# GLYCEMIC INDICES OF FOODS IN ASSOCIATION WITH DIABETES AMONG RURAL WOMEN OF KENYA: CASE OF AMAGORO IN BUSIA COUNTY

BY

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THIS THESIS IS MY ORIGINAL WORK AND HAS NOT BEEN PRESENTED FOR A DEGREE IN ANY OTHER UNIVERSITY.

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## ACKNOWLEDGEMENTS

**DEDICATION**

This thesis is dedicated to my late mum Miriam Ebere who succumbed to diabetes just four days after I defended this thesis and to my dad Benjamin Ebere, Brother David Onyapidi and Sister Sella Omulepu all of whom are suffering from diabetes mellitus type 2. I believe the contents of this thesis will assist them in making informed lifestyle choices in order to manage the condition more effectively. I also extend this dedication to my dear husband Luke Okunya and children Amani, Bahati, Ebere and Siyanja.

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## LIST OF ACRONYMS AND ABBREVIATIONS

**ADA:** American Diabetes Association

**AOAC:** Association of Analytical Chemists

**BMI:** Body Mass Index

**DM1:** Diabetes Mellitus Type 1

**DM2:** Diabetes Mellitus Type 2

**DMI:** Diabetes Management and Information Centre

**FAO:** Food and Agriculture Organization

**FFQ:** Food Frequency Questionnaire

**FGDs:** Focus Group Discussions

**GI:** Glycemic Index

**GL:** Glycemic Load

**HH:** Household(s)

**IAUC:** Incremental Area Under the Curve

**IDF:** International Diabetes Federation

**KII:** Key Informant Interview

**MiMW:** Mjota (Medical Journal of Therapeutics Africa) institute of Medical Writing

**MoPHS:** Ministry of Public Health and Sanitation of the Government of Kenya

**SPSS:** Statistical Package for Social Sciences

**USDA:** United States, Department of Agriculture

**WC:** Waist Circumference

**WHO:** World Health Organization

**WHR:** Waist to Hip Ratio

# ABSTRACT

Diabetes mellitus is a chronic medical condition in which a person's sugar level rises above the normal. This disease has become quite prevalent worldwide. In the year 2018, more than 500 million people were suffering from diabetes mellitus type-2 (DM2) worldwide. In 2010, an estimated seven million cases of diabetes were found in Africa. This figure was predicted to rise to over 18 million by the year 2030. In Kenya, an estimated 1.2 million Kenyans suffer from the disease. This has been projected to rise to 1.5 million by the year 2025. Although DM2 is determined primarily by genes and lifestyle, it has been strongly linked to dietary patterns. However data linking DM2 and Glycemic index (GI) in Kenya remain scarce. Generally, foods with high GI are more likely to lead to a high prevalence of DM2 than foods with low GI. Some studies done in Kenya have indicated relationship between local diets and diabetes. However these studies were hospital-based and not community-based and they did not identify the GI of locally consumed foods and link with DM2. The objective of this study was therefore to assess the glycemic indices of the staple foods consumed by women in a rural population and establish the association of the glycemic load (GL) of foods with DM2. The study was cross sectional in design with analytical components that generated both qualitative and quantitative data. The survey involved 260 women participants aged 15-90 years, GI, focus group discussions (FGDs) and key informant interviews (KIIs) involved a total of 12, 45 and 15 participants respectively. Initially, FGDs and KIIs were conducted to establish community's knowledge and self-perceptions to foods associated with diabetes and to generate a food list that was used in designing a structured food frequency questionnaire (FFQ). The survey was conducted using a pre-tested questionnaire; FGD and KII guide were used to guide the FGDs and KIIs while the GI and proximate composition of foods were determined using standard procedures. The

analytical components included proximate analyses of the foods and determination of glycemic indices (GIs). The GI of various foods was used to calculate the glycemic load (GL). Data were analysed using Microsoft Excel and Statistical Package for Social Sciences. Descriptive statistics were used to analyze and characterize the sample. The data was presented by absolute frequencies and percentages. A chi-square analysis was used to compare the categories of DM2 with other variables. Multivariate logistic regression was used to identify the magnitude of independent variable. Linear regression with mixed-effects was used to establish the differences between GIs of different foods. Results showed that the prevalence of DM2 was 16.9%. The GI of the foods followed the order: Cassava and sorghum *Ugali* with silver fish > rice plain > cassava > whole maize *ugali* with beef > whole maize *ugali* with silver fish = cassava-sorghum *ugali* and cowpea leaves = rice with beef > sweet potato > whole maize *ugali* = rice and beans > whole maize *ugali* with cowpea leaves > beans plain. The glycemic indices of various *ugali* meals were significantly different ($p<0.05$). Women consuming a GL of >840 were 1.36 times more likely to suffer from DM2 as opposed to those who consumed a moderate load although this association was not significant ($p>0.05$). The study concluded that there was no significant association between glycemic index and diabetes among rural women of Amagoro. Cowpea leaves and beans have the potential of lowering the GI of staple foods consumed alongside. Alcohol consumption and physical activity were the strongest independent risk factors for DM2 in this study population. This calls for need to create awareness and sensitize the population on these predisposing factors.

**CHAPTER 1: INTRODUCTION**

**1.1 BACKGROUND TO THE STUDY**

Diabetes mellitus is a chronic medical condition in which a person's sugar level rises above the normal. This results in symptoms such as hunger, thirst and frequent urination (Ripsin et al., 2009). It happens because under normal circumstances, food that is consumed is broken down into glucose which is later taken up into the bloodstream to serve as a source of energy. This process is facilitated by a hormone known as insulin produced by the pancreas. Contrary to this, among diabetics three things might be happening: the pancreas usually fails to produce enough insulin; the body cells fail to respond to the insulin or both scenarios occur thereby resulting in excessive sugar accumulation in the blood. Consequently, the excess sugar may damage the nerves and blood vessels which may result in amputation, blindness, renal failure, infertility among men, heart disease and stroke (American Diabetes Association (ADA), 2004; Majaliwa et al., 2008).

There are three major types of diabetes mellitus namely, gestational diabetes (GD), Diabetes Mellitus Type 1 (DM1) and Diabetes Mellitus Type 2 (DM2). GD mainly develops during pregnancy in women, even those who previously had no diabetes. This type usually disappears after a woman gives birth. DM1 normally occurs due to lack of insulin secretion from the pancreas, while DM2 develops when the body cannot utilize the insulin effectively or when the insulin produced is too little to metabolize the blood sugar effectively (ADA, 2004).

Even though in a minority of the patients, diabetes could be a result of genetic disorder that one inherits from parents (Herder and Roden, 2011), recent studies show that it is largely developed as a result of the lifestyle of an individual. For example, lack of physical activity, excessive

consumption of alcohol and smoking of cigarettes are associated with the development of diabetes (Ripsin, et al., 2009).

Although data on diabetes remains scanty in Kenya, (Maina, 2011) it is eminently becoming prevalent and varies among the different ethnic groups (Christensen et al., 2009) and regions (Chege, 2016; Ayah et al., 2013; El-busaidy et al., 2014). A recent study conducted in a rural population in Northern Kenya reported a relatively high prevalence at 16% (El-busaidy et al., 2014).

Until recently, the main interventions in diabetes management have been curative in nature. Basically, the patients are usually prescribed insulin and related drugs as a remedy coupled with some nutritional advice (MiMW), 2008). Today, lifestyle interventions in diabetes are favored over medical interventions. As a result, experts in the medical field have deliberately advocated the need to educate and empower patients and the public about the knowledge and resources that can facilitate self-care in diabetes. The major drive is geared towards getting people to change their lifestyle by participating more in physical activities, consuming less alcohol and cigarettes and consuming diet that reduce the chances of developing high blood sugar levels such as whole grains and vegetable rich diets.  Apart from the need to be more physically active, the current preventive approach to diabetes management is driven by the need to consume a healthy diet (Otieno et al., 2003).

Despite positive potential of these strategies, several challenges are hindering their success in preventing and managing diabetes. The main challenge is that these strategies are largely not affordable by ordinary citizens.  For example, insulin requires refrigeration yet refrigerators are not ordinarily available in Kenya (McFerran, 2008). At the same time, specially selected diets

and facilities for sports activities are too expensive for ordinary people (MiMW, 2008) considering that more than 56% of Kenyans live below the poverty line; living on less than one dollar per day (Ministry of Health, 2005).

This study therefore investigated the association between diet, especially glycemic indices of foods and DM2 in Amagoro division of Busia County in Western Province of Kenya. The inhabitants of Amagoro who are mainly of the Iteso ethnic group consume mainly starchy diets with small amount of accompaniment (Karp and Karp, 1977). Starch is known to have a direct influence on blood sugar while alcohol is a known risk factor to DM2. Amagoro division was purposively selected because it has a relatively high prevalence of diabetes mellitus. A visit to Kocholya Sub-County hospital and Alupe Sub-District hospitals showed that diabetes is a major health problem in the division. In these hospitals, many suspected cases that were referred to the laboratory to test for blood sugar turned out to be positive for diabetes or pre-diabetes.

## 1.2 STATEMENT OF RESEARCH PROBLEM

Diabetes mellitus type 2 (DM2) is becoming a widespread problem in Kenya (Otieno, 2007; McFerran, 2008; MoPHS, 2005). It causes human suffering and is also an economic burden (Kimani, 2007; Atieno, 2006; Otieno, 2007).

Presently, the Government relies heavily on medical interventions to manage diabetes, among them insulin and other oral hypoglycemic agents. Unfortunately these medications are expensive for a majority of Kenyans (MiMW, 2008) and require refrigeration which most patients cannot afford (Kimani, 2007; MiMW, 2008). Thus investing in preventive strategies in diabetes prevention and management would be cost effective and more beneficial to the public.

The main risk factors for diabetes in Kenya include unhealthy diet, obesity and inadequate physical activity (Atieno, 2006; Ripsin et al, 2009; MoPHS, 2005). Carbohydrate-rich foods are directly linked to blood sugar level and may pose risk for DM2. The impact of these foods on sugar level is determined by GI and GL. The respective GI of a given carbohydrate further depends on whether it is consumed on its own or in a meal. Dietary intervention has been advocated to prevent and manage DM by recommending certain carbohydrate foods (Wanjala et al., 2016). However the GI of a majority of these foods has not been documented and the direct role of GI in development of diabetes remain obscure (Omoregie and Osagie, 2008). Residents of Amagoro rely mainly on a starchy staple food *(ugali)* consumed with an accompaniment (Karp and Karp 1977) despite limited knowledge on their GI. This study therefore investigated the risks foods consumed in Amagoro pose for DM2.

## 1.3 JUSTIFICATION OF THE STUDY

Diabetes is becoming a major health problem in the developing world including Kenya. Through this study, knowledge on GI of foods will provide better guidance on promotion of local foods to the community with regard to prevention and management of DM2. Additionally, information on GI/GL will be of use to health professionals and general public with regard to DM prevention and management. This study will also improve knowledge in areas of clinical nutrition and food science both in theory and research methodology and the policy makers can develop guidelines on diet, agriculture and health that reduce DM2 risk in rural areas. The knowledge generated from this study will also help the community realize the magnitude of DM2 so that they can be receptive to intervention programs.

**1.4 OBJECTIVES OF THE STUDY**

*1.4.1 Main Objective*

To assess the association between glycemic indices of foods and diabetes mellitus type-2 among rural women in Amagoro Division of Busia County in Western Kenya

*1.4.2 Specific Objectives*

1. To determine socio-demographic and socio-economic characteristics of the households.

2. To determine the food consumption patterns of the respondents.

3. To evaluate the nutritional status of the respondents.

4. To determine the glycemic indices and glycemic loads of selected foods.

**1.5 HYPOTHESIS**

There is an association between glycemic indices of foodstuff and diabetes mellitus among rural women in Amagoro.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 INTRODUCTION

Diabetes mellitus is a chronic medical condition whereby a person's blood sugar level rises above the normal. Normal blood glucose may be indicated by fasting plasma glucose (FPG) levels of <110 mg/dl (6.1 mmol/l) or a glucose tolerance test value of <140 mg/dl (7.8 mmol/l). A random plasma glucose level ≥160 mg/dl (8.9 mmol/l) is considered a positive test result. The diagnosis of diabetes is done through additional re-testing using FPG test or oral glucose tolerance test performed later on (ADA, 2012; ADA, 2000).

Diabetes mellitus results in symptoms such as hunger, frequent urination and thirst (Ripsin et al., 2009). It happens because under normal circumstances, food that is consumed is broken down into glucose which is later taken up into the bloodstream to serve as a source of energy. This process is facilitated by a hormone known as insulin produced by the pancreas. Among diabetics three things might be happening: the pancreas usually fails to produce enough insulin; the body cells fail to respond to the insulin or both thereby resulting in excessive sugar accumulation in the blood. The excess sugar damages blood vessels and nerves which may lead to amputation, blindness, renal failure, impotence among men and vascular diseases including heart disease and stroke (ADA, 2004; Majaliwa et al., 2008).

There are three major types of diabetes mellitus namely, gestational diabetes (GD), diabetes mellitus type 1(DM1) and diabetes mellitus type 2 (DM2). GD mainly occurs during pregnancy, even in women without any previous history of diabetes and usually disappears after giving birth.  DM1 occurs normally due to lack of insulin secretion while DM2 usually develops when

an individual's body cells cannot utilize the insulin hormone effectively or when the hormone produced is inadequate for effective metabolism (ADA, 2004).

Even though in a minority of the patients, diabetes could be as a result of genetic disorder acquired through inheritance (Herder and Roden, 2011), studies also show that it is largely developed as a result of the lifestyle of an individual. For instance lack of physical exercise, excessive consumption of alcohol and smoking of cigarettes have been linked to the development of diabetes (Ripsin, et al., 2009).

## 2.2 GLOBAL PREVALENCE OF DIABETES MELLITUS

The prevalence of diabetes mellitus is rapidly rising. The worldwide diabetes prevalence was estimated at 2.8 % in 2000 and projected to rise above 4.4 % by the year 2030 (Wild et al., 2004). By the year 2011, the prevalence was estimated at 4.5% and it is now projected to reach 4.9% by the year 2030. According to International Diabetes Federation (IDF, 2017) 425 million were suffering from diabetes mellitus. In the year 2018 there were more than 500 million people suffering from diabetes mellitus type-2 (DM2) globally (Kaiser, Zhang and Van Der Pluijm, 2018). The prevalence is projected to increase with the highest growth expected in developing countries despite the fact that most of these countries lack sufficient diabetes diagnostic and monitoring tools (Hall et al., 2011; IDF Diabetes Atlas., 2011). In addition to diabetes, impaired glucose tolerance, is also a major public health problem and if not treated, may develop to DM2 (IDF, 2011).

An estimated 15.5 million adults aged 20-79 years were living with diabetes in the Africa region by the year 2017 (IDF, 2017). In Africa an estimated 78 % of people with diabetes are undiagnosed, and over 90 % of diabetic cases in Sub-Saharan Africa are of type 2 (DM2) (IDF,

2011). Amongst these countries, urban Kenya had the highest prevalence of 12 %, while rural Uganda had the lowest prevalence of 1 % (Dalal et al., 2011). However a recent study conducted in Isiolo town located in Northern Kenya reported a prevalence of 16 % and has elicited great interest (El-busaidy et al., 2014. Nonetheless, there are limited epidemiologic studies in Sub-Saharan Africa (Dalal et al., 2011).

## 2.3 PREVALENCE OF DIABETES MELLITUS IN KENYA

Although data remains scanty (Maina, 2011) diabetes is becoming rampant in Kenya (El-busaidy et al., 2014). The exact number of people living with the disease is unknown and the available data is limited to a few regions although the prevalence countrywide was estimated at 3.3 % with actual prevalence ranging between 2.7 % (rural) and 10.7 % (urban) (Diabetes Management and Information Centre (DMI centre), *personal communication,* 2013). A prevalence of 5.3% has been reported in Nairobi's Kibera slums with prevalence higher in women than men (Ayah et al., 2013). Also, a prevalence of 4.8 % and 4.0 % in women and men respectively was reported in Nairobi's Korogocho and Kibera slums (Oti et al., 2013) and 6.6 % in Nakuru (Mathenge et al., 2010). A recent study in Isiolo County, located in Northern Kenya also revealed a relatively high prevalence at 16 % (El-busaidy et al., 2014).

## 2.4 PREVENTION AND MANAGEMENT OF DIABETES MELLITUS

Diabetes management aims at keeping glucose levels in the blood closer to the normal levels as much as possible. This involves changes in diet, exercise and use of treatment drugs (ADA, 2010). However many diabetic patients cannot afford the treatment due to the high cost resulting in the high mortality and prevalence of complications experienced especially in Sub-Saharan Africa (Hall et al., 2011). Since many persons with DM2 are insulin resistant and

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overweight, the initial therapy involves a healthy diet, weight reduction and physical activity (Dedoussis et al., 2007; Mozaffarian et al., 2009; ADA, 2010; IDF, 2011). In addition, diabetes management also involves limiting alcohol consumption; avoiding cigarette smoking; regular monitoring for associated complications including eye and foot checks, blood sugar and pressure controls and checking risks for kidney and cardiovascular diseases (IDF, 2011).

Since the associated complications are expensive as well as difficult to treat, the best option is to adequately maintain blood sugar levels (Colberg et al., 2010). This can be achieved by maintaining a healthy diet, body weight and physical activity although treatment may require oral glucose-lowering agents and/or insulin injection in addition to these lifestyle changes (ADA, 2010). For instance, a healthy lifestyle involving walking for at least 30 minutes regularly per day reduces the DM2 risk by 35 to 40% (IDF Diabetes Atlas, 2011). Other interventions that can prevent and control diabetes and associated complications include regular screening and health education.

The Kenyan government is facing a number of challenges with regard to diabetes prevention and management. These include lack of routine screening as a result of limited resources leading to many undiagnosed cases; inadequately trained health care workers and lack of necessary equipment to effectively manage diabetes and its complications coupled with low public awareness (Ministry of Public Health and Sanitation (MoPHS), 2005). Also, population-based data on the burden, trends and effective practices for controlling diabetes is lacking (MoPHS, 2005). For example, nutrition education is important in facilitating the adoption of a lower glycemic index (GI) diet by diabetes individuals (Miller et al., 2009) but the GI of most traditional foods consumed by Kenyans remains unknown.

Until recently, the main interventions in the diabetes management have been curative in nature. Basically, the patients are usually prescribed insulin as a remedy coupled with some nutritional advice on the kind of diet to take in order to avoid raising blood sugar level (MiMW, 2008).

Despite their potential positive effect, these strategies are meeting several challenges that hinder their success in preventing diabetes. The main one is that these strategies are largely not affordable by ordinary citizens. For example, insulin requires refrigeration yet refrigerators are not ordinarily available in Kenya (McFerran, 2008). At the same time, specially selected diets may be too expensive for ordinary people (MiMW, 2008) considering that a majority of Kenyans are poor (MoH, 2005; El-busaidy et al., 2014). This means that even though as a result of poverty people might still be taking part in physically demanding activities to facilitate their livelihoods such as digging, cycling and walking long distances, it is highly likely that due to poverty their dietary consumption does not take into account the potential risk of diabetes it exposes them to.

This study therefore investigated the association between diet and diabetes mellitus type-2 (DM2) in Amagoro division of Busia County in Kenya. Blood sugar levels usually rise in response to a carbohydrate-rich meal since the carbohydrates are the preferred energy source for the body. Thus, it is the carbohydrates in the diet that are directly linked to the blood sugar levels (Jenkins et al., 1981) although there are several other factors that may moderate the carbohydrate's effect on blood sugar levels.

## 2.5 ASSOCIATION OF DIET WITH DIABETES MELLITUS

A variety of food consumption/dietary patterns have been associated with increased diabetes risk. These include regular consumption of sugar-sweetened soft drinks and fruit drinks (Palmer

et al., 2008; Forouhi et al., 2018), consumption of meat (Banard et al., 2014) especially processed red meat and refined grains (Forouhi et al., 2018). On the other hand patterns of food intake that are high in vegetables, fruit, whole grains, legumes, nuts, and dairy products have been promoted for prevention and management of diabetes mellitus (Forouhi et al., 2018). Other diets found to reduce the risk of diabetes are vegetarian diet (Chiu et al., 2018) and low-carbohydrate diet (Nanri et al., 2015).

Despite the various dietary patterns, the major influential component of the diet is carbohydrates since it comprises 40 to 80 % of the total food intake and contributes 70 % to 80 % of the calories consumed (Fennema, 1996). Carbohydrates influence satiety and help in maintaining blood sugar by influencing glycemic response and insulin metabolism (FAO/WHO, 1998). A high glycemic load (GL) from dietary carbohydrates increases diabetes and heart disease risk (Liu et al., 2000; Choudhary, 2004; FAO/WHO, 1998). Therefore understanding this connection would be useful considering the fact that previous studies have shown that various carbohydrates differ in physico-chemical properties which affect their degradation rate and bio-availability (Englyst et al., 1999). Similarly, the consumption of carbohydrates together with other macronutrients such as proteins is likely to influence the carbohydrate effect on blood sugar level (van Loon et al., 2003). Although dietary supplements have been used to fight obesity and in the regulation of glucose for diabetic patients (Brennan, 2005), the use of dietary intervention cannot be ignored.

Carbohydrate foods are made up of sugars and starches both of which are metabolized into glucose which then enters the bloodstream. High starch diets that are low in fiber are linked to a higher risk of DM2 (AlEssa et al., 2015). As opposed to sucrose and starch, glucose and fructose sugars are inversely associated with the risk of diabetes (Ahmadi-Abhari et al., 2014).

Studies have shown a positive relation between the rate of degradation of carbohydrate during digestion and the regulation of blood sugar and insulin level (Brennan, 2005). The rate at which these carbohydrates are broken down to glucose as indicated by the glycemic index is of particular importance with regard to blood sugar regulation. Thus most important aspect of diet with regard to hyperglycemia is the glycemic index and glycemic load of the specific foods.

### 2.5.1 Glycemic Index and Glycemic Load

The term glycemic index (GI) was first introduced by Jenkins et al (1981) to classify carbohydrates on the basis of blood glucose response after ingestion. GI is computed by dividing the area under the blood glucose response curve above the fasting blood sugar level after consuming 50 g available carbohydrates from a test food by area under the blood glucose response curve above the fasting level after consuming 50 g available carbohydrates from a standard or reference food and multiplying the resulting value by 100. The reference or standard food is usually white bread or glucose and is normally assigned a GI of 100 (FAO/WHO, 1998). Since dietary fibre resists digestion and absorption in the small intestine, they are not included when calculating the 50 g carbohydrate portion to be administered (FAO/WHO, 1998). The GI therefore measures the glycemic response to 50 g available carbohydrate of a test food relative to an equal amount of glucose or white bread. This is because the glycemic response to a carbohydrate-rich food has been found to increase linearly with the increase in the amounts of carbohydrate up to about 50 g then it levels off (Pi-Sunyer 2002, Wolever, 2003). Nonetheless 25 g available carbohydrate may be used especially if the portion size providing this amount of carbohydrates tends to be large (Aston et al., 2008).

The knowledge of GI has been valuable in evaluating whether particular foodstuffs pose a higher or lower diabetes risk and thereby help in managing DM2. Thus foods have been categorized into low (<55), medium (55-70) and high (>70) GI with glucose as a standard or values of <60, 60-85 and >85 representing low, medium and high GI respectively with white bread as a standard or reference food (Beals, 2005). High GI foods result in a greater blood glucose response as opposed to low GI foods (Foster-Powell et al., 2002). However, consuming a high GI food alongside a low GI food may reduce the overall blood glucose response of a high GI food. For example, the GI of rice has been reduced by vinegar, beans and dairy products when consumed together (Sugiyama et al., 2003).

Glycemic Load (GL) on the other hand has been suggested as an alternative and better measure for blood sugar response. The glycemic load (GL) accounts for both the quality as measured using GI and amount of food consumed (serving size). This means that foodstuff can have a high GI, but only consumed in small amounts in normal circumstances which does not significantly raise the blood sugar; while on the other hand foods possessing low GI may be consumed in large quantities resulting in elevated blood sugar level. Thus, some high GI foods are actually low on the GL and vice versa. The GL is computed by multiplying the amount of available carbohydrate in the diet with the GI of the food and dividing the resulting value by 100 (Foster-Powell et al., 2002). GL = GI/100 x Available carbohydrates (total dietary carbohydrates - dietary fiber). Using this approach, the foods can be classified into low (1-10), medium (11-19) and high ( 20) GL (Foster-Powell., 2002).

