Ewedu soup* (Cochorusolithorus) with a GI of 78 and highest in *Fufu* consumed with *Efoelegusi* soup with a GI of 83. The GI values of 80 and 81 was obtained when *Fufu* was eaten with *Okra* and *Eforiro* soup (*Efo* green- Spinach) respectively. The findings of Nnadi et al, 2016 on the effect of the glycaemic response of three commonly consumed meals in Enugu, Nigeria revealed that the GI of fermented cassava dough (*fufu*) with okra soup and meat was 74 compared to a value of 80 obtained in this study. The slight variance could be linked to specie variation of cassava, and the cooking method and recipe used for the okr*a* soup. Nnadi et al added other constituents such as dry hake, dry fish and ground crayfish which could have contributed to lowering the GI values whereas the okrasoup recipe in this study was prepared plain.Processing and preparation methods of these starchy staples and their recipes vary with ethnic groups and geographical locations (Udentaet al, 2014). A Cameroonian study conducted by Kouame et al, 2014 stated that the GI value of cassava paste with granulates palm sauce also had a high GI value of 86. The findings on the glycaemicindex of cassava based mixed meals in this study is similar withthe values of Ogbuji et al, 2016, which investigated the glycaemicindex of four different cassava products and reported a close GI value of 92 and 84 for *Eba (garri)* and *fufu* respectively.However, a recent study by Ekwe et al, (2019) reported a GI value of 67 for both *fufu* and*Eba (garri)* eaten with *Afang* soup and meat.

The glycaemicindex of cassava based mixed meal of "AmalaLafun" (cassava flour) in this study was lowest in *Lafun* consumed with okra soup with a GI of 84 and highest in *Lafun*consumed with *Eforiro*and Efoelegusisoup with a same GI of 90. The GI values of 86 was obtained when *Lafun* was eaten with *Ewedu* soup (Corchorus olithorus). The high GI values of cassava - based meals analyzed in this study affirms the evidence from literature that cassava food products such as *Eba, fufu, AmalaLafun* contains starch molecules that are easily digestible because of the various degrees of processing and preparation methods. The varying GI values may be explained by the different carbohydrate content and starch structure of the food products (Taiwo, 2006, Ogbuji et al, 2016). Contrary to the observations in this study,Itam et al, 2012 and Fasanmade et al 2007 reported low GI values of 40.12 for cassava flour in non-diabetic healthy subjects. The huge variability in the GI values may be in response to the quantity of available carbohydrate adapted from the 1968 Food Composition table for use in Africa used to calculate the measured portion of the meal served to the subjects as against the proximate analysis conducted for each test meal in this study.

The glycaemicindex of cassava based mixed meal of "Amala" prepared from yam flour in this study was lowest inAmala consumed with *Eforiro* (vegetable soup prepared with spinach leaves) with a GI of 75 and highest in *Amala*consumed with *Ewedu* soup with a GI of 93. The GI values of 78 and 84 was obtained when *Amala* was eaten with *Okro* and *EfoElegusi*soup (melon seeds prepared with pumpkin (ugwu) leaves) respectively. Similar with these findings are those of Omoregie et al (2008), who reported a GI value of 84 though the specific soup consumed was not mentioned. The high GI of Yam flour (*Amala*) can be attributed to the processing and cooking techniques earlier elucidated. However the findings of Jimoh et al, 2008 on the GI of yam flour (*Amala*) and GI of boiled yam is not consistent with findings from this study though the GI value of 81.6 for pounded yam in the report is close to GI values of between 84 - 89 obtained in this study for pounded yam consumed with *Okro* (84), *Efoelegusi* (87), *Ewedu* (88) and *Eforiro* (89) respectively. These slight variations are perhaps due to specie variation and methodological techniques used.Also, the preparation of pounded yam with the aid of a mortar and pestle as eaten in the Nigerian culture makes the food structure of the boiled yam to be softer and finer thus increasing the surface area which in turn makes enzymatic digestibility easier and absorption of glucose more rapid (Jimoh et al, 2008). Kouame et al, (2014) in his study on commonly consumed foods in Cote d'Ivoire also reported a GI value of 94 for pounded yam with eggplant sauce.

The glycaemicindex of cereal based mixed meal of "Semovita" prepared from *wheat flour* in this study was lowest in Semovita consumed with *Eforiro and Ewedu* soup with a same GI of 81 and highest in Semovitaconsumed with *Efoelegusi* soup with a GI of 88. The GI values of 83 was obtained when Semovita was eaten with *Okro* soup. In this study, semovita was categorized as a high glycaemic food which is consistent with the report according to Omoregie et al, 2008 though with a higher GI value of 95.80 as against the lower GI value of between 81 to 88 obtained. Also, the glycaemicindex of cereal based mixed meal of "whole wheat" prepared from *wheat flour* in this study was lowest in wheat consumed with *Eforiro* with a GI of 79 and highest in *Wheat*consumed with *Efoelegusi* soup with a GI of 90. The GI values of 86 and 87 was obtained when *wheat* was eaten with *Okro*and Ewedusoup.Results from studies on wholemeal and white bread reveals that similar values exist for the GI of both thus establishing a lack of effect of wheatfibre on GI. This is consistent with findings that there is no effect on post-prandial glucose when wheat bran is added to breads and other carbohydrate foods (Jenkins et al., 1983; Fontvieille et al., 1988; Jenkins et al., 2002b; Aston et al., 2008). On the other hand, the soluble fibre present in oats and barley known as β-glucan when added to breads and other products has been shown to reduce the GI of bread and other products (Pick et al., 1996;

Tappy et al., 1996; Battilana et al., 2001; Jenkins et al., 2002a; Aston et al., 2008).. The wheat fibre is thus an insoluble fibre, that is not fermentable due to the high degree of lignification. Though it provides bulk to gastrointestinal tract contents, and delays transit time of matter through the tract, it still does not seem to have a reducing effect on the rate or extent of carbohydrate absorption in the gut.β-glucan is a viscous soluble fibre which slows gastric emptying and increases gastrointestinal transit time (Battilana et al., 2001; Astonet al, 2008). These results on the GI value of wheat flour does not agree with Fasanmade et al, 2007 that reported a GI value of 37.50 in healthy subjects and 70.10 in diabetic subjects which is probably due to methodological factors rather than real differences between the foods (Wolever et al., 2003) and specie variation. Another reason for this variation could also be because of use of the 1968 food composition tables to calculate required portion size.

Several factors that can alter the GI of a food includes the particle size, food structure, ripeness, ratio of amylose and amylopectin, starch structure, cooking technique, level of food processing and the presence of other macronutrients such as fat and Protein (Bjorck et al, 1994, Najjar et al, 2004; Henry et al, 2011).The effects of some of these factors are shown by the findings from this study. The particle size and food structure for most of the test meals especially food products from roots and tubers (cassava and yam) and cereals in this study have been reduced through various degrees of processing into flour forms before being turned into paste with hot water. The use of these high temperature and high-pressure extrusion technology used in food processing over the past 5 decades has increased the degree of starch gelatinization. This has resulted in easier digestibility of starch and led to faster digestion and high GI of starch foods which directly accounts for differences in same food prepared in different countries (Henry et al, 2011). The digestibility and structure of starchy food is said to be affected by cooking method which can influence the glycaemic response (Glen et al., 2005). This is due to association of temperature and humidity which modifies the physical and chemical composition of starch thus making the starch molecules easier for digestion. During reconstitution of these processed flours in hot water before conversion to its paste form, the starch granules take up water and become swollen that is the granules become gelatinized such that the crystalline structure of the starch is disrupted irreversibly thus making it possible for hydrolysis by amylase (Soh et al., 1999, Englyst et al, 1987). Foster-Powell et al, (2005), Jimoh et al, 2008, and Ihediohanma, (2011), also reported the effect of processing on the GI of foods stating that increase in processing forms, fermentation and starch retrogradation can affect the GI of a food.

5.1.3 GlycaemicIndex of Single and Mixed Meals

It has been suggested that the GI, based on tests on single foods, may not apply in the setting of mixed meals containing representative amounts of fat and protein (Coulston et al., 1984,Wolever et al, 1986).Generally, people do not eat single or individual meals, rather mixed meals made up of two or more individual meals are eaten (Omage et al, 2017). This study has shown that these mixed meals usually have glycaemicindex that are quite different from that of the individual food type. The glycaemicindex of 94 was derived when boiled yam was consumed alone with water, however when yam was eaten with peppered stew, eaten with fried egg and prepared with palm oil, pepper and other ingredients into yam pottage, a GI value of 85, 84 and 88 was obtained respectively. Asinobi et al (2016)reported a higher GI value of 102.4 for yam stew, the high surface area from the blended fortified test meal could have contributed to this. The lower GI value of 58 reported by Okafor et al (2011)contradicts results in this study. This is potentially associated with the reference food of white bread used which led to the adjustment of GI values relative to glucose.

Worldwide, grains, the seeds of cereal grasses and similar plant families are staple foods and a major source of dietary carbohydrate. Refined grains are processed to remove the protein and fat rich germ and fibre rich bran, leaving only the starchy endosperm (Ludwig et al, 2018). Greater refined grain intake, especially from white rice, is associated with an increased risk of type 2 diabetes (Aune et al, 2013, Hu, 2012). The glycaemicindex of white bread consumed alone was 88 but when consumed with fried egg, *moinmoin* and beans, a lower GI value of 81, 78 and 81 was derived. A high GI for white bread was also reported by Aston et al. (2008). Furthermore, the lowest GI value of 74 was observed when Boiled white rice (long grain) was eaten as a mixed meal with fried plantain and stew, this is next to a GI value of 76 when boiled white rice was eaten together with boiled beans and stew and followed by a GI of 82 when white rice (boiled) was eaten together with boiled beans, fried plantain, stew and meat . A GI value of 83 and 84 was achieved when Boiled white rice was eaten with stew and when it was also eaten with fried plantain, boiled beans, boiled egg and stew respectively. All the GI values for mixed meals combination of boiled white rice were lower than the GI of 93 for boiled white rice consumed as an individual food with water.A lowering effect of boiled rice eaten with different sauces in a Cote D'Ivoire study was also reported and agrees with findings in this study for boiled white rice(Kouame et al, 2014). Though Okafor et al (2011)and Wordu et al (2013)reported a lower GI value of 56 and 66.62 respectively for boiled rice which could be attributed to specie variation, reference food and cooking method used. Onimawo et al (2010), also confirms the effect of four different species of rice varieties on the GI values of rice served with stew with GI values ranging from 75 for (FARO-52) to 98 for (FARO- 51). FARO- 44 and NERICA-1 had a GI value of 77 and 88 respectively. The GI values for the mixed meal of rice and beans, rice and plantain from this study are lower than the values reported by Omage et al (2017) though is consistent in terms of the categorization as a high glycaemicindex meal. The difference in the GI values of rice mixed meals is associated with the varied glycaemic response of meals that changes significantly with heat utilized, cooking method, amount of water and the time of cooking (Collings et al, 1981; Vaaler et al, 1984). GI values published for rice vary widely. This is principally due to variety, with the ratio of amylose to amylopectin being important. High amylose rice such as basmati, have widely been found to have low GI values (Aston et al, 2008). Also, the GI is not only based on the measure of absorption of carbohydrate in the small intestine but is indicative on the effect of other factors in the test meals that can have an influence on the carbohydrate absorption rate in the small intestine (Omage et al, 2017). A lower GI value of 78 was observed when fried rice was eaten with fried plantain as against when it was eaten alone. The same effect was also seen in Jollof rice mixed meal.

Pap (*Ogi* yellow) had a high GI value of 92 when eaten alone as a single food. However, when *Ogi* pap (yellow) was consumed with *akara, moinmoin* and beans porridge a reduced GI value of 77, 76 and 79 was achieved. Boiled beans, *akara, moinmoin* and beans porridge however when eaten as a single meal elicited a high GI value ranging between 85 – 91. Though when boiled beans was eaten with stew and also eaten with fried plantain and stew there was a lower GI value of 88 and 86. The high GI value of 93 elicited when beans was consumed with *garri* soaked in water was due to the increased surface area created by soaking process which increased the digestibility and absorption of the starch granules. The high GI values for bean products as a single and mixed meal ranging from 83 -96 observed in the studycontests with the previous categorization of beans and its products as a low glycaemicindex food. These high GI values for bean products contradicts the report of Akinlua et al, (2013), who gave GI of beans with stew, *akara* and *moinmoin* as 56, 44 and 41; Oboh et al, (2010), who gave GI values of cowpea (brown and white/black varieties) as 29 and 30; Olopade et al, (2017), who gave the median GI of Vigna unguiculate (Linn walp) varities of beans "oloyin", "drum", and "sokoto white" as 12.10, 17.64 and 12.04. The variations in the GI values of beans is attributed to the methodological variations such as the use of subjects not serving as their control, reduced portion size from the use of multiplication factor, specie variation, cooking and preparation method, blood sampling procedure, blood glucose measurement procedure and period, and GI calculation method.

From the overall observed GI values of single and mixed meals, the GI of mixed meals is reduced or lowered when ingested together with a meal containing protein, fiber or fat. A significant reduction in the glycaemic response of a mixed meal in the presence of large amounts of protein or fat increases insulin secretion and delays gastric emptying which was contributed from other ingredients in the test meal (Lok et al, 2010). Co-ingestion of fat or protein lowers the glycaemicindex of individual foods somewhat but does not change their hierarchical relationship with regards to glycaemicindex (Ludwig, 2002).

When unripe boiled plantain was consumed individually, a GI of 89 was calculated as against a GI value of 88 when consumed with peppered stew. This extremely slight variation can be attributed to a high starch gelatinationand physiochemical characteristics of the starch in the unripe plantain upon boiling and cooling which has inhibited the action of other nutrients thus insignificantly affecting the GI of the mixed meal (Kouame et al, 2014). This is close to the values reported by Asinobi et al, (2016) for unripe plantain stew with a GI value of 81.8 but contrary to the findings reported by Oboh et al, (2010) who reported a GI value of 64.94 for boiled unripe plantain possibly due to difference in methodology used as subjects did not serve as their own control.

In Summary, all the glycaemicindex of single and mixed meals commonly consumed in Southwestern Nigeria analyzed in this study are categorized as high glycaemicIndex foods. Within the cassava-based food products and forms, *Eba* consumed with 'Efoelegusi' soup had the lowest GI of 74, this is next to *Fufu* consumed with 'Ewedu' soup with a GI of 78 and then *Fufu* consumed with 'Okra' soup with a GI of 80. Within the Yam based food products and forms, *Amala* consumed with and 'Eforiro' soup had the lowest GI of 75, this is next to *amala* consumed with 'okra' soup with a GI of 78 and then *amala* consumed with 'Efoelegusi' soup. Pounded yam consumed with 'Okra' soup, and boiled yam consumed with egg had a tied GI of 84. Within the cereal based food products and forms, boiled white rice consumed with fried plantain, stew and meat had the lowest GI of 74, this is next to boiled white rice consumed with boiled beans, stew with meat, *ogi* consumed with 'moin-moin' with a tied GI of 76, and then *ogi*consumed with *akara* with a GI of 77. Within the Legume based food products and forms, boiled beans consumed with fried plantain and stew had the lowest GI of 84, this is next to beans porridge with a GI of 85 and then boiled beans and stew with a GI of 88.

The least GI of commonly consumed mixed meal "as eaten" in Southwestern Nigeria was observed to be in *Eba* consumed with "Efoelegusi" with a GI of 74 while the highest GI was observed to be in Beans and Garri (soaked with Water) with a GI of 96, next to *Eba* and 'Ewedu', *Amala* and 'Ewedu' and Bread consumed with Akara having same GI of 93. Overall, there is a difference between the glycaemicindex of a single food and the mixed meals. However, this was not statistically significant in single and mixed meals of *fufu, lafun*, pounded yam, boiled yam, unripe plantain, semovita, wheat, bread, fried Rice, jollof rice and beans. Statistically significant values of $p < 0.05$ was observed in single and mixed meals of *eba, amala*, white boiled rice and *Ogi* yellow. This can be atttibuted to several contributory factors such as protein, fat, and fiber in the mixed meals.The glycaemicindex of a meal is determined mainly by the nature of consumed carbohydrate and other dietary factors that influence the nutrient digestibility or insulin secretion (Ebbeling et al, 2001). This study therefore in alignment with evidence discussed conforms with several studies that have shown that the addition of fat and protein to a carbohydrate food can significantly reduce the glycaemic response (Gulliford et al, 1989, Simpson, et al, 1985; Henry et al, 2011).

5.1.4 Effect of Soups on Commonly Consumed Staple Mixed Meals

Soups are very important accompaniment to main dishes in Nigeria and are made from vegetables which include those leafy and or root parts of plants. They are traditionally consumed in combination with cereals and starchy roots/tubers, after being processed into a form of paste and they provide adequate amounts of vitamins and minerals (Udenta et al, 2014, Joy et al, 2019). Soups are regarded as protective foods and are highly beneficial for the maintenance of good health and prevention of diseases (Joy et al, 2019). Ene-Obong et al, (2013), recorded 110 soup recipes out of 322 recipes in all the 6 geo-political zones in Nigeria which shows diversity in the Nigerian food system.

In this study, four commonly consumed soups in Southwestern Nigeria were served as accompaniment to the main staples' meal analyzed. To reduce the variability in the GI values of the staple mixed meals, the soups (*okra, ewedu, eforiro and efoelegusi)* served with each meal had the same serving portion size.This should not have affected the variability of the GI to any appreciable extent (Fasanmade et al, 2007).Overall, a reducing or lowering effect of each type of soups on the staple main meals was observed in this study.However, there are various degrees of influence, which is attributable to the nutrient composition, ingredients used during preparation of individual vegetable consumed and other factors such as starch composition and structure of the main staple meal, specie variation, dietary fibre, fat, protein content, cooking method and preparation. A study by Joy et al, (2019), on the glycemic index and glycemic load of indigenous vegetable sauces reported that okra soup had the highest dietary fiber of 3.26 compared with lettuce and African spinach analyzed in the study. This confirms how the nutrient composition of these soups can influence the GI of the staple mixed meals.

'Ewedu' soup had the most reducing or lowering effect on GI of *Fufu* from a GI of 88 when *Fufu* is consumed as a single food to a GI of 78 when *Fufu* is consumed as a mixed meal with 'Ewedu', stew and meat. The least reducing effect of *Ewedu* soup was observed to be in *Amala and Eba*consumed with 'Ewedu', stew and meat with a GI of 93 as against a GI of 97 and 99 for *Amala*and *Eba*as a single food.

'Efoelegusi' soup had the most reducing or lowering effect on GI of *Eba* from a GI of 99 when *Eba* is consumed as a single food to a GI of 74 when *Eba* is consumed as a mixed meal with 'EfoElegusi' soup, stew and meat. The least reducing effect of 'Efoelegusi' soup was observed to be in *Lafun* and wheat consumed with *Efoelegusi* with the same GI of 90 as against a respective GI values of 97 and 93 for *Lafun* and wheat as a Single food.

'Okra' soup had the most reducing or lowering effect on GI of *Amala* from a GI of 97 when *Amala* is consumed as a single food to a GI of 78 when *Amala* is consumed as a mixed meal with 'Okra'soup, stew and meat. The least reducing effect of 'Okra' soup was observed to be in wheat consumed with 'Okra' soup and stew with a GI of 86 as against a GI of 93 for wheat as a single food.

'Eforiro' soup had the most reducing or lowering effect on GI of *Amala* from a GI of 97 when *Amala* is consumed as a single food to a GI of 75 when *Amala* is consumed as a mixed meal with 'Eforiro' soup, stew and meat. The least reducing effect of 'Eforiro' soup was observed to be in *Lafun* consumed with 'Eforiro' soup, stew and meat with a GI of 90 as against a GI value of 97 for *Lafun* as a single food.
Each of the single staple foods had high GI values that were different. However, when uniform serving of soups were administered with the staples, the GI values of the staple foods reduced. The most common lowering effect of soups on the GI of main staple meals in this study was observed in *Amala*consumed with two soups (Okra and *Eforiro*) out of the four soups administered while the least common lowering effect across all the soups was observed to be in wheat and *Lafun.*The dietary fibre in okra vegetable and *Eforiro* (spinach) with the vegetable's other nutritional composition may be responsible for this effect across the staple foods consumed. (Joy et al, 2019). Reducing the portion size of the main staple meal and increasing the quantity of soup consumed may elicit a low glycaemic response for staple mixed meals as eaten in Southwest Nigeria.

Glycaemic Load of single and mixed meals

The glycaemic load was calculated by taking the percentage of the foods carbohydrate content in a typical serving and multiplying it by the glycaemicindex value (Atkinson et al, 2008) From this study, no food was ranked as having a low GL. Medium Glycaemic Load values (GL) values were observed in *Moinmoin*: 15, Boiled beans and stew:18, Beans Porridge: 19, Jollof rice and *moinmoin*: 19*, Ogi* yellow: 19, Boiled rice and stew: 19 and Yam Pottage: 19. All the single staple foods which includes Semovita, wheat, boiled yam, *amala*, pounded yam, unripe platain, *fufu, Eba, Lafun*, Boiled beans, *akara*, white rice, and white bread all had high glycaemic load values ranging from 20 in *Amala* and Boiled beans to 45 in white bread. These high glycaemic load values categorizations of foods agree with Omoregie et al, 2008. Consumption of test meals with high glycaemic load values should be limited as they could increase insulin response.

5.2 CONCLUSION

All the identified 18 single staple foods and 52 commonly consumed mixed meals as eaten in Southwestern, Nigeria is high in glycaemicindex as the proximate content of these meals analyzed have a high carbohydrate content with low values of protein and fat.

The glycaemic load of single staple foods analyzed were high in categorization thus consumption of these meals should be limited while other 7 meals with medium glycaemic load values can be moderately consumed.

The glycaemic index of the single staple foods determined, was reduced when eaten as a mixed meal. This study has therefore established that there is a reducing association between single staple foods and their mixed meal forms as the mixed meals have an overall effect on reducing the blood glucose response when compared to single foods.

The four types of soups evaluated had various reducing or lowering effect and impact on the GI of single staple foods when consumed as a mixed meal. This is attributable to the nutrient composition of the individual vegetable, it's ingredients, preparation and several other factors. Out of the four soups administered,the most common lowering effect of soups on the GI of main staple meals in this study was observed in *Amala*consumed with two soups (Okra and *Eforiro*). Hence a reduced portion of *Amala* should be consumed frequently with Okra and *Eforiro* soup.

This study has provided the GI values for 70 commonly consumed single and mixed meals in Southwestern Nigeria. It has also emphasized some of the several features affecting the GI of a food, which further demonstrates the reason why the GI values of meals must be measured rather than drawing inferences from foods of similar account.

In summary findings from this study have important applications for the use of the GI concept in Southwestern Nigeria as it indicates that commonly consumed foods in Southwestern Nigeria raise blood glucose levels quickly that is, they have a high glycaemic response. This isdue to the starch composition which makes these foods get quickly digested and converted into glucose causing a quick and sharp rise in insulin for blood glucose homeostasis. This is inclusive of unripe plantain and beans meals usually recommended for the dietary management of DM. Consistent consumption of these high GI foods will overtime ultimately result in hyperglycemia, obesity, hyperinsulinemia (pancreatic beta cell exhaustion), glucose intolerance, and conversion of pre-diabetes conditions to diabetes. This isas a result ofsurges in the blood glucose concentration which in turn increases therisk of type 2 diabetes and other non-communicable cardiovascular diseases. This can also be associated with the increased prevalence of diabetes mellitus, obesity and other non-communicable cardiovascular diseases in Nigeria. The fact that the disease is no longer associated with affluence can also be re-emphasized or reiteratedas availability and affordability of the common Nigeria staple roots and tubers, cereals and grains has ultimately confirmed this increased trend. However, the more mixed the meals and an increased consumption of soups with reduced portion size of staples, the lower the glycemic index when compared to single foods.

5.3RECOMMENDATIONS

Dietary management is a key cornerstone modality in the attainment of good glycaemic control in diabetic patients. However, to effectively utilize the tool of the glycaemicindex in the dietary management of diabetes mellitus, it is therefore recommended that:

1. The proportion of all foods' high in glycemic index from this study be drastically reduced by half to provide an available carbohydrate of 25g. Perhaps a reduced

portion size, and increased consumption of soups will result in a low glycaemic index value.

2. There should be an increase in the proportion of foods containing protein, fat and fiber in the mixed meal combination as this will release glucose into the blood slowly. The results from this study has illustrated thatthe glycaemic response of a mixed meal and in turn its GI value is dependent on the proportion of each nutrient of carbohydrate, protein, fat and other dietary factors.
3. Soups that have the most reducing or lowering effects on single staple foods should be consumed together. Thus, *Amala* should be consumed with Okra and *Eforiro* soup, *Eba* should be consumed with *Efoelegusi* soup, and *Fufu* should be consumed with *Ewedu* soup.

The above recommendations will serve as a guideline and make GI values elicited adaptable for the prevention, and appropriate dietary and therapeutic management of DM and other NCDs.

5.4CONTRIBUTION TO KNOWLEDGE

Previously, the glycaemic response of few individual foods is what is known but meals are not taken as individual foods but a combination of foods to enhance palatability in the Nigerian culture. Currently, this study has:

1. Provided data on the glycaemicindex of 18 single foods and 52 mixed meals commonly consumed in Southwestern Nigeria.
2. Provided data can be used as a basis for compilation on the glycaemicindex database for Nigerian foods. This in turn can also be used by nutrition practitioners who have the responsibility for counselling and recommending diets for individuals and the diabetic.
3. Shown that there is a reducing or lowering association between the glycaemic index of a single food and its mixed meal form.
4. Shown or illustrated the reducing or lowering effect of four commonly consumed soups on the glycaemic response of some Nigerian staple foods.
5. Provided knowledge about the type of soup best for the different carbohydrate staple foods analyzed for glycemic index

This will guide in the modification of the current dietary recommendations for suitable management of DM. Integrating information about the glycaemicindex of these mixed meals from this study will guide food choices and aid in formulation of standardized mixed meals recipes forthe prevention of diseases such as diabetes, obesity, hypertension and other nutrition related NCDs.

5.5 LIMITATION TO THE STUDY

- The glycaemicindex of the commonly consumed soups in Southwestern Nigeria was not determined.
- Participants Availability: Since the participants had to meet up with lectures and other academic activities, the availability of the same set of individuals consuming one staple test meals with the different soups used in this study could not be achieved. It is therefore expedient to confirm participants' availability even though they are willing to participate in future researches.

5.6 Suggestions for Further Research

1. The foods considered in this study are predominantly consumed in Southwestern Nigeria, there is need for such studies in different regions of the country to better understand the local content of glycaemicindex in Nigeria.
2. There is need to determine the glycaemicindex of commonly consumed Nigerian soups and other underutilized vegetables and evaluate the effect of these soups on glycaemicindex of Nigerian staple foods.
3. The glycaemic index of commonly consumed fruits and vegetables in Nigeria is also recommended for further research.
4. Physiological mechanisms resulting or that have resulted in reduced glycaemicindex of these mixed meals can be further determined by Clinical trials in future research studies.
5. There is need for studies on insulin index, beta cell functions, incretins and adipokines to better understand these mechanisms.
6. There is need to determine the nutrient content of various soups and staple foods and correlate its effect in lowering the GI of main staple Nigerian meals.

7. Since most of the commonly consumed mixed meals in SouthwesternNigeria are quite high in their starch composition, it is suggested for future studies that the serving portions of 50g carbohydrate be substituted with 25g available carbohydrate and tested in subjects to determine the GI values.
8. There is need to correlate the nutrient content of soups with their effect on the glycaemicindex of staples at perhaps different portion sizes using a standardized recipe.

