DEVELOPMENT AND VALIDATION OF PHOTOGRAPHIC FOOD ATLAS OF DOMESTIC MEASURES AND CARBOHYDRATE SERVINGS OF SELECTED FOODS CONSUMED BY DIABETIC PATIENTS IN ENUGU STATE

BY

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FACULTY OF AGRICULTURE
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TITLE PAGE

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RESEARCH WORK SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN HUMAN NUTRITION

DEPARTMENT OF HUMAN NUTRITION AND DIETETICS
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APRIL, 2021

APPROVAL PAGE

This research work has been approved by the Department of Nutrition and Dietetics, University of Nigeria, Nsukka.

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CERTIFICATION

MADUFORO, ALOYSIUS NWABUGO, a postgraduate student with registration number PG/Ph.D/16/83442 in the Department of Nutrition and Dietetics, University of Nigeria, Nsukka has satisfactorily completed the research work for the award of the Degree of Doctor of Philisophy (Ph.D) in Human Nutrition (Community and Public Health Nutrition). The work embodied in this thesis is original and has not been submitted in part or full for any other diploma or degree of this or any other university.

Prof. U. A. Onyechi
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DEDICATION

This thesis is dedicated to the Almighty God for the Life, Good Health, Sound Mind, Grace, Mercy, Wisdom and Strength He granted me to complete this work.

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ABSTRACT

The study developed and validated photographic food atlas using domestic measures (DOM-M) such as serving spoons of edible portions of foods that would supply a specific amount of carbohydrate (carbohydrate servings) and energy. The objectives of the study were to: (1) identify commonly consumed locally available foods by adult diabetic patients seeking the services of Dietitian-Nutritionists in Out-patient department of selected hospitals in Enugu State; (2) determine the proximate (protein, fat, carbohydrates, fibre and ash) composition of the selected foods; (3) develop photographic food atlas with portion sizes of domestic measures and carbohydrate servings (10g, 15g, 20g, 30g and 45g of carbohydrates) of the selected foods and (4) validate the photographic food atlas with portion sizes of domestic measures and carbohydrate servings (10g, 15g, 20g, 30g and 45g of carbohydrates) of selected foods. A cross sectional survey design was used to sample diabetic patients seeking the services of Dietitian-Nutritionist in Out-patient department of selected hospitals in Enugu state to identify the commonly consumed foods. Twenty three (23) foods were purposively selected from foods with higher frequency ($\geq$20 points) among commonly consumed foods and analyzed for their proximate (moisture, protein, carbohydrates, ash, fat and crude fibre) composition using standard methods. The energy content was calculated using Atwater factors for the energy giving food nutrients (carbohydrate [4kcal/g], protein [4kcal/g] and fat [9kcal/g]). Standardized photographs of different portion sizes of the selected foods that will supply 10g, 15g, 20g, 30g, 45g of carbohydrates and photographs of different sizes of domestic measures were captured and their weights recorded. The photographs were formatted in an A4 size paper. Each page contained 3 to 8 photographs. The photographs were validated by out-patient diabetic patients attending selected hospitals. Data were analyzed using mean, standard deviation, percentages, Chi square and student t-test. Statistical significance level was accepted at $p<0.05$. Rice dishes (rice + stew and jollof) was the most frequently consumed food among the patients while macaroni+rice and macaroni were the least commonly consumed. The energy and proximate composition showed that among the banana varieties, red decca had the highest (19.5g/100g) carbohydrate content and green mutant had the lowest (12.3g/100g). Energy was highest (125kcal/100g) in green mutant and least (95kcal/100g) in gross Michel banana variety. The carbohydrate in pineapple, green apple, red apple, pawpaw and watermelon were 18.75g/100g, 16.84g/100g, 15.18g/100g, 13.75g/100g and 4.51g/100g respectively. Local dishes with highest fat were *achicha* (27.2g/100g), *ayaraya-ji* (11.8g/100g), *ayaraya-oka* (16.0g/100g), *abacha* (4.4g/100g), *okpa* (10.8g/100g) and *igbangwu-oka* (13.7g/100g). The carbohydrates in them ranges from 5.0g/100g in *Igbangwu-oka* to 32.1g/100g in *okpa*. The rice dishes had carbohydrates ranging from 13.2g/100g in fried rice prepared with long grain (foreign) rice to 27.9g/100g prepared with basmati rice. The photographic food atlas developed contained 232 photographs from 23 food samples. The mean weights of the different edible food portions that will supply specific amount of carbohydrate and energy were recorded. The validation result showed that 50.1% scored 50% and above while 33.3% scored <40%. This study developed and validated a veritable visual aid for portion size estimation foods.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Photographs have been employed as a veritable teaching aid since ancient times. Individuals remember more easily the image they have seen, more than description without an image (Triacca, 2017). The use of photographs can make nutrition education or dietary counselling session lively, engaging and effective catalyst for communication (Flannery, n.d.; Okeke, 2014; Triacca, 2017). Images are utilized in several scenarios to communicate messages and ideas effectively (Flannery, n.d.; Okeke, 2014). Photographic food atlas is a picture compendium of food in a single booklet specific to a locality (Boateng, 2014; Flannery, n.d.). Photographic food atlas is usually presented in dissimilar food portion sizes ranging from three (3) to eight (8) (Boateng, 2014; Nelson & Haraldsdólttir, 1998a, 1998b). Thus, different serving sizes could be measured based on weight or household measures. The pictures usually show the edible food portions that make a serving. However, pictures of measures such as domestic measures such as cups, plates, spoons, and cans of different sizes may be captured to clarify the illustration in the pictures for easier understanding (Boateng, 2014; Huybregts, Roberfroid, Lachat, Van Camp & Kolsteren, 2008; Nelson, 1998; Nelson & Haraldsdólttir, 1998a).

Photographic food atlas is one of the nutrition communication tools utilized in the estimation of portion sizes of foods clients consume at home or outside the home (Foster et al., 2008; Marjan, 1995; Small et al., 2010). It is also used in the education of clients on food portion sizes which supports better dietary counselling and self-management. The use of photographic food atlas during dietary counselling facilitates comprehension of healthy dietary modification for healthy living as well as easy adaptation at home (Marjan, 1995; Ovaskainen *et al*., 2008; Triacca, 2017).

Thus, clients for effective self-management at home to achieve the desired health goal could also use the photographic food atlas. During food consumption surveys, photographic food atlas could be used as a tool to estimate the quantity of foods consumed by respondents.

Diabetes is a severe, chronic condition that occurs when the body is unable to produce any or sufficient insulin or cannot effectively use the insulin it produces (International Diabetes Federation, 2019). The main categories of diabetes are type 1, type 2 and gestational diabetes mellitus, however, type 2 diabetes mellitus forms 90% of all diabetes cases globally (International Diabetes Federation, 2015, 2019). Diabetes is a major health challenge in both developed and developing countries. The prevalence of diabetes has reached alarming levels today, about half a billion people are living with diabetes globally (International Diabetes Federation, 2019). Ghana, which is located in West Africa houses about 19 million persons living with diabetes mellitus and it is projected to increase by 143% (47 million) in the years 2045 (International Diabetes Federation, 2019). In Nigeria, type 2 Diabetes mellitus client are the most common clients seen by dietitians in the hospital settings in Enugu state.

However, other adult clients/patients who seek dietary counselling in Nigeria suffer from other chronic nutrition-related diseases such as hypertension, obesity, chronic kidney diseases, liver diseases and others. Report show that 56 million deaths occurred in 2012, out of these death; 38 million resulted from non-communicable diseases (NCDs) which included cancer, cardiovascular diseases and chronic respiratory diseases (World Health Organization, 2014). It was reported in Nigeria that 27% of the total deaths in 2008 resulted from NCDs (Federal Ministry of Health, 2015). Unhealthy diet, obesity, tobacco use, sedentary lifestyle among others have been implicated as major causes of NCDs in Nigeria (Federal Ministry of Health, 2014, 2015).

The development of a photographic food atlas that will stand the test of time and effective to achieve the purpose of estimating portion sizes of foods demands that it goes through the required production cycle and process in order to achieve its purpose. One of the most important stages in the photographic atlas development is the determination of the nutrient composition of foods. Thus, all foods and food products demand chemical analysis in the food analysis laboratory to determine the nutrient composition of the particular food(s) in the locality (Nielson, 2010). In every food analysis, the proximate (moisture, fat, carbohydrates, protein, ash and crude fibre) composition is always the initial focus due to its importance in supplying energy, build body tissues and produce chemicals like hormones and enzymes for major body processes (Mahan, Escott-Stump, & Raymond, 2012). It has been reported that macronutrients (lipids, proteins, and carbohydrates) constitute the main structural components of foods (Nielson, 2010). An accurate quantitative and qualitative determination of nutrient and phytochemical composition of foods is vital for accurate nutritional labeling, determination of whether the food meets the standard of identity and to ensure that the product meets manufacturing specifications (Nielson, 2010). The knowledge of the nutrient composition of foods will enable the calculations involved in estimating the accurate nutrient content in a portion of food.

A portion has been defined as the amount of food that one chooses to eat at a sitting and the selected portion may be smaller or larger than the standardized serving of the food (Nelson & Haraldsdólttir, 1998a). Portion size estimation is one of the difficult aspects in medical nutrition therapy during dietary assessment in Nigeria. Estimating the nutrient and energy intake of clients has been based on assumptions and studies carried out in other countries which do not reflect the actual local foods in Nigeria (Food and Agriculture Organization, 2012). However, a new food composition table for use in Nigeria was launched recently which reflects the nutrient composition of foods in Nigeria, the food composition table did not capture all foods consumed in Nigeria, and do not reflect the nutrient composition of different domestic portion sizes of foods especially, composite dishes (Sanusi, Akinyele, Ene-Obong & Enujiugha, 2017). Standardization of domestic portion sizes helps to quantify food and nutrient intake during dietary assessment and counselling (Boateng, 2014). It is also an indispensable aspect of nutrition and health promotion (Boateng, 2014; Foster, Hawkins, Simpson & Adamson, 2014; Foster et al., 2008). Reports abound that most people are ignorant of what makes up a portion size and this has been linked to their inability to control the portion size they consume at a time (Byrd-Bredbenner & Schwartz, 2004). Large portion sizes at meal times have been implicated as a predisposing factor to obesity as well as other non-communicable chronic diseases (Fisher, Rolls, & Birch, 2003; Rolls, Roe, Meengs, & Wall, 2004).

A number of studies have reported the benefits of using photographs to help clients/patients assess portion sizes and nutrient composition of foods they consume (Boateng, 2014; Chambers, Godwin & Vecchio, 2000). Food photographs depicting standardized portion sizes organized in an atlas are helpful in improving the accuracy of food quantification (Byrd-Bredbenner & Schwartz, 2004; Faggiano et al., 1992; Turconi et al., 2005). It has been reported that the number and size of photographs in an A4 sheet vary from three to eight photographs per page (Boateng, 2014; Lombard, Steyn, Burger, Charlton, & Senekal, 2013). Some authors concluded that increasing the number of photographs per food in a page may help improve reporting accuracy (Boateng, 2014; Chambers et al., 2000; Lombard et al., 2013). In Africa, the validity of using food photographs for estimation of portion size has been tested in South Africa, Ghana, and Burkina Faso (Boateng, 2014; Huybregts et al., 2008; Korkalo, Erkkola, Fidalgo, Nevalainen & Mutanen, 2013; Venter, MacIntyre & Vorster, 2000). Studies are yet to be conducted in Nigeria on photographic food atlas and there is none available for use for Nigerian Dietitian - Nutritionist

1.2 Statement of the Problem

Nutrition-related diseases which require dietary modification have been on the increase as the major contributor to death and disability in Africa. In the year 2000, it was reported that 7 million adults were afflicted with diabetes in the African region, 14.2 million in 2015 and it is estimated that by 2040 this figure will increase to 34.2 million adults (International Diabetes Federation, 2015). A recent report showed that the probability of dying between ages 30 and 70 years from the four main forms of NCDs (CVDs, diabetes, cancer and Chronic respiratory diseases) in Nigeria is 20% (World Health Organization, 2014). There is high prevalence of CVDs in Enugu State which was reported to be 20.46% (Oguanobi et al., 2013). Material resources for the treatment of diabetes in most African countries are either scarce or unavailable and most often unaffordable for many diabetic patients (Onyechi, Ibeanu, Eme, & Ossai, 2013). The prevalence of CVD is rated at There is an increase in the prevalence of cancer cases in Nigeria. It has been documented that about 100,000 of cancer incidence occurred in the year 2011 in Nigeria (Federal Ministry of Health, 2015). Hypertension is the most commonly known CVD in Nigeria (Federal Ministry of Health, 2015). General data from the earlier national survey carried out in 1991/92 reflected that the prevalence of hypertension was greater than 20% while hospital medical records in Nigeria projected the prevalence at about 25% in 2015 (Federal Ministry of Health, 2015).

Based on personal clinical experience, another chronic condition that propels clients/patients to seek the services of Dietitian-Nutritionist in Nigeria is obesity and dyslipidemia. Obesity is one of the major causes of all the other non-communicable chronic diseases. Excessive energy intake without corresponding energy expenditure is the major cause of obesity worldwide (Rolfes, Pinna & Whitney, 2006; Webster-Gandy, Madden & Holdsworth, 2006). To solve the problem of excessive energy intake, there is the need for people to be educated on portion size control as most individuals lack knowledge of the nutrient and energy composition of the local foods they consume in Nigeria. Even when people have an idea of the major nutrient composition of a staple, studies on the nutrient composition of composite meals are scarce or unavailable as most studies in Nigeria including the food composition databases for use in Nigeria has reported main single foods. The energy and nutrients present in a portion are also, not known by most people including nutrition professionals.

A report has shown that most of the data used in Nigeria for dietary counselling are based on studies conducted in other countries which may not reflect the accurate nutrient composition of foods found in Nigeria (Food and Agriculture Organization, 2012). There is need therefore to determine the nutrient composition and develop photographic food atlas of different portion sizes of locally available staples, fruits, and vegetables for accurate evidence-based information to enable effective dietary counselling, nutrition communication and dietary intake studies.

The difficulty associated with individuals' capacity to control how much they eat may be as a result of the difficulty they encounter in estimating portion sizes and the nutrients in them (Byrd-

Bredbenner & Schwartz, 2004). Access to easy and reliable tools to estimate the quantity of food and nutrient intake will help nutrition professionals educate and counsel individuals and groups to make healthy food choices (Boateng, 2014).

Portion size estimation is a very important activity required during dietary assessment which is first step of nutrition care process (Nelson & Haraldsdólttir, 1998a). Presently in Nigeria, locally produced unstandardized food models unlike standard cups used in the United States and other developed countries are the only dietary aids used in portion size estimation by nutritionist – dietitians and nutrition-related professionals. However, the nutrient composition of foods using the domestic measures are usually based on estimation from single foods which are subject to errors. Considering the usefulness of the photographic food atlas, it is imperative that such a tool for commonly consumed local and traditional Nigerian foods is developed and validated for use in the country.

1.3 Objectives of the Study

The broad objective of this study was to develop and validate photographic food atlas of domestic measures and carbohydrate servings of selected foods consumed by diabetic patients in Enugu State.

1.3.1 Specific objectives

Specific objectives of the study were to:

1. identify commonly consumed locally available foods consumed by adult diabetic patients seeking the services of Dietitian-Nutritionist in out-patient department of selected hospitals in Enugu state;
2. determine the proximate (protein, fat, carbohydrates, fibre and ash) and energy composition of selected foods consumed by adult diabetic patients in Enugu State;

3. estimate portion sizes of foods using domestic measures and portion sizes of carbohydrate servings (10g, 15g, 20g, 30g and 45g of carbohydrates) of the selected foods;
4. determine the proximate (protein, fat, carbohydrates, fibre and ash) and energy composition of selected foods in each domestic measure and portion sizes of carbohydrate servings (10g, 15g, 20g, 30g and 45g of carbohydrates);
5. develop photographic food atlas with portion sizes of domestic measures and carbohydrate servings (10g, 15g, 20g, 30g and 45g of carbohydrates) of the selected foods,
6. validate the photographic food atlas with portion sizes of carbohydrate servings (10g, 15g, 20g, 30g and 45g of carbohydrates) of the selected foods;
7. assess the socio-demographic, anthropometric and personal characteristics of the validators and
8. compare the relationships between validation result with the socio-demographic, anthropometric and personal characteristics of the validators

1.4 Significance of the Study

It is hoped that awareness of the existence of a photographic food atlas of commonly consumed foods eaten by adult diabetic patients in Enugu state will be created through seminars, workshops, conferences and journal publications.

Access to a validated photographic food atlas of commonly consumed foods eaten by adult diabetic patients will aid Dietitian-Nutritionists in nutrition education/communication, and dietary data collection/counseling of patients and clients

Data derived from using photographic food atlases can be used by Nigerian Nutritionist – Dietitians to plan and evaluate diets for patients and also to plan menus for institutional food service as used by Dietitian-Nutritionists in developed countries.

The result of this study will serve as a baseline for further studies in the development and validation of food photographs of other foods eaten in different parts of Nigeria. A complete food photograph atlas will help dietitian and nutrition experts, as well as other health professionals to counsel, plan and recommend the appropriate therapeutic dietary interventions and treatment.

The output of this study may also be used as a nutrition intervention tool aimed at modifying commonly consumed dishes to improve dietary intake.

Information derived from this study will also provide credible reference material for nutrition and dietetic research.

This study will also, serve to reveal the proximate composition of locally available foods from composite dishes eaten by adult diabetic patients seeking the services of dietitian-nutritionist in the out-patient department in selected hospitals in Enugu state.

The knowledge of portion sizes and the corresponding energy and nutrient composition will help clients and patients manage their conditions better.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Diet-related non-communicable disease

Non-communicable diseases (NCDs) are group of diseases that are chronic in nature, not contagious but reduce the quality of life of the affected individuals and can also lead to death (Federal Ministry of Health, 2014). Diet-related non-communicable diseases (NCDs) as the name implies are those diseases which have a dietary link in their etiology, risk factor and management (Nutrition and Noncommunicable Diseases eGroup, 2011; World Cancer Research Fund International and The NCD Alliance, 2014; World Health Organization, 2011). The control of what we eat, play an important role to prevent, delay or control the onset of such diseases (World Cancer Research Fund International and The NCD Alliance, 2014). More so, in most cases, diet play an important role in the treatment and management of such diseases. Common NCDs in Nigeria include: Cardiovascular diseases including hypertension, Diabetes mellitus, Chronic respiratory diseases and Cancer (Federal Ministry of Health, 2014).

Dietitians and nutritionist in the clinical and community settings are saddled with the responsibility of counselling individuals with diet-related NCDs or providing nutrition education to healthy individuals on how to prevent them. It has been documented that what we eat and our nutritional status has the capacity to influence the delay, prevent or onset of cardiovascular diseases, some types of cancer and diabetes (Federal Ministry of Health, 2015; Nutrition and Noncommunicable Diseases eGroup, 2011; World Cancer Research Fund International and The NCD Alliance, 2014; World Health Organization, 2011). Foods, diet and nutritional status, including overweight and obesity have been scientifically linked to elevated blood pressure, blood cholesterol, and resistance to the action of insulin (diabetes) (Popkin, 2006; World Cancer

Research Fund International and The NCD Alliance, 2014). These conditions are not only risk factors for NCDs, but main causes of chronic diseases, morbidity and mortality (World Cancer Research Fund International and The NCD Alliance, 2014).

There is huge global health threat posed by non-communicable diseases both in developed and developing countries (Nutrition and Noncommunicable Diseases eGroup, 2011). Global report documented that NCDs are responsible for 63% of 57 million deaths and they are disproportionately high in lower and middle income countries (LMIC) and populations (Nutrition and Noncommunicable Diseases eGroup, 2011). In another report, NCDs have been accredited to be the leading cause of death globally killing 36 million people every year. It was also projected that NCDs would increase by 17% in the next 2025 years in high income countries and by 27% in the developing countries especially in Africa (Federal Ministry of Health, 2014; Nutrition and Noncommunicable Diseases eGroup, 2011; World Cancer Research Fund International and The NCD Alliance, 2014). It is estimated that more than 30% of healthcare cost will go for the management of NCDs in the next 10 years (Federal Ministry of Health, 2014). Total NCD mortalities are estimated to increase to 52 million by 2030; additionally, NCDs are estimated to cause almost 75 percent as many deaths as communicable, maternal, perinatal and nutritional diseases by 2020 and to exceed them as the most common causes of death by 2030 (Nutrition and Noncommunicable Diseases eGroup, 2011).

Domestic report in Nigeria have revealed that in the 1990 – 1992 national survey on NCDs, the prevalence of hypertension was 11.2% while that of diabetes mellitus was 2.7% (1.05 million Nigerian above 15 years). However, with the definitional shift of 140/90mmHg in 1999, the prevalence of hypertension now exceeds 20% (Federal Ministry of Health, 2014). It has been predicted that the probability of dying between ages 30 and 70 years from the 4 main from NCDs (CVDs, diabetes, cancer and Chronic respiratory diseases) in Nigeria is 20% (World Health Organization, 2014).

Major risk factors linked to NCDs are broadly categorized into: lifestyles/personal behavior, genetic predisposition and environmental factors including climate change (Federal Ministry of Health, 2014). Above half of these three categories of risk factors are accrued from poor lifestyle choices which are modifiable such as drug use, harmful use of alcohol, tobacco use, unhealthy diet and lack of physical exercise or poor stress management (Federal Ministry of Health, 2014). These risk factors have been documented to result to overweight, obesity, raised blood pressure and high blood levels of glucose and cholesterol (Federal Ministry of Health, 2014; World Cancer Research Fund International and The NCD Alliance, 2014). Diet therapy and Nutrition education form an integral part of management of NCDs

2.2 Diabetes Mellitus

Diabetes mellitus (DM) poses a significant health challenge globally as well as in Nigeria. Recent report have classified the upsurge in the prevalence of diabetes mellitus to be alarming recording 463 million persons with diabetes globally and out of which, 19 million are in the African region, almost 3 million representing 3% of the adult population in Nigeria are suffering from diabetes mellitus (International Diabetes Federation, 2019). Diabetes mellitus, more commonly called diabetes, is a serious group of metabolic chronic disorder that arises when there are elevated levels of blood glucose in an individual due to the inability or inadequate production or ineffective us of insulin (American Diabetes Association, 2020; International Diabetes Federation, 2019; World Health Organization, 2019). Insulin is an important hormone that is produced by the pancreas that is responsible to carry glucose from the bloodstream to the cells where glucose is transformed to energy for body's use (American Diabetes Association, 2020; International Diabetes Federation, 2019; World Health Organization, 2019). Sometimes, the pancreas produced enough insulin but the cells of the body is unable respond to it, this is called insulin resistance. When there is occurrence of any, both or all the following conditions in an individual; inadequate insulin or lack of insulin or insulin resistance, the levels of the blood glucose increases (hyperglycaemia) which is a clinical marker for diabetes mellitus. Other classical symptoms of diabetes mellitus are polyphagia (excessive hunger), polydipsia (excessive thirst) and polyuria (excessive urination) (American Diabetes Association, 2020; International Diabetes Federation, 2019; World Health Organization, 2019).

Currently four diagnostic tests are recommended for diagnosing individuals with diabetes mellitus. These include: (1) measurement of fasting plasma glucose (Fasting is defined as no caloric intake for at least 8 hours) with a diagnostic cutoff of fasting plasma glucose (FPG) values of ≥ 7.0 mmol/L (126 mg/dl); (2) 2-hour (2-h) post-prandial plasma glucose (PG) after a 75 g oral glucose tolerance test (OGTT) with a diagnostic cutoff of 2-h post-prandial plasma glucose ≥ 11.1 mmol/L (200 mg/dl); (2) glycated haemoglobin (HbA1c) with a diagnostic cutoff of HbA1c ≥ 6.5% (48 mmol/mol); (4) a random blood glucose in the presence of signs and symptoms of diabetes with a diagnostic cutoff of a random blood glucose ≥ 11.1 mmol/L (200 mg/dl) in the presence of signs and symptoms are considered to have diabetes. However, if asymptomatic people presents elevated values, it is recommended that the testing if repeated preferentially with the same test as soon as practicable on a subsequent day to confirm the diagnosis (American Diabetes Association, 2020; International Diabetes Federation, 2019; World Health Organization, 2019).

The major types of diabetes mellitus are: type 1 diabetes mellitus (resulting from autoimmune β-cell damage, usually leading to total insulin deficit), type 2 diabetes mellitus (resulting from progressive degeneration of sufficient β-cell insulin production regularly on the experience of insulin resistance), gestational diabetes mellitus (usually detected in the second or third trimester of gestation that was not clearly obvious diabetes prior to pregnancy) and Specific types of diabetes due to other causes, e.g., monogenic diabetes syndromes (such as neonatal diabetes and maturity-onset diabetes of the young), diseases of the exocrine pancreas (such as cystic fibrosis and pancreatitis), and drug- or chemical-induced diabetes (such as with glucocorticoid use, in the treatment of HIV/AIDS, or after organ transplantation) (American Diabetes Association, 2020; International Diabetes Federation, 2019; World Health Organization, 2019). When the blood glucose level is above the normal but below the diagnostic cutoff for diabetes mellitus, this condition is classified as prediabetes. This is also called/used for impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT). The diagnostic criteria for prediabetes is FPG 100–125 mg/dL (5.6–6.9 mmol/L), 2-h PG 140–199 mg/dL (7.8–11.0 mmol/L), HbA1C 5.7–6.4% (39–47 mmol/mol) or ≥10% increase in HbA1C (American Diabetes Association, 2020; International Diabetes Federation, 2019; World Health Organization, 2019). The prediabetes state predisposes an individual for diabetes mellitus development in the future (American Diabetes Association, 2020; International Diabetes Federation, 2019; World Health Organization, 2019).

Chronic uncontrolled hyperglycaemia leads to other complications that cause damage to the different organs and cells of the body(International Diabetes Federation, 2019). Such complications include diabetic neuropathy (nerve damage due to diabetes mellitus) cardiovascular diseases (CVD), diabetic nephropathy (kidney disease due to diabetes mellitus), and diabetic retinopathy (eye disease due to diabetes [can lead to blindness]) (American Diabetes Association, 2020; International Diabetes Federation, 2019; World Health Organization, 2019). However, in a well-controlled and managed diabetes mellitus (hyperglycaemia), these complications are prevented or delayed (International Diabetes Federation, 2019). Many individuals in Nigeria do not know their DM status, rather they are only presented to the hospital with any one or more of these complications (International Diabetes Federation, 2019). This is one of the reasons it is recommended that all adults assess themselves annually to know their health status because early diagnosis ensures early commencement of proper management, reduced healthcare use and related costs and thus delays associated complications (International Diabetes Federation, 2019; World Health Organization, 2019). It was reported in 2019, that one in two (50.1%), or 231.9 million of the global 463 million adults living with diabetes, (type 2 diabetes, aged 20–79 years) are ignorant of their medical condition (International Diabetes Federation, 2019). Thus, recommendation for the need early diagnosis of diabetes mellitus globally (International Diabetes Federation, 2019).

2.3 Carbohydrate servings, serving size and portion size

Carbohydrate is the primary source of energy to the body (Gropper, Smith, & Groff, 2009). Carbohydrates consist of carbon, hydrogen, and oxygen linked together by energy-containing bonds: “carbo” means “carbon”; “hydrate” means “water” (CHO) (Sizer & Whitney, 2014). Basically, all plant based foods contain carbohydrate but the amount of carbohydrates in each one differs from one to the other. Photosynthetic process induces green plants containing chlorophyll in the presence and sunlight to produce carbohydrates (Sizer & Whitney, 2014). The common rich sources of carbohydrates in Nigerian foods are drawn from tuber/root, cereals and grains food groups. Other foods which many “unlearned individuals” in nutrition do not recognize to contain carbohydrates but they do are fruits, legumes/nuts and vegetables. Animal based foods that contain carbohydrates in the form of lactose is milk and milk products. Meat, fish and poultry are not known to be sources of carbohydrates in our meals.

The question many persons ask is what is a serving size or a serving of food? Or carbohydrate serving? What quantity of food makes a serving? Or a carbohydrate serving? The concept of carbohydrate serving was basically based on the carbohydrate content of foods because it was targeted for diabetes management. A serving of carbohydrate is the amount of a particular food that will supply 15 grams of carbohydrate (American Diabetes Association, 2009; Dietitians of Canada, 2018). Thus, this differ from one food type to another. However, it is sometimes generally grouped into food groups. But in a food group, the individual foods that made it up differ in the quantity that makes a carbohydrate serving. While a “serving size” is a standardized quantity of a food, for example a standard cup (250 mls) or 30g of a food or drink (National Institute on Aging, 2019). A serving size is also called a food exchange (Williams, Anderson, & Rawson, 2013). One serving of food in the same group supply similar amount of energy, carbohydrate, fats and protein (American Diabetes Association, 2009; Williams et al., 2013). Similar foods can be compared with serving sizes and it could be used for making choice of foods to eat or during shopping, however, they are not reference standard of how much of a food an individual can consume but could be used in meal planning to define how many servings a person is expected to eat from each food group to obtain an adequate diet (National Institute on Aging, 2019).

Another term that confuse individuals again is serving portion or portion size. These two terminologies are used synonymously. Although there could be minor contextual meaning. A serving portion or portion size is the quantity of food an individual consumed at a sitting (at the same time) (Dietitians of Canada, 2018). This quantity differs from one food to the other and it could contain several servings in a meal (American Diabetes Association, 2009; National Institute on Aging, 2019; Williams et al., 2013). In describing a portion size further, different restaurants have differing portion sizes for their meals, their portion size also differ with how much money of the food an individual is buying. Some restaurants have standardized serving portion/portion size while others are not standardized. In our homes, we dish out foods with household measures like dishing spoons before we eat the food, the quantity that is given to the father, differs from the amount the mother consumes and differs from the amount the individual children of different ages consume, for each of these categories of persons in a household, their serving porting or portion size differs. Their serving portion/portion size do not necessarily contain the same amount of carbohydrates, protein, fat and energy whereas in a serving size the amount of these nutrients and energy are similar (National Institute on Aging, 2019; Williams et al., 2013).

In a carbohydrate serving, an exchange contain 15 grams of carbohydrates no matter the source, but the protein, fat and energy could differ as well as the food could differ in quantity depending on the carbohydrate content of the food (American Diabetes Association, 2009; Fadupin, 2009).

However, another author also pointe that the if the carbohydrates content of the food vary from 8 to 22 grams, it is still considered to be one carbohydrate serving for easy calculation when the food exchange list table is used in the basic carbohydrate counting method usually used in the dietary management for type 2 diabetes mellitus thus, a standard deviation of ±7 grams of carbohydrate is allowed in one carbohydrate serving (15 grams of carbohydrate) (Souto & Rosado, 2010).

2.4 Carbohydrate counting in the management of diabetes mellitus

In diabetes management, the quantity of carbohydrate in the food an individual eats can affect the blood glucose significantly (American Diabetes Association, 2009). While starvation is not an option for dietary management of diabetes mellitus, portion control and consistency with amount of carbohydrate distributed in all the meals and snacks of the day is an important aspect of dietary management in individuals with diabetes mellitus (British Dietetic Association, 2014; Mahan et al., 2012; Nelms, Sucher, Lacey, & Roth, 2011). Persons with type 1 diabetes mellitus who totally depend on exogenous insulin benefits maximally in carbohydrate counting as an integral part of dietary management (Nelms et al., 2011). Although individuals with diabetes mellitus have issues in the metabolism of energy giving food nutrients (carbohydrates, fats and protein), but carbohydrates is the major nutrient that its metabolism is impaired and thus requires strict modifications for each person. Dietary management of diabetes mellitus is individualize and patient-centered in modern dietetics practice unlike when individuals are provided with general rules and dietary advice on the management of diabetes (Mahan et al., 2012).

The method of estimating the amount of carbohydrates in grams an individual (mostly diabetic patient) consumed in a meal or snack in a day is referred to as carbohydrate counting. This is used to plan healthy meal for individual or oral hypoglycaemic drugs only (common for type 2 diabetes mellitus patients) or on insulin therapy only (common for type 1 diabetic patients) or with oral hypoglycaemic drugs. In carbohydrate counting, the amount of carbohydrate needed by individuals per day is distributed to match with the medication of the person. The three major meal of the day (breakfast, lunch and supper) gets almost an equal amount while mid-meal snacks are allocated a particular amount. These snacks are most times made up of fruits (such as mango, oranges, apple, pawpaw, watermelon and others) and high carbohydrate vegetables (such as garden egg [eggplant], cucumber, carrot and others). It is recommended that each meal contain the range of 45 to 60 grams of carbohydrate while each snack contain 15 to 20 grams of carbohydrate (American Diabetes Association, 2009). There are levels of carbohydrate in a food during which the carbohydrate counting is not done. When the carbohydrate is between 0 to 5 grams, it is not counted, when it is between 6 to 10 g, it is counted as half (½) carbohydrate serving, when the carbohydrates is between 11 to 20 grams, it is counted as one (1) carbohydrate serving, when the carbohydrates content is between 21 to 25 grams, it is counted as 1½ carbohydrate servings and when the carbohydrate content is between 26 to 35 grams, it is counted as two (2) carbohydrate servings (Daly, Bolderman, Franz & Kulkarni, 2003). Carbohydrate counting permits additional flexibility in food selections for individuals with diabetes mellitus and it facilitates good glycaemic control (American Diabetes Association, 2009; Daly et al., 2003; Souto & Rosado, 2010).

2.5 History and development of photographic food atlas

A photographic food atlas of food portion sizes is used as a tool for estimation of portion size of food which could reflect the weight of the food as well its nutrient content. It is defined as a compendium of picture or photograph in a single booklet for use by dietitians, nutritionist and researchers to estimate the food and nutrient intake of individuals or groups (Boateng, 2014;

Foster, Hawkins, Simpson & Adamson, 2014; Foster et al., 2008; Huybregts et al., 2018; Marjan, 1995; Nelson & Haraldsdólttir, 1998; Timon et al., 2018). Usually picture on photographic food atlas range from 3 to 8 in an A4 paper size (Boateng, 2014; Jayawardena et al., 2018). Photographic food atlas have been described by the United Kingdom Food Standards Agency as a photograph compilation (album) of different serving portions of commonly consumed foods measure using plates, spoons, cups and cans of varying sizes (Boateng, 2014; Frobischer & Maxwell, 2003).

Several studies have produced photographic food atlas in different countries (Abu Dhabi Food Control Authority, 2014; Boateng, 2014; Faggiano et al., 1992; Flannery, n.d.; Frobischer & Maxwell, 2003; Huybregts, Roberfroid, Lachat, Van Camp & Kolsteren, 2008; Huybregts et al., 2018; Lombard, Steyn, Burger, Charlton & Senekal, 2013; Marjan, 1995; Nelson, 1998; Nelson & Haraldsdólttir, 1998; Ovaskainen et al., 2008; Rasekhala, 2016; Robinson, Morritz, McGuiness & Hackett, 1997; Small et al., 2010; Triacca, 2017). In Nigeria there is scarcity of published study on photographic food atlas, but the neighbouring country Ghana, has a study on it (Boateng, 2014).