### 2.5.2 Methods for Measuring the Glycemic Index
The GI of food has generally been accepted and proven to be very useful in the classification of carbohydrate in relation to health. Two main approaches, namely, *in vitro* and *in vivo*, have

been used.  The *in vitro* method mimics the human digestive system by employing the use of necessary digestive enzymes and activities such as mastication by use of homogenization, grinding etc in a laboratory setting. This method has been suggested to be cheap and quick (Englyst et al., 1999, Foster-Powell et al., 2002) producing reliable results which are comparable to the *in vivo* (Araya, 2003; Brouns et al., 2005; Englyst et al., 1999). However, other studies do not agree that the *in vitro* method produce reliable indications of the metabolic behaviour of carbohydrate-rich foodstuff (Bjorck et al., 1994; Foster-Powell et al., 2002). This is because some of the factors that influence the GI *in vivo* such as gastric emptying and the effect of hormones are not accounted for (Berti et al., 2004). The effect of proteins, fat or dietary fibre which affects gastric emptying may not be mimicked *in vitro* and human trials therefore remains  the gold standard for GI measurement (Foster-Powell et al., 2002).

The *in vivo* approach involves feeding of test-foods to human subjects and measuring their blood glucose within two hours of digestion. Capillary blood sampling has been recommended for measuring the GI whereby fasting blood glucose is taken from a finger-prick after a 10-12 hour fast (in the morning), immediately before the test meal is administered, then every 15 minutes after the test meal has been given for 1 hour and thereafter every 30 minutes for the next 1 hour (Wolever, 2003). Despite being more precise than *in vitro* method, *in vivo* method has its own shortcomings too which influence the result. The GI thus is influenced by a number of factors as discussed below.

### 2.5.3 Factors Affecting the Glycemic Index of Foodstuff

The GI of a carbohydrate-rich food can vary depending on a number of factors. Some of these factors are briefly explained below and they include those related and unrelated to the food itself.

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**a) Food related factors**

**Nature of carbohydrates**

Carbohydrates differ in their physical and chemical properties and this influences their rate of degradation (Engyst et al., 1999; Lovegrove et al., 2017). Starch is composed mainly of amylose and amylopectin, and the ratios of these components influence the physico-chemical properties of starch and hence its digestibility and bioavailability (Lovegrove et al., 2017). Amylose for example form secondary structures that are difficult to disperse hence digested slowly than amylopectin (Thorne et al., 1983; Lovegrove et al., 2017). However, processing may reduce the effect of amylose: amylopectin ratio in some foods with the exception of very high-amylose starches (Gallant et al., 1992). Foods composed of gelatinized starches or free sugars are rapidly digested and absorbed (Englyst et al., 2003). The nature of the monosaccharide components also influences the GI with glucose and fructose being metabolised differently (Bray et al., 2004).

Fibre-rich foods generally have a low glycemic index (GI) (Riccardi et al., 2008) because fibre creates a physical barrier limiting the access of amylolytic enzymes to starch (Vahouny and Kritchevsky, 1986). Thus dietary fibre intake has the potential to reduce diabetes risk (Feldman et al., 2017).

**(b) Presence of other macronutrients**

Generally people consume mixed meals consisting of more than one macronutrient (Beals, 2005). Research has shown that the higher the proportion of carbohydrate in a specific food relative to protein and fat, the higher the GI. This is because protein or fat increase insulin response thereby reducing glycemic response (Pi-Sunyer, 2002). However, the addition of protein or fat may be undesirable since they increase the overall energy content of the food

(Beals, 2005). The GI of mixed meals will therefore vary depending on the proportions of each of these macronutrients despite the fact that minimal research has been conducted on such meals (Araya, 2003). Although some researchers have recommended calculating the GI of a meal from the GI of the individual foods, the use of such calculated values remain controversial (Beals, 2005) and research is now focusing on determining the GI of foods in the combinations they are consumed in normal circumstances (Ruhembe et al., 2014).

**(c) Presence of micronutrients**

Micronutrients including antioxidants, chromium, zinc and herbal supplements have been shown to improve diabetes control (Fowler, 2007). The risk of DM2 has be reduced by intake of zinc (Sun et al., 2009), calcium (Villegas et al., 2009), magnesium (Schulze et al., 2007; Lopez-Ridaura et al., 2004; Villegas et al., 2009; Hopping et al., 2010; Kirii et al., 2010; Dong et al., 2011; Murakami et al., 2005) and vitamin D (Penckofer et al., 2008) while high iron (Lee et al., 2004; Murakami et al., 2005) and selenium (Stranges et al., 2010) have been associated with a higher risk.

**(d) Food preparation, processing and storage**

Food preparation and processing greatly influence the GI (Aston et al., 2008). Cooking affects the degradation of carbohydrate-rich foods (Lovegrove et al., 2017). For example, the low GI of raw potato has been known to increase on cooking because of improved digestibility as a result of starch gelatinization (Pi-Sunyer, 2002). When it cools, resistant starch forms which lower the GI (Beals, 2005) and the rate of digestion further decreases on storage (Agama-Acevedo et al., 2005).

**(e) Ripeness and particle size**

The ripeness and particle size of a foodstuff greatly affects its GI. When a fruit ripens, starch is converted to sugar which has lower GI (Pi-Sunyer, 2002). Reducing the foods particle size increases the surface area for enzyme action and consequently resulting in a rise in the GI (Araya, 2003; Aston et al., 2008).

**(f) Other factors**

Other factors include subject variation and the time of the day that the GI is measured. Glycemic responses vary both between subjects and within a subject to the same test food measured in separate occasions (Wolever, 2003). The time of day when the glycemic response is measured affects the GI. For example when measured in the morning or at midday (Beals, 2005; Pi-Sunyer 2002) as well as the foods consumed earlier. Legumes or whole grains consumed at breakfast decreases glycemic response at lunch and/or dinner while consumption of the same at dinner reduces the response at breakfast the following morning (Higgins, 2012). Nonetheless studies seem to agree on carrying out the tests in the morning after an overnight fast (10-12 hours) to reduce the effect of the previous meal on the GI of the test food (FAO/WHO, 1998).

## 2.6 ASSOCIATION OF NON-DIETARY FACTORS WITH DIABETES MELLITUS

According to the Kenya Ministry of Public Health and Sanitation, Kenya National Diabetes Strategy of 2010; the key risk factors to DM2 in the country included unhealthy diet, obesity and physical inactivity. Others are smoking cigarettes, excessive alcohol consumption, genetics, age, stress, chronic steroid use, socio-economic status, high blood pressure among others

(MoPHS, 2005). There is a greater chance of individuals developing diabetes when they have many of such predisposing risk factors.

### 2.6.1 Clinical and Genetic Factors

Clinical factors are influenced by a combination of genetic and other lifestyle factors (Mathers et al., 2010). Blood pressure, excessive weight, polycystic ovary syndrome and use of steroids are briefly discussed in this section. Hypertension which exists when blood pressure is equal or greater than 140/90 mmHg is a common condition in people suffering from diabetes and it affects 20 to 60% of diabetic patients. Those with hypertension and possess excessive weight are at a greater risk of diabetes irrespective of their age (Weycker et al., 2008; Zanella et al., 2001; ADA, 2002; Chege, 2016). Moderate sodium restriction reduces blood pressure in hypertensive individuals (ADA, 2002) as well as weight loss and physical activity (Zanella et al., 2001; ADA, 2002).

Cases of overweight (BMI of 25 to 30 kg/m$^2$) and obesity (BMI $\geq$ 30 kg/m$^2$) are rising rapidly worldwide and especially in developing countries (Hjartåker et al., 2008). Obesity is a risk factor in diabetes because the fatty tissue causes body cells to be resistant to insulin (Hussain et al., 2010). However, even lean subjects can develop insulin resistance if they accumulate abdominal fat (Kahn et al., 2001).

Polycystic ovary syndrome is a common condition in women of child-bearing age and it increases the risk of DM2 (Gambineri et al., 2012; Moran et al., 2010). Long-term steroid use may also increase diabetes risk and interfere with its control (Faul et al., 1998; Blackburn et al., 2002).

Genetic factors also play a major role in the development of DM2. Even in Kenya where the population is predominantly Africans, the prevalence differs among the 42 tribes (Christensen et al., 2009). The risk of diabetes is even higher if a parent or sibling has DM2 (Dedoussis et al., 2007; Herder and Roden, 2011; Chege, 2016). Women with a history of GD are particularly at an increased risk of DM2 in future (Ryan, 2003; McIntyre et al., 2010) and children born from such mothers are also at an elevated risk (Hillier et al., 2007; Boerschmann et al., 2010).

### 2.6.2 Demographic and Socio-Economic Factors

These include age and socio-economic status. A rapid rise in the prevalence of DM2 worldwide had been associated with an increasing number of elderly (above 65 years) people (IDF, 2011). The risk of DM2 therefore increases with age (Colberg et al., 2010; IDF, 2011; Chege, 2016). This could be due to the weight gained as individual ages and also the fact that physical activity is greatly reduced among the elderly (Donato et al., 2003; Tanaka and Seals, 2008). The excessive weight results in reduced insulin sensitivity especially abdominal obesity (Racette et al., 2006). The pancreas is also ageing and becomes incapable of producing sufficient insulin; the aged body cells become more resistant to insulin although a lifetime of physical activity has been found to prevent insulin resistance (Booth et al., 2011). Nonetheless as people age the co morbidities seem to increase (Grundy et al., 1999).

A number of studies have associated socio-economic status and diabetes (Robbins et al., 2000; Wikström et al., 2011; Corsi and Subramanian 2012; Hwang and Shon, 2014). Economic disadvantage has been linked to increased prevalence of DM2 among African-American women (Robbins et al., 2000) especially low education and household income levels (Wikström.et al., 2011). However Corsi and Subramanian (2012) found greater DM2 risk among those in the

highest socio-economic status in India. In the United Kingdom lower wealth, but not income was associated with diabetes mellitus especially among the elderly (Tanaka et al., 2012).

### *2.6.3 Environmental Factors*

These include factors such as exposure to sunlight, stress as well as endocrine disruptors. Sunlight participates in glucose metabolism which may influence the development of hyperglycemia (Lindqvist et al., 2010). Sunlight helps in the synthesis of vitamin D which is suggested to delay or prevent the onset of diabetes as well as reduce some of its associated complications (Penckofer et al., 2008). A recent study also revealed that in door confinement of cats increased diabetes risk (Ohlund et al., 2017).

Different forms of stress including general emotional stress, depression, anger or hostility, increase diabetes risk (Kato et al., 2009; Rod et al., 2009;  Pouwer et al., 2010 Adriaanse, 2010; Kelly and Ismail, 2015). This could be because people under stress may not be taking good care of themselves with some developing unhealthy behaviors such as poor dietary habits, smoking cigarettes, excessive alcohol consumption and low exercise (Bonnet et al., 2005; Rod et al., 2009).

Many studies have shown that some of the environmental chemicals can interfere with or mimic some hormones resulting in diabetes, obesity and the metabolic syndrome (Alonso-Magdalena et al., 2010; Tang-Péronard et al., 2011; De Coster and van Larebeke, 2012). For example, exposure to bisphenol A and phthalates which are used to manufacture plastics, personal-care products as well as in industry and medical devices have been associated with insulin resistance, weight gain, pancreatic endocrine dysfunction and thyroid hormone disruption, all of which have been linked to the development of diabetes (Svensson et al., 2011; Shankar and Teppala,

2011). However, a later study disputed these findings citing insufficient evidence (Kuo et al., 2013).

### 2.6.4 Behavioural Factors

These are risk factors that can be reduced or eliminated through behaviour or lifestyle change. Apart from unhealthy diet, other behavioural risk factors include: physical inactivity, use of tobacco and excessive use of alcohol. A recent study has emphasized the importance of physical activity and sedentary behavior on the risk of DM2 (Joseph et al., 2016). In fact physical inactivity is associated with approximately 27 % of diabetes disease burden and has been attributed to 6% of deaths globally (WHO, 2009). Physical activity controls body weight, regulates blood pressure, uses up glucose as energy and makes body cells more sensitive to insulin thereby decreasing incidence of DM2 (Helmrich et al., 1991; Hu et al., 1999; Folsom et al., 2000; Colberg et al., 2010). WHO recommends a level of at least 150 minutes per week of moderate-intensity activity for adults (WHO, 2010).

Studies have found an increased risk of DM2 in non alcohol drinkers and those with high alcohol intakes, when compared with moderate alcohol intake (ADA, 2002; Wannamethee et al., 2003; Baliunas et al., 2009) since moderate alcohol improves insulin sensitivity (Mayer et al., 1993; Facchini et al., 1994). A later study investigating the glycemic and insulinemic indices of beer concluded that alcohol increases the postprandial glucose response and suggested the cause to be impaired insulin sensitivity (Hätönen, et al., 2012). Nonetheless, the type of alcoholic beverage is important. For example, wine was associated with a more significant reduced risk of DM2 compared with beer or spirits (Huang et al., 2017).

Also, cigarette smoking increases the risk of DM2 (ADA, 2002; Willi, 2008) with smokers having a 44% more risk compared with non-smokers (Willi, 2008). Thus avoiding smoking cigarettes should be encouraged in diabetes prevention and management (Chang, 2012).

## 2.7 REFLECTIVE COMMENTS ON ASSOCIATION BETWEEN DIABETES AND SELECTED RISK FACTORS

Carbohydrates are the major dietary component that has a direct impact on blood sugar levels. However a number of factors discussed above influence or moderate the effect of carbohydrates on glycemic response. Thus the effect of carbohydrates should be considered alongside other dietary components especially the macronutrients since it may not be possible to determine the effect of each dietary nutritional component. This is also because people do not consume specific nutrients but a variety of them in a meal.  In this regard, this study considered the carbohydrate-rich foods in the combinations with other foods as they are normally consumed.

Although dietary carbohydrates have a direct impact on blood sugar as earlier described, other non-dietary components may moderate its effect on blood sugar levels.  Some of these factors are considered in this study as part of the confounding variables while some and especially the environmental risk factors are not accounted for. This study investigated the effect of dietary carbohydrates in influencing the occurrence of diabetes taking into account these non dietary risk factors specifically, age, income, level of education, blood pressure, physical activity and sedentary behavior, cigarette smoking and alcohol consumption. The results are discussed in the following sections.

# CHAPTER 3: ASSOCIATION BETWEEN SOCIO-ECONOMY, NUTRITIONAL STATUS AND DIABETES PREVALENCE AMONG WOMEN OF AMAGORO

## ABSTRACT

The aim of this study was to establish the prevalence of diabetes mellitus type 2 in association with demography, socio-economy and nutritional status of women in Amagoro Division of Western Kenya. This was a cross-sectional household-based study involving 260 women aged 15-90 years. Households were chosen by cluster and stratified sampling. Data on demography and socio-economy and diabetes status were collected by interviews using pre-tested questionnaires. Blood sugar levels were measured using a glucometer and levels 7.8 mmol/L underwent a confirmatory test using fasting blood sugar. Anthropometric measurements were taken following standard protocols. Body mass index as indicator of nutritional status was calculated by dividing weight (kg) by height ($m^2$) and classified as underweight (<18.5); normal weight (18.5-24.9); overweight (25.0-29.9) and obese ( 30). Waist circumference > 88 cm indicated abdominal obesity. Waist-hip-ratio >0.80 was considered abnormal. Focus group discussions were also conducted and selected repeated themes were noted. The mean age of the participants was 37.1±14.8 years. The prevalence of diabetes mellitus was 16.9%. Although the women were aware of the rising cases of diabetes, they were not aware of the various risk factors. The factors significantly associated with diabetes were employment status (OR=3.16, $p$=0.02), household income (OR=14.21, $p$=0.04) and place of residence (OR=4.54, $p$=0.03).

**3.1 INTRODUCTION**

Diabetes mellitus is a chronic medical condition whereby the blood sugar level of a person rises above normal (ADA, 2010). The three main types of diabetes mellitus are type-1 (DM1), type-2 (DM2) and gestational diabetes (GD) (ADA, 2010). DM2 is the most common of diabetes representing about 85% of the cases worldwide (WHO/IDF, 2008). In Sub-Saharan Africa, DM2 accounts for more than 90% of DM cases (Dalal et al., 2011).

Causes attributed to DM2 are genetic and non genetic factors (ADA, 2010; Herder and Roden, 2011). It is more common in women, especially those with a history of GD (ADA, 2010) and those with a family history of diabetes (Herder and Roden, 2011). Behavioural factors highly associated with DM2 include unhealthy diet, obesity and lack of physical activity (ADA, 2010). These factors are strongly influenced by the demography and socio-economic status of the individuals which have been found to be associated with DM2 (Corsi and Subramanian, 2012; Rao et al., 2010; Veghari et al., 2010). Some of the demographic and socio-economic risk factors include age, marital status and education and income levels.

The risk of DM2 increases with age (Colberg et al., 2010) which could be due to weight gain, reduced physical activity (Donato et al., 2003; Tanaka and Seals, 2008), the ageing pancreas and insulin resistance by cells (Booth et al., 2011). Marital status has also been linked to increased risk of DM2 especially widowed men possibly due to poor lifestyle (Cornelis et al., 2014). There is conflicting evidence on the association between income levels and risk of DM2. A previous study found the household income level to be inversely associated with DM2 (Hwang and Shon, 2014) while others reported contrary results, or found no association at all (Tanaka et al., 2012). DM2 has been found to be inversely associated with the level of

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education (Hwang and Shon, 2014; Lessmann et al., 2012; Veghari et al., 2010). Overweight/obesity especially abdominal obesity has been associated with increased risk of DM2 (Moretto et al., 2015) mainly because of associated insulin resistance (Hussain et al., 2010). Abdominal obesity is indicated by a waist-to-hip (WHR) ratio > 0.80 for females (Ayah et al., 2013) or a BMI > 30.0 (WHO, 2011).  A waist circumference (WC) > 88 cm for women represent an increased diabetes risk (Ayah et al., 2013; Gezawa et al., 2015; WHO, 2011).

In Kenya the prevalence of diabetes mellitus is rising and has been estimated at 2.7% in rural and 10.7% in urban areas (*Personal communication, DMI centre, Nairobi*). A prevalence of 12% and 16% has been reported in an urban and rural population of Kenya respectively (Dalal et al., 2011; El-busaidy et al., 2014). Due to such inconsistency in the results, more prevalence studies need to be conducted. Also the risk factors could not be clearly established due to the limitations in the available data (Dalal et al., 2011). Nonetheless very little research has been done on diabetes mellitus type 2 in Kenya which has specifically targeted women as a group.

The purpose of this study was therefore to determine prevalence of diabetes mellitus and its association with demography, socio-economy and nutritional status of women of Amagoro division in Western Kenya.

## 3.2 STUDY DESIGN AND METHODOLOGY

### 3.2.1 Study Design

A cross-sectional study with both descriptive and analytical components was conducted among women aged 15 – 90 years. The study used a structured questionnaire to collect information through self-reporting. The interviews were conducted at the participants' home by trained

research assistants. Six focus group discussions were also conducted with participants drawn from those who took part in the survey.

### 3.2.2 Study Site

The study was conducted in Amagoro division of Teso North District of Busia County in Western Province of Kenya (see appendix 6). Its administrative headquarters is in Amagoro town. It is bordered by Bungoma district to the North and East, Teso South district in the South and Republic of Uganda in the West. The division has nine administrative locations, namely; Okuleu, Kokare, Amoni, Osajai, Kocholia, Kamolo, Kamuriai, Amagoro and Akadetewai. The inhabitants of Amagoro division are predominantly Tesos. The division has a population of 56,207 (29, 843 female and 26, 364 male) and an area of 114.3 square kilometers. It has a total of 12, 478 households (Kenya census, 2009).

The inhabitants of Amagoro division depend on agriculture, trading across the Kenya-Uganda border and bicycle and motor cycle taxi businesses for livelihood. The major crops grown in this area are maize, beans and sorghum in order of preference with maize being the most preferred. Other crops include millet, cassava and groundnuts among others while the main cash crop is tobacco. The major livestock types are: indigenous chicken followed by zebu cattle, local goats and sheep (Ministry of Agriculture, *Personal Communication,* 2013).

### 3.2.3 Sampling Procedure

From the nine locations in Amagoro division, three locations were sampled for this study. First the locations with less than 1000 households were excluded and these were Okuleu, Kokare and Kamuriai. Of the 6 locations left, three are located along the Kenya-Uganda highway (Kocholia, Amagoro and Akadetewai). Amagoro which is located in the middle was sampled from this group. Two more locations were sampled from the remaining 3 (Amoni, Osajai and Kamolo)

which are located in the interior. To the south of Amagoro were Amoni and Kamolo. Kamolo was sampled since it was more interior and had the highest number of households. To the North of Amagoro and most interior Osajai location was also sampled. Therefore the three locations that participated in this study were Amagoro (central), Osajai (north) and Kamolo (south). The sample size was proportionately distributed among the three locations.

### 3.2.4 Sample Size Calculation

The sample size was calculated according to the formula adopted from Fox, Hunn and Mathers namely: $N = P (100\%-P)/ (SE)^2$. N= Desired sample size; P= Prevalence of diabetes in rural Kenya (Isiolo County) (16%). SE= the confidence interval of 5% divided by 1.96. In this case the SE= 2.55 and therefore N=207. Allowing attrition, 260 households participated in the study.

### 3.2.5 Data Collection Tools

Data were collected using pretested questionnaires, focus group discussion and key informant interviews' guides were also administered. Weight was measured using a bathroom scale and height using a non-stretchable tape. Glucose and blood pressure meters were used to measure blood glucose and blood pressure respectively.

### 3.2.6 Data Collection

The outcome variable was diabetes mellitus which was diagnosed using random and fasting blood sugar levels. This was conducted using the On-Call Plus blood glucose monitoring system (On-Call Plus ACON Laboratories, USA) which is an electrochemical enzymatic assay for the quantitative detection of glucose in capillary whole blood. This system contains a blood glucose meter, blood glucose test strips and control solution. The finger of each participant was pricked using a sterile lancet and blood sample was applied directly to the end tip of the test strip which was connected to the blood glucose meter. The result was read from the meter dis-

play. Each test strip was used only once. Since the whole blood sample was applied directly from the finger tip to the test strip, there were no special handling or storage procedures. A calibration code chip was provided with each vial of test strips. A control was run by applying the glucose control solution to the tip of the test strip that had been inserted into the meter. The result of the control was acceptable within the range indicated on the test strip vial label.

A random blood sugar (RBS) was obtained from a finger prick using a sterile lancet and glucose level was measured using a glucometer. Participants with a RBS 7.8 mmol/l were considered to have hyperglycemia and underwent a confirmatory test the following morning using fasting blood sugar. Total diabetes was thus defined by those who reported to have been diagnosed with diabetes mellitus in addition to the newly diagnosed cases. A fasting blood sugar 7.0 mmol/L was considered as a confirmation for the disease (Ayah, et al., 2013).

Independent variables were demography, socio-economy and nutritional status. Age categorization was adopted from Gezawa et al (2015). Education level and marital status were classified respectively into four (no formal schooling, primary education, secondary education and tertiary education) and four (single, married, divorced/separated, and widowed). Employment status, main source of household income and monthly household income were sorted respectively into four (unemployed, self employed, informal employment, formal employment), three (salary/wages, subsistence farming, small-scale business) and three (KES 0-4999, 5000-10000, 10001-16000).

Nutritional status was assessed in terms of Body Mass Index (BMI). Height and weight were measured using standard protocols with a few modifications (Ayah et al., 2013; Rao et al., 2010). Each participant was asked to remove footwear and headgear. Height was measured using a tape measure and recorded in metres. The tape was stuck onto a flat wall. The

participant was requested to stand on a flat surface adjacent to the wall. A wooden head rest was then placed on the head to allow the measurement to be read on the wall straight from the top of the head. The participant was asked to keep the feet together with the heels against the wall and knees kept straight. The height was taken and recorded to the nearest 0.5 cm. Weight was measured using a bathroom scale (Camry Model: BR 9012) and recorded to the nearest 0.5 kg. These two measurements were then used to calculate body mass index (BMI) using the formula: weight (kg) divided by height (m)$^2$.

BMI was then computed and participants classified into four categories of < 18.5; 18.5-24.9; 25.0-29.9 and 30 representing underweight; normal weight; overweight and obesity respectively (Cornelis et al., 2014). Waist and hip circumference were also measured using standard protocols (WHO, 2011). Waist circumference > 88 cm and WHR > 0.80 were considered to be abnormal (Ayah et al., 2013). Diabetes data and history of diabetes in the family were obtained from the self-reported questions.

After the survey, a few participants were invited to focus group discussions (FGDs). The discussions involved 7 to 10 members and a moderator and were conducted at local churches for convenience. A FGD guide was used and findings were noted. A total of six FGDs were conducted.

### *3.2.7 Ethical Consideration*

Ethical approval was granted by Kenyatta National Hospital and University of Nairobi Ethics, Research and Standards Committee. Participants gave an informed consent and for those below 18 years, consent was sought from the guardian/parent. The inclusion criteria included being female, resides permanently in the household, sound vision, hearing and memory, understands the questions and agrees to participate. The exclusion criteria were poor vision, hearing and memory or being ill (Hussain et al., 2010; Moretto et al., 2015).