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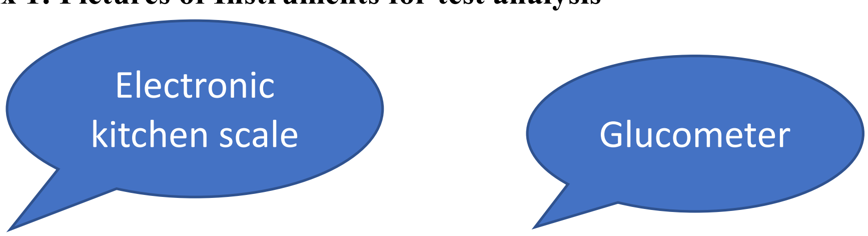
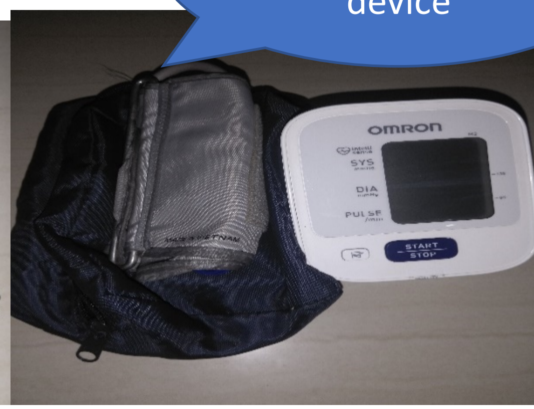
APPENDIX

Appendix 1: Pictures of Instruments for test analysis





Appendix 2: Pictures of Screening Measurements

Waist screening measurements

Screening data entry

Appendix 3: Weight of foods and Ingredients used (g)

BOILED RICE, MEAT AND STEW	BOILED RICE, BOILED BEAN, MEAT AND STEW	BOILED RICE, PLANTAIN AND MEAT
Raw rice – 8 level milk tin	Boiled rice – same as above	Preparation is same as previous ones
Salt – 1tbsp	Stew – same as above	Weight of rice – 136g (40g CHO)
Stew (same as above)	Boiled beans	Weight of plantain – 20g (10g CHO)
Weight of cooked rice – 170.01g	Raw beans – 5 level milk tin	Stew – 45g
Weight of stew – 45g	Salt – ½ tbsp	
	Weight of cooked rice – 136g (40g CHO)	**JOLLOF RICE AND MEAT**
BOILED RICE, BOILED BEANS, PLANTAIN, BOILED EGG	Weight of boiled beans – 46.5g (10g CHO)	Rice – 10 level milk tin
Preparation is the same as the previous ones	Weight of stew – 45g	Grinded pepper – 453g
Weight of cooked rice- 102.0g (30g CHO)		Groundnut oil – 213g
Weight of boiled beans – 46.5g (10g CHO)	**BOILED BEANS AND PLANTAIN**	Maggi- 15g
Plantain – 20g (10g CHO)	Preparation is same as above	Onions – 80g
Boiled egg – 45.3g	Weight of boiled beans – 185.9g (40g CHO)	Tin tomatoes – 350g
Stew – 45g	Plantain – 20g (10g CHO)	Salt – 3tsp
	Stew – 45g	Weight/person – 182.28g

BOILED RICE, BOILED BEANS AND PLANTAIN	JOLLOF RICE, PLANTAIN AND MEAT	FRIED RICE AND MEAT
Preparation is the same as the	Preparation is same as above	Rice – 10 level milk tin

YAM AND STEW	YAM POTTAGE	YAM, BREAD AND FRIED EGG
YAM	Raw yam – 150g	Raw yam – same as above
previous ones		
Weight of cooked rice- 102.0g (30g CHO)	Weight of Jollof rice – 145.8g (40g CHO)	Groundnut oil – 55g
Weight of boiled beans – 46.5g (10g CHO)	Plantain – 20g (10g CHO)	Green pepper – 55g
Plantain – 20g (10g CHO)		Green beans – 230g
Stew – 45g	**FRIED RICE, MOINMOIN AND MEAT**	Carrot – 175g
JOLLOF RICE, MOINMOIN AND MEAT	Preparation is same as above	Salt – 2tbsp
Preparation is same as above	Weight of fried rice – 123.6g (40g CHO)	Maggi – 8g
Weight of jollof rice – 145.8g	Moinmoin – 63.6g (10g CHO)	Fried rice spice (Nora) – 30g
Moinmoin – 63.6g (10g CHO)		Weight/person – 154.5g
	FRIED RICE, MEAT AND PLANTAIN	
	Preparation is same as above	
	Weight of fried rice – 123.6g (40g CHO)	
	Weight of plantain – 20g (10g CHO)	

Raw yam – 150g

Salt – 1tbsp

STEW

Grinded pepper – 200g

Onions – 100g

Groundnut oil – 73g

Maggi – 4g

Smoked fish – 23g

Tin tomatoes – 75g

Salt – 1tsp

Weight/person

Yam – 190.69g

Stew – 45g

BEANS PORRIDGE AND BREAD

Bread (Sun fresh) – 38.9g (20g CHO)

Beans porridge

Beans – 3 level milk tin

Onions – 100g

Pepper – 100g

Palm oil – 122.1g

Beans porridge/person – 134.0g (30g CHO)

Grinded pepper – 200g

Onions – 200g

Palm oil – 122.1g

Maggi – 4g

Salt – 1tbsp, 1tsp

Weight/person – 229.88g

BREAD, PAP AND AKARA

Bread (Sun fresh) – 78g (40g CHO)

Pap – 54.2g (40g CHO)

Akara

Beans – 5 level milk tin

Onions – 100g

Grinded pepper – 200g

Salt – 1tbsp

Maggi- 4g

Groundnut oil (for frying) – 182.5g

Akara weight/person – 42.1g (10g CHO)

Bread (Sun fresh) – 97.3g

Fried egg

Egg – 1 medium size

Groundnut oil – 36.5g

Onions – 20g

Maggi – 2g

Salt – a pinch

Fried egg/person – 55.5g

BREAD, PAP AND MOINMOIN

Bread (Sun fresh) – 58g (30g CHO)

Pap – 40.7g (30g CHO)

Moinmoin

Beans – 5 level milk tin

Grinded pepper – 250g

Onions – 100g

Salt – 1tbsp

Maggi – 4g

Groundnut oil – 146g

Moimoin/person - 127.1g (20g CHO)

EGUSI ELEFO	EFO RIRO	WEIGHT OF STAPLE FOOD PER PERSON
Egusi – 1 level milk tin cup	Efo – 390.8g	Amala – 243.3g

Ugwu – 184.3g
Grinded pepper – 150g
Smoked fish – 30g
Maggi – 4g
Palm oil – 81.4g
Locust beans – 23g
Onions – 30g
Salt – 1/4tbsp
Weight of cooked soup/person – 55.6g

Grinded pepper – 150g
Smoked fish – 30g
Maggi – 4g
Palm oil – 81.4g
Locust beans – 23g
Salt – 1/4tbsp
Onions – 30g
Weight of cooked soup/person - 60g

Lafun – 205g
Eba – 217.77g
Pounded yam – 225.42g
Wheat – 226.35g
Semo - 144.9g
Fufu – 170.94g

EWEDU
Raw ewedu – 107.2g
Locust beans – 12g
Salt – 1/2tsp
Maggi – 0.5g
Weight of cooked ewedu/ person – 5.9g

OKRA
Raw okra – 160g
Locust beans – 12g
Salt – 1/2tsp
Maggi – 0.5g
Weight of cooked okro/person – 41.5g

STEW
Grinded pepper – 570g
Groundnut oil – 146g
Maggi – 8g
Salt – 1/2tbsp
Weight/person – 45g

Appendix 4: Pictures of Glucose Analysis and Feeding Experiments

Participants awaiting FBG test

Participants awaiting FBG test

Appendix 5:Nigerian variety name of main staple foods and soups prepared

Yam: IsuEfuru

Yam flour: AmalaIsushaki

Garri: GarriEgba

Wheat: Local wheat

Rice: Long grain parboiled

Bread: Food co (sliced)

Semovita: Golden Penny

Beans: EwaOloyin

Eforiro: Spinach Vegetable (Efo green)

Efoelegusi: Ugwu (Fluted pumpkin) vegetable was used

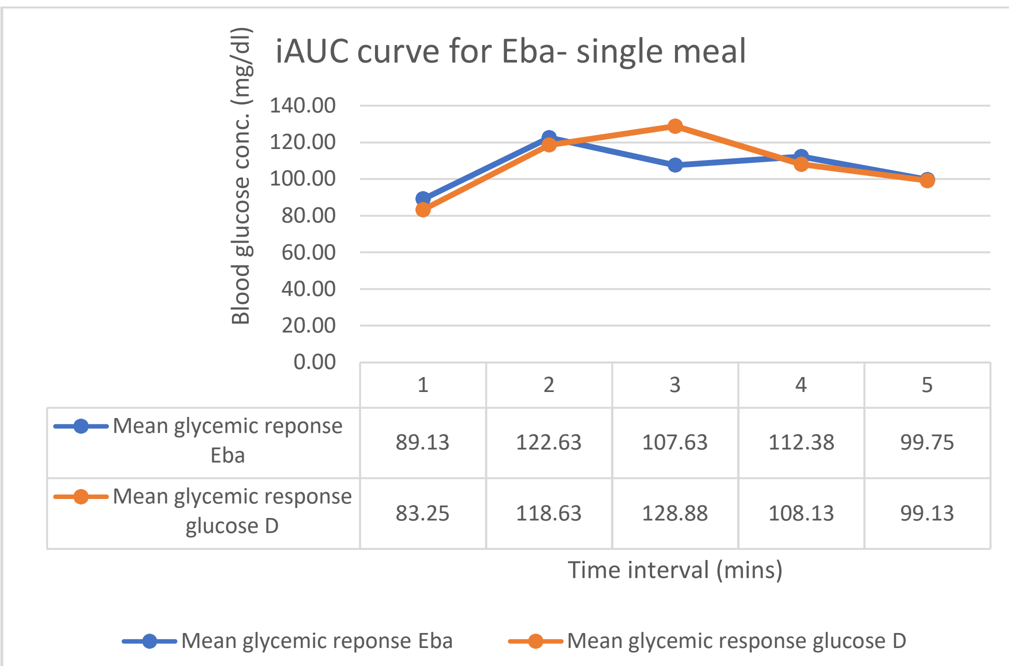
Okro: Ila iwo

Appendix 6.1: Mean glycaemicindex values and mean glycaemic response curves of *Eba*

Table 6.1a -Mean glycaemicindex values of *Eba*

2 HR TEST MEAL- *EBA*		
Time	Test meal	Glucose D
0 mins	89.13	83.25
30 mins	122.63	118.63
60 mins	107.63	128.88
90 mins	112.38	108.13
120 mins	99.75	99.13
AUC	13112.40	13404.9
GI	97.81796209	

Figure 6.1a - **Mean glycaemic response curves of *Eba***

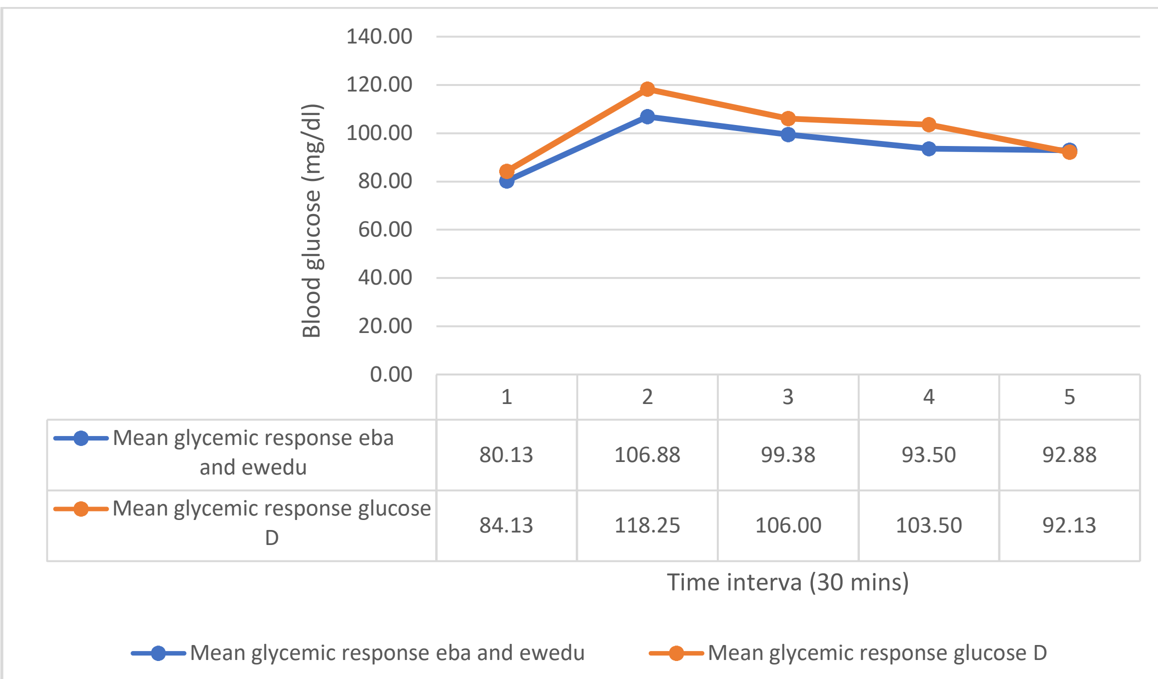


Appendix 6.2:Mean glycaemicindex values and mean glycaemic response curves of *Eba* and *Ewedu* soup

Table 6.2a Mean glycaemicindex values of *Eba* and *Ewedu* soup

2 HR TEST MEAL- *EBA* AND *EWEDU*		
Time	Test meal	Glucose D
0 mins	80.13	84.13
30 mins	106.88	118.25
60 mins	99.38	106
90 mins	93.5	103.5
120 mins	92.88	92.13
AUC	11587.95	12476.4
GI	92.87895547	

Figure 6.2a - **Mean glycaemic response curves of *Eba* and *Ewedu* soup**

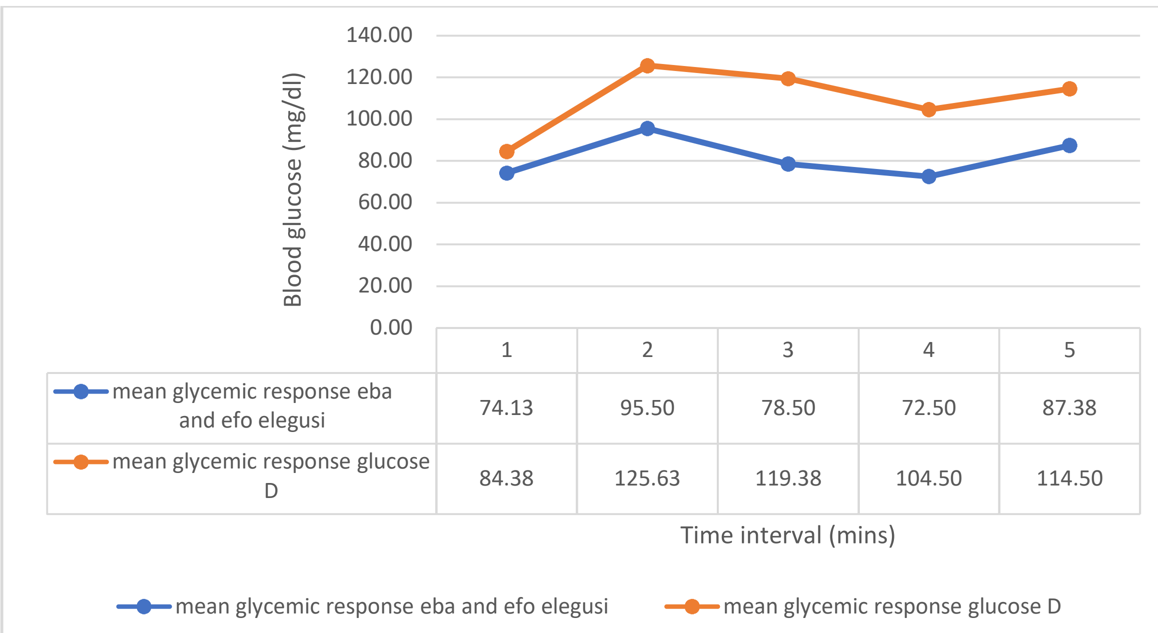


Appendix 6.3: Mean glycaemicindex values and mean glycaemic response curves of Eba and *Efoelegusi* soup

Table 6.3a - **Mean glycaemicindex valuesof *Eba* and *Efoelegusi* soup**

2 HR TEST MEAL- *EBA* AND *EFO ELEGUSI*		
Time	Test meal	Glucose D
0 mins	74.13	84.38
30 mins	95.5	125.63
60 mins	78.5	119.38
90 mins	72.5	104.5
120 mins	87.38	114.5
AUC	9817.65	13468.5
GI	72.89341798	

Figure 6.3a - **Mean glycaemic response curves of Eba and *Efoelegusi* soup**

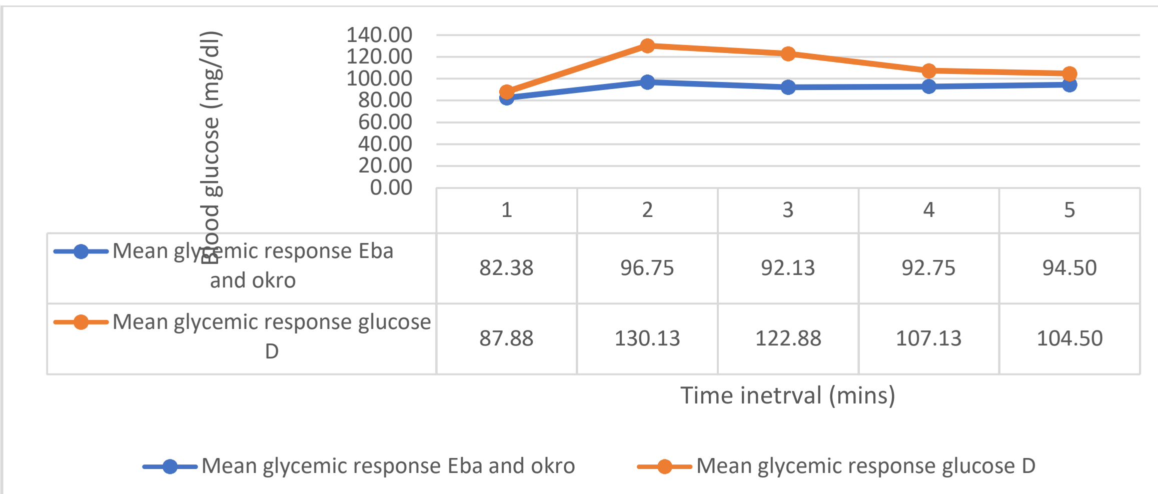


Appendix 6.4: Mean glycaemicindex values and mean glycaemic response curves of *Eba* and okra soup

Table 6.4a - **Mean glycaemicindex valuesof *Eba* and okra soup**

2 HR TEST MEAL- *EBA* AND OKRA		
Time	Test meal	Glucose D
0 mins	82.38	87.88
30 mins	96.75	130.13
60 mins	92.13	122.88
90 mins	92.75	107.13
120 mins	94.5	104.5
AUC	11102.10	13689.9
GI	81.09701313	

Figure 6.4a - **Mean glycaemic response curves of *Eba* and okra soup**

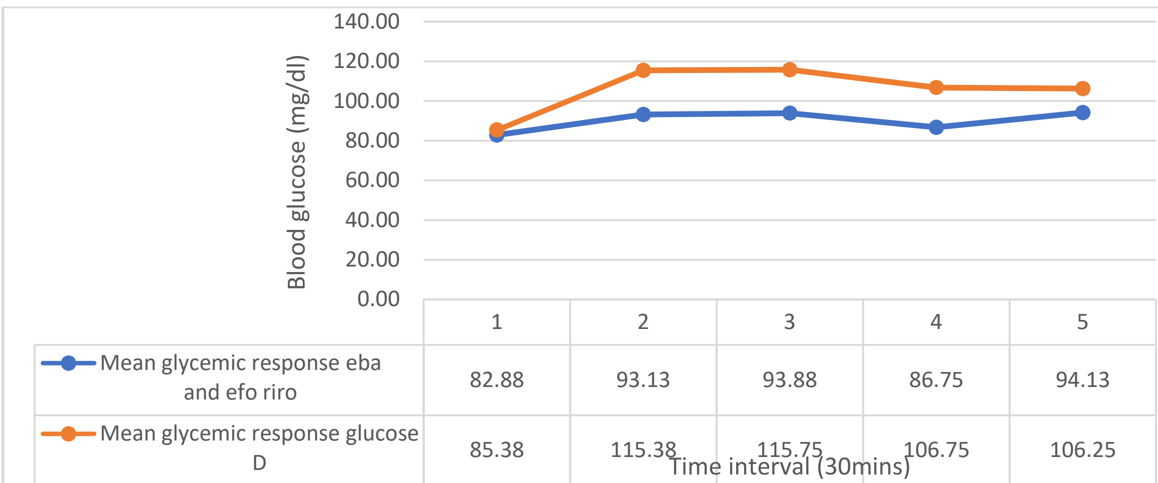


Appendix 6.5: Mean glycaemicindex values and mean glycaemic response curves of Eba and *Eforiro* soup

Table 6.5a - **Mean glycaemicindex valuesof *Eba* and *Eforiro* soup**

2 HR TEST MEAL- *EBA* AND *EFO RIRO*		
Time	Test meal	Glucose D
0 mins	82.88	85.38
30 mins	93.13	115.38
60 mins	93.88	115.75
90 mins	86.75	106.75
120 mins	94.13	106.25
AUC	10867.95	13010.85
GI	83.52990004	

Figure 6.5a - **Mean glycaemic response curves of *Eba* and *Eforiro* soup**

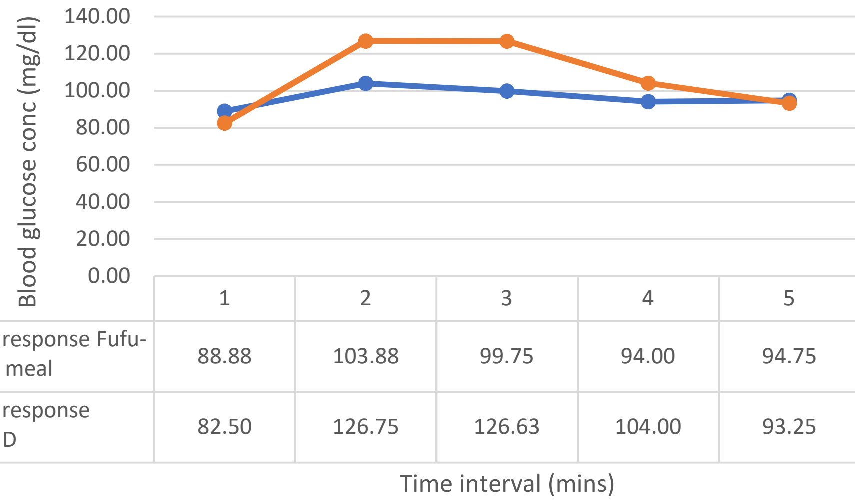


Appendix 6.6: Mean glycaemicindex values and mean glycaemic response curves of *Fufu*

Table 6.6a - **Mean glycaemicindex values of *Fufu***

2 HR TEST MEAL- *FUFU*		
Time	Test meal	Glucose D
0 mins	88.28	82.5
30 mins	103.88	126.75
60 mins	99.75	126.63
90 mins	94	104
120 mins	94.75	93.25
AUC	11674.35	13357.65
GI	87.39823247	

Figure 6.6a - **Mean glycaemic response curves of *Fufu***



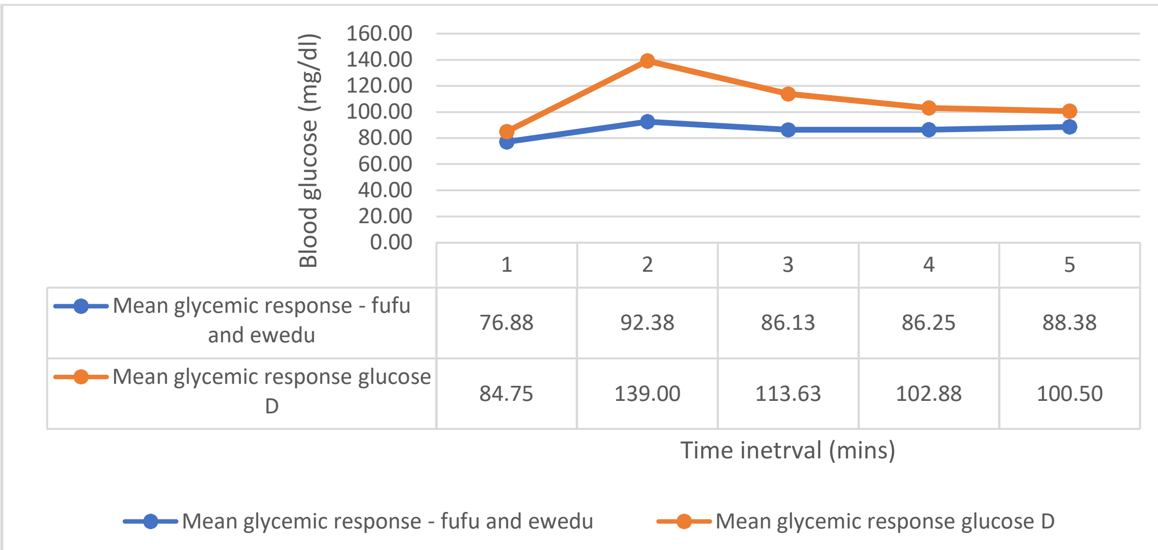
	1	2	3	4	5
Mean glycemic response Fufu- single meal	88.88	103.88	99.75	94.00	94.75
Mean glycemic response glucose D	82.50	126.75	126.63	104.00	93.25

Appendix 6.7: Mean glycaemicindex values and mean glycaemic response curves of Fufu and *Ewedu* soup

Table 6.7a - **Mean glycaemicindex valuesof *Fufu* and *Ewedu* soup**

2 HR TEST MEAL- *FUFU* AND *EWEDU*		
Time	Test meal	Glucose D
0 mins	76.88	84.75
30 mins	92.38	139
60 mins	86.13	113.63
90 mins	86.25	102.88
120 mins	88.38	100.5
AUC	10421.70	13444.05
GI	77.51905118	

Figure 6.7a - **Mean glycaemic response curves of *Fufu* and *Ewedu* soup**

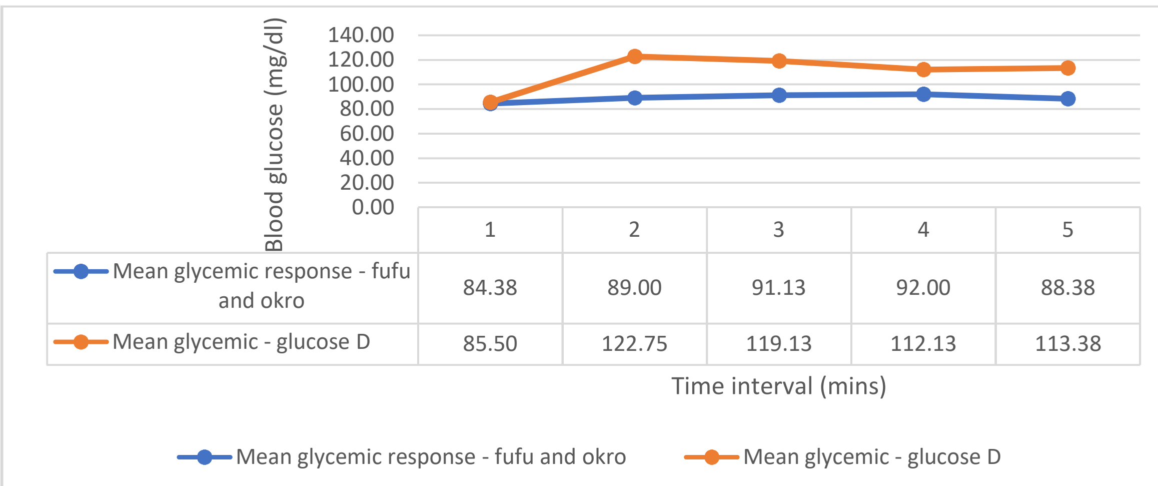


Appendix 6.8: Mean glycaemicindex values and mean glycaemic response curves of *Fufu* and okra soup

Table 6.8a -**Mean glycaemicindex valuesof *Fufu* and okra soup**

2 HR TEST MEAL- *FUFU* AND OKRA		
Time	Test meal	Glucose D
0 mins	84.38	85.5
30 mins	89	122.75
60 mins	91.13	119.13
90 mins	92	112.13
120 mins	88.38	113.38
AUC	10755.30	13603.5
GI	79.06274121	

Figure 6.8a - **Mean glycaemic response curves of *Fufu* and okra soup**

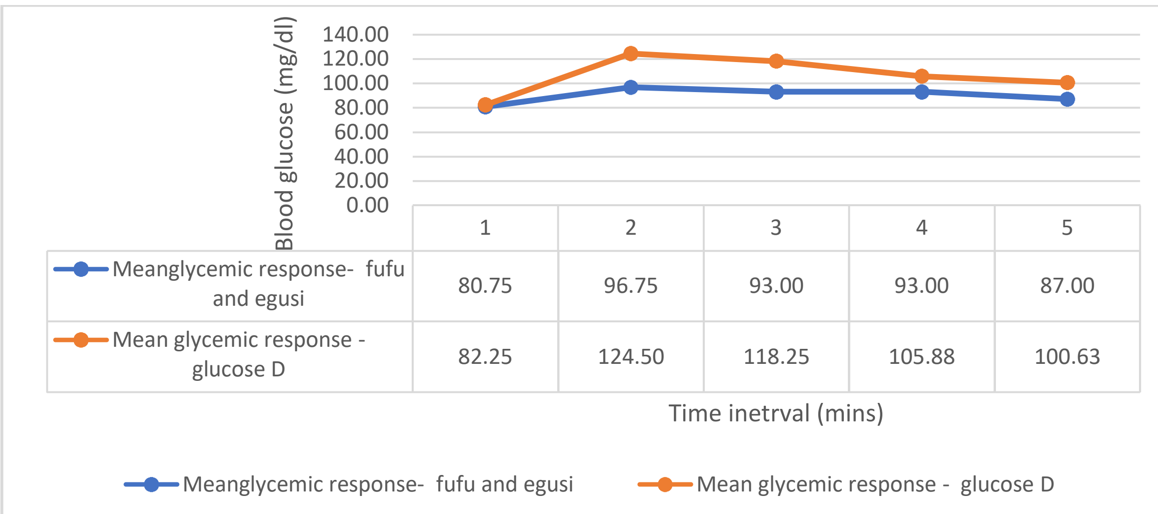


Appendix 6.9: Mean glycaemicindex values and mean glycaemic response curves of Fufu and *Efoelegusi* soup

Table 6.9a - **Mean glycaemicindex valuesof *Fufu* and *Efoelegusi* soup**

2 HR TEST MEAL- *FUFU* AND *EFO ELEGUSI*		
Time	Test meal	Glucose D
0 mins	80.75	82.25
30 mins	96.75	124.5
60 mins	93	118.25
90 mins	93	105.88
120 mins	87	100.63
AUC	10998.75	13202.1
GI	83.31060968	

Figure 6.9a -**Mean glycaemic response curves of *Fufu* and *Efoelegusi* soup**

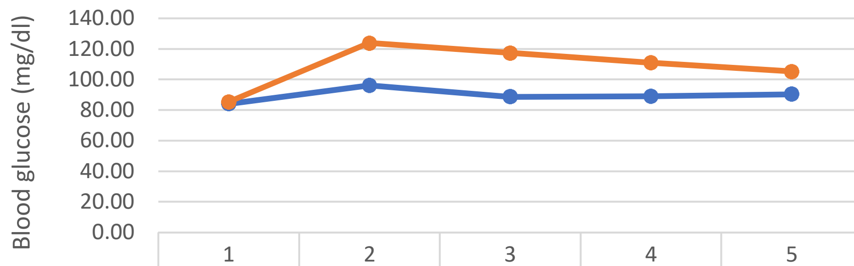


Appendix 6.10: Mean glycaemicindex values and mean glycaemic response curves of *Fufu* and *Eforiro* soup

