UNIVERSITY OF CAPE COAST

DETERMINATION OF GLYCAEMIC LOAD OF KOKONTE, TUO-ZAAFI AND 'WORDEME'

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BY

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Thesis submitted to the Department of Vocational and Technical Education of the Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy degree in Home Economics Education (Food and Nutrition)

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature ……………………………. Date ………………………

Name: ……………………………………………………..…

Supervisor's Declaration

I hereby declare that the presentation and preparation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature ………………………… Date: …………

Name: …………………………………………………….

ABSTRACT

The glycaemic load (GL) measures the number of carbohydrates in the food and the amount of each gram of carbohydrates raises the blood glucose levels of a person after consumption. For the purpose of lowering the incidence of diabetes and non-communicable diseases, understanding a food's glycaemic load is essential. In this study, the glycaemic loads of Kokonte, Tuo-zaafi, and Wordeme was determined by using ten (10) individuals of good health status who received 50 grams of normal glucose before receiving a measured reference and test food which had the same 50 g of carbohydrate. By monitoring the participants' capillary blood glucose levels while they were fasting, after ingesting glucose, and after eating test foods two hours window for postprandial glucose concentration, the Glycaemic Index (GI) values were estimated. Blood samples were taken from participants 30 minutes after consumption, with additional samples taken at the 60th, 90th, and 120th minutes. The incremental area under the glucose response curve for the test foods were subtracted from the incremental area under the glucose response curve for the reference food, and the result multiplied by 100 to determine the GI of the test foods. Using the GI ratings and the typical serving sizes of the test foods, the glycaemic loads were determined. Tuo zaafi and Wordeme' of the test foods had low glycaemic indices and Kokonte had medium glycaemic index value. Wordeme had GL of 35.98%, Tuo-zaafi had 42.10% and Kokonte had 57.64%. This was attributed to the cooking processing. All three test foods were also subjected to a proximate analysis to determine their nutritional components. According to the results of the proximate analysis, Wordeme had the least amount of carbohydrate (71.98%), followed by Tuo-zaafi (82.48%), and Kokonte (84.29%). To reduce the impact on blood glucose levels, consumers should eat smaller portions of carbohydrates-rich foods.

KEYWORDS

Glycaemic load (GL)

Glycaemic index (G

Wordeme (combination of cassava dough and corn flour)

Kokonte

Tuo-zaafi

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DEDICATION

To my supervisor; Prof Sarah Darkwa, parents; Prophet Emmanuel Nartey and Mrs. Mary Buerkie Tokoli-Anim, my husband and children, siblings, friends, and anyone who in diverse ways assisted in getting this far in my education.

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LIST OF ABBREVIATION

BMI - Body Max Index

FAO -Food and Agriculture Organization

FBGT- Fast Blood Glucose

GI - Glycaemic Index

GL -Glycaemic Load

HDL - High-Density Lipoprotein

IAUC - Incremental area under curve

LDL -Low-Density Lipoprotein

MOFA - Ministry of Food and Agriculture

NCDs - NON-Communicable Diseases

TZ -Tuo zaafi

WC -Waste Circumference

WHO - World Health Organization

CHAPTER ONE

INTRODUCTION

Background to the Study

Consumption of food plays several roles in satisfying hunger, maintaining tissues, providing body building, energy giving, and protecting the body against diseases. The correct ways of selecting foods from the functional groups are necessary for balanced meal preparation. In Ghana, the majority of the foodstuffs contain carbohydrates, and both individuals and families organize their daily food around them. Consuming a balanced diet that fulfills all three of food's primary purposes is essential for maintaining good health. Carbohydrates account for between 40 and 80 percent of the calories we consume. According to Mann, Cummings, Englyst, Key, Liu, Riccardi, Summerbell, Uauy, van Dam, Venn, & Wiseman, (2007a), carbohydrates play important roles in our human physiological makeup such as blood glucose regulation, energy provision, primary sources of high energy in the brain, and sparing the use of proteins for energy.

Even though a lot of many local foods are rich in nutrients necessary for a healthy lifestyle, according to Bennett, Bardon and Gibney (2022) people may choose a particular food based on a variety of factors such as culture, religion, cost, their personal preferences and dislikes, and their location without being aware of the food's nutritional value.

The main sources of carbohydrate foods include cereals and grains, starchy root, and plantain (maize, rice, millet, cassava and yam, and potatoes). It differs in terms of physical make-up, particle size, and fiber content, all of which result in various insulin and plasma glucose reactions. Contrary to popular assumption, type 2 diabetes, specifically in Sub-Saharan Africa, is gradually becoming one of the nutritional issues in emerging nations (Wormenor, 2015). Those foods high in carbohydrates have a high glycaemic index because they digest quickly into glucose after consumption, whereas foods low in carbohydrates lead the body to react to insulin more slowly (Ludwig, Aronne, Astrup, de Cabo, Cantley, Friedman, Heymsfield, Johnson, King, Krauss, Lieberman, Taubes, Volek, Westman, Willett, Yancy & Ebbeling, 2021). Some carbohydrates, on the other hand, cause or prevent a rapid insulin response. The glycaemic index gauges how quickly or slowly a food high in carbohydrates affects blood glucose levels after consumption (Ludwig, Aronne, Astrup, de Cabo, Cantley, Friedman, Heymsfield, Johnson, King, Krauss, Lieberman, Taubes, Volek, Westman, Willett, Yancy & Ebbeling, 2021).

Yeboah, Agbenohervi, and Sampson (2019) found that the glycaemic index assesses a food's blood glucose level, enabling us to assess how a product containing a particular amount of carbohydrate would affect the consumer. Controlling glucose levels is essential for preventing the development of diabetes (Martens, Beck, Bailey, Ruedy, Calhoun, Peters, ... & MOBILE Study Group, 2021). The glycaemic index's physiological impacts on the consumer have prompted questions regarding the quality of carbohydrate and the metrics that affect how they are metabolized. Foodstuffs with a high glycaemic index are related to obesity, hypertension, diabetes mellitus, and metabolic syndrome.

Glycaemic index as a scale between 0 to 100, with zero being the lowest rank and 100, being the highest (Ludwig, Aronne, Astrup, de Cabo, Cantley, Friedman, Heymsfield, Johnson, King, Krauss, Lieberman, Taubes, Volek, Westman, Willett, Yancy & Ebbeling, 2021). Clinical studies demonstrated that a low glycemic diet enhances glycemic checks in diabetics, boosts insulin sensitivity, and lowers food intake and body weight. Several studies undertaken pointed to the fact that foods that are rich in carbohydrates possess higher glycaemic index (Zhou, Ye, Lei, Zhou & Zhao, 2022; Oluwajuyitan, Ijarotimi, Fagbemi, & Oboh, 2021; Atkinson, Brand-Miller, Foster-Powell, Buyken & Goletzke, 2021). According to Zhou (2022), the consumption of carbohydrate food with a high glycaemic index is very instrumental in nutritional counseling for diabetic patients. This is because eating carbohydrates has been associated with obesity, an increase in glucose levels, a decline in the health condition of diabetes patients, and other health issues. Ludwig and Daniel (2002) hypothesized that persistent insulin and blood glucose rise would raise the chance of developing diabetes. Another prevalent chronic disease in the world wreaking havoc is type 2 diabetes mellitus, and the frequency of the condition is rising across the board.

Many people in Ghana and other developing countries consume local staples but are unaware of the glycaemic loads of the foods they consume. Kokonte, Tuo-zaafi, and 'Wordeme' are dishes obtained from carbohydrates. Among the staple foods consumed by citizens in Ghana and other parts of West Africa include, akple, banku, kenkey, tuo-zaafi and 'wordeme'. These foods are eaten by most ethnic groups in Ghana like the Ga, Akan, Hausa, Ewe and Fante as well as other Subregional ethnic groupings in West Africa. Eating meals with a low glycaemic index might lessen the danger, and risks of developing diabetes, researchers argued that some local foods including banku, kenkey, akple and Tuo-zaafi could have a high glycaemic index. The above hypothesis was tested by some researchers including who researched the glycaemic index and load of fufu varieties, akple, banku and kenkey. However, there is no known study on the glycaemic load of Kokonte, Tuo-zaafi and ‘Wordeme’. In light of these circumstances, this study's objective was to analyze the glycaemic load of Kokonte, Tuo-zaafi, and "Wordeme" in some parts of Ghana.

Statement of the Problem

It has been demonstrated that the glycemic index of carbohydrates is helpful in the overall control of diabetes. Since the glycaemic index of the majority of developed nations' staple meals in are known, managing diabetes is flexible and straightforward for medical professionals and the patients they treat.

According to Koussasi, Tiahou, Abodo, Camara-Cisse & Amani, (2009), study on the impacts of dietary management on diabetics revealed that conscious and effective dietary management is essential to obtaining improved glycaemic control which will alleviate the possibility of diabetic complications among diabetic patients. Koussasi, Tiahou, Abodo, Camara-Cisse & Amani, (2009) further indicated that effective diet management and minimization of diabetic complications can increase the life span among diabetic patients.

Willett, Manson, and Liu (2002) Worldwide, it is estimated that looked into how eating carbohydrates affected blood glucose levels. According to the study, long-term eating of foods and beverages with a high glycemic index and load foods might cause postprandial blood glucose rises and excessive insulin production. Worldwide, 415 million persons have diabetes, as reported by the International Diabetes Federation (IDF). However, it will be anticipated that by 2040, there will be 642 million people worldwide who have this illness. In Africa, diabetes affects 14.2 million adults (aged 20 to 79), or 6.7% of the population (IDF, 2016). If the populace is informed about the glycaemic index and load of carbohydrate items consumed each day, which play a major role in the growth of this condition, its prevalence can be minimized. Consumers will be very careful about the carbohydrates they take, both in terms of time and quantity, if they have a piece of good information on the effect of local diets on blood glucose level.

Diabetes and other noncommunicable diseases are becoming more prevalent in Ghana and other developing countries. The consumption of foods with a high glycaemic index is to blame for the increase in diabetes and obese persons. In other words, citizens in developing countries like Ghana who consume foods with high glycaemic index are ignorant of the amount of glycaemic index/load of the foods they consume which deteriorates their diabetes status, weight and other carbohydrate-related health problems. Thus, study on the glycaemic load of staple foods are very relevant in dietary management to enable diabetic patients consume foods with a low glycaemic index for healthy living.

Study like Adu-Gyamfi (2018) focused on glycaemic index, was on variety of fufu with cassava-plantain and cassava-cocoyam. Few researchers focused attention on kenkey, banku, but research on the glycaemic load of the local staples of Kokonte, Tuo-zaafi and wordeme has not been extensively researched creating a knowledge gap on the glycaemic index of these frequently consumed local staples. The study sought to fill out this knowledge gap by investigating the glycaemic load of Kokonte, Tuo- zaafi and 'Wordeme'.

Purpose of the Study

The research work aimed at assessing the glycaemic load of Kokonte, Tuo-zaafi, and Wordeme.

Research Objectives

The study sought to:

1. determine the of glycaemic index (GI) and glycaemic loads (GL) of 'Kokonte', 'Tuo zaafi' and 'Wordeme'.
2. examine the effects of Kokonte, Tuo- zaafi and 'Wordeme' on blood glucose level.
3. investigate the nutritional composition (proximate analysis) of 'Kokonte', 'Tuo zaafi' and 'Wordeme.

Research Questions

1. What is the glycaemic index (GI) and glycaemic load (GL) of 'Kokonte', 'Tuo zaafi', and 'wordeme'?
2. What is the effect of 'Kokonte', 'Tuo-zaafi', and 'Wordeme' on blood glucose levels?
3. What are the nutritional components (proximate analysis) of 'Kokonte', 'Tuo-zaafi' and 'Wordeme'?

Research Hypothesis

1. H_0: There is statistically significant difference in glycaemic load of Kokonte, Tuo-zaafi and 'Wordeme'.

Significance of the Study

Study outcomes will supply information on the glycaemic index/load of Kokonte, Tuo-zaafi, and "Wordeme," which will help persons with diabetes and obesity make better eating decisions. The data provided will add to the existing literature on glycaemic index/loads and nutritional values/ compositions of Kokonte, Tuo-zaafi and ‘Wordeme’.

Also, knowledge obtained of the glycaemic load of the various local staple foods understudy could serve as a guide to diabetics and other people in the selection of carbohydrate foods especially the portion per head one should take. The study may help inform health professionals (nutritionists, dieticians and diet therapists) to recommend appropriate carbohydrate intake when prescribing and counseling clients concerning proper dieting.

Delimitation of the Study

The prime focus of this research is channeled on ascertaining the glycaemic load of Kokonte, Tuo-zaafi, and "Wordeme" in Prestea, a town in Ghana's Western Region's Prestea Huni-Valley Municipality. Patients with diabetes were not included in the trial since their blood glucose levels were already high. The findings were not easily extrapolated to other carbohydrate foods. This study concentrated on the consequences of the dish understudy on levels of blood glucose.

Limitations of the Study

The results may not be as generalizable as they could be owing to the limited sample size and the number of participants.

The Prestea settlement in Ghana's Western Region is far from the farming areas where the foodstuffs (Kokonte, Tuo-zaafi, and Wordeme) are cultivated, therefore they weren't gathered straight from the farm. The meal takes a day or two to reach the marketing facilities. The chemical qualities of the meal might be somewhat constrained because it was not just newly harvested. The glycaemic index/load value, however, might not have been impacted by the probable constraint.

It was difficult to gain access to respondents. Because it was expected that the volunteers would be honest, the study assumed that they would adhere to all of the experiment's guidelines. However, this was not verified. It was challenging to organize the members of the Prestea community because the majority of the people thought it was a waste of time was they could use on other initiatives. Because the study participants came from various locations within the community, transportation was a challenge. Putting them together to conduct the test weekly required a lot of work. Finally, the research's findings and conclusions would be applicable in the future because glycaemic index, glyceamic load, and health nutrition issues change over time.

Organization of the Study

The study's history was covered in the first chapter, which explains clearly the idea of glycaemic load, and how it helps to combat the rising incidence of diabetes and related health conditions. The problem statement, study objectives, research questions, study delimitation, limitation, and importance are also included in this chapter. The concepts of glycaemic index and load, and the problems connected to each of them, were explained in detail in chapter two, which also included a thorough assessment of related research. Use was made of the scientific publications and journals that other researchers had produced. The third chapter covered the study's methodology, which covered the research design, field of inquiry, study population, sampling strategies, preparation of the test food, data gathering process, and analysis. Data analysis and explanations of significant findings that are shown in graphs and tables are offered in the fourth chapter. The study's fifth chapter summarises the findings, provides a conclusion, and makes recommendations for further research.

CHAPTER TWO

LITERATURE REVIEW

Introduction

The essential study on calculating the glycaemic index and a variety of chosen Ghanaian staple foods is covered in this chapter. The chapter examines the theoretical and empirical literature on the subject understudy. Several earlier research offers empirical proof of how consuming carbohydrates affects a person's overall wellbeing and blood glucose levels.

Carbohydrate

As the primary energy source in the majority of human diets and the majority of our calories, carbohydrates play a significant role in human physiology. Most households in Ghana organize their meals based on the fact that most Ghanaian diets are carbohydrate-based. The physiological impacts of carbohydrates on human health cannot be emphasized, regardless of their energy content. Carbohydrates are groups of composites made up of monosaccharides that serve as structural building blocks such as disaccharides, oligosaccharides, and monosaccharides, as well as many composite ones like polysaccharides and starch. These carbohydrate foods are classified based on the composition of the chemical process.

In 1977, the US state-senate select commission on human and nutrition needs published a report that used the term "complex carbohydrate" to describe a variety of fruits, whole grains, and vegetables. These categories, however, were primarily concerned with the compositions and characteristics of carbohydrates rather than the specific physiological characteristics, dietary needs, or health implications (Cummings & Stephen, 2007). However, different carbohydrates have different energy contents and digestibility (Mann, Cummings, Englyst, Key, Liu, Riccardi, Summerbell, Uauy, van Dam, Venn, & Wiseman, (2007a). Different carbohydrate foods trigger insulin at different rates (Lin, Wu, Lu, & Lin, 2010). This is because their rates of releasing glucose into the blood differ.

The rate at which a carbohydrate item turns into glucose after consumption determines its glycaemic index (Lavigne, Thouret, Voight, Suwa, & Sumaryono, 2000). When a carbohydrate is consumed, several factors influence its postprandial glycaemic response. Extrinsic elements include differences in the diet as a whole and the composition of the entire meal, whereas intrinsic elements include the amylose to amylopectin ratio, the absence or presence of viscous fibre, and the duration of the monosaccharide units (Björck, Granfeldt, Liljeberg, Tovar, & Asp, 1994). Before being ingested, the majority of Ghanaian carbohydrates (including corn, rice, cassava, yam, and plantain) are processed using several different methods. According to Englyst, Liu, & Englyst, (2007), the processing of a particular carbohydrate food significantly affects both its general qualities and the physiological purpose of the human makeup.

The glycaemic index (GI) value of carbohydrates is directly impacted whenever the physiological action of the carbohydrate present is changed (Bahado-Singh, Riley, Wheatley, & Lowe, 2011). It is crucial to ascertain the GI of foods individually rather than extrapolating from international GI measures of foods with the same qualities since particle size, processing techniques, starch type, and anti-nutrients present have a substantial impact on the physiological aspects of the food (Aston, Gambell, Lee, Bryant, & Jebb, 2008).

Dietary Carbohydrate

The basic mechanism of digestion is the same for everyone, but each person has a different tolerance for and approach to digesting carbohydrates (Atkinson, Foster-Powell & Brand-Miller, 2008). It matters what kind of carbohydrate you consume. Atkinson, Foster-Powell & Brand-Miller, (2008) claimed that the food element has proven to have the biggest impact on carbohydrate. The significance of carbohydrates is not as well understood, even though variations in fat quantity and quality have received a lot of attention (Wolever, Vuksan, & Jenkins, 2011).

Increments in the intake of refined glucose came with slight modifications in meals containing starch in the majority of Ghanaian urbanized neighborhoods. For instance, rice that has been prepared using technology has mostly replaced rice that has been processed traditionally. Because carbohydrates are the main dietary element that affects insulin production and postprandial glycemia, they are considered to contribute a role in the growth of many chronic disorders (Wormenor, 2015). Insulin secretion and postprandial glycemia are impacted by the measure and kind of carbohydrates ingested, with variations that are not explained by glucose chain length. The revaluation started by looking into dietary carbohydrate to better grasp their component of it.

In the proportion of 1:2:1, carbon, hydrogen, and oxygen make up the organic molecules known as carbohydrates (Widdowson & McCance, 2009), the term "carbohydrates" has persisted despite the fact that it was formerly believed that they were carbohydrates, which are carbon compounds that include water. Carbohydrates are polyhydroxic aldehydes or ketones having hydroxy (OH) and aldehyde (CHO) or ketone (C=O) functional groups (Widdowson & McCance, 2009). A few glucose molecules, including glucose or fructose, make up the majority of carbohydrates. Modern people need a steady supply of glycaemic carbohydrates to maintain the health kidney, medulla, brain, red blood cells, and reproductive organs. The brain accounts for 20–25 percent of adult basal metabolic expenditure (Aston, Gambell, Lee, Bryant & Jebb, 2012). The red blood cells also require 20g of glucose daily, which must be taken directly from the bloodstream, in addition to what the brain needs. In other cases, the body's about 170g/day glucose need is met by dietary carbohydrate, gluconeogenesis from non-carbohydrate sources such the glycerol component of lipids, certain amino acids (such as alanine), or absorbed propionate from gastrointestinal fermentations of dietary carbohydrates (Aderson & Woodend, 2013).

Glycaemic carbohydrates are mostly digested to produce monosaccharide glucose which are available form of carbohydrate. According to Jenkins et al (2015), modern dietary energy intake is made up of 40–75% of readily available carbohydrate, with starch being the most prevalent. In its raw, crystalline state, starch digests slowly and ineffectively, but after boiling, it does so more quickly. In addition to cellulose and other geomorphic polysaccharides in cell walls, plants also contain a wide range of mono-, di-, and oligosaccharides.