### *3.2.8 Data Analysis*

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 20.0. Descriptive statistics were used in analyzing and characterizing the sample. Data were presented in absolute frequencies, percentages, mean and standard deviation. A chi-square analysis was used to compare the outcome with independent variables. Binary logistic regression enabled the associations between DM2 and independent variables to be determined while multivariate logistic regression analysis determined the magnitude of the independent risk factors. The significance level adopted in these tests was 5% ($p<0.05$). Findings from FGDs were summarized according to themes.

## 3.3 RESULTS AND DISCUSSION

### *3.3.1 Socio-Demographic Characteristics of the Respondents*

The socio-demographic characteristics included age, education level, marital status, family history of diabetes and place of residence. Participants were mainly from the Iteso ethnic group (91.2%). Luhya's and other tribes were 6.5% and 2.3% of the participants respectively. Their mean age was 37.1 ± 14.8 years. The majority of the women were young (15 – 34 years) and very few (3.1%) were over 64 years (Table 1). Most of them were married (90%). Only 28.9%

had received post primary education and 13.5% never had formal schooling. Those with a family history of DM2 were 7.3%. In addition, only 36 (13.8%) lived in permanent housing while the rest lived on semi-permanent houses with only 7 (2.7%) households connected to electricity. With regard to household size, 54.2% comprised of 4-6 members while 1-3 member and 7-10 member households formed 16.2% and 29.6% respectively.

Low level of education was found among the participants with very few progressing beyond primary school. This is in agreement with an earlier study that found low enrolment of Kenyan women in post primary education and as a result few women are in formal employment as (Onsomu, 2008), a finding supported by this study. This low level of education may explain the relatively high prevalence of diabetes mellitus although this association was not significant. Women in the FGDs although aware of the rising cases of diabetes, could only associate diabetes to eating sugary foods and excessive body weight and were not aware of other predisposing factors such as physical inactivity, alcohol consumption or cigarette smoking.

**Table 1:** Distribution of participants with regard to socio-demographic characteristics

| Variables | Categories | Frequencies | |
|---|---|---|---|
| | | n | % |
| Age (years) | 15-34 | 175 | 67.3 |
| | 35-64 | 77 | 29.6 |
| | 65 | 8 | 3.1 |
| | | | |
| Marital status | Single | 16 | 6.2 |
| | Married | 234 | 90 |
| | Divorced/separated | 5 | 1.9 |
| | Widowed | 5 | 1.9 |
| | | | |
| Level of education | Never gone to school | 35 | 13.5 |
| | Primary education | 176 | 67.7 |
| | Secondary education | 46 | 17.7 |
| | Tertiary education | 3 | 1.2 |
| | | | |
| Family history of diabetes | Yes | 19 | 7.3 |
| | No | 241 | 92.7 |
| | | | |
| Place of residence | Kamolo | 97 | 37.3 |
| | Amagoro | 98 | 37.7 |
| | Osajai | 65 | 25 |

### 3.3.2 Socio-Economic Characteristics of the Respondents

The socio-economic characteristics included employment status, main source of household income and households' monthly income. Most participants were unemployed and as a result nearly 70% relied on subsistence farming (Table 2). The participant's average monthly income level was KES 2438±2592 which mainly came from subsistence farming (69.6%). A majority of the households' average monthly income was below KES 10,000. They all fall under Kenya's low income group. However, this is a rural population that obtains most food through subsistence farming and therefore spends considerably less (KNBS, 2015).

**Table 2:** Distribution of participants according to socio-economic characteristics

| Variable | Categories | Frequency | Percent |
|---|---|---|---|
| Employment status | Unemployed | 135 | 51.9 |
| | Self employed | 65 | 25 |
| | Informal employment | 59 | 22.7 |
| | Formal employment | 1 | 0.4 |
| Main source of household income | Salary/wages | 23 | 8.8 |
| | Farming (subsistence) | 181 | 69.6 |
| | Business (small-scale) | 43 | 16.5 |
| | Other | 13 | 5 |
| Family monthly income (KES) | 0-4999 | 222 | 85.4 |
| | 5000-10000 | 34 | 13.1 |
| | 10001-16000 | 4 | 1.5 |

### 3.3.3 Nutritional Status of the Respondents

The nutritional status was categorized in terms of BMI. In addition WC and WHR were used to define abdominal obesity as one of the risks for DM2. The mean WC, BMI and WHR were 78.7±9.9, 22.7±3.44 and 0.85±0.08 respectively (Table 3). The prevalence of overweight/obesity was 23.1% which was relatively higher than from previous studies in Kenya possibly because this study sampled only women. Most studies have reported a relatively high prevalence of obesity in women than men (Chege, 2010; Mathenge et al., 2010; Dalal et al., 2011; Chege, 2016). Those with abnormal WHR were 75.8%. A majority of the participants (82.7%) had a normal WC. Cases of underweight were also reported among the women (6.9%).

**Table 3:** Distribution of participants according to nutritional status

| Variable | Categories | Frequency | Percent |
|---|---|---|---|
| Body mass index (BMI) | Underweight | 18 | 6.9 |
| | Normal weight | 182 | 70 |
| | Overweight | 52 | 20 |
| | Obesity | 8 | 3.1 |
| Waist circumference (WC) | Normal | 215 | 82.7 |
| | Abdominal obesity | 45 | 17.3 |
| Waist-to-hip ratio (WHR) | Normal | 63 | 24.2 |
| | Abnormal | 197 | 75.8 |

### 3.3.4 Prevalence of Diabetes Mellitus

The prevalence of DM2 among the women across all categories was found to be 16.9%. Of this proportion (36) 13.8% were already diagnosed while (8) 3.1% were newly diagnosed cases. This figure is much higher than earlier reported in Kenya (Dalal et al., 2011). However, the prevalence in rural areas seems to be rising. Isiolo County, a rural population in Northern Kenya reported prevalence of 16% (El-busaidy et al., 2014). The rising prevalence could partly be due to increased awareness about the disease, improved diagnosis (IDF, 2011) and prevalence of human immunodeficiency virus (HIV)/AIDS (Ledergerber et al., 2007) which was 6.4% in women of Western Kenya in 2007 (Onsomu, 2008). HIV drugs are suggested to increase the risk of DM2 (Ledergerber et al., 2007) possibly due to associated obesity and cells developing insulin resistance (Hall et al., 2011).  The women who participated in the focus group discussions (FGDs) also agreed that the prevalence of diabetes is rising. They asserted that the disease can affect anyone and not as earlier believed that it only affects rich people.

### *3.3.5 Demography and Prevalence of Diabetes Mellitus*

Family history of diabetes and place of residence were significantly associated with DM2 ($p<0.05$) (Table 4). The risk of diabetes is usually higher if a parent or sibling has had it (Dedoussis et al., 2007; Herder and Roden, 2011; Chege, 2016). No association was found to exist between DM2 and age, marital status and level of education ($p>0.05$) in this study population.

**Table 4:** Distribution of the participants by socio-demography and diabetes

| Variables | Categories | Yes | | No | | p-value |
|---|---|---|---|---|---|---|
| | | n | % | n | % | |
| Age | <35 | 20 | 45.45 | 116 | 53.7 | $0.318^{ns}$ |
| | 35 | 24 | 54.55 | 100 | 46.3 | |
| Marital status | Never married | 4 | 9.1 | 12 | 5.6 | |
| | Married | 39 | 88.6 | 195 | 90.3 | $0.529^{ns}$ |
| | Divorced/separated/widowed | 1 | 2.3 | 9 | 4.2 | |
| Level of education | No formal schooling | 5 | 11.4 | 35 | 16.2 | |
| | Primary education | 28 | 63.6 | 148 | 68.5 | $0.188^{ns}$ |
| | Secondary/tertiary education | 11 | 25 | 35 | 16.2 | |
| Family history of diabetes | Yes | 11 | 25 | 8 | 3.7 | $0.000^{s}$ |
| | No | 33 | 75 | 208 | 96.3 | |
| Place of residence | Kamolo | 22 | 50 | 75 | 34.7 | |
| | Amagoro | 19 | 43.2 | 79 | 36.6 | $0.008^{s}$ |
| | Osajai | 3 | 6.8 | 62 | 28.7 | |

Note: $^{ns}$: not significant    $^{s}$: significant

No significant association was found between DM2 and age, marital status, level of education. The women in FGDs and key informants also alluded to the fact that diabetes affects people of all ages and not only the older people as earlier believed. Family history of DM2 and place of residence were found to be the factors that significantly influence the prevalence of DM2.

However it is important to note that majority of those that reported to have no family history of the disease was because they were not aware. This is majorly because of the lack of regular screening for DM2. Prevalence of DM2 was higher among residents of Kamolo. These significant variables have been discussed in detail in Table 8.

### 3.3.6 Socio-Economy and Diabetes Mellitus

Employments status and family income were significantly associated with DM2 ($p<0.05$). No association was found to exist between DM2 and income source ($p>0.05$) (Table 5). Majority of those who were suffering from DM2 (>60%) were either unemployed or self-employed and those earning below KES 5000. These significant factors have been discussed in detail after conducting the multivariate analysis (Table 8.).

**Table 5:** Distribution of participants by socio-economic characteristics and diabetes

| Variables | Categories | Yes | | No | | $p$-value |
|---|---|---|---|---|---|---|
| | | n | % | n | % | |
| Employment status | Unemployed | 10 | 22.7 | 125 | 57.9 | |
| | Self employed | 18 | 40.9 | 47 | 21.8 | 0.000[s] |
| | Informal/Formal employment | 16 | 36.4 | 44 | 20.4 | |
| | | | | | | |
| Main source of HH income | Salary/wages | 7 | 15.9 | 16 | 7.4 | |
| | Farming | 27 | 61.4 | 154 | 71.3 | 0.188[ns] |
| | Business | 9 | 20.5 | 34 | 15.7 | |
| | Other | 1 | 2.3 | 12 | 5.6 | |
| | | | | | | |
| Family monthly income (KES) | 0-5000 | 31 | 70.5 | 201 | 93.1 | |
| | 5001-10000 | 10 | 22.7 | 14 | 6.5 | 0.000[s] |
| | 10001-16000 | 3 | 6.8 | 1 | 0.5 | |

Note: [ns]: not significant     [s]: significant

### *3.3.7 Nutritional Status and Diabetes Mellitus*

The prevalence of overweight/obesity was 23.1% with more than 75% having abnormal WHR. Despite this, there was no significant association between BMI, WHR and WC with DM2 ($p>0.05$) (Table 6). However those with abnormal WHR ($>0.80$) were 1.4 times more likely to have DM2 as opposed to those with normal WHR (Table 7). This could possibly be due to the cut-off values used which may not be appropriate for this population. Despite these findings, other studies conducted in different parts of Kenya involving different communities had established a positive association especially between abdominal obesity and DM2 (Chege, 2010; El-busaidy et al., 2014). Although they had low level of education, women in the FGDs were also aware of the link between excessive weight and a number of diseases including diabetes.

**Table 6:** Distribution of the participants by nutritional status and diabetes

| Variables | Categories | Yes | | No | | *p*-value |
|---|---|---|---|---|---|---|
| | | n | % | n | % | |
| Body mass index | <25 | 34 | 77.3 | 166 | 76.9 | |
| | 25 | 10 | 22.7 | 50 | 23.1 | $0.952^{ns}$ |
| Waist circumference | <88 | 39 | 88.6 | 176 | 81.5 | |
| | 88 | 5 | 11.4 | 40 | 18.5 | $0.253^{ns}$ |
| Waist-to-hip ratio | <0.8 | 13 | 29.5 | 50 | 23.1 | |
| | 0.8 | 31 | 70.5 | 166 | 76.9 | $0.367^{ns}$ |

*p*-value: Pearson Chi-Square, $^{ns}$: not significant

### *3.3.8 Socio-Demography and Odds Ratios for Diabetes Mellitus*

With regard to age, the elderly ( 65 years) were 1.2 times more likely to suffer from DM2 as compared to the young (15-34 years) although this finding was not statistically significant

(*p*>0.05) (Table 7). Those who never went beyond primary education or never went to school at all, have higher chances of suffering from DM2 as opposed to those with post primary education.

**Table 7:** Results of univariate logistic regression for diabetes mellitus

| Variables | Categories | *p*-value | OR (95% CI-OR) * |
|---|---|---|---|
| Age (years) | 15-34 (ref) | - | 1.00 |
| | 35-64 | 0.491[ns] | 0.79 (0.40-1.56) |
| | 65 | 0.776[ns] | 1.21 (0.32-4.56) |
| Marital status | Never married (ref) | - | 1.00 |
| | Married | 0.321[ns] | 1.83 (0.55-6.07) |
| | Divorced/separated/widowed | 0.699[ns] | 1.30 (0.35-4.91) |
| Level of Education | Never gone to school | 0.351[ns] | 1.74 (0.54-5.54) |
| | Primary education | 0.287[ns] | 1.53 (0.70-3.35) |
| | Secondary/higher education (ref) | - | 1.00 |
| Employment status | Unemployed | 0.001[s] | 4.55 (1.92-10.76) |
| | Self employed | 0.898[ns] | 0.95 (0.43-2.09) |
| | Informal/formal employment (ref) | - | 1.00 |
| Family monthly income (KES) | 0-5000 | 0.012[s] | 19.20 (1.93-190.67) |
| | 5001-10000 | 0.130[ns] | 6.27 (0.58-67.40) |
| | 10001-16000 (ref) | - | 1.00 |
| Family history of diabetes | Yes | 0.000[s] | 0.12 (0.04-0.31) |
| | No (ref) | - | 1.00 |
| Body mass index | <25(ref) | - | 1.00 |
| | 25 | 0.952[ns] | 1.02 (0.47-2.22) |
| Waist circumference | <88 (ref) | - | 1.00 |
| | 88 | 0.258[ns] | 1.77 (0.66-4.78) |
| Waist-to-hip ratio | <0.8 (ref) | - | 1.00 |
| | 0.8 | 0.368[ns] | 1.39 (0.68-2.86) |
| Place of residence | Kamolo | 0.013[s] | 4.97 (1.41-17.56) |
| | Osajai | 0.570[ns] | 0.82 (0.79-3.49) |
| | Amagoro (ref) | - | 1.00 |

Note: *OR (95% CI-OR): odds ratio and 95% confidence interval for odds ratio. [s]: significant, [ns]: not significant

Family history, employment status, family income and the place of residence showed association with DM2 ($p<0.05$). The influence of family history would not be clearly explained since it was assumed that those who did not know of the history had no history. However, these results show that irrespective of history chances of suffering DM2 are still there in this population.

Compared to those in employment whether formal or informal, unemployed respondents were 4.55 times more likely to suffer from DM2. Residents of Kamolo were more likely to suffer from DM2 as opposed to those from Amagoro and Osajai.

**Table 8:** Results of multivariate logistic regression for diabetes mellitus

| Variables | Categories | $p$-value | OR (95% CI-OR) * |
|---|---|---|---|
| Employment status | Unemployed | 0.02 | 3.16 ( 1.22-8.19) |
| | Self employed | 0.19 | 0.55 (0.22-1.34) |
| | Informal/formal employment (ref) | - | 1.00 |
| | | | |
| Family monthly income (KES) | | 0.04 | 14.21 (1.19-169.69) |
| | 0-4999 | | |
| | 5000-10000 | 0.15 | 6. 0 (0.51-84.61) |
| | 10001-16000 (ref) | - | 1.00 |
| | | | |
| Place of residence | Kamolo | 0.03 | 4.54 (1.17-17.55) |
| | Osajai | 0.19 | 0.58 (0.26-1.30) |
| | Amagoro (ref) | - | 1.00 |

Note: *OR (95% CI-OR) means odds ratio and 95% confidence interval for the odds ratio.

Multivariate logistic regression analysis indicated that employment status, family income and place of residence were significantly associated with diabetes mellitus (p<0.05). Participants who were unemployed were three times more likely to suffer from DM2 as opposed to those in formal employment while those earning less than KES 5000 per month also stood higher chance

of being diabetic than those on a higher income bracket. A similar finding was reported in Northern Kenya where low economic status was associated with higher risk for DM2 (El-busaidy et al., 2014). Being unemployed and thereby having low income may predispose an individual to depression or stress which has been shown to increase diabetes risk (Kato et al., 2009; Rod et al., 2009; Pouwer et al., 2010 Adriaanse, 2010; Kelly and Ismail, 2015). People under stress may not take good care of themselves; they develop unhealthy lifestyle behaviors such as reduced exercise, poor dietary habits, consuming excess alcohol and smoking cigarette (Bonnet et al., 2005; Rod et al., 2009).

Residents of Kamolo were more than four times likely to suffer from diabetes mellitus as opposed to those residing in Amagoro while those in Osajai were less likely to suffer from the disease. These differences in risk could possibly be explained by the fact that a majority of those sample came from Kamolo location and also the possible difference in the type of diet they subsist on, level of alcohol consumption as well as physical activities they could be engaged in. It's also important to note that majority of the participants were sampled from Kamolo location which could contribute to it showing a higher prevalence than other sampled locations.

# CHAPTER 4: DIETARY PATTERNS OF THE WOMEN OF AMAGORO

## ABSTRACT

Kenya is especially experiencing a rise in diabetes incidences as well as other non-communicable diseases. A healthy diet is important in the prevention and management of such diseases. This study was therefore designed to describe the dietary patterns of the Iteso community, the main inhabitants of Amagoro in Western Kenya. The study provides background knowledge on possible diet and health intervention that would help to improve health status. This was a cross sectional survey involving 260 women aged between 15 - 90 years. First, focus group discussions and key informant interviews were conducted to establish cultural and social aspects surrounding food and people's common views towards food. They also helped generate a food list that was used in designing a food frequency questionnaire. This was then followed by a household survey using a pretested structured questionnaire administered through interviews. The results showed that the diet of these people was generally starch-based and was limited in protein. The common food being porridge prepared from maize which lack some essential amino acids such as tryptophan and lysine. Foods were mostly consumed thrice a day. Thin porridge or black tea was popular for breakfast and stiff porridge for lunch and supper. There is therefore need to develop strategies that seek to increase the availability of protein sources and diversify carbohydrate sources. Improving income sources would help in meeting nutritional needs without people having to sell their protein-rich foods for money. The population also needs to be educated on possible adjustment of stiff porridge to relish ratio.

## 4.1 INTRODUCTION

As a result of the rising cases of non-communicable diseases in Kenya (Mohajan, 2014), it is important to understand the foods and culture of various groups of people in order to be able to effectively develop and implement health promotion activities (Kuhnlein et al., 2013). A healthy diet is important in reducing the incidences of such diseases (DGAC, 2015; Ofwona, 2013; Kuhnlein et al., 2013) especially by identifying and promoting intake of culturally-acceptable staple foods (Mattei et al., 2015).

The Kenyan population is divided along ethnic, geographical as well as economical backgrounds (Oniang'o and Komokoti, 1999). Consequently, different ethnic groups have different dietary patterns (Oniang'o and Komokoti 1999; Hansen et al., 2011; Kuhnlein et al., 2013). For example the Kamba, Luo and Maasai have considerably different dietary patterns (Hansen et al., 2011). However, despite the diverse dietary patterns, food insecurity is a major challenge facing a majority of Kenyans irrespective of their ethnicity (Hansen et al., 2011; Mohajan, 2014; Ofwona, 2013; Oiye et al., 2009). This challenge justifies the need to describe various dietary patterns (Hansen et al., 2011; Ofwona, 2013) since it will enable the government to know the extent of the problem and devise policies to address them (Ofwona, 2013; Kuhnlein et al., 2013).

Government interventions must be targeted to specific populations since most indigenous people are located in rural and remote areas. In addition, there are differences in local food sources and socio-cultural characteristics (Kuhnlien et al., 2013). For example in most parts of Kenya food preparation is mainly done by women (Karp and Karp, 1977; Steenbergen et al., 1984; Oiye et al., 2009). The responsibility of growing or purchasing food is left to women (Karp and

Karp, 1977). Consequently, they are responsible for making decisions relating to food including the choice of food, its source, preparation and consumption (Oiye et al., 2009). Socio-demographic characteristics including household sizes, employment status, level of education, may explain both the choice and amount of food consumed (Macharia et al., 2012).

Amagoro division which is located in the northern part of Busia County in Western Kenya is mainly the Iteso community who belong to the Nilotic-speaking group (Karp and Karp 1977). Karp and Karp (1977) conducted a study between 1969 and 1971 in Amukura area of Busia County (then Busia district) which is also inhabited by the Iteso. These anthropologists described the Iteso culture including the foods consumed although their study did not describe the frequencies of consumption of various foods neither did they specify the average serving sizes for various foods. Nonetheless there is a possibility of change in dietary patterns considering they conducted their study 46 years ago.

Despite the known association between dietary and various health outcomes (DGAC, 2015), data on food consumption patterns among the poor populations of Kenya is not readily available (Ofwona, 2013). This study therefore aimed at describing the dietary patterns of the Iteso community living in Amagoro division of Western Kenya. This will provide background knowledge for possible association between diet and health especially with regard to non-communicable diseases among the Iteso community.

## 4.2 STUDY DESIGN AND METHODOLOGY

The study design, site and ethical considerations were as described in Chapter three.

### 4.2.1 Data Collection Tools

The study used a structured pretested questionnaire to collect information through self-reporting. The interviews were conducted at the participants' home. Focus group discussions and key informant interviews were also conducted in the area.

### 4.2.2 Sample Size Determination

The sample size for the survey was calculated according to the formula adopted from Fox et al (2009) namely: N= P (100%-P)/ (SE) $^2$. N= the desired sample size; P= Proportion of main dietary component associated with DM2 (carbohydrates) in the diet (80%). SE= the confidence interval of 5% divided by 1.96. In this case the SE= 2.55 and therefore N=246. Allowing attrition, a total of 260 households participated in the study.

### 4.2.3 Sampling Procedure

Based on FAO recommendations that surveys should target the person who mostly prepare meals for the household, the questionnaires were administered to women mostly involved in preparing meals for the household (FAO, 2008). Food preparation is mainly done by women in the Iteso community (Karp and Karp, 1977). The participants were drawn from three locations selected from the nine locations as described in section 3.1. These were locations with many households, located to the North (Osajai), south (Kamolo) and central (Amagoro). The participants were then proportionately distributed among these locations depending on the number of households in each location.

A maximum of 10 participants each from a different household were recruited then on voluntary basis from each location to participate in focus group discussions (FGDs). Each FGD consisted of between 6-10 participants and a moderator. Each location had 2 FGDs conducted in their local church. A pretested moderators' guide was used and data was taken by recording and note taking.

The key informant interviews (KII) participants were sampled purposively to ensure that the composition of final sample reflects the representatives from the various categories of institutions and people in the study area. Fifteen key informants including a doctor, a clinical officer, nutritionist, social development officer, nurse, religious leaders, teachers, public health officer, agricultural officer, political leader and assistant chiefs were interviewed. The data was collected through recording and note taking.

### 4.2.4 Dietary Assessment Using a Food Frequency Questionnaire

Dietary assessment was conducted by face-to-face interviews at the participants' home using pretested structured questionnaires. A semi-quantitative food-frequency questionnaires (FFQs) were administered to women who were the persons mainly responsible for food preparation. Participants were asked about their food intake in the past one year (Rodrigo et al., 2015). The FFQ contained 54 locally available food items. The frequency of consumption of these foods was assessed and presented as: daily, weekly, monthly or yearly intake. In order to accurately assess the amounts of specific foods consumed, the trained interviewers carried some household measures including cups, bowls and spoons. All the ingredients were also recorded including their amounts.

### 4.2.5 Conducting Focus Group Discussions and Key Informant Interviews

The focus group discussions (FGDs) were conducted using the moderator's guide (Appendix 3). The areas covered included the food consumption patterns in the area and their knowledge on diet in relation to disease. Other social habits were also captured. In addition to the FGDs, key informant interviews (KIIs) provided preliminary information about the foods consumed in the area including the cultural aspects surrounding food consumption. KIIs moderators' guide was used (appendix 4).

### 4.2.6 Proximate Analyses

Proximate composition of the foods was analyzed according to the AOAC official methods (AOAC, 2000) of analysis at University of Nairobi's Food Chemistry Laboratory. Proximate analysis was mainly carried out to help in the calculation of the available carbohydrates and various calories from the meals.

Moisture content was determined by weighing approximately 5 g of sample accurately in an aluminium dish, and dried to constant weight in an air-oven at 80 $^{o}$C. The weight loss of the sample was calculated as percent moisture content.

Crude protein was determined using about 5 g accurately weighed sample as total nitrogen by semi-micro Kjeldahl method and multiplied by an empirical factor of 6.25 to convert to protein.

Crude fibre was determined by digesting about 5 g sample accurately weighed in a 400 ml beaker, with dilute strong alkali and dilute strong acid, drying the residue to constant weight and incinerating in a muffle furnace at 500 $^{o}$C to constant weight. The difference between the weight of dry residue and ash was calculated as percent fibre content of the sample.

Total ash was determined by weighing accurately about 5 g sample in a porcelain crucible. This was then placed in a muffle furnace and incinerated at 500 $^{o}$C to constant weight. The total ash was calculated as percent of sample.