Table 6.10a - **Mean glycaemicindex valuesof *Fufu* and *Eforiro* soup**

2 HR TEST MEAL- *FUFU* AND *EFO RIRO*		
Time	Test meal	Glucose D
0 mins	84	85.13
30 mins	96	123.75
60 mins	88.63	117.25
90 mins	88.88	110.88
120 mins	90.25	105.13
AUC	10819.05	13410.3
GI	80.67716606	

Figure 6.10a - **Mean glycaemic response curves of *Fufu* and *Eforiro* soup**



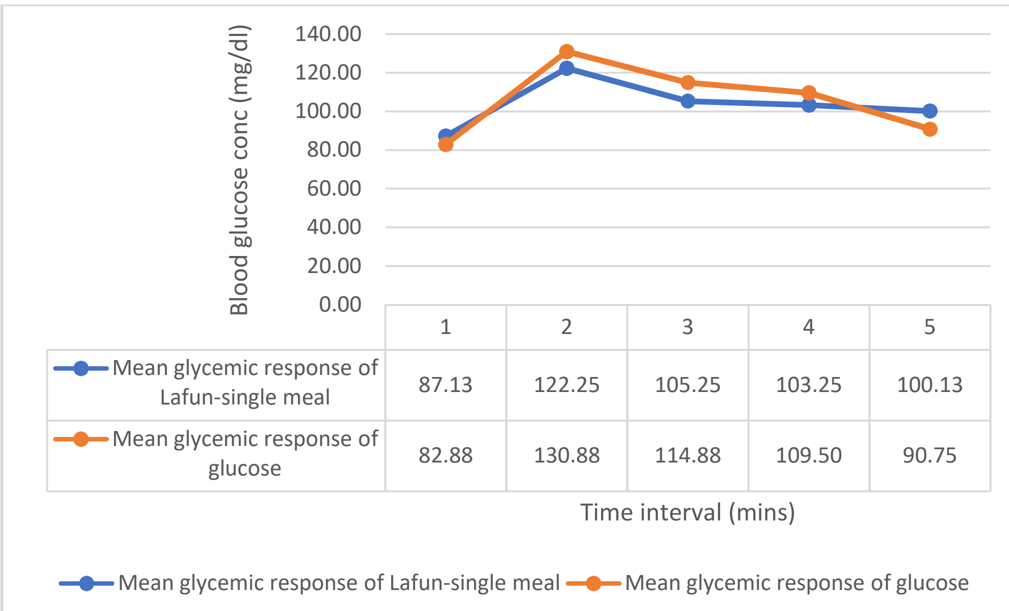
	1	2	3	4	5
Mean glycemic response - fufu anf efo riro	84.00	96.00	88.63	88.88	90.25
Mean glycemic response glucose D	85.13	123.75	117.25	110.88	105.13

Appendix 6.11: Mean glycaemicindex values and mean glycaemic response curves of *Lafun*

Table 6.11a - **Mean glycaemicindex values of *Lafun***

2 HR TEST MEAL- *LAFUN*		
Time	Test meal	Glucose D
0 mins	87.13	82.88
30 mins	122.25	130.88
60 mins	105.25	114.88
90 mins	103.25	109.5
120 mins	100.13	90.75
AUC	12731.40	13262.25
GI	95.99728553	

Figure 6.11a - Mean glycaemic response curves of *Lafun*

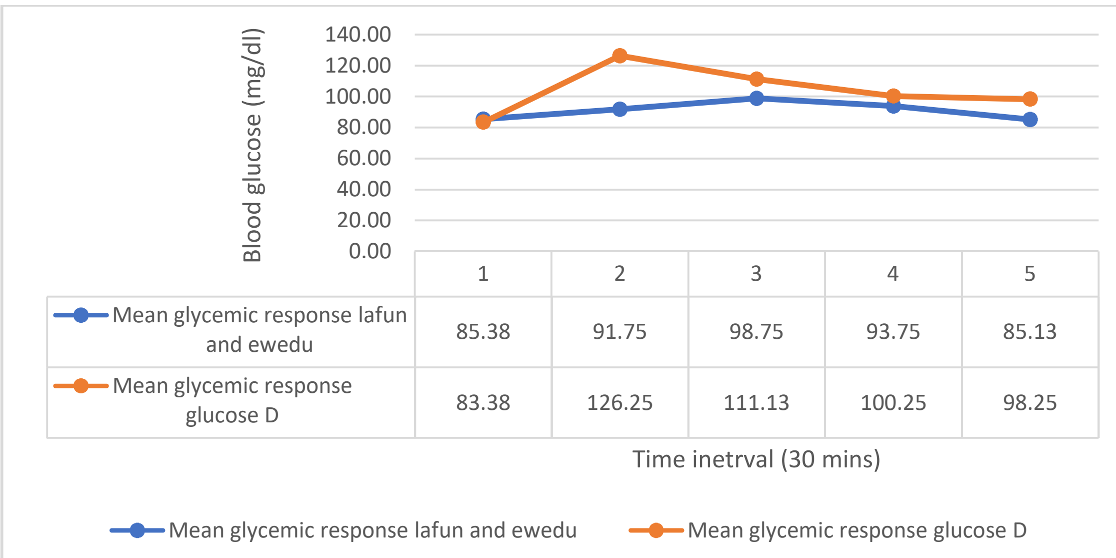


Appendix 6.12: Mean glycaemicindex values and mean glycaemic response curves of *Lafun* and *Ewedu* soup

Table 6.12a -**Mean glycaemicindex valuesof *Lafun* and *Ewedu* soup**

2 HR TEST MEAL- *LAFUN* AND *EWEDU*		
Time	Test meal	Glucose D
0 mins	85.38	83.38
30 mins	91.75	126.25
60 mins	98.75	111.13
90 mins	93.75	100.25
120 mins	85.13	98.25
AUC	11085.15	12853.35
GI	86.2432751	

Figure 6.12a - **Mean glycaemic response curves of *Lafun* and *Ewedu* soup**

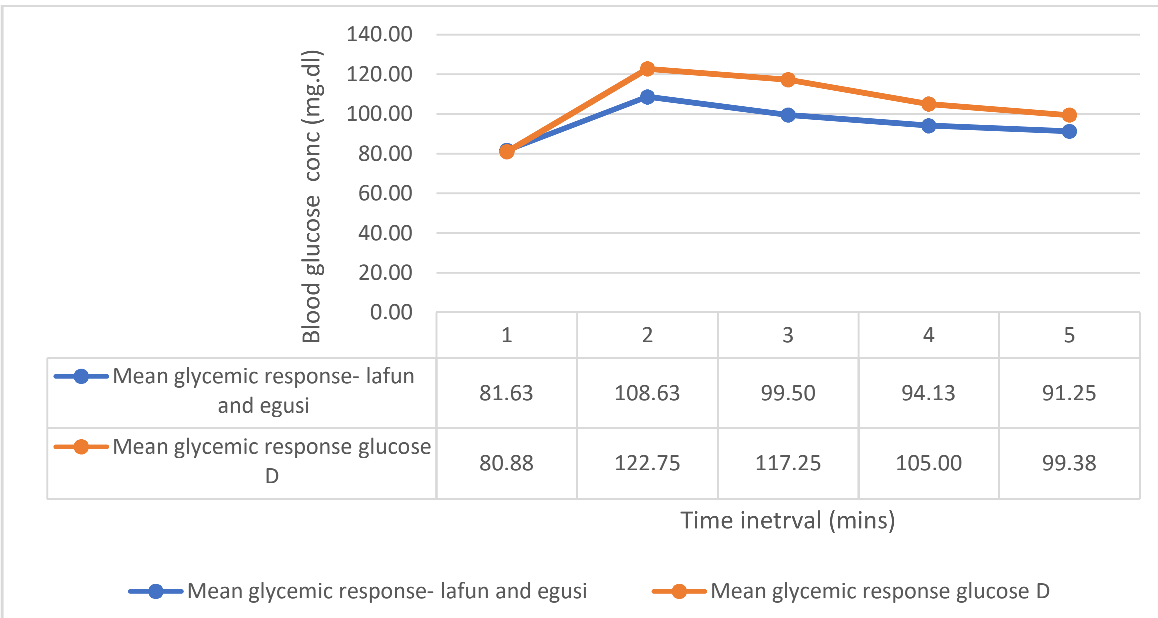


Appendix 6.13: Mean glycaemicindex values and mean glycaemic response curves of *Lafun* and *Efoelegusi* soup

Table 6.13a - **Mean glycaemicindex valuesof *Lafun* and *Efoelegusi* soup**

2 HR TEST MEAL- *LAFUN* AND *EFO ELEGUSI*		
Time	Test meal	Glucose D
0 mins	81.63	80.88
30 mins	108.63	122.75
60 mins	99.5	117.25
90 mins	94.13	105
120 mins	91.25	99.38
AUC	11661.00	13053.9
GI	89.32962563	

Figure 6.13a **- Mean glycaemic response curves of *Lafun* and *Efoelegusi* soup**

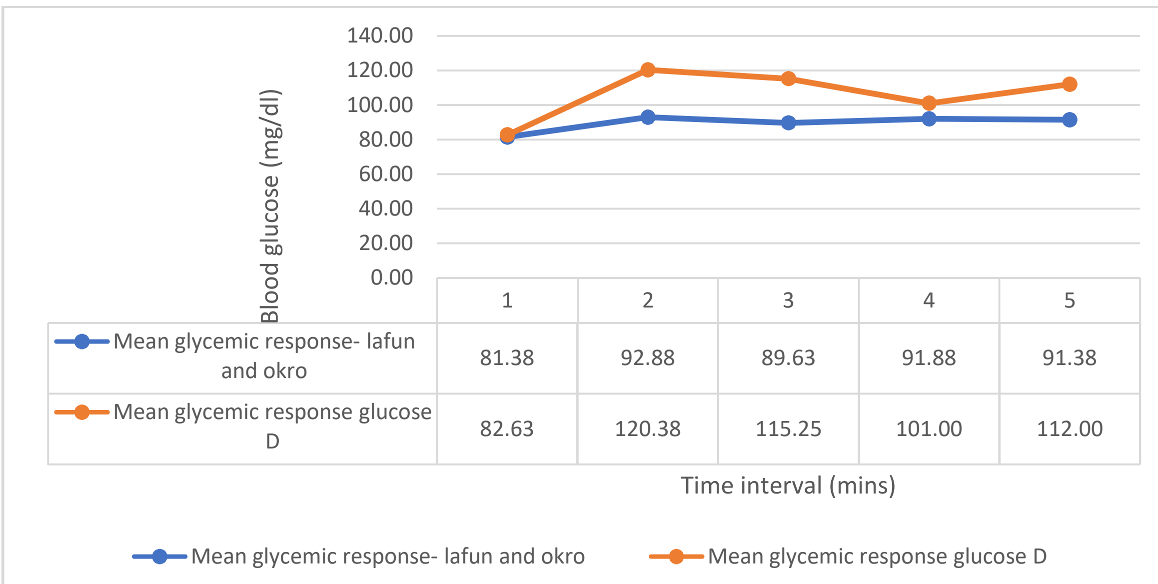


Appendix 6.14: Mean glycaemicindex values and mean glycaemic response curves of *Lafun* and Okra soup

Table 6.14a **- Mean glycaemicindex valuesof *Lafun* and Okra soup**

2 HR TEST MEAL- *LAFUN* AND OKRA		
Time	Test meal	Glucose D
0 mins	81.38	82.63
30 mins	92.88	120.38
60 mins	89.63	115.25
90 mins	91.88	101
120 mins	91.38	112
AUC	10823.10	13018.35
GI	83.13726394	

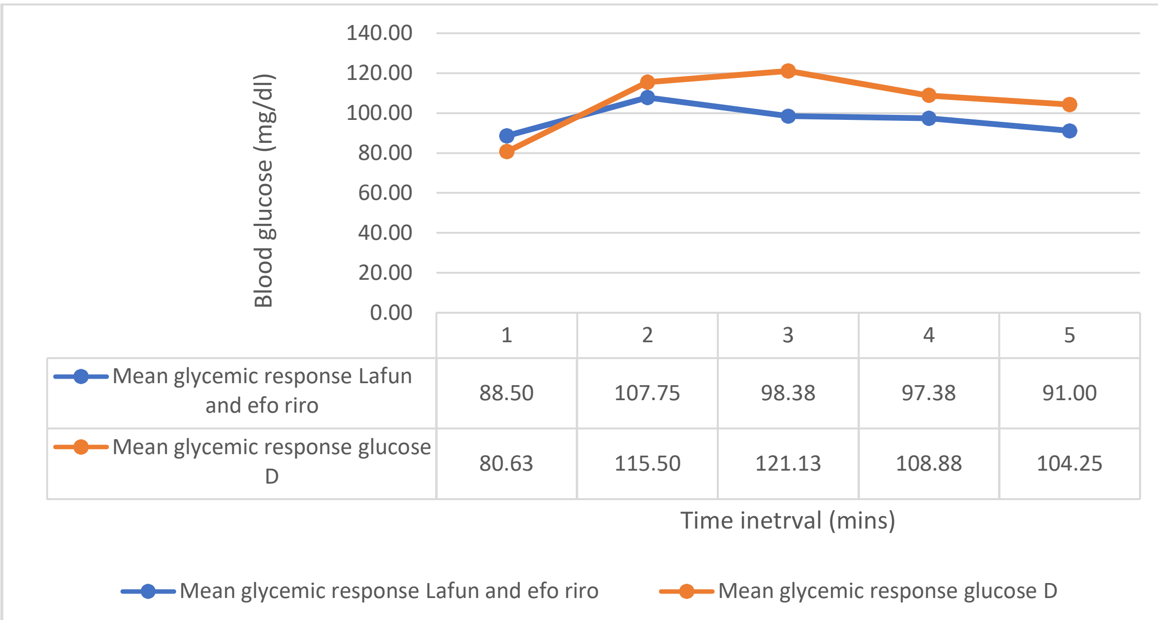
Figure 6.14a - **Mean glycaemic response curves of *Lafun* and Okra soup**



Appendix 6.15: Mean glycaemicindex values and mean glycaemic response curves of *Lafun* and *Eforiro* soup

Table 6.15a - **Mean glycaemicindex valuesof *Lafun* and *Eforiro* soup**

2 HR TEST MEAL- *LAFUN* AND *EFO RIRO*		
Time	Test meal	Glucose D
0 mins	88.5	80.63
30 mins	107.75	115.5
60 mins	98.38	121.13
90 mins	97.38	108.88
120 mins	91	104.25
AUC	11797.80	13138.5
GI	89.79563877	



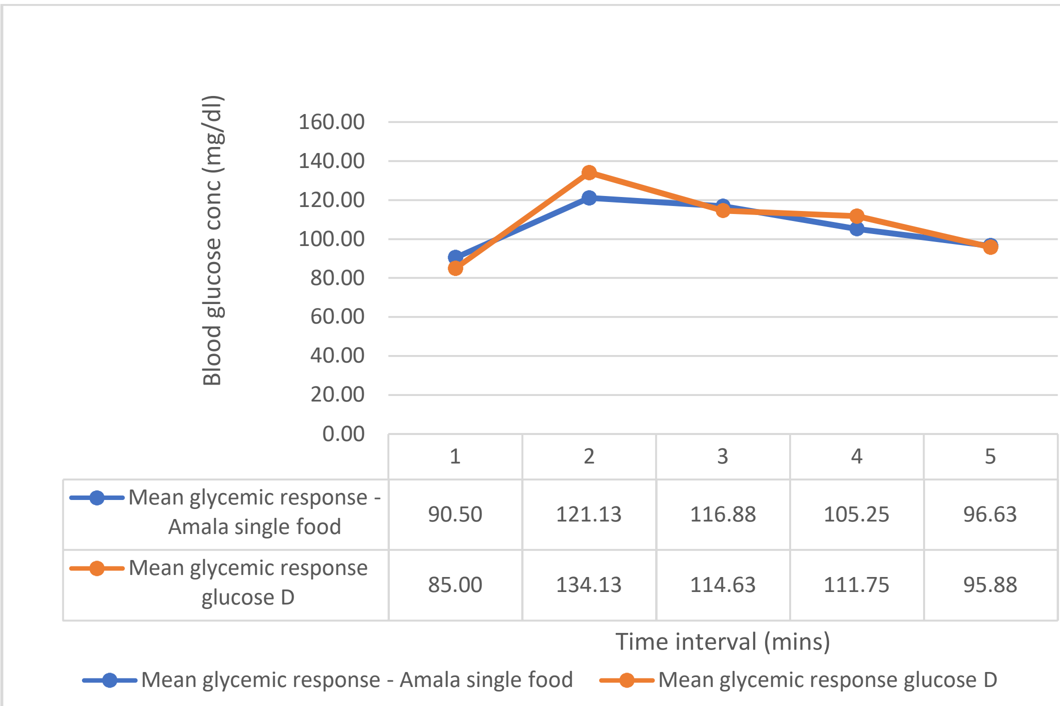
	1	2	3	4	5
Mean glycemic response Lafun and efo riro	88.50	107.75	98.38	97.38	91.00
Mean glycemic response glucose D	80.63	115.50	121.13	108.88	104.25

Appendix 6.16: Mean glycaemicindex values and mean glycaemic response curves of *Amala*

Table 6.16a:**Mean glycaemicindex valuesof *Amala***

2 HR TEST MEAL- *AMALA*		
Time	Test meal	Mean Glucose D
0 mins	90.5	85
30 mins	121.13	134.13
60 mins	116.88	114.63
90 mins	105.25	111.75
120 mins	96.63	95.88
AUC	13104.75	13528.5
GI	96.86772369	

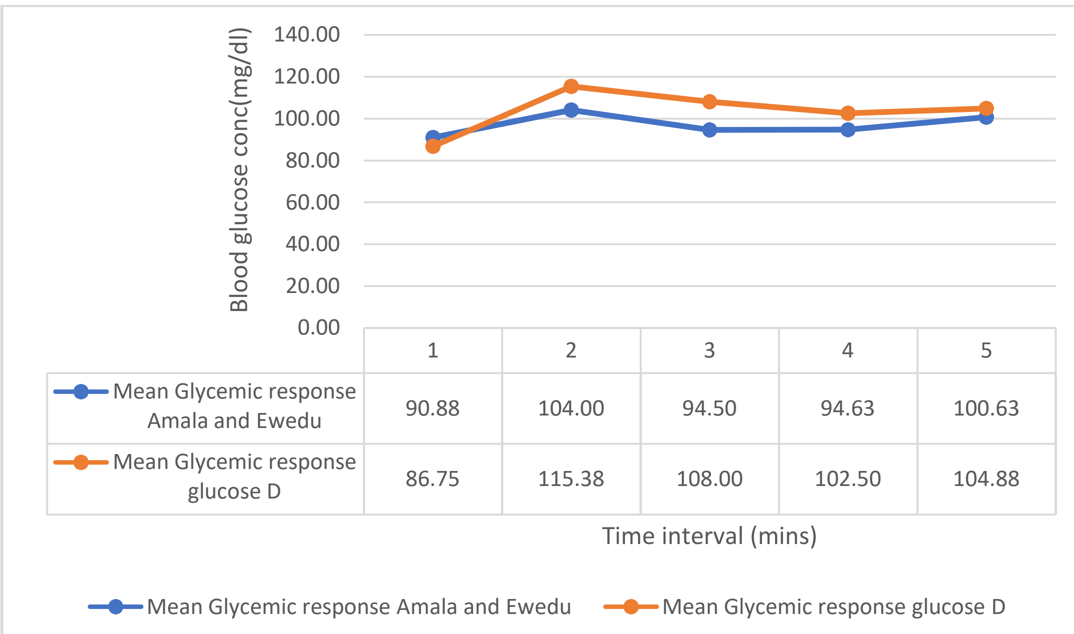
Table 6.16a: **Mean glycaemic response curves of *Amala***



Appendix 6.17: Mean glycaemicindex values and mean glycaemic response curves of *Amala* and *Ewedu* soup

Table 6.17a **- Mean glycaemicindex valuesof *Amala* and *Ewedu* soup**

2 HR TEST MEAL- *AMALA* AND *EWEDU*		
Time	Test meal	Glucose D
0 mins	90.88	86.75
30 mins	104	115.38
60 mins	94.5	108
90 mins	94.63	102.5
120 mins	100.63	104.88
AUC	11666.55	12650.85
GI	92.21949513	

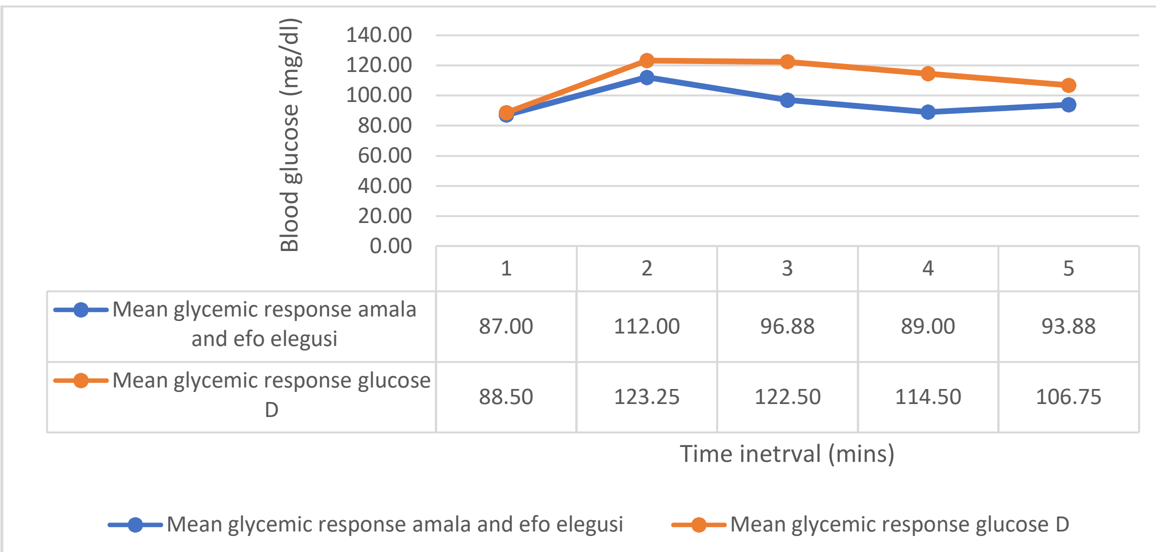


Appendix 6.18: Mean glycaemicindex values and mean glycaemic response curves of *Amala* and *Efoelegusi* soup

Table 6.18a **- Mean glycaemicindex valuesof *Amala* and *Efoelegusi* soup**

2 HR TEST MEAL- AMALA AND EFO ELEGUSI		
Time	Test meal	Glucose D
0 mins	87	88.5
30 mins	112	123.25
60 mins	96.88	122.5
90 mins	89	114.5
120 mins	93.88	106.75
AUC	11649.60	13736.25
GI	84.80917281	

Figure 6.18a **- Mean glycaemic response curves of *Amala* and *Efoelegusi* soup**

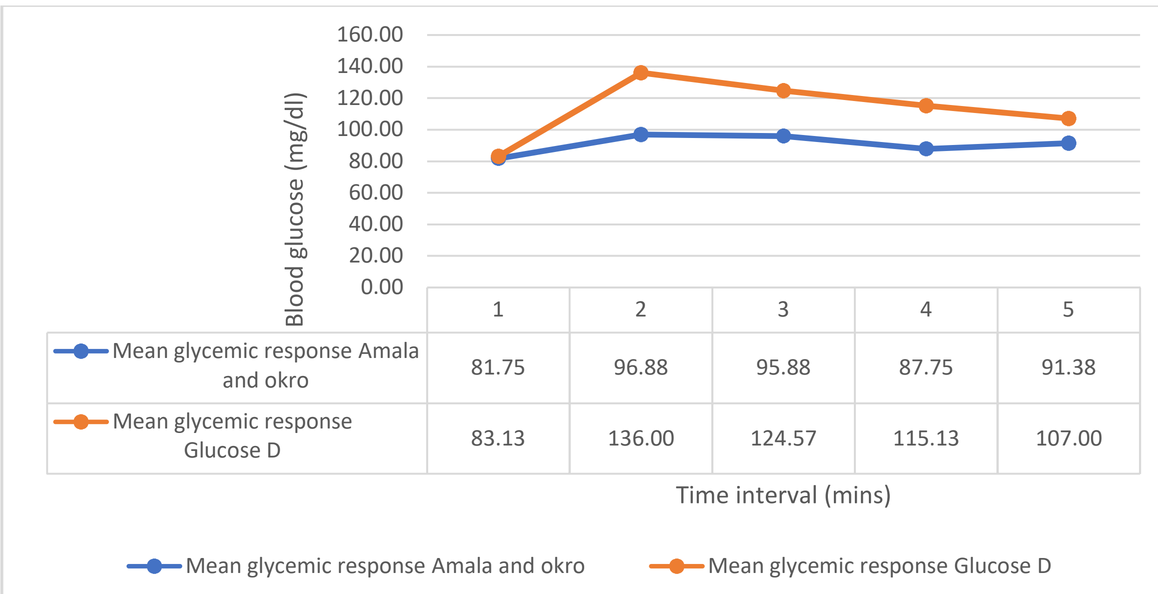


Appendix 6.19: Mean glycaemicindex values and mean glycaemic response curves of *Amala*and Okra soup

Table 6.19a - **Mean glycaemicindex valuesof *Amala*and Okra soup**

2 HR TEST MEAL- *AMALA* AND OKRA		
Time	Test meal	Glucose D
0 mins	81.75	83.13
30 mins	96.88	136
60 mins	95.88	124.57
90 mins	87.75	115.13
120 mins	91.38	107
AUC	11012.25	14122.95
GI	77.97414846	

Table 6.19a - **Mean glycaemic response curves of *Amala*and Okra soup**

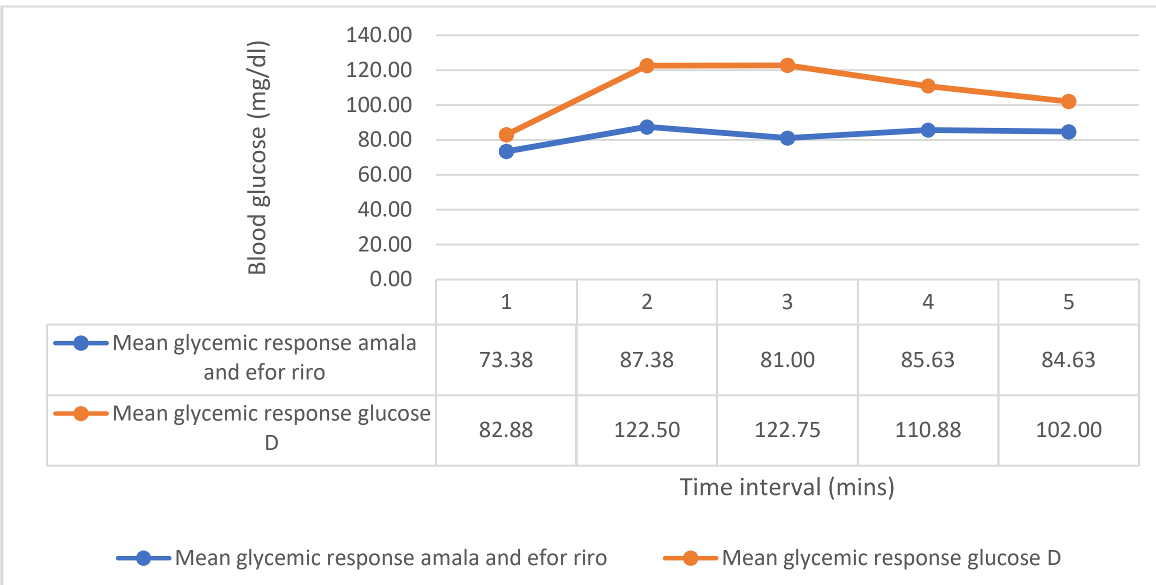


Appendix 6.20: Mean glycaemicindex values and mean glycaemic response curves of *Amala* and *Eforiro* soup

Table 6.20a - Mean glycaemicindex valuesof *Amala* and *Eforiro* soup

2 HR TEST MEAL- *AMALA* AND *EFO RIRO*		
Time	Test meal	Glucose D
0 mins	73.38	82.88
30 mins	87.38	122.5
60 mins	81	122.75
90 mins	85.63	110.88
120 mins	84.63	102
AUC	9990.45	13457.1
GI	74.23924917	