Estimation of portion size of food with the use of photograph was introduced first by Elwood and Bird more than three decades ago (Elwood & Bird, 1983). They reported a prospective study conducted with 25 participants who documented their food intake for 24 hours. A camera with high- quality and speed was given to each participant to capture their pre-meal and post-meal of all foods and beverages consumed within their homes. Participants maintained a standard distance between food and camera with a piece of premeasured string. Pictures of pre-reweighed and pre-measured standard meals were placed beside slides of the food photographs containing food and drinks. A comparison of the pre-meal and post-meal photos by the researchers produced estimated weights of consumed foods. Thus, they concluded that it was a cost-effective way of dietary intake assessment (Elwood & Bird, 1983). Validation of the photographs produced statistically strong relationship between weight of actual foods and the pictures on food. However, their photographic method of dietary intake assessment presented limitations such as unstandardized plate size, expensive nature of the equipment and materials used for the development (Boateng, 2014; Elwood & Bird, 1983; Small et al., 2010).

Other photographic food atlases in existence includes: “A food photograph series for identifying portion sizes of culturally specific dishes in rural areas with high incidence of oesophageal cancer” in South Africa (Lombard et al., 2013); “A photographic atlas of food portions for the Emirate of Abu Dhabi Abu Dhabi” In United Arab Emirates (Abu Dhabi Food Control Authority, 2014), A study conducted in the University of Ghana on “the development of a photographic food atlas with portion sizes of commonly consumed carbohydrate foods in Accra, Ghana” in 2014 is novel study within the west African coast (Boateng, 2014) and many others but not in Nigeria (Ali, Platat, Mesmoudi, Sadig, & Tewfik, 2018; Flannery, n.d.; Foster et al., 2008; Huybregts et al., 2008; Jayawardena et al., 2018; Ovaskainen et al., 2008; Robinson et al., 1997; Triacca, 2017). The number of photos per atlas varied from 15 to 245.

The myriads of photographic food atlas produced in different countries, the nutrient content per portion of the foods were not documented but the weight of the foods was the focus (Abu Dhabi Food Control Authority, 2014; Boateng, 2014; Foster et al., 2014, 2008; Frobischer & Maxwell, 2003; Huybregts et al., 2018; Lombard et al., 2013; Nelson & Haraldsdólttir, 1998). The reasons for the focus on weight of a portion could be that most of the foods were based on single food and some were not therapeutically based unlike in the study which is focusing on portion size for diabetic patients.

2.6 Dietary assessment and application of the photographic food atlas

Several methods are employed in the assessment of food and nutrient intake. These methods include weighed food intake which has been considered as one of the most accurate methods in nutrient intake assessment but it has the limitation that it requires training for the respondents to carry it out, requires a level of education and it is burdensome on the respondent when it is self-administered (British Dietetic Association, 2014). But when the researcher is weighing the foods by himself/herself, it increases the activity and cost of the study. However, when it is well conducted, it has proven to be one of the most accurate methods in dietary assessment (Mahan, Escott-Stump & Raymond, 2012; Nelms, Sucher, Lacey & Roth, 2011). Apart from weighed food intake which is mostly prospective method of dietary assessment, diet diary which involved keeping record of all that is consumed without weighing like in weighed food intake (Sizer & Whitney, 2014; Watson, 2009). Others are mostly retrospective, which depends on memory and the respondent could forget (Gropper, Smith & Groff, 2009; Rolfes, Pinna & Whitney, 2006; The British Dietetic Association, 2014). These methods are not especially an excellent choice for the elderly who has been diagnosed with dementia (Watson, 2009). These methods include: 24-h recall and food frequency questionnaires (British Dietetic Association, 2014; Gropper et al., 2009; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010; Watson, 2009).

Random error and under-reporting or over-reporting may occur during assessment of dietary intake or quantifying nutrient intake (Boateng, 2014; British Dietetic Association, 2014). Results of weighed food intake are analyzed with the food composition table which could have a differing data from the actual food consumed due to geographical, soil and seasonal differences (Maduforo, 2016). It has been reported that weighed food method constitutes constraints in dietary assessment such as time-consuming, presents high burden to respondent and it is not suitable for dietary surveys especially when large population is involved (Ali et al., 2018). Measuring habitual intake do not have a perfect method of assessing thus, the method adopted for any dietary assessment whether for individuals or groups rely on variety of conditions of the study which include the cost of the method, convenience for the subject and the desired level of accuracy (Ali et al., 2018; Boateng, 2014; Sizer & Whitney, 2014; Triacca, 2017). Studies have demonstrated the use of food photographs in the estimation of food portion sizes(Abu Dhabi Food Control Authority, 2014; Ali et al., 2018; Faggiano et al., 1992; Foster et al., 2014, 2008; Frobischer & Maxwell, 2003; Huybregts et al., 2008, 2018; Nelson & Haraldsdólttir, 1998; Rasekhala, 2016; Robinson et al., 1997). Usually, subjects are required to identify which of a series of photograph containing different portion sizes matches most closely the food portion size to be consumed (Robinson et al., 1997). Photographic food atlas have also been employed in the estimation of portion sizes during food diary and 24-hour dietary recall (Boateng, 2014; Robinson et al., 1997; Timon et al., 2018). Also, pictures of food could be used to identify the usual food portion size an individual consumes during diet history (Nelson & Haraldsdólttir, 1998; Robinson et al., 1997). The portion size in a photographic food atlas could be a fraction of the actual amount an individual consumes as a serving size (Robinson et al., 1997). Photographic food atlas could be utilized in different scenarios, such as in clinical setting for dietary counselling of patients or clients to be able to estimate their food portion size, in dietary surveys and in households for self-management.

Three basic elements have been identified to affect the accuracy of photographic food atlas which include; conceptualization, perception and memory (Nelson & Haraldsdólttir, 1998; Robinson et al., 1997). Conceptualization is the capability to conceive a mental picture of a portion size and relate it to that in a photograph (Nelson & Haraldsdólttir, 1998; Robinson et al., 1997). Perception is the capacity of an individual to relate the real food portion in the plate to a similar portion size in photograph (Nelson & Haraldsdólttir, 1998; Robinson et al., 1997). Memory has to do with the ability of an individual to recall the portion size in the next meal and relate it to the picture (Nelson & Haraldsdólttir, 1998; Robinson et al., 1997). However, these factors were considered in this study where the photographic atlas utilized two different methods to measure out the portion sizes, one was based on carbohydrates servings measured out with scale while the second was based on domestic measures used in the home with different sizes of spoons and measures commonly used at home and the mean weight was calculated which was used to compute the carbohydrate and energy content in a measure. The accuracy of the photographic food atlas will depend on the availability of any of the measures in the home. Even when an individual travel outside the home, instead of carrying excess luggage if food models were used, he/she could just travel with the atlas compiled in the form of a booklet for self-management.

Research findings have shown that photographic food atlas could be employed in various ways in the assessment of dietary intake (Boateng, 2014; Faggiano et al., 1992; Nelson & Haraldsdólttir, 1998). In one of the documented studies, a validation of portion size measurement aids was carried out with 10 food images with differing food portion sizes (Faggiano et al., 1992). A total of one hundred and three (103) respondents participated in the study that the photographic food atlas was used to estimate their dietary intake. In their research, the developed photographic food atlas was used to compare the actual weight of the meal they ate in the next-day's dietary recall. The photographic food atlas was developed from Italian dishes. A study in Ghana developed and validated photographic food atlas of carbohydrate foods where a total of 280 respondents validated the study which show that 54.17 % of the participants were able to estimate portions sizes correctly, 29% of participants overestimated portion sizes and 16.66% underestimated portion sizes of the food presented (Boateng, 2014). The conceptualization errors during nutrient composition and portion size estimation was determined using photographic food atlas by another group of researchers (Nelson, Atkinson, & Darbyshire, 1996). It was concluded from the study that larger portion sizes were underestimated while the smaller portions were overestimated. Some factors have been attributed to affect accurate estimation of portion size and nutrient estimation when photographic food atlas is used. Such factors include Body mass index (BMI), gender and age (Boateng, 2014; Nelson et al., 1996; Michael Nelson & Haraldsdólttir, 1998; Ovaskainen et al., 2008).

2.7 Validation of photographic food atlas

Several measures and tools have been employed in food portion size and nutrient estimation in different studies. These include plastic food replicas, three-dimensional models, food photographs, drawings of foods, utensils and volume measures, household measures, abstract and generic shapes and other portion size measurement tools which have been utilized with the purpose of minimizing errors during dietary assessment (Boateng, 2014; Nelson et al., 1996; Nelson & Haraldsdólttir, 1998; Ovaskainen et al., 2008). A study concluded that real image photographs had the highest accuracy in portion size estimation among the four (4) varying food aid measurement tools used in the study (Chambers, Godwin & Vecchio, 2000). In another study, the use of “default” (known) volumes sorted in ascending or descending order was recommended because it resulted to a more accurate portion size estimation (McGuire, Chambers, Godwin & Brenner, 2001). It has been reported that obesity is linked to intake of larger portion sizes and high energy dense foods in another study (Ledikwe, Ello-Martin & Rolls, 2005). On the other hand, another finding reported that BMI, food service methods, age, sex do not possess any link to large portion size and energy intake (Rolls, Morris, & Roe, 2002). Other confounding factors in validation and accuracy of estimating portion sizes of food from literature include; portion size estimation aid used, the type of food, estimation skills of the subject and the consistency of subject's perceptions (Rolls et al., 2002).

Photographic food atlas is alleged to be a valuable tool for portion size estimation of common food items (Ovaskainen et al., 2008). Although, the effectiveness in the use of photographic food atlas in portion size and nutrient estimation depends on the individual’s ability to (a) look at foods in photographs in direct link to actual food portion; (b) Conceptualize foods (the ability to mentally envisage in abstract terms an amount of food that is actually eaten or seen in relation to the amount represented in a photograph); and (c) recollect from memory the amounts eaten (Boateng, 2014; Nelson & Haraldsdólttir, 1998b). The use of a developed photographic food atlas as a portion size measurement aid (PSMA) and nutrient content estimation tool requires that the photographic food atlas is subjected to validation study (Boateng, 2014).

Several studies have been carried out to validate photographic food atlas using household measures and different serving sizes. These studies have shown that the use of photographs had high accuracy in estimating portion size of food (Boateng, 2014; Nelson & Haraldsdólttir, 1998a;

Ovaskainen et al., 2008; Rasekhala, 2016; Small et al., 2010). Among the studies carried out on the development of photographic food atlas around the world, there is scarcity of any documented study in Nigeria. Also, none of these studies was carried out to on carbohydrate servings as in this study. These studies did not develop their atlas to reflect the local foods consumed in Nigeria. Thus, the importance of this study cannot be overemphasized.

2.8 Effect of age and anthropometric parameters on validation of photographic food atlas

Research findings have shown that gender, age, BMI and race were controversial issues in the validation of portion size assessment tools (Boateng, 2014). Being a male is attributed to choosing larger portion of some foods compared to female counterpart (Burger, Kern & Coleman, 2007). On the other hand, many other researchers did not record any significant difference in the choice of larger portions because the subjects were males or females (Boateng, 2014; Byrd-Bredbenner & Schwartz, 2004; Diliberti, Bordi, Conklin, Roe & Rolls, 2004; Foster et al., 2008; Kral, Roe & Rolls, 2004; Nelson & Haraldsdólttir, 1998b; Rolls et al., 2002; Small et al., 2010).

Portion size conceptualization errors in the use of photographic food atlas was discussed found to be present in another study (Nelson et al., 1996). The researchers summarized that sex, body mass index, age and portion size are most likely confounders when photographic food atlas is used to estimate food and nutrient intake. In their study, overestimation was recognized mostly in small portion sizes whilst underestimation was identified in large portion. It was also reported that overestimation had significant association with older participants when compared with the younger participants. Also, underestimation of fat and energy content of foods were reported among obese subjects ($\geq$ 30 kg/m²) whereas the subjects with normal BMI ($\leq$ 25 kg/m²) overestimated fat and energy in the study (Nelson et al., 1996). However, another study reported a contrary findings that accuracy of the use of photographic food atlas do not depend on BMI, gender and age (Turconi et al., 2005). A research in Burkina Faso where photographic food atlas was validated, the educational level of the subjects were attributed to affect their accuracy in estimation food portion size. They reported that educated subjects were two-times as likely to select correct photograph (Huybregts et al., 2008).

Several other factors may influence the reliability of portion size estimation aids during and nutrient portion size estimation by individuals. Some of these factors include; the number, type of PSMA used for recall, type of food, how similar the PSMA is to the food, the food form to be estimated (liquid, solid or amorphous,), the how the PSMA was presented, size and colour of photographs either black and white or coloured and the individual characteristics of the subject evaluating the PSMA (Boateng, 2014; Godwin, Chambers & Cleveland, 2004; Howat et al., 1994; Nelson, Atkinson & Darbyshire, 1994).

2.9 Use of photographic food atlas in the estimation of portion size

A portion has been defined as the amount of food that one chooses to eat at a sitting and the selected portion may be smaller or larger than the standardized serving of the food (Nelson & Haraldsdólttir, 1998a). Portion size estimation is one of the difficult aspects of Medical Nutrition Therapy faced during dietary assessment in Nigeria. Estimating the nutrient and energy intake of clients has been based on assumptions and studies carried out in other countries which do not reflect actual local foods in Nigeria (Food and Agriculture Organization, 2012). However, a new food composition table for use in Nigeria was launched recently which reflects the nutrient composition of foods in Nigeria, however, this food composition table have not been able to capture all the foods and do not reflect the nutrient composition of different portion sizes of foods especially, composite dishes (Sanusi et al., 2017). Standardization of portion sizes helps to quantify food and nutrient intake during dietary assessment and counselling (Boateng, 2014). it is also an indispensable aspect of nutrition and health promotion (Boateng, 2014; Foster et al., 2008).

Several PSMAs are utilized in the estimation of portion sizes of food in various studies and in the hospital settings by nutrition professionals especially dietitians. Some of the PSMAs used include deck of cards which is an example of three-dimensional models, food photographs, diagrams of food, utensils, volume measurement containers especially for amorphous foods, abstract and generic shapes, replicas of plastic food, domestic measures (household measures) and are other PSMAs that have been used to improve portion size recall (Abu Dhabi Food Control Authority, 2014; Boateng, 2014; Ovaskainen et al., 2008; Rasekhala, 2016; Robinson et al., 1997; Steyn et al., 2006; Turconi et al., 2005). Chambers *et al.* (2000) Among all the PSMAs that are utilized in estimating portion sizes, it was alleged that life sized photographs had the highest accuracy when it was utilized by subjects to estimate food portion size (Chambers et al., 2000). In Nigeria, there is no photographic food atlas developed from our indigenous or common foods consumed. It was recommended that domestic (household) measures be used in developing photographic food atlas for portion size estimation (Boateng, 2014) because most persons would not like to buy something new to be using at home but most person will prepare to modify their diet based on what they have available in the homes. Examples of domestic measures used are big soup/stew ladles, cans, spoons and matchboxes (Boateng, 2014). These PSMAs are cumbersome to use because of their bulk.

In nutrition education and dietary counselling, photographic food atlas is utilized in various ways which include: facilitating diet recall, estimating portion sizes and nutrient content of foods, teaching food selection and portion control, serve as reference material for nutrition professionals such as dietitians and nutritionist and could be used for nutrient intake studies in the community as well as in the validation of dietary intake in epidemiological studies (Boateng, 2014; Marjan, 1995; Ovaskainen et al., 2008; Turconi et al., 2005). The use of photographic food atlas in dietary counselling aids the client to appreciate local foods with the colours, aids the description of the food that the name might not be common, appreciate the quality of the food being described, helps in food selection and serves as a reminder to the different types of food the individuals can select food from (Robson & Livingstone, 1999; Small et al., 2010). Photographic food atlas has been used in different intervention studies to help the individuals in dietary modification and portion control (Foster et al., 2014; Small et al., 2010).

2.10 Nutritional status assessment

Nutrition assessment is defined as "a systematic method for obtaining, verifying, and interpreting data needed to identify nutrition-related problems, their causes, and significance" (American Dietetic Association, 2009). Nutrition Assessment is a component of the nutritional care process, which consists of gathering data in the following areas or domains: food and nutrition related history; biochemical data, medical tests and procedures; anthropometric measurements; nutrition-focused physical findings; and client history (American Dietetic Association, 2009; Nelms et al., 2011). Data obtained from the different domains of nutrition assessment may be both subjective and objective in nature (Mahan et al., 2012; Nelms et al., 2011). The assessment process provides data that is used in the next step of nutrition care process (Nutrition Diagnosis). Thus, it then moves to analysis of data so that current and potential nutritional problems can be identified (Mahan et al., 2012; Nelms et al., 2011).

It is important to note that the nutrition assessment component in Nutrition studies have commonly utilized ABCD methods which is anthropometry, biochemical, clinical and dietary assessment methods. Even though this method is still being utilized today, Registered Dietitian-Nutritionist have developed terminologies that is unique to them especially in the clinical and community dietetic practice under the Nutrition care process (NCP). The term “clinical” in the ABCD system was changed to “nutrition-focused physical findings” in NCP system. “Dietary” in ABCD system is changed to “food and nutrition related history” in NCP system. There is addition of “client history” in NCP system which elicit information on health history, social history, demographic history, economic history of the clients.

After nutrition interventions have been implemented, nutrition assessment data serve as yardsticks with which to measure the effectiveness of the intervention provided (Nelms et al., 2011). Methods for nutrition assessment will vary with the population, the nutrition diagnosis, and the desired outcomes for the nutrition therapy (Mahan et al., 2012; Nelms et al., 2011). The type of assessment required for the healthy individual will correlate with goals for a healthy population (American Dietetic Association, 2009; Nelms et al., 2011). There is no single test or nutrition assessment method that measures holistically the nutritional status of individuals or population (American Dietetic Association, 2009; Mahan et al., 2012; Nelms et al., 2011). That is why assessment makes use of many indices to provide a complete picture of nutritional health of individuals or population. However, clinicians have the capability through experience weigh results of multiple measures to critically evaluate the nutritional status of an individual or a population (Nelms et al., 2011).

Having mentioned other assessment methods used in nutrition and dietetics, the discuss will then dwell on the advances in dietary assessment methods. Dietary assessment is defined as an evaluation of food and nutrient intake and dietary pattern of an individual or persons in the household or population group over period (FAO, 2018). Dietary assessment methods are utilized for v reasons from individual assessments in clinical settings, through to use in epidemiology and population studies (British Dietetic Association, 2014). In epidemiology they are used to estimate nutrient/food intakes of populations and establish relationships between nutrition and disease (British Dietetic Association, 2014; Mahan et al., 2012). Dietary assessment methods are also used as a basis for developing dietary guidelines and health policy, for monitoring change in nutrition intervention studies and for evaluating and monitoring the effectiveness of public health interventions (British Dietetic Association, 2014).

Dietary assessment is an imprecise method of nutritional assessment thus, the imprecision can be curtailed by using the suitable method and by an understanding of the errors associated in the methodology used (American Dietetic Association, 2009; Webster-Gandy et al., 2006). Dietary assessment is further affected by the fact that peoples diet change from time to time. Dietary assessment precision varies from very accurate techniques such as metabolic balance studies to the broad estimates of population studies (Webster-Gandy et al., 2006). The methodology chosen must be suitable for the nutrient/s that are being evaluated and for the individual or population being measured. The timing of the evaluation is also vital and must reflect cultural differences such as differences in the week (week day vs weekend day), seasons (wet vs dry season), and special occasions, e.g. Ramadan, Lent and Christmas (Webster-Gandy et al., 2006).

Anthropometric assessment if the physical measurement of the body dimensions and comparing the measured values with reference standards (Gropper et al., 2009; Nelms et al., 2011). In anthropometric measurement, some of the variables are subjected to further data analysis before it could be compared with the reference standard. A typical example is the measurement of weight and height where both are subjected to further data analysis to calculate the body mass index which the ration of weight in kilogram to height in meters squared. The body weight is used in different ways to assess the nutritional status of individuals or groups. Children could be assessed using weight for age indices. Similarly applicable to height/length in children. In adults, the actual body weight could be compared with the ideal body weight or used to calculate percentage weight gain/loss over one, three or six months period respectively. This have a significant correlation clinically (R. D. Lee & Nieman, 2010) . The height of an adult could be used to calculate the ideal body weight when the wrist circumference or elbow height is measured. There are a lot nutrition assessment indices height and weight of individuals could be utilized. They are also utilized in calculating the energy need and nutrient need of individuals both in health and diseases (Mahan et al., 2012; Nelms et al., 2011).

The body weight and height are used to evaluate the overall nutritional status and to classify individuals as at healthy or non-healthy weights. The standard for these have changed over time. The most recent classification is to use the body mass index. BMI of adult population is considered normal at 18.5 km/m^2 to 24.9 km/m^2, overweight at 25.0 km/m^2 to 29.9 km/m^2, obese at equal to or above 30.0 kg/m^2 and underweight at less than 18.5 km/m^2. The BMI is defined as "an index of a person's weight in relation to height, determined by dividing the weight (in kilograms) by the square of the height (in meters)". The BMI is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adult (Gropper et al., 2009). BMI may not correspond to the same degree of fatness in different populations due, in part, to different body proportions(Lee & Nieman, 2010). The health risks associated with increasing overweight and obesity class of BMI are continuous and the interpretation of BMI grading in relation to risk may differ for different populations (Gropper et al., 2009; Lee & Nieman, 2010). Many factors could increase or decrease the body weight of individuals which invariable affects the BMI values. These factors include gender, physiological status like pregnancy and lactation, disease, physical activity, dietary habits, age, and lifestyle (Gropper et al., 2009; Lee & Nieman, 2010; Nelms et al., 2011; Rolfes et al., 2006; Sizer & Whitney, 2014). In nutrition surveillance and monitoring the effectiveness of nutrition intervention programmes or nutrition intervention in the clinical setting which is the third step in the nutrition care process (FAO, 1994; Lee & Nieman, 2010; Nelms et al., 2011). BMI of individuals and groups can be utilized. Also, BMI monitoring provides a platform for inter-country and inter-regional comparisons over seasons, years and decades (FAO, 1994).

2.11 Food consumption patterns in Enugu State

Staple diets in Enugu consist of a wide variety of foods such as cassava (made into garri which is the most common), yam, sweet potatoes, cornstarch, plantain, wateryam, cocoyam, grains, vegetables, fruits, meat and fish. These foods are eaten with soup or sauce or stew as the case may be. Most foods are consumed as a composite dish and not as a single food. The food composition tables most times captures single foods instead of composite foods(Food and Agriculture Organization, 2012; Sanusi et al., 2017) and this hampers on the full knowledge of the nutrient content of composite dishes.

When individuals become sick such as diabetes mellitus, hypertension, renal diseases, liver disease and others, they are restricted from eating some types of common foods either by themselves, relatives, friends and even a healthcare provider. Some of the restrictions or dietary modifications will have to be evidenced based especially when they were counselled by nutrition professionals (Mahan et al., 2012), while many are not supported by any study but by assumptions especially in the community setting where many persons claim to know one thing or the other about nutrition. This is one of the difficult situations face by clinical dietitians in Enugu State and other parts of Nigeria, many diabetic client before seeing the dietitians, they had received dietary advice from several persons including from some non- nutrition health professionals who provide wrong advice to them which they have accepted and practice for a long time, getting them to unlearn such dietary pattern poses great challenge to the dietitian. Drinking of herbs and leave extracts, "stout beer" which is a bitter beer (alcohol) is one of the practices they indulge in of which many believed that the "bitterness" in the extracts will dilute the "sweetness" in their blood glucose. This is however, not evidenced-based and not recommended for diabetes mellitus patients in Nigeria.

Skipping meals and abstinence from known rich sources of carbohydrates is a common practice among diabetics. Studies have shown that breakfast is the most frequently skipped meals by both healthy and unhealthy persons (Awosan, Ibrahim, Essien, Yusuf & Okolo, 2014; Oladapo, Jude-Ojei, Koleosho & Roland-Ayodele, 2013; Olatona, Airede, Aderibigbe & Osibogun, 2019; Popkin, 2002, 2006). Patients with diabetes mostly skip their breakfast on the days of their appointment in the hospital because their fasting blood glucose will be checked, hence they tend to eat foods sold by food vendors within the hospital environment or on their way after the health check-up. Also, the working class group eat outside their homes to meet up with time of work in the morning hours. The meals they eat outside the homes most times is their lunch while some insist on homemade foods. One of the challenges of eating outside the home is that it could be addictive and habitual where an individual feels like eating once he/she is within the environment where he/she usually eats. However, the food consumption pattern of individuals differs from one person to the other. Some are highly disciplined that they insist on eating a type of food or from homemade food only. However, this could hamper on the glucose control of diabetic patients of which starvation could result to hypoglycemia (Mahan et al., 2012). Many others factors that could affect their food consumption pattern is the availability of food, resources to buy food, food preferences, cultural belief, food taboos, traditional foods and eating pattern, family influence and religion (Rolfes et al., 2006; Sizer & Whitney, 2014).

2.12 Energy and proximate composition selected staple foods consumed in Enugu State

Staple foods are consumed in the household for a minimum of three times in a week (Ayogu, Edeh, Madukwe, & Ene-Obong, 2017). In Enugu State, many of the staple foods are mixed dishes. They are combination of two or more food groups which are cooked as a dish and a name is given to it to which are mostly the local names. The quantity of ingredients used in the preparation of staple foods differ from one community to another. Some studies have tried to conduct focused group discussion to standardize the recipes used in the preparation of staple foods in Enugu State (Ayogu et al., 2017; Davidson, Ene-Obong, & Chinma, 2017). However, due to the complexity of the society, it will be difficult for every household to adopt the standardized recipe, also, these researches are not available to all especially many of them who do not have interest in reading articles. The publicity of a research article include reviewing the content which if researcher did not have access to the original article, they might have access to the reviews that cited the original. Few studies have really determined the proximate and energy content of staple foods consumed in Enugu State (Ayogu et al., 2017; Davidson et al., 2017; Food Basket Foundation International, 1995). Reporting the different values by different authors in one article provides a holistic view on the nutrient values in these foods. Most food composition tables for use in Nigeria focused on single foods including the fruits reviewed in this study. It is therefore on this background that the energy and proximate composition of staple foods consumed in Enugu State was reviewed. The foods reviewed in this document include: *Igbangwu-oka* (Maize meal added African oil bean), *achicha* (cocoyam and pigeon pea based meal), *ayaraya-oka* (maize and pigeon pea based meal), *ayaraya-ji* (Yam and pigeon pea based meal), *okpa* (steamed bambara groundnut paste pudding) jollof rice, white (bolied) rice and *abacha* (local cassava salad). Also, the energy and proximate content of the following fruits were reviewed: apple, pineapple, watermelon pawpaw and banana.

2.13 Proximate content of selected staple foods in Enugu State

The proximate content of food which is made up of moisture, fat, carbohydrate, fibre, crude protein and ash is an important aspect determined in food analysis (Nielson, 2010). Fat, protein and carbohydrates are used to determine the energy content of the food. The Atwater factor for carbohydrates is 4kcal in one gram, protein is 4kcal in one gram and fat is 9kcal in one gram. The summation of the the energy in carbohydrates, fats and protein is the total energy (calories) in the food analysed (Food and Agriculture Organization, 2012; Nielson, 2010; Rolfes et al., 2006). Fat, carbohydrates and protein are categorized as the energy giving food nutrients (Rolfes et al., 2006). They are also categorized as the macronutrients including water (Rolfes et al., 2006). Macronutrients are those nutrients need in the body in large quantity (Sizer & Whitney, 2014). Another proximate component of importance is the ash composition which determines the total minerals present in foods (Nielson, 2010). However, these minerals are not differentiated but the ash content provides the clue to the mineral content of the food being analysed (Nielson, 2010). Moisture is of importance in the proximate content of foods (Nielson, 2010). The moisture content of foods determines to a large extent the shelf life of that food (Maduforo, 2016; Nielson, 2010; Onuoha, Oly-Alawuba, Okorie, Tsado & Maduforo, 2015). Foods with lower moisture has lower water activity and longer storage capacity but the higher the moisture in foods, the higher the risk of spoilage through microbial activities due to higher water activity (Maduforo, 2016; Nielson, 2010; Onuoha et al., 2015). Also, when the moisture content of food is high, the concentration of other nutrients in the food are lower, but there is higher concentration of other nutrients when the moisture content is low (Maduforo, 2016; Nielson, 2010).

Staples are foods that consumed in a household or by individuals most days of the week. Research report in Enugu state defined staples as foods that are consumed in the household for at least three (3) times in a week (Ayogu, Edeh, Madukwe & Ene-Obong, 2017). In every locality, there are foods that makes a staple for that locality. In Enugu State, rice dishes, foods prepared with legumes such as beans makes a staple. Many households combine legumes with tuber or cereal or plantain. Examples of identified common foods consumed in Enugu State include: *Igbangwu-oka* (Maize meal added African oil bean), (local name in igbo is "ugba" or "ukpaka"), *achicha* (cocoyam and pigeon pea based meal), *ayaraya-oka* (maize and pigeon pea based meal), *Ayaraya-ji* (Yam and pigeon pea based meal), *okpa* (steamed bambara groundnut paste pudding), jollof rice and beans, jollof rice, white rice with tomato stew, cassava based fufu or gari eaten with different types of soups (bitter leaf soup, ora soup, vegetable soup), yam cooked in different methods and many others (Ayogu et al., 2017). There are many other foods consumed in Enugu State which are single foods but many of the single foods are fruits and vegetables. Common fruits in Enugu State include pawpaw, oranges, mango, cashew fruits, apple, watermelon, banana, and others. Many persons consume vegetables with soups but high carbohydrate vegetables available include cucumber, carrot, eggplant/garden egg, beetroot and others. In other parts of Nigeria, many other foods are consumed (Ayogu et al., 2017; Fadupin, 2009).

2.13.1 Moisture content of selected staple foods consumed in Enugu State

Moisture content of staple foods consumed in Enugu State tend to be high because these foods are not usually consumed as dry foods. However, some foods like confectioneries could have low moisture but other foods which are considered in this study has high moisture content. Fruits analyzed in this study also has higher moisture content. These fruits include three species of banana, two species of apple, pineapple, watermelon and papaw. The common foods are three species of rice prepared as jollof rice, boiled white rice with tomato stew and fried rice respectively. *Igbangwu-oka* (Maize meal added African oil bean), (local name in igbo is "ugba" or "ukpaka"), *achicha* (cocoyam and pigeon pea based meal), *ayaraya-oka* (maize and pigeon pea based meal), *ayaraya-ji* (Yam and pigeon pea based meal), *okpa* (steamed bambara groundnut paste pudding) and *abacha* (local cassava salad) were also studied. The moisture content reported for the *achicha*, *ayaraya-ji*, *ayaraya-oka*, *igbangwu-oka*, jollof rice, white rice without stew and *okpa* in rural communities in Enugu State were 62.7%, 63.1%, 70.4%, 73.1%, 70.2%, 66.2% and 57.0% respectively (Ayogu et al., 2017). The moisture content reported for *abacha* in when the recipe was varied especially the vegetables and protein sources ranged from 53.8% to 65.6% (Davidson, Ene-Obong & Chinma, 2017).

The variability in the nutrient content of foods especially in mixed dishes is majorly attributed to the recipes of the meal (Ayogu et al., 2017; Davidson et al., 2017). All these foods reported have moisture content exceeding 50% which indicates that they will be highly perishable due to the activities of microorganisms if they are not stored properly (Maduforo, 2016; Nielson, 2010; Onuoha et al., 2015). However, these foods are usually eaten as soon as they are cooked in most homes except for some households that cook food in bulk and store in their freezer. Water added to food during preparation add up to the higher moisture content and the reports showed as the individuals consume them as these foods are not dried before consumption (Ayogu et al., 2017; Davidson et al., 2017).

Another category of food considered in this study in the development of photographic atlas was fruits. Research findings shows that red (red delicious) and green (golden delicious) apples contained 82.68% and 83.72% moisture respectively (Jasia, Tehmeena, Naik & Hussain, 2017). Another study reported the moisture content in apple with and without the skin to be 83.9% and 84.5 % respectively (Lee, 2012). Pineapple is known to be high in moisture, 86.3% moisture was reported in a study on the nutrient content of edible fruits in oil producing communities of River State, Nigeria (Ogoloma, Nkpaa, Akaninwor & Uwakwe, 2013). Another study reported 87.3% moisture in pineapple pulp (edible portion) (Hossain, Akhtar & Anwar, 2015). Watermelon is one of the fruits that is widely consumed in Nigeria and it is generally known to contain high moisture. Finding have reported moisture content ranging from 93.4% 94.6% for different species of watermelon (Inuwa, Aina, Gabi, Aimola & Thompson, 2011; Olayinka & Etejere, 2018). Pawpaw is another fruit that is rich in moisture, a study report moisture level of 88.75% (Nwofia, Ojimelukwe & Eji, 2012). The moisture content in different banana species ranges from 60.06% to 75.25% (Ashokkumar, Elayabalan, Shobana, Sivakumar & Pandiyan, 2018; Kookal & Thimmaiah, 2018). The moisture content of fruits could vary depending on the season, variety and level of exposure of the fruits before the moisture determination. The region where the fruit is harvested or sold, the freshness of the fruit as well as the degree of ripeness of the fruit could affect the moisture content significantly (Ashokkumar et al., 2018; Hossain et al., 2015; Inuwa et al., 2011; Kookal & Thimmaiah, 2018; Lee, 2012; Nielson, 2010; Nwofia et al., 2012; Ogoloma et al., 2013; Olayinka & Etejere, 2018).

2.13.2 Protein content of selected staple foods consumed in Enugu State

Protein in food is an important nutrient needed by the body to repair worn-out tissues, make hormones, enzymes and synthesize the cells of the immune system. Protein is utilized by the body as a source of energy. One gram of protein supplies 4 kilocalories (Nielson, 2010). Protein in foods is one of the basic component determined during food analysis. The protein content of staples could be sourced from plant or animal products including fish and meat used in preparing the meals. The protein content of *achicha*, *ayaraya-ji*, *ayaraya-oka*, *igbangwu-oka*, jollof rice, white rice without stew and *okpa* in rural communities of Enugu State as reported in literature are 7.9%, 3.1%, 3.6%, 4.5%, 2.0%, 2.6% and 15.1% respectively (Ayogu et al., 2017). The protein content reported for *abacha* when the recipe was varied especially the vegetables content and protein sources ranged from 2.21% to 10.45% (Davidson, Ene-Obong & Chinma, 2017).

Fruits are not known to be rich sources of protein, however, there are few reports on the protein content of various fruits used in this study. The protein content of ripened banana of different varieties ranged from 1.1% to 3.75% (Ashokkumar et al., 2018; Kookal & Thimmaiah, 2018). Protein content of 0.47% to 1.17% have been reported for different species of ripe pawpaw pulp (Marfo, Oke & Afolabi, 1986; Nwofia et al., 2012; Santana et al., 2019; Vij & Prashar, 2015). The protein in apple varieties have been reported by different authors to range from 0.19% to 0.44% (Jasia et al., 2017; Lee, 2012). Pineapple pulp contained protein ranging from 0.35% to 3.7% (Ackom & Tano-Debrah, 2012; Food and Agriculture Organization, 2012; Food Basket

Foundation International, 1995; Hossain et al., 2015; Ogoloma et al., 2013; Platt, 1962; Sanusi et al., 2017). Although most of the values in literatures were within the range of 0.35% to 0.55% (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Hossain et al., 2015; Ogoloma et al., 2013; Platt, 1962; Sanusi et al., 2017), only one study reported higher value of protein (3.7%) in pineapple (Ackom & Tano-Debrah, 2012). Watermelon is not a good source of protein in our daily meal but studies have found small proportion of protein in watermelon ranging from 0.34% to 0.60% (Inuwa et al., 2011; Olayinka & Etejere, 2018).