Soluble or digestible carbohydrate content was calculated as difference [100 − (moisture + crude protein + crude fat + crude fibre + total ash)].

### 4.2.7 Data Analysis

The data was analyzed using SPSS version 20.0 and Microsoft Excel. Data analysis procedure for the food frequency questionnaire was adopted from Fanzo et al., 2011. A Consumption frequency score (CFS) was computed for every food item. It was defined as the number of times the food item was consumed in a week with a score of 1 represented once weekly, 7 represented once daily and other values scaled accordingly (Fanzo et al., 2011).

The 13 food categories were: cereals; roots, tubers and plantains; legumes; vegetables; fruits; eggs; fish and poultry; meat; nuts and seeds; milk and milk products; fats and oils; sweets, other soft beverages. This study did not distinguish between organ meat and flesh meat. The CFS for a food group was computed by summing up the CFSs of foods in that food group (Fanzo et al., 2011). Categorization of specific foods or food groups were based on the consumption frequencies of at least daily scored at 7, and 'at least weekly' and 'at least monthly' receiving a score of 1 and 0.25 respectively. Daily consumption was represented by those with a CFS of that food group being 7. The percentage of individuals consuming each of the food groups either on a daily, weekly or monthly basis was determined.

Individual food variety scores (FVS) for various categories; daily, weekly and monthly were calculated as the number of food items consumed in the respective frequency category. In addi-

tion, individual diet diversity scores were generated for daily, weekly and monthly time periods based on the 13 categories of food. These were calculated as the number of food groups that were consumed daily, weekly or monthly respectively (Fanzo et al., 2011).

Descriptive statistics were used in analyzing and characterizing the survey participants. The data was presented in frequencies including percentages; and by mean including standard deviation. Data from the key informant interviews and focus group discussions was transcribed, summarized and key/repeated phrases noted.

## 4.3 RESULTS AND DISCUSSION

### 4.3.1 Food Consumption Frequencies

The food consumption frequency was described in terms of food variety and diet diversity as shown below.

### 4.3.2 Consumption of Various Food Types (Food Variety)

Most of the participants (71.9 %) consumed more than 4 different foods on a daily basis (medium to high food variety) with a mean of 5±3 foods types (Table 9). The mean food varieties consumed on a weekly and monthly basis were 9±4 and 7±3 food types respectively.

However it's possible that these foods belong to similar food groups. For this reason diet diversity scores were also analysed (Table 10).

**Table 9:** Individuals consuming different foods on a frequency of daily, weekly and monthly

| Number of foods | Number of individuals consuming various foods n (%) | | |
| --- | --- | --- | --- |
| | At least daily | At least weekly | At least monthly |
| Lowest food diversity ( 3 foods) | 73 (28.1) | 21 (8.1) | 45 (17.3) |
| Medium food diversity (4-5 foods) | 95 (36.5) | 34 (13.1) | 46 (17.7) |
| High food diversity ( 6 foods) | 92 (35.4) | 205 (78.8) | 169 (65.0) |
| Mean food types | 5±3 | 9±4 | 7±3 |

### 4.3.3 Consumption of the Various Food Groups (Diet Diversity)

Most women (68.6%) consumed more than 6 food groups on a daily basis (Table 10). This provides adequate nutrition (FAO/WHO, 1996). Participants on the lowest diet diversity on a daily basis were 0.8%. The mean for food groups consumed daily, weekly and monthly were about 3, 1 and 1 respectively (Table 10).

**Table 10:** Individuals consuming various food groups on a daily, weekly and monthly basis

| Number of foods | Number of individuals consuming various foods n (%) | | |
|---|---|---|---|
| | At least daily | At least weekly | At least monthly |
| Lowest diet diversity ( 3 food groups) | 2 (0.8) | 163 (62.5) | 240 (92.0) |
| Medium diet diversity (4-5 food groups) | 79 (30.3) | 74 (28.4) | 18 (6.9) |
| High diet diversity ( 6 food groups) | 179 (68.6) | 22 (8.4) | 2 (0.8) |
| Mean (range) food groups | 2.68 (1-3) | 1.46 (1-3) | 1.08 (1-3) |

As expected the food group mainly consumed on a daily basis in this population was cereals (Figure 1). This is because their chief carbohydrate source is stiff porridge mainly prepared from whole maize flour. Stiff porridge is consumed at least twice a day by a majority of the population; for lunch and supper. Sometimes a thin porridge prepared from the same flour is consumed at breakfast. The sweets were mainly the sugar used in tea and sugarcane which supplemented the Iteso meals (Karp and Karp, 1977).

The most frequently consumed foods included cereals, sugar, fats and oils, tea, vegetables and fruits. At least more than 50% of the participants consumed these foods on a daily basis. As expected the food group mainly consumed on a daily basis in this population was cereals. This is because their chief carbohydrate source is stiff porridge mainly prepared from whole maize flour. Stiff porridge is consumed at least twice a day by a majority of the population; for lunch

and supper. Sometimes a thin porridge prepared from the same flour is consumed at breakfast. The sweets were mainly the sugar used in tea and sugarcane which supplemented the Iteso meals (Karp and Karp, 1977). The traditional diet of stiff porridge prepared from maize flour is accompanied mostly by green leafy vegetables. The vegetable is boiled in sour milk or is sometimes flavoured with ash filtrate made from the ashes of certain leaves (Karp and Karp, 1977).

Milk, eggs and meat are expensive and are only consumed by very few people. It is worth noting that milk and eggs are seldom consumed by the majority. Sugar and tea as well as fats and oils are used every other day on average. Fat and oils are majorly used in the preparation of vegetables or meat and is frequently part of the daily diet. Vegetable consumption is high mainly because it's cheap, it's the main accompaniment to stiff porridge and also, a majority plants them on their own farms.

The overall food consumption pattern seems to be limited in protein despite the fact that the households produce legumes. The frequency of consumption of protein-rich foods (legume, meat, eggs and milk) was very low. This could be due to high levels of poverty as demonstrated by high unemployment and low income as well as low level of education. Household income has been suggested to have higher impacts on meat consumption (Bett et al., 2012) for example. Increase in household income also increased consumption of roots and tubers as well as fruits especially in rural populations (Musyoka et al., 2014). In Amagoro, most household rely on subsistence farming as a source of food and income. Some of these protein sources can be got from own farms but they rather sell these products for money instead of own consumption.
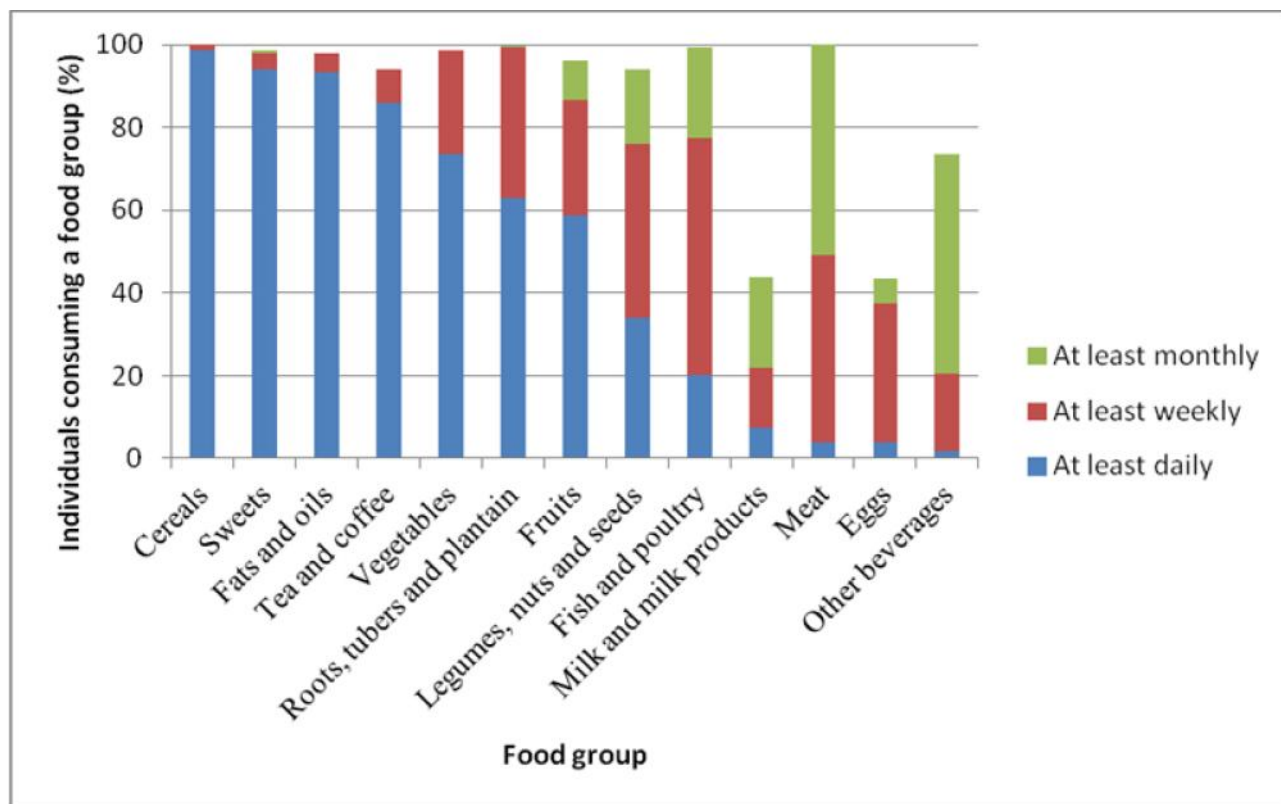
**Figure 1:** Average consumption of various food groups

### *4.3.4 Frequency of Ugali Consumption*

The main staple in this population was stiff porridge with 240 (92.3%) households consuming it on a daily basis and 20 (7.3%) consuming it at least weekly. *"We are all alive because of ugali",* Jane emphasized in a FGD. *"Ugali is strength"*, the women concurred. The stiff porridge is mainly prepared from whole maize meal but also from sifted maize meal, cassava, sorghum, millet or any combination thereof (Wanjala et al 2016).

The frequency of consumption followed the order whole maize > cassava-sorghum> cassava-sorghum-millet > sifted maize > cassava-millet. The choice usually depends on preference, availability and affordability. This is because in rural areas, the type of food consumed mainly depends on the households' own production (Oiye et al., 2009; Macharia et al., 2012; Wanjala et al., 2016).

The results of the key informant interviews (KIIs) and focus group discussions (FGDs) concurred with this finding. The most preferred *ugali* is prepared from whole maize while cassava mixed with either millet, sorghum or both is popular mainly during the famine season when maize stocks have run out and also due to the fact the maize is more expensive as opposed to cassava. The popular mixture for cassava-based *ugali* is cassava and sorghum. This is because millet is expensive unless it is harvested from own farm. *"What is eaten in the home depends mainly on what is available on the farm"* concurred the women in FGDs.

### 4.3.5 Foods for Various Groups of People and Specific Occasions

**a) Pregnant and lactating women**

Pregnant women are discouraged from the traditionally distilled liquor *(chang'aa)* and black tea. The lactating women are given plenty of white tea and thin porridge prepared from plain millet or composite flour. They also eat stiff porridge with meat or chicken although this special diet lasts for only 3 days after delivery to help the mother regain her energy. Apart from thin porridge, other foods believed to boost milk production include sugarcane, groundnuts, sesame seeds, local alcoholic brew *(busaa)*, bone soup and local green leafy vegetables prepared with sour milk and peanut and/or sesame butter. Cowpeas leaves and any vegetable prepared from special ash filtrate *(abalang)* are not recommended for lactating women. They are believed to lower milk production.

**b) Infants**

The infants are breastfed until the recommended age of six months although mothers who did not produce enough milk opted to wean the child earlier. Milk is introduced first followed by thin porridge. However some cannot afford milk and give the thin porridge. Thin porridge is usually prepared form composite flour containing maize, millet, sorghum, soya beans,

groundnuts, silver fish or beans depending on the availability. This composite flour porridge is believed to boost energy and improve the health of the baby especially its ability to fight disease. Other foods may include fruits, Irish potatoes or green bananas or pumpkins mashed with pumpkin leaves or mashed foods from the family table. There was no special food for toddlers, school going children and adolescents.

## c) Children, adolescents and adults

Foods are normally consumed three times in a day; breakfast, lunch and supper. However some people skip breakfast and only eat twice a day especially during times of scarcity. Snacks are not part of the daily meals. Nonetheless fruit or sugarcane can be eaten if it's available on own farm, sometimes black tea with or without accompaniment can be taken as a snack. *"What is eaten in the home depends mainly on what is available on the farm"* was the common statement from FGDs and KIIs.

Foods commonly consumed for breakfast are black tea or thin porridge flavored with sugar. In addition porridge may be flavored with milk, sugar, lemon juice or sometimes margarine. Black tea is popular due to lack of access to milk. The thin porridge is prepared mainly from whole maize or millet. Millet is expensive and is therefore only consumed when it's harvested in the home. Tea can be consumed with sweet potatoes, cassava, green maize, groundnuts, roasted soya beans, plantains, mixture of maize and beans, eggs, *chapatti*, bread or *mandazi*.

There is no difference between the foods consumed at lunch and supper. The most common food is stiff porridge *(ugali).* In most cases the left over vegetables at lunch time are used for supper. In this case only *ugali* is freshly prepared.

*Ugali* is either made from whole maize or cassava in combination with millet, sorghum or both. The most preferred stiff porridge is from whole maize while cassava based is popular mainly during the famine season when maize stocks have run out and also due to the fact the maize is more expensive compared to cassava. Millet is expensive and therefore rare. *Ugali* is usually consumed with local green leafy vegetables or silver fish popularly known as *omena*. Meat, poultry and fish may also accompany *ugali*. Most of these vegetables are simply boiled or boiled in ash filtrate. During the famine season, the popular vegetable is cowpeas leaves cooked with special ash filtrate (*abalang*) with groundnut paste and/or fresh milk. This way no cooking oil is required.

Other foods that may be consumed for lunch especially in famine season include sweet potatoes and cassava which are eaten with black tea or local vegetables or mashed with beans; plantain; rice with Irish potatoes; beans; green grams or mixture of maize and beans. Beans dishes are only prepared when beans are in season. This is because of the high price of beans.

The sick people eat depending on their appetite although what they request for must be available in the home. In most cases, the best they can get is eggs, fruits and plain millet porridge in addition to the usual family diet.

**d) Special occasions**

Different groups of people have different unique variety of foods. The social settings where some of these foods are consumed are of great significance (Kuhnlein et al., 2013). The Iteso community is no exemption. Special occasions include weddings and visiting in-laws and these demand special foods. During weddings special foods include *ugali* prepared from cassava, millet and sorghum served alongside *elumuch* (sauce prepared from smoked-dried meat, sour

milk, sesame and/or groundnut paste) and a mixture of boiled local green leafy vegetables flavored with sour milk, peanut and/or sesame butter. Other foods include rice, meat, *chapatti*, chicken, *pilau* (spiced meal prepared from rice and beef), local alcoholic brew (*busaa*), soft drinks, white tea served with groundnuts or *mandazi*. In addition cake is served during wedding ceremonies.

**e) Average serving size and nutrient composition of some foods**

Bowls and cups were used to standardize some food measures. For example a bowl of *ugali* weighed 500 g (as is basis) and the women consumed an average of one serving (500 g) while participants consumed an average of one cup of thin porridge and 2 cups of tea (Table 11). Cereals formed the main source of energy in the diet and included *ugali*, *chapatti* and rice with *ugali* contributing the largest portion size. The vegetables included kales, cowpea leaves and local vegetables. A cup of kales and cowpea leaves weighed 100 g while local vegetables weighed 200 g. This is because most local green leafy vegetables are soft and less fibrous as opposed to kales or cowpeas and thus, a larger quantity. The participants consumed more of these vegetables. Other foods included groundnuts, *mandazi*, beef stew, silver fish, sweet potato and cassava. Although the participants consumed 4 serving of sweet potato or cassava, they consumed more of sweet potato in total, this could be because of the sweetness associated with the sweet potato that encourages more intake as opposed to cassava.

**Table 11:** Average portion sizes of some foods consumed in Amagoro

| Food | Measure for serving ("as is" basis) | Average serving reported |
|---|---|---|
| Stiff porridge | 1 bowl (500 g) | 1 |
| Thin porridge | 1 cup | 1 |
| Tea | 1 cup | 2 |
| Ground nuts (dried) | 110 g (3 handfuls) | 1 |
| Beans | 1 cup | 4 |
| *Chapatti* | 1 *chapatti* (85 g ) | 3 |
| Rice | 1 bowl (350 g) | 1 |
| *Mandazi* | 1 *mandazi* (50 g) | 3 |
| Kales | 1 cup (100 g) | 1 |
| Cowpea leaves | 1 cup (100 g) | 1 |
| Local vegetables | 1 cup (200 g) | 1 |
| Beef stew | 3 pieces (90 g) | 1 |
| Sweet potato | 1 piece (140 g) | 4 |
| Cassava | 1 piece (100 g) | 4 |
| Silver fish | 1 cup (170 g) | 1 |

Participants generally consumed large portions of carbohydrates mainly inform of *ugali* (500 g). When *ugali* is not available especially when maize is out of stock, beans, cassava or sweet potato would be consumed as the main meal for the household mostly without an accompaniment. This partly explains the large portion sizes apart from the fact that snacking does not form part of their dietary habit. For breakfast, participants consumed mainly black tea or thin porridge and in most cases without an accompaniment. Meals are also consumed after vigorous physical activity mainly involving digging as well as other farm and household activities.

### *4.3.6 Proximate Composition and Energy Contents of some Foods Consumed in Amagoro*

The proximate composition and energy for various ready to eat foods were calculated as grams per 100 g on dry weight basis and energy values were expressed as KCal/100 g (Table 12). Means and standard deviation values were computed. The energy values were calculated from the available carbohydrates, protein, fat, and fibre values by multiplying with their respective empirical conversion factors of 4, 4, 9 and 2 respectively (Stadlmayr et al., 2012). Although earlier studies did not consider fibre as a source of energy, the West African food composition table which shares some similarity with Kenyan foods documented that fibre contributes 2 Kcal/100 g.

The moisture content varied among various *ugali* types, cereals grains including maize, sorghum and millet shown lower moisture content compared to those types that contain cassava in their formulation. This could be attributed to the differences in the nature of starch that might have influenced water uptake. It could also be due to the fact that cassava forms a sticky mass during preparation that is difficult to mix and thus the tendency to use less flour as opposed to cereal grains formulations. Cowpea leaves had the highest moisture content while silver fish had the lowest. This is because cowpea leaves naturally have high moisture content and was also stewed as opposed to sun-dried silver fish with naturally low moisture content. In terms of fat content, silver fish had the highest while sweet potatoes had the lowest. This is because of the vegetable oil added during the vegetable preparation as opposed to sweet potato that was simply boiled in water. Among the *ugali* formulations, whole maize *ugali* had the highest fat due to the inclusion of the oil-rich germ. As expected the highest protein and fibre content was reported in silver fish and cowpea leaves respectively and consequently, these two foods reported the highest ash content. The highest carbohydrate content was reported in *ugali* and the

least in cowpea leaves. This is because the *ugali* was mainly cereal or cassava based. Cowpea leaves had the highest energy content mainly because of vegetable oil used in its preparation which significantly contributed to energy as is the case with silver fish. However, the energy contribution from *ugali* could still be high due to the higher *ugali* to cowpea leaves or silver fish ratio in a normal serving. Although rice and beans have close energy contents, most of the energy of rice comes from carbohydrates while beans also contain relatively high protein and fat in addition to carbohydrate. Other foods analyzed included boiled cassava and boiled sweet potato whose energy contents were nearly similar.

**Table 12:** Proximate composition and energy values for selected ready to eat foods

| Sample name | Moisture (%) | Fat (%) | Protein (%) | Fibre (%) | Total Ash (%) | Soluble Carbohydrates(%) | Energy (Kcal/100g) |
|---|---|---|---|---|---|---|---|
| *Ugali* (whole maize) | 66.14±1.50 | 2.74±0.05 | 1.65±0.35 | 2.04±0.50 | 1.48±0.05 | 92.09±0.27 | 403.70 |
| *Ugali* (millet) | 65.06±1.15 | 0.94±0.15 | 2.49±0.05 | 3.86±0.25 | 3.03±0.05 | 89.87±0.30 | 385.62 |
| *Ugali* (sorghum) | 63.16±0.20 | 2.22±0.12 | 1.11±0.11 | 3.20±0.25 | 2.20±0.02 | 90.17±0.25 | 391.50 |
| *Ugali* (cassava) | 71.63±1.00 | 2.61±0.16 | 1.52±0.14 | 1.23±0.10 | 2.33±0.20 | 92.46±0.25 | 401.87 |
| *Ugali* (cassava-millet) | 68.34±0.50 | 1.07±0.25 | 1.67±0.02 | 3.00±0.15 | 1.64±0.15 | 92.80±0.50 | 392.15 |
| *Ugali* (cassava-sorghum) | 68.09±0.10 | 1.85±0.40 | 1.50±0.60 | 2.63±0.20 | 2.23±0.06 | 91.79±0.12 | 395.07 |
| *Ugali* (cassava-sorghum-millet) | 65.70±0.13 | 1.79±0.03 | 1.55±0.10 | 2.24±0.15 | 2.51±0.20 | 92.07±0.24 | 395.07 |
| *Ugali* (sifted maize meal) | 69.03±0.60 | 2.13±0.15 | 7.65±0.05 | 1.19±0.03 | 0.77±0.05 | 88.34±0.30 | 457.66 |
| Cowpeas leaves | 80.17±0.25 | 36.86±0.05 | 17.85±0.25 | 15.23±0.12 | 11.20±0.06 | 18.86±0.05 | 509.34 |
| Silver fish | 61.89±0.24 | 18.00±0.25 | 33.59±1.10 | 1.99±0.03 | 11.99±0.10 | 34.45±0.03 | 438.14 |
| Sweet potatoes | 66.96±0.50 | 0.12±0.30 | 2.94±0.60 | 2.97±0.35 | 3.66±0.05 | 90.04±0.03 | 378.94 |
| Cassava | 63.67±0.25 | 3.70±0.15 | 4.82±0.15 | 3.22±0.45 | 3.17±0.10 | 78.81±0.45 | 374.26 |
| Rice | 70.00±1.00 | 3.30±0.05 | 8.90±0.44 | 1.07±0.35 | 1.20±0.02 | 86.60±0.12 | 413.84 |
| Beans | 71.43±0.50 | 7.56±0.20 | 27.23±0.30 | 5.18±0.50 | 3.92±0.02 | 56.12±0.15 | 411.80 |

Note: All analyses were performed in duplicate and averages ± standard deviations computed. Contents are in "grams per 100g" reported on "dry weight basis" except for moisture content.

*Ugali* generally had higher carbohydrate content although the carbohydrate content of whole maize meal *ugali* was slightly higher than that of cassava-sorghum *ugali*. Silver fish had the

highest protein content while cowpea leaves and silver fish were rich in lipids since they were fried and stewed respectively using vegetable oil.

Whole maize *ugali* recorded slightly higher carbohydrate content than cassava-sorghum possibly due to the final consistency achieved. Cassava-sorghum is difficult to cook since it forms a sticky mass and consequently has slightly higher moisture content. Likewise, similar products from West Africa recorded high carbohydrate content (Omoregie and Osagie, 2008) despite the different processing methods. Slightly lower carbohydrate content which could be attributed to different preparation methods especially as regards to the amount of flour used to obtain the desired consistency has been reported (Ruhembe et al., 2014). Cowpea leaves and silver fish had high fat content translating to high energy values.

On the other hand sweet potatoes had higher carbohydrate content (90.04 %) than cassava (78.81 %). The dry matter and fibre, fat and protein were higher for cassava (36.33 %) than for sweet potatoes (33.04 %). In a separate study conducted in Nigeria, boiled sweet potato had a carbohydrate content of 70.54 % (Abubakar et al., 2010). The differences could be attributable to the variety since starch content has been found to vary widely (9.5 % to 40.5 %) among different cassava varieties (Ntawuruhunga and Okidi, 2010). The average dry matter content of cassava in this study was found to be within the range of 24 to 42 % reported for different varieties (Ntawuruhunga and Okidi, 2010) while that of sweet potatoes was also within the range of 30.2 % to 39.2 % reported for different varieties in the neighboring Uganda (Nabubuya et al., 2012).

# CHAPTER 5: GLYCEMIC INDICES OF CASSAVA AND SWEET POTATOES

## ABSTRACT

There is a rapidly growing interest on the Glycemic Index (GI) with regard to its role in preventing and managing diabetes mellitus. Glycemic index is used to classify carbohydrate-rich foods especially those containing at least 15 % carbohydrates. This study therefore investigated the glycemic indices of cassava and sweet potato which are widely produced and consumed in Western Kenya. Proximate analysis of the samples was conducted according AOAC methodology and glycemic index was determined according to the methodology recommended by FAO/WHO using eight healthy volunteers. The results of the proximate analysis showed the carbohydrate content for cassava to be 90 % and sweet potato at 78% on dry weight basis. Cassava had a glycemic index 74 which is considered high while sweet potatoes had a GI of 65 which is medium. However these test foods were not significantly different ($p$>0.05). Despite differences in GI both cassava and sweet potato had high glycemic load. Thus, they should be consumed in moderation by individuals suffering from diabetes mellitus.