Figure 6.20a - Mean glycaemic response curves of *Amala* and *Eforiro* soup

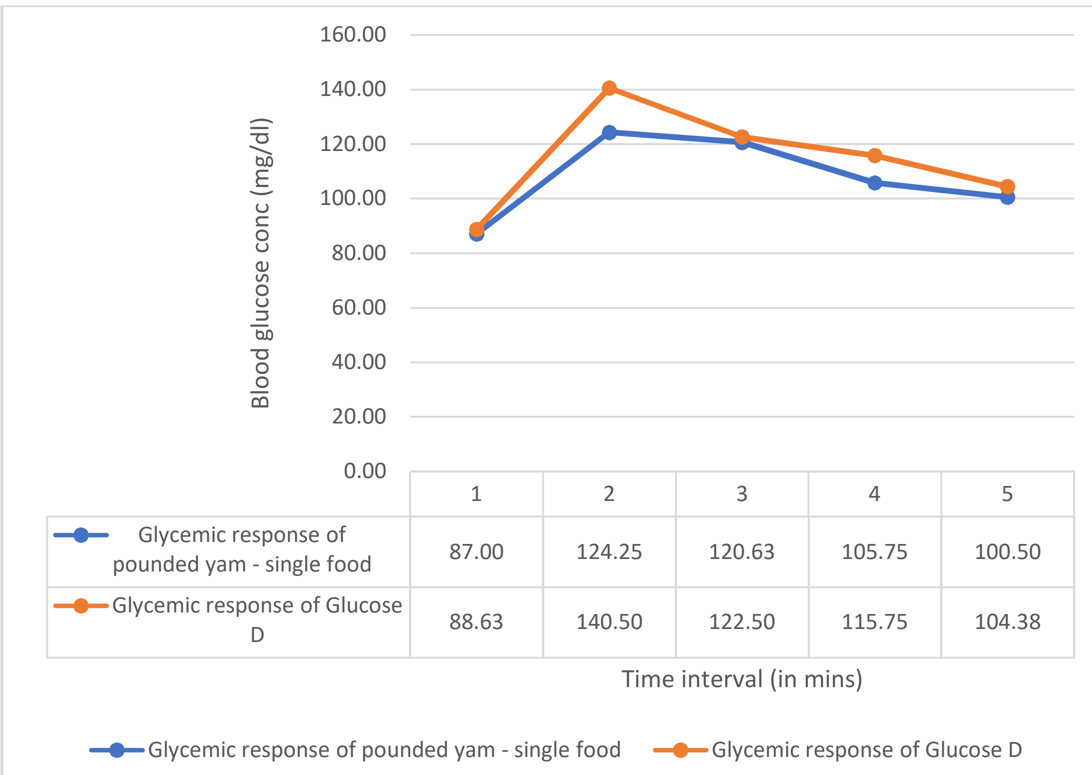


Appendix 6.21: Mean glycaemicindex values and mean glycaemic response curves of Pounded yam

Table 6.21a **- Mean glycaemicindex valuesof Pounded yam**

2 HR TEST MEAL- POUNDED YAM		
Time	Test meal	Glucose D
0 mins	87	88.63
30 mins	124.25	140.5
60 mins	120.63	122.5
90 mins	105.75	115.75
120 mins	100.5	104.38
AUC	13331.40	14257.65
GI	93.5034876	

Figure 6.21a **- Mean glycaemic response curves of Pounded yam**

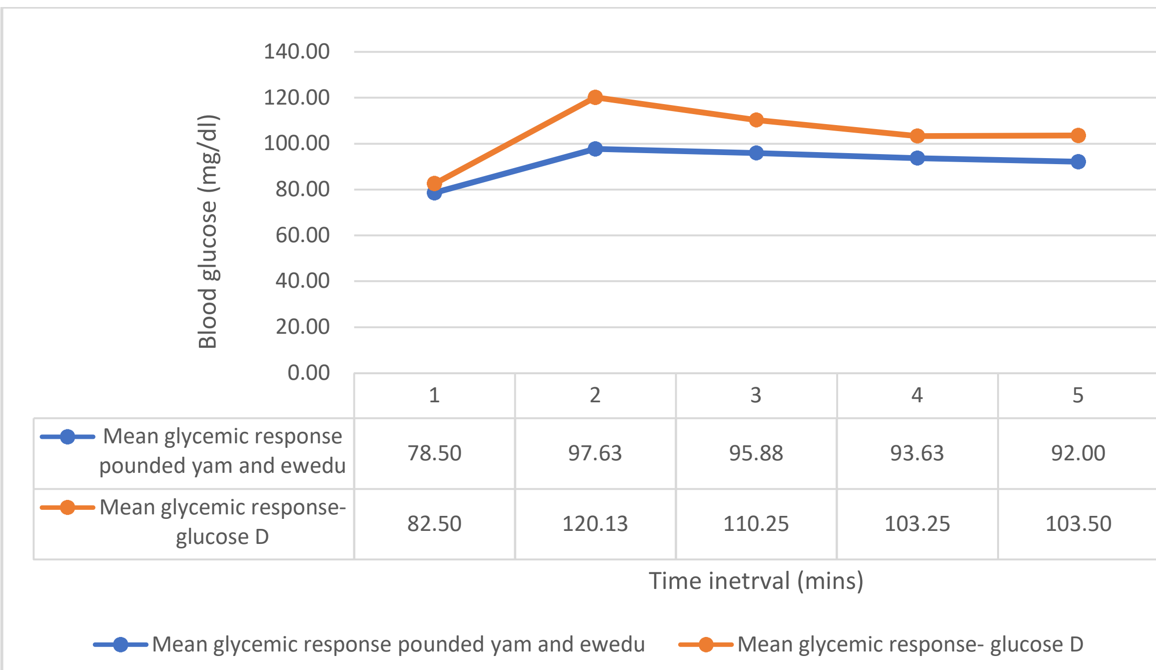


Appendix 6.22: Mean glycaemicindex values and mean glycaemic response curves of Pounded yam and *ewedu* soup

Table 6.22a **- Mean glycaemicindex valuesof Pounded yam and *ewedu* soup**

2 HR TEST MEAL- POUNDED YAM AND *EWEDU*		
Time	Test meal	Glucose D
0 mins	78.5	82.5
30 mins	97.63	120.13
60 mins	95.88	110.25
90 mins	93.63	103.25
120 mins	92	103.5
AUC	11171.10	12798.9
GI	87.28171952	

Table 6.22a - **Mean glycaemic response curves of Pounded yam and *ewedu* soup**

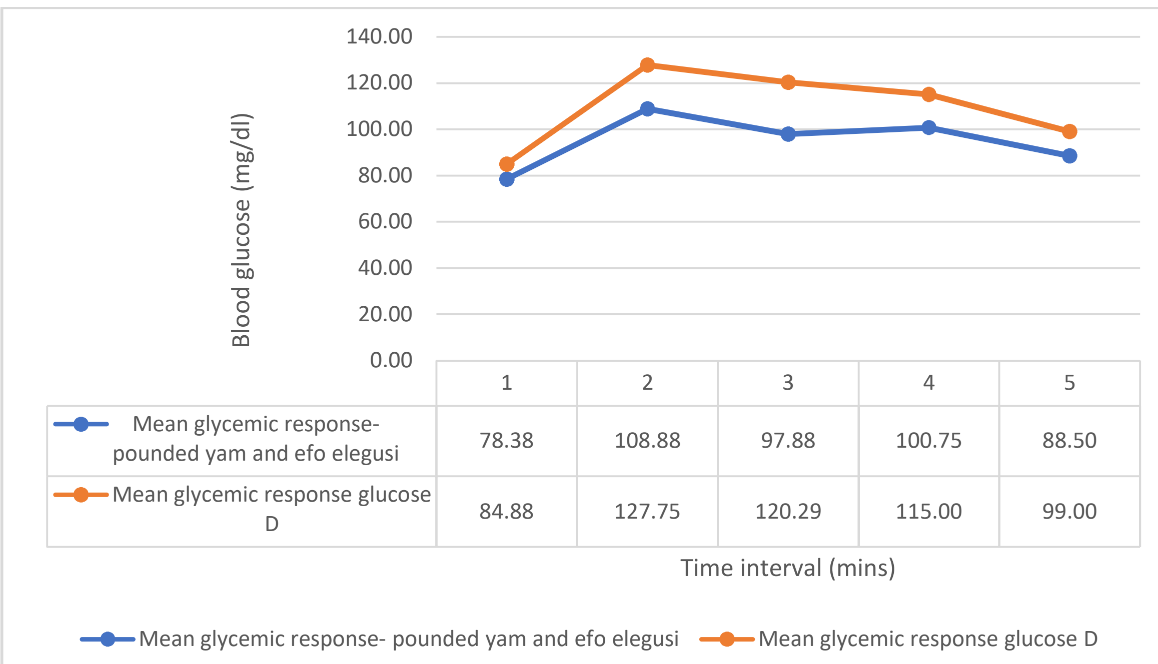


Appendix 6.23: Mean glycaemicindex values and mean glycaemic response curves of Pounded yam and *efoelegusi* soup

Table 6.23a-**Mean glycaemicindex valuesof Pounded yam and *efoelegusi* soup**

2 HR TEST MEAL- POUNDED YAM AND *EFO ELEGUSI*		
Time	Test meal	Glucose D
0 mins	78.38	84.88
30 mins	108.88	127.75
60 mins	97.88	120.29
90 mins	100.75	115
120 mins	88.5	99
AUC	11728.50	13649.4
GI	85.92685393	

Figure 6.23a - **Mean glycaemic response curves of Pounded yam and *efoelegusi* soup**

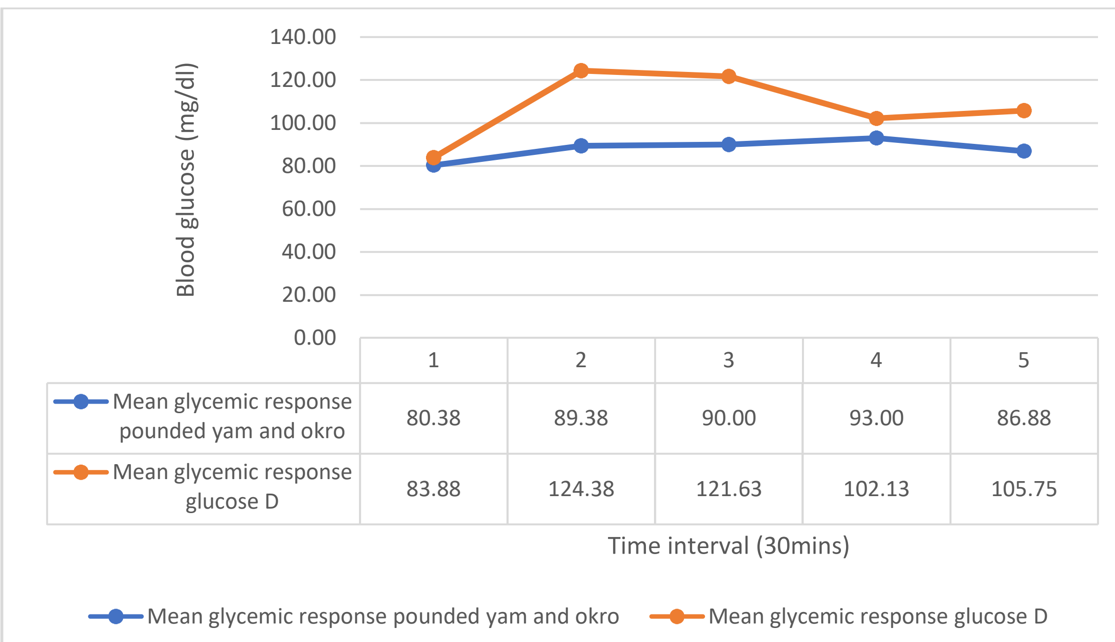


Appendix 6.24: Mean glycaemicindex values and mean glycaemic response curves of Pounded yam and okra soup

Table 6.24a - **Mean glycaemicindex valuesof Pounded yam and okra soup**

2 HR TEST MEAL- POUNDED YAM AND OKRA		
Time	Test meal	Glucose D
0 mins	80.38	83.88
30 mins	89.38	124.38
60 mins	90	121.63
90 mins	93	102.13
120 mins	86.88	105.75
AUC	10680.30	13288.65
GI	80.37159531	

Figure 6.24a - **Mean glycaemic response curves of Pounded yam and okra soup**

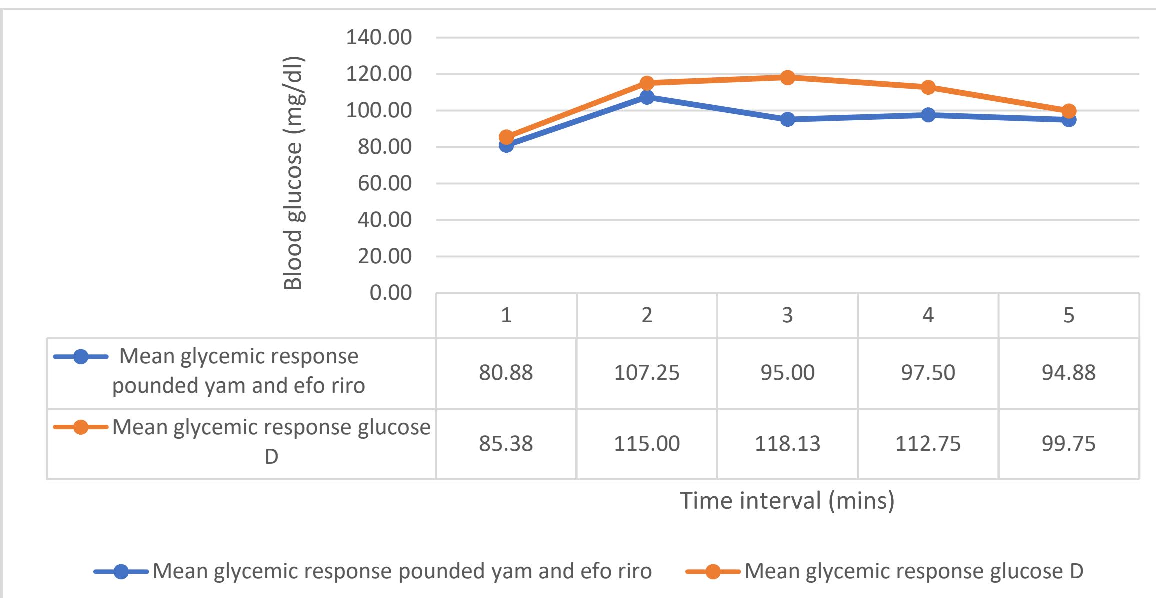


Appendix 6.25: Mean glycaemicindex values and mean glycaemic response curves of Pounded yam and *eforiro* soup

Table 6.25a **- Mean glycaemicindex valuesof Pounded yam and *eforiro* soup**

2 HR TEST MEAL- POUNDED YAM AND *EFO RIRO*		
Time	Test meal	Glucose D
0 mins	80.88	85.38
30 mins	107.25	115
60 mins	95	118.13
90 mins	97.5	112.75
120 mins	94.88	99.75
AUC	11628.90	13153.35
GI	88.41017688	

Table 6.25a **- Mean glycaemic response curves of Pounded yam and *eforiro* soup**

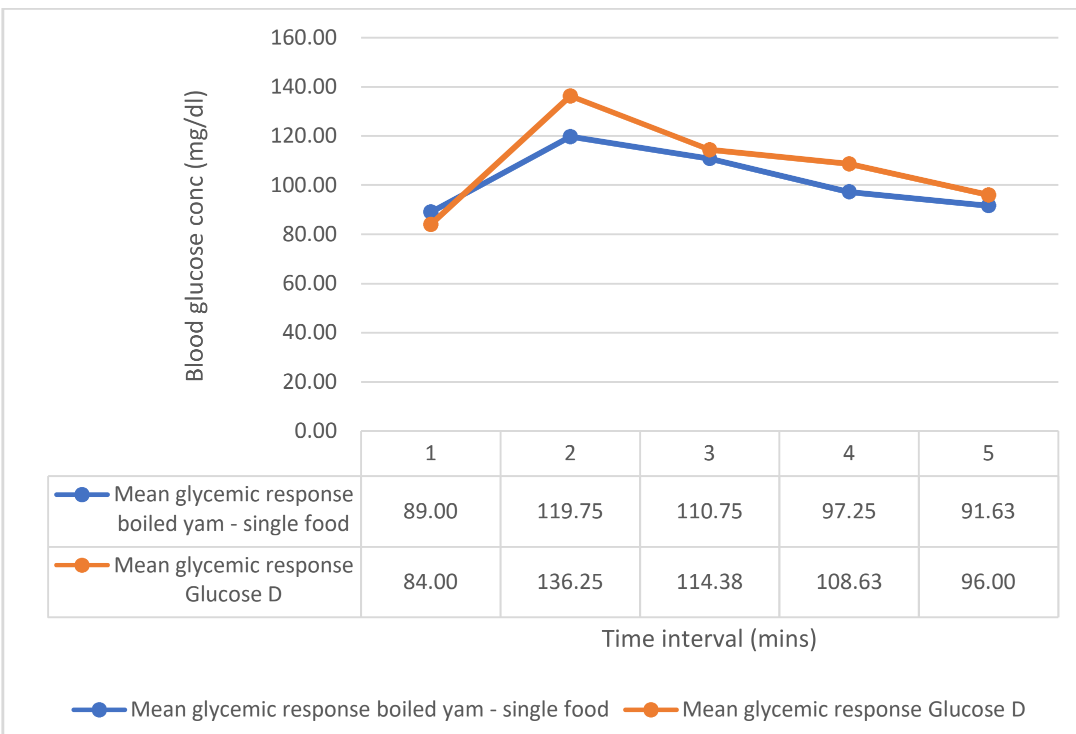


Appendix 6.26: Mean glycaemicindex values and mean glycaemic response curves of boiled yam

Table 6.26a - **Mean glycaemicindex valuesof boiled yam**

2 HR TEST MEAL- BOILED YAM		
Time	Test meal	Glucose D
0 mins	89	84
30 mins	119.75	136.25
60 mins	110.75	114.38
90 mins	97.25	108.63
120 mins	91.63	96
AUC	12541.95	13477.8
GI	93.05635935	

Figure 6.26a - Mean glycaemic response curves of boiled yam

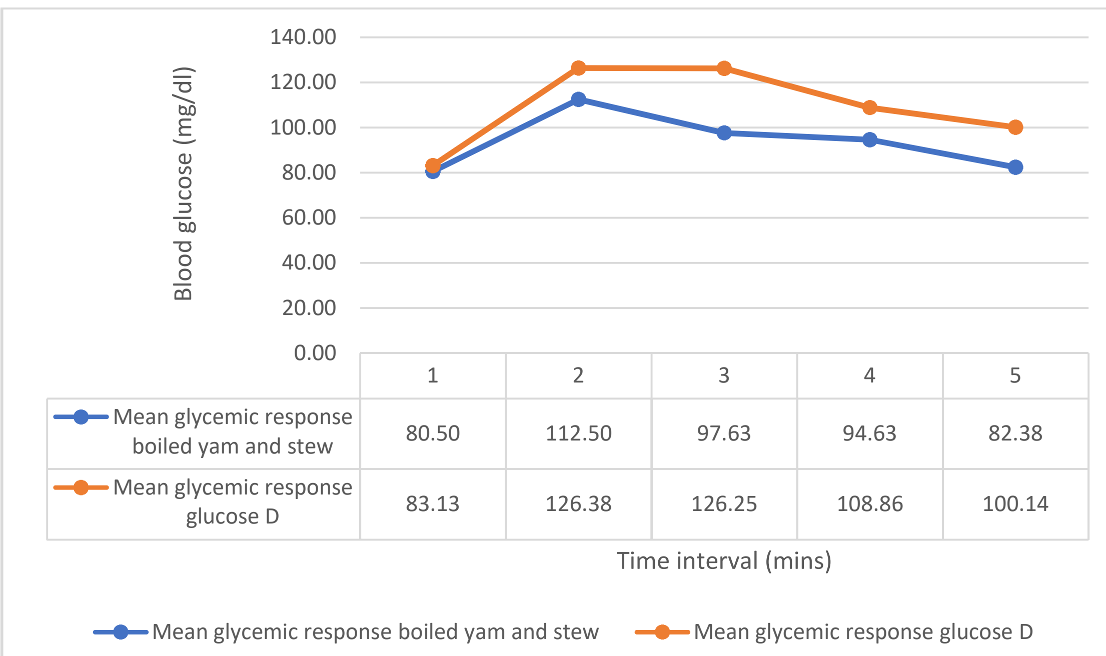


Appendix 6.27: Mean glycaemicindex values and mean glycaemic response curves of Boiled yam and stew

Table 6.27a **- Mean glycaemicindex valuesof Boiled yam and stew**

2 HR TEST MEAL- BOILED YAM AND STEW		
Time	Test meal	Glucose D
0 mins	80.5	83.13
30 mins	112.5	126.38
60 mins	97.63	126.25
90 mins	94.63	108.86
120 mins	82.38	100.14
AUC	11586.00	13593.75
GI	85.23034483	

Figure 6.27a**- Mean glycaemic response curves of Boiled yam and stew**

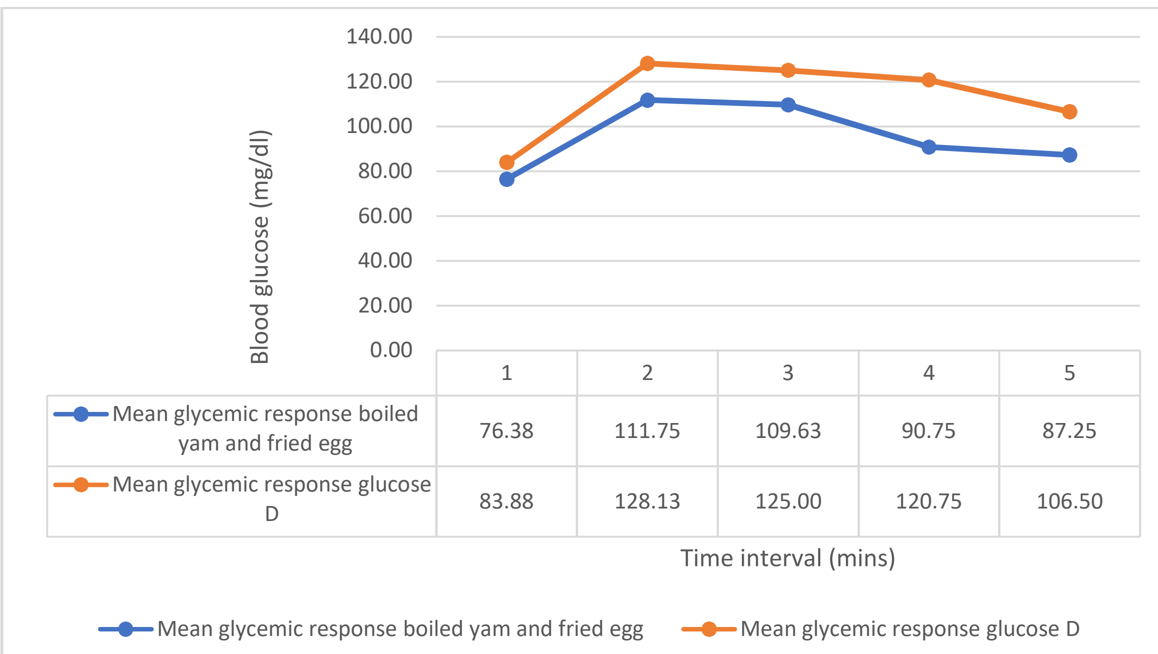


Appendix 6.28: Mean glycaemicindex values and mean glycaemic response curves of Boiled yam and fried egg

Table 6.28a **- Mean glycaemicindex valuesof Boiled yam and fried egg**

2 HR TEST MEAL- BOILED YAM AND FRIED EGG		
Time	Test meal	Glucose D
0 mins	76.38	83.88
30 mins	111.75	128.13
60 mins	109.63	125
90 mins	90.75	120.75
120 mins	87.25	106.5
AUC	11586.00	14072.1
GI	82.33312725	

Figure 6.28a **- Mean glycaemic response curves of Boiled yam and fried egg**

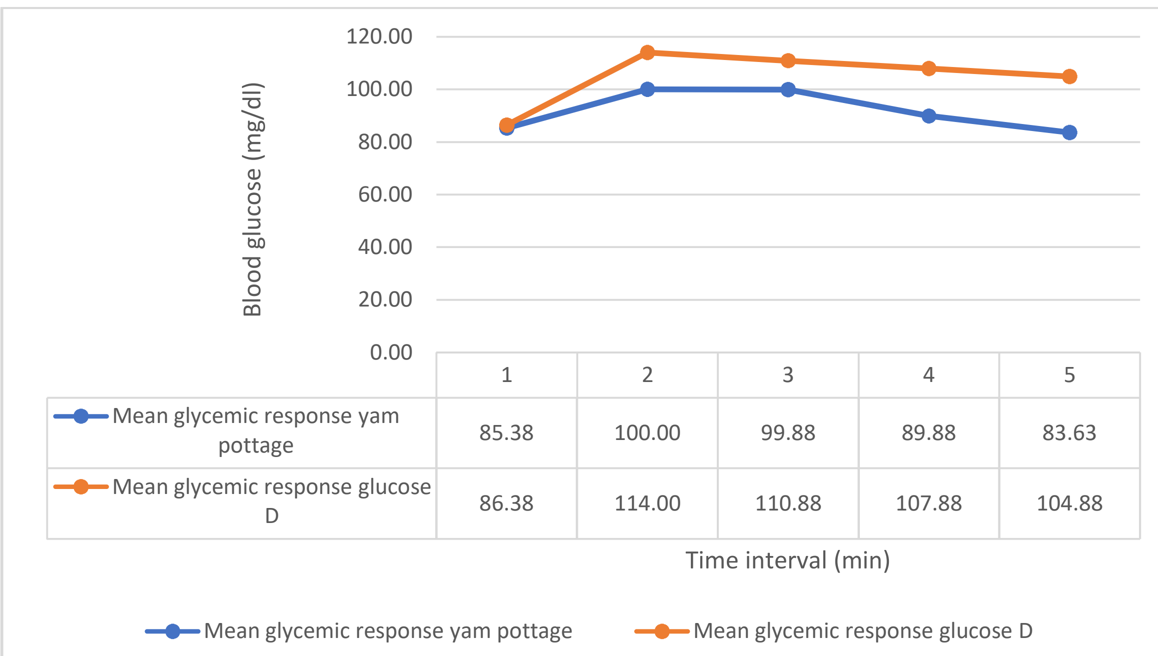


Appendix 6.29: Mean glycaemicindex values and mean glycaemic response curves of Yam pottage

Table 6.29a - **Mean glycaemicindex valuesof Yam pottage**

2 HR TEST MEAL- YAM POTTAGE		
Time	Test meal	Glucose D
0 mins	85.38	86.38
30 mins	100	114
60 mins	99.88	110.88
90 mins	89.88	107.88
120 mins	83.63	104.88
AUC	11227.95	12851.7
GI	87.36548472	

Figure 6.29a - **Mean glycaemic response curves of Yam pottage**

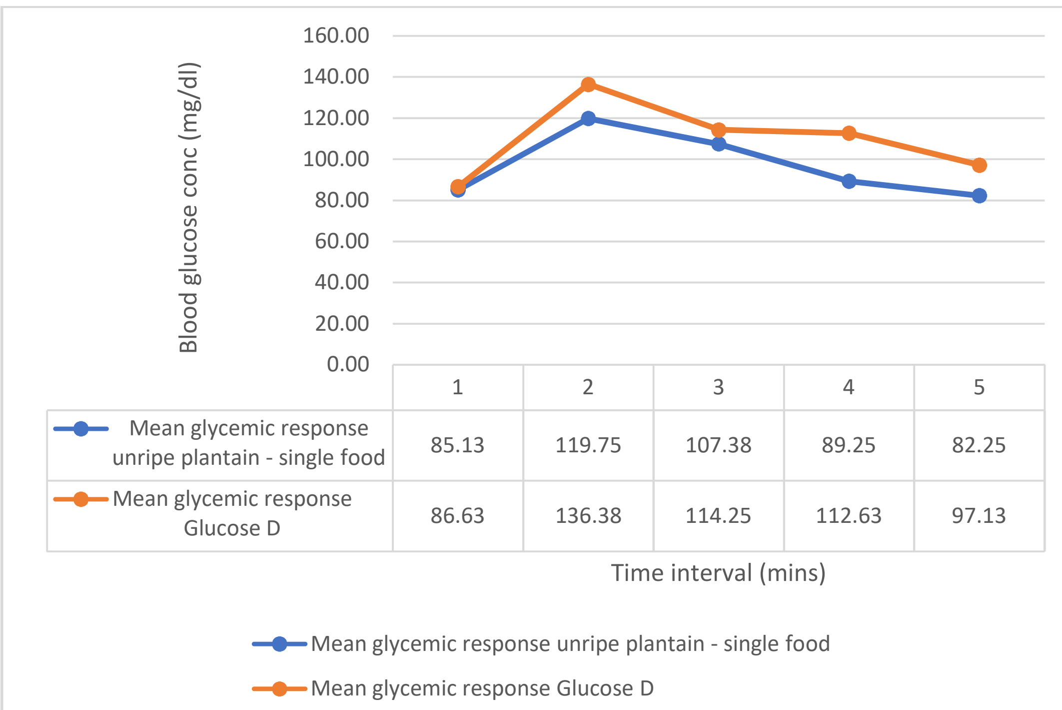


Appendix 6.30: Mean glycaemicindex values and mean glycaemic response curves of unripe plantain

Table 6.30a **- Mean glycaemicindex valuesof unripe plantain**

2 HR TEST MEAL- UNRIPE PLANTAIN		
Time	Test meal	Glucose D
0 mins	85.13	86.63
30 mins	119.75	136.38
60 mins	107.38	114.25
90 mins	89.25	112.63
120 mins	82.25	97.13
AUC	12002.10	13654.2
GI	87.90042624	