2.13.3 Ash content of selected staple foods consumed in Enugu State

Ash content of food reflect the total mineral content in the food (Nielson, 2010). Ash is one of the proximate component determined during food analysis (Nielson, 2010). Minerals are micronutrient required in the body in small quantity for vital functioning of the cells of the body. Iron is required for heamoglobin synthesis, iodine is required for proper cognitive development, calcium is required for strong bones, potassium and sodium are required to maintain the osmolality of body fluid and the control of blood pressure, phosphate is utility in the Krebs cycle for phosphorylation of energy molecules, enzyme and hormone synthesis in the body require various minerals, some nutrients require minerals for the body to absorb it properly such as in nutrient-nutrient interaction (British Dietetic Association, 2014; Gropper et al., 2009; Lee & Nieman, 2010; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010; Webster-Gandy et al., 2006). Therefore, the ash content of foods which reflect the sum of all the minerals in that particular food provides information on the nutrient density of the food.

The ash content of staples could be could be influenced by the ingredients used in preparing the meals and the food group the food is drawn from. Meat, fish and poultry food group, Milk and milk products food group, legumes and nuts food group and fruits and vegetable food group are known to be rich sources of minerals (British Dietetic Association, 2014; Sizer & Whitney, 2014). Thus, foods prepared that contain substantial amount of foods sourced from the aforementioned food groups will probably supply higher ash content. However, there could be variability of the ash content in foods as a result of the soil where the food is cultivated, method of cooking, moisture content of the food, and the recipe of the foods. Some single foods might contain high ash content such as milk, egg, meat, fish and nuts but when they are combined as mixed dishes, more minerals will be derived from them (Maduforo, 2016). Consuming local staple as mixed dishes from different food groups increases dietary diversity and nutrient density of foods.

The ash content documented for different local staples: *achicha*, *ayaraya-ji*, *ayaraya-oka*, *igbangwu-oka*, jollof rice, white rice without stew and *okpa* consumed in rural communities of Enugu State are 2.3%, 4.0%, 5.2%, 3.0%, 3.2%, 0.3% and 4.0% respectively (Ayogu et al., 2017). The ash content reported for *abacha* ranged from 0.87% to 1.44% (Davidson, Ene-Obong & Chinma, 2017). Fruits are considered to contain appreciable amount of minerals making up the ash content of foods. The ash content of ripened banana of different varieties ranged from 0.82% to 4.5% (Food Basket Foundation International, 1995; Kookal & Thimmaiah, 2018; Sanusi et al., 2017). Ash content of 0.37% to 3.9% have been reported for different species of ripe pawpaw pulp (Nwofia et al., 2012; Ogoloma et al., 2013; Sanusi et al., 2017). The ash in apple varieties have been reported by different authors to range from 0.14% to 4.6% (Jasia et al., 2017; Lee, 2012; Sanusi et al., 2017). Pineapple pulp contained ash ranging from 0.22% to 3.16% (Ackom & Tano-Debrah, 2012; Ogoloma et al., 2013; Sanusi et al., 2017). However, most of the values in literatures were within the range of 0.22% to 0.76% (Ogoloma et al., 2013; Sanusi et al., 2017), only one study reported higher value (3.16%) of ash in pineapple (Ackom & Tano-Debrah, 2012). The ash content reported for watermelon ranged from 0.31 to 0.59% (Inuwa et al., 2011; Olayinka & Etejere, 2018; Sanusi et al., 2017).

2.13.4 Carbohydrate and fibre content of selected staple foods consumed in Enugu State

Carbohydrates is the primary source of energy to human containing 4kcals in one gram (Gropper et al., 2009; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010). Fibre is a type of carbohydrate which the body do not have enzyme to digest but the activities of microorganisms in the large intestine digest it and make the nutrients available to humans (Gropper et al., 2009; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010). Most plant based foods are rich sources of carbohydrates such as the local staples consumed in Enugu State. The most abundant nutrient in fruits is water and carbohydrates. The carbohydrate composition reported for *achicha*, *ayaraya-ji*, *ayaraya-oka*, *igbangwu-oka*, jollof rice, white rice without stew and *okpa* in rural communities in Enugu State were 22.4%, 23.7%, 4.8%, 7.1%, 16.6%, 30.1% and 16.7% respectively (Ayogu et al., 2017). The carbohydrate content reported for *abacha* ranged from 17.42% to 28.34% (Davidson, Ene-Obong & Chinma, 2017). It is important to note that the above two studies (Ayogu et al., 2017; Davidson et al., 2017) standardized the recipes used in their study after conducting a focused group discussion in rural communities of Enugu State. In this study, food samples were based on foods sold by food vendors or restaurants in Enugu State. The crude fibre reported for *achicha*, *ayaraya-ji*, *ayaraya-oka*, *igbangwu-oka*, jollof rice, white rice without stew and *okpa* were 0.2%, 0.3%, 0.3%, 0.2%, 0.5%, and 0.2% respectively (Ayogu et al., 2017) while crude fibre reported for *abacha* with varying quantity of vegetables in the ingredients ranged from 1.49% to 1.67% (Davidson et al., 2017). Fibre is an important dietary component required by diabetic patients, it helps to regulate the release of glucose in foods, increase satiety, adds bulk to food to reduce excessive caloric intake as well as help in the removal of cholesterol from the body (Gropper et al., 2009; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010).

Research findings shows that carbohydrate content of apples ranged from 9.25% to 15.3% (Jasia et al., 2017; Lee, 2012; Mukhtar, Gilani & Bhatty, 2010; Sanusi et al., 2017). Pineapple contained 6.75% to 13.7% from previous reports (Ackom & Tano-Debrah, 2012; Hossain et al., 2015; Ogoloma et al., 2013; Sanusi et al., 2017). The reported carbohydrate content in watermelon ranged from 4% to 6.5% from previous studies (Inuwa et al., 2011; Olayinka & Etejere, 2018; Sanusi et al., 2017). Studies reported wide range of carbohydrate values in pawpaw ranging from 2.9% to 9.51% (Marfo et al., 1986; Nwofia et al., 2012; Ogoloma et al., 2013; Santana et al., 2019; Sanusi et al., 2017). The wide range in the carbohydrate is mostly due to the moisture content which was as high as 88.3% and 91.4% in pawpaw harvested at Rivers State and Benue State respectively (Ogoloma et al., 2013). The carbohydrate content in different ripe banana species ranges from 21.8% to 22.84% (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Sanusi et al., 2017). The degree of ripeness of the fruits could affect the carbohydrate content significantly (Ashokkumar et al., 2018; Hossain et al., 2015; Inuwa et al., 2011; Kookal & Thimmaiah, 2018; Lee, 2012; Nielson, 2010; Nwofia et al., 2012; Ogoloma et al., 2013; Olayinka & Etejere, 2018).

The fibre content of banana is affected by the degree of ripeness of the banana. The more the ripeness, the higher the simple sugars and lower fibre content. A study showed that the crude fibre content of banana was higher in the unripe species than in the ripe ones of similar species. The crude fibre content of ripe banana of different species ranges from 1.58% to 2.6%

(Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Kookal & Thimmaiah, 2018; Sanusi et al., 2017). The crude fibre in watermelon reported in previous studies ranged from 0.29% to 0.40% (Food and Agriculture Organization, 2012; Inuwa et al., 2011; Olayinka & Etejere, 2018; Sanusi et al., 2017). Different varieties of pawpaw pulp contained crude fibre ranging from 0.77% to 0.93% two studies (Nwofia et al., 2012; Santana et al., 2019). However, other studies reported different values ranging from 2.47% to 2.93% (Ogoloma et al., 2013); 6% (Food Basket Foundation International, 1995; Sanusi et al., 2017); 1.9% (Food and Agriculture Organization, 2012). The crude fibre content of varieties of apple as reported in previous studies were 0.77% (Lee, 2012) and 2.3% (Sanusi et al., 2017). The value of crude fibre reported in various studies in pineapple include 1.2% (Food Basket Foundation International, 1995; Sanusi et al., 2017); 1.4% (Food and Agriculture Organization, 2012; Hossain et al., 2015); 2.25% and 7.21% (Ogoloma et al., 2013).

2.13.5 Fat content of selected staple foods consumed in Enugu State

Fat is a high energy currency nutrient containing 9kcal per kilogram. It is a very important nutrient need by humans for various purposes including synthesis of steroid hormones, cholesterol, insulation of organs, formation of cells of the immune system especially the essential fatty acids and production of energy for the body (British Dietetic Association, 2014; Gropper et al., 2009; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010). The fact content of staple foods consumed in Enugu State have been reported by various studies and in food composition table for use in Nigeria as well as in the West African food composition table (Ackom & Tano-Debrah, 2012; Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Hossain et al., 2015; Inuwa et al., 2011; Kookal & Thimmaiah, 2018; Marfo et al., 1986; Mukhtar et al., 2010; Nwofia et al., 2012;

Ogoloma et al., 2013; Olayinka & Etejere, 2018; Platt, 1962; Santana et al., 2019; Sanusi et al., 2017; Vij & Prashar, 2015).

The fat content documented for different local staples: *achicha*, *ayaraya-ji*, *ayaraya-oka*, *igbangwu-oka*, jollof rice, white rice without stew and *okpa* consumed in rural communities of Enugu State are 4.5%, 5.8%, 15.4%, 12.0%, 7.7% 0.2% and 7.0 % respectively (Ayogu et al., 2017). The fat content reported for *abacha* ranged from 1.54% to 14.15% (Davidson, Ene-Obong & Chinma, 2017). Fruits are considered to contain low or negligible fat values. The fat content of ripened banana of different varieties reported in various literatures was: 0.3% to 0.5% (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Sanusi et al., 2017); 1.63% to 2.59% (Kookal & Thimmaiah, 2018). The fat content of ripe pulp of pawpaw in various studies ranged from 0.1% to 0.7% (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Marfo et al., 1986; Nwofia et al., 2012; Santana et al., 2019; Sanusi et al., 2017; Vij & Prashar, 2015), however, higher values were reported in a single study in Rivers State were pawpaw species were harvested from Rivers State and Benue State respectively and the result reported fat content ranging from 1.11% to 1.85% for pawpaw harvested in Rivers State and Benue State respectively (Ogoloma et al., 2013). The fat composition of apple varieties have been reported by different authors. A study reported fat content of 0.36% in apple analyzed with the skin which is edible portion in Nigeria (Lee, 2012), a value of 0.2% was reported for red delicious apple in the Nigerian food composition table (Sanusi et al., 2017). Another study reported a value of 1.95% of fat in red delicious and 2.21% in golden delicious apple respectively (Mukhtar et al., 2010). The fat contained in ripe pineapple pulp as reported by various authors include 0.47% (Ackom & Tano-Debrah, 2012), 2.0% to 3.5% (Ogoloma et al., 2013), 0.3% (Food and Agriculture

Organization, 2012) and 0,12% (Sanusi et al., 2017). The fat content reported for watermelon in various literatures ranged from 0.1% to 0.24% in some reports (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Inuwa et al., 2011; Olayinka & Etejere, 2018; Sanusi et al., 2017).

2.14 Energy content of selected staple foods consumed in Enugu State

Energy is defined as the ability to do work. The energy in food is measured in kilocalories (kcal) or kilojoules (kj) (British Dietetic Association, 2014; Nielson, 2010; Rolfes et al., 2006). The energy giving food nutrients are fat, carbohydrates and protein supplying 9kcal, 4kcal and 4kcal per gram of the nutrient respectively (Gropper et al., 2009; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010). These factors are used in calculating the energy present in foods after the analysis of the proximate composition of foods, the fat, carbohydrate and energy values are known which is then used to derive the energy value per 100g as food composition tables are presented per 100g of the food samples analyzed (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Platt, 1962; Sanusi et al., 2017). The value of energy in food samples especially in mixed dishes vary due to the recipes used in the preparation of the food. Frying food with oil makes the food to absorb oil, thus increasing the fat content of the food and invariably the energy content (Lean, 2006). Some local foods in Enugu State like *ayaraya-oka*, *ayaraya-ji*, *achicha*, *abacha* and *okpa* require large quantity of oil in its preparation, most times, the quantity of oil added to these foods vary from household to household. Two studies have tried to standardize the preparation of these foods, though, a focused group discussion was carried out by the researchers, but there is still high tendency of variation in the energy content of foods consumed in different household when compared with the values they standardized (Ayogu et al., 2017; Davidson et al., 2017).

The knowledge of the energy content of foods helps consumers to make informed decision on what to eat and what quantity to eat any type of food as well as deciding to modify the recipes to suite the physiological condition. Dietary modification takes energy need per day as the most important factor to determine for every individual. The energy needed by people is considered with regards to many factors such as weight, body mass index, height, age, physical activity level, stress factors, physiological condition and the purpose of dietary modification. Knowing the energy content of the food therefore is a sin qua non for proper dietary counselling and appropriate nutrition education. The energy content per 100g reported for the following selected foods: *achicha*, *ayaraya-ji*, *ayaraya-oka*, *igbangwu-oka*, jollof rice, white rice without stew and *okpa* consumed in rural communities of Enugu State are 161.6kcal, 159.5kcal, 175.6kcal, 154.3kcal, 143.5kcal, 134.0kcal and 190.1kcal respectively (Ayogu et al., 2017). The energy content per 100g reported for *abacha* ranged from 152kcal to 263kcal (Davidson, Ene-Obong & Chinma, 2017). The variation in the energy content for *abacha* for instance is majorly due to changes in the quantity of vegetables and oil added during preparation (Davidson et al., 2017).

The major source of energy in fruits is its carbohydrate content. Fruits are good sources of vitamin and minerals as well as water but they are not relied upon to supply fat and protein except for few of them such as avocado pear and coconut which are not considered as fruit though (Sanusi et al., 2017). Some fruits considered in this review are banana, apple, watermelon, pawpaw and pineapple. The energy content reported for these fruits in different literatures vary, which is directly related to the variations reported for their carbohydrate, fat and protein content (Ackom & Tano-Debrah, 2012; Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Hossain et al., 2015; Inuwa et al., 2011; Jasia et al., 2017; Kookal & Thimmaiah, 2018; Lee, 2012; Marfo et al., 1986; Mukhtar et al., 2010; Nwofia et al., 2012; Ogoloma et al., 2013; Olayinka & Etejere, 2018; Platt, 1962; Santana et al., 2019; Sanusi et al., 2017; Vij & Prashar, 2015).

The energy content per 100g of ripe banana of different varieties ranged from 89kcal to 103.89kcal (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Sanusi et al., 2017) The energy content per 100g reported for pawpaw ranged from 32kcal to 53.48kcal (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Santana et al., 2019; Sanusi et al., 2017). The energy per 100g of apple varieties reported by different researchers ranged 59kcal to 69.54kcal (Jasia et al., 2017; Lee, 2012; Sanusi et al., 2017). Energy content per 100g reported for ripe pineapple pulp in by various authors range from 46kcal to 56kcal (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Hossain et al., 2015; Sanusi et al., 2017). Authors reported energy content per 100g in watermelon which range from 22kcal to 30.9kcal (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Olayinka & Etejere, 2018; Sanusi et al., 2017).

This section of the review have provided a comprehensive report on the energy and proximate content of staple foods consumed in Enugu State Nigeria. There are conflicting results from different studies but some studies agree on the nutrient composition. More studies on these foods ate recommended especially on the foods that are sold by restaurants and food vendors which will provide a general outlook of what majority of the populace eats frequently. This will as well serve as a better guide for dietary recommendation since most individuals eat food prepared outside their homes.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Design

The study adopted a cross-sectional and experimental study design.

3.2 Study Area

The study was carried out in Enugu State. Enugu State is one of the five states in South East, Nigeria. The state shares border with Abia State and Imo State to the south, Ebonyi State to the east, Benue State to the northeast, Kogi State to the northwest and Anambra State to the west. Enugu, the capital city of Enugu State, is approximately three driving hours away from Port Harcourt, where coal shipments exited Nigeria. Enugu has close proximity with Onitsha, one of the biggest commercial cities in Africa and two hours' drive from Aba, another very large commercial city, both of which are trading centres in Nigeria.

Enugu State is divided into three senatorial zones: Enugu West, Enugu East, and Enugu North senatorial zones. Enugu West senatorial zone is made up of five local government areas (Aninri, Awgu, Ezeagu, Oji-River and Udi), Enugu East six local government areas (Nkanu East, Nkanu West, Isi Uzo, Enugu South, Enugu North and Enugu East) and Enugu North six local government areas (Igbo Etiti, Igbo-Eze North, Igbo-Eze South, Nsukka, Udenu, and Uzo-Uwani). Thus, there are 17 local government areas (LGAs) in Enugu state. Enugu state has an estimated population of 3,267.837, (1,596,042 males and 1,671,795 females) and a population density of about 6,400/km^2 (National Population Commision, 2006).

The study collected data from two tertiary hospitals (University of Nigeria Teaching Hospital (UNTH) Ituku/Ozalla, and Enugu State University Teaching Hospital, Parklane Enugu (ESUTH) and one Mission (Private) hospital (Mother of Christ Special Hospital Enugu) which are hospitals with Nutrition and Dietetics departments and have large patient turnout.

3.3 Study Population

The population of the study was all adult diabetic patients aged eighteen to seventy (18 -70) years old seeking services of dietitian-nutritionist in the out-patient department of University of Nigeria Teaching Hospital (UNTH) Ituku/Ozalla, Enugu, Enugu State University Teaching Hospital, Parklane Enugu and Mother of Christ Specialist Hospital Enugu from May to July, 2019.

3.4.0 Data Collection

3.4.1 Ethical approval and informed consent

Approval for the study was obtained from the Ethics Clearance Committee of the Enugu State University Teaching Hospital, Parklane Enugu. Permission was also, obtained from the authorities of the study sites before the commencement of the study. The study was conducted according to the Nigeria National code for Health Research Ethics and Committee (NHREC) and the declaration of Helsinki (DOH) was adopted. All the respondents were informed of the details of the study and their oral permission was sought before their participation in the study.

3.4.2 Method of Data Collection

The study was carried out in phases: The first phase collected data on the most commonly consumed foods amongst diabetic patients eighteen to seventy (18 -70) years old seeking services of dietitian-nutritionist in the selected hospitals. The second phase of the study was a laboratory food analysis of selected commonly consumed food samples (including fruits). The food samples were analysed as consumed either cooked or raw. The third phase of the study was the development of photographic food atlas of the selected commonly consumed food samples. The photographic atlas composed of different portion sizes of domestic measures and carbohydrate servings for each selected food sample. The final phase of the study was validation of photographic food atlas by diabetic patients eighteen to seventy (18 -70) years old seeking services of dietitian-nutritionist.

3.4.3 Survey of commonly consumed foods and food consumption pattern

This was the first phase of the study which was carried out to identify foods that were commonly consumed amongst adult diabetic patients eighteen to seventy (18 -70) years old seeking services of dietitian-nutritionist in out-patient departments of tertiary hospitals in Enugu state. The commonly consumed food was assessed using food frequency questionnaire. The list of foods were asked based on foods consumed at least 4 times per week which was scored one (1) point and foods consumed less than 4 times per week was scored half (0.5) points. Foods were ranked in the order of points they scored. The foods with high scores (≥20) were considered as the commonly consumed foods. Foods with high scores (≥20) were purposively selected for further chemical analysis and development of photographic food atlas.

3.4.4 Sampling size determination and sampling technique

A preliminary visit to the Out-patient units of Department of Nutrition and Dietetics at the three hospitals (University of Nigeria Teaching Hospital (UNTH) Ituku/Ozalla Enugu, Enugu State University Teaching Hospital, Parklane Enugu and Mother of Christ Specialist Hospital Enugu revealed that they attended to a total of 200 diabetic patients in 2016 as recorded in their respective register. Thus, due to the small sample size, convenient sampling technique was used to sample all the adult client/patient seeking services of dietitian-nutritionist in the three hospitals for a period of 3 months was carried out for the survey of commonly consumed foods. The 3 months' period is because most of the appointments for a review given to patients/clients did not exceed 3 months except for special cases. Some of the appointments were as short as 7 days' interval or fortnightly. A total of 81 (40% of the population) diabetic respondents completed the questionnaire for commonly consumed foods. A sub-sample for validation was calculated to be 15% (12) of the total population that completed the questionnaire for commonly consumed foods but not necessarily the individuals that completed the questionnaire, however, all were diabeti.

3.4.5 Recruitment of research assistants

The researcher recruited and trained twenty five (25) volunteers made up of five (5) therapeutic diet cooks, ten (10) registered dietitian-nutritionist working in the out-patient department of the three hospitals that assisted in the recruitment of participants and data collection and ten (10) assistants (students) for production of photo atlas. Prior to the distribution of the questionnaires, the purpose of the study was explained to the subjects. Those who willingly opted to participate in the study were given informed consent forms to sign.

3.4.6 Questionnaire

A structured validated questionnaire was used to collect information on commonly consumed foods of the respondents. The questionnaire was given to five Registered Dietitian-Nutritionists for validation before it was administered.

3.5 Procurement of food samples

The selected foods consumed by diabetic patients were purchased from a minimum of three (3) different food vendors and restaurants. However, because basmati rice was not one of the varieties of rice sold by food vendors, it was purchased from Shoprite mall and was cooked using the mean quantity of ingredients from 4 online similar recipes for the three types of rice dishes (jollof, fried and boiled rice with tomato stew). See table 3.1 below for details of each and their sources. The samples were homogenized differently and subjected to proximate analysis. Table 3.1 shows the selected analyzed foods and their sources.

Table 3.1: The selected analyzed foods and their sources

S/N	Sample	Source	No of samples analyzed
1	Jollof, fried and boiled rice and tomato stew made with foreign (long grain) rice	3 Top restaurants in Enugu urban (Roots, Dolphin restaurants Ntachi-osa)	9 samples (3 samples for each variety of rice)
2	Jollof, fried and boiled rice and tomato stew made with local (Abakaliki rice) rice	Food vendors in Enugu urban	15 samples (5 samples for each variety of rice)
3	Jollof, fried and boiled rice and tomato stew made with basmati (Indian grain) rice	Cooked using mean values of ingredients from 4 online recipes in Diet Therapy Laboratory	3 samples (1 samples for each variety of rice)
2	*ayaraya-oka* (maize and pigeon pea meal)	Food vendors in Nsukka urban	5 samples
3	*Ayaraya-ji* (yam and pigeon pea meal)	Food vendors in Nsukka urban	5 samples
4	*Achicha* (dry cocoyam and pigeon pea meal)	Food vendors in Nsukka urban	5 samples
5	*Abacha* (African Salad) (cassava chips and vegetable)	Food vendors in Enugu urban	5 samples
6	*Igbangwu-oka* (maize pudding or corn moimoi)	Food vendors in Nsukka urban	5 samples
7	Bambaranut pudding (*Okpa*)	Food vendors in Nsukka urban	5 samples
8	Three banana species (Gros Michel, Red Dacca and Green Mutant)	Fruit vendors in Nsukka urban	15 samples (5 for each species of banana)
9	Water melon	Fruit vendors in Nsukka urban	5 samples
10	Pawpaw	Fruit vendors in Nsukka urban	5 samples
11	Two species of apple (red and green)	Fruit vendors in Nsukka urban	10 samples (5 for each species of apple)
12	Pineapple	Fruit vendors in Nsukka urban	5 samples

Recipes of the foods in the table 3.1 are shown in the appendix

3.6.0 Proximate composition determination

3.6.1 Moisture determination

The moisture content of the homogenized samples was determined using the hot air oven method described by Association of Official Analytical Chemists (AOAC) procedure for hot air oven method of moisture determination (AOAC, 2000). This method is based on the drying of a food sample under controlled pressure and temperature until constant weight is obtained (ASEAN Network of Food Data Systems, 2011). Moisture content is required to express the nutrient content per dry weight basis.

The Silica dishes for placing the samples were washed and dried in hot air oven at 100 degrees Celsius for ten minutes. Two grams of flour was weighed into the silica dishes. Taking note of the weight of silica dishes, the representative portion of the ground samples were weighed into the dishes. The samples were dried in the moisture extraction oven at 100 degrees centigrade for 24 hours and removed from the oven, cooled in desiccators and re-weighed. The residual moisture was also be determined using the method.

$$\% \text{ moisture} = \frac{\text{Wet weight} - \text{dry weight} \times 100}{\text{Weight of Sample}}$$

3.6.2 Protein determination

Protein content was determined by automated Micro-Kjeldahl method (AOAC, 1990). The method is based on the digestion of proteins and other organic food components in the sample with sulfuric acid in the presence of catalyst (e.g., sodium or potassium sulfate) to release nitrogen from protein and retain it as an ammonium salt. Ammonia gas is liberated upon addition of excess alkali (concentrated sodium hydroxide) and is distilled into a boric acid solution to form an ammonium-borate complex. The ammonia liberated from the complex is titrated with a standardized hydrochloric acid. The amount of nitrogen in the sample is determined from the milligram equivalent of the acid used. Crude protein is determined by multiplying the nitrogen content with a conversion factor (6.25) which is specific to the food matrix (ASEAN Network of Food Data Systems, 2011).

Two grams of each sample was weighed into a micro-Kjeldahl flask. Five grams of anhydrous sodium sulphate, one gram of copper sulphate, a speck of selenium and 5ml of concentrated sulphuric acid were added. The solution was heated in fire chamber and shaken occasionally until the solution changed to green, the heating continued until the green colour disappears. The digest was allowed to cool and transferred to a 100ml volumetric flask with several items of washing and made up of 100ml with distilled water. During distillation process, the conical flask containing 5ml of 4% boric acid and a mixture of blue and red methyl green as an indicator was placed in the flask. The solution was steamed through to collect enough ammonium sulphate. The receiving flask was removed and used for filtration using 0.01N hydrochloric acid until the neutral point was attained. The crude protein was determined by the difference between the initial burette and the final burette reading.

$$\% \text{ nitrogen} = \frac{\text{Litre} \times \text{Normality} \times \text{dilution factor} \times N_2 \times 100}{\text{Sample Weight}}$$

3.6.3 Fat determination

The fat content of the samples was determined using Soxhlet extraction method (AOAC, 2000). In this method, the sample was hydrolyzed by hydrochloric acid at 70-80 ^{o}C. Protein, if any, can be dissolved in the acid, crude fat is then manually extracted by diethyl and petroleum ether. The solvent is removed by evaporation and the oily residue is dried and weighed (ASEAN Network of Food Data Systems, 2011).

A flat bottom extraction flask was thoroughly washed and dried in an oven for about 30 minutes at 105-110 degree centigrade and cooled in a desiccator. Two grams of each of the samples was weighed into a thimble and put in the boiling flask that contains about 40ml of petroleum either. The Soxhlet apparatus was set and allowed to reflux for about 6 hours. The thimbles were removed and the petroleum either on top of the container was collected until the flask was free of petroleum ether. The extract in the flask was dried for 1 hour, cooled in a desiccator and weighed.

$$\% \text{ fat} = \frac{\text{Weight of Extract} \times 100}{\text{Weight of Fat Sample}}$$

3.6.4 Ash content determination

Ash was determined according to AOAC dry ashing methods (AOAC, 2000)**.** This method involved the separation of minerals from the food matrix by the destruction of the organic matter of the sample through dry ashing or wet digestion (ASEAN Network of Food Data Systems, 2011).

Crucibles were washed thoroughly, dried in a hot-air oven at 1000^0c, cooled in a desiccator and weighed. One gram (l g) of the sample was weighed into the crucible of known weighed and put in a muffle furnace. Heat was applied gradually until the temperature rises to 600^0c. The temperature was maintained for about 6h. The crucible with its content was removed, cooled in a desiccator and weighed. The weighed of the ash was calculated by subtracting the weight of the empty crucible from the weight of crucible and ash sample and dividing by the original weight sample.

$$\% \text{ ash} = \frac{\text{Weight of extract + flask – weight of empty flask} \times 100}{\text{original Weight of Sample}}$$

3.6.5 Crude fibre determination

The determination of crude fibre was done using AOAC procedure (AOAC, 2000). Two grams (2g) of the sample was put into a 250ml beaker (W_1), boiled (digested) for 30 minutes with 100ml 1.25% dilute H_2S0_4 and filtered using a Buckner flask covered with a white calico cloth connected to vacuum pump. The filtered residue was washed with boiling water several times until the washing is no longer acidic and was returned to the same beaker using a spatula. About 100ml 1.25% NaOH was measured and added into the flask and digested again for 30 minutes. Filtration was done as before using the vacuum pump. The residue was washed several times with hot water, rinsed again with 1% HCl to neutralize any trace of alkaline. It was rinsed with methylated spirit three times to remove any trace of oil in the residue. The residue was transferred into a weighed crucible and dried in the oven for 1h. The crucible with its content was cooled in a desiccator and then weighed (W_2). This was transferred into a muffle furnace for ashing at 600^{o}C for about 2h. The ash sample was removed from the furnace after the temperature had cooled and put into the desiccator and latter weighed (W_3). The crude fibre content was obtained by determining the difference between the weight before and after incineration. The percentage of crude fibre was calculated thus:

$$\%\text{ Crude fibre} = \frac{W_2 - W_3}{W_1} \times 100$$

3.6.6 Carbohydrate determination

This is based on the fact that once all the other proximate parameters are determined, the balance of the residue is regarded as carbohydrates. Carbohydrates was calculated by difference (100 – % Moisture + Ash + Protein + Fat + crude fibre) (Food and Agriculture Organization, 2012).

3.7 Energy determination

Energy was determined by the "Atwater factor". The energy value of the samples was calculated by multiplying the values for fat, CHO and protein with 17:37:17 the "Atwater factors" respectively (Food and Agriculture Organization, 2012).

Where

Protein	=	17KJ/g or 4 kcal/g
Fat	=	37KJ/g or 9 kcal/g
Carbohydrates	=	17KJ/g or 4 kcal/g

3.8.0 Development of the photographic food atlas

This phase of the study involved preparation of food for picture development, portion size determination, food photographs and photographic food atlas development and validation. Materials and methods used for food selection, the determination of number of portions per food selected, the preparation of selected foods, the picture taking process and the development of the photographic food atlas are discussed under this section.

3.8.1 Preparation of food for picture development

The selected fruits were purchased from Nsukka urban in Enugu state. The foods were cooked by the research team. Research assistants from Nsukka cooked the Nsukka local dishes used in the study. This included: *igbangwu-oka*, *achicha*, *ayaraya-ji* and *ayaraya-oka*, while those from Udi in Enugu State cooked *okpa* and *abacha* (African salad), the rice dishes were cooked by trained therapeutic diet cooks working in the Diet Therapy Laboratory of the department of Nutrition and Dietetics, University of Nigeria Nsukka. The domestic measures (DOM-M) were labelled A to I as shown in the figure 4.24a. The food photographs were labelled based on the DOM-M used in measuring out the food portions. The first alphabet (A to I) in the label stands for the particular DOM-M used in measuring out the food portions in the plates while the second alphabet stands for the first letter of the type of food photographed which included: "B" for basmati rice, "L" for local (Abakaliki rice) rice, "F" for foreign (long grain) rice, "AC" for *achicha*, "AY" for *ayaraya-oka* , "AJ" for *ayaraya-ji* and "AB" for *abacha*.

3.8.2 Portion size estimation

The selected food was portioned into 9 different portion sizes each using domestic dishing spoons/measures based on key informants' (retailers of kitchen equipment and utensils in Ogbaete market) information on the commonly sold domestic dishing spoons/measures in a major market in Enugu urban. Different domestic measures labelled alphabets A to I were used to weigh out cooked portions. The specifications for the domestic measures are shown in Table 3.2. The mean weights of the slightly heaped domestic measures were recorded after four (4) different measures by four different adult individuals. The photographs of domestic measures (DOM-M) were captured and the heaping of different selected foods were shown in figures 4.24b to 4.24h. Five carbohydrate serving sizes (quantity that will supply 10g, 15g, 20g, 30g and 45g carbohydrates respectively) based on the carbohydrate servings used in the clinical setting for carbohydrate counting (Nelms et al., 2011). Studies have reported that higher number of portion sizes in the photographs increases higher accuracy in estimation of portion sizes (Nelson, Atkinson, & Darbyshire, 1996). The weights of the foods for each portion was measured before taking the picture using a digital kitchen scale. These weights were used to estimate the proximate and energy content per picture represented.

Table 3.2: The measurement specifications for the domestic measures used in the study

Household Measures	Volume (ml)	Length (cm)	Width (cm)	Depth (cm)	Length of handle (cm)
A	96	8.9	9.6	2	24.8
B	32	9.6	6.8	1.5	22.8
C	42	11	7.3	1.3	29.3
D	40	10	7.8	1.5	29.7
E	154	9	10.3	3.5	26.6
F	52	10.5	8	1.5	23.5
G	147	11.3	12.5	0.8	13.8
	Volume (ml)	**Diameter (cm)**		**Depth (cm)**	
H	161	14		0.5	-
I	325	9.7		6.4	-
Serving plate	867	27.7		0.8	

3.8.3 Food photographs and photographic food atlas development

Each food portion was placed in white coloured flat plate as used in previous studies (Boateng, 2014; Flannery, n.d.; Michael Nelson & Haraldsdólttir, 1998a; Timon et al., 2018). The plate had outer diameter of 27.8 cm, depth of 1cm, and inner central diameter of 20 cm. Each plated food portion was placed in a square white table top. Coloured photographs were taken from the top of the food using Nikkon D60 digital camera on a focal length of 26mm and with a vertical and horizontal resolution of 300dpi and 300dpi respectively. The angle the photograph captured was 48.234 Arcseconds per Pixel calculated from an online field of view calculator https://www.howardedin.com/articles/fov.html. Computer program was used to format the pictures without altering the true image as reported in earlier studies (Boateng, 2014; Flannery, n.d.; Michael Nelson & Haraldsdólttir, 1998a; Timon et al., 2018).

3.9 Validation of the photographic food atlas

The validation of the photographic food atlas took place at University of Nigeria Teaching Hospital Enugu Cafeteria. The subjects were 12 diabetic patients consulting Registered Dietitian-Nutritionist from the three selected hospitals in Enugu who consented to participate in the validation. The selected foods were validated for carbohydrate serving. The domestic portion sizes had the picture of the spoons/measures used for the measurement as well as the heaping levels of the spoons which makes identification very easy. The different portions sizes validated for were 10g, 15g, 20g, 30g and 45g carbohydrate servings in the picture. Food items in the pictures were each weighed and placed in a flat plate to match with the weight of equal portion in the food photographs. Codes was inscribed under each of the plated portions. The respondents were asked to match foods in plates with pictures to validate usefulness of the photographic food atlas. The matching script of each respondent was marked, scored and categorized as follows: poor (<40%), fair (40-49%), good (50 – 59%), very good (60 – 69%), and excellent (≥70%).