## 5.1 INTRODUCTION

Glycemic index (GI) refers to a number (index) used to rank carbohydrate-rich foods depending on how they raise the blood sugar levels (FAO/WHO, 1998). Carbohydrates are the major influential dietary component since it's comprised of sugars and starches that are broken down in the digestive system into glucose that enters the bloodstream (FAO/WHO, 1998). Of particular importance is the rate at which these carbohydrates are broken down to glucose as indicated by the Glycemic Index (GI) which differs among different foods (Bahado-Singh, Riley, Wheatley and Lowe, 2011; Eli-Cophie, Agbenorhevi and Annan, 2017). Meals with low GI have been suggested to reduce both postprandial blood glucose and insulin responses as opposed to those with a high GI (Brand-Miller et al., 2009).

GI is determined by dividing the incremental area under the curve for a test meal by incremental area under curve of reference food (glucose or white bread) after consuming 50 g available carbohydrates for the test food and glucose (standard). GL is an alternative measure of blood sugar response and it is computed by dividing the GI of the food by the available carbohydrate and multiplying by 100 (Jenkins et al., 1981). A high dietary glycemic load (GL) from carbohydrates has been associated with increased risk of diabetes mellitus and heart disease (Choudhary, 2004; FAO/WHO, 1998; Liu et al., 2000).

The GI has been found to vary depending on their origin, variety, processing and preparation, maturity, other nutrients consumed with the food, the time of the day the GI is measured, the method used to measure the GI and the physical and chemical characteristics of the foods (Pi-Sunyer, 2002; Foster-Powell et al., 2002; Arvidsson-Lenner et al., 2004; Lin, Wu, Lu and Lin, 2010; Bahado-Singh et al., 2011; Eli-Cophie et al., 2017).

GI and GL concepts have taken into consideration the carbohydrate quality and quantity issues as the influence postprandial glucose levels (Wheeler and Pi-Sunyer, 2008). However, in order to guide on food choices, it is advisable not to consider the GI alone but in relation to other nutritional components of the food (Arvidsson-Lenner et al., 2004; Venn and Green, 2007; Riccardi, Rivellese and Giacco, 2008). For example the food might be of low GI but contain high amount of fats which may impart negatively on health.

Although the significance of GI is still unclear in healthy people (Arvidsson-Lenner et al., 2004), knowledge of the GI of starchy foods is important in the management and even prevention of diabetes mellitus (Lin et al 2010). For example, low and medium GI foods may be beneficial to people suffering from diabetes (Arvidsson-Lenner et al., 2004; Allen et al., 2012).

Cassava (*Manihot esculenta Crantz*) and sweet potato (*Ipomoea batatas L.*) are carbohydrate-rich, drought tolerant crops which are widely produced and consumed in developing countries (FAO, 1998; Ogbuji and David-Chukwu, 2016). They are important in ensuring food security (FAO, 1998). Cassava comes first followed by sweet potato in terms of production and consumption worldwide among the tuberous roots (Padmaja et al., 2012), similar to observation made in Western Kenya (Nungo, 1999). Sweet potato varieties include white-, orange- yellow- and purple-fleshed as discussed earlier in (chapter 4, 2008). In Western Kenya, common varieties include the white-fleshed and a few yellow-fleshed (Nungo, 1999) and orange-fleshed varieties. The preparation methods include boiling, roasting and mashing with other foods (Nungo, 1999).

Although the GI of cassava and sweet potato has been investigated elsewhere, the same has not been conducted in Western Kenya considering the variations in origin, variety and preparation

methods. This study therefore investigated the GI and GL of cassava and sweet potato consumed in Western Kenya. This study fills a gap in knowledge on the GI of carbohydrate-rich foods consumed in Kenya.

## 5.2 STUDY DESIGN AND METHODOLOGY

### 5.2.1 Experimental Design

Eight healthy adults were served cassava, sweet potato and glucose on separate occasions. This was done each day after 10-12 hours of overnight fast. Testing started at 0800 hours and participants were requested to eat the last meal by 2100 hours. Subjects were requested to avoid strenuous physical activity and alcohol on the day prior to the experiment. The samples contained 50 g available carbohydrate. 50 g of glucose was given as a reference food on three separate occasions. All samples were consumed with 250 ml of water. Blood glucose was recorded at different time intervals for a total period of 2 hours.

### 5.2.2 Participants' Inclusion and Exclusion Criteria

The participants were chosen on voluntary basis. Inclusion criteria included healthy males and females with normal BMI, blood pressure, blood sugar and not on medication; the females were not pregnant or lactating; between 18–75 years old and not suffering from diabetes mellitus. Exclusion criteria included those with HIV/AIDS or diabetes; BMI $25kg/m^2$; those on medication and those uncomfortable with the experimental procedures (Robert et al., 2008; Wolever et al., 2008).

### 5.2.3 Preparation of Test Foods

The food samples were locally purchased from Amagoro market in Busia County of Western Kenya. Anhydrous glucose was purchased from a local supermarket in Amagoro. The food samples included fresh cassava *(Manihot esculenta Crantz)* and white-fleshed sweet potato

(*Ipomoea batatas L.*). These foods were peeled, washed and boiled in sufficient amount of water until tender. Excess water was then drained off.

### 5.2.4 Proximate Analyses

Proximate composition of the foods was analyzed according to the AOAC official methods as described in Chapter four.

### 5.2.5 Blood Sugar Determination

The food portions were packed in similar containers for each participant. Each participant consumed glucose as a standard or reference food on three different occasions with blood sugar being recorded on each occasion. The test foods were consumed with 250 ml of water. The anhydrous glucose was dissolved in same amount of water before drinking. Test meals were consumed within 7 minutes. Timing for blood samples started with the first bite of the test meal and results recorded in a table in the following time intervals: 0 (fasting blood sugar), 15, 30, 45, 60, 90 and 120 minute after consuming the test food. Blood glucose levels were measured using a glucometer (*On-Call* Plus ACON Laboratories, Inc.USA). Participants' finger was pricked using a sterile lancet. Blood sample was applied directly to the end tip of the test strip which was connected to the blood glucose meter and the result was shown on the meter display.

### 5.2.6 Ethical Approval

Kenyatta National Hospital/University of Nairobi, Research and Ethics Committee approved this study. All subjects signed an informed consent form before commencing the experiment.

### 5.2.7 Data Analysis

Blood sugar against time was plotted in Microsoft Excel spreadsheets using a scatter diagram. Linear mixed effect model of SPSS package version 20.0 was used to determine whether the means of the samples were different ($p$ set at 0.05). The IAUC was then calculated using the trapezoidal rule (FAO/WHO, 1998; Wolever, 2003; Omoregie and Osagie, 2008). The glycemic index (GI) was computed using the formula: GI= IAUC for the test food ÷ IAUC for reference food ×100. The glycemic index of a food was obtained as a mean of the glycemic index of the food by different individuals (FAO/WHO, 1998). Data was then presented by graphs, means and standard deviation values. The glycemic load (GL) was calculated by multiplying the dietary carbohydrate content with the GI of the food and dividing by 100 (Foster-Powell et al., 2002). GL = GI/100 x Net Carbohydrates (Net carbohydrates = total carbohydrates - dietary fibre). The portion sizes served to participants contained 50 g available carbohydrates.

## 5.2 RESULTS AND DISCUSSION

### 5.2.1 Characteristics of the Subjects

The study involved eight volunteers drawn from Amagoro division of Western Kenya. They were 22 to 40 years old with a mean age of 32.6±5.32 years. The BMI ranged from 18.75 to 24.8 kg/m$^2$ with a mean of 20.67±2.09 kg/m$^2$. The mean fasting blood sugar was 4.8±0.29 mmol/L. The mean systolic and diastolic blood pressure was 124±10.14 and 74.4±4.2 mm Hg respectively. These participants were all healthy as shown by their BMI (18.5-24.9 kgm$^{-2}$) (Cornelis et al., 2014; Veghari et al., 2010; Gezawa et al., 2015), fasting blood sugar (  5.5 mmol/L) (ADA, 2012; ADA, 2000) and blood pressure below 140/90 mmHg (Weycker et al., 2008; Zanella et al., 2001; ADA, 2002; Ayah et al., 2013; Gezawa et al., 2015; Chege, 2016). In

addition these individuals were not on any medication due to the possibility of the illness or medication to interfere with an individual's metabolism and consequently the GI of the food.

### 5.2.2 Blood Sugar Response Curves

The nutritional composition of the test foods is as described in Table 12 of Chapter 4. Despite the fact that all the foods consumed supplied 50 g available carbohydrates, the quality of the carbohydrates differed depending on the source. Glucose produced the highest response followed by cassava with sweet potato showing the least response (Figure 2). This is because glucose is directly absorbed into the blood stream as opposed to cassava and sweet potatoes whose carbohydrate has to been broken down to glucose before it's taken up into the blood. These foods also contain other macronutrients which have been known to influence the blood sugar response (Pi-Sunyer, 2002; Beals, 2005). All the foods reached the peak response at 45th minute.
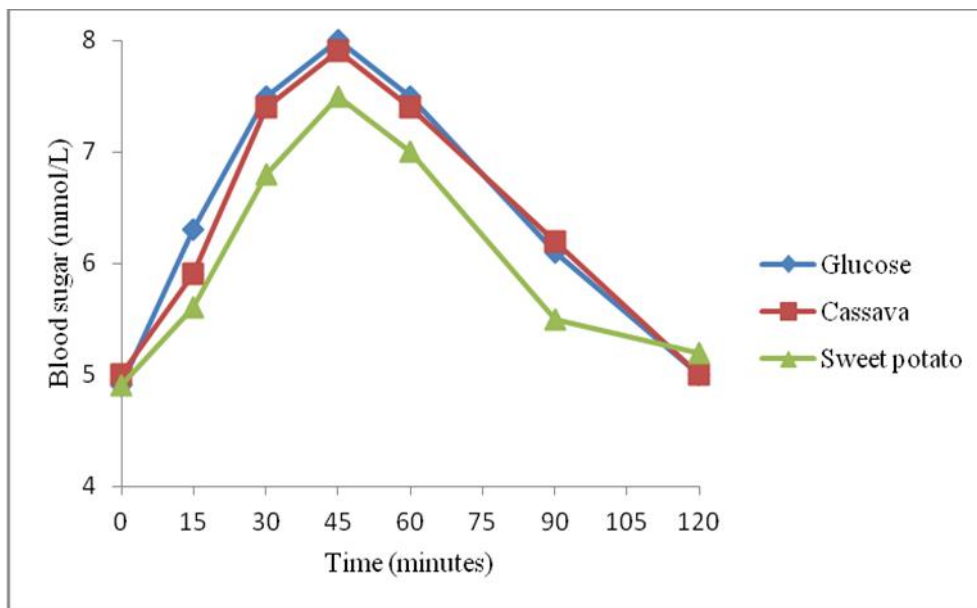


**Figure 2:** Blood glucose response curves for cassava, sweet potato and glucose

The incremental area under the blood glucose response curves (IAUC) were calculated for each subject for the test foods and the standard (glucose). The glycemic index (GI) was computed using the formula: GI= IAUC for the test food ÷ IAUC for reference food ×100 (Table 13). The GI of a food was obtained as a mean of the GI of the food by different individuals. The GL was then calculated by multiplying the dietary carbohydrate content with the GI of the food and dividing by 100.

### 5.2.3 Glycemic Indices and Glycemic Load

In order to provide an equivalent of 50 g available carbohydrates, 175 g of cassava and 168 g of sweet potatoes were served to participants. Cassava and sweet potato both had high glycemic load (GL) despite sweet potato having a moderate glycemic index (GI) (Table 13).

**Table 13:** Glycemic indices and glycemic loads of cassava and sweet potato

| Food type | GI (mean±sd) | GL (mean±sd) | *p*-value |
| --- | --- | --- | --- |
| Cassava | 74.10±17.85 | 36.99±9.42 | 0.16 |
| Sweet potato | 64.54±20.13 | 32.27±10.76 | |

The two test foods were not statistically different ($p>0.05$). This could be because of the close similarity between starch composition of these foods both of which belong to root and tubers classification. The mean GI of these two foodstuffs which are not statistically different would be 69 thereby classifying them as medium GI. However, the load remains high (>20).

### 5.2.4 Glycemic Index of Cassava

The glycemic index for boiled cassava was 74 ranking it a high GI food. This is consistent with other finding that reported cassava food products as having high GI (Omoregie and Osagie, 2008; Ogbuji and David-Chukwu, 2016). Processing and preparation methods have a strong influence on the glycemic index (GI) of cassava (Eli-Cophie et al., 2017). Boiling has been

known to increase starch gelatinization and digestibility (Pi-Sunyer, 2002; Lin et al., 2010; Bahado-Singh et al., 2011). Cassava also has high amylopectin to amylose ratio (USDA, 2002) which may have been responsible for the high GI since amylopectin being more branched is more susceptible to amylolytic enzymes (Arvidsson-Lenner et al., 2004). Amylose on the other hand tends to form secondary structures that are difficult to disperse making it to be slowly digested than amylopectin (Thorne et al., 1983; Gallant et al., 1992). In fact the amylose content may vary within the same variety depending on differences in cultural conditions and geographic location/origin (Gao et al., 2014).

### 5.2.5 Glycemic Index of Sweet potato

The GI of sweet potato was medium in this study. This is in agreement with Foster-Powell et al (2002) who reported a GI of 61. However, another study recorded a low GI for the boiled sweet potato among the different varieties investigated in Jamaica (Bahado-Singh et al., 2011). This could be due to the sweet potato variety (Bahado-Singh et al., 2011) as well as origin (Pi-Sunyer, 2002; Foster-Powell et al., 2002). Food processing preparation method seem to play a major role as opposed to variety  (Bahado-Singh et al., 2011; Allen et a., 2013; Eli-Cophie et al., 2017) although some researchers dispute this finding arguing that food preparation methods has no effect on glycemic indices of foods (Ogbuji and David-Chukwu, 2016). As opposed to baking and roasting, boiled sweet potato had the lowest GI (Bahado-Singh et al., 2011). Steamed, baked and microwaved sweet potato exhibited moderate GI while raw sweet potato and dehydrated sweet potato recorded a low GI (Allen et al., 2012). Despite the many findings of low to medium GI for sweet potatoes, some research has reported a high GI (Allen et al., 2013) which could be due to difference in variety and geographical location (Pi-Sunyer, 2002; Foster-Powell et al., 2002; Gao et al., 2014).

The results of this study support earlier review which recommended the consumption of sweet potatoes in moderation by diabetic individuals due to lack of sufficient evidence to recommend sweet potato to people suffering from diabetes mellitus (Dutta, S., 2015). This could be because sweet potatoes can cause a higher rise in blood sugar among diabetics (Fatema et al., 2011).

### 5.2.6 Glycemic Load of Cassava and Sweet Potato

Both foodstuff possessed a high glycemic load (>20). This is because of the large portion sizes normally consumed (about 400 g of cassava and 560 g of sweet potato at each serving). This explains why despite the average of the two ranking them as moderate GI, they have a high glycemic load. This is because the GL accounts not only on the quality of carbohydrate as measured by the GI but also the total amount of available carbohydrate in the diet (Foster-Powell et al., 2002). Other studies above (Bahado-Singh et al., 2011; Allen et al., 2013) carried conducted ton glycemic indices of sweet potato did not consider the GL. Foster-Powell et al (2002) reported a GL of 17 as opposed to a GL of 32 in this study. This would be because of the differences in the portion size which was 150 g as opposed to 560 g in this study. Studies on the GI of cassava (Omoregie and Osagie, 2008; Ogbuji and David-Chukwu, 2016; Eli-Cophie et al., 2017) did not calculate the GL.

# CHAPTER 6: EFFECT OF ACCOMPANIMENT ON GLYCEMIC RESPONSES OF THICK PORRIDGE "*UGALI*" AND RICE

## ABSTRACT

The term glycemic index has been used to categorize carbohydrate-rich foods on the basis of their blood sugar raising potential. Despite the existence of a table of glycemic indices of some foods, the glycemic indices of staple foods consumed in Kenya is still very scanty. This study therefore was designed to evaluate the glycemic indices (GI) of rice and *ugali* (stiff/thick porridge), the most commonly consumed foods in Kenya in the way they are normally prepared and consumed. *Ugali* is usually served with side dishes of cowpea leaves or beef and rice is usually served with either beans or beef stews. The foods were analyzed for proximate composition using the AOAC methods. Glycemic index was determined following FAO/WHO recommended methodology. From the results of proximate analyses, it was established that the content of carbohydrates varied in the order: *Ugali* > rice > beans > cowpea leaves. Glycemic indices followed the order plain rice > *ugali* and beef > rice and beef > rice and beans equal to plain *ugali* > *ugali* and cowpea leaves > plain beans. These GI values were found to be significantly different ($p<0.05$). All the foods had a high glycemic load ( 20). Cowpea leaves and beans lowered the GI of *ugali* and white rice respectively. This GI lowering is especially important in the dietary management of diabetes mellitus.

## 6.1 INTRODUCTION

Type 2 diabetes mellitus is rising rapidly both in urban (Dalal, et al 2011) and rural (El-busaidy et al., 2014) Kenya. As a result, there is growing interest on the role of diet and especially the carbohydrate-rich foods which possess the ability to raise blood sugar. This effect of carbohydrate-rich foods can be explained in terms of glycemic glycemic index (GI) which refers to a number (index) used to rank foods depending on their effect on blood sugar levels relative to a reference food (Jenkins et al., 1981). The GI is calculated by dividing the incremental area under the blood glucose curve (IAUC) after ingestion of a test food containing 50 g available carbohydrate by IAUC of an equal amount of a reference food and multiplying by 100 (Jenkins et al., 1981, FAO/WHO, 1998). Carbohydrates that cannot be digested and absorbed in the small intestine such as dietary fibre are not be included in the 50 g carbohydrate portion (Wolever 2003).

The reference food which is either glucose or white bread is assumed to have a glycemic index of 100 and most foods record a GI below 100 (Lin et al., 2010). However some studies have found GI of some foods to be even higher than for reference foods (Foster-Powell et al., 2002; Mahgoub et al., 2013; Asinobi et al., 2016; Mlotha et al., 2016). Foods with a high GI produce a greater blood glucose response than low GI (Foster-Powell et al., 2002) foods and are beneficial in controlling blood sugar for diabetes patients (Wang et al., 2015). The consumption of a high GI food in combination with low GI foods may lower the blood glucose response of a high GI food (Sugiyama et al., 2003; Kouame et al., 2014). Nonetheless people mostly consume meals composed of mixed foods as opposed to single foods.

With glucose as a reference, foods have been classified into low (<55), medium (55-69) and high (>70) GI (Beals, 2005). In addition to the GI of the food, it is also important to investigate the overall blood sugar response to a meal in relation to the quantity consumed. Thus, glycemic load (GL) has been used as an alternative measure for blood sugar responses. The (GL) takes account of both the quality and quantity of the food consumed. The GL is calculated by multiplying the available carbohydrate content with the GI of the food and dividing by 100 (Foster-Powell et al., 2002).

Despite the much emphasis and benefits attributed to the GI concept especially with regard to management of metabolic conditions such as diabetes mellitus, GI of most traditional foods in Kenya is yet to be evaluated. This will guide better the promotion of local foods to the community (Idril et al., 2013), even for management of such conditions as diabetes mellitus although the GI concept is applicable for foods containing at least 15 g available carbohydrates per serving (Arvidsson-Lenner et al., 2004).

The experts have stated an urgent need to pass the information to health professionals and the general public about responses (GI and GL) of foods (Augustin et al., 2015) yet the glycemic responses of most foods consumed in Kenya remain unknown. This study considered two major staple foods in Kenya which include stiff or thick porridge *(ugali)* which is mostly prepared from maize flour (Wanjala et al., 2016) and locally grown rice. These carbohydrate-rich foods are usually consumed with a side dish. This study therefore investigated the GI/GL of *ugali* and rice and the effect of various side dishes on their GI/GL.

## 6.2 STUDY DESIGN AND METHODOLOGY

Experimental design, inclusion and exclusion criteria for the subjects, proximate analyses and protocol for the determination of blood sugar responses, ethical approval and data analysis were as described in Chapter five.

### 6.2.1 Processing and Preparation of the Meals

Dry maize, dry beans, beef and cowpea leaf vegetables were purchased from Kocholya market in Amagoro, Busia County. Rice (Mwea pishori) was purchased from Nice Rice Millers in Mwea town. Food samples were prepared using traditional methods (Table 14).

**Table 14:** Preparation of various test foods

| Purchased Food | Pre-Processing Operations | Food Preparation |
| --- | --- | --- |
| Maize | Cleaned and milled into whole meal using *posho mill* at a local market. | Five hundred and seventy grams of maize meal was added into 750ml of boiling water and heating continued until boiling resumed. The mixing was done using a flat wooden cooking stick until a stiff and homogenous paste was formed. Heat was lowered and heating continued with intervals of mixing and turning for the next 7 to 10 minutes. *Ugali* was then turned onto a large plate from where it was shared. |
| Rice | Rice was sorted to remove any impurities and washed with portable water to remove surface starch. | The ratio or rice to water was 1:2. Water was brought to boil then cleaned rice was added. Some salt was added to taste. Boiling continued until the water was almost at level with rice. Heat was then lowered, the pan covered and simmering continued under low heat until the water was completely used up. The rice was then served into a serving bowl. |
| Beans (Rose coco) | Beans was sorted to remove any impurities and washed with clean tap water to remove soil and debris. | The beans were soaked overnight in 3x their weight of water and drained. They were boiled in equal weight of water until tender. Water was added and the excess water drained off. One large onion was finely chopped, placed in a cooking pan with 40 ml of cooking oil and fried till brown, Two large tomatoes were finely chopped and added to the oil-onion mixture and cooking continued till the tomatoes were soft. Four cups of boiled beans were added and cooking continued at low heat for 15 minutes. Salt was added to taste. |
| Cowpea leaves | Edible portion was separated and the leaves were then washed with portable water and drip dried. | One large onion was finely chopped and then heated in four tablespoons of cooking oil until the onions were golden brown. Two chopped medium-sized tomatoes were added to the oil-onion mixture and cooked until tender. Four bunches of vegetable was then added and simmered with addition of little water for 10 minutes. Salt was added to taste. |
| Beef | Beef was trimmed of excess fat, washed in clean portable water and cut into approximately 3 cm pieces. | Beef was boiled with about half a cup of water until tender. One large chopped onion was heated in four tablespoons of vegetable oil until golden-brown; two chopped medium-sized tomatoes were added to the oil-onion mixture and cooked until tender. Meat was then added and simmered with addition of broth and half a cup of clean water for 10 minutes. Salt was added to taste. |

## 6.3 RESULTS AND DISCUSSION

### 6.3.1 Proximate Composition

The proximate composition of the meals was calculated as grams per 100 g on "wet weight basis" and energy values were expressed as Kcal/100 g. All analyses were performed in two replications. Means and standard deviation values were then computed. Plain *ugali* had the highest carbohydrate content, while cowpea leaves had the lowest following the order *ugali* > rice > beans > cowpea leaves. Protein content was in the order of beans > cowpea leaves > rice > *ugali* while fibres followed the order, cowpea leaves > beans > *ugali* > rice (Table 15).