Figure 6.30a **- Mean glycaemic response curves of unripe plantain**

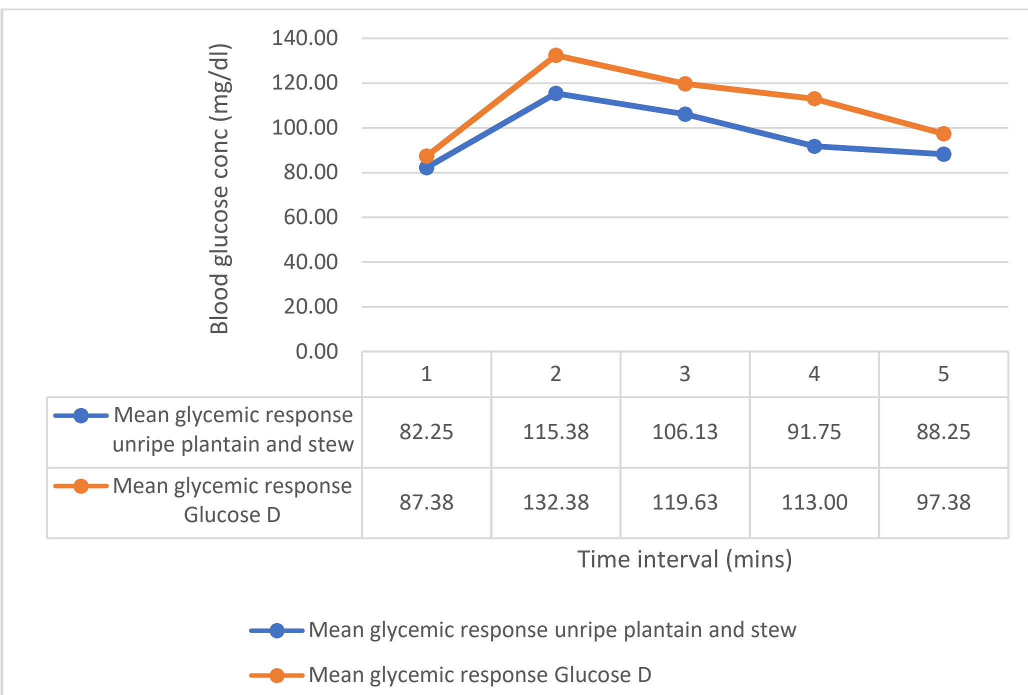


Appendix 6.31: Mean glycaemicindex values and mean glycaemic response curves of unripe plantain and stew

Table 6.31a - **Mean glycaemicindex valuesof unripe plantain and stew**

2 HR TEST MEAL- UNRIPE PLANTAIN WITH STEW		
Time	Test meal	Glucose D
0 mins	82.25	87.38
30 mins	115.38	132.38
60 mins	106.13	119.63
90 mins	91.75	113
120 mins	88.25	97.38
AUC	11955.30	13721.7
GI	87.12695949	

Figure 6.31a - **Mean glycaemic response curves of unripe plantain and stew**

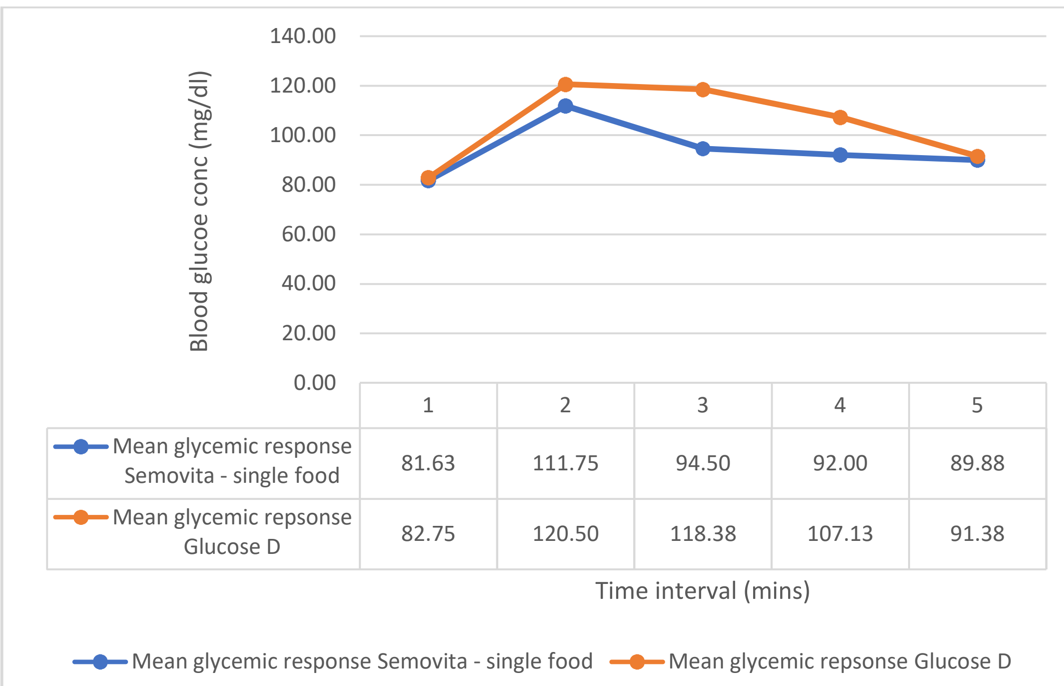


Appendix 6.32: Mean glycaemicindex values and mean glycaemic response curves of semovita

Table 6.32a **- Mean glycaemicindex values of semovita**

2 HR TEST MEAL-SEMOVITA		
Time	Test meal	Glucose D
0 mins	81.63	82.75
30 mins	111.75	120.5
60 mins	94.5	118.38
90 mins	92	107.13
120 mins	89.88	91.38
AUC	11520.15	12992.25
GI	88.66939906	

Table 6.32a - Mean glycaemic response curves of semovita



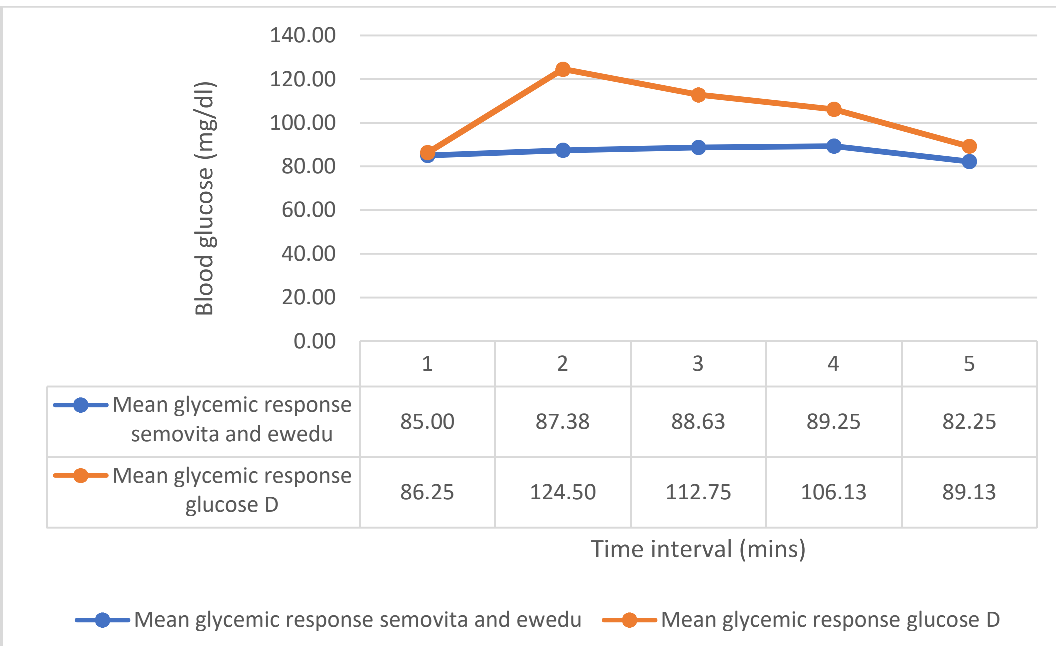
	1	2	3	4	5
Mean glycemic response Semovita - single food	81.63	111.75	94.50	92.00	89.88
Mean glycemic repsonse Glucose D	82.75	120.50	118.38	107.13	91.38

Appendix 6.33: Mean glycaemicindex values and mean glycaemic response curves of semovita and *ewedu* soup

Table 6.33a -**Mean glycaemicindex valuesof semovita and *ewedu* soup**

2 HR TEST MEAL- SEMOVITA AND *EWEDU*		
Time	Test meal	Glucose D
0 mins	85	86.25
30 mins	87.38	124.5
60 mins	88.63	112.75
90 mins	89.25	106.13
120 mins	82.25	89.13
AUC	10466.55	12932.1
GI	80.93465098	

Figure 6.33a **- Mean glycaemic response curves of semovita and *ewedu* soup**

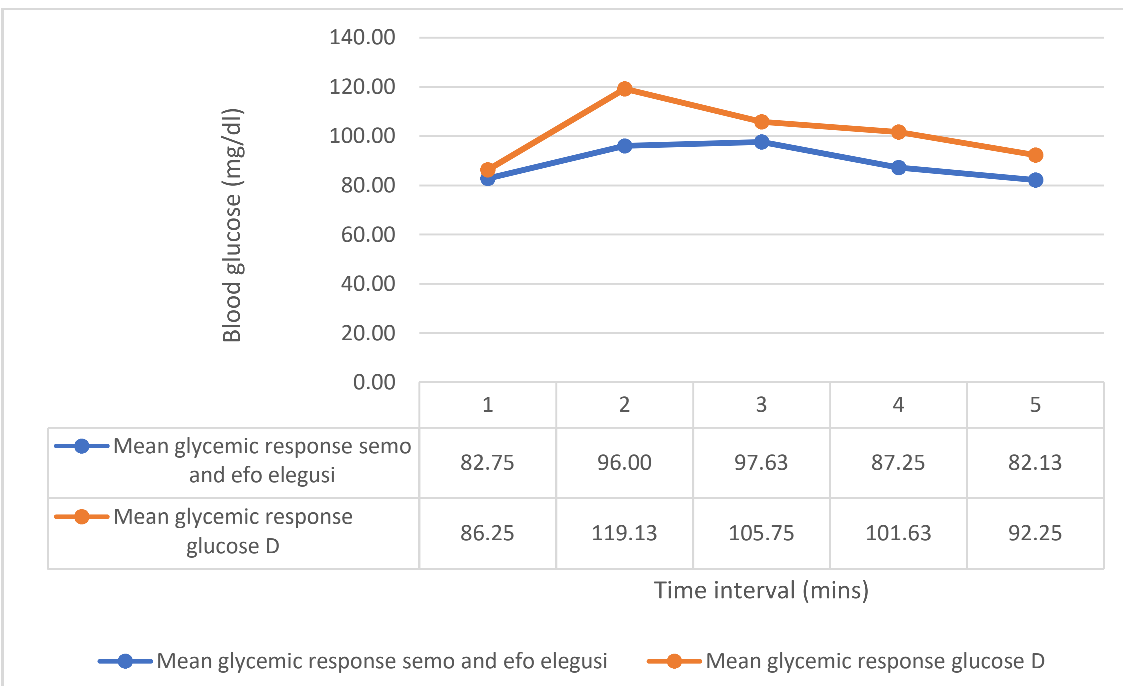


Appendix 6.34: Mean glycaemicindex values and mean glycaemic response curves of semovita and *efoelegusi* soup

Table 6.34a - **Mean glycaemicindex valuessemovita and *efoelegusi* soup**

2 HR TEST MEAL- SEMOVITA AND *EFO ELEGUSI*		
Time	Test meal	Glucose D
0 mins	82.75	86.25
30 mins	96	119.13
60 mins	97.63	105.75
90 mins	87.25	101.63
120 mins	82.13	92.25
AUC	10899.60	12472.8
GI	87.38695401	

Figure 6.34a - Mean glycaemic response curves of semovita and *efoelegusi* soup

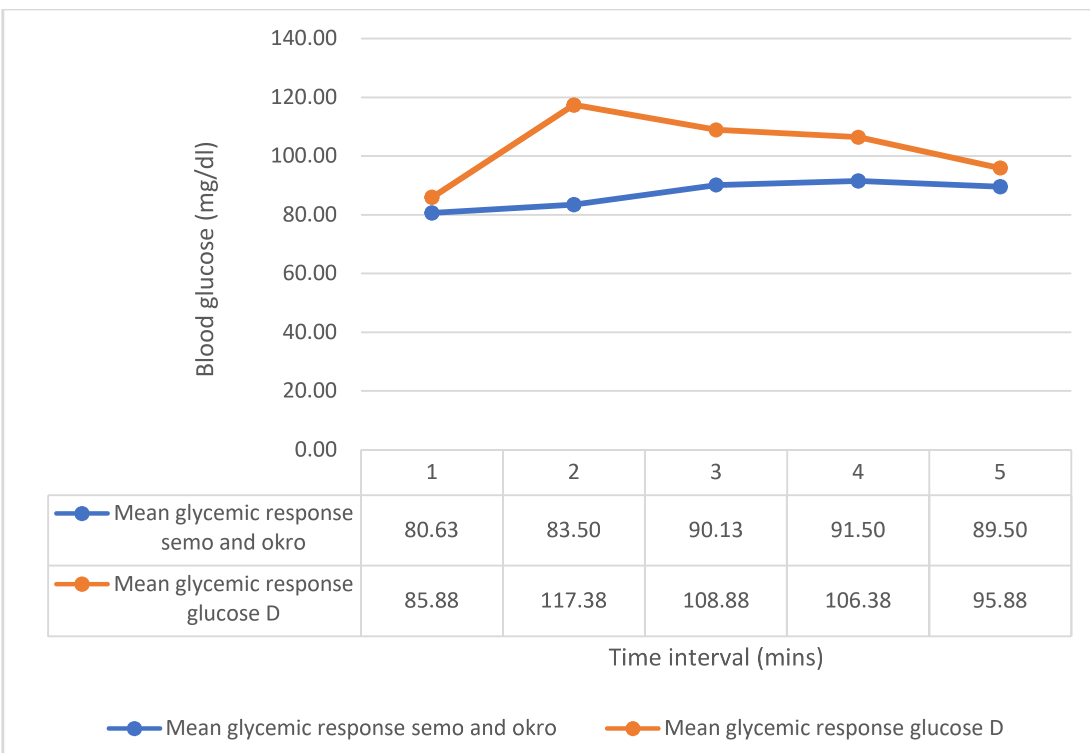


Appendix 6.35: Mean glycaemicindex values and mean glycaemic response curves of semovita and okra soup

Table 6.35a - **Mean glycaemicindex valuesof semovita and okra soup**

2 HR TEST MEAL- SEMOVITA AND OKRA		
Time	Test meal	Glucose D
0 mins	80.63	85.88
30 mins	83.5	117.38
60 mins	90.13	108.88
90 mins	91.5	106.38
120 mins	89.5	95.88
AUC	10505.85	12707.6
GI	82.67375429	

Figure 6.35a - **Mean glycaemic response curves of semovita and okra soup**

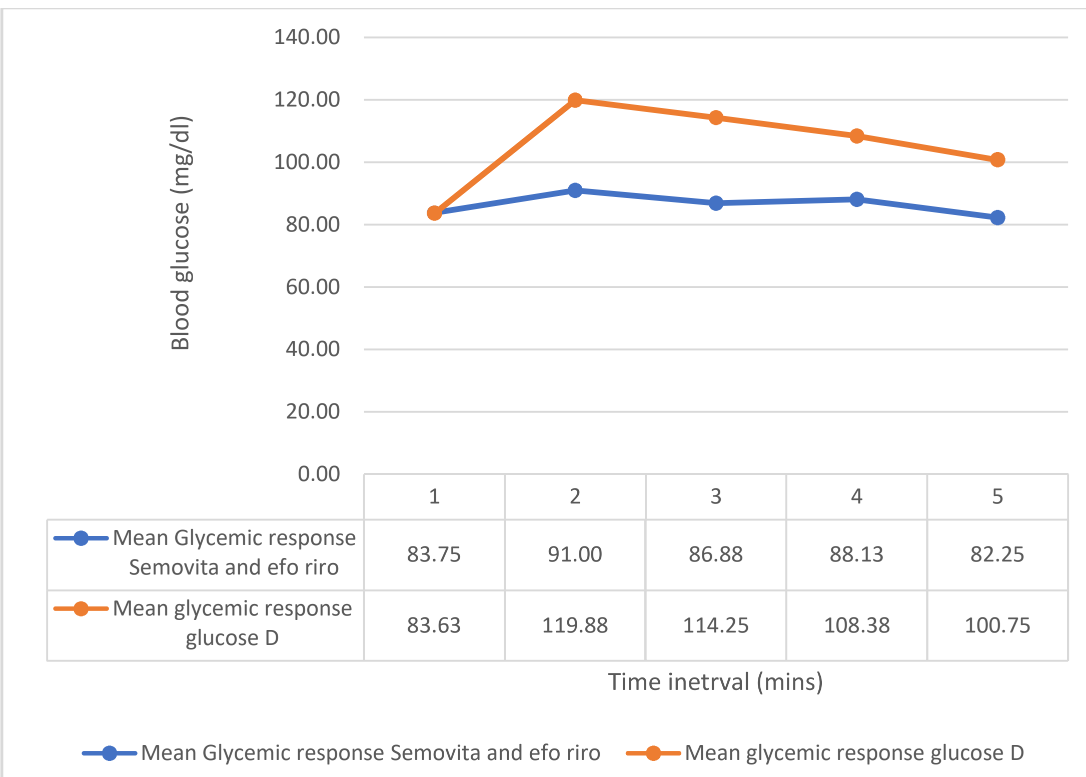


Appendix 6.36: Mean glycaemicindex values and mean glycaemic response curves of semovita and *eforiro* soup

Table 6.36a - Mean glycaemicindex valuesof semovita and *eforiro* soup

2 HR TEST MEAL- SEMOVITA AND *EFO RIRO*		
Time	Test meal	Glucose D
0 mins	83.75	83.63
30 mins	91	119.88
60 mins	86.88	114.25
90 mins	88.13	108.38
120 mins	82.25	100.75
AUC	10470.30	13041
GI	80.28755464	

Figure 6.36a - **Mean glycaemic response curves of semovita and *eforiro* soup**

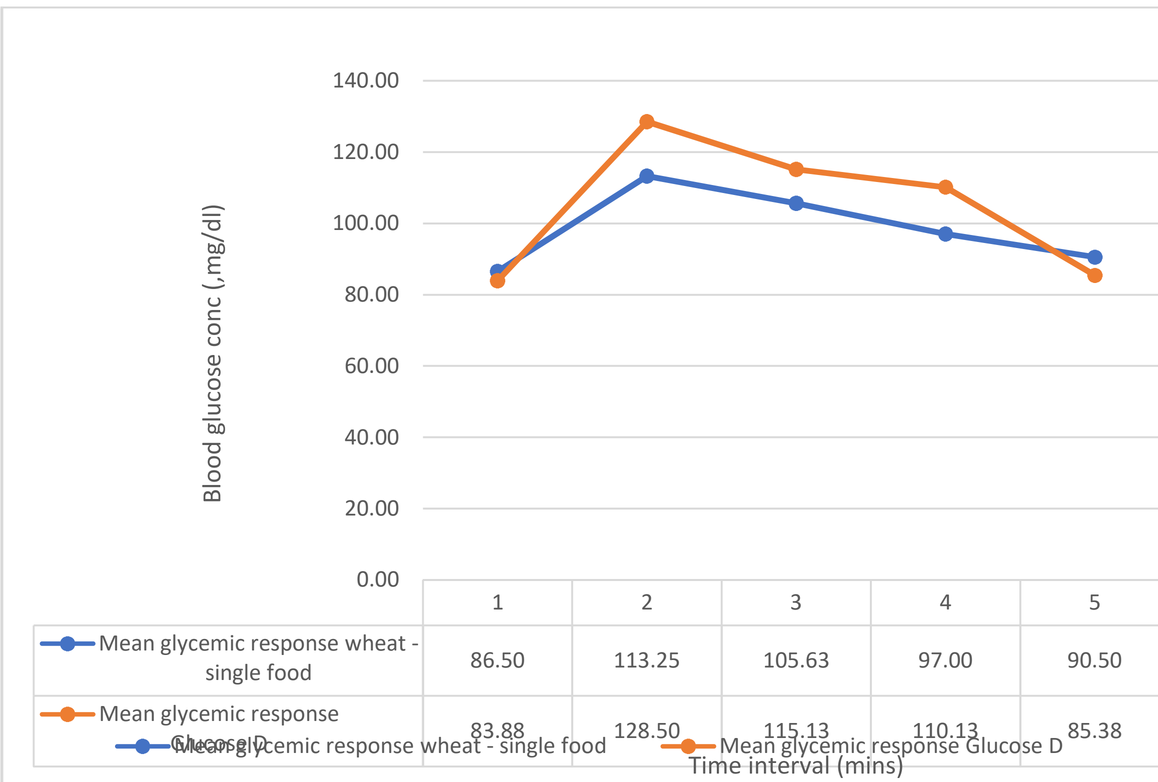


Appendix 6.37: Mean glycaemicindex values and mean glycaemic response curves of wheat

Table 6.37a - **Mean glycaemicindex valuesof wheat**

2 HR TEST MEAL- WHEAT		
Time	Test meal	Glucose D
0 mins	86.5	83.88
30 mins	113.25	128.5
60 mins	105.63	115.13
90 mins	97	110.13
120 mins	90.5	85.38
AUC	12131.40	13151.7
GI	92.24206757	

Figure 6.37a - **Mean glycaemic response curves of wheat**

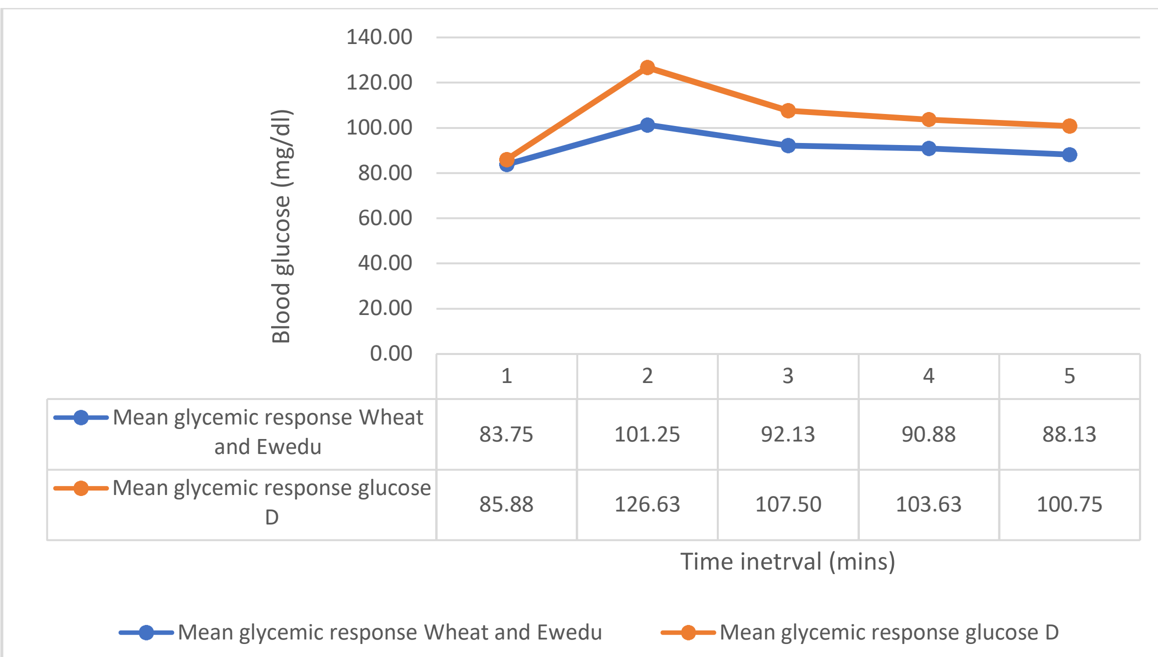


Appendix 6.38: Mean glycaemicindex values and mean glycaemic response curves of wheat and *ewedu* soup

Table 6.38a - **Mean glycaemicindex valuesof wheat and *ewedu* soup**

2 HR TEST MEAL- WHEAT AND *EWEDU*		
Time	Test meal	Glucose D
0 mins	83.75	85.88
30 mins	101.25	126.63
60 mins	92.13	107.5
90 mins	90.88	103.63
120 mins	88.13	100.75
AUC	11106.00	12932.25
GI	85.87832744	

Figure 6.38a - **Mean glycaemic response curves of wheat and *ewedu* soup**

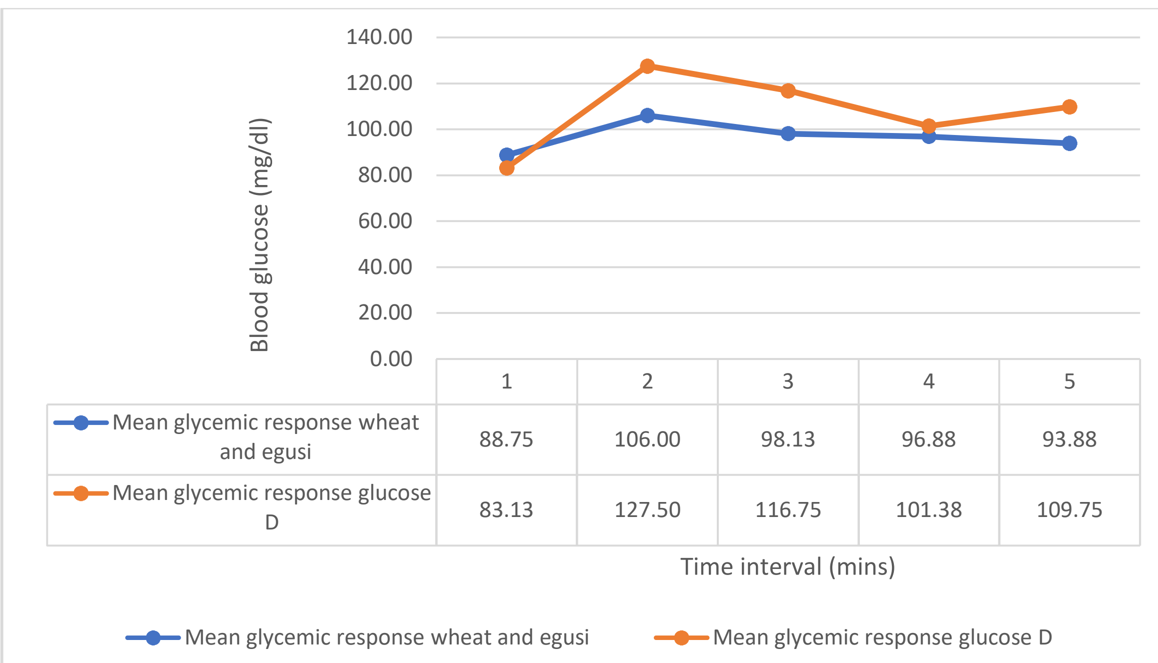


Appendix 6.39: Mean glycaemicindex values and mean glycaemic response curves of wheat and *efoelegusi* soup

Table 6.39a - **Mean glycaemicindex valuesof wheat and *efoelegusi* soup**

2 HR TEST MEAL- WHEAT AND *EFO ELEGUSI*		
Time	Test meal	Glucose D
0 mins	88.75	83.13
30 mins	106	127.5
60 mins	98.13	116.75
90 mins	96.88	101.38
120 mins	93.88	109.75
AUC	11769.75	13262.1
GI	88.74725722	

Figure 6.39a – **Mean glycaemic response curves of wheat and *efoelegusi* soup**

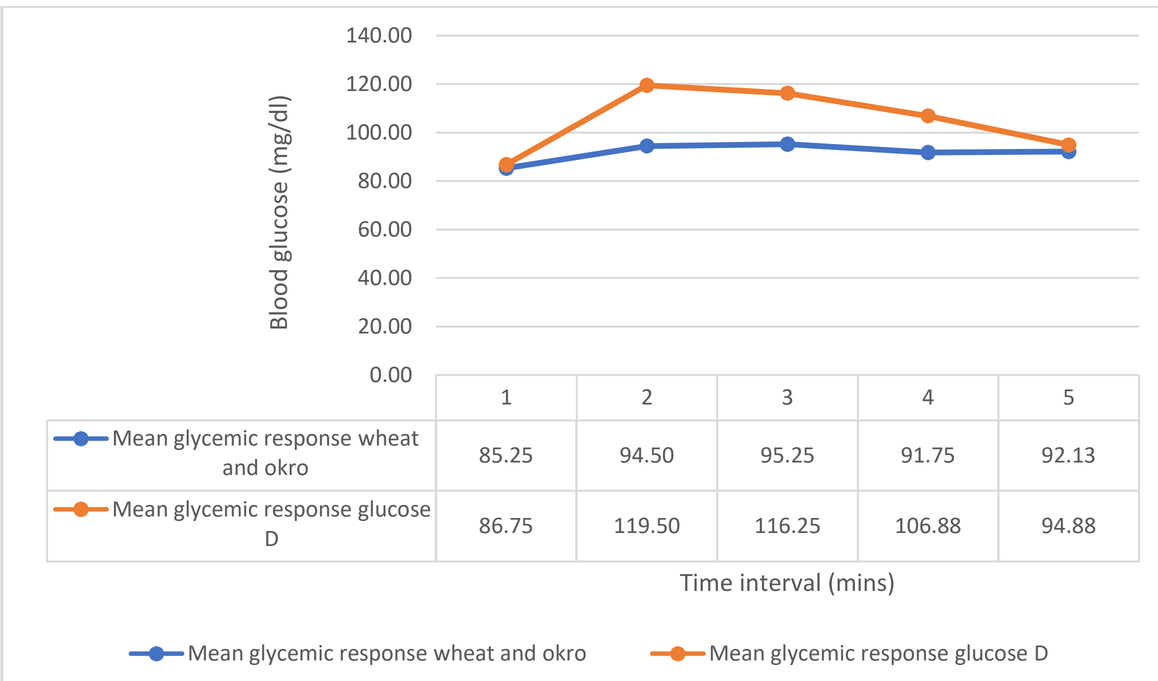


Appendix 6.40: Mean glycaemicindex values and mean glycaemic response curves of wheat and okra soup

Table 6.40a - **Mean glycaemicindex valuesof wheat and okra soup**

2 HR TEST MEAL- WHEAT AND OKRA		
Time	Test meal	Glucose D
0 mins	85.25	86.75
30 mins	94.5	119.5
60 mins	95.25	116.25
90 mins	91.75	106.88
120 mins	92.13	94.88
AUC	11105.70	13003.35
GI	85.40645295	