3.10 Statistical analysis

Statistical analyses was performed using IBM SPSS Statistics software, version 22 for Windows and Microsoft Excel version 2016. Data from proximate composition analysis was described with mean and standard deviation for 100g portion size analysed. The mean of the 100g portion size was used in calculating the portions that supplied the different carbohydrate portions and the proximate content of the domestic measures by proportion. Chi square and Pearson correlation were used to determine the relationship between demographic and health data of the validators with validation score. Results were summarized as means, standard deviation, and percentages and presented in tables and figures.

CHAPTER FOUR

4.0 RESULTS

4.1 Sociodemographic characteristics of persons with diabetes in Enugu State

Table 4.1 shows the sociodemographic characteristics of persons with diabetes in Enugu State. More (56.8%) were females while 43.2 were males. Majority (93.8) are Igbo by ethnicity, 43.2% had tertiary education, and 27.2% were traders.

Table 4.1: The sociodemographic characteristics of persons with diabetes in Enugu State.

Variable	Frequency	Percent
Sex		
Male	35	43.2
Female	46	56.8
Total	**81**	**100.0**
Ethnic Background		
Igbo	76	93.8
Yoruba	2	2.5
Others	3	3.7
Total	**81**	**100.0**
Educational Qualification		
No Formal Education	6	7.4
Primary	14	17.3
Secondary	26	32.1
Tertiary	35	43.2
Total	**81**	**100.0**
Occupation		
Civil Servant	20	24.7
Farmer	15	18.5
Trader	22	27.2
Artisan	2	2.5
Retired	9	11.1
Unemployed/Housewife	12	14.8
Student	1	1.2
Total	**81**	**100.0**
Religion		
Islam	1	1.2
Christianity	78	96.3
Others	2	2.5
Total	**81**	**100.0**
Average Monthly Income in Naira		
<18000	22	27.2
18000 - 30000	14	17.3
31000 - 50000	14	17.3
51000 - 80000	11	13.6
81000 - 100000	8	9.9
>100000	12	14.8
Total	**81**	**100.0**
Marital Status		
Single	11	13.6
Currently Married/Cohabiting	51	63.0
Separated/Divorced	5	6.2
Widow/Widower	14	17.3
Total	**81**	**100.0**
Residing Area		
Urban	55	67.9
Rural	26	32.1
Total	**81**	**100.0**

4.2 The commonly consumed staple foods among diabetic patients in Enugu State

Figure 4.1 presents the commonly consumed foods among adult diabetic clients seeking services of Dietitian-Nutritionists in Out-patient department of selected hospitals in Enugu State. Rice dishes (rice + stew (46 points) and jollof (43.5 points) and *okpa* (45.5 points) were the most commonly consumed food by the clients while macaroni + rice (6.5 points) and Akara + Quaker oat (6.5 points) scored least commonly consumed

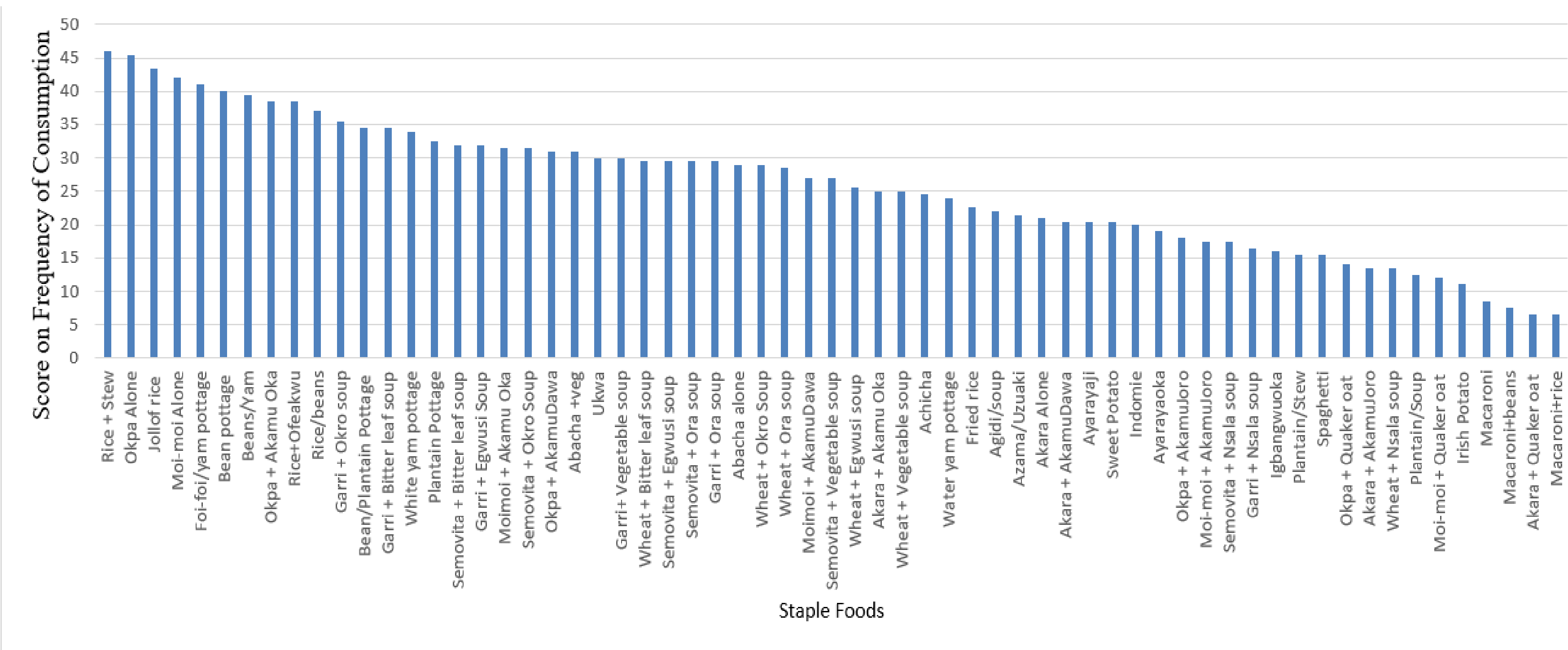


Figure 4.1: The commonly consumed foods among adult diabetic clients seeking services of Dietitian-Nutritionists in Out-patient department of selected hospitals in Enugu State (n=81).

4.3 Proximate and energy content of 100g edible serving portions of selected fruits and foods consumed by diabetic patients in Enugu State

4.3.1 Proximate and energy content of 100g edible serving portions of selected fruits consumed by diabetic patients in Enugu State

Table 4.2 presents the energy and proximate composition of selected fruits consumed by diabetic patients in Enugu State. The carbohydrate content of the fruits ranged from 4.51% in watermelon fruit to 19.5% in Red Dacca banana variety. Protein was highest (2.20%) in Gros Michel banana variety and least (0.30%) in Green Mutant banana variety. Moisture was highest (93.93%) in watermelon fruit and least (75.49) in Red Dacca banana variety.

Table 4.2: Energy and proximate composition of selected fruits consumed by diabetic patients in Enugu State per 100g edible portion

Fruits	Energy (kcal)	Energy (kj)	Moisture (%)	Protein (%)	Fat (%)	Carb (%)	Crude fibre (%)	Ash (%)
Gros Michel banana	95.00	399.00	76.90 ±0.20	2.20 ±0.01	1.40 ±0.01	18.20 ±0.02	0.04 ±0.00	1.26 ±0.01
Red Dacca banana	106.00	445.20	75.49 ±0.20	1.40 ±0.01	2.50 ±0.01	19.50 ±0.20	0.01 ±0.00	1.10 ±0.01
Green Mutant banana	125.00	525.00	78.50 ±0.30	0.30 ±0.00	8.20 ±0.02	12.30 ±0.10	0.03 ±0.00	0.67 ±0.00
Red apple	74.32	312.14	81.45 ±0.20	1.04 ±0.01	0.20 ±0.00	15.18 ±0.30	1.91 ±0.01	0.22 ±0.00
Green apple	80.13	336.55	79.90 ±0.20	0.86 ±0.01	0.13 ±0.00	16.84 ±0.05	2.04 ±0.01	0.23 ±0.00
Pineapple	91.67	385.01	76.95 ±0.10	1.03 ±0.01	0.15 ±0.00	18.75 ±0.20	2.80 ±0.01	0.32 ±0.00
Watermelon	23.82	100.04	93.93 ±0.30	0.58 ±0.00	0.10 ±0.00	4.51 ±0.01	0.64 ±0.00	0.24 ±0.00
Pawpaw	66.57	279.59	82.87 ±0.20	0.87 ±0.00	0.05 ±0.00	13.75 ±0.06	1.91 ±0.00	0.55 ± 0.00

Mean ± standard deviation of 3 determinations; Carb = Carbohydrate

4.3.2 Proximate and energy content of 100g edible serving portions of selected foods consumed by diabetic patients in Enugu State

Table 4.3 presents the energy and proximate composition of selected foods consumed by diabetic patients in Enugu State. The energy content of the foods per 100g edible portion ranged from 310.5 kcal in *achicha* to 112.3 kcal of local boiled rice and tomato stew. The carbohydrate content ranged from 32.1% in *okpa* to 5.0% in *igbangwu-oka*. The fat content was highest in *achicha* (27.2%) but lowest in basmati fried rice (1.6%). Basmati jollof rice had the least (1.4%) protein per 100g edible portion which protein was highest in abacha (12%).

Table 4.3: Energy and proximate composition of selected foods consumed by diabetic patients in Enugu State per 100g edible portion.

Foods	Energy (kcal)	Energy (kj)	Moisture (%)	Protein (%)	Fat (%)	Carb (%)	Crude fibre (%)	Ash (%)
Basmati Jollof rice	165.1	693.42	64.3 ±0.05	1.4 ±0.02	5.3 ±0.01	27.9 ±0.02	0.2 ±0.00	0.9 ±0.01
Basmati boiled rice and tomato stew	166.4	698.88	63.6 ±0.04	7.7 ±0.01	4.8 ±0.01	21.4 ±0.03	1.7 ±0.01	0.8 ±0.01
Basmati fried rice	133.2	559.4	67.2 ±0.02	6.1 ±0.01	1.6 ±0.02	22.6 ±0.02	1.1 ±0.01	1.4 ±0.02
Local fried rice	132.0	554.4	70.2 ±0.04	5.2 ±0.01	3.3 ±0.01	17.9 ±0.02	2.5 ±0.01	0.9 ±0.00
Local jollof rice	120.8	507.4	71.7 ±0.04	6.4 ±0.01	2.4 ±0.02	16.2 ±0.03	2.2 ±0.01	1.1 ±0.01
Local boiled rice and tomato stew	112.3	471.7	73.6 ±0.05	4.9 ±0.01	1.8 ±0.01	16.4 ±0.03	2.7 ±0.01	0.6 ±0.00
Foreign fried rice	137.0	575.4	70.0 ±0.02	10.0 ±0.01	4.5 ±0.01	13.2 ±0.02	1.3 ±0.01	1.0 ±0.01
Foreign jollof rice	138.0	579.6	69.0 ±0.04	8.0 ±0.01	4.4 ±0.02	15.1 ±0.03	1.7 ±0.00	1.8 ±0.01
Foreign boiled and tomato stew	129.0	541.8	70.8 ±0.04	8.8 ±0.01	3.6 ±0.01	14.7 ±0.02	0.8 ±0.00	1.3 ±0.01
Achicha	310.5	1304.1	54.5 ±0.02	3.8 ±0.01	27.2 ±0.01	8.5 ±0.01	4.1 ±0.01	1.9 ±0.01
Ayaraya-Oka	189.2	794.6	68.1 ±0.02	3.7 ±0.01	16.0 ±0.01	7.0 ±0.01	0.6 ±0.01	4.6 ±0.02
Ayaraya-Ji	206.0	865.2	59.9 ±0.02	3.2 ±0.02	11.8 ±0.01	21.2 ±0.01	0.5 ±0.01	3.4 ±0.01
Okpa	249.9	1049.6	49.1 ±0.02	6 .0 ±0.01	10.8 ±0.01	32.1 ±0.02	0.1 ±0.00	1.9 ±0.01
Igbangwu-oka	163.0	684.6	73.8 ±0.02	4.3 ±0.01	13.7 ±0.01	5.0 ±0.02	0.4 ±0.00	2.8 ±0.2
Abacha	190.2	798.8	56.8 ±0.02	12.0 ±0.02	4.4 ±0.02	22.8 ±0.02	2.9 ±0.01	1.1 ±0.01

4.4 Photographic food atlas, proximate and energy content of carbohydrate servings of selected fruits consumed by diabetic patients in Enugu State

4.4.1 The proximate and energy composition of different carbohydrate servings of Gros Michel banana fruit

Table 4.4 shows the proximate and energy composition of different carbohydrate servings of Gros Michel banana fruit. The amount supplying 10g, 15g, 20g, 30g, and 45g of carbohydrate respectively differed in their proximate composition. The serving weights (g) of the banana that supplied the different servings ranged from 55g for 10g carbohydrate servings to 247g for 45g carbohydrate servings. Gros Michel banana contained 76.9g moisture, 2.2g crude protein, 1.4g crude fat, 18.2g carbohydrate, 0.04g crude fibre and 1.26g ash.

Table 4.4: The proximate and energy composition of different carbohydrate servings of Gros Michel banana fruit

Carbohydrate servings (g)	Serving weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Crude Protein (g)	Fat (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
	100	95	397	76.9	2.2	1.4	18.2	0.04	1.26
10g Carb	55.00	52.25	218.35	42.30	1.21	0.77	10.01	0.02	0.69
15g Carb	82.00	77.90	325.54	63.06	1.80	1.15	14.92	0.03	1.03
20g Carb	110.00	104.50	436.70	84.59	2.42	1.54	20.02	0.04	1.37
30g Carb	165.00	156.75	655.05	126.89	3.63	2.31	30.03	0.07	2.08
45g Carb	247.00	234.65	980.59	189.94	5.43	3.46	44.95	0.10	3.11

4.4.2 The Photographic food atlas of different carbohydrate servings of Gros Michel banana fruit

Figure 4.2 presents the photographic atlas of different carbohydrate servings of Gros Michel banana. Pictures are labelled GMI-10 to GMI-45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

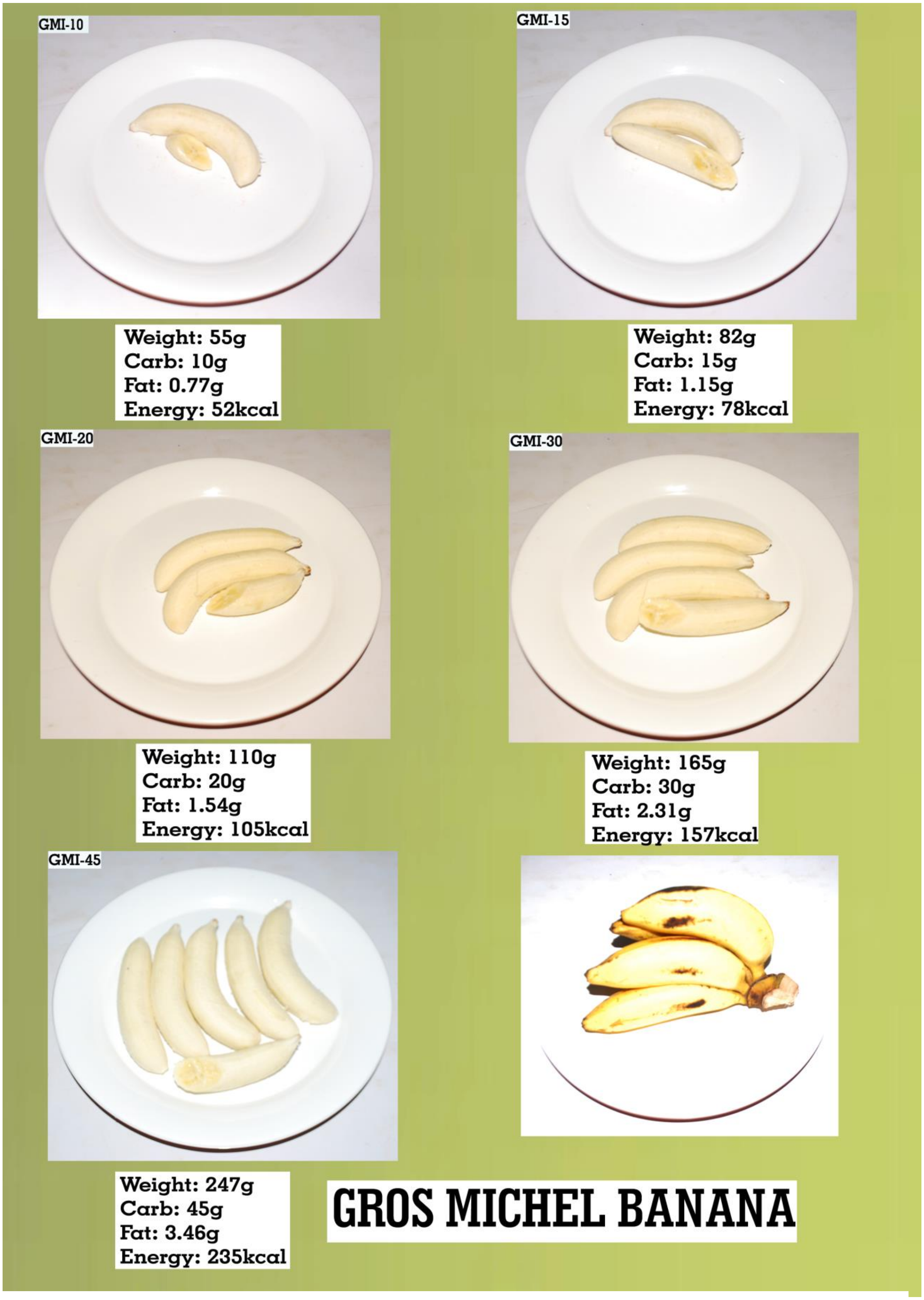


Figure 4.2: The photographic atlas of different carbohydrate servings of Gros Michel banana.

4.4.3 The proximate and energy composition of different carbohydrate servings of red dacca banana fruit

The proximate and energy composition of different carbohydrate servings of Red Dacca banana fruit specie is presented in Table 4.5. The quantity of red dacca banana that supplied 10g, 15g, 20g, 30g and 45g of carbohydrates varied in their proximate composition. The serving weights (g) of edible portions of Red Dacca banana that supplied the different servings ranged from 51g for 10g carbohydrate serving to 231g for 45g carbohydrate servings. The table showed that the Moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents were 75.49g, 1.4g, 2.5g, 19.5g, 0.01g and 1.1g respectively.

Table 4.5: The proximate and energy composition of different carbohydrate servings of red dacca banana fruit

Carbohydrate servings (g)	Serving weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Crude Protein (g)	Fat (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
	100.00	106.00	444.00	75.49	1.40	2.50	19.50	0.01	1.10
10g Carb	51.00	54.06	226.44	38.51	0.71	1.28	9.95	0.01	0.56
15g Carb	77.00	81.62	341.88	58.14	1.08	1.93	15.02	0.01	0.85
20g Carb	103.00	109.18	457.32	77.77	1.44	2.58	20.09	0.01	1.13
30g Carb	154.00	163.24	683.76	116.27	2.16	3.85	30.03	0.02	1.69
45g Carb	231.00	244.86	1025.64	174.41	3.23	5.78	45.05	0.02	2.54

4.4.4 The Photographic food atlas of different carbohydrate servings of red dacca banana fruit

Figure 4.3 presents the photographic atlas of different carbohydrate servings of red dacca banana. Pictures are labelled R10 to R45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

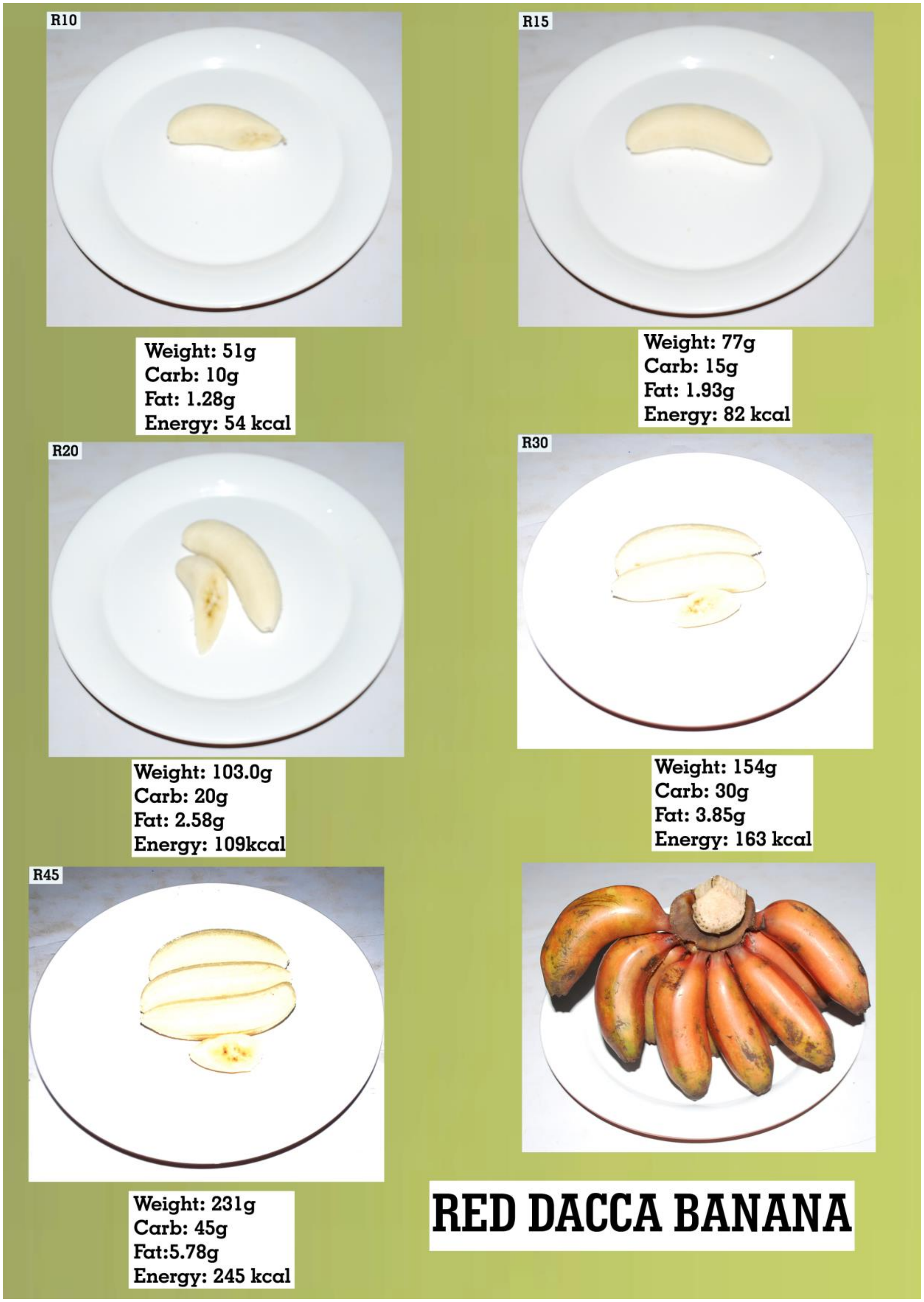


Figure 4.3: The photographic atlas of different carbohydrate servings of Red Dacca banana.

4.4.5 The proximate and energy composition of different carbohydrate servings of green mutant banana fruit

The proximate and energy composition of different carbohydrate servings of banana green mutant fruit specie is presented in Table 4.6. The 10g, 15g, 20g, 30g and 45g of carbohydrate servings varied in their proximate composition. The serving weights (g) of edible portion of banana green mutant that supplied the different servings ranged from 81g for 10g carbohydrate serving to 366g for 45g carbohydrate serving. The table shows that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents were 78.50g, 0.30g, 8.20g, 12.30g, 0.03g and 0.67g respectively.

Table 4.6: The proximate and energy composition of different carbohydrate servings of banana Green Mutant fruit

Carbohydrate servings (g)	Serving weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Crude Protein (g)	Fat (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
	100	125.00	522.00	78.50	0.30	8.20	12.30	0.03	0.67
10g Carb	81.00	101.25	422.82	63.59	0.24	6.64	9.96	0.02	0.54
15g Carb	122.00	152.50	636.84	95.77	0.37	10.00	15.01	0.04	0.82
20g Carb	163.00	203.75	850.86	127.96	0.49	13.37	20.05	0.05	1.09
30g Carb	244.00	305.00	1273.68	191.54	0.73	20.01	30.01	0.07	1.63
45g Carb	366.00	457.50	1910.52	287.31	1.10	30.01	45.02	0.11	2.45

4.4.6 The Photographic food atlas of different carbohydrate servings of green mutant banana fruit

Figure 4.4 presents the photographic atlas of different carbohydrate servings of green mutant banana. Pictures are labelled GMU10 to GMU45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

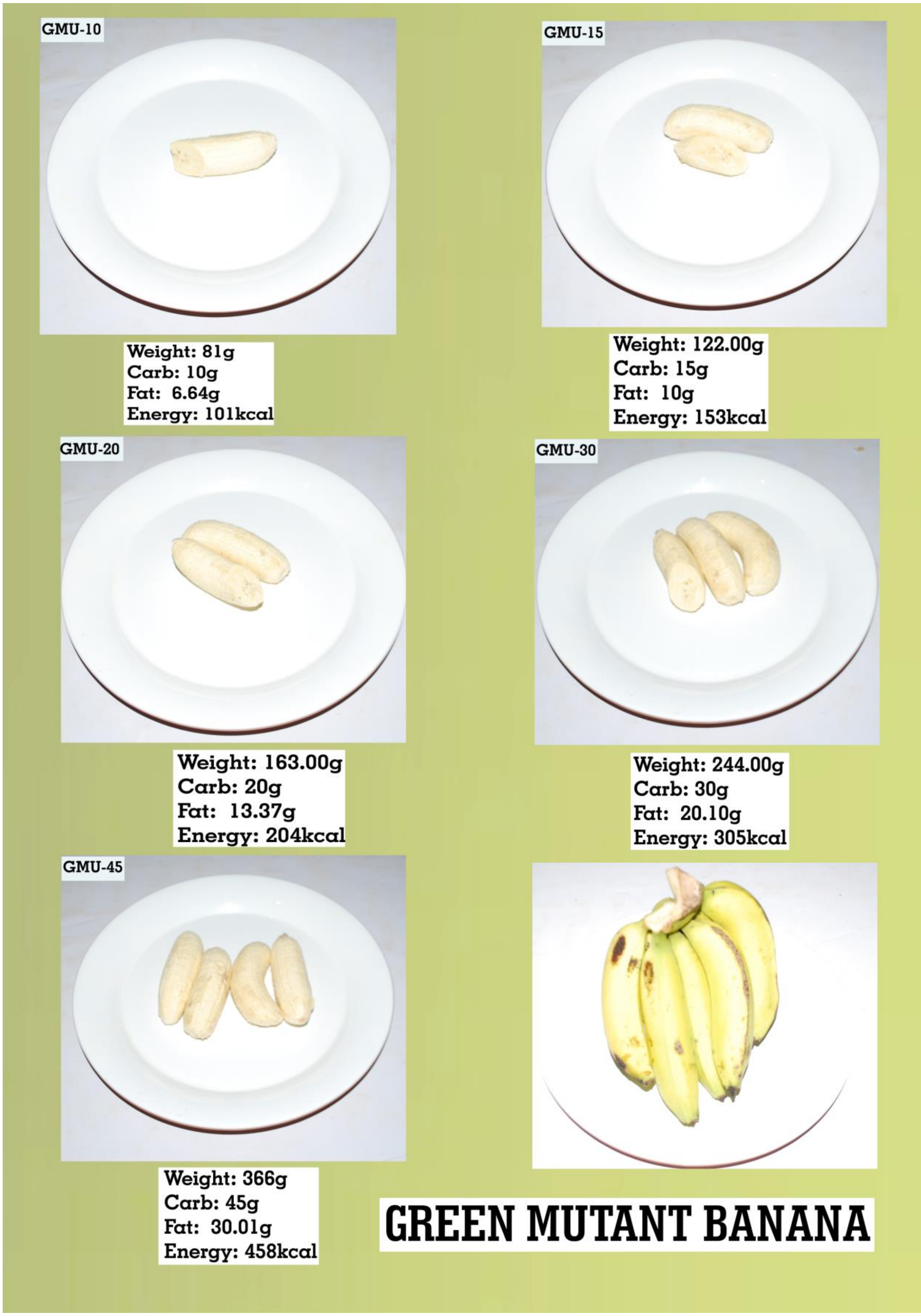


Figure 4.4: The photographic atlas of different carbohydrate servings of Green mutant

4.4.7 The proximate and energy composition of different carbohydrate servings of red apple fruit

The proximate and energy composition of different carbohydrate servings of red delicious apple fruit specie is presented in Table 4.7. The amount supplying 10g, 15g, 20g, 30g and 45g of carbohydrate respectively varied in their proximate composition. The serving weights (g) of edible portion of red delicious apple that supplied the different servings ranged from 66g for 10g carbohydrate serving to 296g for 45g carbohydrate serving. The table showed that the Moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents were 81.45g, 1.04g, 0.2g, 15.18g, 1.91g and 0.22g respectively.

Table 4.7: The proximate and energy composition of different carbohydrate servings of red apple

Carbohydrate servings (g)	Serving weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Crude Protein (g)	Fat (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
	100	74.32	312.44	81.45	1.04	0.2	15.18	1.91	0.22
10g Carb	66	49.05	206.01	53.75	0.69	0.13	10.02	1.26	0.15
15g Carb	99	73.58	309.02	80.63	1.03	0.20	15.03	1.89	0.22
20g Carb	132	98.10	412.02	107.50	1.37	0.26	20.04	2.52	0.29
30g Carb	198	147.15	618.04	161.25	2.06	0.40	30.06	3.78	0.44
45g Carb	296	219.99	923.93	241.06	3.08	0.59	44.93	5.65	0.65

4.4.8 The Photographic food atlas of different carbohydrate servings of red apple fruit

Figure 4.5 presents the photographic atlas of different carbohydrate servings of red apple. Pictures are labelled RA-10 to RA-45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

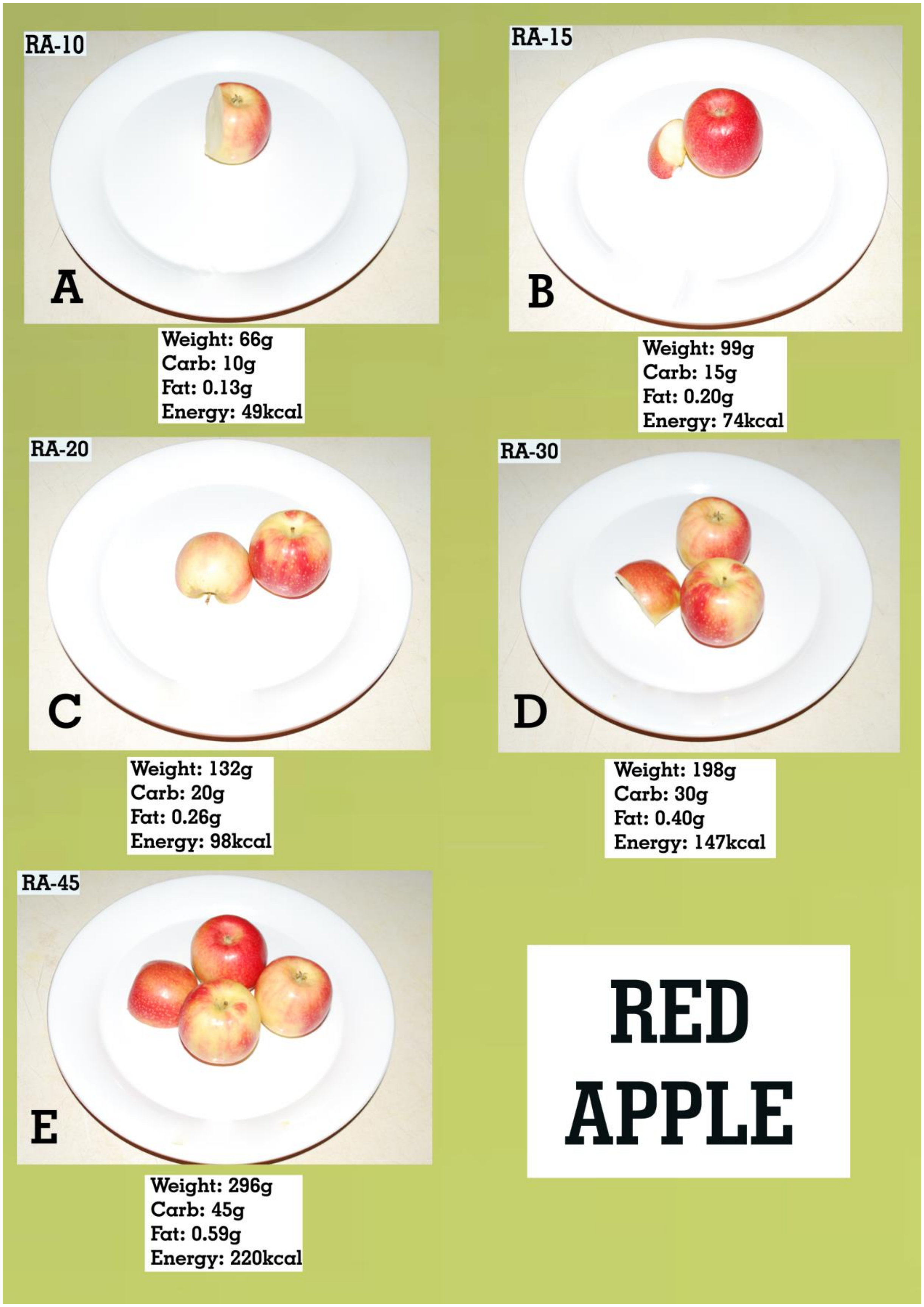


Figure 4.5: The photographic atlas of different carbohydrate servings of red apple.

4.4.9 The proximate and energy composition of different carbohydrate servings of green apple fruit

The proximate and energy composition of different carbohydrate servings of green apple fruit specie is presented in Table 4.8. The quantity of green apple that supplied 10g, 15g, 20g, 30g and 45g of carbohydrates respectively varied in their proximate composition. The serving weights (g) of edible portion of green apple that supplied the different servings ranged from 59g for 10g carbohydrate serving to 267g for 45g carbohydrate servings. The table showed that the Moisture, crude protein, fat, carbohydrate, crude fibre and ash contents were 79.9g, 0.86g, 0.13g, 16.84g, 2.04g and 0.23g respectively.