**Table 15:** Proximate composition of the meals (% mean ± standard deviation)

| Food | Moisture | Fat | Protein | Fibre | Ash | CHO* | Energy (Kcal/100g) |
|------|----------|-----|---------|-------|-----|------|--------|
| *Ugali* | 66.14±1.50 | 0.93±0.05 | 0.56±0.35 | 0.69±0.50 | 0.50±0.05 | 31.18±0.27 | 135.33 |
| Cowpeas leaves | 80.17±0.25 | 7.31±0.05 | 3.54±0.25 | 3.02±0.12 | 2.22±0.06 | 3.74±0.05 | 94.95 |
| Boiled white rice | 70.00±1.00 | 0.99±0.05 | 2.67±0.44 | 0.32±0.35 | 0.36±0.02 | 25.98±0.12 | 123.51 |
| Bean stew | 71.43±0.50 | 2.16±0.20 | 7.78±0.30 | 1.48±0.50 | 1.12±0.02 | 16.03±0.15 | 114.68 |

*Carbohydrates

### 6.3.2 Blood Sugar Responses to Ugali Meals

The blood sugar responses are presented separately for *ugali* meals and for rice meals. There was a sharp rise in blood sugar in the first 30 minutes of consuming each meal except for plain *ugali* (Figure 3). The reference glucose presented the highest rise each time. *Ugali* meals reached peak at $30^{th}$ minute as opposed to glucose and plain *ugali* that peaked at $45^{th}$ minute. Although plain *ugali* showed lower response, it is rarely consumed as so, but with a relish. Cowpea leaves give lower response as opposed to beef. These two are some of the commonly used accompaniments to *ugali*.
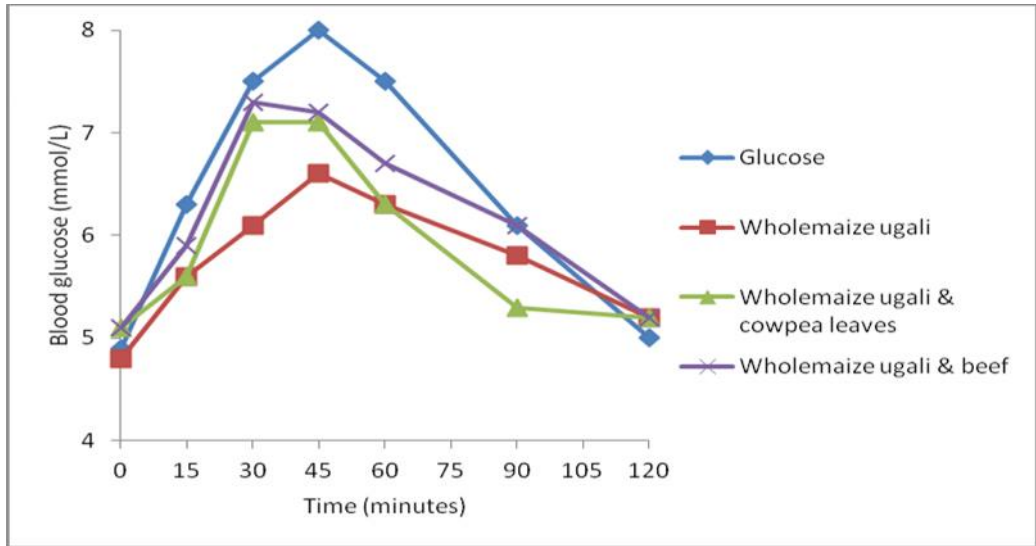
**Figure 3:** Average blood sugar responses to *ugali* meals

Rice and beef meal and glucose resulted in a sharp rise in blood sugar as opposed to other test foods (Figure 3). Stewed beans seem to have a considerably lower blood sugar response than the reference glucose meal and other rice meals. Beans seem to lower the blood sugar level of rice as opposed to beef. Rice and beef as well as rice and beans reached a peak at 30th minute while other test foods reached peak at $45^{th}$ minute. It's also evident that beans sustains blood sugar levels above fasting levels for longer as opposed to other foods that showed sharp drop in blood sugar.
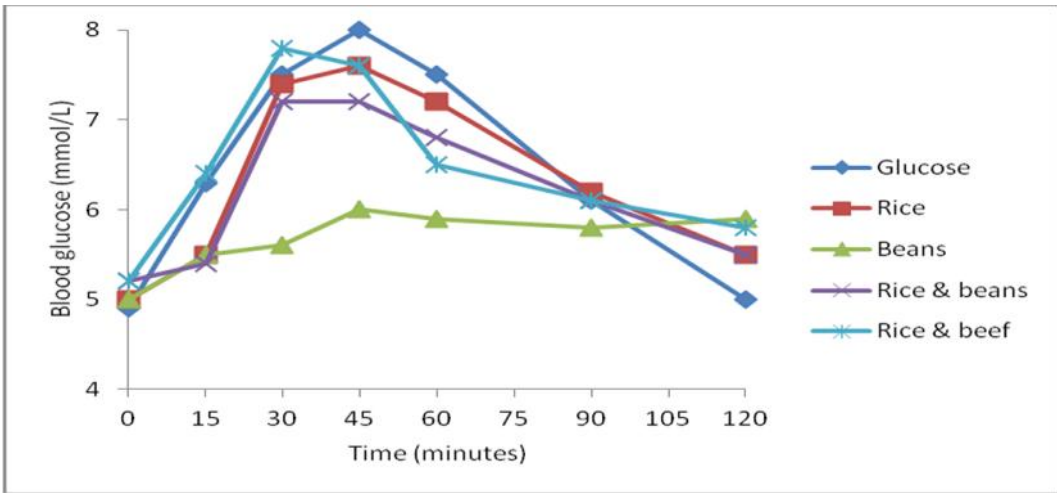


**Figure 4:** Average blood sugar responses to rice meals

### 6.3.3 Glycemic Indices of Ugali and Rice Meals

The GI concept has been used to rank carbohydrate-rich foods depending on how they raise the blood sugar after consumption. It is thus only appropriate to be applied to foods that provide at least 15 g or 20 g available carbohydrates per normal serving (Arvidsson-Lenner et al., 2004). This study therefore considered the main carbohydrate-rich staple foods consumed in Kenya.

The sample size for glycemic index (GI) determination provided 50 g available carbohydrate and this amount was used to compute the glycemic load. The GI was highest in rice and lowest in beans. Meals containing beef had higher GI as opposed to meals composed of beans and cowpea leaves. Although incorporating beef in rice seem to have lowered the GI of rice, beef seems to have increased the GI of *ugali*. In this analysis beef was assumed to provide zero carbohydrates (Table 16).

**Table 16:** Food ration sizes, glycemic indices (GI) and glycemic loads (GL) of the meals

| Food sample (ration size) | GI | GI class | *p*-value | GL |
|---|---|---|---|---|
| Plain *ugali* (160 g) | 62±25.3 | Medium | | 30.9±11.8 |
| *Ugali* (158 g) & cowpea leaves (50 g) | 45±18.7 | Low | | 22.7±8.7 |
| *Ugali* (160 g) & beef (150 g) | 71±19.0 | High | | 35.4±8.6 |
| Rice (192 g) | 77±16.1 | High | 0.035 | 38.6±8.0 |
| Beans (312 g) | 44±28.3 | Low | | 21.8±15.1 |
| Rice (142 g) & beans (80 g) | 62±14.6 | Medium | | 31.1±7.8 |
| Rice (192g) & beef (150g) | 69±21.8 | Medium | | 34.5±11.7 |

These foods were found to be statistically different ($p>0.05$) in terms of glycemic index

### 6.3.4 Glycemic Indices of Ugali Meals

The carbohydrate content of *ugali* in this study was found to be higher compared to that consumed in Tanzania (Table 16). This is attributable to the different cooking methods with Tanzanians *ugali* having a higher moisture content of 76.54% as opposed to 66.14% reported in this study (Ruhembe et al., 2014). The glycemic index of plain whole maize *ugali* was medium (62). However, *ugali* is always accompanied by a side dish/relish. Consuming *ugali* with beef raised the GI while cowpea leaves reduced the GI of *ugali.* The glycemic index of whole maize *ugali* consumed with beef was high (71) in this study as opposed to low (51) in a study conducted in Tanzania (Ruhembe et al., 2014). This could be because in this study, it was assumed that beef had zero carbohydrate content. The difference could also be attributed to different methodology and food processing/preparation methods including the foods' particle size. For example a study on stiff porridges prepared from whole-maize flour and grits were found to be about 94 and 110 respectively (Mlotha et al., 2016).

Tanzania's and Malawi's stiff porridge had more moisture and low percent carbohydrate (Ruhembe et al., 2014; Mlotha et al., 2016) compared to this study. Also, the digestible carbohydrate from rats was used to predict available carbohydrate (Ruhembe et al., 2014). A GI of about 107 was recorded in Malawi (Mlotha et al., 2016) and 90 in Botswana (Mahgoub et al., 2013) as opposed to 62 in this study. Nonetheless, none of the studies specified the maize variety used as this could also influence the GI (Miller, Pang and Bramall, 1992; Pi-Sunyer, 2002; Foster-Powell et al., 2002; Onimawo et al., 2010; Mohan et al., 2016). Cowpea leaves being rich in fibre lowered the GI of *ugali* since fibre can limit access of the amylases to the starch (Vahouny and Kritchevsky, 1986). This further supports the finding that green leafy vegetables consumed with a staple cereal result in a lower glycemic response (Mani et al., 1994).

### 6.3.5 Glycemic Indices of Rice Meals

Rice had the highest glycemic index (77) (Table 16). Foster-Powell et al (2002) reported a GI of 112 for boiled Kenyan rice in agreement with a high GI ranking in this study. Combining rice with beans and beef reduced the GI to 62 and 69 respectively. Other studies on rice meals found a GI of 75 to 108 observed for different varieties of rice served with stew in Nigeria (Onimawo et al., 2010; Asinobi et al., 2016; Idril et al., 2013). The differences in the GI could be due to the difference in rice varieties, origin, processing and preparation methods (Miller et al., 1992; Pi-Sunyer, 2002; Foster-Powell et al., 2002; Onimawo et al., 2010; Mohan et al., 2016). Asinobi et al., (2016), blended the rice with stew to prepare test meals. This means the particle size of the meal was considerably reduced which might have led to their higher GI value.

Beans had a low GI (44) in agreement with Foster-Powell et al (2002) who reported a GI of 29.

Consuming beans together with white rice lowered the GI of rice. This is in agreement with earlier studies (Thompson et al., 2012) despite the difference in bean varieties. A similar effect was observed in soybean products (Sugiyama et al., 2003). This could be because of the higher fibre content of beans (Asinobi et al., 2016). Fibre-rich foods generally have a low glycemic index (GI) and have been shown to lower postprandial glucose (Riccardi et al., 2008) since fibre creates a physical barrier limiting the access of amylolytic enzymes to starch (Vahouny and Kritchevsky, 1986). Asinobi et al., (2016) reported a GI of 87 for bean stew as opposed to 44 in this study which could be attributed to the variety, processing and preparation methods. Asinobi et al., (2016) served blended foods as opposed to whole beans in this study. It could therefore be argued that the effect of fibre seems to be lost during food processing. However, the lowering effect of beans on the GI of rice could also be due to the fact that beans being a low GI food may have diluted the effect of the high GI rice. Nonetheless the GI of rice may be lowered by other accompaniments such as groundnut sauce which was found to have a GI of 45 when consumed with rice (Kouame et al., 2014).

This study involved healthy volunteers as opposed to diabetic individuals (Thompson et al., 2012). This shows that a meal comprising of rice and beans which is widely consumed worldwide (Thompson et al., 2012) could be used in both prevention and even management of existing type 2 diabetes mellitus. It is therefore important that before low GI foods are recommended to diabetic individuals, GI testing should first be undertaken among people suffering from diabetes. Bangladeshi Irish potatoes and sweet potatoes for example produced a much higher glucose response when given to diabetics (GI of 162 and 191 respectively) despite the fact that they are low to medium GI foods (Fatema et al., 2011).

In general the differences in the GI among different studies could be attributed to the many factors that influence the GI of foods including their origin (Pi-Sunyer, 2002; Foster-Powell et al., 2002), variety (Pi-Sunyer, 2002; Foster-Powell et al., 2002; Allen et al., 2013; Idril, et al., 2013; Atayoglu et al., 2016; Mohan et al., 2016), processing and preparation (Bahado-Singh et al., 2011; Allen et al., 2012; Ogbuji and David-Chukwu, 2016), maturity of the food (Pi-Sunyer, 2002; Foster-Powell et al., 2002), other nutrients that are consumed with the food (Pi-Sunyer, 2002; Foster-Powell et al., 2002), as well as the physical/chemical characteristics of the foods (Pi-Sunyer, 2002; Foster-Powell et al., 2002; Atayoglu et al., 2016).

# CHAPTER 7: GLYCEMIC RESPONSES TO DIFFERENT TYPES OF *UGALI*

## ABSTRACT

Glycemic responses which have been measured in terms of glycemic indices (GIs) differ among various carbohydrate-rich foods. Despite the existence of a GI Table of most common foods, the records of the GIs of most Kenyan traditional foods still remain scanty. This study therefore evaluated the GIs of Kenya's most popular food, *ugali* which is a stiff mash of maize meal, cassava, finger millet, sorghum or any combinations thereof with water. This study considered *ugali* from whole maize and cassava-sorghum flours which were served in accompaniment with cowpea leaves or silver fish. The meals were analyzed for proximate composition by AOAC method and the amount of carbohydrates varied in the order: whole-maize *ugali* > cassava-sorghum *ugali* > silver fish > cowpea leaves. GI was determined following FAO/WHO recommended methodology and results followed the order: cassava-sorghum *ugali* with silver fish > GI whole maize *ugali* with silver fish = cassava-sorghum with cowpeas leaves > whole maize *ugali* with cowpea leaves. These meals were found to be significantly different ($p<0.05$). Cowpea leaves seem to lower the GI of *ugali* which is important in planning diets for people with tendency to hyperglycemia such as diabetes mellitus patients.

**7.1 INTRODUCTION**

As a result of rising cases of chronic diseases such as diabetes mellitus, there is a growing interest globally on the effect foods rich in carbohydrates have on blood sugar responses. These responses can be measured in terms of glycemic indices and glycemic loads. The term glycemic index (GI) is used to indicate the potential of a food to raise blood glucose. GI is defined as *"the incremental area under the blood glucose curve (AUC) after ingestion of 50 grams available carbohydrate of a test food , expressed as a percentage of the AUC of an equal amount of a reference food (usually glucose or white bread)"* (Jenkins et al., 1981). Foods have thus been classified into low (GI <55), medium (55-70) and high GI (>70) using glucose as a standard (Beals, 2005). High GI foods produce a greater rise in blood glucose than low GI foods (Foster-Powell et al., 2002). Blood glucose response to a high GI food may however be lowered by consuming the food in combination with a food that has low GI (Sugiyama et al., 2003).

Irrespective of the GI of a foodstuff, the blood sugar response to a carbohydrate-rich meal also depends on the portion size. Glycemic Load (GL) has therefore been used as an alternative measure for blood sugar response. The GL takes account of both the quality and quantity of the meal consumed. The GL is calculated by multiplying the dietary carbohydrate content with the GI of the food and dividing by 100. The higher the GL, the greater is the rise in blood glucose (Foster-Powell et al., 2002). The GL of foods has thus been categorized as low (GL=1-10,) medium (GL=11-19) and high (GL 20) (Foster-Powell et al., 2002).

Although there are many studies on the GI and GL of foods, only limited information is available on African traditional foods (Omoregie and Osagie, 2008). *Ugali* as it is popularly known in Kenya is a thick porridge which is mainly prepared from maize (*Zea mays* L.) flour

and boiling water (Wanjala et al., 2016). It is served as the main dish usually for lunch or supper and is consumed alongside a side dish (relish) composed of vegetables, fish, legumes, meats or mixtures thereof (Karp and Karp, 1977; Onyango, 2014; Wanjala et al., 2016). *Ugali* may also be prepared from flours of cassava (*Manihot esculenta* Crantz L.), finger millet (*Eleusine coracana* (L.) Gaertn), sorghum (*Sorghum bicolor* (L.) Moench), or combinations thereof. The choice depends on the preference, availability and cost of the raw materials as well as the predominant crop in the locality (Wanjala et al., 2016). The stiff porridge is also widely consumed in other parts of Africa including, Tanzania (Ruhembe et al., 2014), Malawi (Mlotha et al., 2016), Cote d'Ivore (Kouame et al., 2015), Botswana (Mahgoub et al., 2013), Nigeria (Omoregie and Osagie, 2008) and South Africa (Mbhenyane et al., 2001).

Using dietary intervention is one of the strategies being advocated for preventing and managing diabetes as well as delaying the development of related complications (Otieno et al., 2003; Ruhembe et al., 2014; Wanjala et al., 2016). Whole-milled maize, sorghum and finger millet have been recommended for making *ugali* for people with DM2 in Western Kenya (Wanjala et al., 2016) despite lack of data on their associated glycemic response. This study was therefore designed to determine the nutritional composition and glycemic responses of some traditional *ugali*-based meals consumed in Western Kenya and it is the first study so far of this kind. The knowledge generated from this study is important in evaluating the potential of particular *ugali* meals to pose risk of diabetes and thereby hinder or help in the management of DM2 both locally and in other parts of Africa.

## 7.2 STUDY DESIGN AND METHODOLOGY

Experimental design, inclusion and exclusion criteria for the subjects, proximate analyses and protocol for the determination of blood sugar responses, ethical approval and data analysis were as described in Chapter five.

### 7.2.1 Preparation of Food

The food ingredients were locally purchased from Kocholya market in Busia County of Western Kenya. The food samples included maize *(Zea mays),* fermented and sun-dried cassava *(Manihot esculenta)* pieces, sorghum *(Sorghum bicolor)*, cowpea *(Vigna unguiculata)* and silver fish *(Rastrineobola argetea)* (locally known as *omena* or *dagaa*), Beef was purchased from a local butchery. The foods were prepared using traditional recipes as shown in Table 17.

**Table 17:** Preparation of test meals

| Purchased Food | Pre-Processing Operations | Food Preparation |
| --- | --- | --- |
| Maize *ugali* | Maize was milled using hammer mill at a local *posho mill* at Kocholya market. | Five hundred and seventy grams of maize flour was added into four cups (750ml) of boiling water and heating continued until boiling resumes. The mixing is done using a flat wooden cooking stick until a stiff paste was formed. Mixing then continued for the next 7 to 10 minutes. |
| Cassava & Sorghum *ugali* (3:1) on weight basis | The cassava had undergone fermentation, chopped into pieces and dried. The mixture of cassava and sorghum was milled using hammer mill at a local posho mill at Kocholya market. | Four cups of water was brought to boil then 490g of flour was added while stirring with a flat wooden cooking stick until a thick semi-solid paste was formed. Mixing continued for the next 5 to 7 minutes. |
| Silver fish | Sorted and washed with warm water. | Three tablespoons of cooking oil was heated in a cooking pan, 1 large onion was added and fried until brown. Three medium sized chopped tomatoes were added and cooked until tender. Three cups of silver fish were added and simmered in little water for 10 minutes. Salt was added to taste. |
| Cowpea leaves | Edible tender upper leaves were picked from growing crop. The leaves were then washed with water. | One large onion was heated in four tablespoons of cooking oil. Two chopped medium-sized tomatoes were added and cooked until tender. Vegetable was then added and simmered with addition of little water for 10 minutes. Salt was added to taste. |

## 7.3 RESULTS AND DISCUSSION

### 7.3.1 Blood Sugar Responses to Test Meals

Blood sugar measurements were taken for 2 hours after each test meal or reference food (glucose) was taken. After consumption, all the test foods resulted in a rise in blood sugar which peaked at 30 and 45 minute (Figure 5). The highest peak was recorded for glucose followed by cassava-sorghum *ugali* served with cowpea leaves. The samples were found to be significantly different ($p<0.05$). Despite cassava-sorghum *ugali* meals reaching peak at 30 minutes, the release of glucose seems to be sustained for longer as indicated by higher reading after two hours as compared to whole maize *ugali* meals. All the test meals recorded a lower peak with reference to glucose.
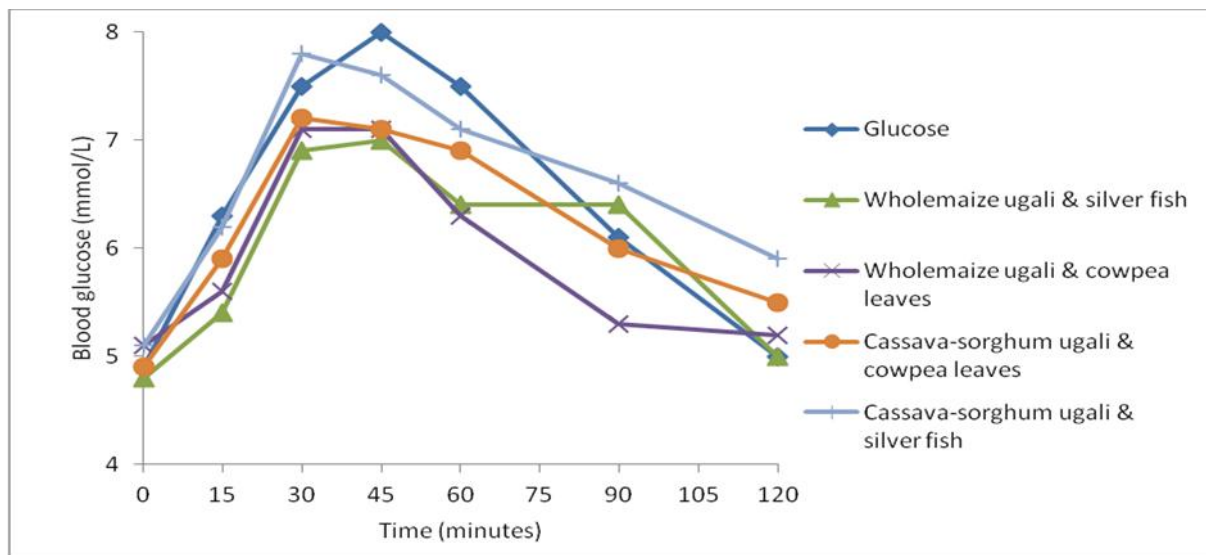


**Figure 5:** Blood response curves for test meals in relation to glucose

The incremental area under the blood glucose response curve was calculated for glucose (standard) and each test food consumed by each subject. Cassava-sorghum *ugali* consumed with silver fish had the largest area above the fasting level while whole maize *ugali* consumed with cowpea leaves had the least (Table 18).

**Table 18:** Incremental area under curve for various test foods and reference food

| | IAUC | |
|---|---|---|
| | Food sample | Glucose |
| Whole maize *ugali* with silver fish | 158.26±70.51 | 231.92±52.88 |
| Whole maize *ugali* with cowpea leaves | 104.62±45.04 | 231.92±52.88 |
| Cassava-sorghum *ugali* with cowpea leaves | 158.19±63.64 | 231.92±52.88 |
| Cassava-sorghum *ugali* with silver fish | 192.69±86.25 | 231.92±52.88 |

There was great variability among subjects for the same meal provided in this study. This means a food product may cause a high blood glucose response in some individuals and low or moderate in others. Also for a similar product, an individual may have different responses as was seen in the case of glucose. This could be due to differences in metabolism exhibited by different individuals (Ruhembe et al., 2014). Other studies showed similar findings (Mlotha et al., 2016). Mixed meals give different blood glucose responses depending on the components of the meal as shown in this study and others (Mahgoub et al., 2013). This could be due to the effect of both macronutrients such as fibre (Riccardi et al., 2008), fat (Choudhary, 2004; Jenkins et al., 1981; MacIntosh et al., 2003) and the possible effect of various micronutrients on the GI of foods.

### 7.3.2 Glycemic Indices and Glycemic Loads of Test Meals

The GI results showed that cassava-sorghum *ugali* consumed with silver fish had the highest GI at 83, followed by whole-maize *ugali* with silver fish and cassava-sorghum with cowpeas leaves both at 69 and the lowest was whole maize *ugali* with cowpea leaves at 45 (Table 19). These meals were found to be statistically different using linear regression mixed effect model of

analysis. Glycemic index values were then used to classify foods into three broad classes; low, medium and high GI. As regards GL, all the test meals were of high glycemic load ( 20).

**Table 19:** Glycemic indices and glycemic loads of the meals

| Food Sample | GI (Mean ± SD) | GI class | *p*-value | GL |
|---|---|---|---|---|
| Whole maize *ugali* & silver fish | 69.1±31 | Medium | | 34.5±14.5 |
| Whole maize *ugali* & cowpea leaves | 45±18.7 | Low | 0.014 | 22.7±8.8 |
| Cassava-sorghum *ugali* & cowpea leaves | 69±25.5 | Medium | | 34.6±11.7 |
| Cassava -sorghum *ugali* & silver fish | 83±34.0 | High | | 41.6±15.9 |

These foods were found to be significantly different (*p*<0.05).

### 7.3.3 Glycemic Index of various Ugali Meals

*Ugali* is never consumed alone but with a relish. Consuming it with beef or silver fish raised the glycemic index of *ugali* while cowpeas as a side dish/relish reduced the glycemic index of the meal. This could probably be due to the fact that beef and silver fish are richer in protein than cowpea leaves. Previous research had associated animal protein diets with increased risk of diabetes (Sluijs et al., 2010) although the mechanism is not understood. It could be because protein can promote insulin secretion in patients with DM2 (Franz et al., 2002; Frid et al., 2005) and healthy individuals (Nilsson et al., 2004) or protein could be having an effect on the GI. Although insulin secretion has been found to predict progression to diabetes (Kitabchi et al., 2005), the mechanism by which it happens is not known although incretin hormones and insulinogenic amino acids have been hypothesized (Frid et al., 2005; Nilsson et al., 2004; van Loon et al., 2003).