Contrarily, a lot of polysaccharides and oligosaccharides are regarded as inaccessible because they enter into the large intestine instead of being digested by human upper gut enzymes, where some of them are then fermented by gut microbes. These fermentations create butyrate, propionate, and acetate, three short-chain fatty acids that can be absorbed via the gut and supply 5 to 10% of an adult's energy needs (Wormenor, 2015). According to the degree of polymerization, the Food and Agriculture Organisation (FAO) / World Health Organization (WHO) report divides the primary forms of dietary carbohydrates into different categories (see Table 1). This imminent is a cross between a physiological and chemical categorization.

Table 1: Major Dietary Carbohydrates

Class (DP*)	**Sub-Group**	**Components**
Glucoses (1-2)	Monosaccharides	Glucose, galactose,
	Disaccharides	fructose, Sucrose,
	Polyols	lactose, trehalose,
		Sorbitol, mannitol
Oligosaccharides (3-9)	Malto-oligosaccharides	Maltodextrins,
	Other oligosaccharides	Raffinose, stachyose,
		fructo-oligosaccharides
Polysaccharides (>9)	Starch	Amylose, amylopectin,
	Non-starch	modified starches
	polysaccharides	Cellulose,
		hemicellulose, pectins,
		hydrocolloids

Source: FAO/WHO, 2014 DP * = Degree of polymerization

Despite the fact that people eat a variety of carbohydrates, digestion reduces complex carbohydrate to the simple monomer’s glucose, fructose, and galactose for use in metabolism (Wormenor, 2015). About 80% of the products are made up of glucose, which is also the main substance that is delivered to tissues' cells. The liver is where the majority of the fructose and galactose are transported and are changed to glucose. Last but not least, glucose is transported to cells where it is metabolized or stored as glycogen (Brand, Nicholson, Thorburn & Truswell, 2016). The breakdown of carbohydrates is briefly covered in this section.

Concept of Glycaemic Index

The glycaemic index (GI) measures the blood glucose reaction after consuming a sample of food (Hettiaratchi, Ekanayake & Welihinda, 2012) It offers an knowledge regarding how food can cause blood glucose levels to rise and what that means for the body of the consumer (Arvidsson-Lenner, Axelsen, Bryngelsson, Haapa, Järvi, Vessby, 2004; Foster-Powell, Holt, & Brand-Miller, 2002). It also indicates how quickly or slowly food sources breakdown as well as how quickly blood glucose levels rise after eating (Omoregie & Osagie, 2008). GI is a crucial tool for managing illnesses (such obesity, diabetes, and heart disease) and wellbeing, and its implementation is ongoing in some high-level countries (Foster-Powell, Holt, & Brand-Miller, 2002).

In order to make food decisions that promote human subsistence and healthy living, the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) have recommended the use of GI characteristics in conjunction with food production tables (Foster-Powell, Holt, & Brand-Miller, 2002). High-Density Lipoprotein (HDL) content in healthy people can be accurately predicted by GI, which has been found to be a very valuable nutritional phenomena for categorizing carbohydrates (Nnadi & Keshinro, 2016). Since Ludwig, Aronne, Astrup, de Cabo, Cantley, Friedman, Heymsfield, Johnson, King, Krauss, Lieberman, Taubes, Volek, Westman, Willett, Yancy and Ebbeling (2021) introduced the concept of GI, around 800 items have had their GI determined and documented over time (Omoregie & Osagie, 2008).

Based on how a food affects postprandial blood glucose, the glycaemic index assigns foods a ranking out of 100 (Nnadi & Keshinro, 2016; Omoregie & Osagie, 2008). The index spans from 0 – 100 percent, with 0-55 percent denoting low GI meals, 56-69 percent and 70-100 percent denoting medium and high GI diets, respectively (Eleazu, 2016).

When consumed, low GI foods release a small amount of glucose into the blood. Low Density Lipoprotein (LDL) cholesterol, a risk factor for thrombosis, and blood glucose levels are all improved or maintained by these foods in diabetic individuals (Nnadi & Keshinro, 2016). Healthy people who eat low-GI foods have less hypoglycemia and excessive insulin response between meals (Egba, Adimuko, Akokwu, Omeoga, & Okafor, 2017; Omoregie & Osagie, 2008). Conversely, high GI meals result in higher blood glucose levels and a higher insulin response, which can lead to obesity, cancer, blindness, heart disease, erectile dysfunction, strokes, death, renal disease, and amputations (Arvidsson-Lenner, Axelsen, Bryngelsson, Haapa, Järvi, Vessby, 2004; Egba, Adimuko, Akokwu, Omeoga, & Okafor, 2017; Nnadi & Keshinro, 2016).

Glycaemic Index Notion

The term "glycaemic index" (GI) refers to a system for categorizing foods according to their capacity to raise blood glucose levels (Jenkins, 2012). According to FAO/WHO (2014), the GI is calculated by comparing the incremental area under the blood glucose response curve following consumption of a test meal (food) containing 50g of available carbohydrate to the response elicited by a reference food.

Commonly glucose or white bread). In contrast to glycaemic impact, which is a measurement of the weight of glucose needed to produce a glycaemic response equivalent to that produced by a given amount of food, glycaemic index measurement is therefore equivalent to carbohydrate because equal amounts of readily available carbohydrate are involved (Miller-Jones 2007). Though it appears to be a simple index, the glycaemic index is a more established concept (FAO/WHO, 2014).

The glycaemic index, according to Yeboah, Agbenohervi, & Sampson, (2019), assesses a food's blood glucose level and enables us to assess how a product containing a particular amount of carbohydrate would affect the consumer. According to Ludwig, Aronne, Astrup, de Cabo, Cantley, Friedman, Heymsfield, Johnson, King, Krauss, Lieberman, Taubes, Volek, Westman, Willett, Yancy and Ebbeling (2021), the glycaemic index is measured on a scale from 0 to 100, with 100 being the highest value.

A recognized approach for categorizing carbohydrates is the glycaemic index (GI), a straightforward numerical metric that gauges a carbohydrate's capacity to increase blood glucose levels (FAO/ WHO, 1998). A food's glycaemic index is calculated by comparing the postprandial glycaemic response to that of a reference food (FAO/WHO, 1998). There are two types of carbohydrates: simple and complex.

The glycaemic index of a diet primarily determined by the quantity and type of carbohydrates it contains, but it is also influenced by other factors like the amount of carbohydrates that are trapped within the food's fat and protein content, the amount of organic acids (or their salts), whether the food is cooked, and how it is cooked (BeMiller, 2017). According to BeMiller (2017), it is beneficial for measuring how quickly the body breaks down carbohydrates when only the accessible carbohydrate (total carbohydrate minus fiber) in a food is taken into account.

When GI is averaged across a population, it can be used to determine the burden of an insulin response to a food but does not predict an individual's glycaemic response to a food. Chronic diseases and how carbohydrate affect blood glucose that they are linked to are not taken into account when classifying them as simple or complex (FAO/WHO, 1998). The glycaemic index, which was created to quantify the direct impact various carbohydrate-rich meal types have on blood glucose, is thought to be a more accurate system of categorizing carbohydrate, especially starchy foods (The nutrition source, 2016).

How rapidly or slowly a food high in carbohydrates cause blood glucose to rise after intake is determined by its glycaemic index (Jenkins et al., 1985). High glycaemic index foods can cause blood glucose to increase. According to studies by de Munter, Hu, Spiegelman, Franz, & van Dam (2007), Beulens, de Bruijne, Stolk, Peeters, Bots, Grobbee, & van der Schouw (2007), and even obesity, this may raise the risk of Type 2 diabetes, heart disease, and even obesity (Ebbeling, Leidig, Feldman, Lovesky & Ludwig, 2007).

Glycaemic Load

The glycaemic load (GL) of a food is a measurement of how much it will raise someone's blood glucose after eating (Yeboah, 2017). It determines how many grams of carbohydrates are in a food and how much each gram elevates blood glucose levels. A serving of food's overall glycaemic impact is determined using the GL value. The GL is calculated by multiplying the number of grams of easily available carbohydrate in the food by the item's GI and dividing by 100. To put it another way, the GL considers both a food's GI and the amount of carbohydrate in the portion that is consumed. For one serving of a food, a GL of 20 or greater is regarded as high, a GL of 11–19 as medium, and a GL of 10 or less as low. Nearly usually, foods with low GI have low GL in a typical serving size. Foods having an intermediate or high GL range from very low to very high GI in a normal serving size (Yeboah, 2017).

100 GL = [GI x Carbohydrate].

Where Carbohydrate =This represents the amount of available carbohydrate in a given serving size of food. Not all foods with high GI values also have high GL values. For instance, a 3 oz serving of carrots is tiny (GL = 11.8) despite having a high GI value (GI = 131). This is because carrots are low in carbohydrates. 3oz of carrot contains only 9g of carbohydrate. As a result, diabetic patients should not base their food selection solely on GI values.

Table 2: Classification of Glycaemic Load

Value	Glycaemic Load
High	>20
Moderate	11-19
Low	<10

Source: Venn and Green, (2007); Burani (2006); Barclay et al., (2005); Brand-Miller (2003)

Eating modest portions of foods that are generally high in carbohydrates but have a low GI could result in a low GL diet (Venn & Green, 2007). Foods that are rich in protein, low in carbohydrates, and high in fat may also be included in a low GL diet. The variety of foods that can be incorporated into a low GL diet implies that food choice shouldn't be made only on the basis of GL. It is important to be aware of various food characteristics, including portion size, energy density, fat content, type of fat, and fat content.

Glycaemic Index versus Glycaemic Load

The best way to assess how a carbohydrate will affect blood glucose is not to look at the glycaemic index of the food. This is because it doesn't consider how much total carbohydrate, excluding fibre, it supplies that is digested (The Nutrition Source, 2016). As a result, scientists created a system for classifying foods that considers their glycaemic index, their carbohydrate content, and how they affect blood glucose levels. The term for this is "glycaemic load" (Liu & Willet, 2002; Willet, Manson & Liu, 2002).

A food's glycaemic load is determined by multiplying its glycaemic index by the quantity of carbohydrates it contains. A glycaemic load of 20 or more is regarded as high, one of 11 to 19 as medium, and one of 10 or less as low (Venn, Wallace, Monro, Perry, Brown, Frampton, & Green, 2006). Livesey, Taylor, Livesey, & Liu, (2013) found that those who consume diets with lower glycaemic loads is less likely to develop type II diabetes relative to those who consume diets with greater glycaemic loads. In a related study, Mirrahimi, de Souza, Chiavaroli, Sievenpiper, Beyene, Hanley, Augustin, Kendall, & Jenkins, (2012) discovered that diets with a higher glycaemic load are linked to a higher risk of coronary heart disease.

Determination of Glycaemic Index

As early in the 20th century, GI idea was first proposed and numerous investigations have been carried out to ascertain the GI of various foods. The FAO/WHO expert consultation group has supported the value of GI, but its use has been challenging because it is uncertain what the GI of many typical foods in underdeveloped countries is (Jahan, 2013). Additionally, the GI values of several foods in these nations reported by different laboratories varied, which could be explained by the method of preparation or cooking used. Maize, rice, and millet are typical examples of such food items in Ghana (Wormenor, 2015).

A standardized method of determination, such as GI and GL, is used to foster harmony and reduce variation in GI values obtained for the same food at diverse places. FAO/WHO suggestions (as cited in Wolever, Vuksan, & Jenkins, 2011) state that the in vivo method is the accepted standard method for calculating a food's GI. This method involves ingesting a test food with 50g of available carbohydrate and monitoring how quickly the food is broken down and absorbed into the bloodstream. In vitro digestion models that mimic what happens in the human gastrointestinal tract are used to show how the glycaemic response is affected by the pace of digestion and absorption.

Traditional Foods

Without a doubt, human survival, health, and existence depend on the nutrients we consume from food (Alt, Al-Ahmad & Woelber, 2022). Traditional cuisines vary from one geographical region to another in its nature, content, preparation methods, and the beliefs, ancestry, and eating customs connected to them (Weichselbaum, Benelam, & Soares-Costa, H. (2009), Ivanova and Trifonova, 2014; Laryea, Akoto, Oduro, & Appaw, 2016).

According to Soto-Méndez, Campos, Hernández, Orozco, Vossenaar, & Solomons, (2011), traditional foods are extremely rich in nutrients, energy, and other phytochemicals important for nourishing, human health, disease management, growth, and development. Not because they provide nourishment, but rather because of the role they serve as a medium for cultural expression, projection, and transmission, they have found significant relevance in human activity (Alt, Al-Ahmad & Woelber, 2022).

Fufu, eto, apranpransa, kokonte, akyeke, apiti, etc. are names given to people from Ghana, whereas *eba, abacha, obe, ewedu, amala, and ila* are names given to people from Nigeria **(**Laryea, Akoto, Oduro, & Appaw, 2016). Traditional foods are a crucial component of tourism and should be given top priority in the sector for national and worldwide recognition since they pique and maintain travelers' attention (Amuquandoh & Asafo-Adjei, 2013). This demonstrates unequivocally that traditional foods meet the nutritional needs of a nation's citizens and play important socioeconomic roles in that nation.

Therefore, it is crucial to focus research on the preservation and conservation of these foods and look into any potential influences on consumption.

Cassava Production and Utilization

A perennial shrub, starchy tuberous root crop, or plant, cassava (Manihot esculentun crantz) is a member of the *Manihot* genus and family of euphorbiaeceae (Nabyonga, Basamba, Nyakoojo & Ssenku, 2022). Due to its ability to tolerate or withstand poor soil and extreme climatic environmental circumstances, it grows and performs well in many tropical areas. Small-scale farmers cultivate it for subsistence and use it in other agricultural products and food systems because of its high yield, cheap production cost, low risk of disease and pest infestation, and ability to maintain soil fertility (Nweke, 2004; Sadou et al., 2004; Oppong-Apane, 2013; Nabyonga, Basamba, Nyakoojo & Ssenku, 2022).

It is the third most popular carbohydrate and is very important economically (Food and Agriculture Organization of the United Nations, 2014). Food products made from cassava include "tapioca" and "gari." Additionally, it is boiled and combined with other carbohydrate-rich crops, such as yam, cocoyam, and plantains, to make fufu, a traditional Ghanaian delicacy.

Most African nations have adopted and are actively cultivating cassava as a key crop to help combat food insecurity and poverty (Nabyonga, Basamba, Nyakoojo & Ssenku, 2022; Yidana & Amadu, 2013). In Africa, it is regarded as the second-most significant crop after maize in terms of calories produced (Nweke, 2004). In various human diets or staple foods, cassava has been classified as the fourth and sixth most significant sources of calories in

Africa and around the globe, respectively (Nabyonga, Basamba, Nyakoojo & Ssenku, 2022). In Africa, the top five producers of cassava are Nigeria, Ghana, and the United States (Buhari, 2017; Bedford, Gliga, Shephard, Elsabbagh, Pickles, Charman & Johnson, 2017). Nigeria is the world's top producer of cassava. Cassava cultivation and export to nearby West African nations have boosted Ghana's economic growth and export rate (Chauvin, Mulangu, & Porto, 2012).

Cassava is therefore extremely important to Ghanaians and production gradually increased from 16,524,000 to 19,139,000 metric tonnes between 2014 and 2017, with annual per capita consumption reaching at 32,500 kg (Bedford, Gliga, Shephard, Elsabbagh, Pickles, Charman, & Johnson, 2017). The amylose-amylopectin ratio in 100g of raw cassava is 30:70, with 38g of carbohydrates, 1.8 grams of fibre, and 1.7 grams of glucose. Department of Agriculture of the United States, 2002). Because it contains more amylopectin, which is more branched and more obtainable to digestive amylases, cassava is more likely to generate a larger glucose reaction when consumed. Whether something is cooked for human consumption by frying, roasting, or boiling, the nutritional value will change (United States Department of Agriculture, 2002).

By creating high-yielding varieties, labour-saving harvesting methods, and improved processing technologies, science and technology have made significant efforts to reduce the cost of cassava cultivation and processing. These enhanced or high-yielding varieties are pest and disease resistant, early bulking, have great processing properties, a broad canopy, and low cyanogen levels. They also have in-ground storage stability (Newke, 2004; Nweke, 2005). These kinds were first introduced to Ghana in 1993, and the Eastern, Greater Accra, and Volta regions have praised them greatly (FAO and IFAD, 2005). One of the enhanced cassava varieties created by the University of Cape Coast (UCC) is called *capevars bankye* and it is perfect for traditional meals made with cassava.

Cassava roots, particularly the sweet kinds, can be eaten raw, roasted, fried, or cooked. Preparation of chickwangue, kpokpo gari, mapanga, kanyanga, attoupkou, tuozaafi ampesi, gari, konkonte, yakeyake, agbelima, akyeke or attieke, and fufu, banku, gari, konkonte, attoupkou, and other staple foods for people in tropical and subtropical climates uses them (Nweke, 2005; Peprah, 2020; In some nations, it has also been used to complement food products and produce ethanol and starch (Aliyu and Aliyu, 2014; Oppong Apane, 2013; FAO & IFAD, 2005). Figure 1 displays a fresh cassava tuber.

Figure 1: A photo showing fresh tuber of cassava

Kokonte Processing and Production

Processing traditional cassava into Kokonte is easier than processing gari. Depending on the sun's strength, the peeled roots are cut into little pieces and dried in the sun for 3 to 6 days. Larger pieces take longer to dry than smaller ones. Drying causes fermentation, which gives the dried product its desirable scent. When drying is finished fast, the growth of mould is decreased. The dried good has a protracted shelf life and can be kept in whole chip form for several weeks. The flour from this intermediate product is utilized to prepare a cooked traditional meal (Quaye, Gayin, Yawson, & Plahar, 2009).

To make Kokonte," roots were traditionally peeled, cut into little pieces, and dried in the sun for 4–6 days. The smaller the pieces, the shorter the drying time. Fermentation occurred during drying, imparting a desirable aroma to the dried product. It was claimed that if the sun-drying process went too slowly, mould growth was promoted, producing a product that was either dark brown or greenish black. The dried product might be kept for several weeks as entire chips. A cooked traditional meal that was served with soup or stew was prepared using this intermediate product, which was then milled into flour.