Table 4.8: The proximate and energy composition of different carbohydrate servings of green apple

Carbohydrate servings (g)	Serving weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Crude Protein (g)	Fat (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
10g Carb	100	80.13	336.57	79.9	0.86	0.13	16.84	2.04	0.23
15g Carb	59	47.28	198.58	47.14	0.51	0.08	9.94	1.20	0.14
20g Carb	89	71.32	299.55	71.11	0.77	0.12	14.99	1.82	0.20
30g Carb	119	95.35	400.52	95.08	1.02	0.15	20.04	2.43	0.27
45g Carb	178	142.63	599.09	142.22	1.53	0.23	29.98	3.63	0.41
10g Carb	267	213.95	898.64	213.33	2.30	0.35	44.96	5.45	0.61

4.4.10 The Photographic food atlas of different carbohydrate servings of green apple fruit

Figure 4.6 presents the photographic atlas of different carbohydrate servings of green apple. Pictures are labelled GA-10 to GA-45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

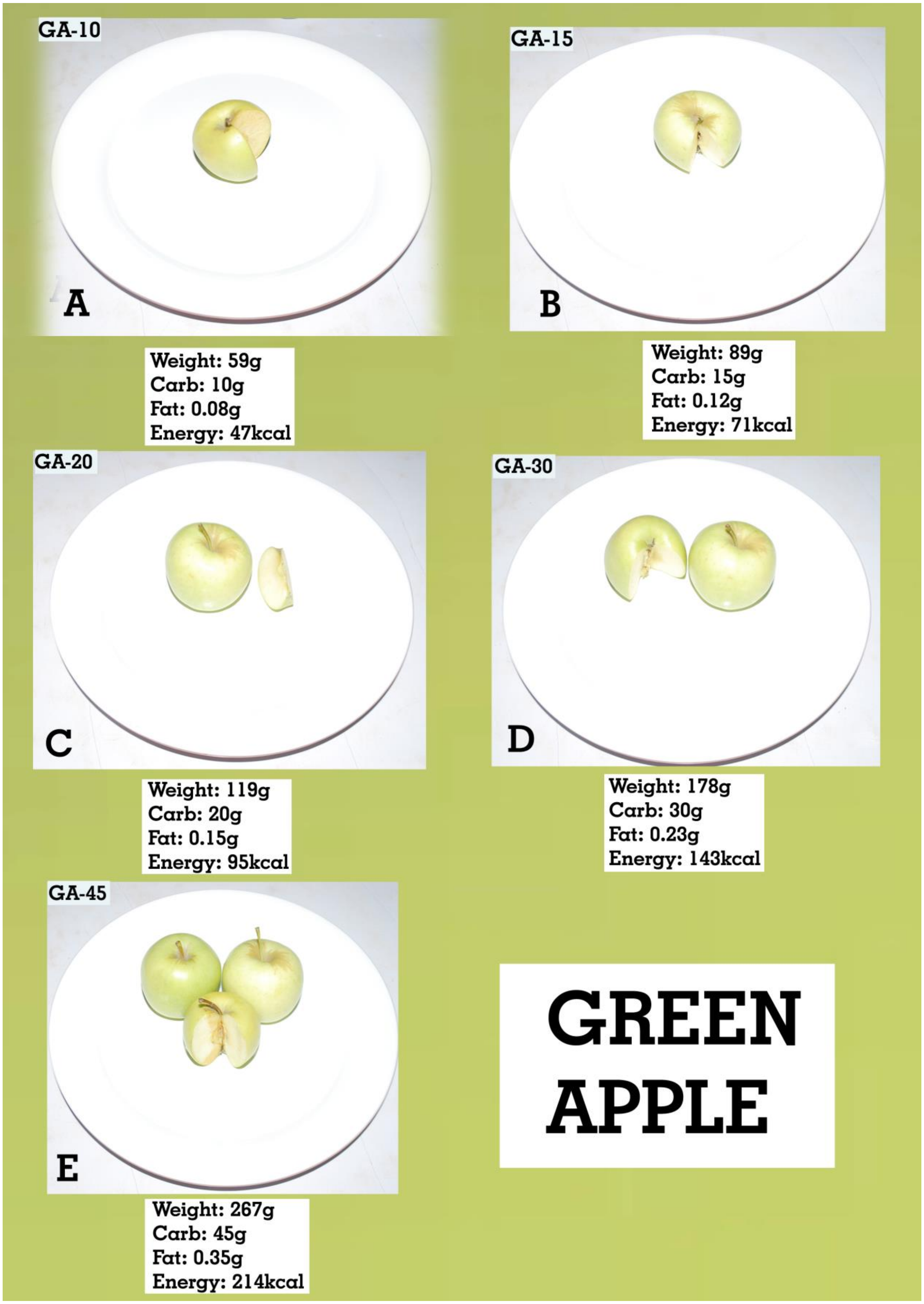


Figure 4.6: The photographic atlas of different carbohydrate servings of green apple.

4.4.11 The proximate and energy composition of different carbohydrate servings of pineapple fruit

The proximate and energy composition of different carbohydrate servings of pineapple fruit is presented in Table 4.9. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of edible portion of pineapple that supplied the different servings ranged from 53g for 10g carbohydrate serving to 240g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents were 76.95g, 1.03g, 0.15g, 18.75g, 2.80g and 0.32g respectively.

Table 4.9: The proximate and energy composition of different carbohydrate servings of pineapple

Carbohydrate servings (g)	Serving weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Crude Protein (g)	Fat (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
	100	91.67	385	76.95	1.03	0.15	18.75	2.80	0.32
10g Carb	53	48.59	204.05	40.78	0.55	0.08	9.94	1.48	0.17
15g Carb	80	73.34	308.00	61.55	0.82	0.12	15.00	2.24	0.26
20g Carb	107	98.09	411.95	82.33	1.10	0.16	20.06	3.00	0.34
30g Carb	160	146.67	616.00	123.10	1.65	0.24	30.00	4.48	0.51
45g Carb	240	220.01	924.00	184.66	2.47	0.36	45.00	6.72	0.77

4.4.12 The Photographic food atlas of different carbohydrate servings of pineapple

Figure 4.7 presents the photographic atlas of different carbohydrate servings of pineapple. Pictures are labelled PA10 to PA45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

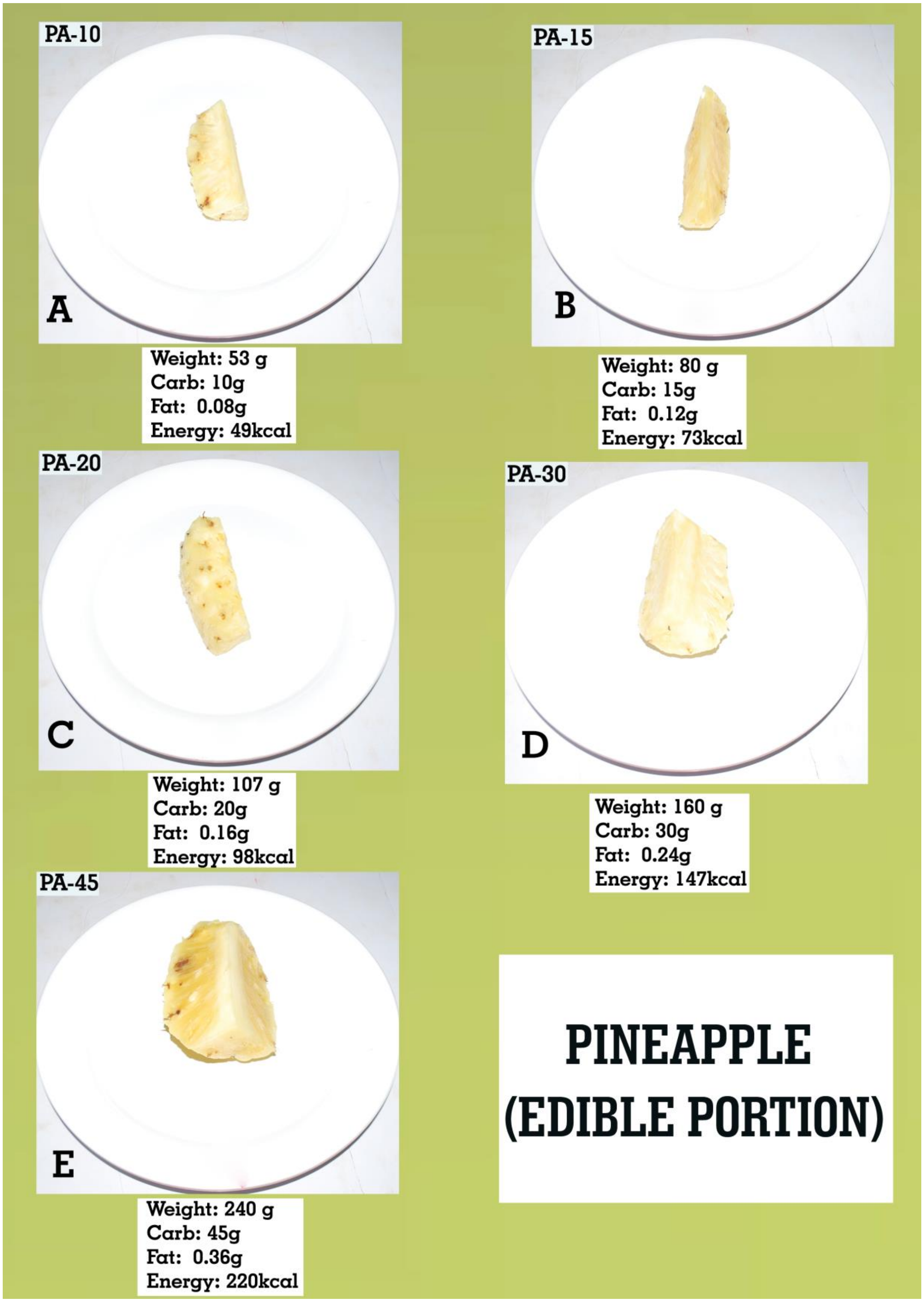


Figure 4.7: The photographic atlas of different carbohydrate servings of pineapple.

4.4.13 The proximate and energy composition of different carbohydrate servings of watermelon fruit

The proximate and energy composition of different carbohydrate servings of watermelon fruit specie is presented in Table 4.10. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of edible portion of watermelon that supplied the different servings ranged from 222g for 10g carbohydrate serving to 998g for 45g carbohydrate servings. The table showed that the Moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents were 93.93g, 0.58g, 0.10g, 4.51g, 0.64g and 0.24g respectively.

Table 4.10: The proximate and energy composition of different carbohydrate servings of watermelon fruit

Carbohydrate servings (g)	Serving weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Crude Protein (g)	Fat (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
	100	23.82	100.4	93.93	0.58	0.1	4.51	0.64	0.24
10g Carb	222	52.88	222.89	208.55	1.29	0.22	10.01	1.42	0.53
15g Carb	333	79.32	334.33	312.82	1.93	0.33	15.01	2.13	0.80
20g Carb	443	105.52	444.77	416.15	2.57	0.44	19.98	2.84	1.06
30g Carb	665	158.40	667.66	624.70	3.86	0.67	29.99	4.26	1.60
45g Carb	998	237.72	1001.99	937.52	5.79	1.00	45.01	6.39	2.40

4.4.14 The Photographic food atlas of different carbohydrate servings of watermelon fruit

Figure 4.8 presents the photographic atlas of different carbohydrate servings of watermelon. Pictures are labelled W10 to W45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

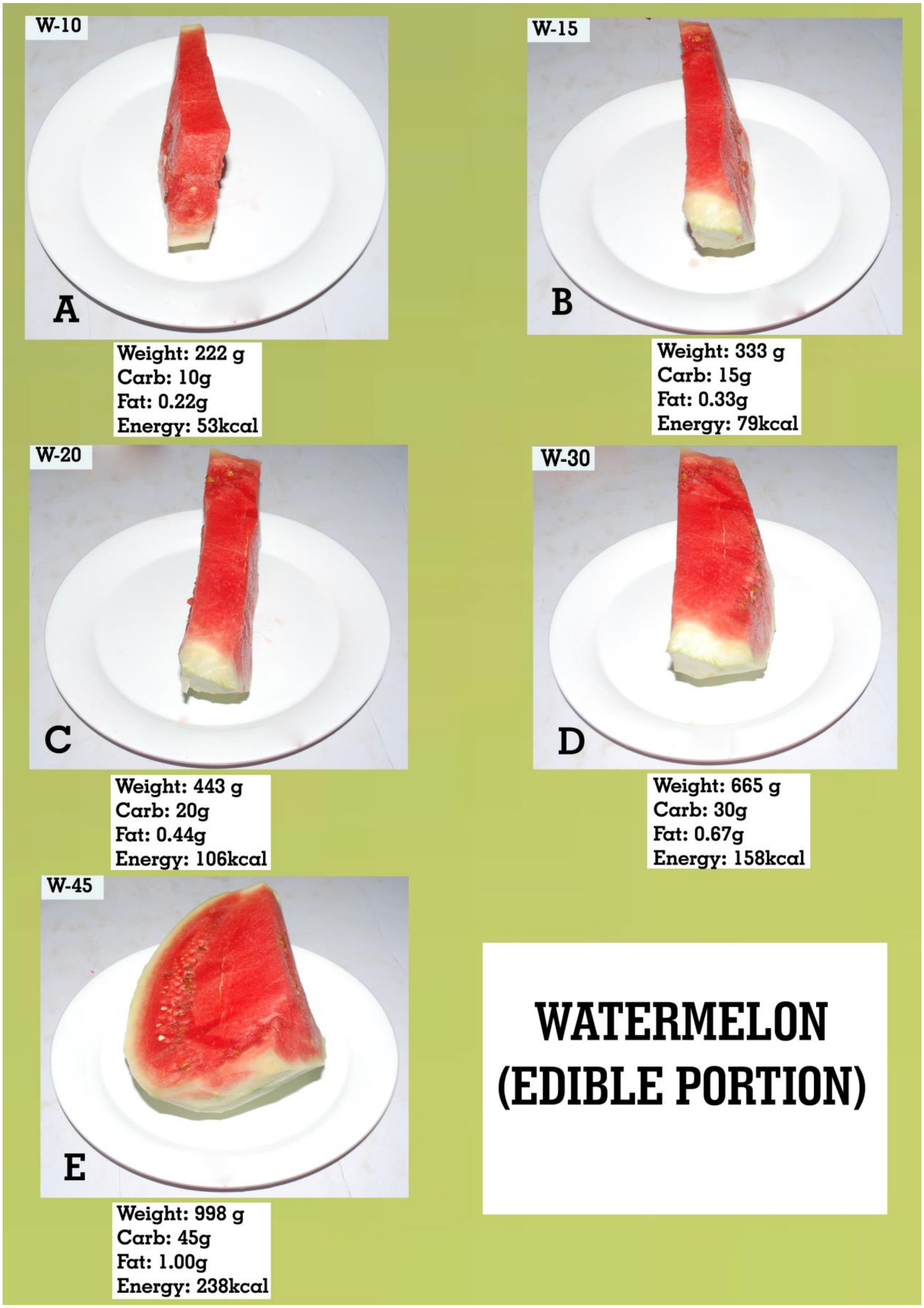


Figure 4.8: The photographic atlas of different carbohydrate servings of watermelon.

4.4.15: The proximate and energy composition of different carbohydrate servings of pawpaw fruit

The proximate and energy composition of different carbohydrate servings of pawpaw fruit specie is presented in table 4.11. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of edible portion of pawpaw that supplied the different servings ranged from 82g for 10g carbohydrate serving to 368g for 45g carbohydrate servings. The table showed that the Moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents are 82.87g, 0.87g, 0.05g, 13.75g, 1.91g and 0.55g respectively.

Table 4.11: The proximate and energy composition of different carbohydrate servings of pawpaw

Carbohydrate servings (g)	Serving weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Crude Protein (g)	Fat (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
	100	66.57	276.59	82.87	0.87	0.05	13.75	1.91	0.55
10g Carb	73	48.60	204.10	60.82	0.64	0.04	10.04	1.39	0.40
15g Carb	109	72.56	304.75	90.82	0.95	0.05	14.99	2.08	0.60
20g Carb	146	97.19	408.20	121.65	1.27	0.07	20.08	2.79	0.80
30g Carb	218	145.12	609.51	181.64	1.90	0.11	29.98	4.16	1.20
45g Carb	327	217.68	914.26	272.46	2.84	0.16	44.96	6.25	1.80

4.4.16 The Photographic food atlas of different carbohydrate servings of pawpaw fruit

Figure 4.9 presents the photographic atlas of different carbohydrate servings of pawpaw. Pictures are labelled P10 to P45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

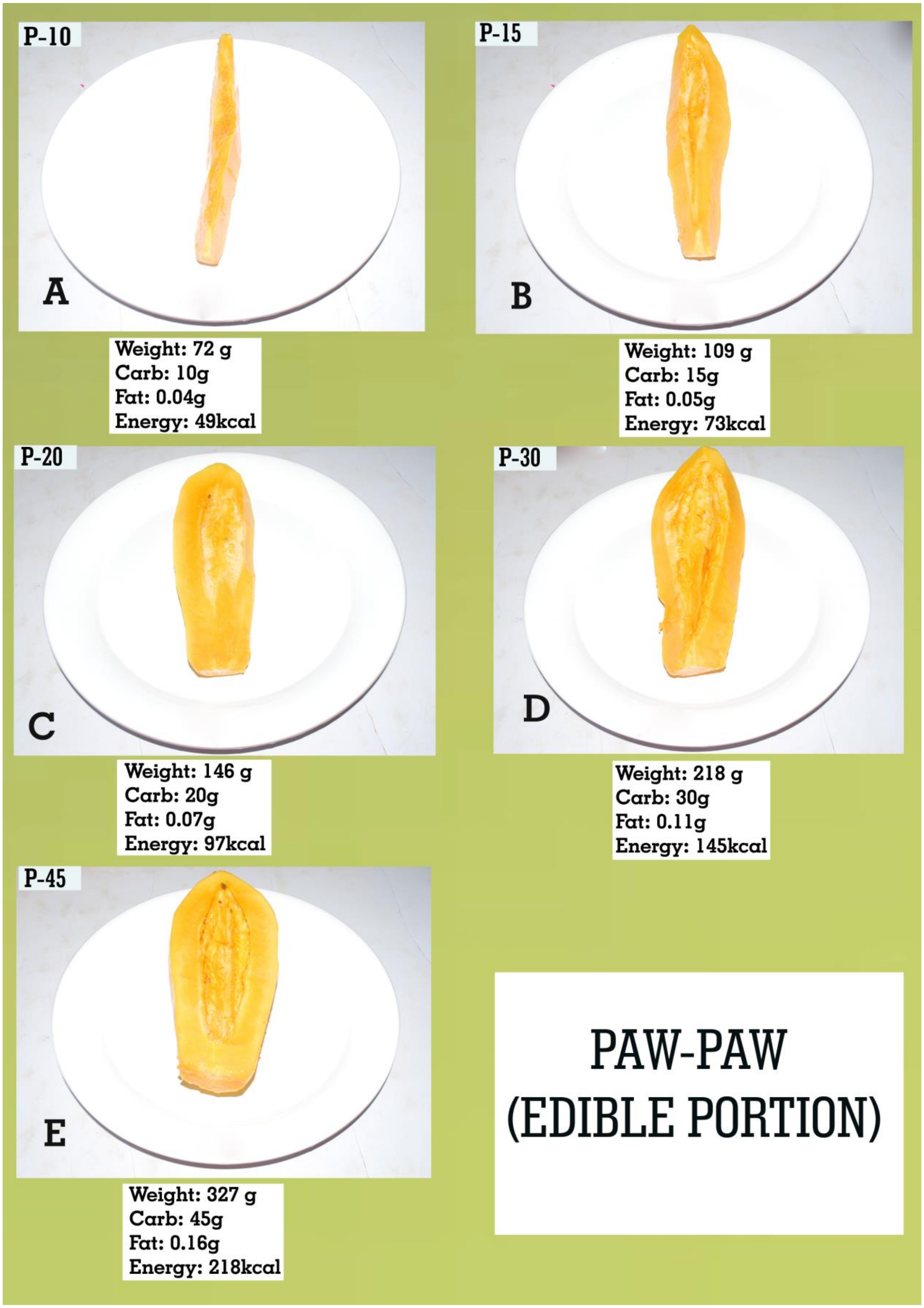


Figure 4.9: The photographic atlas of different carbohydrate servings of pawpaw.

4.5 The photographic food atlas, proximate and energy content of carbohydrate servings of selected foods consumed by diabetic patients in Enugu State

4.5.1 The proximate and energy content of carbohydrate servings of jollof rice prepared with basmati rice

The proximate and energy composition of different carbohydrate servings of jollof rice prepared with basmati rice is presented in Table 4.12. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of jollof rice that supplied the different servings ranged from 36g for 10g carbohydrate serving to 161g for 45g carbohydrate servings. The table showed that the Moisture, crude protein, fat, carbohydrate, crude fibre and ash contents were 64.30g, 1.40g, 5.30g, 27.90g, 0.20g and 0.90g respectively.

Table 4.12: The proximate and energy composition of different carbohydrate servings of jollof rice prepared with basmati rice

Carbohydrate Serving	Serving Weight (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude Fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	165.1	693.4	64.3	0.9	1.4	0.2	5.3	27.9
10g Carb	36.0	59.4	249.6	23.2	0.3	0.5	0.1	1.9	10.1
15g Carb	54.0	89.2	374.4	34.7	0.5	0.8	0.1	2.8	15.1
20g Carb	72.0	118.9	499.26	46.3	0.6	1.0	0.2	3.8	20.1
30g Carb	107.0	176.7	742.0	68.8	0.9	1.5	0.2	5.6	29.9
45g Carb	161.0	265.8	1116.4	103.6	1.4	2.3	0.3	8.5	45.0

4.5.2 The photographic food atlas of carbohydrate servings of jollof rice prepared with basmati rice

Figure 4.10 presented the photographic atlas of different carbohydrate servings of jollof rice prepared with basmati rice. Pictures are labelled B10 to B45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

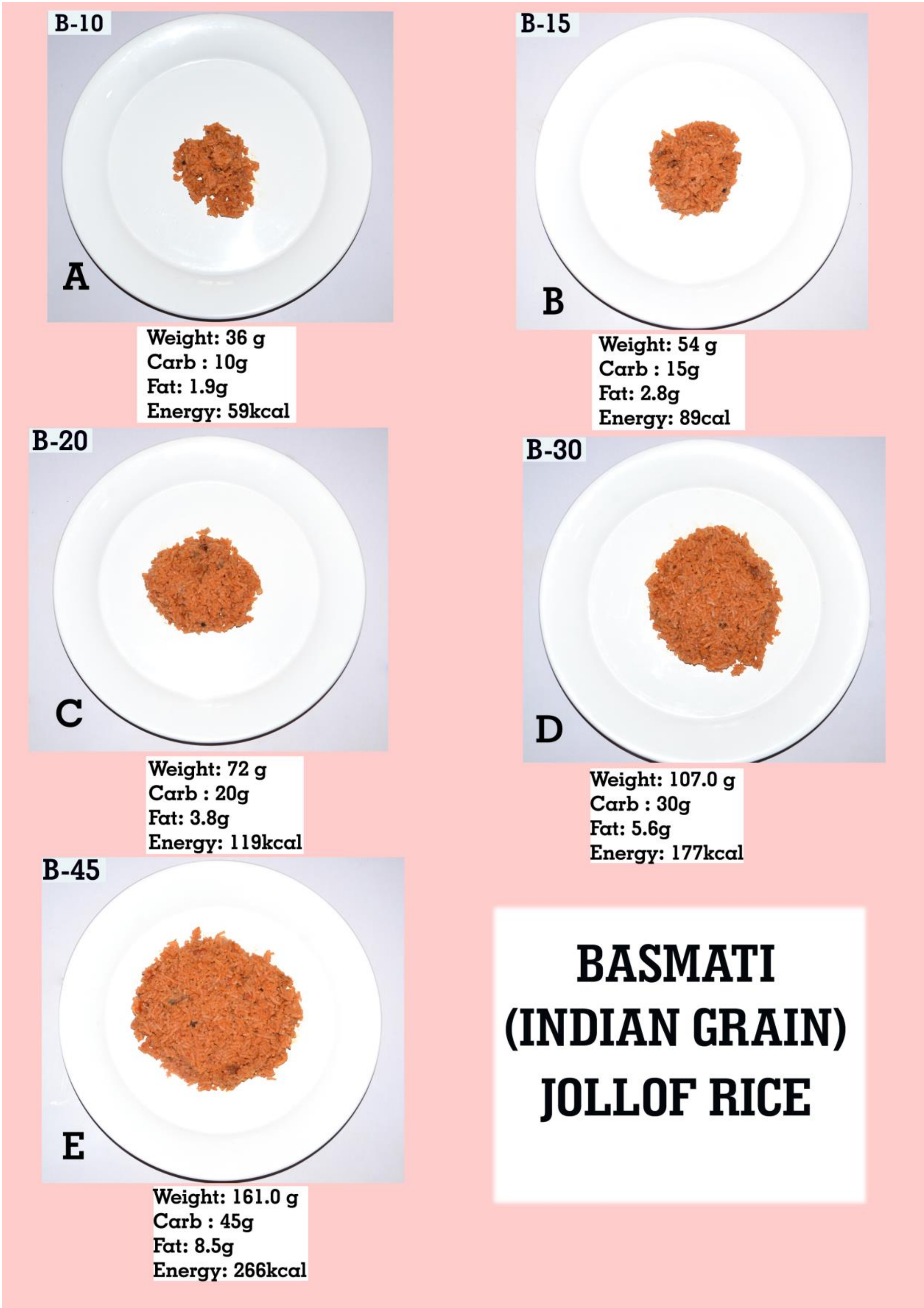


Figure 4.10: The photographic atlas of different carbohydrate servings of jollof rice prepared with basmati rice

4.5.3 The proximate and energy content of carbohydrate servings of boiled rice and tomato stew prepared with basmati rice

The proximate and energy composition of different carbohydrate servings of boiled rice and tomato stew prepared with basmati rice is presented in Table 4.13. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of boiled rice and tomato stew that supplied the different servings ranged from 47g for 10g carbohydrate serving to 210g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents were 63.60g, 7.70g, 4.80g, 21.40g, 1.70g and 0.80g respectively.

Table 4.13: The proximate and energy composition of different carbohydrate servings of boiled rice and tomato stew prepared with basmati rice

Carbohydrate Serving	Serving Weight (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	166.4	698.7	63.6	0.8	7.7	1.7	4.8	21.4
10g Carb	47.0	78.2	328.4	29.9	0.4	3.6	0.8	2.2	10.1
15g Carb	70.0	116.5	489.1	44.5	0.6	5.4	1.2	3.3	15.0
20g Carb	93.0	154.8	649.8	59.1	0.8	7.2	1.6	4.4	19.9
30g Carb	140.0	233.0	978.2	88.9	1.2	10.8	2.4	6.7	30.0
45g Carb	210.0	349.4	1467.4	133.4	1.7	16.2	3.6	10.0	45.0

4.5.4 The photographic food atlas of carbohydrate servings of boiled rice and tomato stew prepared with basmati rice

Figure 4.11 shows the photographic atlas of different carbohydrate servings of boiled rice and tomato stew prepared with basmati rice. Pictures are labelled B10 to B45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

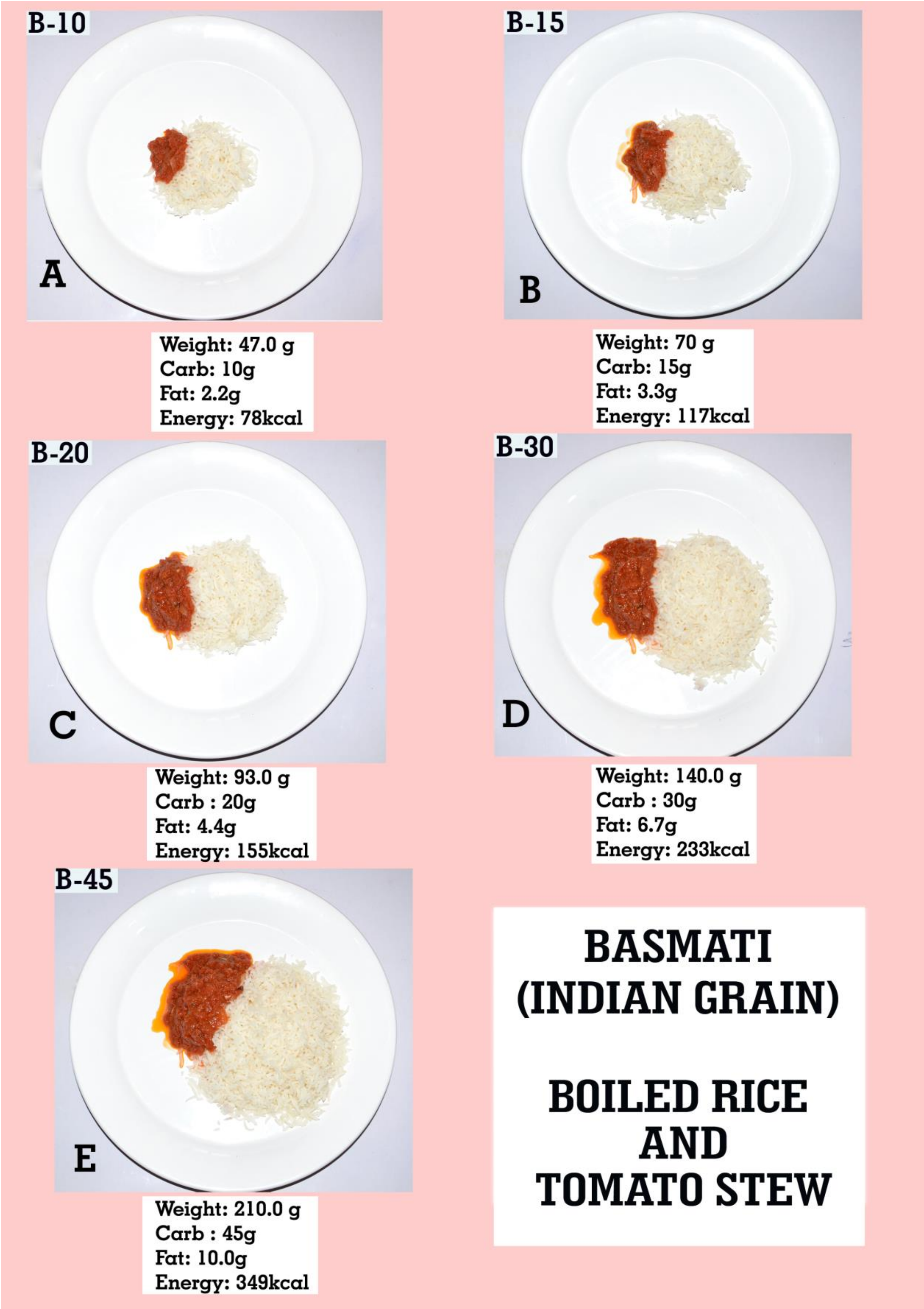


Figure 4.11: The photographic atlas of different carbohydrate servings of boiled rice prepared with basmati rice

4.5.5 The proximate and energy content of carbohydrate servings of fried rice prepared with basmati rice

The proximate and energy composition of different carbohydrate servings of fried rice prepared with basmati rice is presented in Table 4.14. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of fried rice that supplied the different servings ranged from 44g for 10g carbohydrate serving to 199g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents were 67.20g, 6.10g, 0.60g, 22.60g, 1.10g and 1.40g respectively.

Table 4.14: The proximate and energy composition of different carbohydrate servings of fried rice prepared with basmati rice

Carbohydrate Serving	Serving Weight (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	133.2	559.3	67.2	1.4	6.1	1.1	1.6	22.6
10g Carb	44.0	58.6	246.1	29.6	0.6	2.7	0.5	0.7	9.9
15g Carb	66.0	87.9	369.1	44.4	0.9	4.0	0.7	1.0	14.9
20g Carb	88.0	117.2	492.2	59.2	1.2	5.4	0.9	1.4	19.9
30g Carb	133.0	177.1	743.8	89.5	1.9	8.1	1.4	2.1	30.1
45g Carb	199.0	265.0	1112.9	133.8	2.8	12.1	2.1	3.1	45.0

4.5.6 The photographic food atlas of carbohydrate servings of jollof rice prepared with basmati rice

Figure 4.12 presents the photographic atlas of different carbohydrate servings of fried rice prepared with basmati rice. Pictures are labelled B10 to B45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

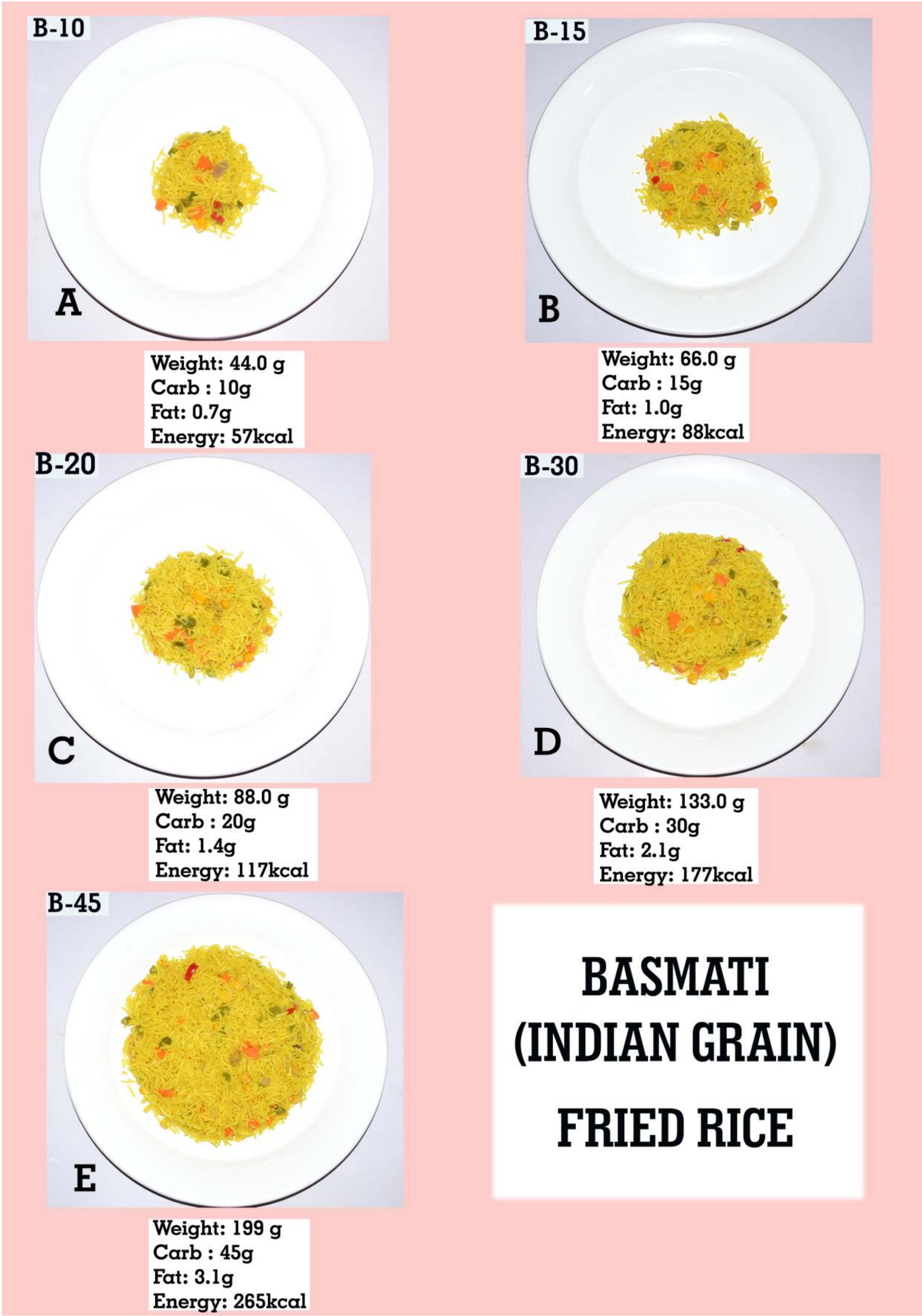


Figure 4.12: The photographic atlas of different carbohydrate servings of fried rice prepared with basmati rice

4.5.7 The proximate and energy content of carbohydrate servings of fried rice prepared with local rice

The proximate and energy composition of different carbohydrate servings of fried rice prepared with local rice is presented in Table 4.15. The fried rice containing 10g, 15g, 20g, 30g and 45g of carbohydrate respectively varied in their proximate composition. The serving weights (g) of fried rice that supplied the different servings ranged from 56g for 10g carbohydrate serving to 251g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents were 70.20g, 5.20g, 3.30g, 17.9g, 2.50g and 0.90g respectively.