Cowpea leaves on the other hand contained high fat content. Fat reduces the glycemic response to a carbohydrate meal when the two are consumed together since fats tend to slow digestion

resulting in delayed gastric emptying (Choudhary, 2004; Collier et al., 1984; Jenkins et al., 1981; MacIntosh et al., 2003). Cowpea leaves were also rich in fibre. Fibre-rich foods generally have a low GI (Riccardi et al., 2008). Apart from its effect on the GI, fibre also has additional known health benefits (Beals, 2005). Dried bean leaf stew has been found to lower the GI of *ugali* in a South African Study (Mbhenyane et al., 2001) emphasizing the possible effect of leafy vegetables on the GI of *ugali*. Generally, meals containing silver fish posed a high GI as opposed to cowpea leaves irrespective of *ugali* type. Comparing silver fish and cowpea leaves dishes; whole maize *ugali* meals had a lower GI as opposed to cassava-sorghum meals. This is despite the fact that sorghum grains contain slowly digestible starches, resistant starches and dietary fibre (Stefoska-Needham et al., 2015). However sorghum was mixed with cassava which may have diluted the effect of sorghum on the GI of the meals.

The GI of whole maize *ugali* was within the range of 51 to 105 as reported by other studies in Africa. For example, Tanzania reported a GI of 51 when consumed with meat (Ruhembe et al., 2014). Other countries recorded different values including; Cote d'Ivore 74 (Kouame et al., 2015), 76 in Botswana (Mahgoub et al., 2013) while Malawi reported 94 (Mlotha et al., 2016) and South Africa 105 (Mbhenyane et al., 2001). The difference in the GI values could be attributed to *ugali* accompaniment and the different preparation methods which may have influenced the level of starch gelatinization. The method of ccooking and food processing, nature of monosaccharide components and, nature of starch (Bjorck et al., 1994; FAO/WHO, 1998; Lee et al., 2005; Foster-Powell et al 2002; Pi-Sunyer, 2002) all affect the GI in different ways. The differences in various studies could also be due to the possible differences in physical properties of maize meal used in the preparation of *ugali* which has been found to be variable in sub Saharan Africa (Onyango, 2014). In this study, the test foods were dried, milled

into flour and cooked in boiling water to obtain the *ugali*. This means there was reduction in particle size and gelatinization which influenced the GI. For example the physical properties of hammer-milled maize meal differ from that of sifted maize meal in terms of absorption, solubility and viscosity (Onyango, 2014) which may impact on the gelatinization process and ultimately the GI.

This study found GI of cassava-sorghum meals to be 69 to 83. Omoregie and Osagie (2008) in Nigeria and Ruhembe et al., (2014) in Tanzania found a GI of 85 and 66 respectively for dehulled sorghum product. Cassava meal had a GI of about 50 (Ruhembe et al., 2014). The sorghum used in this study was whole and it was mixed with cassava contributing to the difference in GI values.

All the meals in this study had high glycemic loads. Considering that the GL was calculated on the portion size given to participants, the load could be much higher since the average serving size of *ugali* is about 500 g in Western Kenya. Further research could therefore focus on exploring different food combinations to reduce the GI of popular staple foods.

# CHAPTER 8: ASSOCIATION BETWEEN GLYCEMIC LOAD AND DIABETES MELLITUS: CASE OF AMAGORO DIVISION OF WESTERN KENYA

## ABSTRACT

Glycemic load (GL) has been found to be a stronger measure for glycemic response to carbohydrate-rich foods. This is because it accounts for both the quality and quantity of carbohydrates consumed. This study therefore investigated the association between the total glycemic load from Kenya's most popular staple food "*ugali*", with diabetes mellitus type 2 (DM2). The study was cross-sectional study involving 260 women aged 18 – 90 years drawn from households located in Amagoro division of Western Province of Kenya. Households were chosen by cluster and stratified sampling. Data on demography, socio-economy and diabetes status were collected by interviews using pre-tested questionnaires. Blood sugar levels were measured using a glucometer and levels 7.8 mmol/L underwent a confirmatory test using fasting blood sugar. Anthropometric measurements were taken following standard protocols with some modifications. Body mass index was obtained by dividing weight (kg) by height (m$^2$) and classified as underweight (<18.5); normal weight (18.5-24.9); overweight (25.0-29.9) and obesity ( 30). Waist circumference > 88 cm indicated abdominal obesity. Waist-hip-ratio >0.80 was considered abnormal. The total GL was calculated by adding glycemic load of individual *ugali*-based meals. The odds ratio showed that those consuming glycemic load 840 per week were 1.25 times more likely to have DM2 as opposed to those consuming GL less that 840 per week although this finding was not statistically significant (OR= 1.25, 95% CI - OR 0.48-3.27, p=0.646). After controlling for confounding variables, no significant association was found between GL and DM2 although those consuming more >840 were 1.36 times more likely to suffer from DM2 as opposed to those on moderate load. Physical activity and alcohol consumption were the independent risk factors for DM2 in this population (*p*<0.05).

## 8.1 INTRODUCTION

As a result of rising cases of chronic diseases such as diabetes mellitus, there is a growing interest globally on the effect that foods rich in carbohydrates have on blood sugar responses. These responses can be measured in terms of glycemic indices (GI) and glycemic loads (GL).

Irrespective of the GI of a foodstuff, the blood sugar response to a carbohydrate-rich meal also depends on the portion size. Glycemic Load (GL) has therefore been used as an alternative measure for blood sugar response. The GL takes account of both the quality and quantity of the meal consumed. The GL is calculated by multiplying the dietary carbohydrate content with the GI of the food and dividing by 100. The higher the GL, the greater is the rise in blood glucose (Foster-Powell et al., 2002). The GL of foods has thus been categorized as low (GL=1-10,) medium (GL=11-19) and high (GL 20) (Foster-Powell et al., 2002).

Only limited information is available on glycemic responses of African traditional foods (Omoregie and Osagie, 2008). *Ugali* as it is popularly known in Kenya is a thick porridge which is mainly prepared from maize (*Zea mays* L.) flour and boiling water (Wanjala et al., 2016). It is served as the main dish usually for lunch or supper and is consumed alongside a side dish (relish) composed of vegetables, fish, legumes, meats or mixtures thereof (Onyango, 2014, Wanjala et al., 2016). *Ugali* may also be prepared from flours of cassava (*Manihot esculenta* Crantz L.), finger millet (*Eleusine coracana* (L.) Gaertn), sorghum (*Sorghum bicolor* (L.) Moench) or combinations thereof. The choice depends on the preference, availability and cost of the raw materials as well as the predominant crop in the locality (Wanjala et al., 2016). The stiff porridge is also widely consumed in other parts of Africa including, Tanzania (Ruhembe et al., 2014), Malawi (Mlotha et al., 2016), Cote d'Ivore (Kouame et al., 2015), Botswana

(Mahgoub et al., 2013), Nigeria (Omoregie and Osagie) and South Africa (Mbhenyane et al., 2001) among others.

In Amagoro Division of Western Kenya, the commonly consumed stiff porridge is prepared from flours of whole maize or cassava and sorghum mix. Dietary intervention has been advocated for preventing and managing diabetes as well as delay the development of related complications (Otieno et al., 2003, Ruhembe et al., 2014, Wanjala et al., 2016). Despite this, the direct role of the glycemic load (GL) of foods in the development of diabetes especially in populations that subsist on high carbohydrate diets remain obscure (Villegas et al., 2007).

Whole-milled maize, sorghum and finger millet have been recommended for making *ugali* for people with DM2 in Western Kenya (Wanjala et al., 2016) despite lack of data on their associated glycemic response.

This study therefore investigated the association between glycemic responses of some *ugali*-based meals consumed in Busia County of Kenya and it is the first study conducted on such meals from the region. The knowledge generated would be important in evaluating the potential of particular *ugali* meals to pose risk of diabetes and thereby hinder or help in the management of DM2 both locally and in other parts of Africa.

## 8.2 STUDY DESIGN AND METHODOLOGY

### 8.2.1 Study Design

This was a cross-sectional study conducted among women aged 18 – 90 years. The study used a structured questionnaire to collect information through self-reporting. The interviews were conducted at the participants' home.

### 8.2.2 Study Site

Amagoro division is located in Teso North District of Busia County in Western Kenya.

### 8.2.3 Sample Size Determination

The sample size for the survey was calculated as described in Chapter four.

### 8.2.4 Ethical Considerations

Kenyatta National Hospital and University of Nairobi Ethics, Research and Standards Committee reviewed and approved this study. Participants gave an informed consent and for those below 18 years, consent was sought from the guardian/parent. The inclusion criteria included being female, residing permanently in the household, having sound vision, hearing and memory, understanding the questions and agreeing to participate. The exclusion criteria were poor vision, hearing and memory or being ill (Moretto et al., 2015).

### 8.2.5 Sampling Procedure

From the nine locations in Amagoro division, three locations were sampled for this study. First the locations with less than 1000 households were eliminated and this included Okuleu (860 HHs), Kokare (823 HHs) and Kamuriai (273 HHs). Of the 6 locations left, three are located along the Kenya – Uganda highway (Kocholia, Amagoro and Akadetewai). Amagoro which is located along the highway was sampled from this group. Two more locations were sampled from the remaining 3 (Amoni, Osajai and Kamolo) which were located in the interior. To the south of Amagoro was Amoni (1525 HHs) and Kamolo (1589 HHs). Kamolo was sampled since it was more interior and had the highest number of households. To the North of Amagoro and most interior Osajai location was sampled. Therefore the three locations that participated in this study included Amagoro (central), Osajai (north) and Kamolo (south). The sample size was proportionately distributed among the three locations. To determine the sample size per

location, the total number of HHs in that location was divided by the total number of HHs (4467) in the three locations and divided by the total desired sample size required for the study.

For the household surveys, interviews were conducted to obtain the information on socio-demographic and clinical risk factors as well as physical activity and dietary intake. Measurements were then taken for blood pressure using a blood pressure monitor (AutoTensio SPG 420, France), random blood sugar using a glucometer (*On call* plus, USA) and anthropometric measurements were taken and BMI calculated as described in section 3.1.

Age, level of education, household income and glycemic load were classified into three categories. Family history of diabetes, blood pressure, blood sugar, cigarette smoking, alcohol consumption and self-reported diabetes were each classified into two categories while level of education was categorized into seven. For statistical purposes some of these categories were merged into either two or three categories.

A global physical activity questionnaire developed by the World Health Organization was adopted in this study with some modifications. Vigorous and moderate physical activity were multiplied by 8 and 4 respectively to convert them into metabolic equivalent for task (MET) which were then summed as total physical activity and scored in MET hours per day.

### 8.2.6 Data Analysis

The analyses were conducted using SPSS version 20.0. Descriptive statistics were used in analyzing and characterizing the survey participants. The data was presented in frequencies including percentages; and by mean including standard deviation. A chi-square analysis was used to compare blood sugar levels with independent variables. In order to determine associations between DM2 and independent variables, binary logistic regression analyses were

performed and multivariate logistic regression analysis was used to determine the magnitude of the independent risk factors. The significance level adopted in these tests was 5% ($p<0.05$).

## 8.3 RESULTS AND DISCUSSION

### 8.3.1 Socio-Economic Characteristics of the Household Survey Participants

These characteristics are as described in chapter 3. About half of the survey participants were below the age of 35 years while the elderly were the least at 6.9% (Table 20). A majority of those who went to school did not go beyond primary level. In fact only 17.7% completed primary education. This probably explains the low level of household income, with about 85% earning below KES 5000 per month.

**Table 20:** Socio-economic characteristics of the household survey participants

| Risk factor | Categories | Frequency | Percent |
|---|---|---|---|
| Age | <35 | 136 | 52.3 |
| | 65 years | 18 | 6.9 |
| Education level | Never gone o school | 35 | 13.5 |
| | Primary incomplete | 129 | 49.6 |
| | Primary complete | 46 | 17.7 |
| | Secondary incomplete | 19 | 7.3 |
| | Secondary complete | 28 | 10.8 |
| | Tertiary | 3 | 1.2 |
| Income level (KES) | < 5000 | 222 | 85.4 |
| | 5000-9999 | 28 | 10.8 |
| | 10000 | 10 | 3.8 |
| Family history of diabetes | Present | 19 | 7.3 |
| | Absent | 241 | 92.7 |

### 8.3.2 Behavioural Factors of the Participants

They were generally very active physically, all above the recommended levels by the World Health Organization (Table 21). A few smoked cigarettes (3.1%) and less than half the sampled population consumed alcohol.

**Table 21:** Behavioral characteristics of participants

| Risk factor | Categories | Frequency | Percent |
|---|---|---|---|
| Physical activity (MET hours) | < 25 | 87 | 33.5 |
| | 25-49 | 150 | 57.7 |
| | 50 | 23 | 8.8 |
| Cigarette smoking | Smokers | 8 | 3.1 |
| | Non-smokers | 252 | 96.9 |
| Alcohol consumption | Yes | 88 | 33.8 |
| | No | 172 | 66.2 |

### *8.3.3 Clinical Factors*

Some of these factors have been described in Chapter 3. A few participants were underweight (6.9%) or obese (3.1%) while the majority (70%) had a normal body weight (Table 22). Hypertension was at 22.3% and while 16.9% were suffering from DM2.

**Table 22:** Clinical characteristics of the participants

| Risk factor | Categories | Frequency | Percent |
|---|---|---|---|
| Body mass index (kgm$^{-2}$) | Underweight | 18 | 6.9 |
| | Normal weight | 182 | 70 |
| | Overweight | 52 | 20 |
| | Obesity | 8 | 3.1 |
| Blood pressure (mmHg) | Normal | 202 | 77.7 |
| | Hypertensive | 58 | 22.3 |
| Glycemic load (GL) | < 420 | 121 | 46.5 |
| | 421-840 | 79 | 30.4 |
| | >840 | 60 | 23.1 |
| Diabetes mellitus (DM2) | Diabetic | 44 | 16.9 |
| | Normal | 216 | 83.1 |

### *8.3.4 Glycemic Load of Ugali Meals*

The results in the Table below were adapted from Chapters six and seven.

**Table 23:** Glycemic load of the test meals

| Test meals | Glycemic load |
|---|---|
| Whole maize *ugali* eaten with beef | 35.4 |
| Whole maize *ugali* eaten with silver fish | 34.5 |
| Whole maize *ugali* eaten with cowpea leaves | 22.7 |
| Cassava-sorghum *ugali* eaten with silver fish | 41.0 |
| Cassava-sorghum *ugali* eaten with cowpea leaves | 34.6 |

*Ugali* was the food of choice because it is the most commonly as shown in Chapter 4.

The total glycemic load was categorized into three low, medium and high considering the cut-off values of 10 (representing low GI), this study considered that the participants normal average serving size is thrice the above value (from 50g available carbohydrates), and *ugali* was mostly consumed twice a day (for lunch and supper) and considering seven days of the week then the lower category was therefore computed by multiplying 10 by 3 by 2 by seven to get the weekly load which was 420. The same was considered for the high GL foods ( 20) resulting to a load of  840. The figures in between formed the moderate GL values (421-840).

### 8.3.5 Glycemic Load in Association with Diabetes Mellitus

The mean weekly glycemic load from *ugali* meals was 593.08±466.98. The distribution of diabetes mellitus, with regard to GL was computed (Table 24).

**Table 24:** Distribution of participants by total glycemic load in relation to diabetes status

| Glycemic Load | Diabetes Status | |
|---|---|---|
| | Diabetic n (%) | Normal n (%) |
| <420 | 19 (43.2) | 101(46.8) |
| 421-839 | 16 (36.4) | 63 (29.2) |
| 840 | 9 (20.5) | 52 (24.1) |

### 8.3.6 Univariate Logistic Regression for Diabetes in Relation to Glycemic Load

Logistic regression analysis for diabetes mellitus in relation to total glycemic load from *ugali* meals was conducted. The odds ratio showed that those consuming glycemic load  840 per week were 1.25 times more likely to have DM2 as opposed to those consuming glycemic load less that 840 per week although this finding was not statistically significant (OR= 1.25, 95% CI for OR 0.48-3.27, p=0.646). After controlling for other variables, this association was lost

although those who consumed   840 per week were 1.25 times higher chance for DM2 as opposed to those consuming 421-839 per week as shown by the odds ratio although this finding was not statistically significant.

**Table 25:** Multivariate regression results for participants characteristics in relation to DM2

| Risk factor | Categorization | $p$-value | OR (95% CI for OR) |
|---|---|---|---|
| Age (years) | <35 (ref) | - | 1.00 |
| | 35-64 | 0.95 | 0.97 (0.38-2.47) |
| | 65 | 0.75 | 0.69 (0.07-6.96) |
| Education level | No schooling | 0.27 | 2.74 (0.45-16.50) |
| | Primary education | 0.33 | 1.73 (0.57-5.25) |
| | Secondary education (ref) | - | 1.00 |
| Household income (KES) | < 5000 | 0. 20 | 4.49 (0.46-43.65) |
| | 5001-10000 | 0.30 | 3.64 (0.32-41.89) |
| | >10000 (ref) | - | 1.00 |
| Family history | Present | 0.00 | 0.06 (0.20-0.24) |
| | Absent  (ref) | - | 1.00 |
| Physical activity (MET hrs/day) | <25 | 0.00 | 12.41 (3.00-51.37) |
| | 25-49 | 0.04 | 3.30 (1.07-10.18) |
| | 50 (ref) | - | 1.00 |
| Cigarette smoking | Smokers | 0.26 | 0.20 (0.01-3.36) |
| | Non-smokers (ref) | 1 | 1.00 |
| Alcohol consumption | Drinkers | 0.03 | 2.78 (1.08-7.15) |
| | Non-drinkers (ref) | - | 1.00 |
| Body mass index (kgm$^{-2}$) | <25 (ref) | - | 1.00 |
| | 25 | 0.96 | 0.97 (0.34-2.76) |
| Blood pressure (mmHg) | Normal (ref) | - | 1.00 |
| | High | 0.31 | 1.77 (0.59-5.32) |
| Glycemic Load | 0-420 (ref) | - | 1.00 |
| | 421-839 | 0.21 | 0.53 (0.20-1.41) |
| | 840 | 0.61 | 0.72 (0.21-2.51) |

After controlling for the confounding variables this study did not find any association between age, family history of diabetes, cigarette smoking, BMI and glycemic load with diabetes mellitus (Table 25).

Although not statistically significant socio-economic status as represented by level of education and household income is an important variable with regards to DM2. As opposed to those who had post primary education, those who never went to school were 2.74 times more likely to suffer from DM2. In fact there were 1.58 times more likely to suffer than those who simply went to primary school. Those who earned less than KES 10,000 per month were more likely to suffer from DM2 as compared to those earning above KES 10, 000 although all these fall under low income group. This is the case despite the fact that a majority rely on subsistence farming for their livelihood.

Those with hypertension were 1.77 times more likely to suffer from DM2 as opposed to those with normal blood pressure. Hypertension has been found to be common in diabetic people and is estimated to affect 20–60% of the patients (ADA, 2002).

### 8.3.7 Independent Risk Factors for Diabetes Mellitus

Physical activity and alcohol consumption were the factors significantly associated with DM2 in this population ($p<0.05$) (Table 25). Those who exercised moderately were 3.3 times more like to suffer from DM2 as opposed to those who exercised highly ( 50 MET Hours/day) and those with lower physical activity in this population were 12.41 more likely to suffer from DM2 as opposed to those with higher levels. This was the case in this population despite the fact that all the participants level of activity was much higher than that recommended by the World Health Organization (WHO, 2010). This could mean that this population needs higher levels of physical activity to maintain good health and protect against DM2.

Physical activity is known to reduce the risk of DM2 by 35% to 40% (IDF Diabetes Atlas, 2011) approximately 27% of diabetes disease burden has been attributed to physical activity (WHO, 2009). However the cut-off values may not be applied across the population. Although WHO recommends level of 150 minutes of activity of moderate-intensity per week for adults (WHO, 2010) and others recommend walking for 30 minutes per day (Roberts and Barnard, 2005), this population surpassed all these recommendations and yet physical activity remains an independent risk factor.

This study supports the fact that physical activity is important risk factor for DM2 and especially in this population. Physical activity apart from controlling body weight by utilizing glucose in the process, it regulates blood pressure and makes body cells more sensitive to insulin thereby decreasing incidence of DM2 (Helmrich et al., 1991; Hu et al., 1999; Folsom et al., 2000; Colberg et al., 2010).

The other independent risk factor was alcohol consumption (Table 25). Although earlier studies had found an increased risk of developing DM2 in non drinkers and heavy drinkers, when compared with moderate drinkers (Wei et al., 2000; Ajani et al., 2000; ADA, 2002; Wannamethee et al., 2003), this study found that irrespective of the amount of alcohol, those who consumed alcohol were 2.78 more likely to suffer from DM2 as opposed to those who never consumed alcohol.

**CHAPTER 9: GENERAL DISCUSSION**

The prevalence of diabetes mellitus among women of Amagoro division was 16.9%. A similar high prevalence (16%) was previously reported in a rural population in Northern Kenya (El-busaidy et al., 2014). Several other studies have reported varying prevalence among ethnic groups in Kenya (Christensen et al., 2008) and regions (Ayah et al., 2013; Oti et al., 2013; El-busaidy et al., 2014). The rising prevalence has been associated to increased awareness, improved diagnosis (IDF, 2011), rising prevalence of human immunodeficiency virus (Onsomu, 2008) and the rapidly changing lifestyle of Kenyans (Waweru, 2017).

Diet has a direct role in influencing the level of blood sugar in the body. This study found out that *ugali* and rice had high glycemic responses that were modulated by an accompaniment. For instance beans and cow pea leaves lowered the GIs of rice and *ugali* respectively. This supports earlier studies that reported meal combination may influence the GI of a staple food (Sugiyama et al., 2003; Ruhembe et al., 2014). In this study, beans and cow pea leaves were found to be rich in protein and fat. These macronutrients have been shown to reduce glycemic response as a result of increased insulin sensitivity (Pi-Sunyer, 2002). Additionally, beans and cowpea leaves possessed high ash content. These leaves have been previously reported to be rich in calcium, zinc, iron (Imungi and Potter, 1983; Mamiro et al., 2011) and phosphorus (Imungi and Potter, 1983). Also beans are known to contain magnesium, zinc and phosphorus which have been shown to improve insulin sensitivity (Larsson and Wolk, 2007; Ortega et al., 2012; Khattab et al., 2015). Besides minerals, beans and cowpea leaves also contain vitamin K known to reduce insulin resistance (Yoshida et al., 2008). Cow pea leaves and beans have been suggested for consideration during meal planning for diabetic patients (Mani et al, 1994). In line with these findings, this study recommends that cowpea leaves and beans can be consumed alongside

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staple foods to modulate blood sugar in diabetic patients. However this study was limited to glycemic responses of a few *ugali*-based meals which are the main staple food in this population. Therefore there is need to establish glycemic responses to other foods including fruits in order to provide better guidance on dietary choices for people suffering from diabetes.

However this study did not find significant association between glycemic responses of foods and diabetes mellitus among rural women in Amagoro. The strongest independent risk factors in this population were physical activity and alcohol consumption. Physical activity improves insulin sensitivity (Balkau et al., 2008), prevents hypertension (Diaz and Shimbo, 2013) and utilizes glucose as a source of energy. Although the participants fulfilled WHO recommended level of physical activity (WHO, 2010), it is clear that this cut-off may not be sufficient to offer protection against DM2 in this population. Gill and Cooper, (2008) had earlier suggested that much higher levels of physical activity may be necessary to significantly minimize the risk of diabetes in those with many other associated risk factors. In line with this, it is necessary to establish different threshold for physical activity in different populations.

Alcohol consumption was also identified as an independent risk factor for DM2. Those who consumed alcohol were more likely to suffer from DM2 as opposed to those who did not. Earlier studies had found an increased risk of developing DM2 in non-drinkers and heavy drinkers when compared with moderate drinkers (Wei et al., 2000; Ajani et al., 2000; ADA, 2002; Wannamethee et al., 2003). More studies are required to establish the effect of the amount of alcohol consumed on DM2 in this population.

# CHAPTER 10: CONCLUSIONS AND RECOMMENDATIONS

## 10.1 CONCLUSIONS

Socio-demographic and economic characteristics: Population was characterized by low level of education, high unemployment and low income.

Food consumption patterns: Food was consumed thrice a day and snacks were not a part of their diet. The diet was generally starch-based mainly presented inform of thick porridge with limited protein in the overall diet.

Nutritional status: Prevalence of excessive weight was relatively high although cases of under-weight were also reported.

Food consumption patterns: Food consumed thrice a day without snacks. The diet of this population is highly starch-based presented in form of porridge with little protein in the overall diet.

Association between glycemic indices and DM2: Prevalence of diabetes was relatively high. Glycemic indices and load of staples were generally high. Cowpea leaves and beans lower the GI of staple foods. No significant association between glycemic responses from *ugali* meals and DM2 especially after controlling for the confounding variables ($p$>0.05. Alcohol consumption and physical activity were the strongest independent risk factors for DM2 in this population.

## 10.2 RECOMMENDATIONS

The finding from this study could be used by county government for:

  i.  Creating awareness and undertaking regular screening for DM2.
  ii. Empowering women by improving access to education and employment so that they may boost their income levels and improve on their nutrition and health.

iii. Developing strategies that increase availability of protein sources and diversify carbo-hydrate sources.

iv. Sensitizing women on effect of physical activity and alcohol consumption.

v. Focusing on factors that put rural population at risk; expand welfare programs to include all ages; increase funding on research and collaboration to develop low GI food varie-ties.