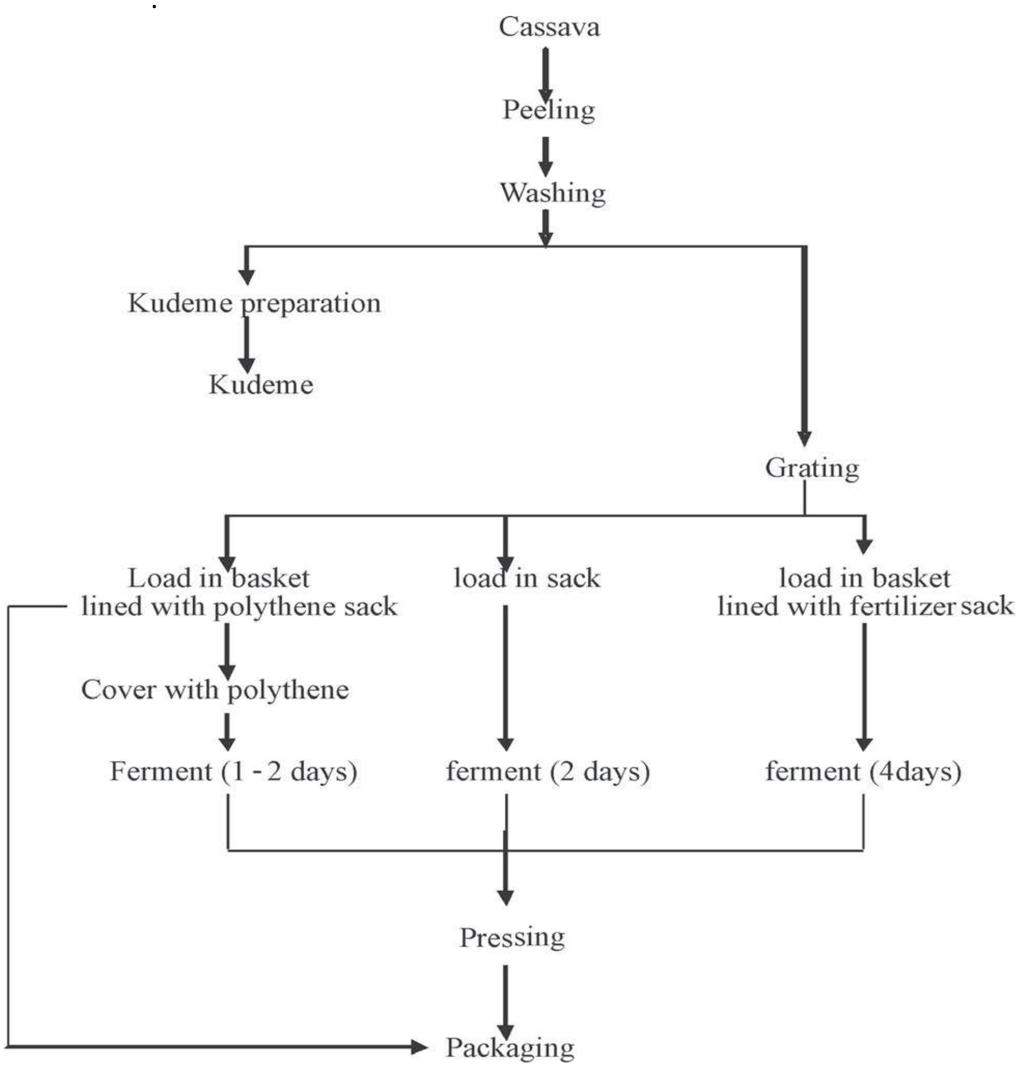

Figure 2: Flow chart for processing cassava into Kokonte

Source: Researcher's construct

Figure 2 depicts the flow chart for processing cassava into Kokonte. Peeling, washing, slicing, drying, cooling, and packaging were used as unit processes. Sharp knives were used to physically peel and wash cassava roots. The cassava was then thinly sliced after being cleaned and peeled to aid in drying. In order to eventually be milled into flour and utilized in other food applications, the dry product was chilled and packaged as an intermediate product.

Misconceptions about Cassava Staples by Consumers

Consumers all throughout the world have expressed a variety of worries regarding cassava as a crop and its main foods. The poor protein, certain mineral, and vitamin contents of cassava have significantly reduced the amount of people who can use and consume cassava (Oppong-Apane, 2013). Cuisine policy researchers down play cassava food and view it as inferior food because per capita consumption declines with rising consumer per capita income, according to an FAO and IFAD study from 2005. It is hence regarded as "poor man's fare."

Ugandans consider the consumption of cassava leaves, which are rich in protein, minerals, and vitamins, by some populations in Tanzania and the Democratic Republic of the Congo to be a sign of poor socioeconomic level (Nweke, 2004). Consumption of the leaves and roots of cassava, which are edible components, has been discovered to contain some cyanogen, which puts consumers at serious risk. However, research has shown that when these toxic cyanides are processed for human consumption, they are lowered to a tolerable or appreciated level (Oduro, 2018; Peprah, 2020). This necessitates greater investigation into processing techniques and how they affect the glycaemic index of traditional cuisines based on cassava.

Maize (Zea Maize)

Ghana's most important cereal, maize, which is also known as corn in most Anglophone nations, accounts for 55% of the nation's total grain output (Wormenor, 2015). The entire production increased significantly between 2008 and 2010 as well (Angelucci, 2012). Although the young corn can be consumed uncooked, as it becomes older, it becomes harder. So, for it to be edible, it must be treated. For human consumption, it could be roasted, boiled, or fried. Many Ghanaian cuisines, such as Banku, Tuo Zaafi, Kenkey, and

"Apapransa," contain maize. Freshly harvested maize has 0.64 g of glucose, 7.3 g of fibre, and 74 g of carbohydrates per 100 g Angelucci, (2012).

On average, maize has 10.3% protein, 60.5% starch, 1.2% glucose, 2.5% crude fiber, and other ingredients (Addo-Quaye, Darkwa & Ampiah, 2011). Additionally, it contains a lot of dietary fibre (12.19%) but little ascorbate and trace minerals (Hornick & Weiss, 2011). Common maize types have a protein level that ranges from 8 to 11% of the weight of the kernel (FAO, 2014). Methionine and cystine, which are sulfur-containing amino acids, are abundant in the protein, but lysine and tryptophan are few (Okoh, 2014).

Table 3: Some Nutrients found in Maize and their corresponding Roles in the Human Body

Nutrient	Function
Carbohydrates (starch, cellulose, glucose)	Employed for short-term energy needs or stored after being digested and absorbed as glucose.
Folate	Improves cardiovascular health and lowers the chance of birth abnormalities.
Vitamin B1 (Thiamin)	Memory improvement
Vitamin B3 (Niacin)	Reduces stress and depression
Vitamin B5 (Pantothenic acid)	aids in the release of energy from proteins, lipids, and carbohydrates
Others include:	
Vitamin A	Plays a role in vision, immune function and gene transcription
Vitamin C	Formation of collagen and healthy teeth and gums
Dietary fibre	Improves bowl function
Manganese	Co factor for the proper function of certain enzymes
Phosphorus	Important for repair of body cells and tissues.

Source: Liu, 2004 (Modifield by MacCarthy, 2011, cited in the MarcCarthy 2014).

Figure 3: A photo showing fresh and dried maize

Source: Anim, 2021

Principle of Glycaemic Index Determination and Methods

The two main methods for determining the food glycaemic index (GI) are the in-vivo assay and the in-vitro assay (Hettiaratchi, Ekanayake & Welihinda, 2012). Human volunteers are used in in-vivo GI experiments to calculate the rate of glucose response after consuming a specific diet. Typically, subjects receive 50 or 25 g. of the test foods' accessible carbohydrate portion, along with glucose or bread as a reference (Brouns, Bjorck, Frayn, Gibbs, Lang, Slama, 2005; Hettiaratchi, Ekanayake & Welihinda, 2012; Wolver Wolever, Vuksan, & Jenkins, (2011)

Foods can be categorized based on their glycaemic response and effect using the in-vivo assay, which produces consistent and repeatable results (Foster-Powell et al., 2002). Despite this, capillary blood samples are preferred to venous blood samples since they have a greater glucose concentration, there is a connection between the two (Brouns, F., Bjorck, Frayn, Gibbs, Lang, Slama, 2005; Foster-Powell, Holt, & Brand-Miller, (2002). Although the GI results from the in-vivo test are trustworthy, they are expensive, time-consuming, labor-intensive, and require people's cooperation, which makes it exceedingly challenging (Hettiaratchi, Ekanayake & Welihinda, 2012).

The carbohydrates in meals are hydrolyzed by digestive enzymes to glucose in an in-vitro GI experiment (Englyst, Liu & Englyst, 2003, 2007; Hettiaratchi, Ekanayake & Welihinda, 2012). It uses amylase, amyloglucosidase, and other proteolytic enzymes to simulate how carbohydrate are broken down physiologically in humans (Englyst, Liu & Englyst, 2007). It is straightforward, affordable, less laborious, and yields results that closely resemble those of in-vivo GI tests (Brouns, F., Bjorck, Frayn, Gibbs, Lang, Slama, 2005).

Factors Affecting Glycaemic Index of Foods

The glycaemic index measures how different foods react glycaemically to the same amount of carbohydrate; as a result, it provides insight into the quality of the carbohydrates in diverse foods (Onimawo, Ijeh, Ukoha, & Nwachukwu, 2007). Nutritional and physiological factors influence the glycaemic index of any food. These variables may include how proteins interact with starch, how easily starch is digested, how much and what kind of fat, fiber, and glucose are present, how much processing has been done, and how big the particles are (Egba, S. I., Adimuko, Akokwu, Omeoga, & Okafor, 2017). The following perspectives show how the aforementioned variables impact food glycaemic index:

Cooking methods

The digestibility of starchy foods is impacted by cooking processes, which alter their structural makeup. Because of the different cooking techniques employed in food preparation, the glycaemic responses to meals high in carbohydrates may vary. Glycaemic index can rise or fall depending on the manner of cooking used to prepare the dish (Eleazu, 2016). According to Bahado-Singh, Riley, Wheatley, & Lowe, (2011), if other factors are not considered, the glycaemic index (GI) of dry food processing techniques like baking and roasting is higher than that of moist processing techniques like boiling and frying. High temperatures and the presence of water during wet processing increase the gelatinization and disintegration of starch granules, which is why these foods have a high GI (Eleazu, 2016). The structure, digestibility, and physicochemical qualities of food, as well as its glycaemic index, are all impacted by conventional cooking techniques including boiling, frying, steaming, and others (Bahado-Singh, Riley, Wheatley, & Lowe, (2011).

a. Boiling

It has been claimed that the common food processing technique of boiling affects the glycaemic index of foods high in starch. According to Koussasi, Tiahou, Abodo, Camara-Cisse, & Amani, (2009), yams cooked in water (boiled) had a higher glycaemic index than yams cooked in an oven. This difference may have resulted from the interaction of temperature and humidity, which alters the physical and chemical states of starch and, consequently, its digestibility. Boiling causes starch granules to absorb water and swell (gelatinize), irreversibly shattering their crystalline structure and leaving them vulnerable to amylase hydrolysis (Raigond, Ezekiel & Raigond, 2015).

With increasing starch digestibility by enzymes, glycaemic response and glycaemic index rise. According to Nayak, Berrios, & Tang, (2014), sufficient water while boiling allows for complete starch gelatinization, which lowers the content of resistant starch and raises digestibility. According to Bahado-Singh, Riley, Wheatley, & Lowe, (2011), boiled sweet potatoes had a lower glycaemic index than roasted, baked, and fried sweet potatoes. In comparison to fried and baked sweet potatoes, boiled sweet potatoes had the lowest glycaemic index, according to research by**.** (Itam, Itam, Odey, Ejemot-Nwadiaro, Asenye, & Ezike, (2012). This was due to the fact that boiling produces the least amount of cell wall rupture, starch gelatinization, and digestibility when compared to baking and roasting (Jimoh, Adediran, Adebisi, Biliaminu, & Okesina, 2008). Additionally, increased amylose-lipid synthesis occurs during baking, roasting, and frying, which lowers the glycaemic index and starch digestibility (Krishnan, Mondal, Thomas, Singh & Praveen, 2021 Leeman, Ostman, & Bjock, 2008).

Starch gelatinization occurs after boiling at 60–90 C, according to Allen, Corbitt, Maloney, Butt, & Truong, (2012) and Krishnan, Mondal, Thomas, Singh and Praveen (2021), which improves the starch's availability to alpha and beta amylases. However, as a result of the establishment of intermolecular hydrogen bonds, gelatinized starch retrogrades or recrystallizes upon cooling, making the amylose sections less accessible to or resistant to amylases. As a result, the rate of starch digestion is slowed, the glycaemic response is slowed, and the glycaemic index is lowered (Eleazu, 2016).

Additionally, boiling has the potential to leach some simple glucoses, and the presence of resistant starches would dampen glycaemic response because they are indigestible.

b. Steaming

The severity of steaming (increased steaming pressure/steaming time) reduce the glycaemic index of basmati rice. Steaming totally gelantnizes the starch in parboiled rice. Kale, Jha, & Nath, (2017) studied the effects of varying steaming on the chemical composition, starch properties and glycaemic index.

c. Extrusion

The majority of foods are subjected to high heat and pressure during extrusion cooking, explosion puffing, instantization, and other processes. Shearing can divide certain starch molecules into shorter chains with better water solubility when combined with high temperatures and low water content. Convenience foods that have been restructured and texturized using extrusion processes are made of protein and starch (Leoro, Clerici, M, Chang, & Steel, (2010). The outcome is a partially gelatinized starch that has a high glycaemic index and high glycaemic reactions.

d. Baking, roasting and frying

According to Bahado-Singh, Riley, Wheatley, & Lowe, (2011) the higher fat content (during frying) slowed starch degradation, delaying stomach emptying and glycaemic response. This resulted in lower glycaemic indices for fried sweet potatoes than baked and roasted sweet potatoes. The glycaemic reaction of roasted flaked product was comparable to the glycaemic response of raw wheat flakes, according to Bjorck, Granfledt, Liljeberg, Tovar & Asp, (2000), and modest roasting prior to flaking maintained high crystallinity in finished products. Increased crystallinity inside starch granules can be achieved by lowering the degree of starch gelatinization. Additionally, Leeman, Ostman, & Bjock, (2008) suggested that amylose is prone to react with lipids during frying to produce amylose-lipid complexes, resulting in decreased glycaemic reactions and glycaemic index readings. Compared to frying, roasting, and boiling, baking sweet potatoes had the greatest glycaemic index, according to Itam, Itam, Odey, Ejemot-Nwadiaro, Asenye, & Ezike, (2012), research. This is because dry air or heat have a greater potential to sabotage the organized granular structure and result in substantial alterations in the food's physical form. This raises the food's GI both in-vivo and in-vitro while improving starch digestion and absorption (Jimoh, Adediran, Adebisi, Biliaminu, & Okesina, 2008)

Preliminary Processing Operations

According to Fernandes, Velangi, & Wolever, (2005) processing conditions or procedures modify the postprandial glucose responses of starch by upsetting the granule's cell wall and structure and resulting in enhanced gelatinization, which raises the glycaemic index. The GI of foods is affected by the preliminary processing methods or operations listed below.

a. Fermentation

Starch digestibility and glycaemic index are both affected by fermentation during food processing. It could either enhance or decrease a food's glycaemic index and starch digestibility (Scazzina, Siebenhandl-Ehn, & Pellegrini, 2013). Singh, Sethi, Gupta, Kaur, & Wood, 2019) asserted that shorter fermentation times resulted in lower glycaemic index values, and vice versa. It has been demonstrated in numerous studies that organic acids created during fermentation lower blood glucose levels in postprandial glycemia.

It has been demonstrated that postprandial glycemia and insulinemic can be decreased by adding lactic acid (directly or by fermentation) or the sodium salt of propionic acid to bread products, as well as by mixing lactic acid with vegetables in meals (Ostman, 2003). These organic acids reduce food glycaemic index by preventing starch from being hydrolyzed by hydrolytic enzymes (Hu, Tan, Jin, Li & Zhou, 2014). However, Batra, Sharma and Seth (1994) discovered that fermentation raised the glycaemic index of Bengal gramme cheela and green gramme cheela by 2.26% and 2.71%, respectively. They claimed that this was because complex carbohydrates like starch and other polysaccharides were broken down to less complex forms (disaccharides and monosaccharides).

It is well known that complex carbohydrates boost blood glucose levels more gradually than simple carbohydrates. Ihekoronye and Ngoody (1985) claimed that during fermentation, maltose is created at some point, and that this maltose is hydrolyzed into D-glucose in aqueous solutions. As the fermentation period lengthens, more glucose is produced, which could lead to an increase in the rate of digestion, absorption (glycaemic response) and glycaemic index.

b. Drying

By lowering a product's moisture content and limiting microbial growth, drying is one of the most straightforward ways to preserve food. According to research, drying affects the glycaemic index of foods (Donlao & Ogawa, 2016). When Jaisut, Prachayawarakorn, Varanyanond, Tungtrakul, &

Soponronnarit, 2008) studied how brown fragrant rice dried at different temperatures, they discovered that some of the rice starch had started to gelatinize and the starch granules had lost their form. The development of an amylase-lipid complex lowered starch hydrolysis and consequently the glycaemic index of the brown fragrant rice, as shown by a DSC thermogram for the treated rice.

According to Omolola, Jideani, and Kapila, 2015), drying results in foods that have a low or moderate glycaemic index yet are high in calories, vitamins, and minerals. Donlao and Ogawa (2016) observed in one of their investigations that hot-air drying of rice samples led to a relatively reduced hydrolysis rate when cooked. As the hot-air drying treatment temperature rose from 40 to 90 C, the rate of hydrolysis of the cooked rice decreased. In comparison to samples produced through sun-drying treatment, all cooked rice samples obtained through hot-air drying displayed relatively lower hydrolysis index and estimated glycaemic index values. According to studies by Ogbo and Okafor (2015); and Donlao and Ogawa (2016), sun drying boosts the number of resistant starches and lowers glycaemic index.

c. Particle size reduction

The hydrolysis and digestibility of starch are significantly influenced by particle size and the surface area to starch ratio (Lanka & Lanka, 2012). For the bulk of the food consumed, digestion periods are similar as a result of the more uniform size of the food particles. The meal's surface area grows significantly after particle size reduction, giving the enzymes considerably easier access to the food and facilitating faster digestion. Higher digestibility and quicker absorption of food into the bloodstream are caused by an increase in surface area (Eleazu, 2016). Because of the increased surface area and enhanced sensitivity to enzymes, milling flours before heating greatly increases the starch hydrolysis and digestibility (amylases).

The stone ground millet flour (larger particle size) recorded a lower glycaemic index than the millet flour from industrial milling process, as demonstrated by Jayasinghe, Ekanayake, Nugegoda, (2013) in their investigation on two millet flour samples; prepared by a traditional stone grinder and industrial milling machine (lower particle size). Pureeing or extracting the juice from whole apples increased the blood glucose and insulin response, according to research by Haber and Heaton from 1977.

d. Temperature changes and storage of food

The bioavailability of starch in vivo is impacted by cooling and storage. According to (Fernandes, Velangi, & Wolever, (2005), eating hot red potatoes (GI = 89) released 40% more glucose into the blood than eating cold red potatoes (GI = 56) that had been precooked, frozen, and reheated in contrast to freshly cooked New Zealand potato varieties, cooked and refrigerated New Zealand potato varieties had less swiftly and more slowly digested starch, according to Nayak, Berrios, & Tang, (2014). Additionally, frequent heating and cooling of food increases the amount of resistant starch, which slows down the absorption of starch and has an immediate effect on the glycaemic response (Raigond, Ezekiel & Raigond, 2015).

Amylose and Amylopectin Content

The ratio of amylose to amylopectin, which results from the chemical makeup of starchy foods, has a substantial effect on how quickly glucose is broken down and absorbed. The lower metabolic response associated with meals like rice and pasta's higher amylose content may be caused by a higher likelihood of amylose interaction (Xue, Newman, & Newman (1996). When gelatinized starch cools, retrograded amylose fractions are generated that are poorly digested or less vulnerable to amylases (Liljeberg, Andersson, A., Lövestam, & Nydahl, 2018**;** Siljestrom Siljeström, Björck, Eliasson, A. C., Lönner, Nyman, & Asp, 1988**).** Amylose often interacts with dietary components like lipids, which reduces amylose both in vivo and in vitro (Krishnan, Mondal, Thomas, Singh & Praveen, 2021).

Raw starches high in amylopectin digest more quickly than those high in amylose, according to research (Arvidsson-Lenner, Asp, Axelsen, Bryngelsson, Haapa, Järvi, & Vessby, 2004; Eli-Cophie et al., 2017). According to Nayak, Berrios, & Tang, (2014) and amylopectin is a larger molecule than amylose, which has an average molecular weight of 104. (Zhang, Qian, Rao, Chen, Zhong & Wang, 2021). As a result, because amylopectin has a larger surface area per molecule than amylose, they digest starch in distinct ways. Tako, Tamaki, Teruya, & Takeda, (2014) and Eli-Cophie, Agbenorhevi, & Annan, (2017) found that the hydrogen bonds between the glucose chains of amylose starch and amylopectin are more tightly bound (more branched glucose chains).

Dietary Fibre Content

The American Dietetic Association (2008) defines dietary fibre as the plant's primary storage substance and the polysaccharides in its cell walls that cannot be broken down by human digestive enzymes. It has been demonstrated that dietary fiber, both soluble and insoluble, makes the stomach bulkier, which improves satiety and decreases nutrient absorption. Regarding diabetes, body weight, insulin sensitivity, and small intestine cancer, it has been observed that dietary fibre from cereal is superior to that from fruit and vegetables, regardless of the physiological effect (Scazzina, Siebenhandl-Ehn, & Pellegrini, 2013).