Table 4.15: The proximate and energy composition of different carbohydrate servings of fried rice prepared with local rice

Carbohydrate Serving	Serving Weight (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	132.0	554.3	70.2	0.9	5.2	2.5	3.3	17.9
10g Carb	56.0	73.9	310.4	39.3	0.5	2.9	1.4	1.8	10.0
15g Carb	84.0	110.9	465.6	59.0	0.8	4.4	2.1	2.8	15.1
20g Carb	111.0	146.5	615.3	78.0	1.0	5.7	2.7	3.7	19.9
30g Carb	167.0	220.4	925.7	117.3	1.5	8.7	4.1	5.5	30.0
45g Carb	251.0	331.3	1391.3	176.3	2.3	13.0	6.1	8.3	45.0

4.5.8 The photographic food atlas of carbohydrate servings of fried rice prepared with local rice

Figure 4.13 presented the photographic atlas of different carbohydrate servings of fried rice prepared with local rice. Pictures are labelled L10 to L45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

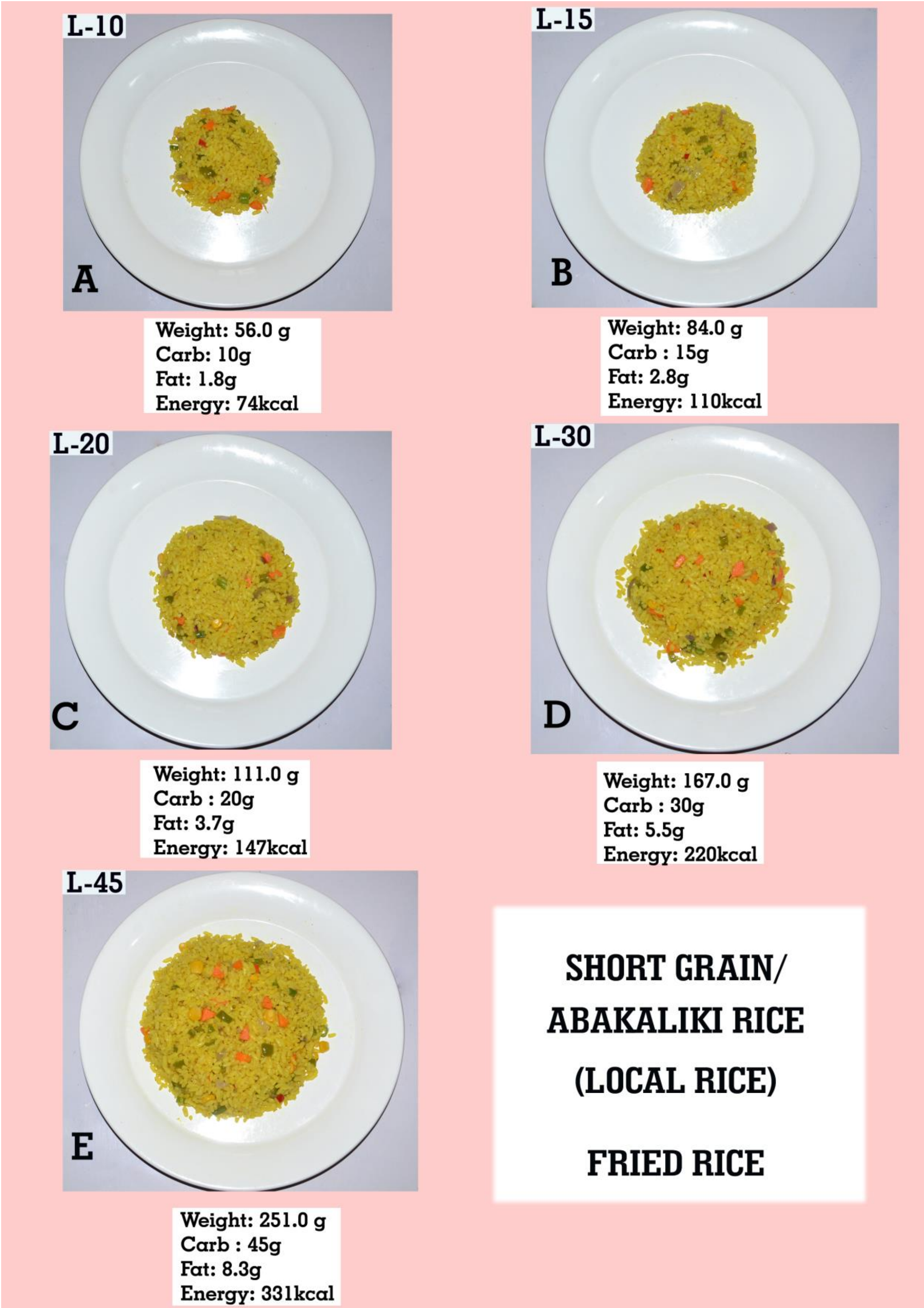


Figure 4.13: The photographic atlas of different carbohydrate servings of fried rice prepared with local rice

4.5.9 The proximate and energy content of carbohydrate servings of jollof rice prepared with local rice

The proximate and energy composition of different carbohydrate servings of jollof rice prepared with local rice is presented in Table 4.16. The quantity of jollof rice containing 10g, 15g, 20g, 30g and 45g of carbohydrate respectively varied in their proximate composition. The serving weights (g) of jollof rice that supplied the different servings ranged from 61g for 10g carbohydrate serving to 276g for 45g carbohydrate servings. The table showed that the moisture, protein, fat, carbohydrate, crude fibre and ash contents are 71.70g, 6.40g, 2.40g, 16.20g, 2.20g and 0.10g respectively.

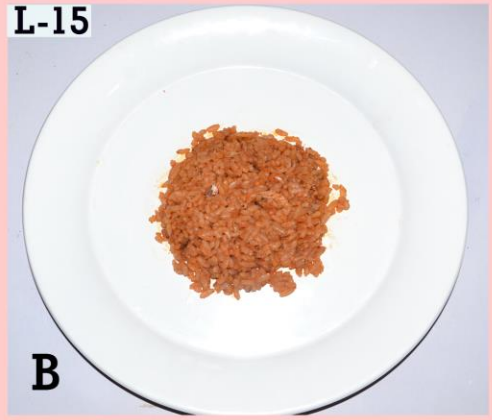
Table 4.16: The proximate and energy composition of different carbohydrate servings of jollof rice prepared with local rice

Carbohydrate Serving	Serving weight (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	120.8	507.2	71.7	1.1	6.4	2.2	2.4	16.2
10g Carb	61.0	73.7	309.4	43.7	0.7	3.9	1.3	1.4	10.0
15g Carb	92.0	111.1	466.7	65.9	1.0	5.9	2.0	2.2	15.0
20g Carb	122.0	147.3	618.8	87.4	1.3	7.8	2.6	2.9	19.9
30g Carb	184.0	222.2	933.3	131.9	2.0	11.7	4.0	4.4	30.0
45g Carb	276.0	333.3	1400.0	197.8	3.0	17.6	6.0	6.5	45.1

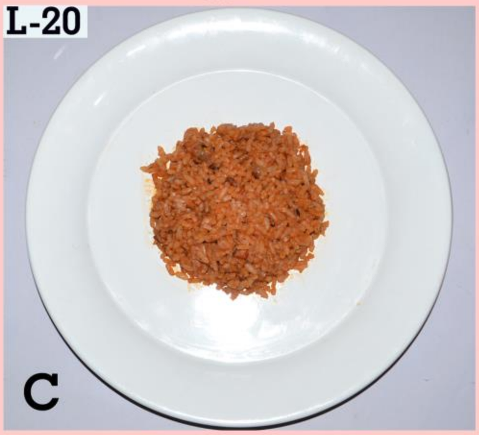
4.5.10 The photographic food atlas of carbohydrate servings of jollof rice prepared with local rice

Figure 4.14 presents the photographic atlas of different carbohydrate servings of jollof rice prepared with local rice. Pictures are labelled L10 to L45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

Weight: 61.0 g
Carb : 10g
Fat: 1.4g
Energy: 74kcal



Weight: 92.0 g
Carb : 15g
Fat: 2.2g
Energy: 111kcal



Weight: 122.0 g
Carb : 20g
Fat: 2.9g
Energy: 147kcal

Weight: 184.0 g
Carb : 30g
Fat: 4.4g
Energy: 222kcal

Weight: 276.0 g
Carb : 45g
Fat: 6.5g
Energy: 333kcal

SHORT GRAIN/ ABAKALIKI RICE (LOCAL RICE)

JOLLOF RICE

Figure 4.14: The photographic atlas of different carbohydrate servings of jollof rice prepared with local rice

4.5.11 The proximate and energy content of carbohydrate servings of boiled rice and tomato stew prepared with local rice

The proximate and energy composition of different carbohydrate servings of boiled rice and tomato stew prepared with local rice is presented in Table 4.17. The amount of boiled rice and tomato stew supplying 10g, 15g, 20g, 30g and 45g carbohydrate respectively varied in their proximate and energy composition. The serving weights (g) of boiled rice and tomato stew that supplied the different servings ranged from 61g for 10g carbohydrate serving to 274g for 45g carbohydrate servings. The table showed that the moisture, protein, fat, carbohydrate, crude fibre and ash contents are 73.60g, 4.90g, 1.80g, 16.40g, 2.70g and 0.60g respectively.

Table 4.17: The proximate and energy composition of different carbohydrate servings of boiled rice and tomato stew prepared with local rice

Carbohydrate Serving	Serving weight (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	112.3	471.6	73.6	0.6	4.9	2.7	1.8	16.4
10g Carb	61.0	68.5	287.7	44.9	0.4	3.0	1.6	1.1	10.0
15g Carb	91.0	102.2	429.1	66.9	0.6	4.5	2.4	1.6	15.0
20g Carb	122.0	137.0	575.3	89.8	0.7	6.0	3.3	2.2	20.1
30g Carb	182.0	204.3	858.3	133.9	1.1	8.9	4.9	3.3	29.9
45g Carb	274.0	307.6	1292.1	201.6	1.7	13.5	7.3	4.9	45.0

4.5.12 The photographic food atlas of carbohydrate servings of boiled riceand tomato stew prepared with local rice

Figure 4.15 presents the photographic atlas of different carbohydrate servings of boiled rice and tomato stew prepared with local rice. Pictures are labelled L10 to L45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

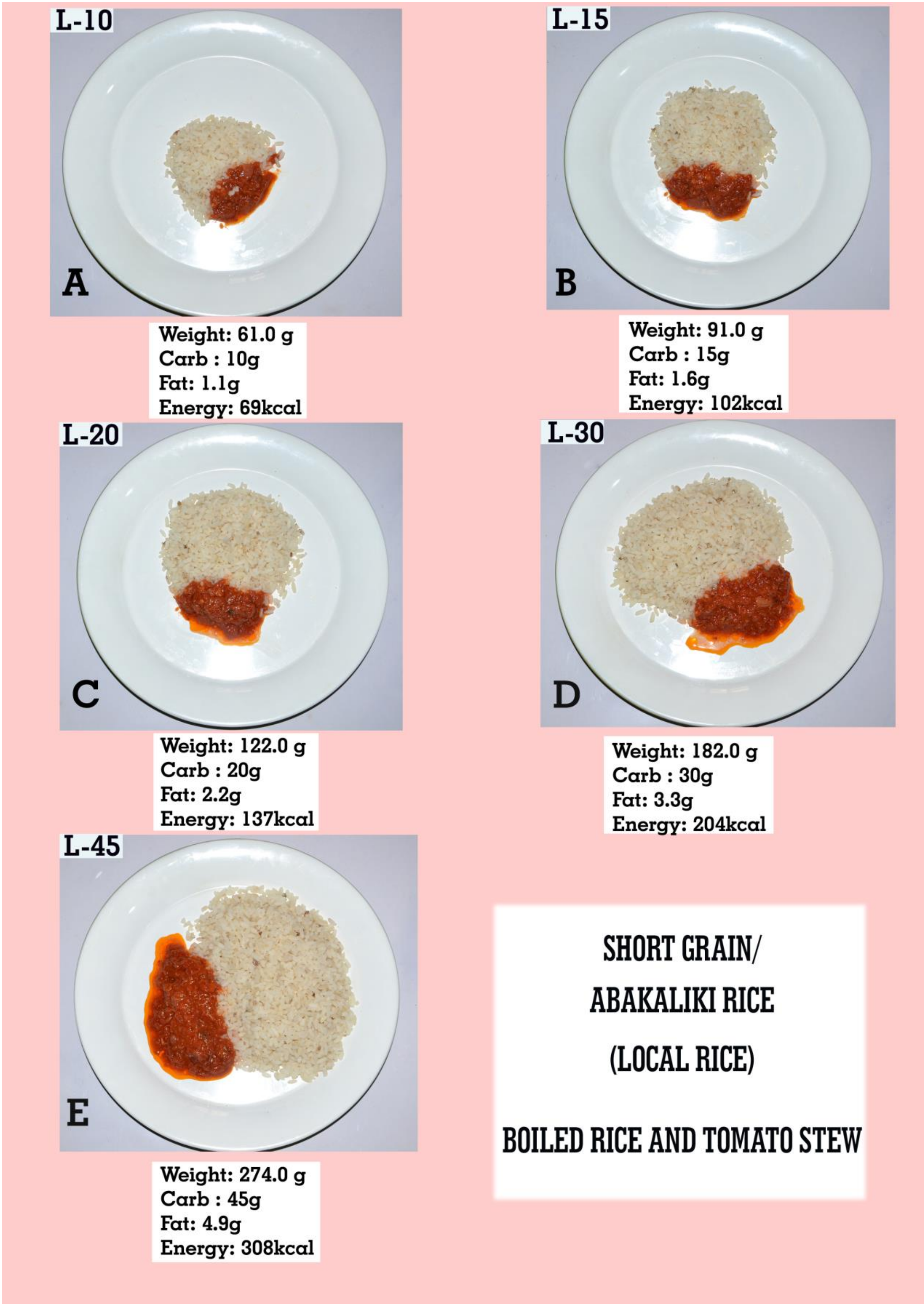


Figure 4.15: The photographic atlas of different carbohydrate servings of boiled rice and tomato stew prepared with local rice

4.5.13 The proximate and energy content of carbohydrate servings of fried rice prepared with long grain rice

The proximate and energy composition of different carbohydrate servings of fried rice prepared with long grain (foreign) rice is presented in Table 4.18. The amount of fried rice that supplied 10g, 15g, 20g, 30g and 45g of carbohydrate varied in their proximate and energy composition. The serving weights (g) of fried rice that supplied the different servings ranged from 76g for 10g carbohydrate serving to 341g for 45g carbohydrate servings. The table showed that the Moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents are 70.00g, 10.00g, 4.50g, 13.20g, 1.30g and 0.10g respectively.

Table 4.18: The proximate and energy composition of different carbohydrate servings of fried rice prepared with long grain (foreign) rice

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	137.0	576.0	70.0	1.0	10.0	1.3	4.5	13.2
10g Carb	76.0	104.1	437.8	53.2	0.8	7.6	1.0	3.4	10.0
15g Carb	114.0	156.2	656.6	79.8	1.2	11.4	1.5	5.1	15.1
20g Carb	151.0	206.9	869.8	105.7	1.6	15.0	2.0	6.7	19.9
30g Carb	227.0	311.0	1307.5	158.9	2.3	22.6	3.0	10.1	30.0
45g Carb	341.0	467.2	1964.2	238.7	3.5	34.0	4.5	15.2	45.0

4.5.14 The photographic food atlas of carbohydrate servings of fried rice prepared with long grain rice

Figure 4.16 presents the photographic atlas of different carbohydrate servings of fried rice prepared with long grain (foreign) rice. Pictures are labelled F10 to F45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

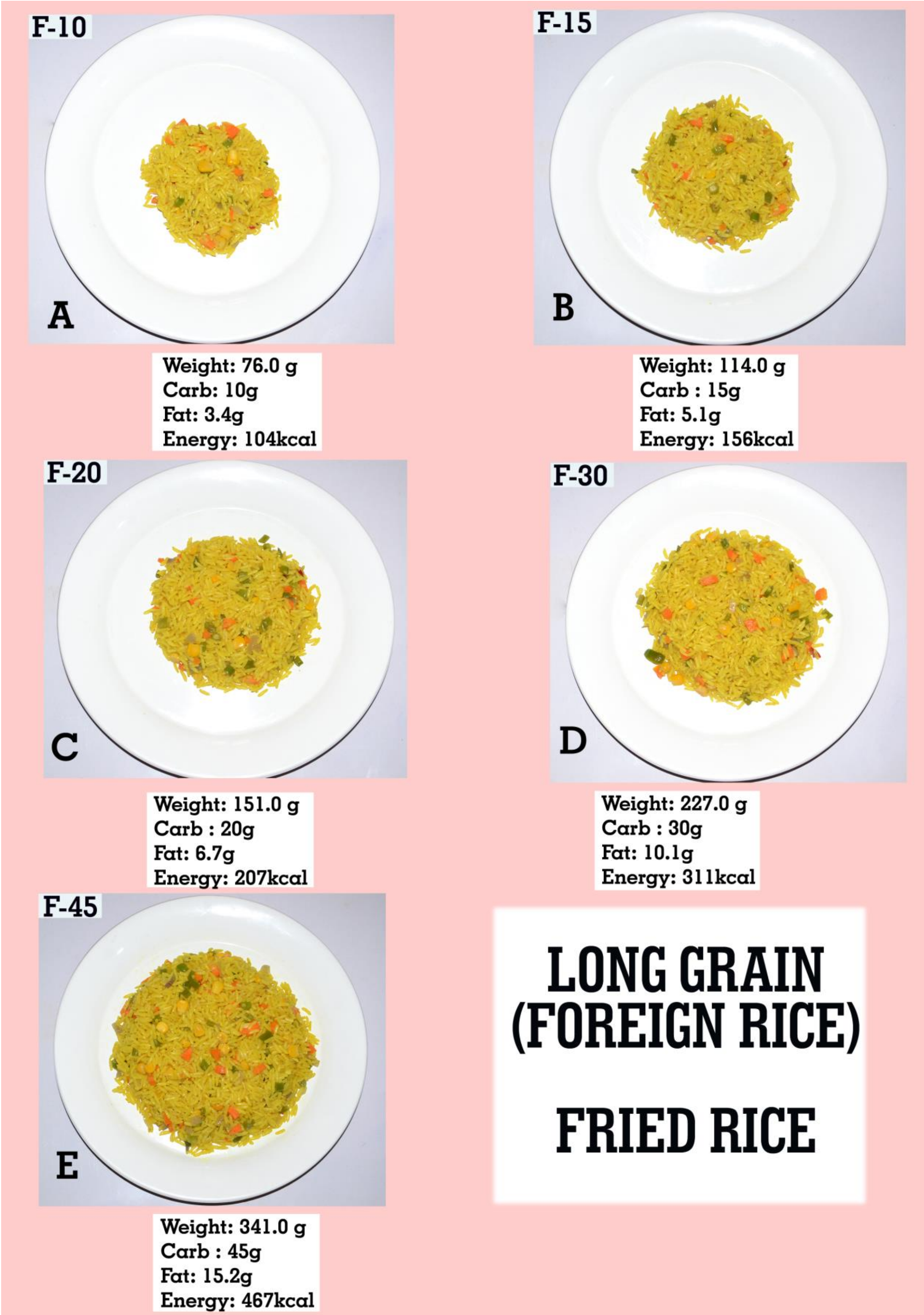


Figure 4.16: The photographic atlas of different carbohydrate servings of fried rice prepared with long grain (foreign) rice

4.5.15 The proximate and energy content of carbohydrate servings of jollof rice prepared with long grain rice

The proximate and energy composition of different carbohydrate servings of jollof rice prepared with long grain (foreign) rice is presented in Table 4.19. The quantity of jollof rice that supplied 10g, 15g, 20g, 30g and 45g of carbohydrate respectively varied in their proximate composition. The serving weights (g) of jollof rice that supplied the different servings ranged from 66g for 10g carbohydrate serving to 295g for 45g carbohydrate servings. The table showed that the moisture, protein, fat, carbohydrate, crude fibre and ash contents are 69.00g, 8.00g, 4.40g, 15.10g, 1.70g and 0.80g respectively.

Table 4.19: The proximate and energy composition of different carbohydrate servings of jollof rice prepared with long grain (foreign) rice

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	138.0	580.0	69.0	1.8	8.0	1.7	4.4	15.1
10g Carb	66.0	91.1	382.8	45.5	1.2	5.3	1.1	2.9	10.1
15g Carb	98.0	135.2	568.4	67.6	1.7	7.8	1.6	4.3	14.9
20g Carb	131.0	180.8	759.8	90.3	2.3	10.4	2.2	5.7	20.0
30g Carb	197.0	271.9	1142.6	135.9	3.5	15.7	3.3	8.6	30.0
45g Carb	295.0	407.1	1711.0	203.4	5.2	23.5	4.9	12.9	45.0

4.5.16 The photographic food atlas of carbohydrate servings of jollof rice prepared with long grain rice

Figure 4.17 presents the photographic atlas of different carbohydrate servings of jollof rice prepared with long grain (foreign) rice. Pictures are labelled F10 to F45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

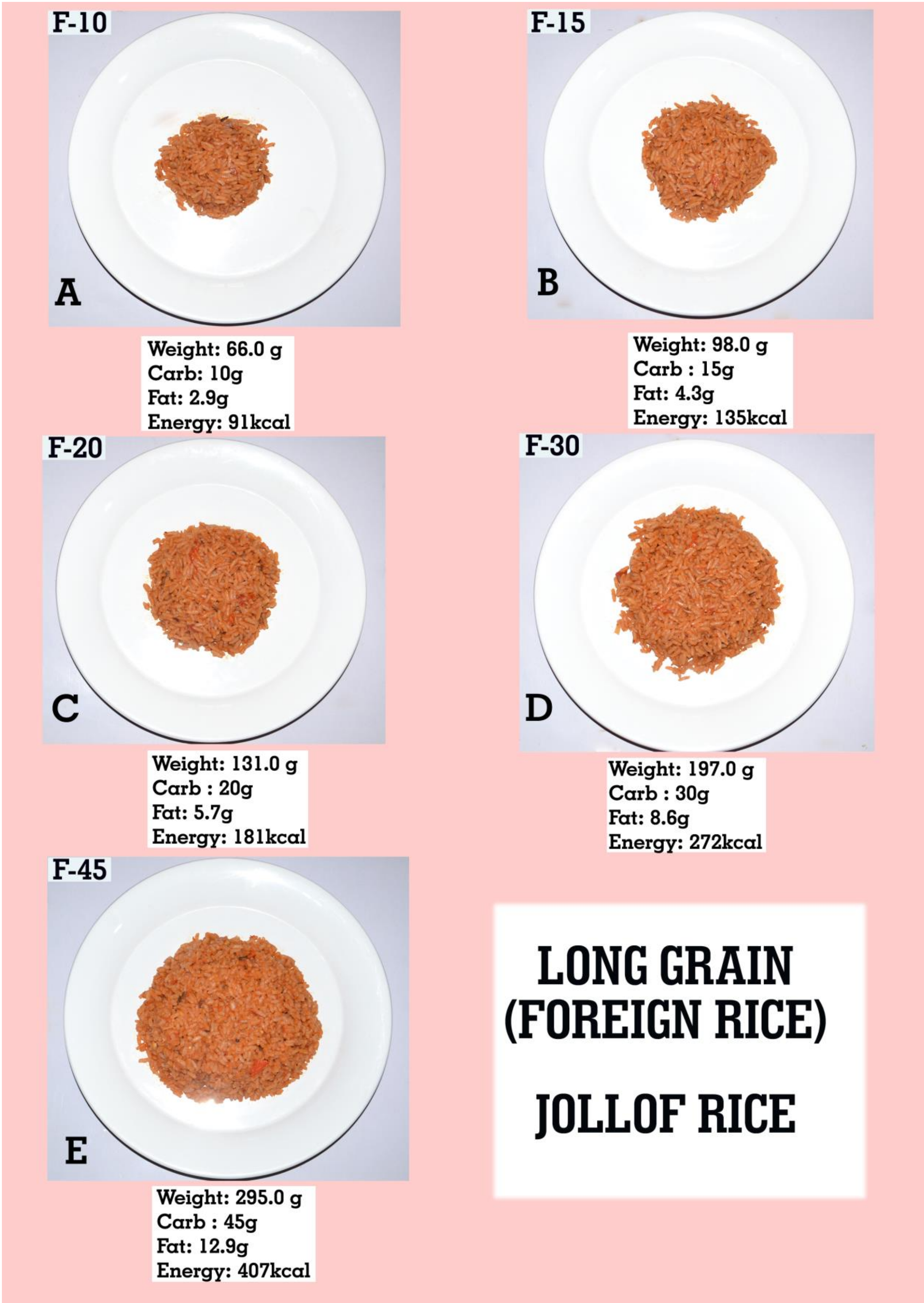


Figure 4.17: The photographic atlas of different carbohydrate servings of jollof rice prepared with long grain (foreign) rice

4.5.17 The proximate and energy content of carbohydrate servings of boiled rice and tomato stew prepared with long grain rice

The proximate and energy composition of different carbohydrate servings of boiled rice and tomato stew prepared with long grain (foreign) rice is presented in Table 4.20. The amount of boiled rice and tomato stew containing 10g, 15g, 20g, 30g and 45g of carbohydrate respectively varied in their proximate composition. The serving weights (g) of boiled rice and tomato stew that supplied the different servings ranged from 68g for 10g carbohydrate serving to 306g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents are 70.08g, 8.80g, 3.60g, 14.70g, 0.80g and 1.30g respectively.

Table 4.20: The proximate and energy composition of different carbohydrate servings of boiled rice and tomato stew prepared with long grain (foreign) rice

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	129.0	541.0	70.8	1.3	8.8	0.8	3.6	14.7
10g Carb	68.0	87.7	367.9	48.1	0.9	6.0	0.6	2.4	10.0
15g Carb	102.0	131.6	551.8	72.2	1.3	9.0	0.8	3.6	15.0
20g Carb	136.0	175.4	735.8	96.2	1.7	12.0	1.1	4.8	20.0
30g Carb	204.0	263.2	1103.6	144.4	2.6	18.0	1.7	7.2	30.0
45g Carb	306.0	394.7	1655.5	216.5	3.9	27.0	2.5	10.9	45.0

4.5.18 The photographic food atlas of carbohydrate servings of boiled rice and tomato stew prepared with long grain rice

Figure 4.18 shows the photographic atlas of different carbohydrate servings of boiled rice and stew prepared with long grain (foreign) rice. Pictures are labelled F10 to F45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

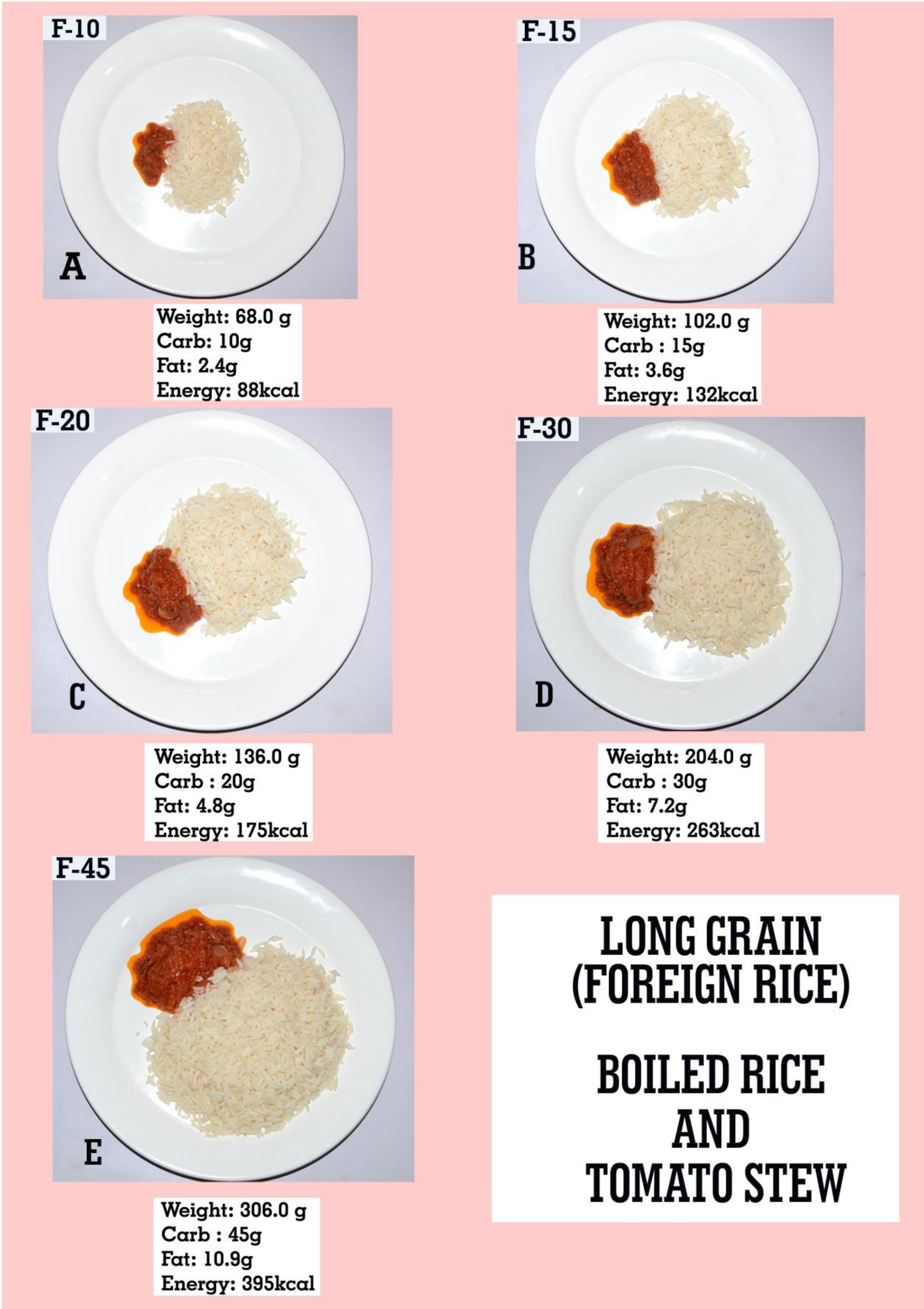


Figure 4.18: The photographic atlas of different carbohydrate servings of boiled rice and tomato stew prepared with long grain (foreign) rice

4.5.19 The proximate and energy content of carbohydrate servings of *achicha*

The proximate and energy composition of different carbohydrate servings of *achicha* is presented in Table 4.21. The quantity supplying 10g, 15g, 20g, 30g and 45g of carbohydrate respectively varied in their proximate composition. The serving weights (g) of *achicha* that supplied the different servings ranged from 116g for 10g carbohydrate serving to 542g for 45g carbohydrate servings. The table showed that the moisture, protein, fat, carbohydrate, crude fibre and ash contents are 54.50g, 3.80g, 27.20g, 8.50g, 4.10g and 1.90g respectively.

Table 4.21: The proximate and energy composition of different carbohydrate servings of *achicha*

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	310.5	1304.2	54.5	1.9	3.8	4.1	27.2	8.5
10g Carb	116.0	360.2	1512.9	63.2	2.2	4.4	4.7	31.6	10.0
15g Carb	175.0	543.3	2282.4	95.3	3.4	6.6	7.1	47.6	15.0
20g Carb	233.0	723.4	3038.8	126.9	4.5	8.8	9.4	63.4	20.0
30g Carb	349.0	1083.6	4551.7	190.1	6.7	13.2	14.1	94.9	30.0
45g Carb	524.0	1626.9	6834.0	285.4	10.1	19.8	21.2	142.5	45.0

4.5.20 The photographic food atlas of carbohydrate servings of *achicha*

Figure 4.19 presents the photographic atlas of different carbohydrate servings of *achicha* (Cocoyam [*Colocasia esculenta*] and pigeon pea [*Cajanus cajan*] based meal). Pictures are labelled AC10 to AC45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

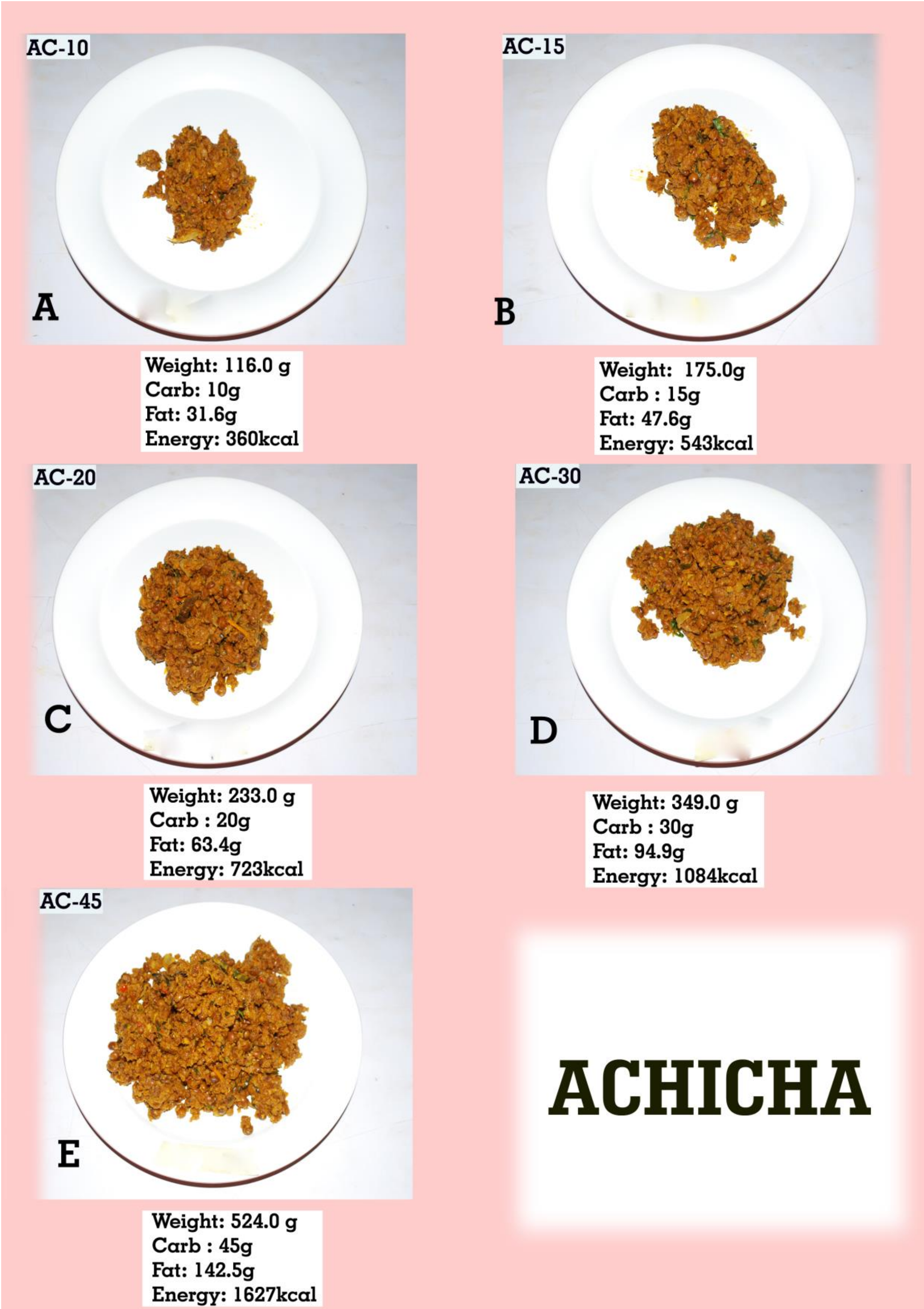


Figure 4.19: The photographic atlas of different carbohydrate servings of *achicha*

4.5.21 The proximate and energy content of carbohydrate servings of *ayaraya-oka*

The proximate and energy composition of different carbohydrate servings of *ayaraya-oka* is presented in table 4.22. The quantity of *ayaraya-oka* that contained 10g, 15g, 20g, 30g and 45g of carbohydrate varied in their proximate composition. The serving weights (g) of *ayaraya-oka* that supplied the different servings ranged from 139g for 10g carbohydrate serving to 626g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents are 68.1g, 3.70g, 16.00g, 7.0g, 0.60g and 4.60g respectively.