Figure 6.40a - **Mean glycaemic response curves of wheat and okra soup**

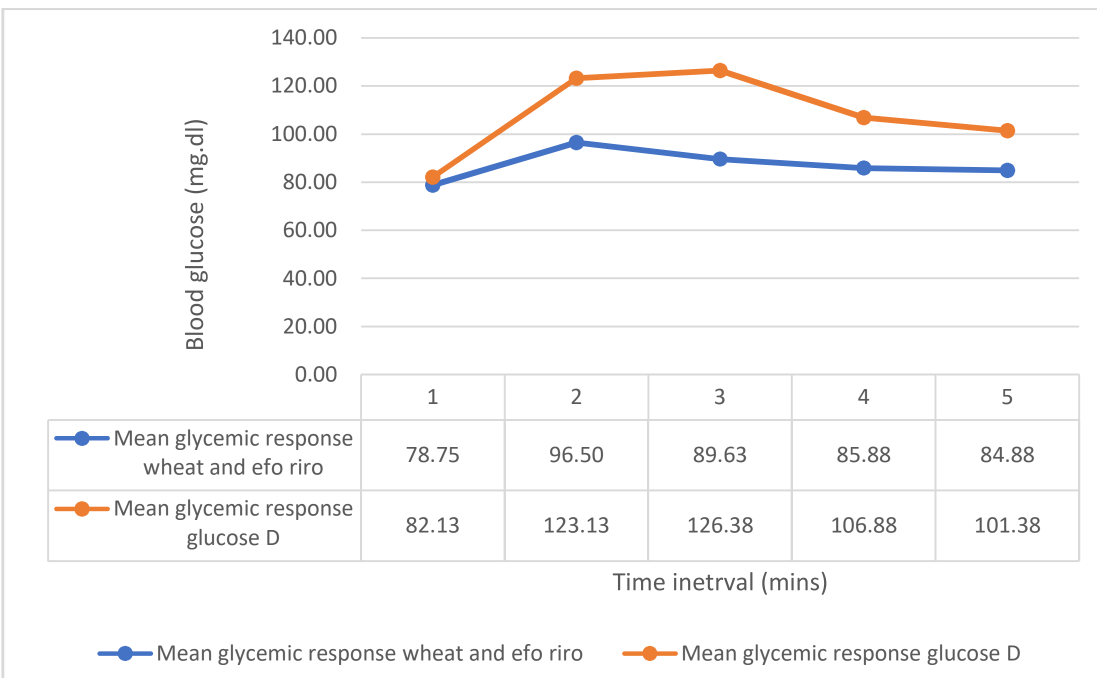


Appendix 6.41: Mean glycaemicindex values and mean glycaemic response curves of wheat and *eforiro* soup

Table 6.41a - **Mean glycaemicindex valuesof wheat and *eforiro* soup**

2 HR TEST MEAL- WHEAT AND *EFO RIRO*		
Time	Test meal	Glucose D
0 mins	78.75	82.13
30 mins	96.5	123.13
60 mins	89.63	126.38
90 mins	85.88	106.88
120 mins	84.88	101.38
AUC	10614.75	13444.35
GI	78.95324058	

Figure 6.41a - **Mean glycaemic response curves of wheat and *eforiro* soup**

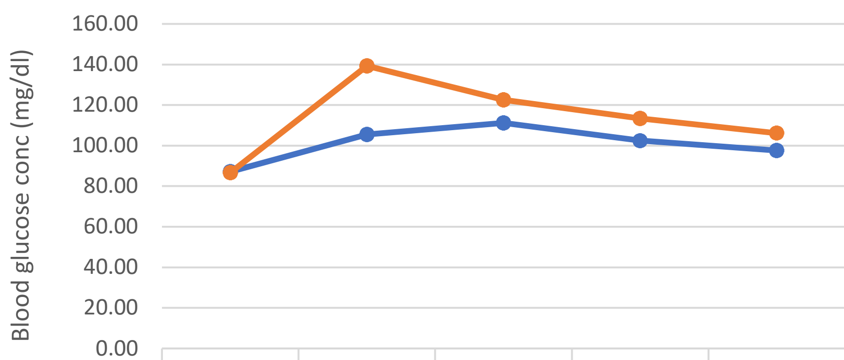


Appendix 6.42: Mean glycaemicindex values and mean glycaemic response curves of white bread (Foodco)

Table 6.42a - **Mean glycaemicindex valuesof white bread (Foodco)**

2 HR TEST MEAL- WHITE BREAD		
Time	Test meal	Glucose D
0 mins	87.13	86.63
30 mins	105.38	139.25
60 mins	111.13	122.5
90 mins	102.38	113.38
120 mins	97.5	106.13
AUC	12336.15	14145.3
GI	87.21023944	

Figure 6.42a - **Mean glycaemic response curves of white bread (Foodco)**



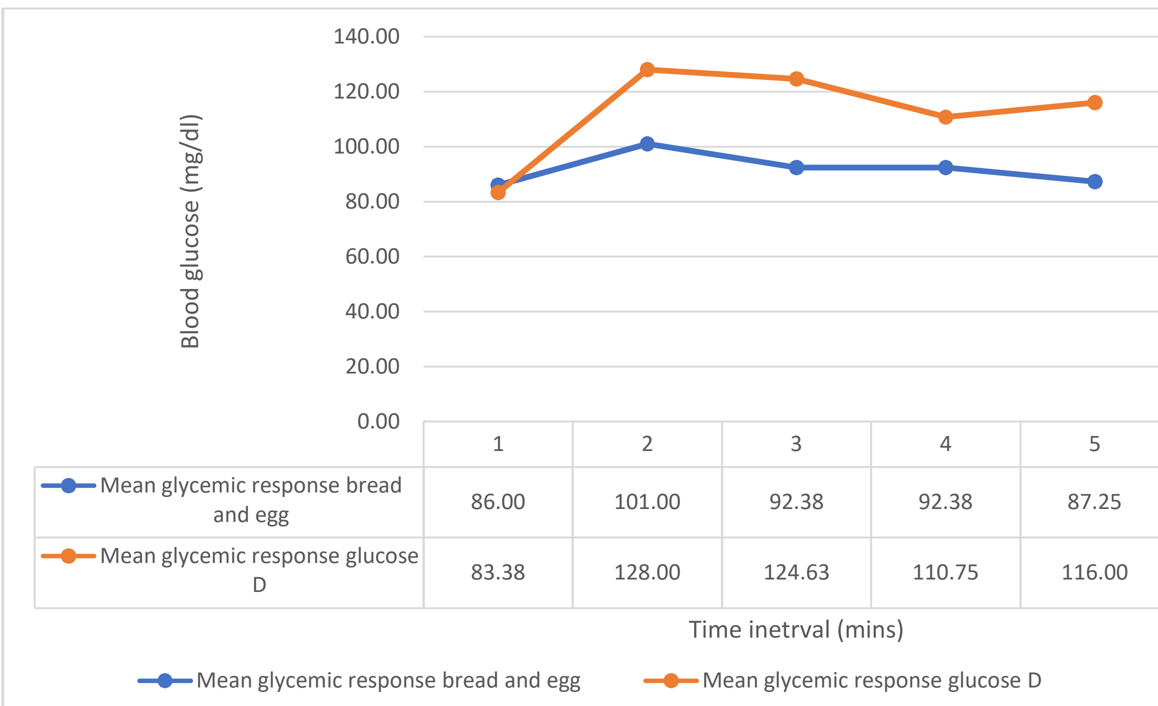
	1	2	3	4	5
Mean glycemic response white bread -single food	87.13	105.38	111.13	102.38	97.50
Mean glycemic response glucose D	86.63	139.25	122.50	113.38	106.13

Appendix 6.43: Mean glycaemicindex values and mean glycaemic response curves of bread and egg

Table 6.43a **- Mean glycaemicindex valuesof bread and egg**

2 HR TEST MEAL- BREAD AND EGG		
Time	Test meal	Glucose D
0 mins	86	83.38
30 mins	101	128
60 mins	92.38	124.63
90 mins	92.38	110.75
120 mins	87.25	116
AUC	11171.55	13892.1
GI	80.41656769	

Figure 6.43a **- Mean glycaemic response curves of bread and egg**

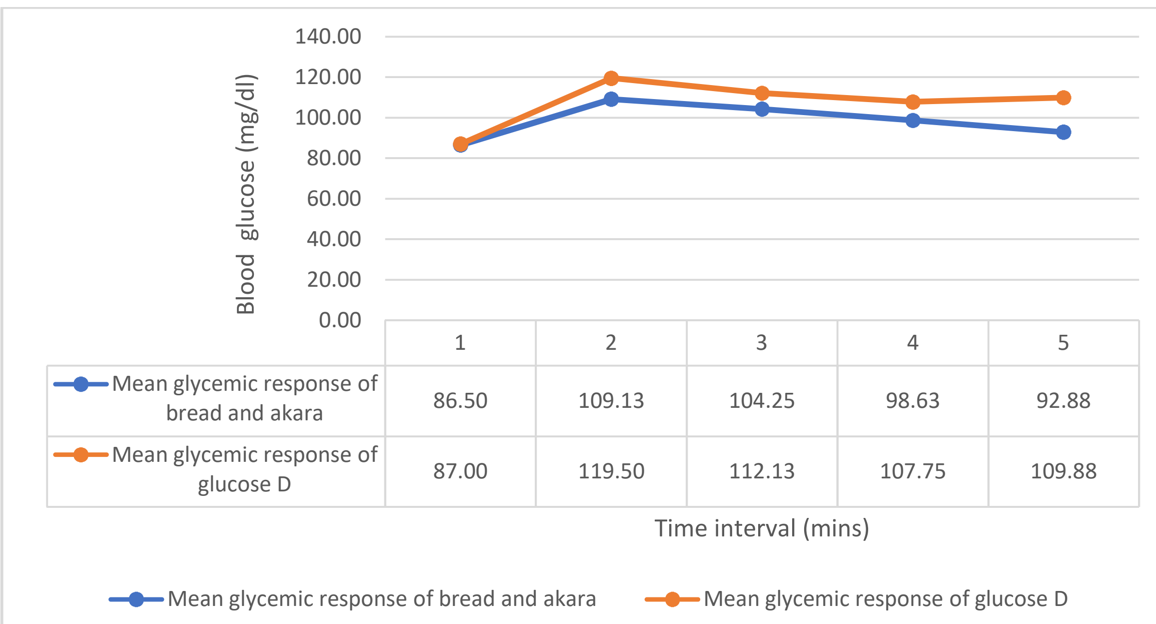


Appendix 6.44: Mean glycaemicindex values and mean glycaemic response curves of bread and *akara*

Table 6.44a - **Mean glycaemicindex valuesof bread and *akara***

2 HR TEST MEAL- BREAD AND *AKARA*		
Time	Test meal	Glucose D
0 mins	86.5	87
30 mins	109.13	119.5
60 mins	104.25	112.13
90 mins	98.63	107.75
120 mins	92.88	109.88
AUC	12051.00	13134.6
GI	91.75003426	

Figure 6.44a - **Mean glycaemic response curves of bread and *akara***

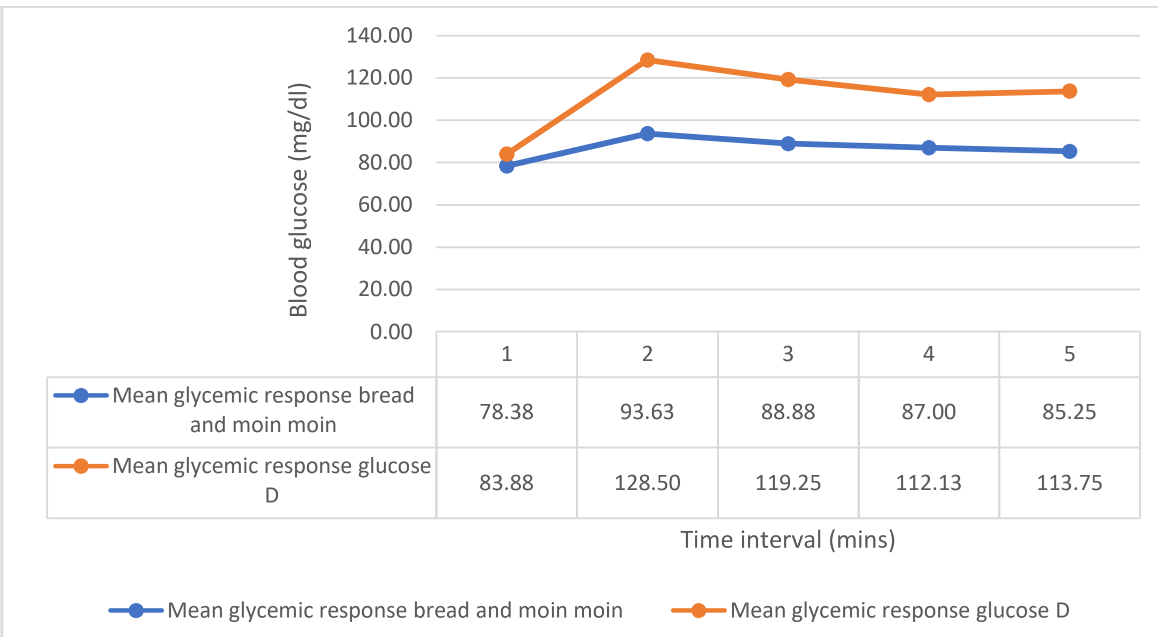


Appendix 6.45: Mean glycaemicindex values and mean glycaemic response curves of bread and *moinmoin*

Table 6.45a - **Mean glycaemicindex valuesof bread and *moinmoin***

2 HR TEST MEAL- BREAD AND *MOIN MOIN*		
Time	Test meal	Glucose D
0 mins	78.38	83.88
30 mins	93.63	128.5
60 mins	88.88	119.25
90 mins	87	112.13
120 mins	85.25	113.75
AUC	10539.75	13760.85
GI	76.59228899	

Figure 6.45a - **Mean glycaemic response curves of bread and *moinmoin***

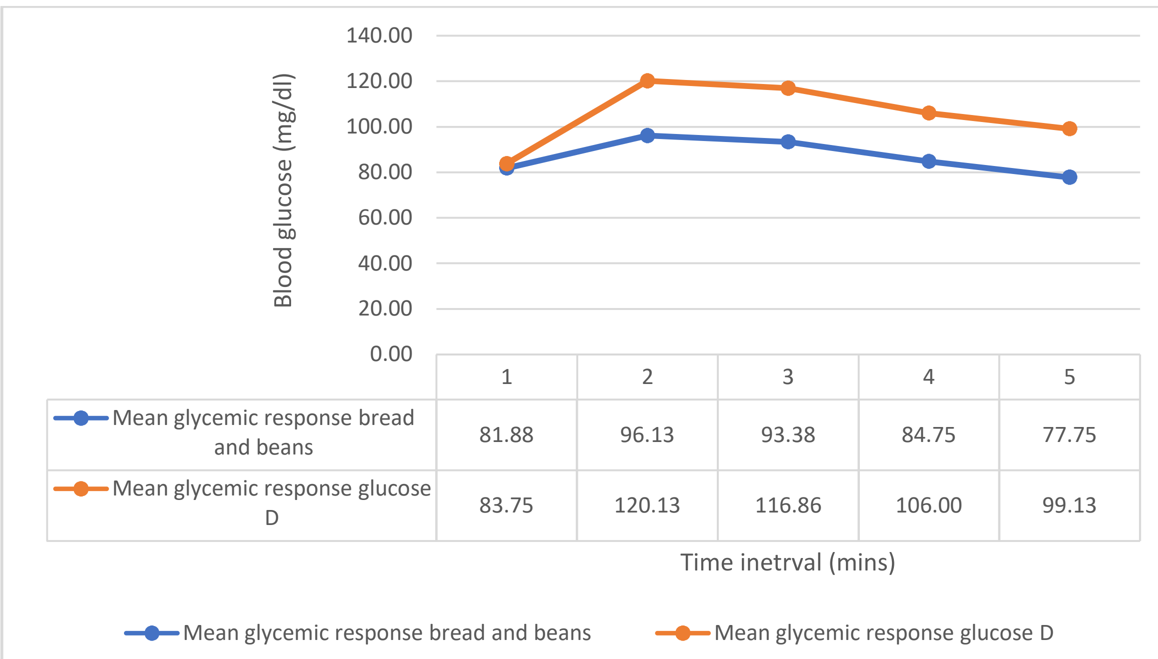


Appendix 6.46: Mean glycaemicindex values and mean glycaemic response curves of bread and beans

Table 6.46a - **Mean glycaemicindex valuesof bread and beans**

2 HR TEST MEAL- BREAD AND BEANS		
Time	Test meal	Glucose D
0 mins	81.88	83.75
30 mins	96.13	120.13
60 mins	93.38	116.86
90 mins	84.75	106
120 mins	77.75	99.13
AUC	10622.25	13032.9
GI	81.50334922	

Figure 6.46a - **Mean glycaemic response curves of bread and beans**

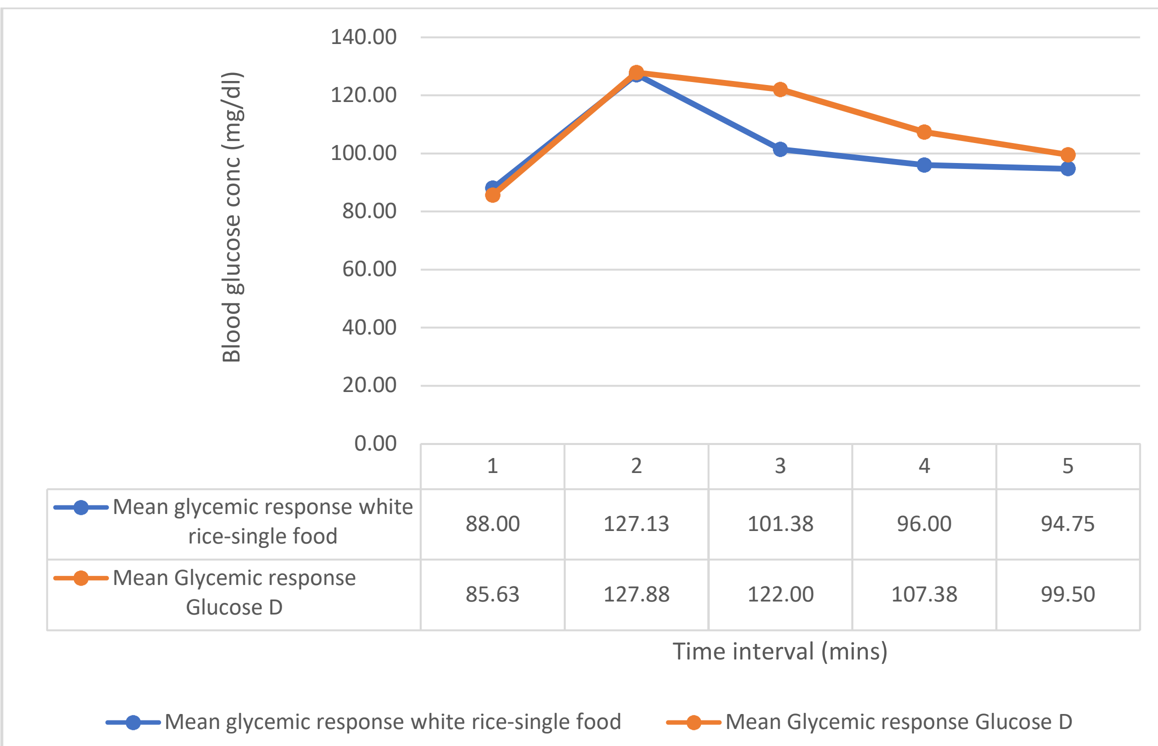


Appendix 6.47: Mean glycaemicindex values and mean glycaemic response curves of White rice – boiled

Table 6.47a - **Mean glycaemicindex valuesof White rice - boiled**

2 HR TEST MEAL- WHITE RICE - BOILED		
Time	Test meal	Glucose D
0 mins	88	85.63
30 mins	127.13	127.88
60 mins	101.38	122
90 mins	96	107.38
120 mins	94.75	99.5
AUC	12476.55	13494.75
GI	92.45484355	

Figure 6.47a - **Mean glycaemic response curves of White rice – boiled**

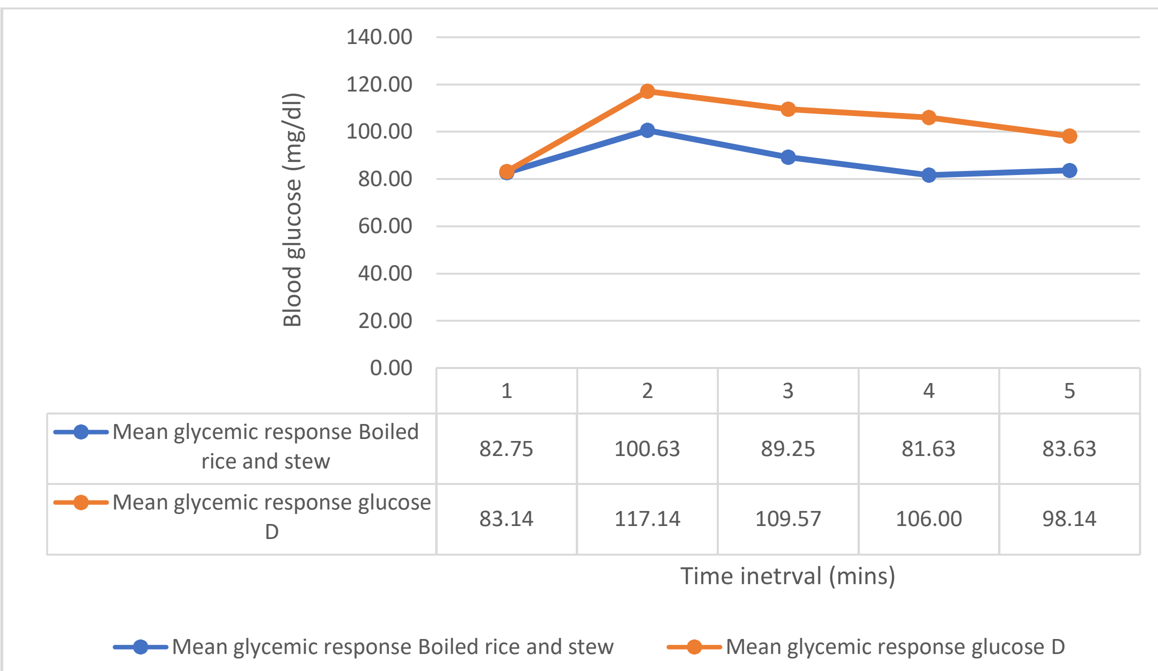


Appendix 6.48: Mean glycaemicindex values and mean glycaemic response curves of boiled rice and stew

Table 6.48a - **Mean glycaemicindex values of boiled rice and stew**

2 HR TEST MEAL- BOILED RICE AND STEW		
Time	Test meal	Glucose D
0 mins	82.75	83.14
30 mins	100.63	117.14
60 mins	89.25	109.57
90 mins	81.63	106
120 mins	83.63	98.14
AUC	10641.00	12700.5
GI	83.78410299	

Figure 6.48a - **Mean glycaemic response curves of boiled rice and stew**

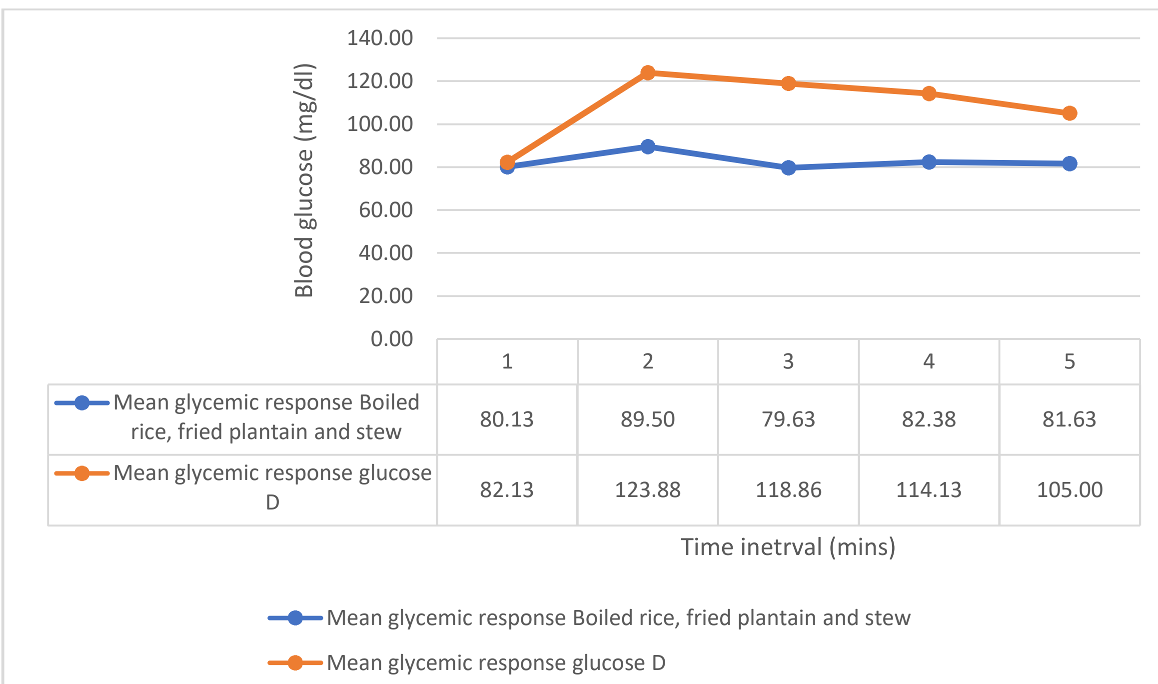


Appendix 6.49: Mean glycaemicindex values and mean glycaemic response curves of boiled rice, fried plantain and stew

Table 6.49a **- Mean glycaemicindex valuesof boiled rice, fried plantain and stew**

2 HR TEST MEAL- BOILED RICE, FRIED PLAINTAIN AND STEW		
Time	Test meal	Glucose D
0 mins	80.13	82.13
30 mins	89.5	123.88
60 mins	79.63	118.86
90 mins	82.38	114.13
120 mins	81.63	105
AUC	9971.70	13513.05
GI	73.7931111	

Figure 6.49a **- Mean glycaemic response curves of boiled rice, fried plantain and stew**

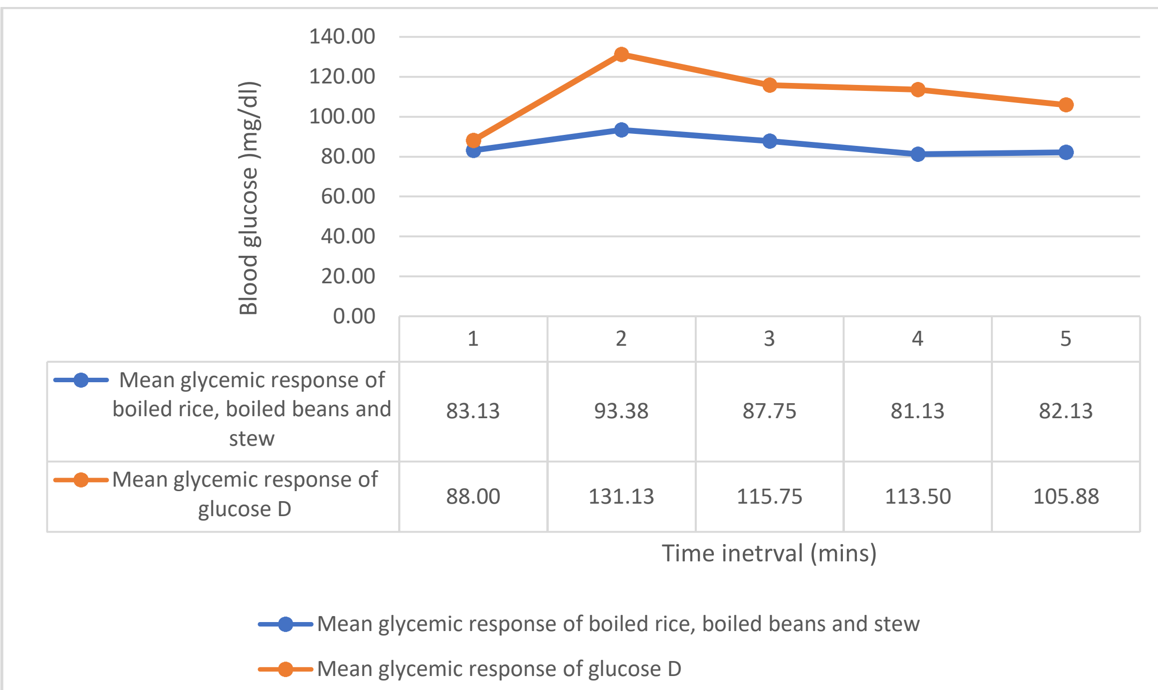


Appendix 6.50: Mean glycaemicindex values and mean glycaemic response curves of boiled rice, boiled beans and stew

Table 6.50a **-Mean glycaemicindex valuesof boiled rice, boiled beans and stew**

2 HR TEST MEAL- BOILED RICE, BOILED BEANS AND STEW		
Time	Test meal	Glucose D
0 mins	83.13	88
30 mins	93.38	131.13
60 mins	87.75	115.75
90 mins	81.13	113.5
120 mins	82.13	105.88
AUC	10346.70	13719.6
GI	75.41546401	

Figure 6.50a **- Mean glycaemic response curves of boiled rice, boiled beans and stew**