The modest glycaemic responses to meals that were observed in Fairchild's work are attributed to the presence of viscous dietary fibre, which delays stomach emptying and inhibits nutrient absorption in the small intestine. Adding increasing amounts of fibre to a bread breakfast (0, 6 and 12g) significantly decreased the postprandial glucose and insulin responses in healthy adults, according to dose-response research (Nnadi & Keshinro, 2016; Lu, 2016). It has been shown that D-glucan, a different soluble dietary fibre, is effective at reducing postprandial glycaemic and insulin responses (Scazzina, Siebenhandl-Ehn, & Pellegrini, 2013)

In a study on Sri Lankan diets by Pirasath, Balakumar, & Arasaratnam, (2015), it was discovered that foods with higher dietary fibre content had lower glycaemic indexes. Additionally, dietary fibre significantly reduced the glycaemic index of pittu produced with millet flour and, to a lesser amount, of legumes. Due to slower stomach emptying and modest intestinal absorption, high-fiber diets have a low glycaemic response, according to research by Scazzina, Siebenhandl-Ehn, & Pellegrini, (2013) Whole-barley bread has been shown to reduce insulin and glucose response when viscous dietary fibres such oat, beta glucan, and linseed are added, according to Bjorck, Granfledt, Liljeberg, Tovar & Asp, (1994).

It has been demonstrated that fibre from legumes and other non-cereal sources can help to reduce the glycaemic and insulin responses of food after meals. It has been proven that substituting Detarium senegalense Gmelin (an African legume) flour for a portion of the white bread reduces the glycaemic response by over 60%. (Onyechi, Judd, & Ellis, 1998). High soluble fibres like guar gum and galactomannan are known to lower bread's glycaemic index and glycaemic response (Scazzina, Siebenhandl-Ehn, & Pellegrini, 2013).

Moisture Content

The portion size and subsequent glycaemic load of the food are both significantly influenced by the amount of moisture in the food. The amount of water injected during heat treatment and the moisture level of the food ingredients have an impact on the degree of gelatinization, starch digestibility, and glycaemic index. Foods with higher moisture contents have faster rates of starch breakdown and glucose release, as well as higher glycaemic indexes. However, porridges with a high-water content have a low GI, which is brought on by a reduction in the activity of the digestive enzymes that break down starch in the mouth and gastrointestinal tract as well as a delay in this process, according to a study by Pathirannehelage (2022). The presence of water affects the quantitative changes in specific starches under particular processing circumstances.

Food Structure and Nature of Starch

According to some reports, tampering with food's botanical structures makes the carbohydrate moiety more accessible for digestion and absorption. The food's structure has an impact on both the glycaemic response and enzyme activity in starchy foods (Bjorck, Granfledt, Liljeberg, Tovar & Asp, 2013). According to Arvidsson-Lenner, Asp, Axelsen, Bryngelsson, Haapa, Järvi, & Vessby, (2004), heat treatment (gelatinization) or mechanical destruction (grinding) of the food's gross structure accelerates digestion, improves glycaemic response, and lowers the food's glycaemic index. When potatoes are raw, they have a high resistant starch content, which drops when the potatoes start to gelatinize (Nayak, Berrios, & Tang, 2014). Additionally, the glycaemic index of a food increases as its cellular structure ripens. Brand, Nicholson, Thorburn, & Truswell, (1985) found that eating cooked as opposed to raw starch and pureed as opposed to whole foods results in a much higher blood glucose response.

Anti-nutrients

Anti-nutrients may prevent the gastrointestinal tract from properly digesting starch. Starch digestibility and glucose response may be impacted by antinutrients like phytates, enzyme inhibitors, and lectins (Thompson, Movva, Tizard, Crameri, Davies, Lauwereys, & Botterman, 1987). In research by Kakade and Evans, lectins and enzyme inhibitors were discovered to produce hypoglycemia and lower development rates in rats (1961). According to Puls and Keup. some amylase inhibitors have been proven to decrease glucose absorption in people and rats when measured by the peripheral glucose response (1973).

Yoon, Thompson, & Jenkins, (1983) discovered that the rate of release of starch digestion products in vitro and the glucose response were both decreased when phytic acid supplements were provided to unleavened white bread as opposed to ordinary unleavened white bread. By interacting with the amylase protein and or binding to salivary minerals like calcium, which is known to accelerate amylase activity, it was proposed that phytic acid could lower blood glucose levels (Thompson, Movva, Tizard, Crameri, Davies, Lauwereys, & Botterman, 1987). Despite the fact that heat treatment destroys anti-nutrients, some do survive depending on the cooking technique.

Carbohydrate Staples in Ghana

The body can receive carbohydrates from a variety of foods, but in Ghana and other developing nations, the majority of the carbohydrate are taken from maize, rice, plantains, or cassava (FAO/WHO, 1998).

Carbohydrate Digestion

The large number of research carried out on GI is a result of how carbohydrate affect our hormonal response, human diseases, and physiologic and metabolic processes (FAO/WHO, 1998). Characterizing the role of carbohydrates in metabolism requires knowledge of the location, extent, and rates of digestion in the gastrointestinal tract as well as the rate of absorption from it (Mann, Cummings, Englyst, Key, Liu, Riccardi, Summerbell, Uauy, R., van Dam, R. M., Venn, B., & Wiseman, 2007). Important factors that are helpful in characterizing and categorizing carbohydrates in terms of their physiological roles include digestibility and absorption.

The rate of a carbohydrate's digestion and absorption directly impacts the item's glycaemic index. The mouth is where carbohydrate digestion starts. Aston, Peters., & Carrell, 2008 study’s revealed the GI differences between coarsely ground wholemeal bread and stone-ground wholemeal bread (Aston, Peters., & Carrell, 2008). As a result, how thoroughly food is chewed in the mouth before swallowing may have an impact on how quickly it breaks down in the stomach and small intestines. By expanding the area where enzymes may be active, chewing would speed absorption and digestion.

In the gastrointestinal system, digestion and absorption occur with the help of certain fluids and enzymes. Many enzymes work on the food that has been ingested from the mouth to the small intestine. Some carbohydrates and other food components like fibre may elude digestion in the large intestine, where they may be fermented into gases and other advantageous metabolic by-products like butyrate and propionates.

Impacts of the Consumption of Foods with High Glycaemic Index on Health

There are several hormonal and metabolic changes that are known to be connected to the rate of glucose release into the blood and the period of time when postprandial blood glucose levels rise and may influence health and disease characteristics (Gannon, Nutall, Neil, & Westphal, 2012). According to a recent systematic review and meta-analysis by George (2015), using low glycaemic index/glycaemic load meals as part of an intervention reduced risk markers for those who are overweight, obese, diabetic, or at risk for coronary heart disease. Information from 45 controlled dietary intervention trials was gathered for this meta-analysis. The findings show that type 2 diabetes, obesity, and cardiovascular disease are all independently associated with high GI/GL diets.

The relationship between high GL diets and increased risks for type 2 diabetes and cardiac events has been studied using the GL. In a significant meta-analysis of 24 prospective cohort studies, researchers discovered that people who eat lower GL diets had a decreased risk of developing type 2 diabetes than those who consumed higher GL meals (Livesey, Taylor, Livesey, & Liu, 2013). A similar type of meta-analysis revealed that higher

GL diets were connected to an increased risk for coronary heart disease events (Mirrahimi, de Souza, Chiavaroli, Sievenpiper, Beyene, Hanley, Augustin, Kendall, & Jenkins, 2012).

Meyer's glucostatic hypothesis of regulating food intake states that low blood glucose is one of the physiological cues for hunger (as in Arvidsson-Lenner, Asp, Axelsen, Bryngelsson, Haapa, Järvi, & Vessby, (2004) stated. Later studies, however, showed that rather than the absolute blood glucose content, glucostatic receptors in the central nervous system acquire their signal that the body is low on fuel and needs to be refuelled from the transient reduction in blood glucose (Livesey, Taylor, Livesey, & Liu, 2013; Walker, 2014). According to Livesey, Taylor, Livesey, & Liu, (2013), ratings of hunger are more severe the more blood glucose drops after a meal-induced high. As a result, eating foods with a high GI can trigger insulin-induced hypoglycemia, which can cause weight gain as the body's homeostatic mechanism seeks to refuel. But low-GI foods promote satiety, lower postprandial insulin release, and hence lower subsequent voluntary food intake (Ludwig & Daniel, 2002; Brand, Nicholson, Thorburn & Truswell, 2016).

Long-term consumption of meals with high glycaemic loads and glycaemic indices has been linked to higher postprandial blood glucose increases and significant insulin release, according to Willett, Manson, & Liu, (2002). This might result in the pancreatic beta-cells losing their ability to secrete insulin, which would cause Type 2 *Diabetes mellitus* that is irreversible. One of the most prevalent chronic diseases in the world today is *Diabetes mellitus* Type 2, and according to Ludwig and Daniel (2002), the prevalence of the condition is rising across the board. In the globe today, 415 million people have diabetes, according to the International Diabetes Federation (IDF). However, it is anticipated that the number of persons with this illness would increase to 642 million by 2040.

In Africa, 6.7% of people (ages 20 to 79) are expected to have diabetes (IDF, 2016). When individuals are made aware of the glycaemic loads and indexes of the foods they consume, which play significant roles in the onset of this illness, the prevalence of this condition can be reduced to a lower rate. When customers are well-informed about how quickly the glucose in our local foods enters the bloodstream, they will make extremely careful meal choices and even consider when and how much of these foods they eat.

Data shows that improving glycaemic control through food management is essential for reducing the risk of diabetic complications and extending life (Koussasi, Tiahou, Abodo, Camara-Cisse & Amani, 2009). A major goal of diabetes nutritional therapy is to improve glycaemic control by balancing dietary intake with insulin levels (Krishnan, Mondal, Thomas, Singh, & Praveen, 2021). Glycaemic index and glycaemic load are therefore the best ways to maintain a balance between blood glucose and insulin levels going ahead (Mash & Brand-Miller, 2008).

The role of low GI diets in weight loss and the risk of metabolic illnesses is currently of great scientific and public interest (Aston, Peters., & Carrell, 2008). There are a number of connections between specific medical disorders and dietary glycaemic index that have been discovered. A systematic review and meta-analysis conducted by Fan, J., Song, Y., Wang, Y., Hui, R., & Zhang, W. (2012**)** revealed a tenuous association between dietary glycaemic index and coronary heart disease. The control of blood lipids by a low glycaemic diet was also discovered by Jenkins, Wolever, Kalmusky, Giudici, Giordano, & Wong, (1985).

Effects of Kokonte, Tuo-zaafi and 'Wordeme' on Blood Glucose Level

In order for diabetic patients to obtain an appropriate intake of glucose in accordance with their physiological requirements, GI was initially developed to enhance the carbohydrate exchange list already in use by individuals with diabetes. Gilbertson's team hypothesized, however, that low-GI dietary approaches could offer individuals with type 1 blood glucose levels a greater quality of life than carbohydrate exchange dietary approaches (Similä, 2012). Similä (2012) asserts that low GI meals can be beneficial since they enhance glycaemic management and lessen the post-prandial stress placed on the pancreatic beta cell.

Low-GI foods resulted in decreased levels of insulin and glucose. According to Jenkins (2012), people with type 2 blood glucose levels who ate low-GI diets had lower plasma glucose and insulin levels than those who ate high-GI diets. This demonstrates that long-term consumption of diets high in Kokonte, Tuo-zaafi, and Wordeme may lead to greater postprandial blood glucose concentrations and exaggerated insulin release. This could contribute to the loss of insulin-secreting capacity in pancreatic beta-cells and result in type 2 blood glucose levels that are permanent (Willett, Manson & Liu, 2012).

A higher incidence of type 2 blood glucosuria has been linked to high-GI and -GL diets in a number of sizable prospective cohort studies. Consuming foods with the highest GI as opposed to the lowest GI was linked to a 44 percent higher risk of type 2 diabetes in the Nurses' Health Study (NHS I), a 20 percent higher risk in the NHS II, and a 30 percent higher risk in the

Health Professionals Follow-up Study (HPFS), according to a recent updated analysis of three large US cohorts (Bhupathiraju, Tobias & Malik, 2014).

Bhupathiraju, Tobias & Malik, (2014) also discovered that only in the NHS I and in the combined analysis of the three studies (+10%) were high-GL diets linked to an elevated risk of type 2 diabetes (+18%). Furthermore, compared to low-GI and high-cereal-fibre diets, eating high-GI foods that are low in cereal fiber was linked to a 59% higher risk of developing diabetes. Compared to low-GL and high-cereal-fibre diets, high-GL and low-cereal-fibre diets were linked to a 47% increase in risk. Furthermore, compared to lean participants who consumed low-GI or -GL diets, obese participants who ate foods with high GI or GL values had a risk of acquiring type 2 blood glucose levels that was more than ten times higher (Bhupathiraju, Tobias & Malik, 2014).

Nutritional Component of Kokonte, Tuo-zaafi and 'Wordeme'

Kokonte, Tuo-zaafi and Wordeme are essential parts of millions of people's lives all across the world, particularly in African nations. It offers 9% of the world's per capita carbohydrates with 15% of the energy needed by humans (Bjorck, Granfledt, Liljeberg, Tovar & Asp, 2013). The primary component of Kokonte, Tuo-zaafi and Wordeme is starch, which makes up around 90% of the total dry weight and 81.0% of the overall calorie content. The starch, which gives rice its texture and digestibility, is composed of long glucose chains called amylose and amylopectin. When global research on rice were evaluated, a wide variety of outcomes in GI and GL were obtained (Akoto, 2015; Brown, J., Mssallem, Frost, & Hampton, 2015; Jahan, 2013;

Lu, 2016; Passos, Sampaio, Arruda, deMelo, Lima1 & Rocha, 2014; Rahaman, 2017).

When bread was employed as the reference food, the GI of white Kokonte, Tuo-zaafi, and Wordeme ranged from as low as 54 to as high as 121 (Jenkins, 2012). Because of this, it is challenging to identify these carbohydrate diets as high or low GL foods. When compared to Tuo-zaafi and Wordeme, consumption of Kokonte with groundnut soup was substantially associated with a lower incidence of central adiposity and impaired fasting glucose (Akoto, 2015).

Many domesticated animals and people get the majority of their daily calories from Kokonte, Tuo-zaafi and Wordeme (Cheng, Shi, Jiang, Ge, Wu, & Jahn, 2012). In actuality, the GI of any of these carbohydrate diets varies more depending on the variety and preparation method. For example, the distinctive flavor of Tuo-zaafi makes it simple to pair it with 'ayoyo' (green, green) soup for improved flavor and nutritional balance. Studies have shown that Kokonte, Tuo-zaafi, Wordeme and flattery have some negative consequences on one's health (Brown, Mssallem, Frost, Hampton, 2015**;** Lu, 2016; Rahaman, 2017). Because it possesses anti-oxidative or anti-inflammatory properties, the pigment of some Kokonte, Tuo-zaafi, and Wordeme can prevent the development of atherosclerotic plaque.

Rahaman (2017) notes that other studies have also highlighted the benefits of combining Kokonte, Tuo-zaafi, and Wordeme with groundnut soup, 'ayoyo' soup, and *bobi taadi*, respectively. Better postprandial results, such as lower glucose, insulin, and ghrelin levels after meals, as well as improved lipid profiles and antioxidant enzyme activity, are among these advantages. Although the majority of related studies show that excessive consumption of Kokonte, Tuo-zaafi, and Wordeme is linked to unfavorable metabolic consequences, possible mechanisms have not been spelled out in detail (Rahaman, 2017).

Foods with equal carbohydrate contents do not always affect blood glucose levels in the same way, according to the GI principle (Rahaman, 2017). Rahaman (2017) states that as the amount of consumed carbohydrates affects glycaemic response, GL has been regarded as a superior criterion to quantify the effect of carbohydrates on glycaemia. In order to better understand the postprandial glucose response of several varieties of Kokonte, Tuo-zaafi, and Wordeme that are popular in Ghana, the researcher was inspired to calculate the GL of each.

Significant Difference in Glycaemic Index/Loads of Kokonte, Tuo-zaafi and Wordeme

Numerous hormonal and metabolic changes that may have an impact on health and disease parameters are known to be caused by the pace at which glucose is released into the bloodstream, as well as how long it takes for blood glucose levels to rise after eating (Gannon, Nutall, Neil, & Westphal, 2012). A recent systematic review and meta-analysis by George (2015) found that risk markers associated with persons who are overweight, obese, diabetic, or at risk of coronary heart disease decreased when low GI/GL meals were used in the intervention. Data from 45 regulated dietary intervention trials were gathered for this meta-analysis. The results demonstrate that high GI/GL diets are independently linked to higher chances of acquiring type 2 diabetes, obesity, and cardiovascular disease.

It has been investigated using the GL if high GL diets are linked to higher risks for type 2 diabetes and cardiac events. Researchers found that those who consumed lower GL diets had a lower chance of acquiring type 2 diabetes than those who consumed higher GL meals in a major meta-analysis of 24 prospective cohort studies (Livesey, Taylor, Livesey, & Liu, 2013) Higher GL diets were found to be linked to an elevated risk for coronary heart disease events by a similar sort of meta-analysis (Mirrahimi, de Souza, Chiavaroli, Sievenpiper, Beyene, Hanley, Augustin, Kendall, & Jenkins, 2012).

Low blood glucose is one of the metabolic signals for hunger, according to Meyer's glucostatic hypothesis of food intake regulation (as described in Arvidsson-Lenner, Asp, Axelsen, Bryngelsson, Haapa, Järvi, & Vessby, (2004) Later research, however, revealed that the central nervous system's glucostatic receptors receive their signal that the body needs to refuel from the temporary decrease in blood glucose rather than the absolute blood glucose concentration (Livesey, Taylor, Livesey, & Liu, 2013; Walker, 2014).

According to Livesey, Taylor, Livesey, & Liu, 2013, the greater the blood glucose decrease after a meal-induced peak, the more intense the assessments of hunger. Because of this, eating high-GI foods can result in insulin-induced hypoglycemia, which can lead to weight gain as the body's homeostatic system tries to replenish energy. However, low-GI foods induce satiety, reduce postprandial insulin release, and hence reduce subsequent voluntary food intake (Ludwig, 2012; Brand, Nicholson, Thorburn, & Truswell, 2016).

Empirical Studies

Research on the consumption of carbohydrate items and their effect on blood glucose levels was done by Willett, Manson, & Liu, 2002. The study found that eating foods with high glycaemic loads and glycaemic indices causes postprandial blood glucose rises to increase and excessive insulin release. Eli-Cophie, Agbenorhevi, Annan, (2017) another researcher, examined the glycaemic index of a number of carb-rich Ghanaian staple meals. Fufu (locally pounded and neat fufu), Ga kenkey, banku, and Tuo Zaafi are some of the dishes (TZ).

Ten (10) healthy, non-diabetic individuals were used to determine the glycaemic index of the local staples. Participants received 50g servings of pure glucose twice, followed by the test foods with 50g of readily available carbohydrate. Within a 2-hour window, the patients' capillary blood glucose levels were assessed both while they were fasting and after consuming the glucose and test foods. By dividing the incremental area under the glucose response curve (IAUC) of the test food by the IAUC for the reference food and multiplying the result by 100, the GI of the test foods was determined.

The results showed that locally pounded fufu (55), ga kenkey (41) and processed-powdered fufu (31), all of which had low GI, had the lowest glycaemic response. Banku (73), had a relatively high GI, while Tuo Zaafi (68) had a medium GI. The GIs of locally pounded fufu and powdered fufu (industrially processed fufu flour) differed significantly when compared between the foods using ANOVA ($p = 0.026$). According to this study, the five main Ghanaian staples had GI values that ranged from low to moderate, and they should be taken into account when making recommendations to diabetic patients.

Adu-Gyamfi (2018) studied the glycaemic index of various fufu cultivars in Ghana. The trial involved 10 healthy participants who consumed 50 g of pure glucose before receiving a measured serving of each of three test items, each of which contained 50g of carbohydrates: cassava-yam, cassava-cocoyam, and cassava-plantain fufu. Within a 2-hour timeframe after eating the test items, capillary blood was also taken, and the postprandial glucose concentration was assessed. Using the GI ratings and accounting for the typical fufu portion size, the glycaemic loads were calculated. The most popular variant was determined by sensory examination.