Table 4.22: The proximate and energy composition of different carbohydrate servings of *ayaraya-oka*

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	189.2	759.0	68.1	4.6	3.7	0.6	16.0	7.0
10g Carb	139.0	263.0	1055.0	94.6	6.4	5.1	0.8	22.2	10.0
15g Carb	209.0	395.5	1586.3	142.2	9.6	7.6	1.2	33.3	15.0
20g Carb	278.0	526.1	2110.0	189.2	12.8	10.1	1.6	44.3	20.0
30g Carb	417.0	789.1	3165.0	283.8	19.2	15.2	2.4	66.5	30.0
45g Carb	626.0	1184.6	4751.3	426.0	28.8	22.8	3.6	99.8	45.0

4.5.22 The photographic food atlas of carbohydrate servings of *ayaraya-oka*

Figure 4.20 presents the photographic atlas of different carbohydrate servings of *ayaraya-oka* (meal prepared from cowpeas *(Vigna unguiculata)*, maize (Zea mays) and vegetables blend). Pictures are labelled AY10 to AY45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

Figure 4.20: The photographic atlas of different carbohydrate servings of *ayaraya-oka*

4.5.23 The proximate and energy content of carbohydrate servings of *ayaraya-ji*

The proximate and energy composition of different carbohydrate servings of *ayaraya-ji* is presented in Table 4.23. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of *ayaraya-ji* that supplied the different servings ranged from 47g for 10g carbohydrate serving to 212g for 45g carbohydrate servings. The table shows that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents are 59.90g, 3.20g, 11.80g, 21.2g, 0.50g and 3.40g respectively.

Table 4.23: The proximate and energy composition of different carbohydrate servings of *ayaraya-ji*

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	206.0	856.1	59.9	3.4	3.2	0.5	11.8	21.2
10g Carb	47.0	96.8	402.4	28.1	1.6	1.5	0.2	5.6	10.0
15g Carb	71.0	146.3	607.8	42.5	2.4	2.3	0.3	8.4	15.1
20g Carb	94.0	193.6	804.7	56.3	3.2	3.0	0.5	11.1	20.0
30g Carb	141.0	290.5	1207.1	84.4	4.8	4.5	0.7	16.7	30.0
45g Carb	212.0	436.7	1814.9	126.9	7.2	6.7	1.0	25.0	45.1

4.5.24 The photographic food atlas of carbohydrate servings of *ayaraya-ji*

Figure 4.21 presents the photographic atlas of different carbohydrate servings of *ayaraya-ji* (yam and pigeon peas based meal). Pictures are labelled AJ10 to AJ45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

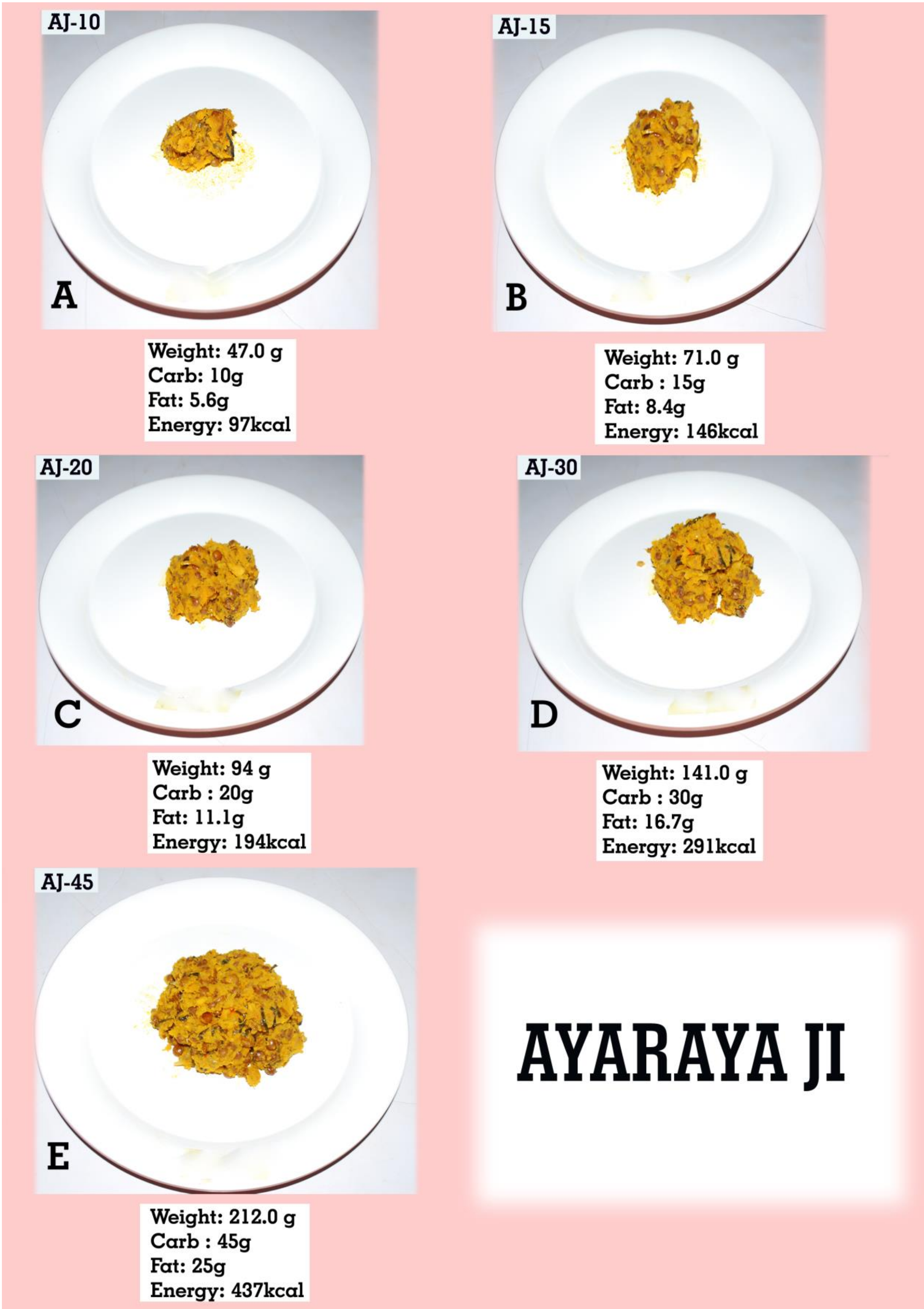


Figure 4.21: The photographic atlas of different carbohydrate servings of *ayaraya-ji*

4.5.25 The proximate and energy content of carbohydrate servings of *okpa*

The proximate and energy composition of different carbohydrate servings of bambara nut pudding (*okpa*) is presented in Table 4.24. The quantity of *okpa* the supplied 10g, 15g, 20g, 30g and 45g of carbohydrate varied in their proximate composition. The serving weights (g) of *okpa* that supplied the different servings ranged from 31g for 10g carbohydrate serving to 140g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents are 49.1g, 6.0g, 10.8g, 32.1g, 0.1g and 1.9g respectively.

Table 4.24: The proximate and energy composition of different carbohydrate servings of bambara nut pudding (*okpa*)

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	249.9	1049.5	49.1	1.9	6.0	0.1	10.8	32.1
10g Carb	31.0	77.5	325.3	15.2	0.6	1.9	0.0	3.3	10.0
15g Carb	47.0	117.5	493.3	23.1	0.9	2.8	0.0	5.1	15.1
20g Carb	62.0	154.9	650.7	30.4	1.2	3.7	0.1	6.7	20.0
30g Carb	93.0	232.4	976.0	45.7	1.8	5.6	0.1	10.0	29.9
45g Carb	140.0	349.9	1469.3	68.7	2.7	8.4	0.1	15.1	45.1

4.5.26 The photographic food atlas of carbohydrate servings of *okpa*

Figure 4.22 presents the photographic atlas of different carbohydrate servings of *okpa* (bambara-nut pudding). Pictures are labelled OK-10 to OK-45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

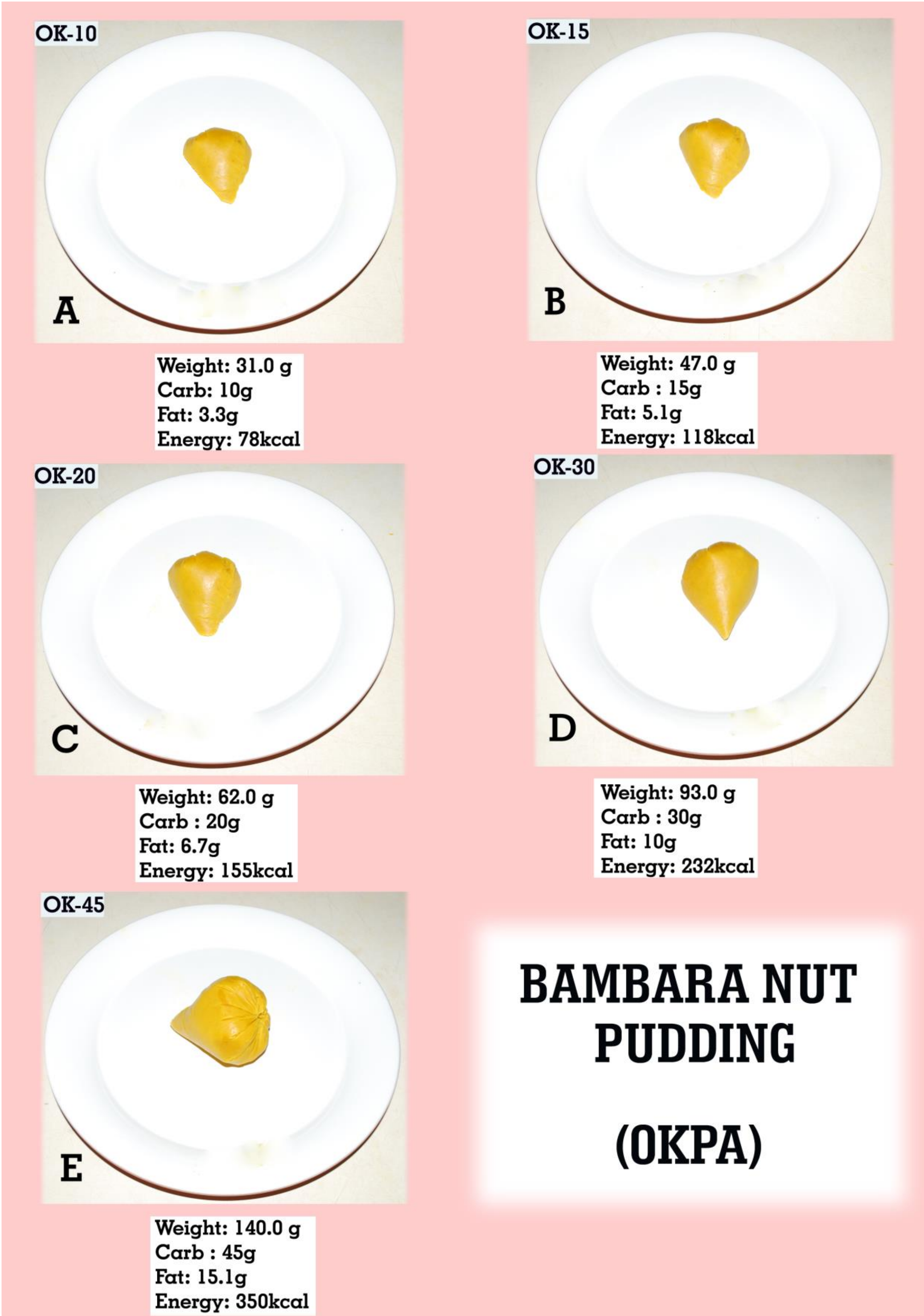


Figure 4.22: The photographic atlas of different carbohydrate servings of bambara nut pudding (*okpa*)

4.5.27 The proximate and energy content of carbohydrate servings of *igbangwu-oka*

The proximate and energy composition of different carbohydrate servings of *igbangwu-oka* is presented in table 4.25. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of *igbangwu-oka* that supplied the different servings ranged from 193g for 10g carbohydrate serving to 870g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents are 73.80g, 4.30g, 13.7g, 5.0g, 0.40g and 2.80g respectively.

Table 4.25: The proximate and energy composition of different carbohydrate servings of *igbangwu-oka*

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	163.0	683.0	73.8	2.8	4.3	0.4	13.7	5.0
10g Carb	193.0	314.6	1318.2	142.4	5.3	8.2	0.7	26.5	10.0
15g Carb	290.0	472.7	1980.7	214.0	8.0	12.3	1.0	39.8	15.0
20g Carb	386.0	629.2	2636.4	284.8	10.6	16.4	1.4	52.9	20.0
30g Carb	580.0	945.4	3961.4	427.9	16.0	24.7	2.0	79.5	30.0
45g Carb	870.0	1418.1	5942.1	641.9	23.9	37.0	3.0	119.3	45.1

4.5.28 The photographic food atlas of carbohydrate servings of *igbangwu-oka*

Figure 4.23 presents the photographic atlas of different carbohydrate servings of *igbangwu-oka* (maize pudding). Pictures are labelled IG-10 to IG-45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

Figure 4.23: The photographic atlas of different carbohydrate servings of *igbangwu-oka*

4.5.29 The proximate and energy content of carbohydrate servings of *abacha*

The proximate and energy composition of different carbohydrate servings of *Abacha* is presented in table 4.26. The 10g, 15g, 20g, 30g and 45g varied in their proximate composition. The serving weights (g) of *Abacha* that supplied the different servings ranged from 44g for 10g carbohydrate serving to 197g for 45g carbohydrate servings. The table showed that the moisture, crude protein, crude fat, carbohydrate, crude fibre and ash contents are 56.80g, 12.0g, 13.7g, 22.80g, 2.90g and 1.10g respectively.

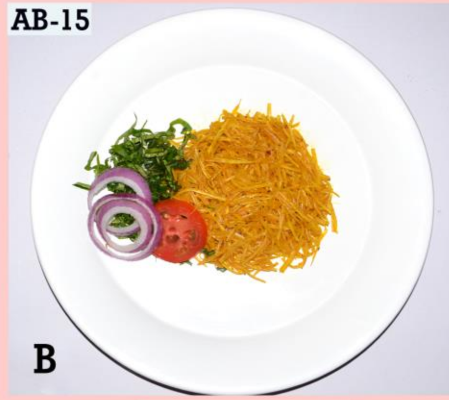
Table 4.26: he proximate and energy composition of different carbohydrate servings of *abacha*

Carbohydrate Serving	Serving size (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fibre (g)	Fats (g)	Carbohydrate (g)
	100.0	190.2	799	56.8	1.1	12	2.9	13.7	22.8
10g Carb	44.0	83.5	350.8	24.9	0.5	5.3	1.3	1.9	10.0
15g Carb	66.0	125.2	525.7	37.4	0.7	7.9	1.9	2.9	15.0
20g Carb	88.0	166.8	700.7	49.8	1.0	10.5	2.5	3.9	20.0
30g Carb	132.0	250.3	1051.5	74.7	1.4	15.8	3.8	5.8	30.0
45g Carb	197.0	375.5	1577.2	112.1	2.2	23.7	5.7	8.7	45.0

4.5.30 The photographic food atlas of carbohydrate servings of *abacha*

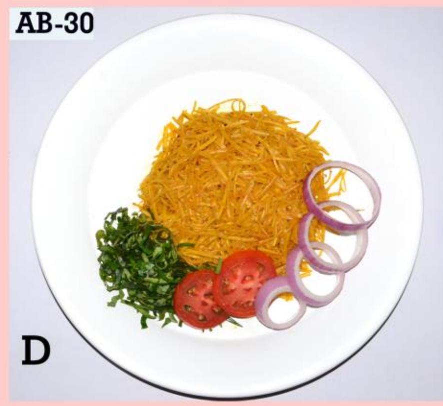
Figure 4.24 presents the photographic atlas of different carbohydrate servings of *abacha*. Pictures are labelled AB-10 to AB-45 showing the servings that will supply 10g carbohydrates to 45 grams of carbohydrates respectively.

Weight: 44g
Carb : 10g
Fat: 1.9g
Energy: 84kcal



Weight: 66g
Carb : 15g
Fat: 2.9g
Energy: 125kcal

Weight: 88g
Carb : 20g
Fat: 3.9g
Energy: 167kcal



Weight: 132g
Carb : 30g
Fat: 5.8g
Energy: 250kcal

Weight: 197g
Carb : 45g
Fat: 8.7g
Energy: 376kcal

ABACHA

Figure 4.24: The photographic atlas of different carbohydrate servings of *abacha*

4.6 Portion size estimation using domestic measures of selected foods consumed by diabetic patients in Enugu State

4.6.1 Domestic measures used for portion size estimation

Figure 4.25a shows the domestic measures used in the study. Figures 4.25b, 4.25c, 4.25d, and 4.25e show the sample demonstrations of the heaping of fried basmati rice, boiled basmati rice, jollof basmati rice, "*ayaraya-ji*," "*ayaraya-oka*", "*achicha*" and "*abacha*" respectively, using the domestic spoons/measures

Figure 4.25a: The domestic measures used in measuring out the weighed photographed foods.

4.6.2 Sample demonstrations of the heaping of selected foods consumed by diabetic patients in Enugu State using the domestic spoons/measures.

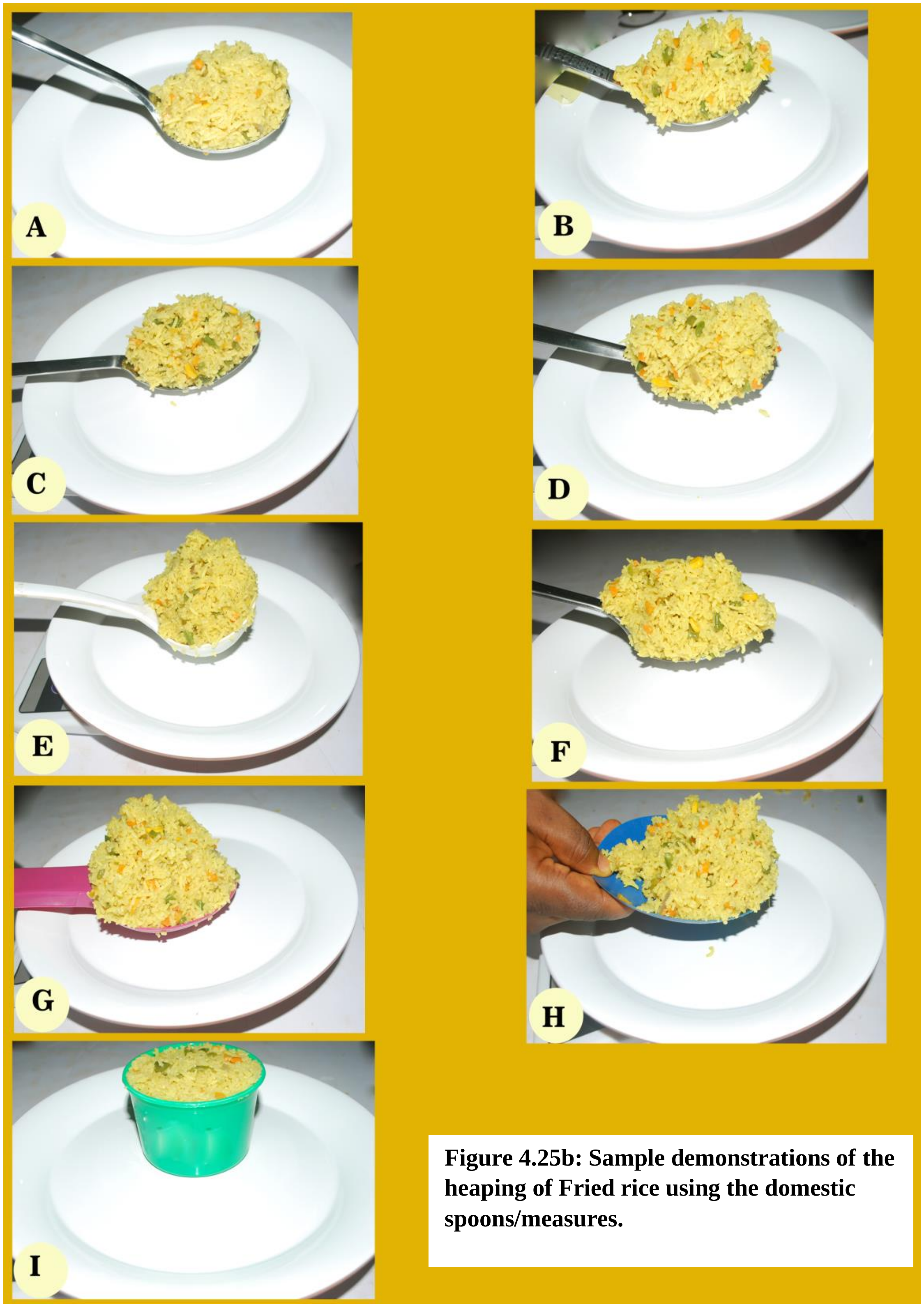


Figure 4.25b: Sample demonstrations of the heaping of Fried rice using the domestic spoons/measures.

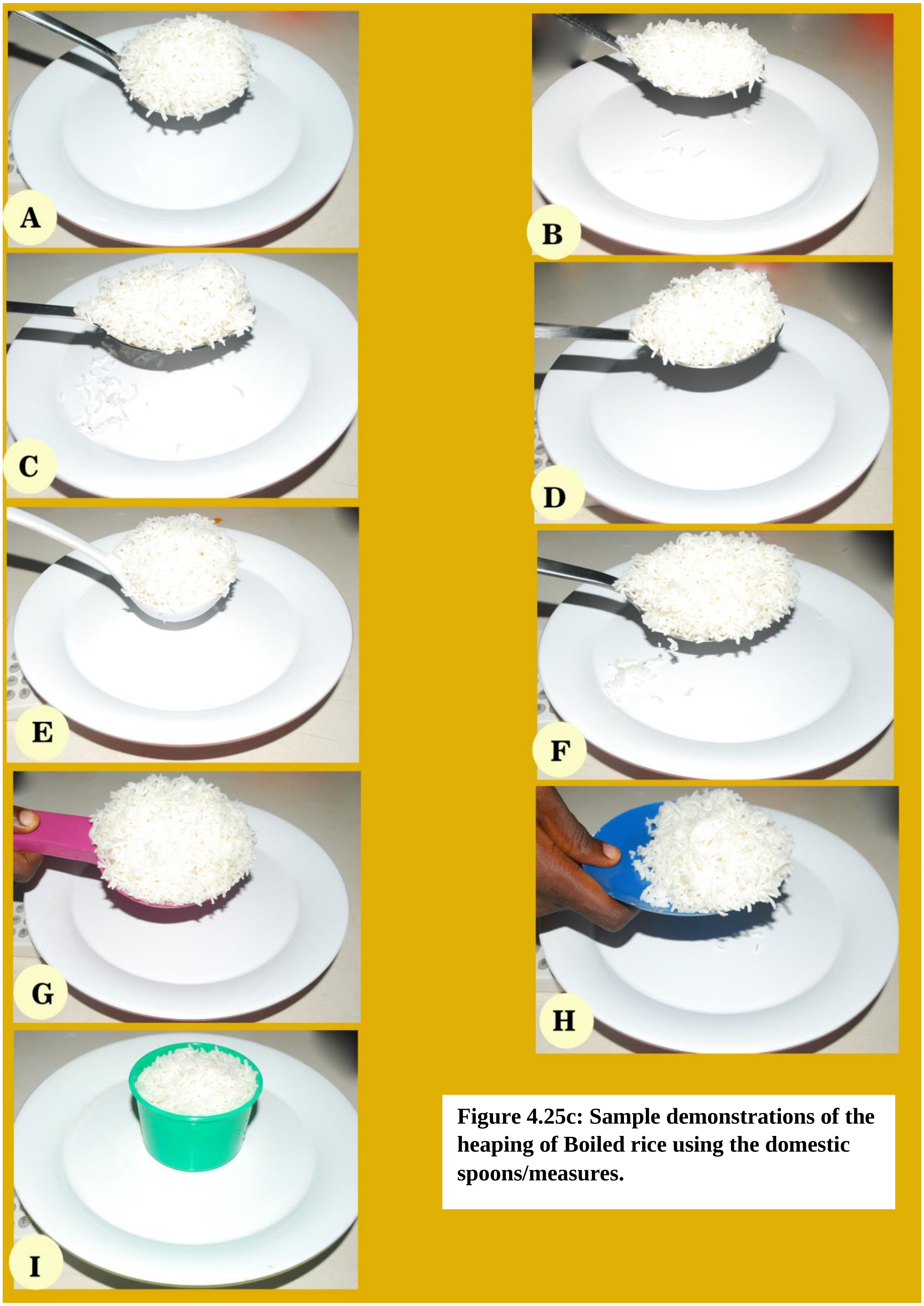


Figure 4.25c: Sample demonstrations of the heaping of Boiled rice using the domestic spoons/measures.

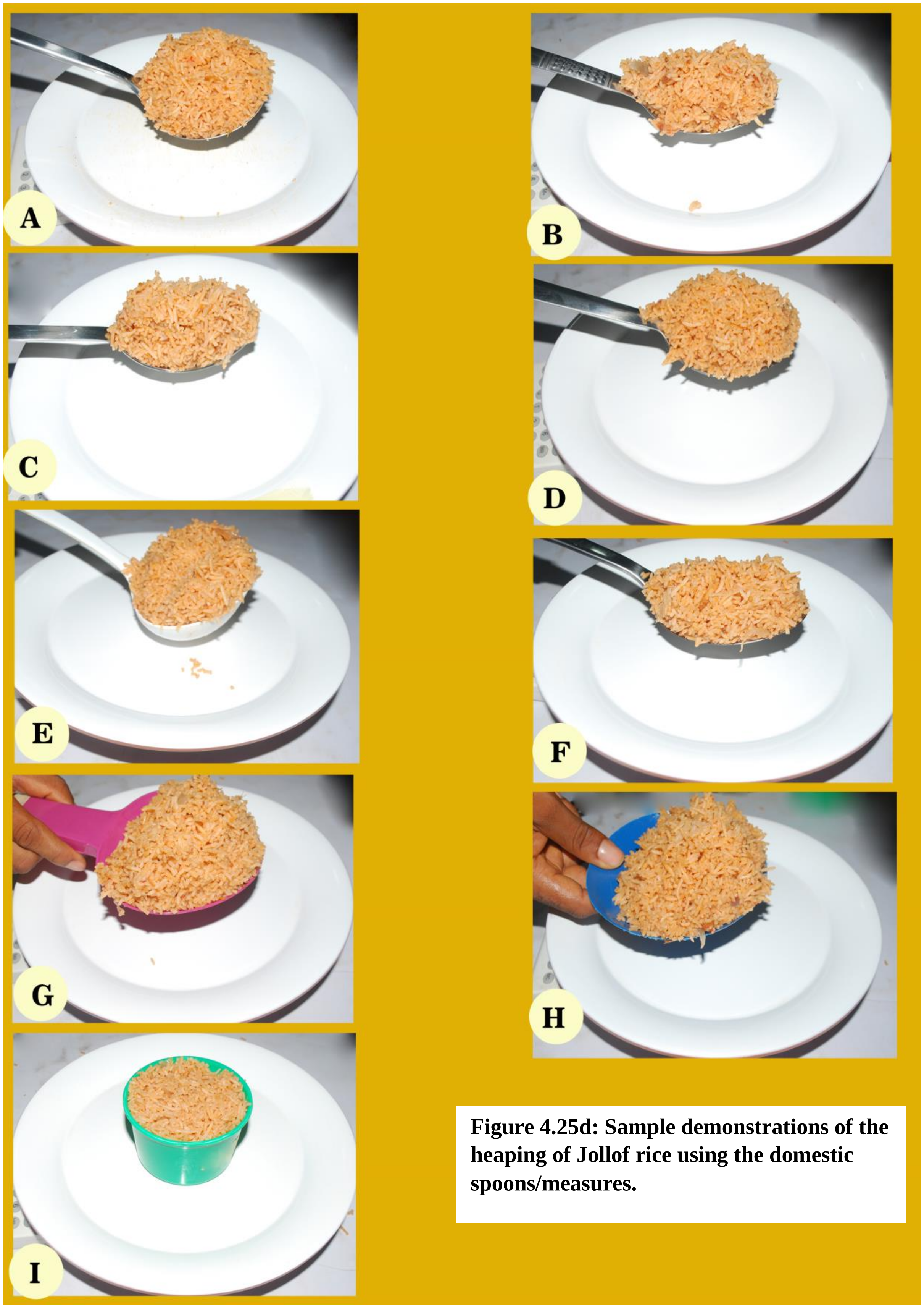


Figure 4.25d: Sample demonstrations of the heaping of Jollof rice using the domestic spoons/measures.

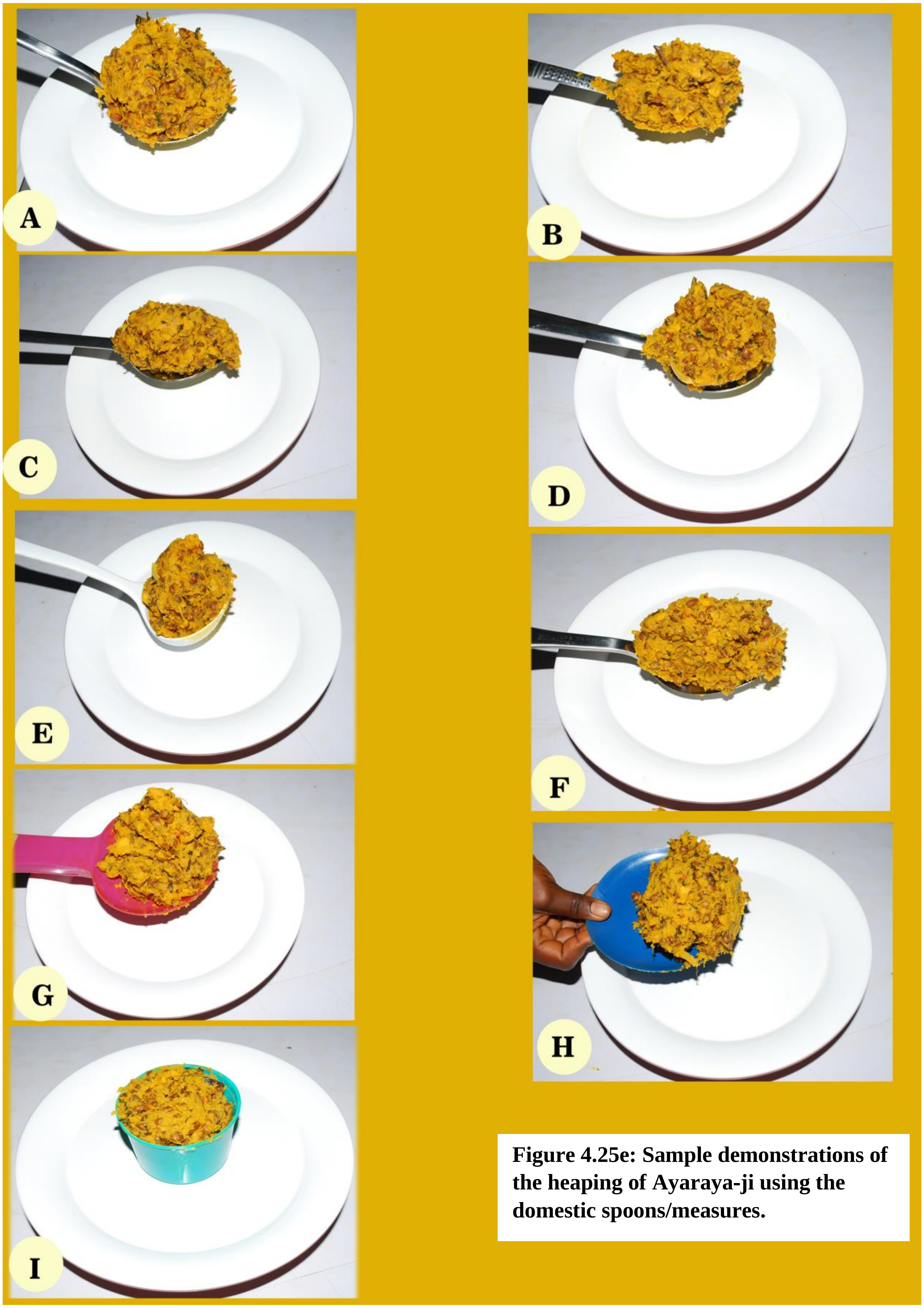


Figure 4.25e: Sample demonstrations of the heaping of Ayaraya-ji using the domestic spoons/measures.