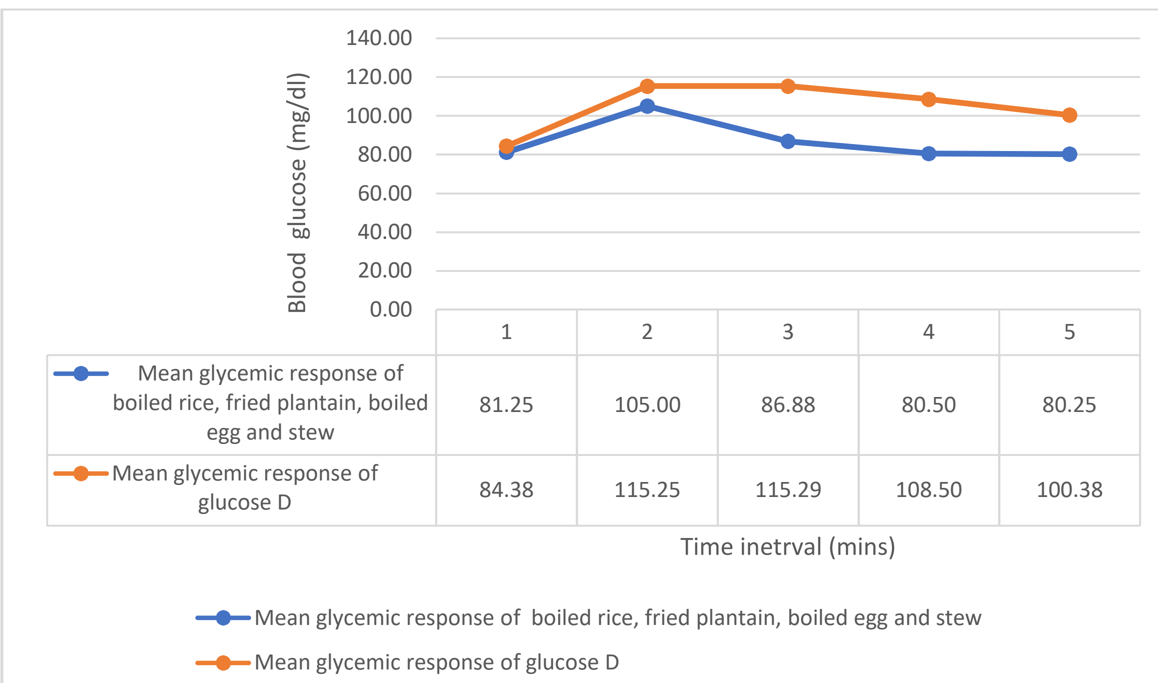


Appendix 6.51: Mean glycaemicindex values and mean glycaemic response curves of boiled rice, fried plantain, boiled beans, boiled egg and stew

Table 6.51a - **Mean glycaemicindex valuesof boiled rice, fried plantain, boiled beans, boiled egg and stew**

2 HR TEST MEAL- BOILED RICE, FRIED PLANTAIN, BOILED BEANS, BOILED EGG AND STEW		
Time	Test meal	Glucose D
0 mins	81.25	84.38
30 mins	105	115.25
60 mins	86.88	115.29
90 mins	80.5	108.5
120 mins	80.25	100.38
AUC	10593.90	12942.6
GI	81.85295072	

Figure 6.51a - **mean glycaemic response curves of boiled rice, fried plantain, boiled beans, boiled egg and stew**

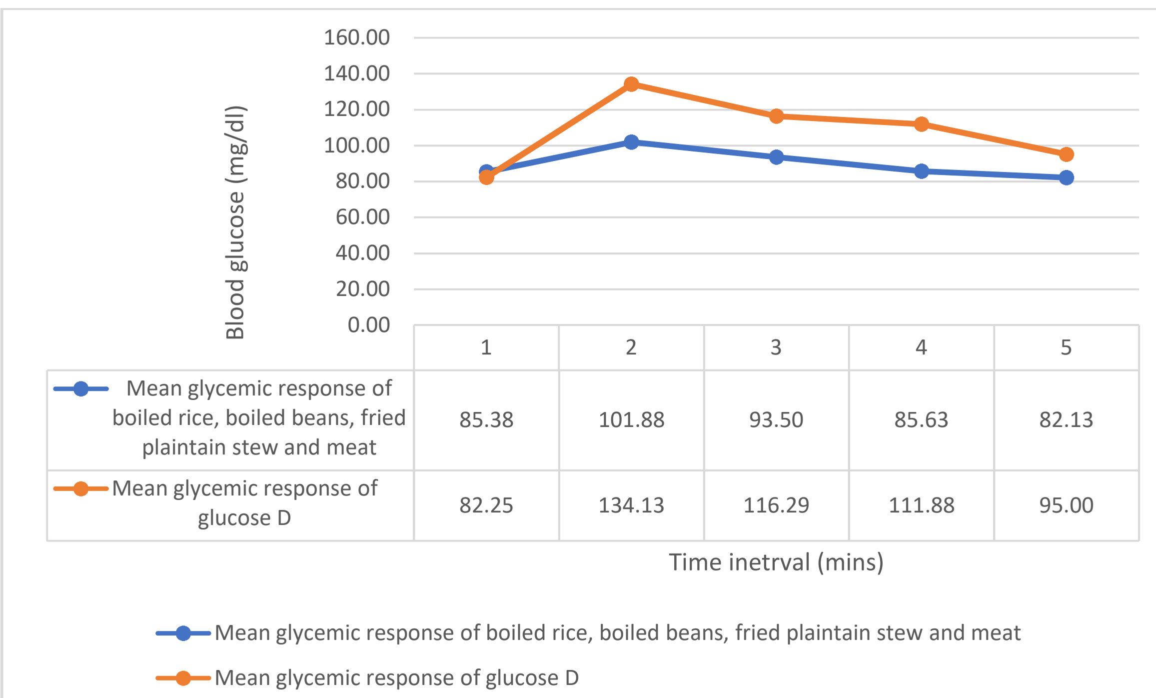


Appendix 6.52: Mean glycaemicindex values and mean glycaemic response curves of boiled rice, boiled beans, fried plantain and stew

Table 6.52a - **Mean glycaemicindex valuesof boiled rice, boiled beans, fried plantain and stew**

2 HR TEST MEAL- BOILED RICE, BOILED BEANS, FRIED PLANTAIN, AND STEW WITH MEAT		
Time	Test meal	Glucose D
0 mins	85.38	82.25
30 mins	101.88	134.13
60 mins	93.5	116.29
90 mins	85.63	111.88
120 mins	82.13	95
AUC	10942.95	13527.75
GI	80.89260964	

Figure 6.52a - **Mean glycaemic response curves of boiled rice, boiled beans, fried plantain and stew**

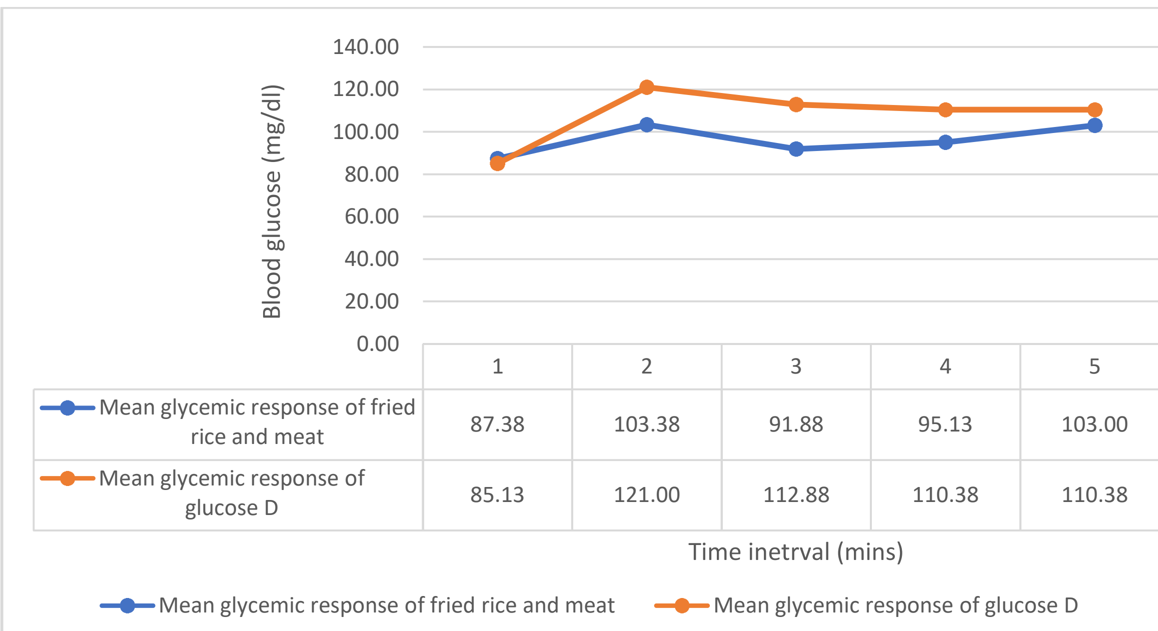


Appendix 6.53: Mean glycaemicindex values and mean glycaemic response curves of Fried rice and meat

Table 6.53a **- Mean glycaemicindex valuesof Fried rice and meat**

2 HR TEST MEAL- FRIED RICE, WITH MEAT		
Time	Test meal	Glucose D
0 mins	87.38	85.13
30 mins	103.38	121
60 mins	91.88	112.88
90 mins	95.13	110.38
120 mins	103	110.38
AUC	11567.40	13260.45
GI	87.23233374	

Figure 6.53a **- Mean glycaemic response curves of Fried rice and meat**

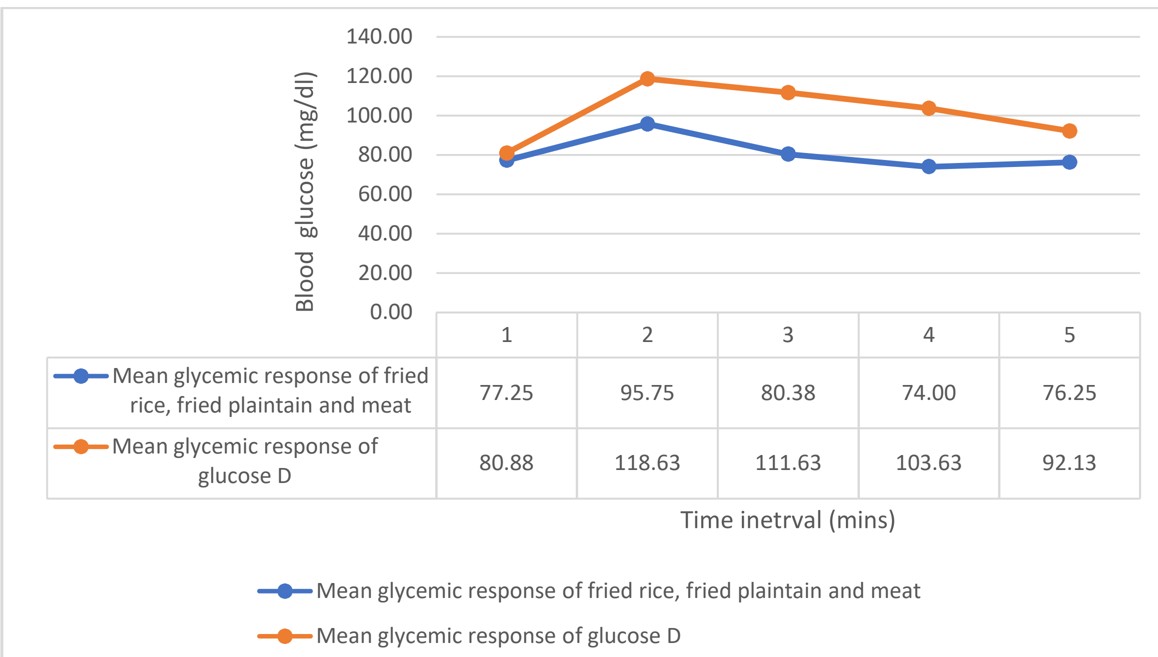


Appendix 6.54: Mean glycaemicindex values and mean glycaemic response curves of Fried rice, fried plantain and meat

Table 6.54a - **Mean glycaemicindex valuesof Fried rice, fried plantain and meat**

2 HR TEST MEAL- FRIED RICE, FRIED PLAINTAIN WITH MEAT		
Time	Test meal	Glucose D
0 mins	77.25	80.88
30 mins	95.75	118.63
60 mins	80.38	111.63
90 mins	74	103.63
120 mins	76.25	92.13
AUC	9806.40	12611.85
GI	77.75544428	

Figure 6.54a - **Mean glycaemic response curves of Fried rice, fried plantain and meat**

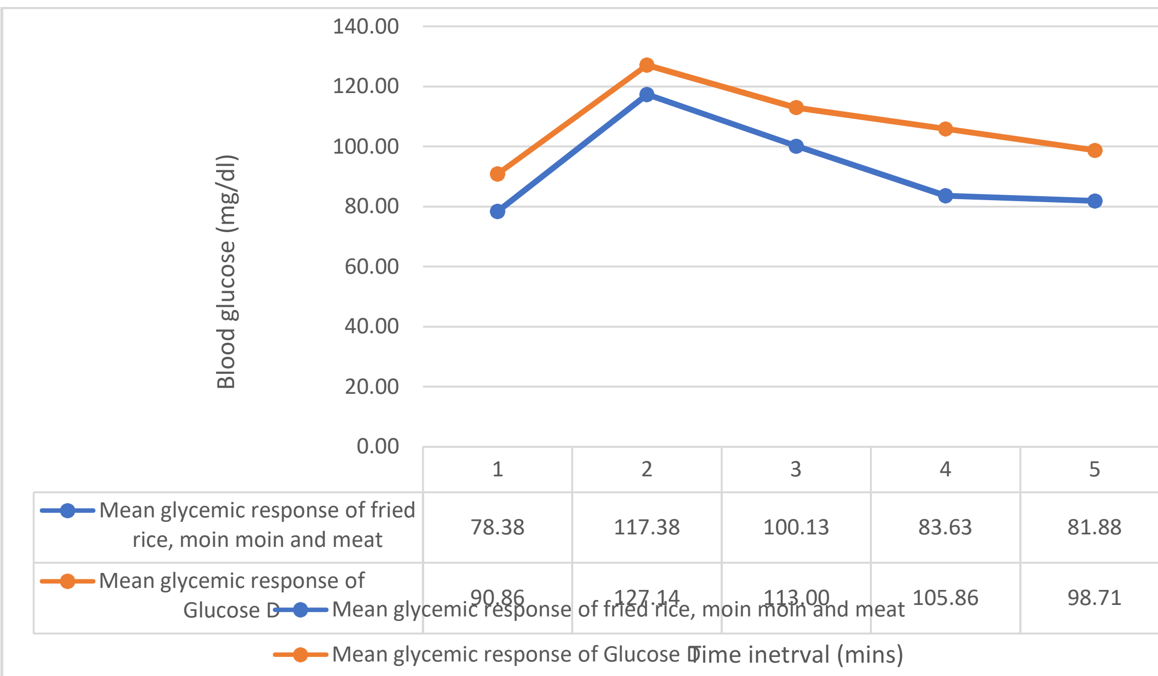


Appendix 6.55: Mean glycaemicindex values and mean glycaemic response curves of fried rice, *moinmoin* and meat

Table 6.55a - Mean glycaemicindex valuesof fried rice, *moinmoin* and meat

2 HR TEST MEAL- FRIED RICE, *MOIN MOIN* WITH MEAT		
Time	Test meal	Glucose D
0 mins	78.38	90.86
30 mins	117.38	127.14
60 mins	100.13	113
90 mins	83.63	105.86
120 mins	81.88	98.71
AUC	11438.10	13223.55
GI	86.49795252	

Figure 6.55a - Mean glycaemic response curves of fried rice, *moinmoin* and meat

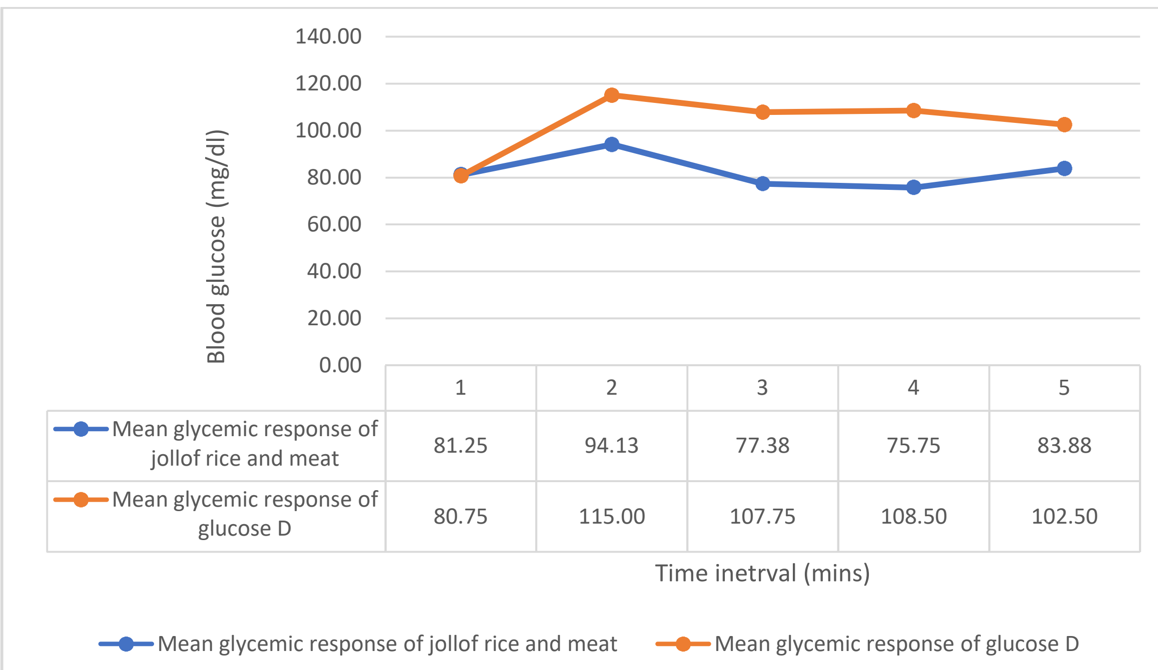


Appendix 6.56: Mean glycaemicindex values and mean glycaemic response curves of jollof rice and meat

Table 6.56a **- Mean glycaemicindex valuesof jollof rice and meat**

2 HR TEST MEAL- JOLLOF RICE, WITH MEAT		
Time	Test meal	Glucose D
0 mins	81.25	80.75
30 mins	94.13	115
60 mins	77.38	107.75
90 mins	75.75	108.5
120 mins	83.88	102.5
AUC	9894.75	12686.25
GI	77.99586166	

Figure 6.56a **- Mean glycaemic response curves of jollof rice and meat**

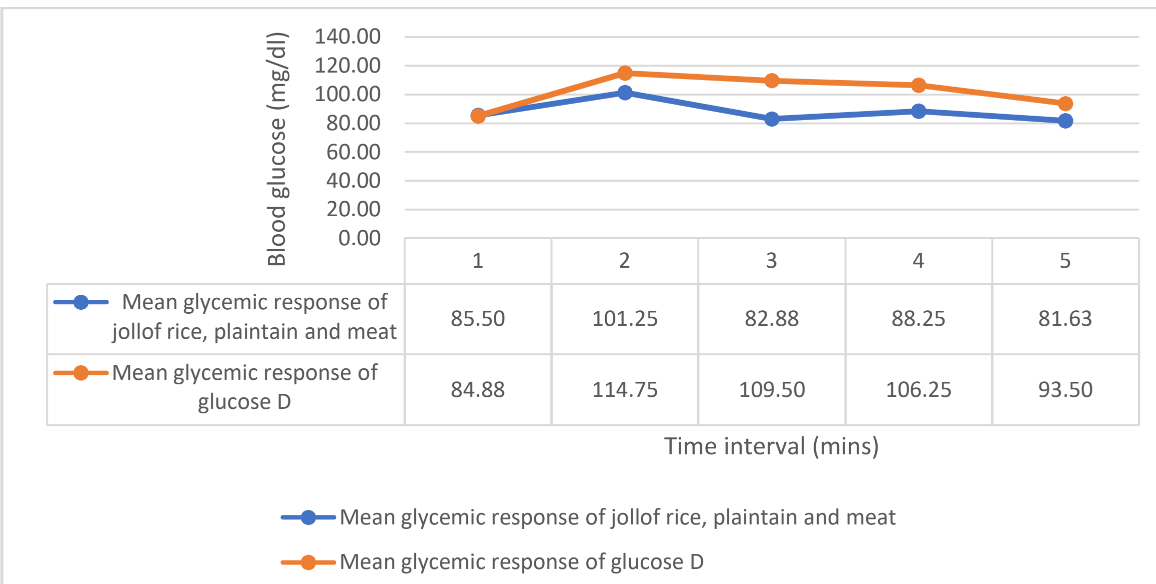


Appendix 6.57: Mean glycaemicindex values and mean glycaemic response curves of Jollof rice, fried plantain and meat

Table 6.57a - **Mean glycaemicindex valuesof Jollof rice, fried plantain and meat**

2 HR TEST MEAL- JOLLOF RICE, FRIED PLANTAIN WITH MEAT		
Time	Test meal	Glucose D
0 mins	85.5	84.88
30 mins	101.25	114.75
60 mins	82.88	109.5
90 mins	88.25	106.25
120 mins	81.63	93.5
AUC	10678.35	12590.7
GI	84.81140842	

Figure 6.57a - **Mean glycaemic response curves of Jollof rice, fried plantain and meat**

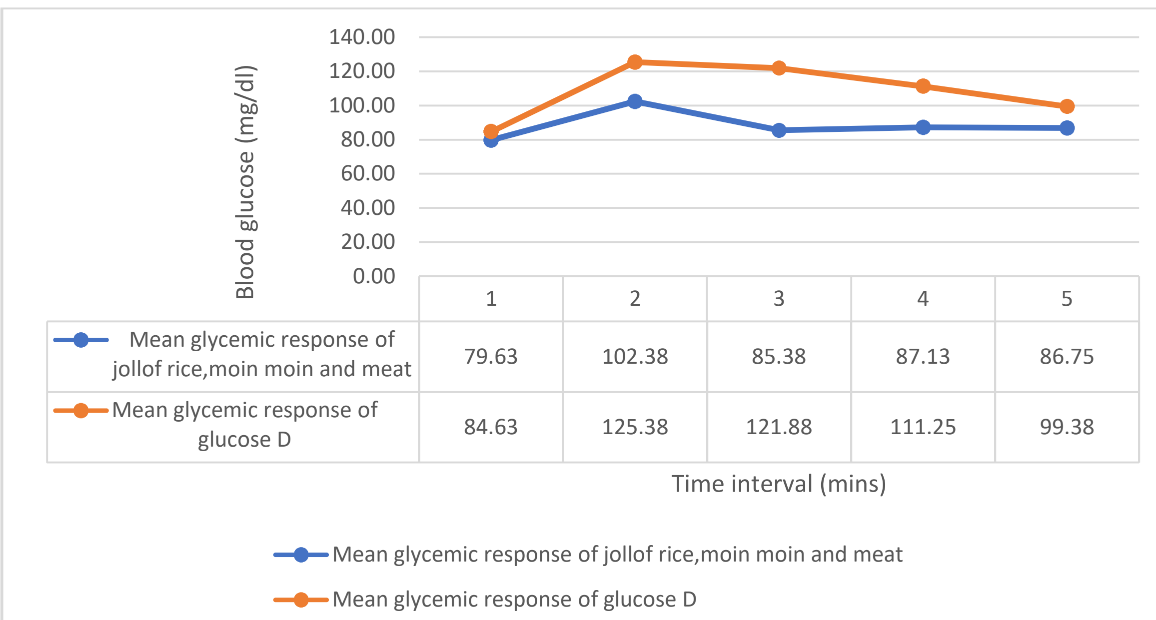


Appendix 6.58: Mean glycaemicindex values and mean glycaemic response curves of jollof rice, *moinmoin* and meat

Table 6.58a - **Mean glycaemicindex valuesof jollof rice, *moinmoin* and meat**

2 HR TEST MEAL- JOLLOF RICE, *MOIN MOIN* WITH MEAT		
Time	Test meal	Glucose D
0 mins	79.63	84.63
30 mins	102.38	125.38
60 mins	85.38	121.88
90 mins	87.13	111.25
120 mins	86.75	99.38
AUC	10742.40	13515.45
GI	79.48237018	

Figure 6.58a - **Mean glycaemic response curves of jollof rice, *moinmoin* and meat**

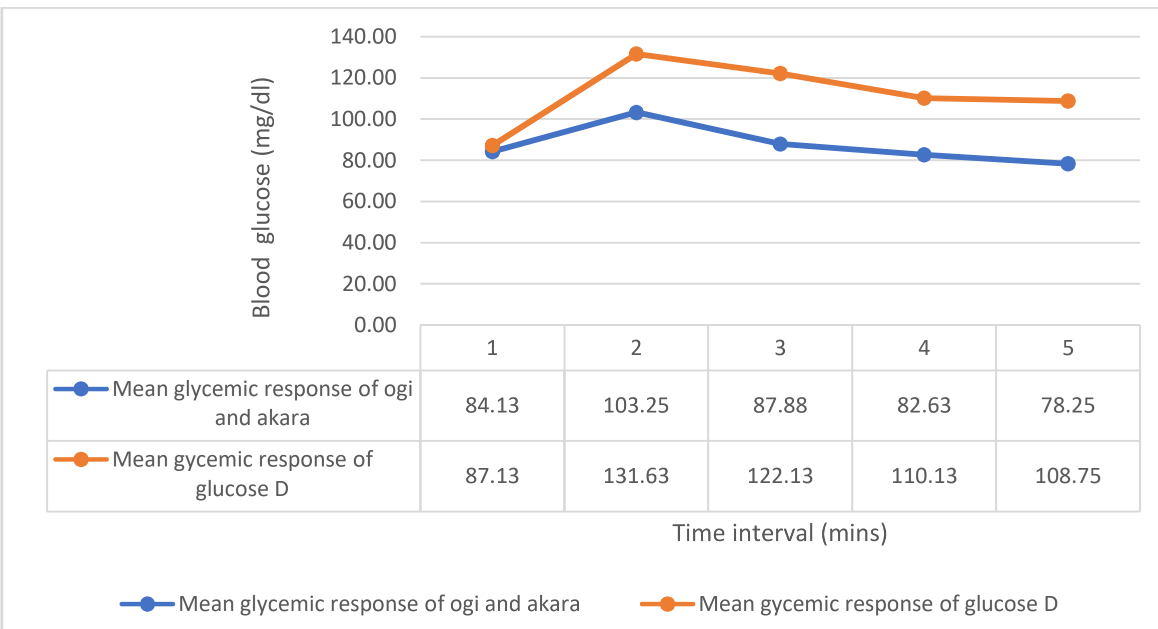


Appendix 6.59: Mean glycaemicindex values and mean glycaemic response curves of *ogi* and *akara*

Table 6.59a - **Mean glycaemicindex valuesof *ogi* and *akara***

2 HR TEST MEAL- *OGI* AND *AKARA*		
Time	Test meal	Glucose D
0 mins	84.13	87.13
30 mins	103.25	131.63
60 mins	87.88	122.13
90 mins	82.63	110.13
120 mins	78.25	108.75
AUC	10648.50	13854.9
GI	76.85728515	

Figure 6.59a - **Mean glycaemic response curves of *ogi* and *akara***

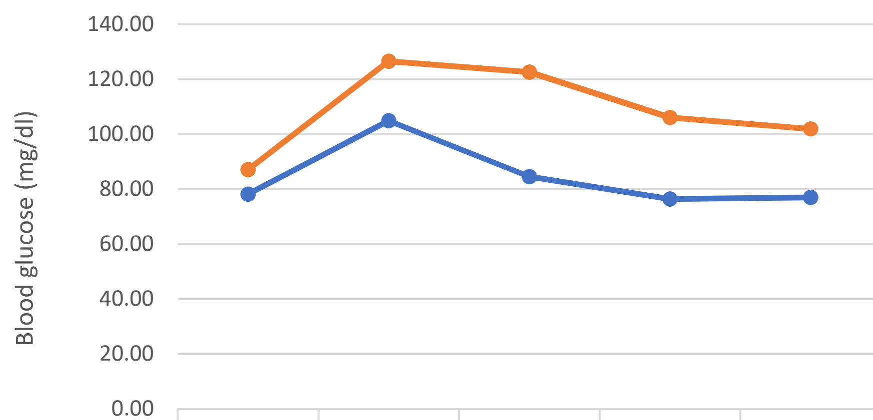


Appendix 6.60: Mean glycaemicindex values and mean glycaemic response curves of *ogi* and *moinmoin*

Table 6.60a - Mean glycaemicindex valuesof *ogi* and *moinmoin*

2 HR TEST MEAL- *OGI* AND *MOIN-MOIN*		
Time	Test meal	Glucose D
0 mins	78.13	87
30 mins	104.88	126.5
60 mins	84.5	122.5
90 mins	76.38	106
120 mins	77	101.88
AUC	10299.75	13483.2
GI	76.38950694	