All three types underwent a proximate study to determine their nutritional make-up. According to results from proximate analysis, the combination of cassava and plantain contained the least amount of carbohydrates (34.87%), followed by that of cassava and cocoyam (36.10%), and that of cassava and yam (43.000%). All three of the types have high GL despite having low GI. The GL of cassava-plantain fufu was 40%, that of cassava-yam fufu was 22%, and that of cassava-cocoyam fufu was 29%. According to the results of the sensory study, the cassava-plantain fufu variant was the most popular of the three. The biggest factor that panelists cited for why they chose one fufu variation over another was culture. To lessen the impact on their blood glucose level, consumers must consume fewer portions of any fufu variation.

In order to ascertain and evaluate the GI of various staple corn and cassava products from Ghana. Yeboah (2017) conducted a study. She also looked into the impact of processing on these products. By using a cross over trial, ten healthy volunteers were included, five male and five female. On two separate occasions, the study participants were given 50 grams of pure glucose dissolved in 200 ml of pure water. Additionally, on particular days, they were given specific portions of test meals that each included 50g of readily available carbohydrates.

The GI was evaluated by measuring the blood glucose levels of research participants while they were fasting and after ingesting test foods and glucose during a 2-hour period at intervals of 15, 30, 45, 60, 90, and 120 minutes. By dividing the blood glucose incremental area under the glucose response curve for the test food by the blood glucose incremental area under the curve for the reference food and multiplying by 100, the GI value for the test food was determined for each participant. The mean or average of the ten study participants serves as the GI value for each test food. Locally produced Kokonte had the lowest glycaemic index (GI) of all the test foods, coming in at 7, followed by processed Kokonte at 18, and low-GI kafa at 29.

The medium GI values for abolo and akple were 58 and 69, respectively. The average age, BMI, weight, height, and waist circumference were 23.1-2.60 years, 24.39-3.10 kilograms per square meter, 64.1-2.9.0 kg, 161.40-6.04.cm, and 74.6-6.9 cm, respectively. The GI of processed Kokonte and locally produced Kokonte did not differ significantly from one another ($p > 0.05$), showing that the kind of processing did not significantly affect the GI of Kokonte. The study's findings are crucial because they will help diabetics, consumers, and healthcare professionals choose and prepare meals with local staples.

Quartey, Domfeh, Dapaah, Apuri, & Duah, (2019), investigated the overall postprandial glycaemic effects of four common Ghanaian meals in non-diabetic adult subjects. After an overnight fast, the test meals (*Ampesi, Fufu, Banku and Ga Kenkey*) served as mixed meals were consumed by the participants on separate days. Blood glucose levels were observed at baseline and 30-minutes intervals for three (3) hours.

The percentage postprandial glycaemic retention, peak postprandial glycaemia, and total postprandial glycemia area under the curve were used to measure postprandial outcomes. Despite previously mentioned variances in the glycaemic indexes of the foods, the study's findings revealed that, with few exceptions, there were no significant changes in the total postprandial glycaemic responses of the meals. The relative differences in their postprandial glycaemic patterns may rather suggest implications in individuals on insulin therapy in terms of dosage and timing.

Wormernor (2015) looked assessed the glycaemic index (GI) of a few staple foods from Ghana that are high in carbohydrates in order to determine how processing affects the GI of foods. 10 seemingly healthy participants in the crossover trial study were given 50g amounts of pure glucose on two separate occasions. They were then given measured portions of the test foods, each of which included 50g of readily available carbohydrate. The GI values were calculated by monitoring the patients' capillary blood glucose levels while they were fasting and two hours after ingesting the glucose and test foods.

Following the initial sample, samples were obtained at 15, 30, 45-, 60-, 90-, and 120-minutes following intake. Each subject's glucose response curve was created for both the reference food and the test food. By dividing the incremental area under the glucose response curve for the test meal by the incremental area under the glucose response curve for the reference food and multiplying the result by 100, the GI of the test foods was determined.

Ten apparently healthy persons (8 males and 2 females) with mean ages of 30.96.4 years, 26.945.2 kg/m2, and 88.613.8 cm, respectively, were tested for their glycaemic reactions to four prominent Ghanaian staples: *Banku*, *Tuo Zaafi*, *Fufu* (Pounded and Industry Processed), and Ga Kenkey. The results showed that locally pounded fufu, Ga Kenkey, and fufu prepared from fufu flour that had undergone industrial processing all fell into the Low GI category and had the lowest glycaemic response. Banku had a moderately high GI, while Tuo Zaafi had a medium GI. The GI of locally pounded fufu (LPF) and fufu made from industrially-processed fufu flour (IPF) differed significantly ($p = 0.026$) in an ANOVA multiple comparison of the GI of the different items, suggesting that the processing had an impact on glycaemic quality.

CHAPTER THREE

MATERIALS AND METHODS

Introduction

This chapter presents the study's methodology. The research design, study area, population, sampling method, techniques, and materials, data collection process, ethical consideration, and the analysis and interpretation of the gathered data are all seen as being parts of the research techniques.

Research Design

The fundamental layout of a study, the nature of the hypothesis, and the variables used in the investigation are all described by the research design (Bist, 2014). A research design, according to Babbie and Mouton (2002), is a strategy or plan for how the study will be carried out. It offers a procedural roadmap for how any investigation should be carried out, reflecting the plan that outlines how information pertaining to a particular construct should be gathered and analyzed.

An experimental design was used for the investigation. In an experiment, a researcher modifies at least one independent variable while controlling other significant variables and watching the effects on the subjects (Amedahe, 2009). This sort is only one that can successfully test theories about the cause-and-effect relationship. The set of circumstances that allow researchers to draw valid conclusions regarding the links between independent and dependent variables is known as the design of an experiment.

As a result, it gives the researcher the chance to compare as specified in the experiment's hypotheses and enables her to interpret the study's findings in a relevant way (Stoney & Johnson, 2012). This is the first study to evaluate the impact that each test food has on a person's blood glucose levels after consumption. The glycaemic index and load of the independent variables Kokonte, Tuo-zaafi, and "Wordeme" were determined in order to manipulate and evaluate the effect that each food had on the body's glucose levels. This study focused on the glycaemic load of Kokonte, Tuo-zaafi and ‘Wordeme’ as well as investigating the proximate analysis (nutritional compositions) of the foods understudy.

Study Area

The study was conducted at Prestea, Ghana's Western Region, 50 kilometers (km) north of the Atlantic Ocean's shore, in the southwest. The capital of Prestea, Bogoso, is located in the Prestea Huni-Valley Municipality and is situated on the western side of the Ankobrah River. On the Tarkwa-Takoradi route, Bogoso Junction is around 60 miles (100 kilometers) away. Due to the gold mining operations, Prestea, which is on Wassa soil, is primarily inhabited by a number of different ethnicity but is predominated by the Fantes and Nzemas (Population and Housing Census [GPHC], 2010).

The town is made up of a variety of working classes from various facets of the Ghanaian economy. For example, small-scale (illegal) gold mining, traders of various goods and services, and gold miners make up the majority of the community's workforce. Prestea, which had a settlement population of 35,760 individuals in 2010, is the 46th most populous city in Ghana (Ghana Population and Housing Census, 2010). Because it is simple to convince individuals to consume all of the test foods there, and because the researcher works at Prestea, the study was conducted there. Again, the area of study is ‘galamsey’ dominated because of gold mining activities, people from diverse ethnic groups settle for greener pasture.

Source: Ghana Statistical Service, GIS (2010)

Figure 4: Study Map showing Prestea

Population

The population is the target group that the researcher is interested in learning more about in order to draw conclusions, according to Amedahe (2014); Frankel and Wallen (2006). All people between the ages of 18 and 60 who were healthy and free of any chronic health conditions made up the study's target population. This group of individuals were used because they were within the class who volunteered to be used for the study.

Glycaemic index can be accurately calculated when ten patients are studied.

According to the FAO/WHO (1998) recommendation, ten (10) participants were willingly selected and engaged for the blood glucose level determination. Participants between the ages of 18 and 60 who were free of diabetes, had a normal Body Mass Index (BMI), and were not on any medications were therefore used.

Ten (10) non-diabetic subjects made up the sample size, and the researcher also took gender into account by purposefully choosing five (5) males and five (5) females. A medical doctor aided in the screening of the participants to verify they were healthy for the study, free of diabetes, and had a BMI between 18.5 and 24.9 Kg/m^2. Prior to the experiment date, the participants received a two-day orientation to help them understand the significance of the study and how to follow the experiment's rules and regulations. For instance, participants in the study were strictly forbidden from drinking, smoking, and indulging in any intense exercise.

Inclusion criteria of Participants

The pursuing inclusion standards were applied: People who were included in the study were healthy, between age 18 to 60 and had no underlying health conditions such diabetic, cardiovascular diseases (CVDs) and within normal Body Mass Index (BMI) range took part in the study.

Exclusion criteria of Participants

Through a careful medical evaluation, those under the age of 18 and older who have metabolic abnormalities or any disease or discomfort are excluded. According to the FAO/WHO (1998) standard on determining the glycaemic index of meals, people or participants who were younger than 18 and older than 60 were not deemed suitable for the study. These participants were recruited for screening with the assistance of laboratory personnel. These individuals were oriented based on the purpose of the research.

In order to measure the blood glucose level for the glycaemic index and load after consuming the reference and test foods (diets), they observed a 12-hour fast. The Food and Agricultural Authority (FAO)/World Health Organization (WHO) (1998) approved techniques for determining glycaemic index/load were used when determining the number of participants for the study. The population involved were selected conveniently from public places like school, market, hospital, bank and church. For the proximate analysis, cassava and maize were obtained from Prestea market which were processed into flour and dough for the research work.

Sample and Sampling Procedure

Purposive and practical sampling strategies were applied for the study's sample size. The subjects for the blood glucose test were chosen using these sampling strategies. The purposeful sampling technique involves selecting participants based on specific criteria, but it also uses a wide range of inferential statistics. This method is not random and does not require underlying theories or a predetermined number of participants (Bernard, 2002). Only willing participants were chosen to take part in the study using a purposeful sampling technique.

According to Dornyei (2007), convenience sampling is a type of non-probability or non-random sampling where members of the target population are included for the purpose of the study if they meet specific practical criteria, such as easy accessibility, geographic proximity, availability at a specific time, or a willingness to participate. Convenience sampling is also affordable, easy and subjects are readily available at the time of collection (Battaglia, 2008). By adopting convenience sampling, the study used ten (10) participants who were willing and ready to participate in the study. These participants were selected based on their familiarity with the test foods to prevent any adverse reactions and allergies. Adults within the age group of 18-60 years without any health issues and who were not on medication but volunteered were listed and further screened by the laboratory technicians. Participants' anthropometric measurements, including age, height, weight, and waist circumference, were determined at the hospital laboratory during screening. Weight per square of height was used to compute Body Mass Index (BMI).

The BMI and the waist circumference helped the researcher to screen healthy participants per the World Health Organization (1988) and selected participants with normal BMI of 18.5 - 24.5 Kg/m^2 for the study. Participants were instructed to fast for 12 hours before the test during the orientation (8pm-8am). This helped the researcher to obtain reliable readings for the fast glucose levels after the participants were given the glucose and the test foods. Raw ingredients for the study were purchased from Prestea market and were processed into flour and dough for the study.

The ingredients prepared were served with ‘‘ayoyo’’ stew and leaves for all the test foods by the researcher in the hospital restaurant/kitchen with the help of research assistants. This was to ensure that ingredients used were measured appropriately in accordance to ways of preparing the various test foods under hygienic condition. The results of the study were also documented for easy comparison for other researchers.The prepared test foods were taken to the testing centre (hospital) each morning.

Materials and Methods

For the test foods (Kokonte, Tuo-zafi, and Wordeme), white corn (maize) and sweet cassava varieties were used as raw materials, which were obtained at Prestea Market two days after harvesting.

Processing cassava into flour and dough

The fresh sweet cassava roots which have lower cyanide content and safer for consumption were first washed to get rid of the clay and peeled. The cassava was then divided into two halves, one for flour and other for dough that was used for the preparation of Wordeme. The first half peeled roots were washed and cut into tiny pieces or blocks pieces about 5x0.5x0.2 cm and sun dried with temperature of 25℃ to 35℃ for one week (7 days) to reduce the moisture content, prevent bacterial growth, retain nutrients and achieve optimal drying to obtain 1000g of flour. In order to eliminate debris and chaff, the dry chips were ground into a powder and then sieved through a fine mesh size (100-120 mesh). The flour was stored in a cleaned airtight container of 150 -300g in a room temperature till ready for use in the preparing of Kokonte and Tuo-zaafi for a month. The quantity used for Kokonte was 100g to 200mls of water each. The remaining half of the roots were cleaned, grated, and combined into a smooth dough weighed 300g that was refrigerated (-18t°C to -12°C) in an airtight plastic bag.

Processing of corn flour

Maize (white corn) of 2400g was bought from the market and sieved with a mesh size of 40-50 to remove stones and other particles. Half 1200g (3cups) of the maize was commercially milled and stored in a room temperature of 20°C -22°C in a clean air tight container for four weeks (a month) use in preparing the Wordeme. Wordeme was prepared using the combination of corn flour and cassava dough, thus 70 g of corn flour to 30 g of cassava dough with 250mls of water for each participants.

The remaining 1200g of the maize was dehulled/ polished and milled into flour using customer service mill. The flour was stored in a clean air tight container till ready for use in the preparation of Tuo-zaafi. To 300mls of water, 120g of polished corn flour and 80g of cassava flour were combined to make Tuo zaafi for each. In some parts of Northern region, Tuo-zaafi is mostly prepared using millet and yam flour instead of combination of corn and cassava flour as used in this study.

Preparation of the Test Foods

Kokonte

Kokonte is a traditional Ghanaian dish made from dried cassava or yam. In the preparation cassava chopped into smaller or more suitable pieces, rinsed, and repeatedly dried until the moisture content is gone as discussed earlier. A metallic pot of 2000mls of water boiled for 100°C, the flour of 700g was added after fetching 500mls and stirred continuously. To avoid the food on the stove from becoming lumpy, the remaining 300g flour was added and constantly stirred for 5mins. Additional hot water was added to achieve desired thickness. The food was creamed till a smooth texture is obtained and allowed to cook for 15-20 min. The cooked product was weighed with measuring scale and moulded into 174g portions that each contained 50 g of readily available carbohydrates for ten participants.

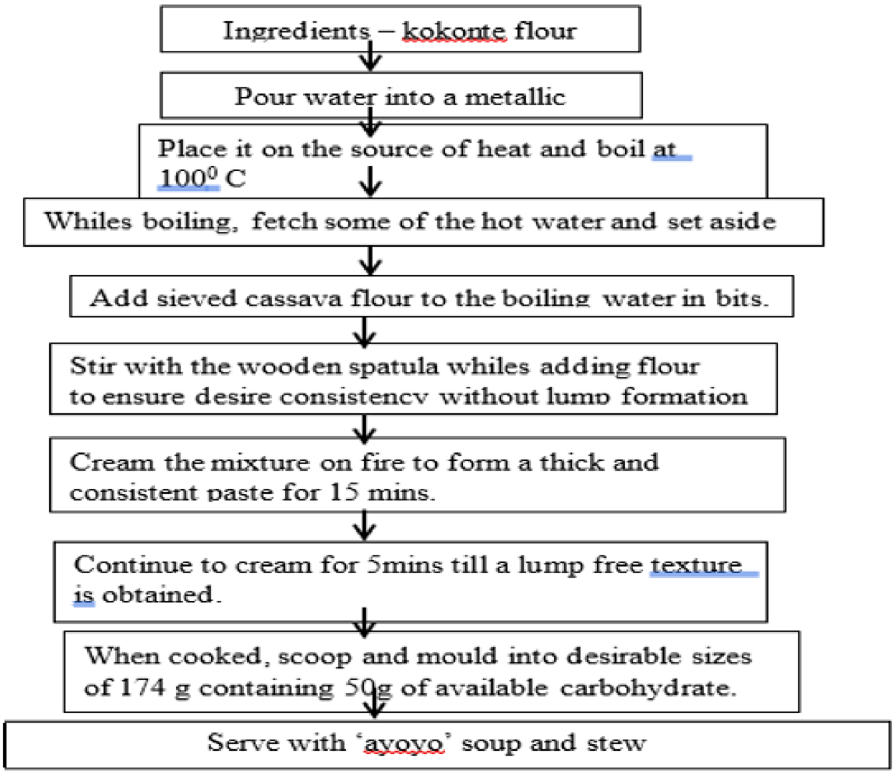

Figure 5: Flow chart for preparing Kokonte

Source: Researcher's Construct

Tuo zaafi

Tuo-zaafi is of the staple foods among the people of Northern Region. The dish was prepared from polished corn flour and cassava powder or yam flour. Cassava (800g) flour was obtained by cutting peeled cassava into considerable sides, washed and dried till the moisture content in the foodstuff reduced to about 10%. The dried foodstuff was pounded, milled and simply sieved. Tuo-zaafi was also prepared by mixing weighed corn and cassava powder together with measuring scale in the ratio of 3:2 (120 g corn flour to 80 g cassava flour for each participants) as in Figure 5.

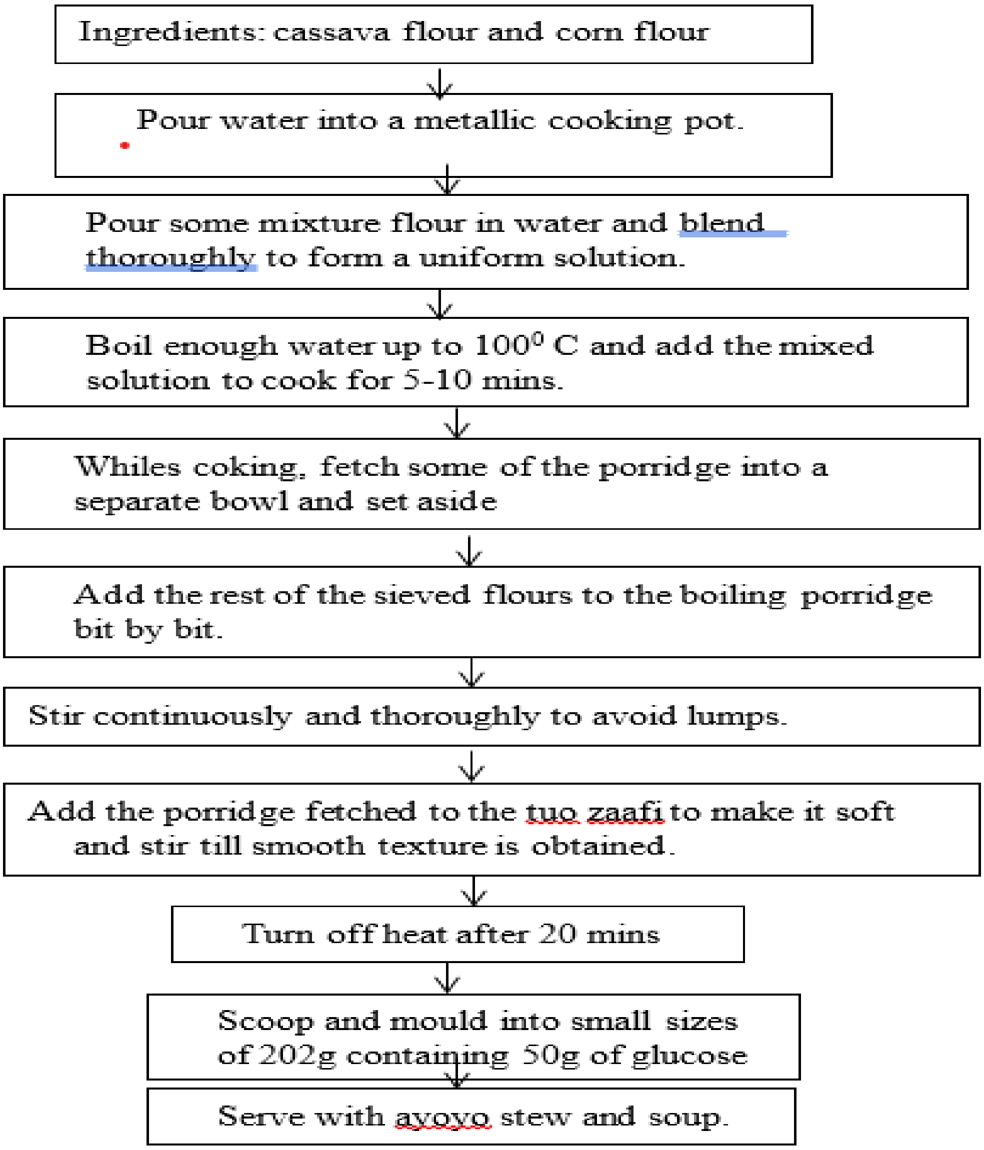

Figure 6: Flow chart for preparing Tuo–zaafi

Source: Researcher’s Construct

The cassava and corn flours were mixed in cold water (400g) before adding to the boiling water of 100°C to prepare porridge. Six hundred (600mls) of the porridge was fetched. The remaining flour was added to the boiling mixture and stirred continually till desirable texture was attained. To get the soft consistency/ desired thickness of Tuo-zaafi more liquid was added.