**Further research could focus on:**

i. Factors in the cowpea leaves and beans that lower GI.

ii. Effect of leaf maturity and preparation methods.

iii. Effect of other green leafy vegetables and legumes GI

iv. Effect of type and amount of alcohol.

v. Suitable physical activity threshold for local population.

vi. Developing crops with low GI

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# APPENDICES

## Appendix 1: Ethical Clearance

**UNIVERSITY OF NAIROBI**
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13th February 2013

Rebecca Aya Ebere
School of Public Health
College of Health Sciences
University of Nairobi

Dear Rebecca

**RESEARCH PROPOSAL: THE ASSOCIATION BETWEEN DIET AND PREVALENCE OF DIABETES IN AMAGORO DIVISION OF BUSIA COUNTY (P643/11/2012)**

This is to inform you that the KNH/UoN-Ethics & Research Committee (KNH/UoN-ERC) has reviewed and **approved** your above revised proposal. The approval periods are 13th February 2013 to 12th February 2014.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH/UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH/UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH/UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH/UoN-Ethics & Research Committee for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

For more details consult the KNH/UoN ERC website **www.uonbi.ac.ke/activities/KNHUoN**

*"Protect to Discover"*
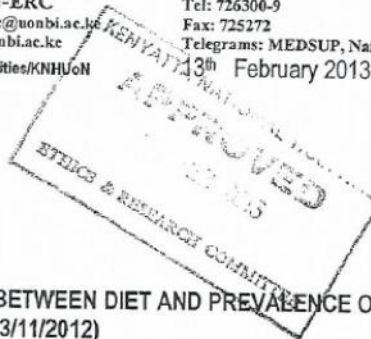
**Appendix 2: Household Survey Questionnaire**

**General Information**

Date…………… Location ……………. Sub-location ………….. Interviewer …………..

Language used: Kiswahili [  ] Ateso [  ] Both [  ] Time Started:…… Time Ended: …..……

**Section A. Socio-Demographic and Socio-Economic Status**

1. Personal Information

Name: ………………………………. …………………….. Age: …………………………

Marital status: ………………………………………… Ethnicity: …………………

Highest level of education: ……………………………… Employment: …………….

Number of family members: ………………….

2. What is the main source of income for the household?

 Salary/wages [  ]   Farming [   ] Business [   ] Earnings from assets [  ] other (specify)……...

3. What is your households' monthly income (salary/non salary)?  KES ……………………….

**Section B: Diabetes, History and Physical Activity**

1. Do you know whether you are suffering from diabetes? Yes  [   ]    No [   ]

2. Does any of your parent or sibling suffer from diabetes? Yes  [   ]   No [   ]

*Activity at Work*

3.a) Does your work involve vigorous-intensity activity such as carrying or lifting heavy loads, digging or construction work for at least 10 minutes continuously?   Yes   [   ]  No   [   ]

b) If yes, how many days in a week?    [      ] Number of days

c) How much time do you spend doing these vigorous-intensity activities at work on a typical day? ………..hrs

4.a) Does your work involve moderate-intensity activity such as brisk walking or carrying light loads for at least 10 minutes continuously?  Yes   [ ]    No  [ ]

b) If yes, how many days in a week?  [      ] Number of days

c) How much time do you spend doing moderate-intensity activities at work on a typical day? ………hrs

*Travel to and from places*

The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work,  shopping, market or to place of worship.

5.a) Do you walk or use a bicycle for at least 10 minutes continuously to get to and from places? Yes  [  ]   No [  ]

b) If yes, how many days in a week?  [      ] Number of days

c) How much time do you spend walking or bicycling for travel on a typical day? ……..hrs

**Sedentary Behavior**

The following question is about relaxing. It includes time spent sitting at a desk, sitting with friends, traveling in a vehicle, reading or watching television, but not the time spent sleeping.

6. How much time do you usually spend sitting or relaxing on a typical day?  ..……..hrs

## Section C: Dietary Intake

## Table 2:  Food Frequency Questionnaire

 How often did you eat the following foods over the past month?

| Food | Description (popular cooking method) | Amount | Per Day | Per Week | Per Month | Seldom /Never |
|---|---|---|---|---|---|---|
| (a)  Cereals & legumes | | | | | | |
| *Ugali* | Whole meal maize | servings | | | | |
| | Sifted maize meal | servings | | | | |
| | Cassava/millet | servings | | | | |
| | Cassava/sorghum | servings | | | | |
| | Cassava/millet/sorghum | servings | | | | |
| *Ugali* and meat | | | | | | |
| *Ugali* and green vegetables (specify) | | | | | | |
| *Ugali* and other relish (specify) | | | | | | |
| Porridge | Whole maize meal | cups | | | | |
| | Sifted maize meal | cups | | | | |
| | Millet | cups | | | | |
| | Other (specify) | cups | | | | |
| Bread | White/Brown | slices | | | | |
| Rice | White/brown | servings | | | | |
| *Chapatti* | White/brown | | | | | |
| Green maize | | cobs | | | | |
| *Githeri*: maize-beans | | servings | | | | |
| *Mandazi* | | | | | | |
| Groundnuts | | bowls | | | | |
| Sesame seeds | | balls/bowls | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Beans | | bowls | | | | |
| Soya beans | | bowls | | | | |
| Cowpeas seeds | | bowls | | | | |
| Green grams | | bowls | | | | |
| *Fruits & vegetables* | | | | | | |
| Mango | | | | | | |
| Guava | | | | | | |
| Avocado | | | | | | |
| Banana | | | | | | |
| Pineapples | | | | | | |
| Passion | | | | | | |
| Lemon/lime | | | | | | |
| Orange | | | | | | |
| Watermelon | | | | | | |
| Kales | | bowls | | | | |
| Cowpeas leaves | | bowls | | | | |
| Local vegetables (specify) | | bowls | | | | |
| Cassava | | pieces | | | | |
| Cassava-beans mash | | servings | | | | |
| Sweet potatoes | Flesh color | pieces | | | | |
| Sweet potato - beans mash | Boiled/fried | ……servings | | | | |
| Plantain | | servings | | | | |
| Mushrooms | | bowls | | | | |
| *Beverages & Cigarette* | | | | | | |
| Tea | | cups | | | | |
| Soft drinks | | bottles/cups | | | | |
| Alcohol | *Busaa* (local brew) | cups | | | | |
| | *Chang'aa* (local distilled liquor) | cups | | | | |

| | Industrial beer/wine | cups | | | | |
|---|---|---|---|---|---|---|
| Cigarette | | | | | | |
| *Meat* | | | | | | |
| Red meat | | bowls | | | | |
| Lamb mutton | | bowls | | | | |
| Goat mutton | | bowls | | | | |
| Pork | | bowls | | | | |
| Beef offals (*matumbo*) | | bowls | | | | |
| *Fish & poultry* | | | | | | |
| Chicken | | pieces | | | | |
| Fish | | pieces | | | | |
| Silver fish | | bowls | | | | |
| | | bowls | | | | |
| *Eggs* | | | | | | |
| *Dairy products* | | | | | | |
| Fresh milk | | cups | | | | |
| Mala | | cups | | | | |
| Yoghurt | | cups | | | | |
| Are there other foods/beverages not listed that you consumed in the past year? If so, explain: | | | | | | |
| | | | | | | |

## Section D: Anthropometry

Weight (kg)………Height (m)……Waist Circumference (cm) ………………………………….

Hip Circumference (cm) …….Blood Pressure (mmHg).........Blood Sugar (mmol/L)...................

**Thank you for your cooperation and patience.** Your telephone number please ………………
**Good-bye!**

**Appendix 3: Focus Group Discussion Moderator's Guide**

**1. Food consumption pattern in the area**

What foods do you normally consume in this area? ………………………………………..

How many times do you eat in a normal day? ……………………………………………

Do you have any specific foods for special occasions such as for weddings, in-laws or for the sick? ……………………………………………………………………………………

If yes, what foods are these? ……………………………………………… ……………

Are there any foods that you consider as taboo foods? (e.g. for elderly, young, pregnant, lactating women) If yes, which ones? …………………………………………………………

What specific foods are meant for infants, young children, pregnant and lactating women? ........................................................................................................................................

**2. Diet and diseases knowledge**

What foods do you consider as healthy foods? ……………………………………

Are there any foods that you associate with disease? If yes, which foods and what diseases? ……………………………………………………………………………………………

Is overweight associated with disease? What diseases are caused by being overweight? …………………………………………………………………………………………..

**3. Knowledge about diabetes**

What do you think causes diabetes? Who is affected by it? What treatment is available here? What do you normally do to prevent and manage existing diabetes? Is the healthcare available here sufficient? What do you think can be done to improve the healthcare in this area?

Causes: …………………………………………………………………………………

Affected group: ………………………………………………………………………

Prevention and management: …………………………………………………………

What foods do you associate with diabetes?

Foods for diabetes management: …………......................…………………………………

Foods that cause diabetes: ……………………………………………………………….

Training on nutrition; understanding of glycemic index …………………………………………

Barriers to management of diabetes and suggestions to improve diabetes management ….…..…..

## 4. Social and health habits

Do you know of any health problems caused by drinking too much alcohol or smoking cigarettes? If yes, which ones?

Drinking too much alcohol: …………………………………………………………………

Smoking cigarettes: ……………………………………………………………………… .

Do you have any questions or final comments?  Is there anything important you think I missed?

**Thank you for your cooperation!** "May I have your telephone number please?" …………….

**Appendix 4: Key Informant Interview Moderator's Guide**

**Food consumption patterns in the area**

What foods do people normally consume in this area? ………………………………………….

How many times do people eat in a normal day? ……………………………………………

Do people have any specific foods for special occasions (weddings/in-laws/the sick)…………..

If yes, what foods are these? ……………………………………………………………..

Are there any foods that people consider as taboo foods? If yes, which ones? …………………………………………………………………………………………………

What specific foods are meant for infants, young children, pregnant and lactating women? ........................................................................................................................................

**2. Diet and diseases knowledge**

What foods do people consider as healthy foods? ………………………………………… ..

Are there any foods that people associate with disease? If yes, which foods and what diseases?

………………………………………………………………………………………… …

What diseases do people think can result from eating too much carbohydrate, fat or sugar?

Carbohydrates: ………………………………………………………….………………..

Fat: …………………………………………………………...........................……………

Sugar: …………………………………………………………………………………..

Is overweight associated with disease? What diseases are caused by being overweight?

…………………………………………………………………………………………..

**3. Knowledge about diabetes**

What do people think causes diabetes? Who is affected by it? What treatment is available here? How do people normally prevent and manage existing diabetes?    Is the healthcare available here sufficient? What do you think can be done to improve the healthcare in this area?

Causes: ..……………………………………………………………………………………

Affected group: …………………………………………………………………………………….

Prevention and management: ……………………………………………………………………

What foods do people associate with diabetes?

Foods for diabetes management: ……………………………………………………………….

Foods that cause diabetes: ……………………………………………………………………..

Training on nutrition; understanding of glycemic index:  ……………………………………...

Barriers to management of diabetes and suggestions to improve diabetes management ………

**4. Social and health habits**

Do you know of any health problems caused by drinking too much alcohol or smoking cigarettes? If yes, which ones?

Drinking too much alcohol: …………………………………………………………………

Smoking cigarettes: …………………………………………………………………. …..

Do you have any questions or final comments?  Is there anything important you think I missed?

**Thank you for your cooperation!** "May I have your telephone number please?" …....................

**Appendix 5: Informed Consent Forms**

**(a) Household Survey Participants**

**Researchers Statement**

We are requesting you to participate as a volunteer in our research. The study is titled "the glycemic indices in association with diabetes in rural women of Kenya: case of Amagoro in Busia County".

This consent form is meant to give you the necessary information you may need in order to decide whether to be a participant or not. Please read this form carefully and ask for clarification where necessary.

**Purpose of the Study**

This study is aimed at helping us understand why diabetes is prevalent in Amagoro. The information will particularly help us understand whether the foods we consume play any role. We shall be able to know if people are eating enough and if they are healthy. This information will help health care personnel and policy makers to gain additional understanding on ways of improving diabetes management in this region.

**Study Procedures**

We want to find out what people living in this area eat and drink. First we shall questions about yourself and your family in general. I will later on go through a list of foods and drinks and I would like you to tell me: - if you eat the food - how the food is prepared - how much of the food you eat at a time - how many times a day you eat it and if you do not eat it every day, how many times a week, month or in a year you eat it. We have cups, spoons and bowls that you can use to estimate the amount of food you ate. Estimate if you are not sure. There is no right or wrong answer in this interview. We estimate that the interview may take 30 to 40 minutes. You participation is voluntary and you can therefore agree or refuse to participate. You can also decline to answer specific questions that you feel you are uncomfortable with.

**Risks**

Since the information released during the interview might be personal and sensitive, the researcher will carry out debrief for all the participants to ensure that anybody who might have been negatively affected during the process gets the necessary help.

**Benefits**

The information gathered from this study will be communicated back to you and if you have any questions regarding the relationship between diet and disease especially diabetes, you may ask. You can also have free testing to establish whether you are diabetic or not if you wish to. We can also share some information on healthy living at the end of our session if you will be interested. We also expect that there will be benefits to the society as information gathered from this study will help health care personnel gain more knowledge that would improve diabetes management in this region.

**Confidentiality**

All the information you will give will be kept in a secure place and destroyed after it has been analyzed. With the exception of the research team, nobody else will have access.

**Voluntary Participation**

You have the absolute freedom to decide whether to participate in the study or not. You can also decline to answer any question that you are uncomfortable with. However since your views are very important, we hope that you will agree to participate in this survey.

**Leaving the Study**

You are free to leave the discussion at any time.

**Your Rights as a Participant**

Kenyatta National Hospital and University of Nairobi Ethics and Research Committee (KNH/UoN-ERC) have reviewed and approved this research. If you have any questions about your rights, you may contact the principal investigator, study supervisor or the Chairman (KNH/UoN-ERC) on the following numbers.

Principal investigator: Rebecca Ebere-0738 877 050

Supervisor: Prof Violet Kimani-0722 445 120

Chairman KNH/UoN-ERC:-020726300

Your participation in this survey would be highly appreciated. You are required to sign this consent form before we start. If you have any questions about the study you may ask them now.

**Statement of Consent and Signatures**

This document that describes procedures for the research titled "The glycemic indices in association with diabetes in rural women of Kenya: case of Amagoro in Busia County" including its risks and benefits has been explained to me. By signing this form, I do understand that I do not give up my rights as a participant.

**Signed (Signature or thumb print)**

Participant ………………………    Date …………………………

Study staff ………………………    Date …………………………

Witness……………………………..    Date…………………………

**Copies to:** 1. Investigator    2. Study participant

**(b) Key Informant Interview (KII) Participants**

**Researchers' Statement**

We are requesting you to be a volunteer in a research study titled "The glycemic indices in association with diabetes in rural women of Kenya: case of Amagoro in Busia County".

This consent form gives you the information that will help you to decide whether to be in the study or not. Read this form carefully and ask for clarification where necessary.

**Purpose of the Study**

This study is aimed at helping us understand why diabetes is prevalent in Amagoro. The information will particularly help us understand whether the foods we consume play a role in increasing its prevalence here. This information will help health care personnel gain more understanding on ways of improving diabetes management in this region.

**Study Procedures**

We are requesting you to share with us information about the diet in this region. I would like us to discuss some issues about food consumption and the relationship between food and disease especially diabetes in this region as well as other health issues. We are going to discuss about the foods normally consumed here, how frequently its consumed, and foods eaten on special occasions as well as foods that we relate to disease especially diabetes. This discussion will be led by a moderator and a research assistant will be present to note and tape-record the discussion so that none of the important insights and discussions is missed. Both of them will maintain your information confidential. The interview will not be recorded if you do not prefer it to be. The audiotape will not have your name on it and will be kept in a secure location. You are only requested to participate only once, however we may contact you for some clarification if necessary. We estimate that the interview may take 15 to 25 minutes.

**Risks**

Since the information released during discussion might be personal and sensitive, the researcher will carry out debrief for all the participants to ensure that anybody who might have been negatively affected during the process gets the necessary help.

**Benefits**

The information gathered from this study will be communicated back to you and if you have any questions regarding the relationship between diet and diabetes, you may ask. You will get free testing so that you can know your diabetes status. We can also share some information on healthy living at the end of our session if you will be interested. We also expect that there the information gathered from this study will help health care personnel improve their understanding on ways of improving diabetes management in this region.

**Confidentiality**

The recorded tapes shall only be accessible to the principal investigator. The recorded information transcribed later and the recorded information will not be presented in any forum. All the information you will give will be destroyed once the discussions are analyzed which should be within one year.

**Voluntary Participation**

You are free to choose whether you want to participate in this study or not. You may decline to answer any question that you may be uncomfortable with. You may also stop the interview at any point without having to offer any explanation. Your views are very important to us and we therefore hope that you agree to participate.

**Leaving the Study**

You are free to leave the discussion at any time.

**Your Rights as a Participant**

Kenyatta National Hospital and University of Nairobi Ethics and Research Committee (KNH/UoN-ERC) has approved this study. If you have any questions about your rights, you may contact the principal investigator, study supervisor or the Chairman (KNH/UoN-ERC) on the following numbers.

Principal Investigator: Rebecca Ebere-0738 877 050

Supervisor: Prof Violet Kimani-0722 445 120

Chairman KNH/UoN-ERC:-020726300

You are required to sign this consent form before we start. If you have any questions about the study you may ask them now.

**Statement of Consent and Signatures**

This document explaining the procedures, benefits and risks for the research titled "The glycemic indices in association with diabetes in rural women of Kenya: case of Amagoro in Busia County" has been explained to me and all my questions have been answered.

**Signed (Signature or thumb print)**

Participant …………………………    Date …………………………

Study staff …………………………    Date …………………………

Witness……………………………..    Date…………………………..

**Copies to:** 1. Investigator      2. Study participant

**(c) Focus Group Discussions (FGD)**

**Researchers Statement**

We are requesting you to volunteer to participate in a research study. The study is titled *"The glycemic indices in association with diabetes in rural women of Kenya: case of Amagoro in Busia County"*.

This consent form gives you the information you need in order to make a decision whether to participate in the study or not. Please read this form carefully and ask for clarification where necessary.

**Purpose of the Study**

This study is aimed at helping us understand why diabetes is prevalent in Amagoro. The information will particularly help us understand whether the foods we consume contribute to the increasing cases of diabetes in Amagoro. The information generated will help health care personnel gain more understanding regarding ways of improving diabetes management in this region.

**Study Procedures**

We are requesting you to share with us information about your diet in general. I would like us to discuss some issues about food consumption and the relationship between food and disease especially diabetes as well as other health issues. We are going to discuss about the foods we normally consume. There is no right or wrong response in this discussion. You only need to share your opinions and beliefs. The discussion will be led by a moderator and a research assistant will be present to tape record the discussion so that none of the important insights and discussions is missed. Both of them will maintain confidentiality. The interview will not be recorded if you do not want. The audiotape will not have your name on it and will be kept in a secure location. Please be honest; your individual comments will remain confidential but will be compiled into a report. Be respectful and avoid personal attacks; if you disagree, please tell us but in a calm and respectful manner. Just stay on the subject. We are asking you to sign this form before you participate in the discussion. You will only attend a single discussion. The discussion will last about 30 to 45 minutes. You may decline to contribute to questions that you are not comfortable with.

**Risks**

Since the information released during discussion might be personal and sensitive, the researcher will carry out debrief for all the participants to ensure that anybody who might have been negatively affected during the process gets the necessary help. Those taking part in this discussion will be requested not to discuss what they hear from the discussion to other people outside this discussion although this cannot be guaranteed.

**Benefits**

The information gathered from this study will be communicated back to you and if you have any questions regarding the relationship between diet and disease especially diabetes, you may ask. You will also be able to get free testing so that you may know whether you are diabetic or not. We can also share some information on healthy living at the end of our session if you will be interested. We also expect that there will be benefits to the society as information gathered from this study will help health care personnel provide better advice to patients with regard to diabetes management.

The government may also use the information generated from this study to plan health care services.

**Confidentiality**

We shall request those taking part in the discussion group not to discuss what they hear from the discussion to people outside this group although we may not guarantee that everyone will comply. The recorded tapes shall only be accessible to the principal investigator. All the information you will give will only be accessible to the research time and it will be destroyed once the discussions are written down and analyzed.

**Voluntary Participation**

You can choose to participate in this study or decline. You do not have to respond to questions that you may feel not comfortable with.

**Leaving the Study**

You are free to leave the discussion at any time.

**Your Rights as a Participant**

Kenyatta National Hospital and University of Nairobi Ethics and Research Committee (KNH/UoN-ERC) has approved this study. If you have any questions about your rights, you may contact the principal investigator, study supervisor or the Chairman (KNH/UoN-ERC) on the following numbers.

Principal investigator: Rebecca Ebere-0738 877 050

Supervisor: Prof Violet Kimani-0722 445 120

Chairman KNH/UoN-ERC:-020726300

Your participation in this discussion would be highly appreciated. You are required to sign this consent form before we start. If you have any questions about the study you may ask them now.

**Statement of Consent and Signatures**

This document describing the procedures, risks and benefits for the research titled *"The glycemic indices in association with diabetes in rural women of Kenya: case of Amagoro in Busia County"* has been explained to me and all my questions have been answered. I understand that participation in this study is voluntary.

**Signed (Signature or thumb print)**

Participant …………………………    Date …………………………

Study Staff …………………………    Date …………………………

Witness……………………………..    Date…………………………...

**Copies to:** 1. Investigator     2. Study participant

**(d) Glycemic Index Participants**

**Researchers Statement**

We are requesting you to volunteer to participate in a research study. The study is titled "The glycemic indices in association with diabetes in rural women of Kenya: case of Amagoro in Busia County".

The consent form provides you with the information you need in order to decide whether to participate. Please read it carefully and ask for clarification where necessary.

**Purpose of the Study**

This study is aimed at helping us understand why diabetes is prevalent in Amagoro. The information will particularly help us understand whether the foods we consume increase is associated with this illness in Amagoro. This information may be useful to health care personnel who normally give advice on ways of improving diabetes management.

**Study Procedures**

If you choose to participate in this study, we shall give you some food samples to consume then take a blood sample to find out your blood sugar. Blood will be taken by pricking you finger. The blood samples will drawn at 15 minutes interval during the first 1 hour then after every 30 minutes for the next one hour after the meal (at times 0, 15, 30, 45, 60, 90, 120 min; the beginning of the food intake will be time 0). The tests shall take approximately two and a half hours after which breakfast will be served to all the participants.

**Risks**

There is risk of infection since it involves drawing blood samples. However this will be avoided by ensuring that we use a new sterile lancet for each test and surgical spirit will also be provided. You will also experience some slight sharp pain during the pricking of your finger lasting approximately five seconds but this will immediately go away.

**Benefits**

The information gathered from this study will be communicated back to you and if you have any questions regarding the relationship between diet and disease especially diabetes, you may ask. You will also be able to know whether you have diabetes or not. We can also share some

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information on healthy living at the end of our session if you will be interested. We also expect that there will be benefits to the society as information gathered from this study will help health care personnel in improving diabetes management in this region. The government may also use this information in planning their health services.

**Confidentiality**

Your name will not appear on the final report and all the information we shall get from you will only be accessible to the research team. All the information gathered here will be destroyed once the discussions are analyzed.

**Voluntary Participation**

You can choose to be a participant in this study or not. In case you are not comfortable with any question then you may remain decline to comment. Your views are very important to us and we therefore hope that you will participate.

**Leaving the Study**

You are free to leave the discussion at any point without having to explain.

**Your Rights as a Participant**

Kenyatta National Hospital and University of Nairobi Ethics and Research Committee (KNH/UoN-ERC) reviewed and approved this research. In case of any queries regarding your rights as a participant you may contact the principal investigator, study supervisor or the Chairman (KNH/UoN-ERC) on the following numbers.

Principal investigator: Rebecca Ebere: 0738 877 050

Supervisor: Prof Violet Kimani: 0722 445 120

Chairman KNH/UoN-ERC: 02 072 6300

You are required to sign this consent form before we start. If you have any questions about the study you may ask them now.

**Statement of Consent and Signatures**

This document that describes the procedures, benefits and risks for the research titled *"The glycemic indices in association with diabetes in rural women of Kenya: case of Amagoro in*

*Busia County"* has been explained to me and all my questions have been answered. I understand that my is voluntary and can also withdraw at any time if wish to. By signing this form, I do not give up any rights that I have as a research participant.

**Signed (Signature or thumb print)**

Participant ………………………    Date …………………………

Study Staff …………………………    Date …………………………

Witness…………………………...    Date…………………………...

**Copies to:** 1. Investigator    2. Study participant

**Appendix 6: Map of Teso District**