Figure 6.60a **- Mean glycaemic response curves of *ogi* and *moinmoin***



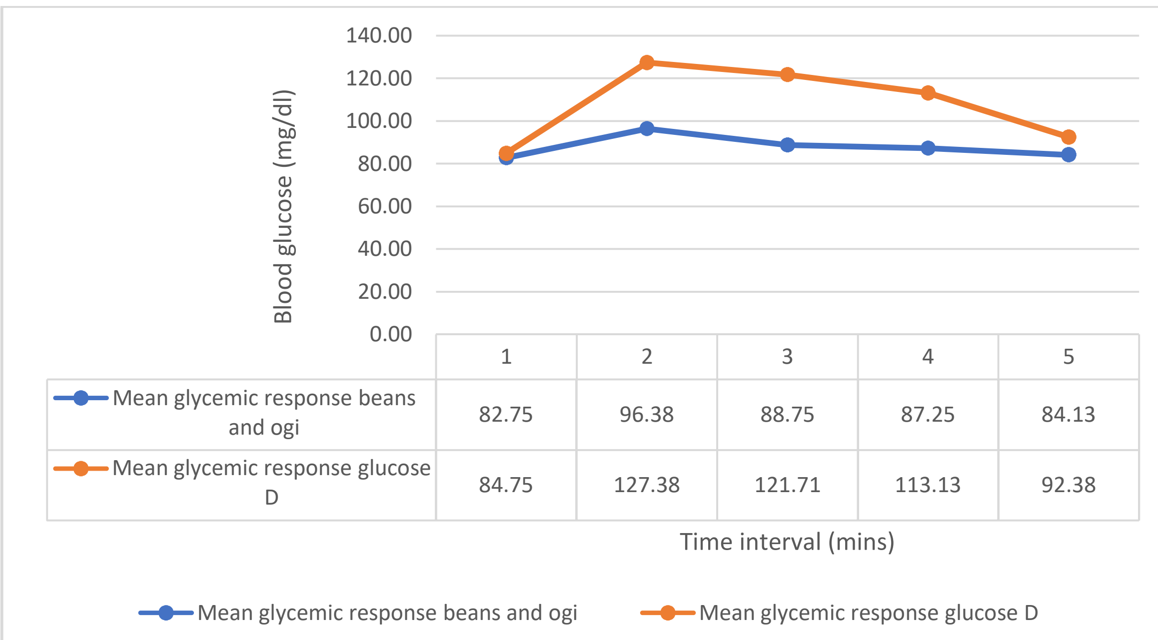
	1	2	3	4	5
Mean glycemic response Ogi and moin moin	78.13	104.88	84.50	76.38	77.00
Mean glycemic response glucose D	87.00	126.50	122.50	106.00	101.88

Appendix 6.61: Mean glycaemicindex values and mean glycaemic response curves of beans and *ogi*

Table 6.61a - **Mean glycaemicindex valuescurves of beans and *ogi***

2 HR TEST MEAL- BEANS AND *OGI*		
Time	Test meal	Glucose D
0 mins	82.75	84.75
30 mins	96.38	127.38
60 mins	88.75	121.71
90 mins	87.25	113.13
120 mins	84.13	92.38
AUC	10674.60	13523.55
GI	78.93341615	

Figure 6.61a - **Mean glycaemic response curves of beans and *ogi***

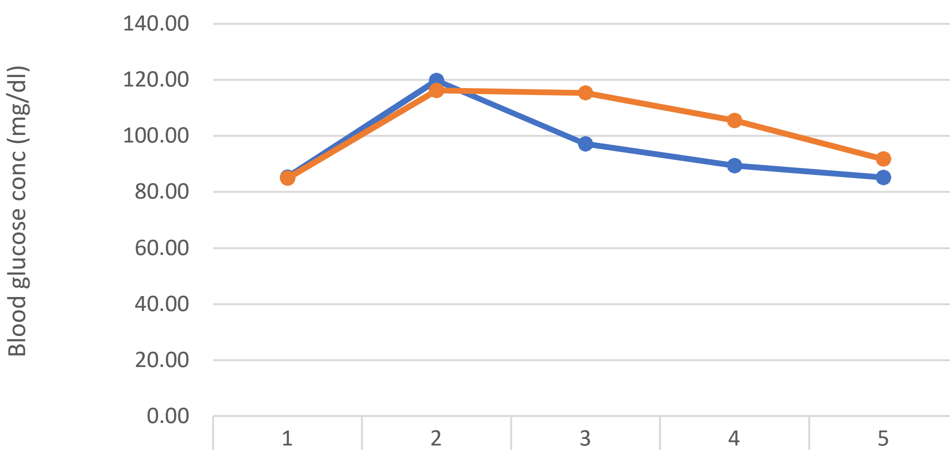


Appendix 6.62: Mean glycaemicindex values and mean glycaemic response curves of *ogi*yellow

Table 6.62a - **Mean glycaemicindex valuesof *ogi*yellow**

2 HR TEST MEAL- *OGI* YELLOW		
Time	Test meal	Glucose D
0 mins	85.25	84.88
30 mins	119.75	116.25
60 mins	97.13	115.38
90 mins	89.38	105.5
120 mins	85.13	91.75
AUC	11743.50	12763.35
GI	92.00954295	

Figure 6.62a - **Mean glycaemic response curves of *ogi*yellow**



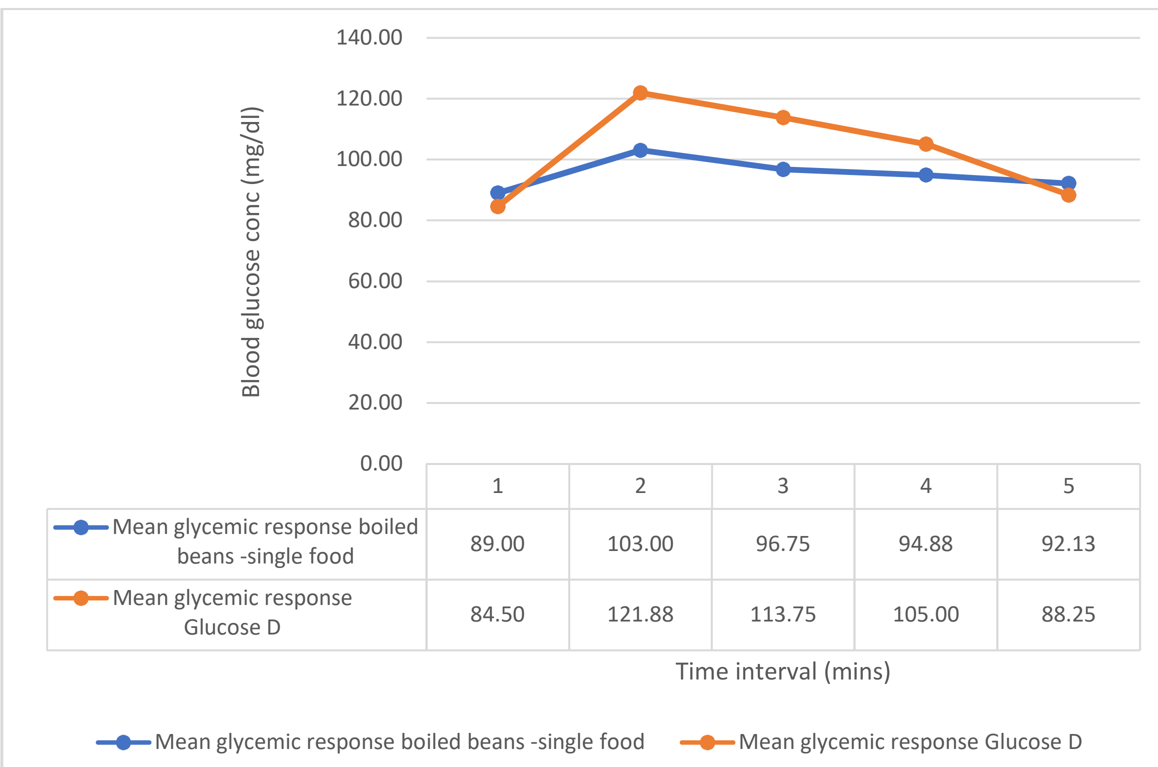
	1	2	3	4	5
Mean glycemic response ogi yellow-single food	85.25	119.75	97.13	89.38	85.13
Mean glycemic response Glucose D	84.88	116.25	115.38	105.50	91.75

Appendix 6.63: Mean glycaemicindex values and mean glycaemic response curves of boiled beans

Table 6.63a **- Mean glycaemicindex valuesof boiled beans**

2 HR TEST MEAL- BOILED BEANS		
Time	Test meal	Glucose D
0 mins	89	84.5
30 mins	103	121.88
60 mins	96.75	113.75
90 mins	94.88	105
120 mins	92.13	88.25
AUC	11555.85	12810.15
GI	90.20854557	

Figure 6.63a **- Mean glycaemic response curves of boiled beans**

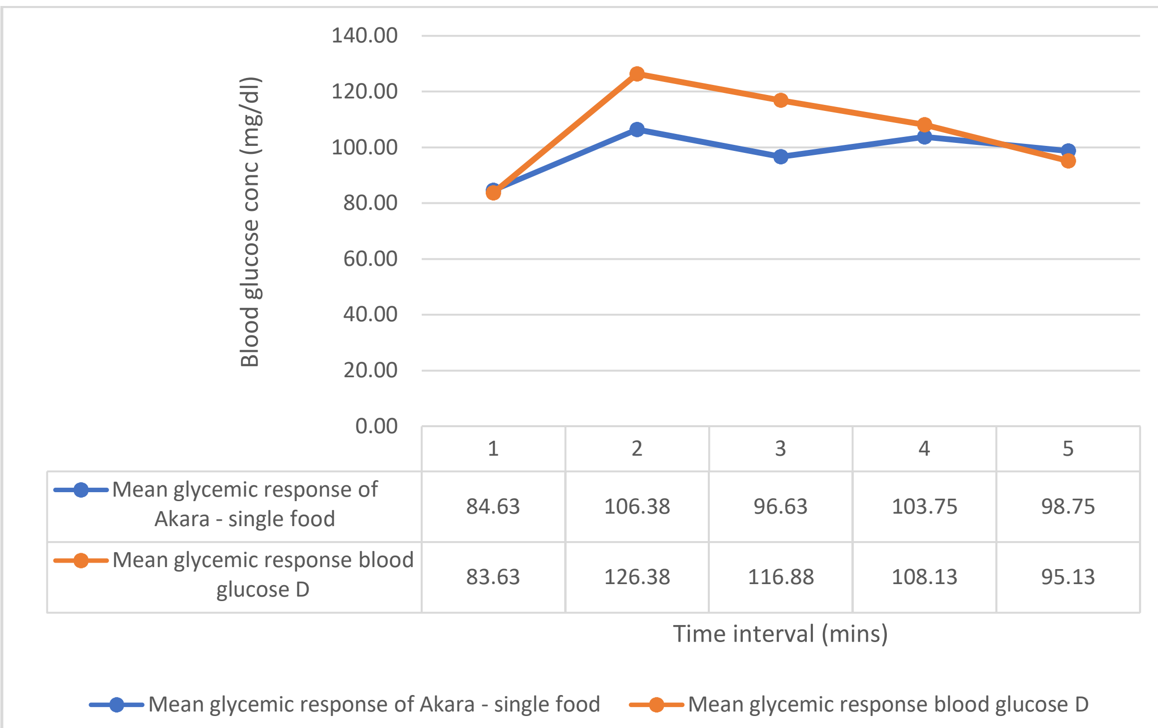


Appendix 6.64: Mean glycaemicindex values and mean glycaemic response curves of *akara*

Table 6.64a **- Mean glycaemicindex valuesof *akara***

2 HR TEST MEAL- *AKARA*		
Time	Test meal	Glucose D
0 mins	84.63	83.63
30 mins	106.38	126.38
60 mins	96.63	116.88
90 mins	103.75	108.13
120 mins	98.75	95.13
AUC	11953.50	13223.1
GI	90.3986206	

Figure 6.64a **- Mean glycaemic response curves of *akara***

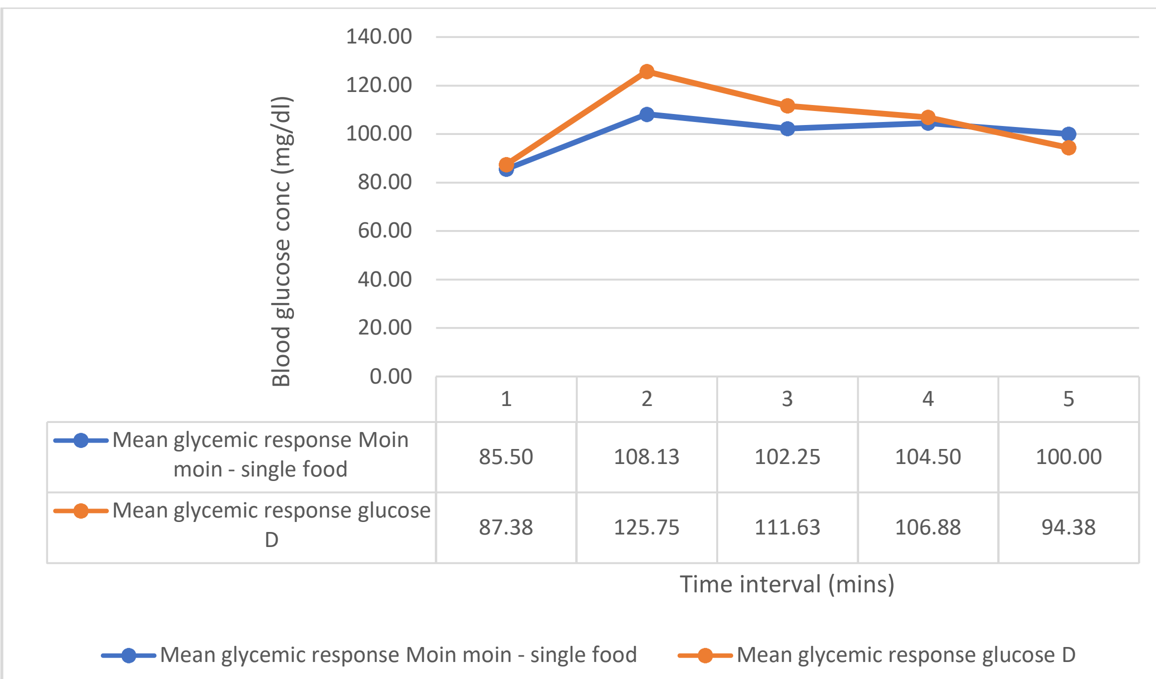


Appendix 6.65: Mean glycaemicindex values and mean glycaemic response curves of *moinmoin*

Table 6.65a **- Mean glycaemicindex valuesof *moinmoin***

2 HR TEST MEAL- *MOIN-MOIN*		
Time	Test meal	Glucose D
0 mins	85.5	87.38
30 mins	108.13	125.75
60 mins	102.25	111.63
90 mins	104.5	106.88
120 mins	100	94.38
AUC	12228.90	13054.2
GI	93.67789677	

Figure 6.65a **- Mean glycaemic response curves of *moinmoin***

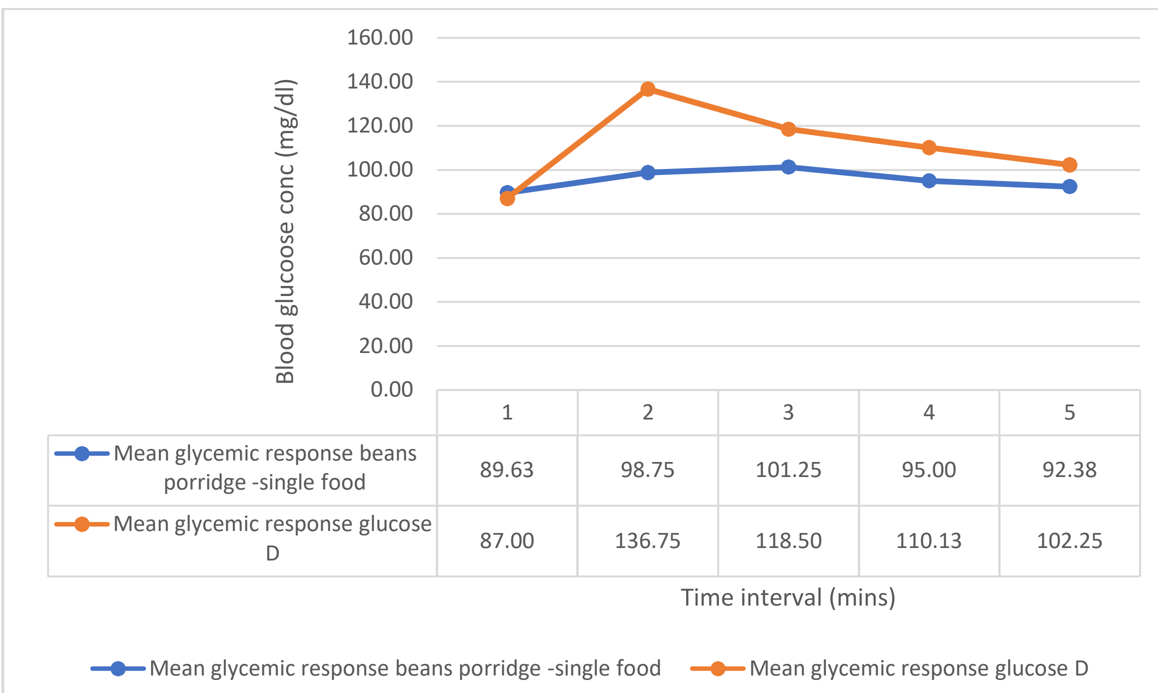


Appendix 6.66: Mean glycaemicindex values and mean glycaemic response curves of beans porridge

Table 6.66a **- Mean glycaemicindex valuesof beans porridge**

2 HR TEST MEAL- BEANS PORRIDGE		
Time	Test meal	Glucose D
0 mins	89.63	87
30 mins	98.75	136.75
60 mins	101.25	118.5
90 mins	95	110.13
120 mins	92.38	102.25
AUC	11580.15	13800.15
GI	83.91321833	

Figure 6.66a **- Mean glycaemic response curves of beans porridge**

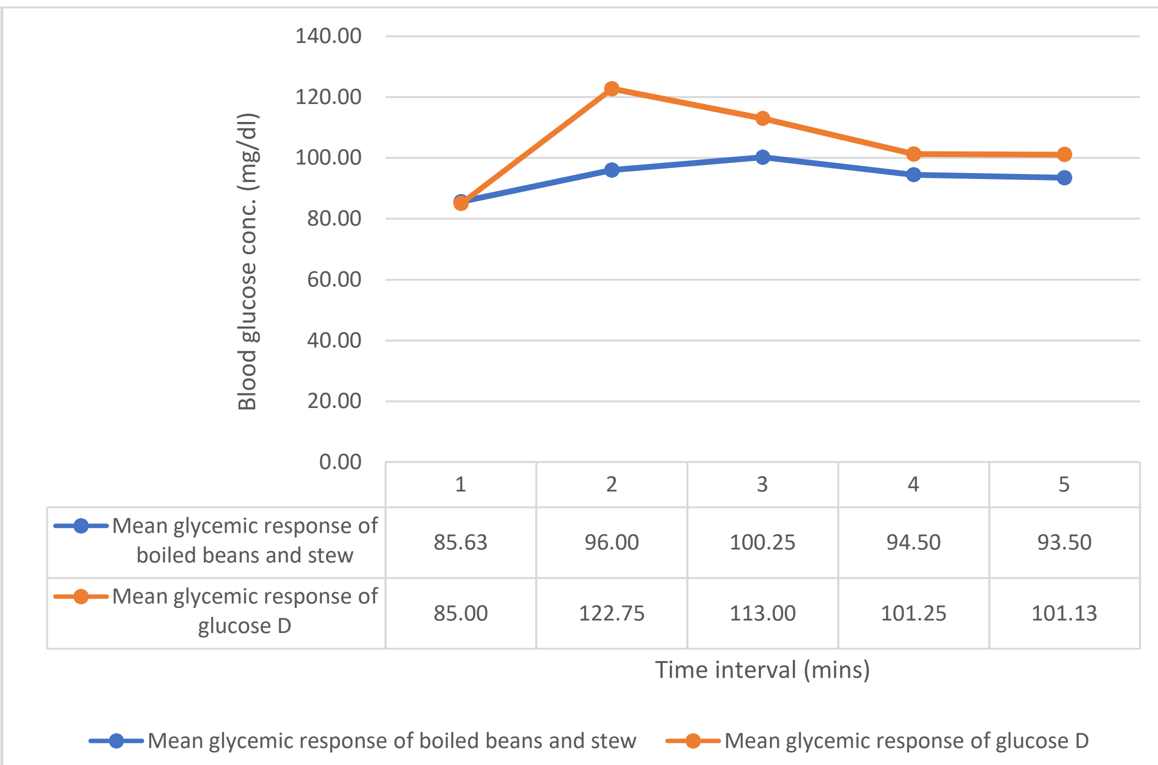


Appendix 6.67: Mean glycaemicindex values and mean glycaemic response curves of boiled beans and stew

Table 6.67a **- Mean glycaemicindex valuesof boiled beans and stew**

2 HR TEST MEAL- BOILED BEANS AND STEW		
Time	Test meal	Glucose D
0 mins	85.63	85
30 mins	96	122.75
60 mins	100.25	113
90 mins	94.5	101.25
120 mins	93.5	101.13
AUC	11409.45	12901.95
GI	88.43198121	

Figure 6.67a **- Mean glycaemic response curves of boiled beans and stew**

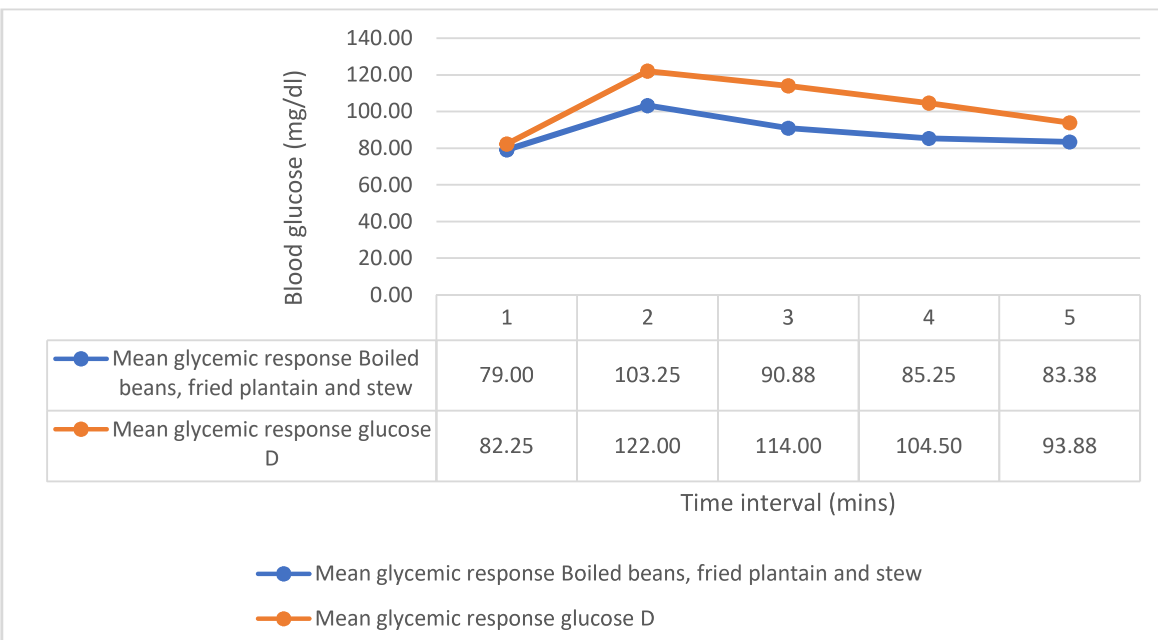


Appendix 6.68: Mean glycaemicindex values and mean glycaemic response curves of boiled beans, fried plantain and stew

Table 6.68a **- Mean glycaemicindex valuesof boiled beans, fried plantain and stew**

2 HR TEST MEAL- BOILED BEANS, FRIED PLAINTAIN AND STEW		
Time	Test meal	Glucose D
0 mins	79	82.25
30 mins	103.25	122
60 mins	90.88	114
90 mins	85.25	104.5
120 mins	83.38	93.88
AUC	10817.10	12856.95
GI	84.13426201	

Figure 6.68a **- Mean glycaemic response curves of boiled beans, fried plantain and stew**

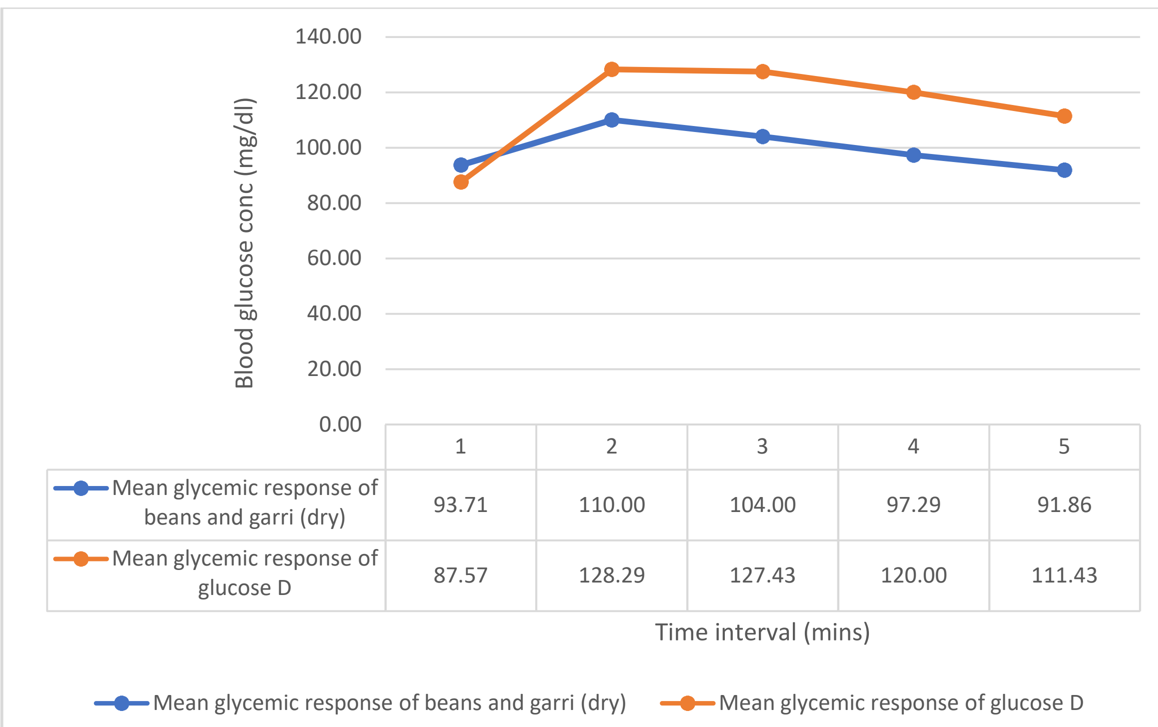


Appendix 6.69: Mean glycaemicindex values and mean glycaemic response curves of boiled beans and garri dry

Table 6.69a **- Mean glycaemicindex valuesof boiled beans and garri dry**

2 HR TEST MEAL- BOILED BEAN AND GARRI DRY		
Time	Test meal	Glucose D
0 mins	93.71	87.57
30 mins	110	128.29
60 mins	104	127.43
90 mins	97.29	120
120 mins	91.86	111.43
AUC	12122.25	14256.6
GI	85.02903918	

Figure 6.69a **- Mean glycaemic response curves of boiled beans and garri dry**

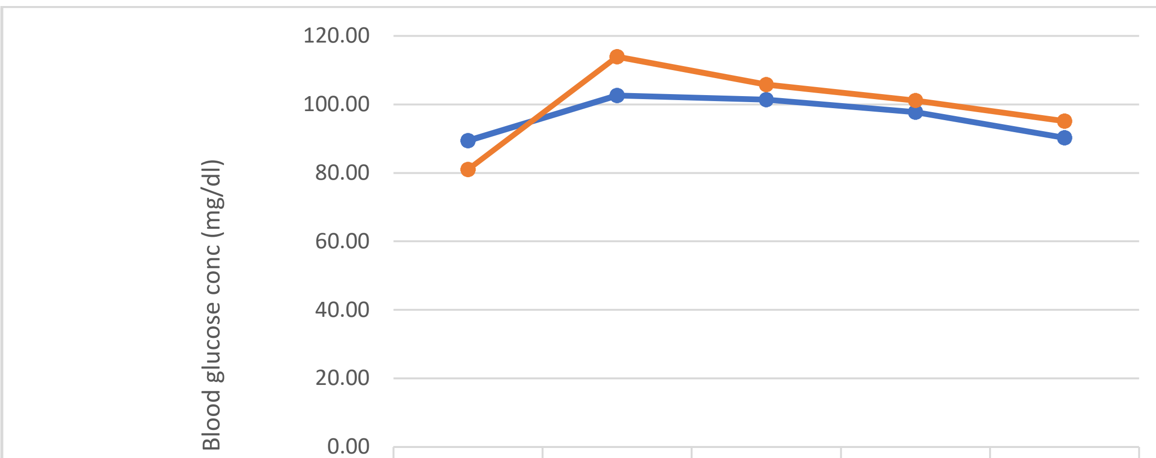


Appendix 6.70: Mean glycaemicindex values and mean glycaemic response curves of beans and garri (soaked)

Table 6.70a - **Mean glycaemicindex valuesof beans and *garri* (soaked)**

2 HR TEST MEAL- BEANS AND *GARRI* + WATER		
Time	Test meal	Glucose D
0 mins	89.38	81
30 mins	102.63	113.88
60 mins	101.38	105.75
90 mins	97.75	101.13
120 mins	90.25	95.13
AUC	11747.25	12264.75
GI	95.78059072	

Figure 6.70a - **Mean glycaemic response curves of beans and garri (soaked)**



	1	2	3	4	5
Mean glycemic repsonse for beans+garri+water	89.38	102.63	101.38	97.75	90.25
mean glycemic response for glucose D	81.00	113.88	105.75	101.13	95.13

Appendix 7: RESEARCH VALIDITY

Blood samples were randomly taken from study participants for blood glucose analysis using the classical laboratory analytical method.

S/N	PARTICIPANTS CODE	LAB METHOD READINGS (mg/dl)	GLUCOMETER READINGS (mg/dl)	
1	20	82	79	
2	29	78	89	Correlation co-efficient
3	30	85	94	0.163
4	33	75	81	
5	133	79	89	p - value 0.730
6	24	75	72	
7	10	80	91	
8	37	71	86	
9	31	85	88	
10	78	78	72	