The dish was creamed and stirred continuously to prevent lumps and have smooth texture in appearance and was allowed to cook for 20 min (see Figure 6). Figure 6 shows a flow chart summarising the preparation of Tuo-zaafi. The prepared food was scaled into 202g portions that each hold 50g of carbohydrates. The Tuo-zaafi prepared with corn and yam flour is more expensive than the one with corn and Kokonte and difficult to get.

Wordeme

Wordeme' was mixture of workple /Akple with addition of cassava dough. The 400g corn flour was dissolved in cold water and then added to a boiling water of 100°C in a metallic pot. The sieved cassava dough of 300g was also added to the corn flour mixture (akple) and cooked for 10minutes. The 700g corn flour was then added to the porridge – like liquid and stirred on fire till well mixed. The remaining 100g making a total grams of 1200g corn flour was added and stirred to avoid lumps for 20 to 30 minutes at a moderate heat. Figure 7 shows a flow chart for the preparation of Wordeme. With the aid of a food scale, the finished product was moulded into suitable sizes of 160 g containing 50 g of readily available carbohydrates.

A nutrient analysis table was used to calculate the amount of carbohydrate in grams. 'Wordeme' is commonly prepared among the people of the ethnic groups of Ewe could be eaten with groundnut soup, okro soup or stew, palmnut and 'ayoyo' stew which the researcher used. 'Ayoyo' stew was used as accompaniment for Kokonte, Tuo-zaafi and 'Wordeme' for the experiment (See Appendix F for 'ayoyo' soup and stew recipe).

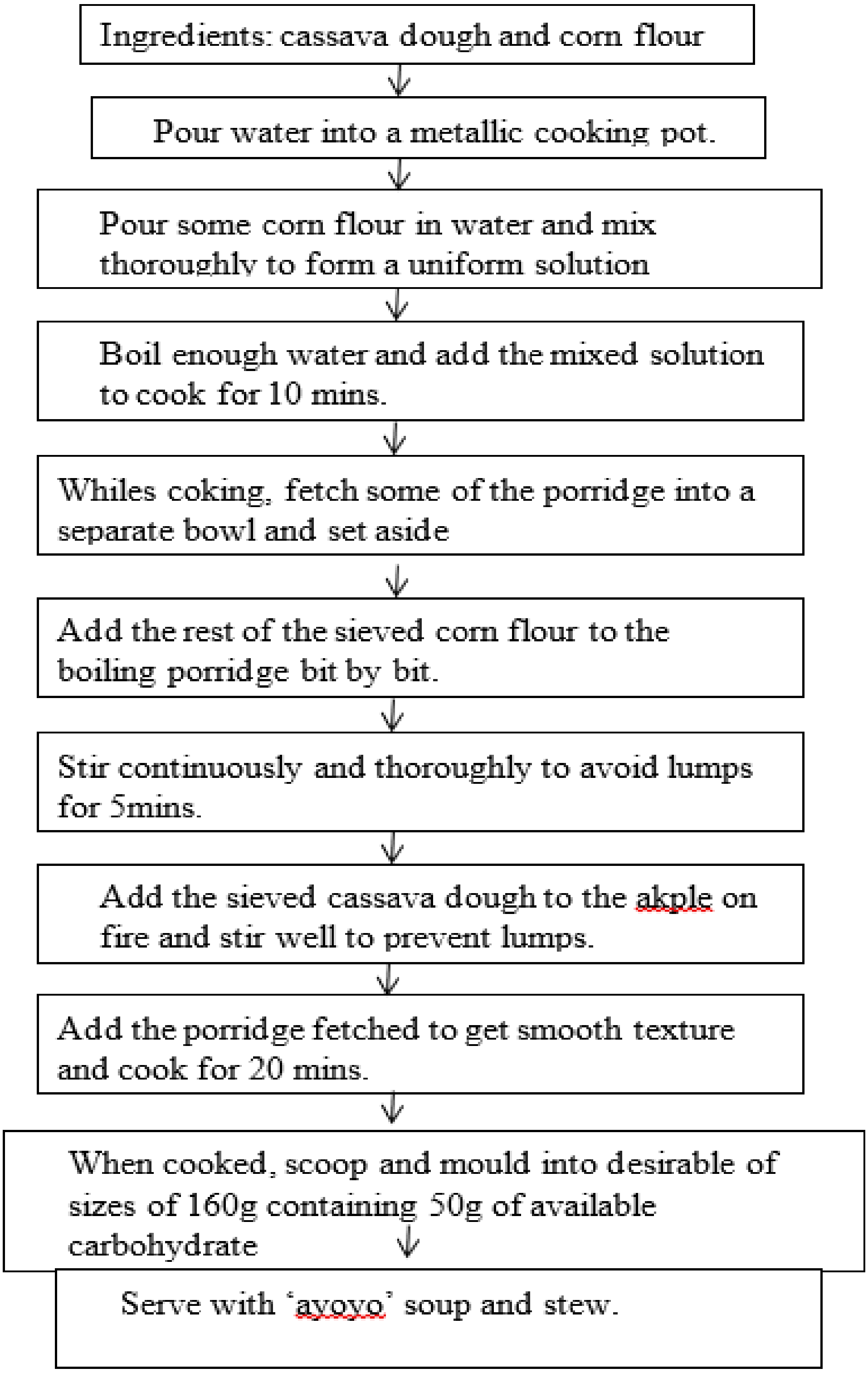

Figure 7: Flow chart for preparing Wordeme

Source: Researcher's Construct

Proximate Analysis

The proximate composition of each of the starchy foods without the sauce was determined. The analysis carried out were determination of:

a. Moisture

b. Ash

c. Protein

d. Fat

e. Fibre

f. Soluble carbohydrates

Moisture content

Ten grams of the sample was weighed into a clean moisture dish and dried in an oven for 48 hours at 105°C. After being taken out of the oven, the samples were placed in a desiccator to cool for 30 minutes and weighed were calculated. The following formula was used to calculate the samples' percentage moisture content:

Moisture content (%) =

$$\frac{\text{Weight of fresh sample} - \text{weight of dried sample(g)}}{\text{weight of fresh sample (g)}} \times 100$$

Ash content

The milled samples (Kokonte, Tuo-zaafi and Wordeme) were weighed at a rate of approximately 3 g into an empty, previously weighted crucible. The samples were heated to 100°C in a crucible for 24 hours. The crucible was taken out of the oven and put into a furnace, where it was heated to 550^{o}C. After cooling for 30 minutes in a desiccator, the crucible was taken out of the furnace and weighed. The following formula was used to determine the percentage of ash in the samples:

$$\text{Ash content (\%)} = \frac{\textit{Ash weight}}{\textit{weight of sample}} \times 100$$

Determination of Protein content by the Kjeldhal protein method

Weighing 0.2 g of the samples into various digestion flasks, then adding 4.5 ml of the digestion mixture, was used to calculate the protein content. On a digester, the samples in the flask were digested for two hours. The flasks were removed after digestion and let to cool. The solution was then placed into a 100ml conical flask after each flask had been cleaned with distilled water. Following a 20 ml aliquot of the solution, 10 ml of NaOH solution was pipetted into the distillation apparatus.

A 50 ml conical flask was also pipetted with 5 ml of boric acid. The unit's funnel was repeatedly positioned beneath each conical flask holding boric acid to collect 50 ml of the distillate. Using 1/140 MHCL, the distillate changed from green to red wine. The following formula was used to determine the sample's nitrogen content as a percentage:

% N = (S – B) x M x 14.007 x 100 x 100/2

Weight of sample (mg)

Where;

S = sample titre (ml)

B = blank titre (ml)

M = molarity of HCI

The following formula was used to determine the sample's protein content:

% protein = % N x 6.25, where 6.25 is the protein-nitrogen factor.

Determination of Fat content by Soxhlet Extraction

The milling samples (Kokonte, Tuo-zaafi, and Wordeme) were weighed into a 50 x 10 mm Soxhlet extraction thimble at a weight of about 10

g. The sample was then put into a Soxhlet extractor with a 50 ml capacity. Under the Soxhlet extraction device, a 250 ml round-bottom flask that was clean and dry was put. Using a heating mantle, 50 ml of petroleum ether was measured out, added to the Soxhlet extraction thimble containing the sample, and extracted for six hours. Later, the flat-bottom flask was taken out and put in an oven. The sample was baked for three hours at 60 degrees Celsius. The oil-filled round bottom flask was taken out, placed in a desiccator to cool, and then weighed. The following formula was used to determine the sample's fat content:

$$\text{Fat content (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Determination of Fibre content by solubilization

Weighing around 0.5 g of the samples into separate, previously dried crucibles allowed us to calculate their fibre content. The fibertec Hot Extraction Unit received the crucible. The sample was mixed with 100 ml of a concentrated H_2SO_4 (1.25%) solution, and the mixture was allowed to boil for exactly 30 minutes after it started to boil. The sample in the crucibles was cooked, then washed with hot distilled water, washed again, and then heated for an additional 30 minutes with 100ml of 1.25 NaOH. After being moved to the Fibertec cold extraction unit, the crucibles underwent a methanol wash. Later, the crucible was taken out, dried at 105 °C for an entire night, and weighed. The samples in the crucibles were ashed at 500°C for approximately 3 hours before being cooled and weighed in the desiccator. The following formula was used to calculate the percentage of fiber content;

$$\text{Fibre content (\%)} = \frac{\text{weight loss through ashing}}{\text{Weight of oven – dry sample}} \times 100$$

Soluble carbohydrates content

Using a conventional laboratory approach as described in FAO (2008) and Page, Miller and Keeney (1982) the amount of soluble carbohydrates in the sample was determined. The first process entailed material extraction, while the second concerned colour development.

Extraction of Materials

The materials were weighed into various 50 ml conical flasks at a weight of about 0.01 g, and 30 ml of distilled water was then added. The flasks' necks were fitted with a glass bubble, which was then simmered for two hours on a hotplate. The conical flasks were routinely topped off with distilled water to the 30ml level. After allowing the samples to cool, the solution was added, and a 50 ml volumetric flask with No. 44 Whatman filter paper was fitted with the solution. With distilled water, the solution was diluted to 50 ml. Using distilled water, a blank solution was also created.

Colour development

Standard solution in two (2) ml portions was pipetted into various combinations of boiling tubes. Additionally, another set of boiling tubes received two (2) ml of the extract pipetted into them. The boiling tubes containing the sample solutions and the blank received ten (10) ml of anthrone reagent, which was then completely mixed in a cold bath. Kokonte, Tuo-zaafi, and Wordeme were the milling samples that were placed in a beaker with boiling water, kept in a dark cabinet, and heated for 10 minutes. In the dark, the tubes were transferred from the boiling water to the cool water. Using the spectrophotometer, the optical densities of the sample and the control were determined at 625 nm (CE 1000 series). Plotting absorbance against concentration for the standard solution resulted in a calibration graph. Using the formula, the samples' glucose content (mg) was calculated.

$$\textbf{\textit{Soluble carbohydrates}}\ (\%) = \frac{\text{C (mg) x extract volume}}{\text{10 x aliquot volume x sample weight}}$$

Data Collection Instrument

For proximate analysis, the glycaemic response and glycaemic load of all food types as well as participants background data were evaluated using a glucose profile sheet (See Appendix A.) These tools were used to do proximate analysis on the different food types:

i. The amount of moisture: determined using the dry oven method

ii. Ash content: used total burning of food.

iii. Protein content: used Khjedah apparatus method.

iv. Desiccators, heating mantle, round bottom flask, Soxhlet extractor, thimbles for Soxhlet extraction, fat content utilized heat extraction for fiber content.

v. Spectrophotometric method used to determine the amount of soluble carbohydrates.

No. 44 Filter paper from Whatman, a pipette, boiling tubes, and a spectrophotometer.

Ethical Considerations

Before gathering data for the study, the Institutional Review Board (IRB) of the University of Cape Coast was consulted regarding ethical considerations. For the letter of approval, see Appendix B. Participants' willingness to take part in the study was again subject to informed consent. In no way were participants forced to take part in the study. In this study, privacy, anonymity, and confidentiality concerns received top importance. All potential study participants were addressed one-by-one after receiving IRB of UCC approval to request their consent to engage willingly in the study. Since other participants were not permitted to know about or access the anthropometric data of the other participant, ethical consideration and the privacy of the participants were completely confidential.

Persons interviewed for the study were given identity codes in order to preserve the confidentiality of their data. Pieces of material that were quoted from earlier research to support the review of related literature were correctly acknowledged through citation and referencing. Participants were recruited to participate in the study after they signed an informed consent form and had been fully informed about the investigation. This was especially crucial with regard to the ethical aspects of the study.

Data Collection Procedures

For formal authorization from the Research and Teaching Farm of the School of Agriculture, University of Cape Coast-Cape Coast (UCC) to conduct the proximate analysis and that of the hospital, an introductory letter was received from the Department of Vocational and Technical Education. The government hospital in Prestea-Huni Valley Municipality performed the blood glucose test. Blood samples of the participants were sampled and screened. The researcher recruited two health professionals and one research assistant to help during the data collecting stage.

The health professional assisted in taking the blood samples of participants and recorded the glucose levels after consumption. As a health professional, issues that required attention with regards to participants' health such as allergies, stomach pain and many more were dealt with. The research assistant helped to portion out the test foods for each participant and went over the rules to prevent them from contravening any planned activities that might have an impact on the study's findings. By educating every team member on data collection and other study procedures, ethical concerns were addressed.

Fasting Blood Glucose Test (FBGT)

People taking part in the OneTouch Glucose Test were pricked with a lancet to draw a drop of capillary blood after wiping the fourth left finger. 95% of individual glucose test results lie within 15mg/dl (0.83mmol/litre) over the glucose range, according to the manufacturer.

Each participant had their Fasting Blood Glucose (FBG) measured before the test was given that day.

Oral Glucose Tolerant Test (OGTT)

For each participant, a standardized glucose solution was made in five minutes using 50 g of glucose and 250 ml of water. The glucose solution was administered to subjects within five minutes using a timer. Following the consumption of the glucose solution, a sample of capillary blood was obtained from each participant and evaluated for its glucose content. At 30, 60, 90, and 120 minutes, participants' samples were collected to measure the levels of glucose. To ensure accuracy and precision on the first and second days of the data collection plan, the OGTT were administered at the scheduled time of 7:30 a.m.

Test foods

Each participant's test foods were weighed individually. Following the second OGTT, the first test meal sample (Kokonte with stew called "ayoyo") was administered. Participants were reminded of their 12 hour fasting after

8pm last meal. The fasting blood glucose test (FBGT) was taken when participants arrived at the hospital at 7:30am after wiping the finger tips with gauze pad or alcohol swab to collect blood sample.

The data was collected within five days after ethical approval for data collection was given to the researcher. The data collection started exactly at 7:30 a.m. early in the morning to check the Fasting Blood Glucose before the participants took in the reference food (glucose solution) and Test food (Kokonte, Tuo zaafi and Wordeme) at exactly 8:00 a.m. Each day's activity took two hours to complete for each participant. This made it simple to compare the levels of glucose before and after consuming the reference and test foods.

First and second days; participants were given Oral Glucose Tolerate Test (OGTT) and their blood samples were taken at 30 min intervals till two hours' (30^{th}, 60^{th}, 90^{th} and 120^{th} min). Third day; participants were served with Kokonte, fourth day they were given Tuo-zaafi and fifth day participants were served with Wordeme all with equal quantities of 'ayoyo' soup and stew. Their blood samples were taken at 30 minutes intervals till two hours (30^{th}, 60^{th}, 90^{th} and 120^{th} min) respectively. Participants were urged to abide by the directives not to engage in stressful activities or eat after 8 o'clock in the evening. Records of their previous meals were also taken.

Additionally, they were instructed to abstain from drinking and smoking throughout the experiment. Guidelines were followed throughout the data collecting stage of the study. The data was recorded in a sugar profile sheet as indicated in Appendix A.

Data Processing and Analysis

Each person's glycaemic response to eating test foods was determined by the incremental area under the glucose response curve (IAUC) of each participant using the trapezoid rule. The anthropometric data was analysed using statistical methods including percentile, median, mean, standard deviation, and coefficient of variation. The ratio of each test foods IAUC to the mean IAUC of the reference food, multiplied by 100 was used to determine each participant's percentage GI. This formula was employed:

$$\text{GI (\%)} = \left(\frac{\text{IAUC test food}}{\text{IAUC reference food}}\right) \text{ x } 100$$

The mean result obtained from all participants were then used to compute the GI of each test foods sample. The following formula was used to determine the GL of a typical serving of each test food:

$$\text{GL} = \frac{(GI\ x\ grams\ of\ carbohydrate\ in\ a\ serving)}{100}$$

Using IBM-SPSS version 21 for Windows, statistical methods were used to analyze the research objectives. The glycaemic loads of Kokonte, Tuo-zaafi, and Wordeme were calculated using statistical techniques (means and standard deviations). One-way Analysis of Variance (ANOVA) was used to assess the study hypothesis.

CHAPTER FOUR

RESULTS AND DISCUSION

Introduction

The study's findings regarding the glycaemic index and load of Kokonte, Tuo-zaafi and Wordeme are presented in this chapter. In response to the study questions and hypothesis, the findings are presented in two stages. After the test foods Kokonte, Tuo-zaafi and Wordeme had been consumed by the participants and the data on them were gathered. Additionally, data on the participants' anthropometric traits was gathered. The results are presented in tables, histogram, and a line graph for easy comprehension.

Anthropometric Characteristics of Participants

Descriptive data are provided for the subjects' anthropometric traits. The following metrics were utilized to analyse the anthropometric data: percentile, median, mean, standard deviation, and coefficient of variance. Anthropometric information of participants provided a brief background information about the participants. The anthropometric measurements for the ten participants have been presented in Table 4.

The study's 10 volunteers met all of the requirements required, according to the findings. They ranged in age from 18 to 60 and were all non-diabetics. Age, weight, height, waist circumference, and body mass index had mean values that ranged from 22.38 to 59.52. The respondents ranged in age from 19 to 56, with 19 being the minimum and 56 being the most.

Table 4: Anthropometric Characteristics of Participants

Characteristics	Age (yr)	Weight (Kg)	Height (cm)	WC (cm)	BMI (Kg/m^2)
Number	10	10	10	10	10
Mean	29.20	59.52	163.20	34.20	22.38
SE	1.53	2.16	3.32	0.80	0.57
Median	29.50	59.50	162.50	34.00	22.59
SD	4.83	6.85	10.49	2.53	1.80
Minimum	19	50.00	150.00	30.00	18.59
Maximum	36	74.00	187.00	38.00	24.43
Percentiles 25	26.75	55.23	154.00	32.00	21.26
Percentiles 75	32.75	62.75	168.50	37.00	24.00
CV	0.17	0.12	0.06	0.07	0.08

SE = standard error, SD = standard deviation, CV = coefficient of variation

Source: Anim (2021)

The mean age of the participants was 29.20 with an error margin of the mean was 1.53 which is low. The mean and median values of the ages of the participants were almost the same with the median value being more by 0.30 which does not make any significant difference. The 25th percentile of the ages was lower than the mean and median values. The 75th percentile value was about 33 and the difference in the two percentiles was six (6). The co-efficient of variation for the age was 0.17 which was the size of the standard deviation that was 17% of the size of the mean.

Looking at the ages presented, it can be deduced from the result that all the participants were adults per the age classification. According to the 1992 Constitution of Ghana, persons aged 18 years and above are classified as adults. This is an indication that the information collected from the participants for the study was more reliable since it came from adults.

The mean minimum weight of the participants was 50Kg while the maximum weight was 74Kg. A mean weight of 59.52Kg was determined for the participants. This indicates that the minimum and the maximum weights of the participants revolved around the mean value. Meanwhile, the median value of the weight was 59.50. The standard deviation was 6.85 and the standard error of the mean was 2.16. The weight fell into the 25th and 75th percentiles at 55.23 and 62.75, respectively. The co-efficient of variation was 0.12 and presents the size of the standard deviation of 12% of the size of the mean.

The least height as one of the anthropometric parameters of the participants was 150 cm and the maximum height was 187 cm. The difference in their heights was 37cm which was about four times the height of the shortest participant. The mean and median heights of the participants were 163.20 cm and 62.50 cm respectively. The heights of the participants were close to each other in terms of range.

The median height of the participants was practically equal to the mean height. When compared to the figures for the maximum and minimum heights, the standard error of the mean was roughly 3.0, which didn't appear excessive. The standard deviation value for the mean was 10.49 compared to the mean. This cannot be high since that of the mean was much more. The percentile values of 154 and 168.50 for 25^{th} and 75^{th} respectively also had a wide difference. The coefficient of variation calculated as the standard deviation size of mean was 6%.

Mean value of the waist circumference (WC) was 34.20 and this value was in the domain of the median value for waist circumference. The standard deviation of the waist circumference was found to be 2.53 while the minimum value of the same attribute was 30 cm and its maximum value was 38 cm. the 25^{th} and 75^{th} percentiles were 32 and 37 cm respectively. In the case of the co-efficient of variation for the waist circumference, 7% of the size of standard deviation has been found as presented in Table 4.

According to World Health Organization (2006) guidelines, the Body Mass Index (BMI) is one of the crucial anthropometric data factors that plays a key part in assessing a person's level of health. Based on the participants' weight and height, the Body Mass Index (BMI) values showed that the least value was 18.59 and the maximum value was also 24.43. In the case of the mean value, it was found to be 22.38.

The median figure also came out to be 22.59, indicating that the participants' average body mass index was between 19 and 24.43. The standard deviation was 1.80 and the standard error of the mean was 0.57. The percentile values for the 25^{th} and 75^{th} of the participants' body mass index were 21.26 and 24 respectively. The coefficient of variation around the standard deviation was calculated as 0.08.

The result in Table 4 shows that all the participants in the study met the WHO (2006) estimation of healthy persons with emphasis on obesity and diabetic persons. Healthy persons took part in the study and were accounted for in the chapter three of this thesis as those who met the inclusion criteria. In order to determine the nutritional status of the chosen participants who were deemed fit for the study, the basic anthropometric parameters such as weight, height, body mass index, and waist circumference were calculated. The study's selection criteria for participants confirmed that none of them were overweight, diabetic, or suffering from any other kind of metabolic condition. The Body Mass Index (BMI) also had a role in choosing study participants.

People who were overweight or obese as determined by their Body Mass Index (BMI) and excessive waist circumference were not chosen for this study. The determination of a food's glycaemic load and index are rendered invalid, according to WHO (2006) and Wormenor (2015), when BMI levels are outside of the recommended range. The anthropometric data of the current study therefore suggested that all other data collected from the ten participants with respect to this study have a firm grounding in theory. The result supports the fact that the ten (10) participants met the inclusion criteria outlined in this thesis. Waist Circumference (WC) is the current guidelines for assessing type 2 *Diabetes mellitus* (DM) recommended for patients BMI'S as the primary measure (Feller, Boeing & Pischon, 2010).

Research Question 1: What is the glycaemic index (GI) and glycaemic load (GL) of Kokonte, Tuo zaafi and Wordeme?

The three study foods Kokonte, Tuo zaafi, and 'Wordeme' were given to the participants with the proper accompaniments in order to answer the study's first research question, which was to determine the glycaemic index (GI) and glycaemic load (GL) of each food. A test food's glycaemic index shows how it may affect a person's blood glucose level. Glycaemic index of food is a measure from 0 -100 of carbohydrate in food quickly rise in the blood glucose of the blood while the glycaemic load is a number that estimates how much the food will raise a person's blood glucose level after it is eaten.The standard and equal amount of pure glucose is represented by the number 100. Normally, it is rated from zero (zero) to one hundred (100).

Low glycaemic index (GI) is defined as a GI of 0 to 55. Values between 70 and 100 are categorized as high GI and values between 56 and 69 as medium GI.

Glycaemic load of the studied food ranged from 57.64 – 35.98 i.e 35.86 for Wordeme and 57.64 for Kokonte respectively (Table 5). Tuo-Zaafi had a GL value of 42.10. Gycaemic loads of food of > 20 are classified as high, 11–19 as medium, and <10 or less as low) (Yeboah, 2017). Therefore the glycaemic loads Kokonte, Tuo zaafi and Wordeme were all high. Kokonte had the medium glycaemic index score of 68.50 whereas 'Wordeme' recorded the least and lower glycaemic index score of 50.03. The glycaemic index for Tuo zaafi was also found to be 51.16 as indicated in Table 4.

Table 5: Glycaemic Load, Mean Score of Kokonte, Tuo-zaafi and 'Wordeme'

Food Type	Glycaemic Load (GL)	Glycaemic Index (GI)
Kokonte	57.64	68.50
Tuo-Zaafi	42.10	51.16
'Wordeme'	35.98	50.03

Source: Anim (2021)

Ghanaian staples (Fufu, Ga-kenkey, Banku, and Tuo Zaafi) showed low to moderately high glyceamic index, according to earlier studies. The results of this study, in contrast to those reported by Yeboah et al. in 2019, showed that processed Kokonte had a medium glycaemic index. The components and production method may have contributed to the glyceamic index (GI) differences between Kokonte, Tuo zaafi, and Wordeme and the staples in the earlier tests. This study has proven that food processing techniques have an impact on GI. The majority of Ghanaian carbohydrates foods (such corn and cassava) go through a variety of processing steps before being ready for consumption. According to Englyst, Liu, S., & Englyst, (2007), a food's processing greatly affects its general characteristics, which have a big impact on how the body's physiological systems work.

Additionally, when a carbohydrate's physiological effect is changed, the glycaemic index value is directly impacted (Bahado-Singh, Riley, Wheatley, & Lowe, (2011). Factors like particle size, processing techniques, the nature of the starch, and antinutrients present have a significant impact on the physiological properties of food (Aston, Gambell, Lee, Bryant, & Jebb, 2008).

In general, and for the majority of foods, boiling is thought to raise the GI because it causes more gelatinization, which increases glucose response and improves starch digestion (Lin, Wu, Lu, & Lin, 2010; Bahado-Singh, Riley, Wheatley, & Lowe, (2011). This may account for Kokonte and Tuo-zaafi mild glyceamic index levels given their minimal fibre and high carbohydrate content. Also, Kokonte and Tuo-zaafi are prepared from cassava flour and polished corn and Kokonte (i.e., having cassava). The cassava might have affected the GI results. The ratio of amylopectin to amylose is greater in cassava. Due to its increased branching and susceptibility to digestive amylases, amylopectin would boost the glucose response (Arvidsson-Lenner, Asp, Axelsen, Bryngelsson, Haapa, Järvi, & Vessby, 2004).

Cassava went through a number of processing steps before being boiled for consumption. Processes include sun drying/fermentation, pounding, grinding, and sieving/shifting. 'Wordeme' and 'Tuo zaafi' had lower GI and Kokonte had a moderate GI but high glycaemic load.

Brand, Nicholson, Thorburn, & Truswell, (1985), claim that sun drying and cooling have an impact on starch breakdown, which has an impact on glycaemic response and glycaemic index values. Kokonte, Wordeme and Tuo Zaafi had a moderate GI rating, compared to Kokonte with a low GI and Wordeme with a high GI. Retrograded starches may have been present in small levels as a result of the hot temperature treatment and cooling cycles that happened during cassava flour manufacturing. The three test foods, Wordeme, Tuo Zaafi, and Kokonte, may have had a different glycaemic load depending on how they were prepared.

According to Eleazu, (2016), cooking methods do influence glycaemic index by either increasing or decreasing the glyceamic index. Glycaemic index is an essential component of calculating glycaemic load. In fact, glycaemic index must first be determined before the calculation of glycaemic load can be determined (GL = ((GI x grams of carbohydrate in a serving))/100). This therefore indicates that varying cooking methods and the amount of heat used could have effects on glycaemic index (GI) /glycaemic load (GL). The test foods in this case demanded a lot of heat application during cooking. In the case of Wordeme, 35 min was used whereas Tuo-zaafi and ‘Kokonte’ were cooked within 30 and 20 min respectively.

The cassava dough had a lot of starch and it contains water as well, therefore, during the Wordeme or Tuo zaafi preparation heat caused the disintegration of the starch and gelatinization which would lead to GI increase. High temperature and the presence of water during wet processing according to Eleazu (2016) cause an increase in starch granule disintegration and gelatinization. This could be the cause as to why the glycaemic loads were high in the test foods (Kokonte, Wordeme and Tuo -zaafi). At any point in time that the glycaemic index value increases, it makes the glycaemic load value also to increase. According to Brand-Miller (2003), Venn and Green (2007), Burani (2006), and Barclay, Brand-Miller, & Wolever, (2005), and maybe the preparation's temperature, the glycaemic load for the Kokonte was high. The water has to boil at the standard atmospheric pressure before the cassava flour is poured into the water. This temperature has to be maintained for some time before reduction. Even when extra water is added to make the food soft to taste, the heat has to be increased again.

Boiling of foods during processing has also been found to alter glycaemic index (Koussasi, Tiahou, Abodo, Camara-Cisse & Amani, 2009). It can therefore be noted that throughout the preparation stage, the heat has to be high almost at every stage. This may undoubtedly affect the rise in the glycaemic index, which directly affected the glycaemic load. The eating of the test foods in large quantities and on a regular basis increases the risk of type 2 diabetes. Literature available have also showed that type 2 diabetes can lead to heart related issues (Arvidsson-Lenner, Asp, Axelsen, Bryngelsson, Haapa, Järvi, & Vessby, 2004). Egba, Adimuko, Akokwu, Omeoga, & Okafor, 2017; Nnadi & Keshinro, 2016). The method of preparing the Wordeme, Tuo-Zaafi and the Kokonte which required application of more heat is likely to be the reason why digestion of the food into the blood stream was slow. This claim has a strong historical foundation in the literature (Bahado Singh, Riley, Wheatley, & Lowe, 2011; 20 Aston, Gambell, Lee, Bryant, & Jebb, 2008).

The test foods that have been examined glycaemic index can be changed by the heat used in cooking.

The heat from the sun used to dry the maize and cassava before preparing them into flour could also have an effect on their glycaemic load. Whereas Omolola, Jideani, and Kapila, (2015) and Donlao and Ogawa (2016) opined that sun drying may increase concentration of resistant starch and lower GI, this study rather recorded high GL for all the test foods. Any altering of the glycaemic index which has direct impact in the determination of the glycaemic load is bound to occur. Fermentation in cassava dough used in the preparation of Wordeme could be accounting for the rise in the glycaemic load as identified by Scazzina, Siebenhandl-Ehn, & Pellegrini (2009). Unfermented cassava dough is not used for preparing Wordeme. The fermentation of the cassava dough may have contributed to the elevated glycaemic load discovered in the current investigation.

Wordeme, Tuo Zaafi and Kokonte are all foods that have high glycaemic load values. Studies show that foods with high load affect a person's blood sugar level after consumption. The negative effect after the consumption of these foods would be a rise in the blood glucose. The interesting part of the glycaemic load foods is the constant consumption that could trigger its negative effect. It might be due to some of these reasons that dieticians advise individuals against the constant eating of a particular food over and over without changing the menu. They often recommend taking varied food to avoid such situations.

The detrimental impact on the person who eats the food may be lessened by the addition of vegetables and protein sources. Although

Wordeme in the current study had a relatively high glycaemic load, its impact on the rise in blood glucose level may have been significantly better than that of the other test foods. The nutrients composition such as proteins, fats and fibre in Wordeme were high compared with that of Tuo-zaafi and Kokonte. Wordeme might have had the least GL value due to high nutrients composition recorded and their effects on glycaemic index (GI) /glycaemic load (GL).

Glucose response to the three test foods showed that the concentration of the 'Wordeme' in the blood stream reduced faster as compared to Tuo Zaafi and Kokonte. Also, in the case of the food concentration in the bloodstream of the participants, Tuo Zaafi also declined quicker than Kokonte but picked up to increase again at the 120th min during the experiment, Kokonte had finally declined far more than Tuo Zaafi. The consumption of Wordeme, Tuo Zaafi and Kokonte by the community members in Prestea in the Western Region of Ghana, could pose challenges associated with high glycaemic foods. The result thus showed that Kokonte, digested faster than Tuo-zaafi and Wordeme and therefore absorbed into the bloodstream faster hence their GL values.

The response to the glycaemic index on the graph varied when the foods were ingested into the body. Participants in the study differed in their states of glycaemic response, as did some of the same participants. Other researchers have verified that the glycaemic response differs (Brouns, Bjorck, Frayn, Gibbs, Lang, Slama, 2005). People's reactions to food after ingestion may be responsible for variances in post-prandial blood glucose levels at various time intervals. Previous research on high-glycaemic meals suggested that type 2 diabetes could result from frequent ingestion of consumed foods (Willett, Manson, & Liu, 2002). The majority of type 2 diabetes cases are caused by dieting. The knowledge on the current study pointing to the fact that the tests foods took time to be absorbed into the blood stream would help to limit diseases associated with the consumption of high glycaemic foods.

Research Question 2: What is the effect of Kokonte', Tuo-zaafi' and Wordeme' on blood glucose level?

To address the second research question, the study also determined how Kokonte Tuo-zaafi and Wordeme affected consumers' blood glucose levels. In answering the research question two, the participants ate the test foods after their Oral Glucose Tolerant Test (OGTT) had been determined. The participants were fed with standardized glucose in the chemical laboratory condition after twelve hours fasting blood was drawn for the trial from capillaries, specifically from participants' fingertips because that procedure is thought to be more practical and better for gauging glycaemic response. The inclusion factor as the basis of controlling the experiment were all duly followed to the later.

The data were analyzed using the one-way ANOVA to look at this particular objective. Additionally, a Tukey HSD post-hoc analysis was performed to determine the locations of the actual differences. The Eta square value for the discrepancies was determined in order to quantify the disparities and to understand their margin. Tables 6 and 7 provide descriptive information about blood glucose levels of the test foods.

Table 6: Difference in Blood Glucose Levels of Tested Foods

Foods	Sample	Mean	SD	SE	F-value	df	p-value
Kokonte	3	28.60	0.38	0.22			
Tuo-Zaafi	3	24.66	0.22	0.13	453.974	2(6)	0.000
Wordeme	3	31.29	0.17	0.10			

Source: Anim (2021)

The data were analyzed using the one-way analysis of variance to see whether the different test foods had different effects on blood glucose levels. Three (3) groups of the test foods (Group 1: Kokonte; Group 2: Tuo-Zaafi; Group 3: Wordeme) were used. While the blood glucose level was taken into consideration as the dependent variable, the various food kinds evaluated were handled as the independent variables. There were variations in the subjects' mean blood glucose levels, as shown in Table 6. 'Wordeme' had a higher mean score (M = 31.29; SD = 0.17). This was followed by Kokonte (M = 28.60; SD = 0.38) and TZ (M = 24.66; SD = 0.22).

The average score indicates that the test foods consumed by the participants had an impact on their blood glucose levels. $F(2, 6) = 453.974$, $p = 0.000$, the One-Way ANOVA results showed that there was a statistically significant difference or effect of Kokonte, Tuo-zaafi, and 'Wordeme' on consumers' blood glucose levels. This shows that the individuals' meal choices have a statistically significant effect on their blood glucose levels. This result is in line with the findings of ICQC (2014), which said that the type of starchy foods people eat such as Kokonte, Tuo-zaafi, and Wordeme has a statistically significant effect on their blood glucose levels. Starchy foods, such as Kokonte, Tuo-zaafi, and Wordeme have a statistically significant effect on blood glucose levels in humans. The kind of starchy foods that are digested and absorbed slowly and thus cause a slow rise in blood sugar levels are classified as low GI foods. Examples of these foods include Kokonte, Tuo-zaafi, and Wordeme.

The difference in the type of food was examined using a post hoc test. This test was performed using Turkey HSD test. Table 7 presents the findings. As anticipated, there were statistically significant variations in the participants' mean blood glucose levels according to the kinds of foods they consumed.

Table 7: Post Hoc Tests of Multiple Comparisons using Turkey HSD test

(I) Foods	(J) Foods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Kokonte	TZ	3.94229*	.22143	.000	3.2321	4.6525
	Wordeme	-2.69074*	.22143	.000	-3.4009	-1.9805
TZ	Kokonte	-3.94229*	.22143	.000	-4.6525	-3.2321
	Wordeme	-6.63303*	.22143	.000	-7.3432	-5.9228
Wordeme	Kokonte	2.69074*	.22143	.000	1.9805	3.4009
	TZ	6.63303*	.22143	.000	5.9228	7.3432

*. The mean difference is significant at the 0.05 level.

Source: Field data, Anim (2021)

The mean blood glucose levels, for instance, differed statistically significantly between Kokonte (M = 28.60; SD = 0.38) and TZ (M = 24.66; SD = 0.22; p = 0.000) and Wordeme (M = 31.29; SD = 0.17). This significant difference was also observed between Tuo-Zaafi and Wordeme. The findings showing elevated blood glucose levels were caused by glucose are consistent with those of Yeboah (2017), who reported variations in the blood glucose levels of five Ghanaian staples corn and cassava. Yeboah (2017) reported a substantial difference between the test foods whose glycaemic indices were measured and the glucose tested as a benchmark food.

The results, on the other hand, contradict a study by Ofori (2019) that found no statistically significant difference between the different rice evaluated with regard to their blood glucose. Figure 7 shows visually the blood glucose levels of the various sample foods evaluated. The graph was drawn using the Oral Glucose Tolerance Test (OGTT), the test food results and the time. The timing of the participants when they were fed started with 30 min to 120 min. The interval between them was 30 min as it can be gleaned from Figure 8. Three test foods and glucose, a reference food, are shown on a line graph in Figure 8.

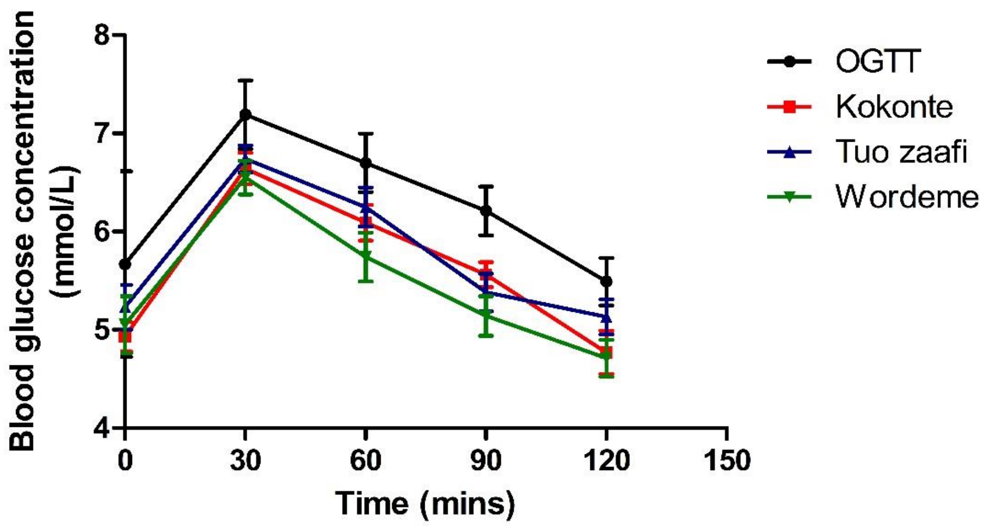

Figure 8: A line graph showing the glycaemic response of Test Foods

Source: Anim (2021)

From Figure 8, the reference food and test foods reached their peaks at the 30th min after consumption. The blood glucose concentration measured for the Oral Glucose Tolerant Test (OGTT) at time zero minute after consuming the glucose was 5.75mmol/L. At the 30th min, the OGTT curve reached its peak of 7.25mmol/L and started to decline to 6.75mmol/L in the 60th min. The decline continued in that order gently to the 90th min at 6.25mmol/L. The glucose concentration then declined and stopped at the 120th min at 5.5mmol/L. The graph clearly showed that the glucose absorption into the blood stream of the individuals was faster compared to the test foods (Wordeme, Tuo zaafi and Kokonte). All other responses to the test foods curves were beneath the Oral Glucose Tolerant Test (OGTT) curve. The curve for Tuo Zaafi at the zero minute, started at 5.25mmol/L while Wordeme's curve started at 5.1mmol/L and last but not the least test food being Kokonte started at 4.95mmol/L.

At the 30th min, after consuming the test foods, Tuo zaafi reached the peak slightly above the two other test foods at the same time. Kokonte also reached the peak at lower value than Wordeme. In the case of Tuo Zaafi, the participants' glucose concentration started to decline from the peak at the 30th min gradually except Wordeme. Wordeme declined in the blood stream from 6.35mmol/L at the 30th min to 5.5mmol/L at the 60th min seemed to be faster to decline steadily in their bloodstream from 6.65mmol/L at the 30th min to 6. 45mmol/L at the 60th min. Meanwhile, the blood glucose response for Kokonte decreased just a little below that of Tuo Zaafi from 6.65mmol/L at the 30th min to about 6.44 mmol/L at the 60th min.

At the 90th min, Wordeme continued to decline further below the curves of Oral Glucose Tolerant Test (OGTT), Kokonte and Tuo Zaafi to a level of 4.75mmol/L. However, 'Tuo Zaafi' started to increase a little from 5.35mmol/L at the 90th min to 5.45mmol/L at the 120th min. Meanwhile, the Kokonte had seen a sharp decline from 5.50mmol/L at the 90th min to about

4.75mmol/L at the 120th min. In general, it can be shown from the study of the test foods' glycaemic responses in relation to the reference food (glucose) that OGTT increased abruptly, peaked at the first 30 minutes, and then started to fall steadily until the 120th minutes. The three test foods also did increase to their peak on the 30th minutes but not to the maximum level of the control food. The three test foods begun to also decline to the 120th minutes but Wordeme further declined far below the other two test foods. It can therefore be concluded that the concentration of the Wordeme in the blood stream reduced faster as compared to Tuo Zaafi and Kokonte. In light of the meal kinds that were examined, Wordeme had the lowest GI. Also, in the case of the food concentration in the blood stream of the participants, Tuo Zaafi also declined quicker than Kokonte and picked up to increase again but at the 120th min, Kokonte had finally declined far more than Tuo Zaafi.

Wordeme prepared from cassava and plantain has a low glycaemic index (GI), which means that when it is consumed and digested, has no effect on blood glucose levels. This could be related to a study suggesting that fufu preparations are particularly good for diabetics (Yeboah, 2019). Consuming foods with a high glycaemic index might no significant blood glucose increases. People who eat a diet high in foods with a high glycaemic index (GI) have a higher chance of acquiring type 2 diabetes than those who consume a diet low in such foods. This may also raise the risk of heart disease, Type 2 diabetes, and even obesity. The recent investigation also confirmed the impact of a person's blood glucose level after consumption. The consumption of high glycaemic foods over the years would then accumulate in the body and eventually cause excessive secretion of insulin (Willett, Manson, & Liu, 2002). The Oral glucose tolerance test (OGTT) curve has demonstrated how long any of the test foods behaved in the blood stream after consumption.

Research Question 3: What are the nutritional components (proximate analysis) of Kokonte, Tuo-zaafi and Wordeme?

Investigating the nutritional profiles of "Wordeme," "Tuo Zaafi," and "Kokonte" was the third study question. Dry matter (DM), moisture, ash, protein, fat/oil, fiber, and carbohydrates were the main topics of discussion (CHO). The mean percentile score was used to analyze the proximal analysis. Table 8 illustrates the outcomes.

Table 8: Proximate Analysis of Kokonte, TZ and Wordeme

Foods	DM %	Moisture %	Ash %	Protein %	F/O %	Fibre %	CHO %
Kokonte	18.32	81.68	1.16	6.56	3.11	5.07	84.10
TZ	14.25	85.75	0.90	8.49	3.42	4.89	82.30
Wordeme	17.72	82.28	1.05	16.26	4.55	6.22	71.92

Source: Anim (2021)

As shown in Table 8, the nutritional components among the ‘Kokonte’, TZ and ‘Wordeme’ varied. The nutrients found in the test foods had shown that the percent moisture and the carbohydrate contents were more profound in the seven nutrients that were found. The percent dry matter (DM) content in ‘Tuo-zaafi’ was a little smaller than that of Kokonte and Wordeme. The last two test foods (Kokonte and Wordeme) seemed to have the same DM content. The estimated DM of Kokonte (18.32%) and Wordeme (17.72%) was higher than that of the Tuo zaafi (14.25%).

The percent moisture presence in the test foods were very high. TZ had the highest moisture content (85.75%) and Kokonte has the least moisture content (81.68%). The percent ash content in the three test foods were 1% for Kokonte, 0.90% for TZ and 1.105% for Wordeme. Percentage protein found however, seem to be a little high. The quantity for Wordeme was about twice the quantity of protein in Kokonte and Tuo-zaafi. The percent fat/oil also look very small in terms of the bar height. The percent fibre also looked small but it could be estimated to be about five. The last but not the least nutrient found in the test foods was carbohydrate.

Comparatively, the percent carbohydrate content in the Kokonte was about 84, Tuo-zaafi was 82 and that of the Wordeme was 71%. The result as presented clearly shows that the predominant nutrients found in the test foods was %DM, %moisture and % CHO. All the other nutrients content with respect to the test foods varied. However, the variations in the quantities relating to the same nutrient were marginal. These findings are connected to the research of Asante (2019), who discovered that the moisture content of boiled plantain was higher than that of yam and cassava, respectively, in terms of order of magnitude.

The finding that the test foods provide the nutrients that the human body requires was an intriguing aspect of the outcome. For instance, the test foods' protein content may contribute to building the body's necessary building blocks for healthy growth and development. This would make the body to support the entire system and limiting the use of protein product would pose a lot of danger to such persons. Fat/oil content in the test foods also shows how generally good the foods would help the body to contain heat and serves as shock absorbers in the system.

Carbohydrate as one of the profound nutrients generally would help the people in the study area to have enough energy for the body's daily use (Mann, Cummings, Englyst, Key, Liu, Riccardi, Summerbell, (2007a). The body's consumption of carbohydrates may have an impact on blood glucose levels. Type 2 diabetes and other cardiac illnesses could easily result from the blood's excessive glucose levels (Ludwig, Aronne, Astrup, de Cabo, Cantley, Friedman, Heymsfield, 2021). The essence of carbohydrate in a person's body cannot be over emphasized. However, more consumption of the same nutrient could also be disastrous to the body as well.

The test foods had high amount of carbohydrate in any serving and literature has indicated that much energy is obtained from carbohydrate. The study area is where a lot of manual or labour workers are. Farmers and miners especially are common in the study area and they need a lot of energy since their works demand such energy. The workers need energy to do their daily chores so eating of Wordeme, Tuo Zaafi and Kokonte may be at a higher demand by the workers.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study's summary, major conclusions, suggestions, and potential areas for additional research are all presented in this chapter.

Summary

The residents of Prestea in Ghana's Western Region were no exception to the widespread use of meals derived from cassava and maize. Prestea is a place where mineral mining and agricultural activities seem to prosper more. Hence, people from different ethnic areas within Ghana move there to work. This has contributed to different kinds of meal that people eat there. According to published research, the load of foods causes an increase in insulin production, which in turn raises blood glucose levels and causes diabetes and other coronary-related diseases.

The investigation to ascertain the glycaemic loads of Kokonte, Tuo-Zaafi, and Wordeme was inspired by the context of this. The finding(s) on the test foods serves as a scientific basis to influence decisions and policies on people's dieting. To direct the entire investigation, three research questions and a hypothesis were established. The pertinent theory and empirical review were explored to provide the investigation with a philosophical foundation. Ten volunteers who agreed to take part in the study comprised the participants. The criteria for inclusion of participants were that participants should be 18 years to 60 years old and should not have any glucose intolerance or of diabetic.

The main factor for inclusion was a healthy person as ascribed to by World Health Organization. The data for the study was in two main parts. The proximate analysis on the test meals made up the first portion, and the blood glucose test on samples taken from the individuals after they had eaten the test foods made up the second. Statistics methods such the median, mode, mean, standard deviation, ANOVA, and histogram were used to analyse the data. Tables were used to present the findings and the results.

Key Findings

The following is a summary of the study's key findings:

1. The glyceamic index of test foods indicated that Wordeme, Tuo-zaafi had a low glyceamic index valve and Kokonte had medium glycaemic index. Prior studies of Yeboah (2017) in similar study reported that Kokonte and Tuo-zaafi had low glycaemic index.
2. There was statistically significant difference in the blood glucose level of consumer based on food types. According to ICQC (2014) studies on this gave a glyceamic index that is similar to the study. (Effect on their blood glucose levels). Again, Yeboah (2017) discovered variations in the glucose of five Ghanaian staples including Kokonte and Tuo-zaafi.
3. Kokonte had a higher percent of dry matter (DM), ash, carbohydrate (CHO) compared to Tuo-zaafi and Wordeme. Irrespective of this, Wordeme had a higher percentages of protein, fat and fibre. Brouns, Bjorck, Frayn, Gibbs, Lang, Slama, (2005), Hettiaratchi, Ekanayake, Welihinda, (2012) and Wolever, Vorster, Bjorck, Brand - Miller, Brighenti, Mann, et al. (2003), study on the nutritional values of carbohydrate foods findings.

Conclusions

1. The glycaemic load of Wordeme and Tuo-zaafi were in low category whiles Kokonte had medium glyceamic index. They are good for consumption to prevent the impacts of high blood glucose. All the test foods had high glyceamic loads less than 20 taking them in moderation will lower blood glucose.
2. Examing the effect of blood glucose on the test foods. It concluded that Wordeme is better than Tuo zaafi, and Kokonte beacuase it declines fast after consumption and with higher mean in line with a study done by ICQC (2014).
3. The study revealed that nutritionally, Wordeme is better than Tuo-zaafi and Kokonte since it has high protein, fibre and fat.

The issue of the people in the study community, Prestea needs a lot of energy to do their hard labour during the day and thus feeding on ‘Wordeme’ provide requisite energy for their tedious work. It has been suggested that having too much oil and fat in the body can harm the human system. The minimal fat and oil content of "Wordeme" makes it beneficial for the body's healthy operation.

Recommendations

On the basis of the findings from this investigation, the recommendations below are given.

1. The consumption of ‘Wordeme’ with nutritious stew or soup is good for the body since its ability to raise glucose level is not all that high with respect to the other two test foods.

2. Dieticians/ Nutritionist /health professionals could recommend these foods to the individuals who may be struggling with controlling their blood glucose. This could easily be done by calling for town hall meetings and even on local radio stations to engage the entire community.
3. The cultivation of maize as one of the essential components for the preparation of Wordeme should be encouraged in communities since its presence in the preparation of Wordeme revealed least glycaemic load value.
4. Home Economics students could be engaged by opinion leaders in the community to come out with different recipes using maize since the carbohydrate level is less per the available literature.
5. The general population should be made aware of the effects of foods with a high glycaemic load by nutritional specialists. This could reduce the number of cases relating to diabetics.

Suggestions for Further Studies

It is recommended that more research be done on the glycaemic load of Wordeme and how it affects hypertension individuals in Prestea. Again, other grains and tubers could be substituted and compared for further research.

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APPENDICES

APPENDIX A

QUESTIONNAIRE

GLUCOSE PROFILE SHEET (SCREENING FORM)

Date……………… Time…………

1. Unique code ………………………………….
2. Gender: Male [ ] Female [ ]
3. Glucose level without taking product sample: ……………………….

   Non diabetic: [ ] Pre-diabetic: [ ] Diabetic: [ ]
4. Do you have past or present history of any of the following conditions:

   Cancer: [ ] Diabetes: [ ] Gastrointestinal disorder: [ ] Hepatitis: [ ]
5. Do you smoke or take alcohol? Yes [ ] No [ ]
6. Previous meal taken:…………………………………………

   Time:………………
7. Did you eat this morning before coming? Yes [ ] No [ ]

Characteristics of subjects that participated in the study

Subjects	Age(Yrs)	Weight(Kg)	Height(M)	BMI(kg/m^2)	WC(CM)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

GLOUCOSE PROFILE SHEET

Background Information

Code: …………………………….	BMI: …………………………
Age: …………………………….	Waist circumference: …………
Sex: ……………………………...	Last meal: ………………….......
Weight: ………………………….	Time of last meal: …………......
Height: ……………………………	

A 5-day Data collecting sheet

DAY	FBGT 7:30AM	OGTT 8:00AM	KOKONTE 8:00AM	TUOZAAFI 8:00AM	'WORDEME' 8:00AM
MONDAY	✓	✓			
TUESDAY	✓	✓			
WEDNSDAY	✓		✓		
THURSDAY	✓			✓	
FRIDAY	✓				✓

DATE………………TIME: 8:00AM……………………………

FASTING BLOOD GLUCOSE TEST: ……………..…………………

ORAL GLUCOSE TOLERANT TEST/ TEST FOOD: ………………

TIME INTERVAL	30MIN	60MIN	90MIN	120MIN

FAST BLOOD GLUCOSE TEST (FBS) TIME………

ORAL GLUCOSE TOLERANCE TEST 1 DATE……

	TIME INTERVAL- OGTT					
subjects	**FBST**	**30MIN**	**60MIN**	**90MIN**	**120MIN**	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

FAST BLOOD GLUCOSE TEST TIME………

ORAL GLUCOSE TOLERANCE TEST 2 DATE…

subjects	TIME INTERVAL					
	FBST	30MIN	60MIN	90MIN	120MIN	
1						
2						
3						
4						
5						

6						
7						
8						
9						
10						

KOKONTE

TIME……………………… DATE…………………….

SUBJECTS	**FBS**	**30MIN**	**60MIN**	**90MIN**	**120MIN**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

TUO ZAAFI 2a

TIME…………………….   DATE…………………………

SUBJECTS	FBS	30MIN	60MIN	90MIN	120MIN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

'WORDEME'

TIME…………………..   DATE…………………………

SUBJECTS	FBS	30MIN	60MIN	90MIN	120MIN
1					
2					
3					
4					
5					

6					
7					
8					
9					
10					

TUO ZAAFI 2b

TIME………. DATE……..

SUBJECTS	FBS	30MIN	60MIN	90MIN	120MIN
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

APPENDIX B

CLEARANCE LETTER FOR DATA COLLECTION

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309
E-MAIL: irb@ucc.edu.gh
OUR REF: UCC/IRB/A/2016/1213
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

17TH JANUARY, 2022

MS. Emelia Otukuor Anim
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms. Anim,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2021/102)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research titled **Glycaemic Load of Kokonte, Tuo-Zaafi and "Wordǫme".** This approval is valid from 17th January, 2022 to 16th January, 2023. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST

APPENDIX C

CONSENT FORM

I'm an MPhil candidate at the University of Cape Coast's Department of Vocational and Technical Education. The " Load of Kokonte, Tuo Zaafi, and Wordeme" study is something I'm working on. The success of this study depends heavily on your participation. You will be needed to submit to a blood glucose test if you accept to participate. To ensure accuracy in the fasting blood glucose test, you will be required to complete a 12-hour fast, which means you won't be allowed to eat after 8 p.m. on the night before the test. For each of the four tests, a two-week period with four sessions lasting two and a half hours each will be necessary (glucose solution, Kokonte, Tuo zaafi and Wordeme). After eating, capillary blood will be collected from your finger tips and analyzed for blood glucose after 30, 60, 90, and 120 minutes. Since trained laboratory professionals will be pricking participants' fingers, care will be made to reduce any potential pain or discomfort. At the conclusion of each test session, you will be given lunch, and transportation to the hospital will be taken care of. Since participation is wholly optional, you are free to stop at any moment without incurring any fees. The Institutional Review Board of the University of Cape Coast has examined and approved this study (UCCIRB). You can speak with the Administrator at the IRB Office between the University of Cape Coast if you have any inquiries regarding your rights as a study participant. Sam Jonah Library128 between the hours of 8:00 am and

4:30 pm via phone at 0332133172 and 0244207814, or by email at irb@ucc.edu.gh.

You have agreed to participate in this study by signing below.

Participant's Signature: ………………………. Date: ………………………..

Name (Initials): ………………… Telephone number: ……………………

E-mail: ………………………………………………………………………..

I hereby agree to be bound by the terms and conditions set forth in this contract, and my signature appears below.

Researcher's Signature:…………………… Date: …………………………

Name: Miss Emelia Otukuor Anim MPhil Home Economics (Food and Nutrition) Telephone number: 0244093711/ 0202066238

APPENDIX D

Load for Test Foods

*GL_Hypo_data_set-Emilia.sav [DataSet1] - IBM SPSS Statistics Data Editor

File Edit View Data Transform Analyze Graphs Utilities Extensions Wind

	PANALIST	Food_type	GL	var	var
1	1	1	36.02		
2	1	1	35.87		
3	1	1	36.07		
4	2	2	42.20		
5	2	2	42.04		
6	2	2	42.08		
7	3	3	57.74		
8	3	3	57.55		
9	3	3	57.54		
10					

APPENDIX E

Pictures of the Test Foods

Kokonte

Tuo Zaafi

Wordeme

APPENDIX F

Recipe for 'Ayoyo' Soup and Stew

INGREDIENT	QUANTITY	METHOD/STEP
'ayoyo' leaves	2 bundles	1.Remove, wash and chop the 'ayoyo' leaves into smaller pieces.
Offal (internal part of mammals)	1 Kg	2.Chop onion into smaller sizes.
Salt peter (potassium nitrate	To taste	1. Add chopped onion, powdered fish, salt petre, dawadawa to boiling water of 100^{0}C and add 'ayoyo' leaves to cook for 20 minutes till it becomes very soft.
Salt	To taste	2. Stir vigorously to further break the leaves into smaller pieces and slimy texture for 5min.
Dawadawa	1 large	5. Remove from fire and serve 2 ladles each equivalent to 50mls.
Ground pepper	3 tsp	**Accompanying stew** 1. Cut offal into preferable sizes, wash, marinate and put into a cooking pot for 15min.
Onion	3. Large	2.Simmer the chopped meat over medium heat for about 10 min.
Seasoning	To taste	3.Heat palm oil on a medium heat, add blended onions, ginger, garlic to the oil and stir until tender and starting to brown for 15min.
Fish seasoning	200 g	4.Add ground pepper, tomato puree and stir intermittently
Spices	To taste	5. Wash salmon and offal and add to the stew as well as all seasonings then allow to cook for 25 min.
Fresh tomatoes	10 medium sizes	6. Remove from fire, transfer it into a bowl and set aside
Tomato puree	250 G	7.Serve one ladle each with 25 g of proteins to participants
Smoked fish salmon)	1 medium each	

Source: Field data, Anim, 2021