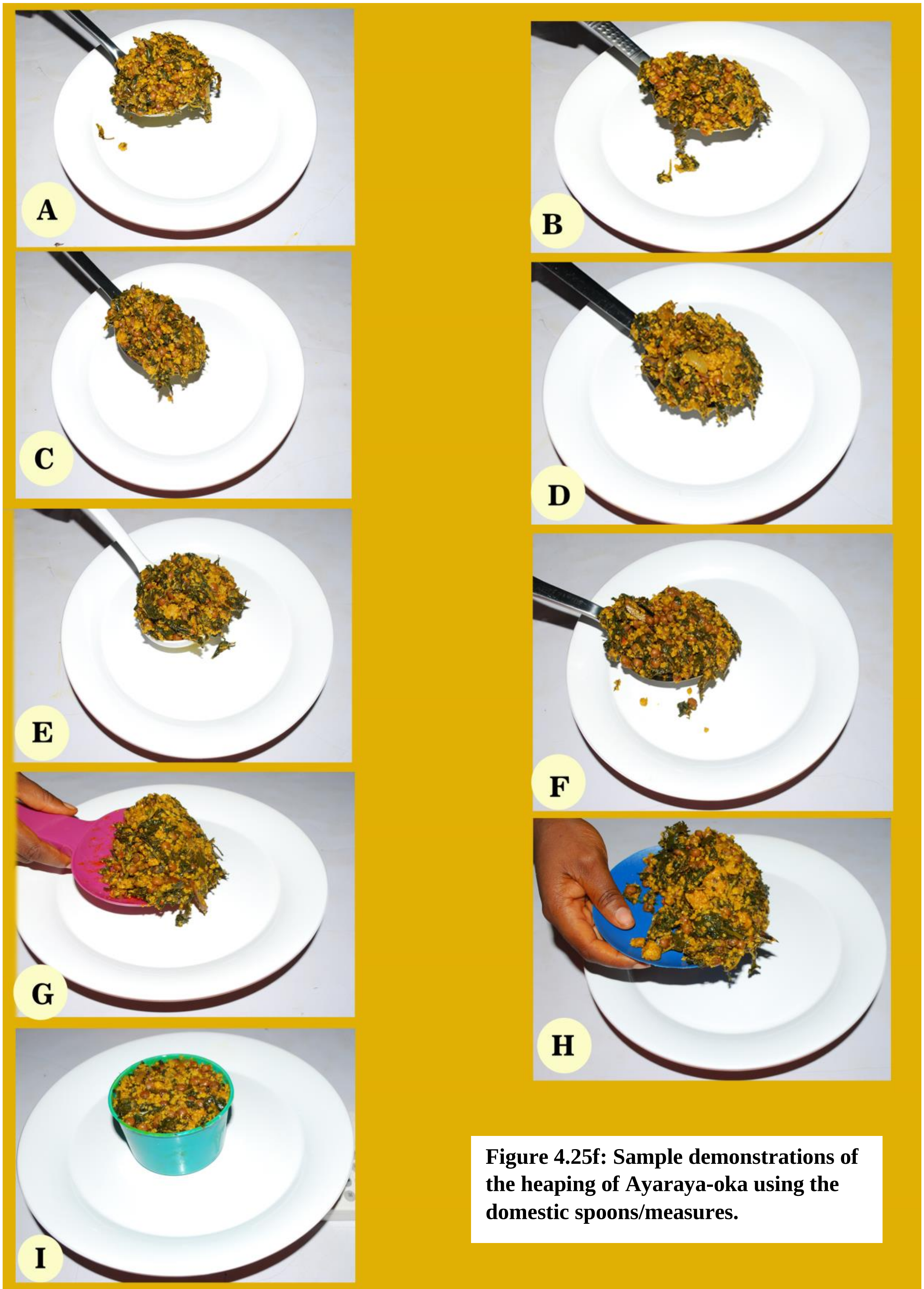


Figure 4.25f: Sample demonstrations of the heaping of Ayaraya-oka using the domestic spoons/measures.

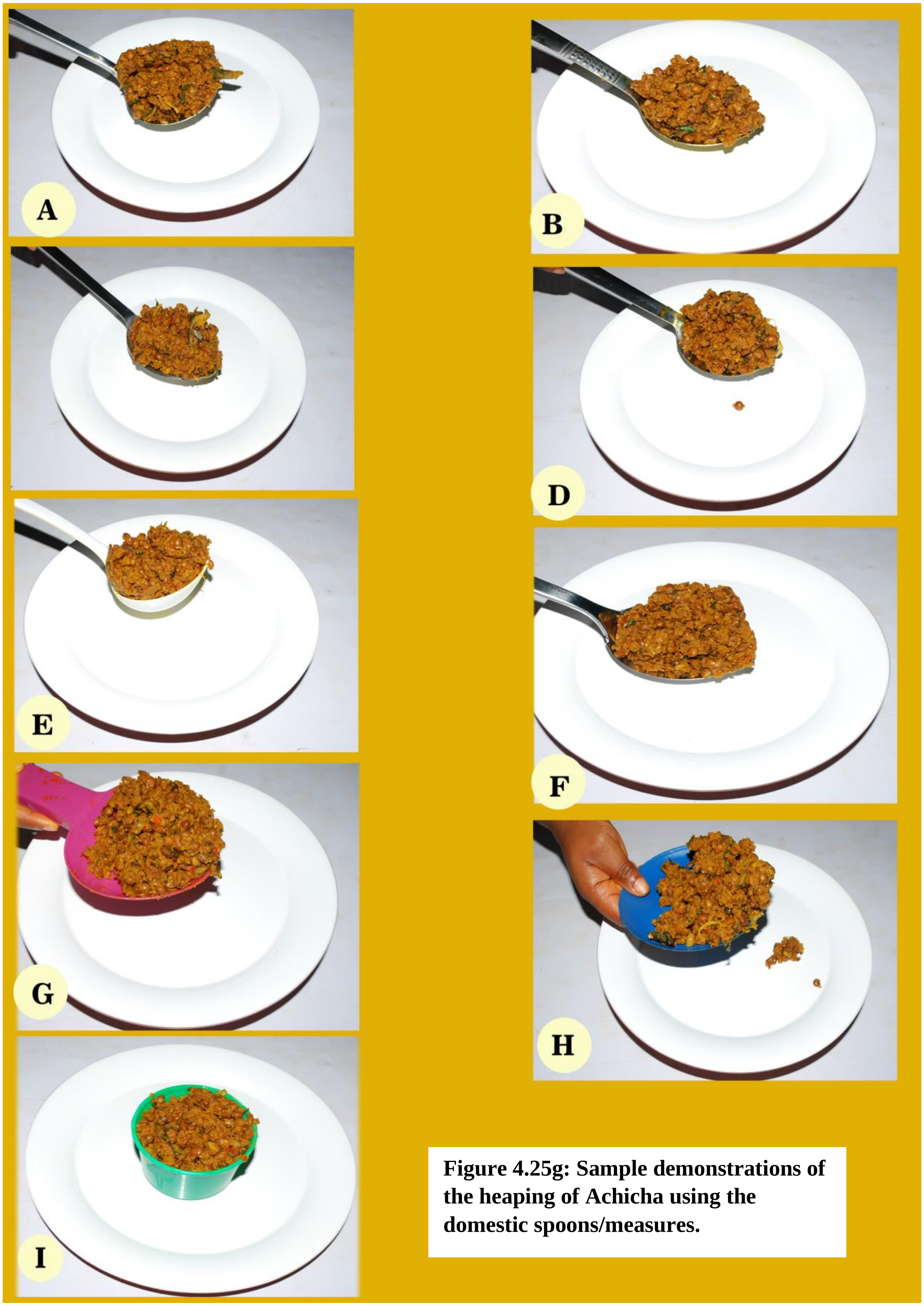


Figure 4.25g: Sample demonstrations of the heaping of Achicha using the domestic spoons/measures.

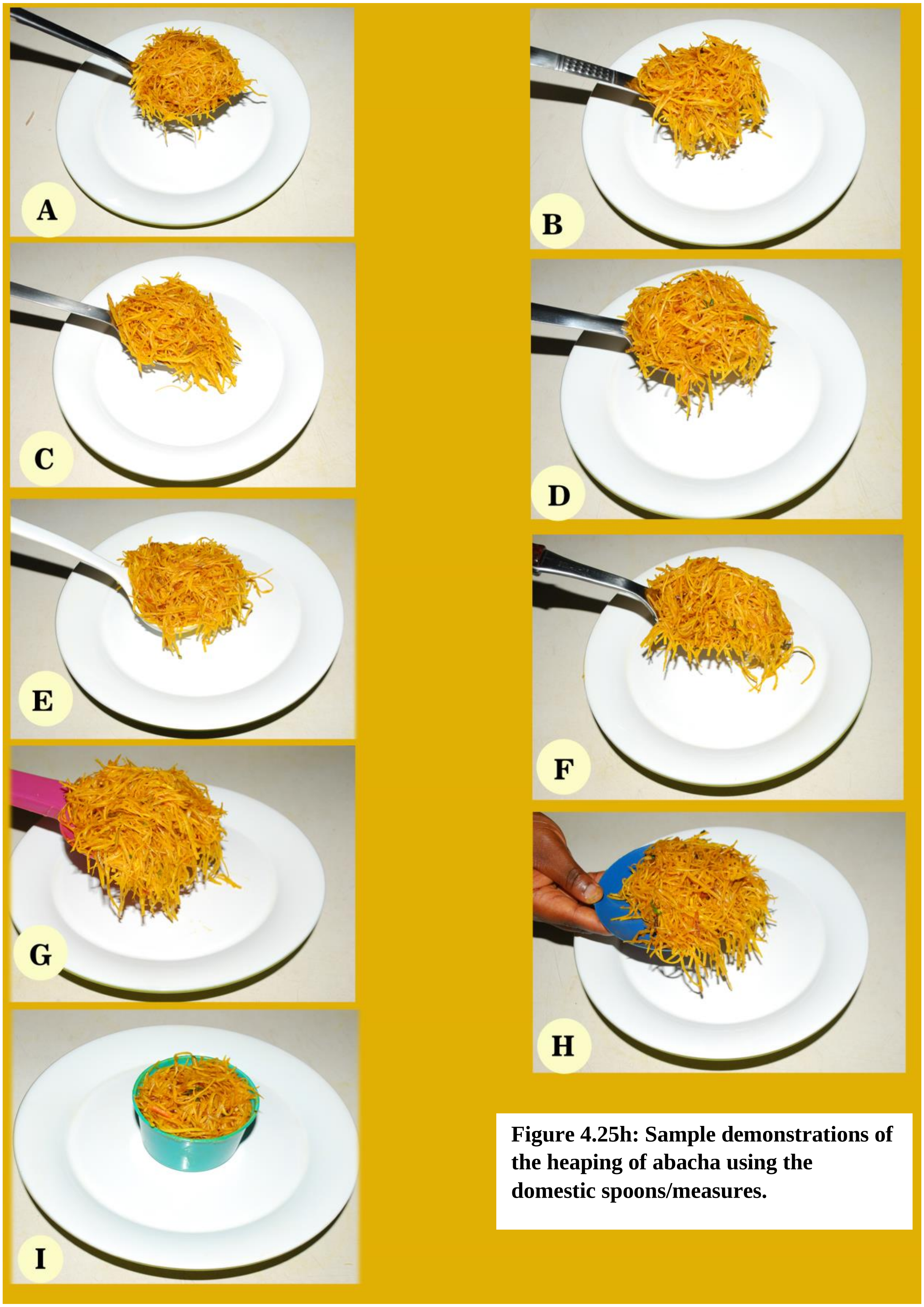


Figure 4.25h: Sample demonstrations of the heaping of abacha using the domestic spoons/measures.

4.7 The Photographic food atlas, proximate and energy content of domestic measures of selected foods consumed by diabetic patients in Enugu State

4.7.1 The proximate and energy content of domestic measures of fried rice prepared with basmati rice

The proximate and energy composition of different domestic measures (DOM-M) of fried rice prepared with basmati rice is presented in Table 4.27. DOM-M-G had a mean serving weight of 275g which is the highest while DOM-M – B had the least serving weight (92g). The carbohydrate composition ranged from 20.8g in B to 62.2g in G. The energy content was 122.5 Kcal in B to 366.2 Kcal in G. The proximate composition per 100g shows that the moisture, ash, protein, crude fibre, fat and carbohydrates to be 67.3g, 1.4g, 6.1g, 1.1g, 1.6g and 22.5g respectively.

Table 4.27: The proximate and energy composition of different domestic measures of fried rice prepared with basmati rice

DOM Measure Code	Serving Weight (g)	Energy (Kcal)	Energy (KJ)	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	133.2	559.3	67.3	1.4	6.1	1.1	1.6	22.5
A	159.0	211.7	889.2	106.9	2.2	9.7	1.7	2.5	35.9
B	92.0	122.5	514.5	61.9	1.3	5.6	1.0	1.4	20.8
C	123.0	163.8	687.9	82.7	1.7	7.5	1.3	1.9	27.8
D	146.0	194.4	816.5	98.2	2.0	8.9	1.5	2.3	33.0
E	194.0	258.3	1085.0	130.5	2.7	11.8	2.1	3.0	43.8
F	187.0	249.0	1045.8	125.8	2.6	11.4	2.0	2.9	42.3
G	275.0	366.2	1538.0	185.0	3.9	16.7	2.9	4.3	62.2
H	178.0	237.0	995.5	119.7	2.5	10.8	1.9	2.8	40.2
I	231.0	307.6	1291.9	155.4	3.2	14.1	2.4	3.6	52.2

4.7.2 The photographic food atlas of domestic measures of fried rice prepared with basmati rice

Figures 4.26a to 4.26b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of the fried rice prepared with basmati rice.

Figure 4.26a: Photographic atlas of DOM-M A to E of fried rice prepared with basmati rice.

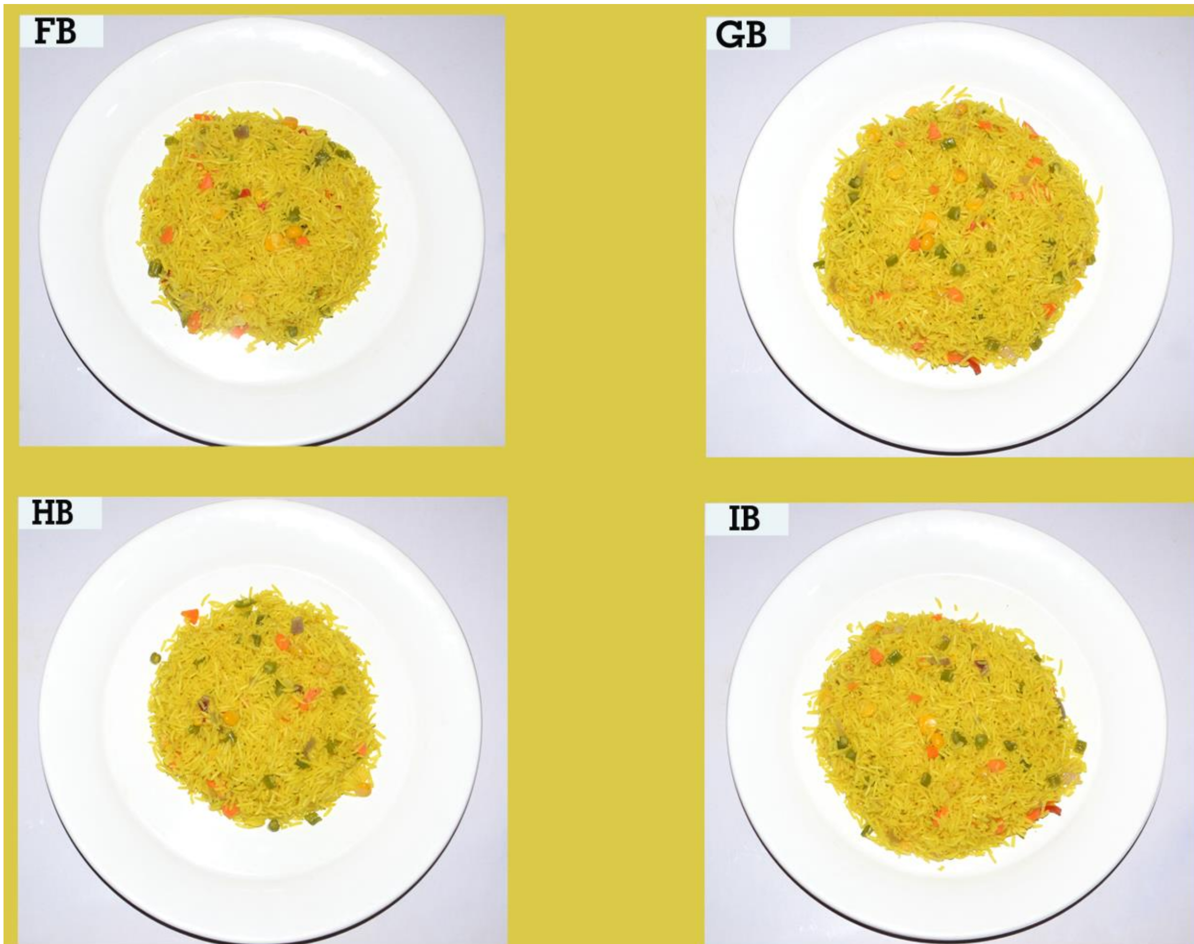


Figure 4.26b: Photographic atlas of DOM-M F to I of fried rice prepared with basmati rice.

4.7.3 The proximate and energy content of domestic measures of jollof rice prepared with basmati rice

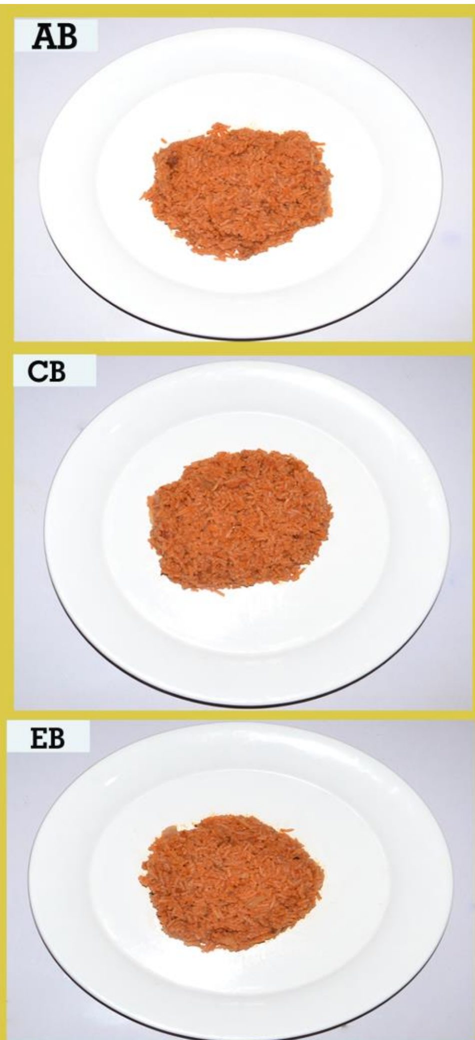
The proximate and energy composition of different domestic measures (DOM-M) of jollof rice prepared with basmati rice is presented in Table 4.28. DOM-M-G had a mean weight of 187g which is the highest while DOM-M – B contained the least (93g). The carbohydrates ranged from 26.0g in B to 52.2g in G. The energy content was 642.6 kcal in B to 1292.2 kcal in G. The proximate composition per 100g shows the moisture, ash, protein, crude fibre, fat and carbohydrates to be 64.3g, 0.9 g, 1.4g, 0.2g, 5.3g and 27.9g respectively.

Table 4.28: The proximate and energy composition of different domestic measures of jollof rice prepared with basmati rice

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	691.0	2902.2	64.3	0.9	1.4	0.2	5.3	27.9
A	129.0	891.4	3743.8	83.0	1.1	1.8	0.3	6.8	36.0
B	93.0	642.6	2699.0	59.8	0.8	1.3	0.2	4.9	26.0
C	120.0	829.2	3482.6	77.2	1.0	1.7	0.3	6.3	33.5
D	116.0	801.6	3366.6	74.6	1.0	1.6	0.2	6.1	32.4
E	161.0	1112.5	4672.5	103.6	1.4	2.3	0.3	8.5	45.0
F	118.0	815.4	3424.6	75.9	1.0	1.7	0.2	6.2	32.9
G	187.0	1292.2	5427.1	120.3	1.6	2.6	0.4	9.9	52.2
H	161.0	1112.5	4672.5	103.6	1.4	2.3	0.3	8.5	45.0
I	177.0	1223.1	5136.9	113.9	1.5	2.5	0.4	9.3	49.4

4.7.4 The photographic food atlas, proximate and energy content of domestic measures of jollof rice prepared with basmati rice

Figures 4.27a to 4.27b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of the jollof rice prepared with basmati rice.



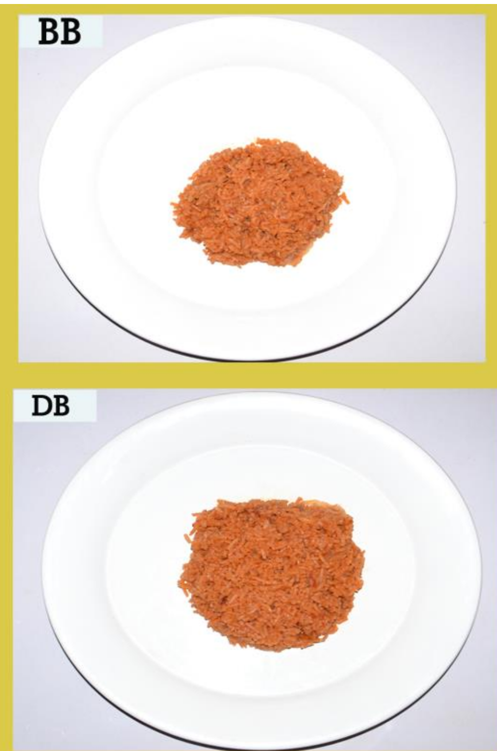


Figure 4.27a: Photographic atlas of DOM-M A to E of jollof rice prepared with basmati rice.

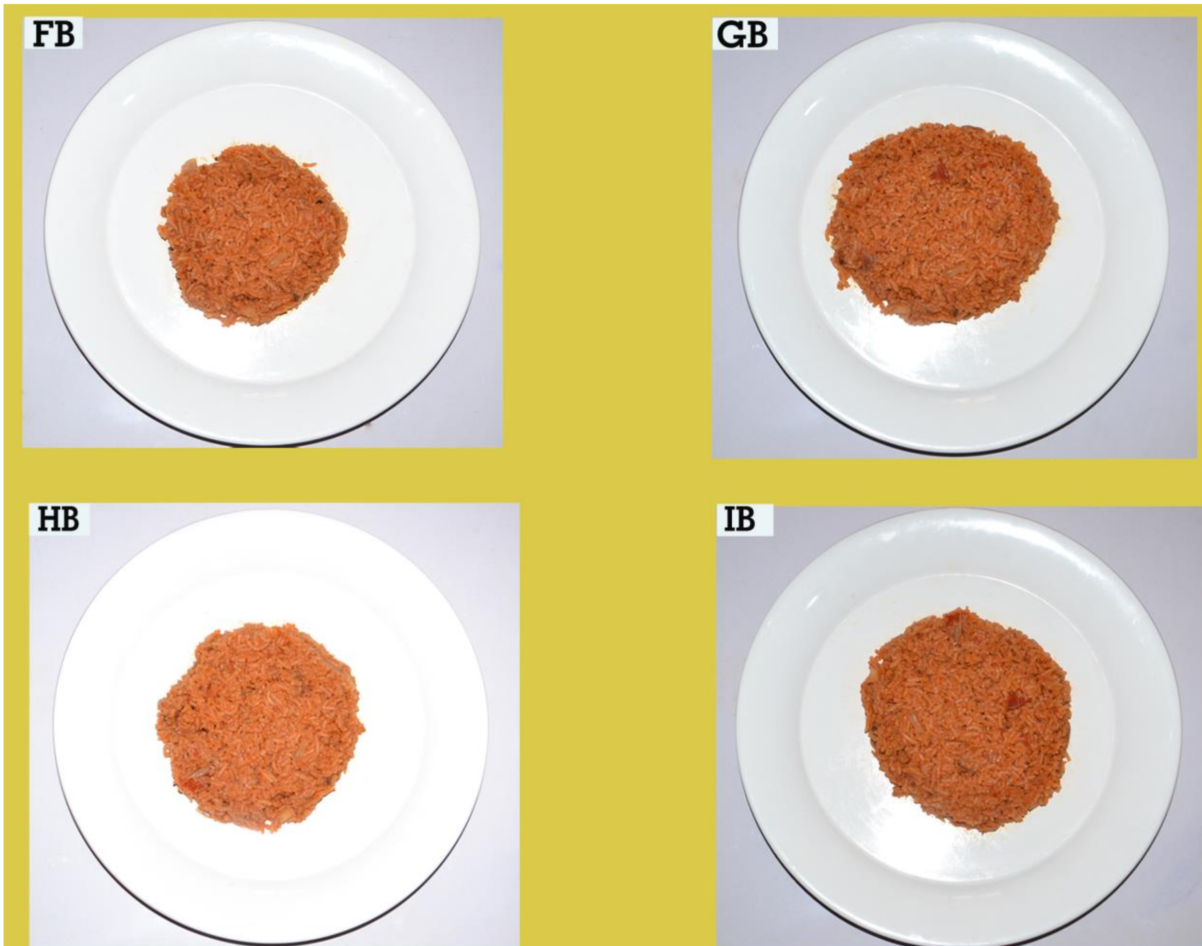


Figure 4.27b: Photographic atlas of DOM-M F to I of jollof rice prepared with basmati rice.

4.7.5 The proximate and energy content of domestic measures of boiled rice and tomato stew prepared with basmati rice

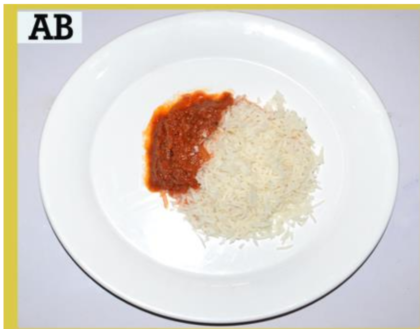
The proximate and energy composition of different domestic measures (DOM-M) of boiled rice and tomato stew prepared with Basmati rice is presented in Table 4.29. DOM-M-G had a mean weight of 270g which is the highest while DOM-M – B contained the least (96g). The carbohydrates ranged from 26.6g in B to 57.9g in G. The energy content was 159.7 kcal in B to 449.3 kcal in G. The proximate composition per 100g shows that the. The moisture, ash, protein, crude fibre, fat and carbohydrates were 63.5g, 0.8 g, 7.7g, 1.7g, 4.8g and 21.4g respectively.

Table 4.29: The proximate and energy composition of different domestic measures of boiled rice and tomato stew prepared with basmati rice

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	166.4	698.9	63.5	0.8	7.7	1.7	4.8	21.4
A	149.0	247.9	1041.3	94.7	1.2	11.5	2.6	7.1	31.9
B	96.0	159.7	670.9	61.0	0.8	7.4	1.7	4.6	20.6
C	115.0	191.4	803.7	73.1	1.0	8.9	2.0	5.5	24.6
D	139.0	231.3	971.4	88.3	1.2	10.7	2.4	6.6	29.8
E	196.0	326.1	1369.8	124.5	1.6	15.1	3.4	9.3	42.0
F	188.0	312.8	1313.9	119.4	1.6	14.5	3.3	9.0	40.3
G	270.0	449.3	1887.0	171.5	2.2	20.8	4.7	12.9	57.9
H	190.0	316.2	1327.9	120.7	1.6	14.6	3.3	9.1	40.7
I	173.0	287.9	1209.1	109.9	1.4	13.3	3.0	8.3	37.1

4.7.6 The photographic food atlas of domestic measures of boiled rice and tomato stew prepared with basmati rice

Figures 4.28a to 4.28b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of boiled rice and tomato stew prepared with basmati rice.



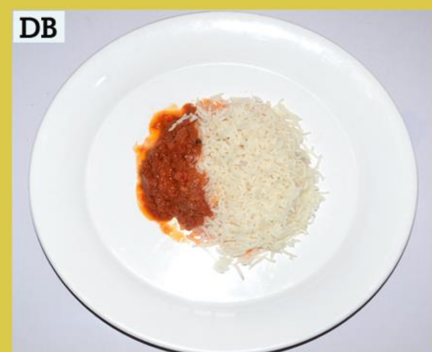


Figure 4.28a: Photographic atlas of DOM- A to E of boiled rice and tomato stew prepared with basmati rice.

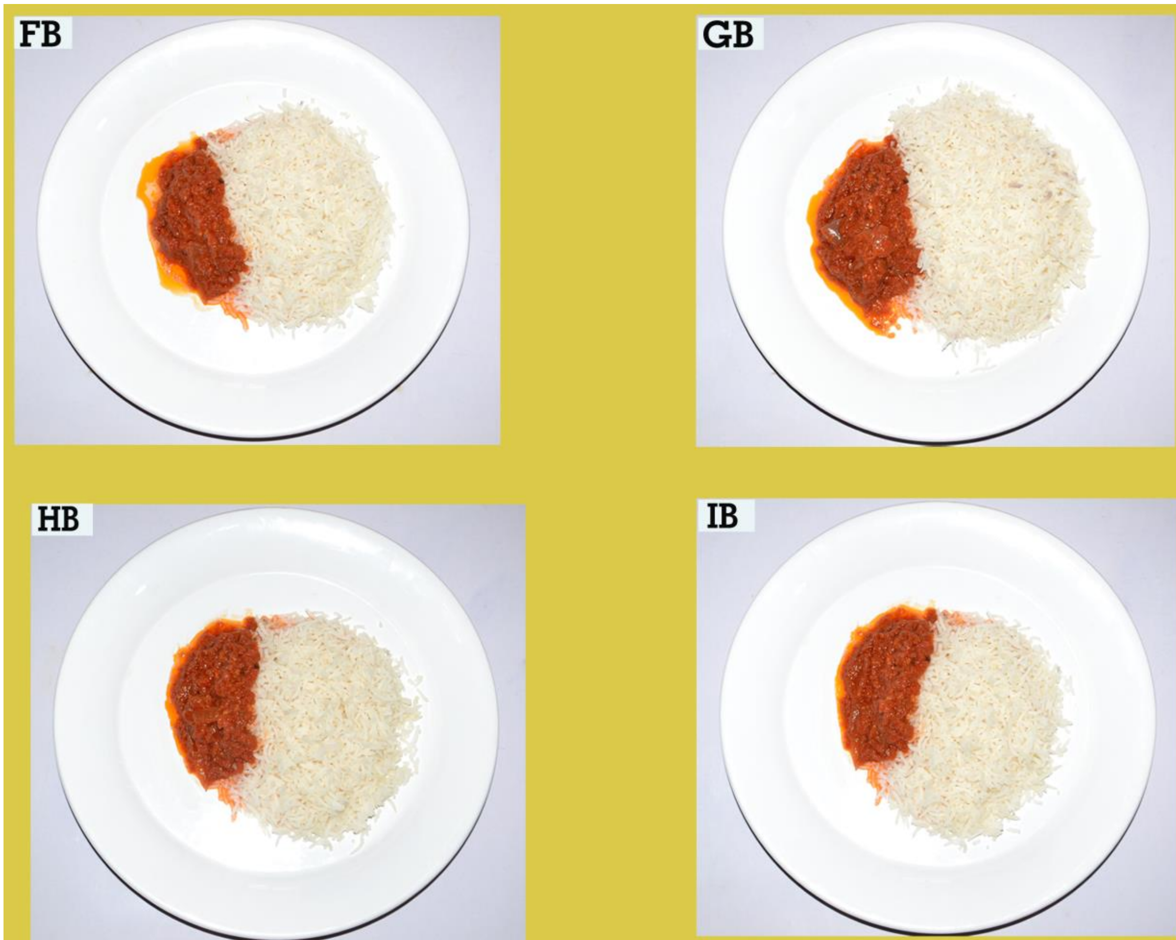


Figure 4.28b: Photographic atlas of DOM-M F to I of boiled rice and tomato stew prepared with basmati rice.

4.7.7 The proximate and energy content of domestic measures of fried rice prepared with local rice

The proximate and energy composition of different domestic measures (DOM-M) of fried rice prepared with local rice is presented in Table 4.30. DOM-M-G had a mean weight of 278g which is the highest while DOM-M – B contained the least (146g). The carbohydrates ranged from 26.2g in B to 49.9g in G. The energy content was 192.7 kcal in B to 367.0 kcal in G. The proximate composition per 100g shows that the moisture, ash, protein, crude fibre, fat and carbohydrates were 70.2g, 0.9g, 5.2g, 2.5g, 3.3g and 17.9g respectively.

Table 4.30: The proximate and energy composition of different domestic measures of fried rice prepared with local rice

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	132.0	554.4	70.2	0.9	5.2	2.5	3.3	17.9
A	214.0	282.5	1186.4	150.3	1.9	11.1	5.2	7.1	38.4
B	146.0	192.7	809.4	102.5	1.3	7.6	3.6	4.8	26.2
C	169.0	223.1	936.9	118.7	1.5	8.8	4.1	5.6	30.3
D	184.0	242.9	1020.1	129.2	1.7	9.5	4.5	6.1	33.0
E	205.0	270.6	1136.5	144.0	1.8	10.6	5.0	6.8	36.8
F	189.0	249.5	1047.8	132.7	1.7	9.8	4.6	6.2	33.9
G	278.0	367.0	1541.2	195.2	2.5	14.4	6.8	9.2	49.9
H	200.0	264.0	1108.8	140.5	1.8	10.4	4.9	6.6	35.9

4.7.8 The photographic food atlas of domestic measures of fried rice prepared with local rice

Figures 4.29a to 4.29b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of fried rice prepared with local rice.

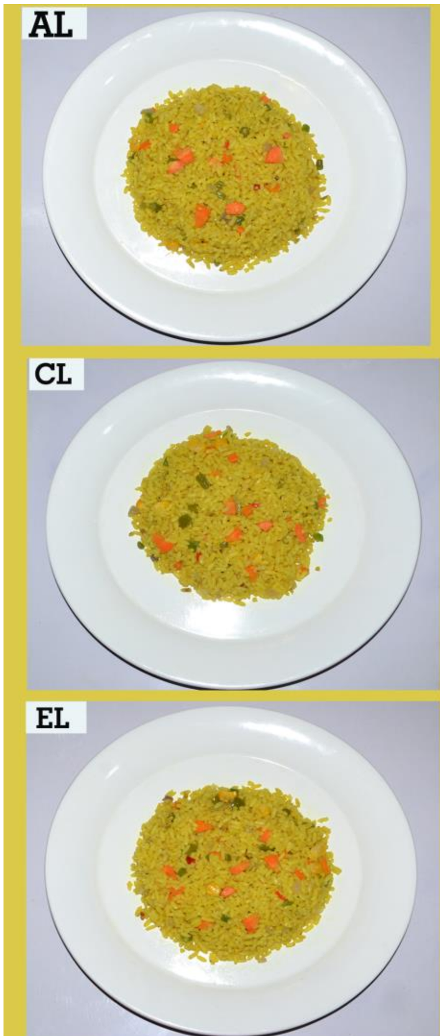


Figure 4.29a: Photographic atlas of DOM-M A to E of fried rice prepared with local rice (Abakaliki rice).

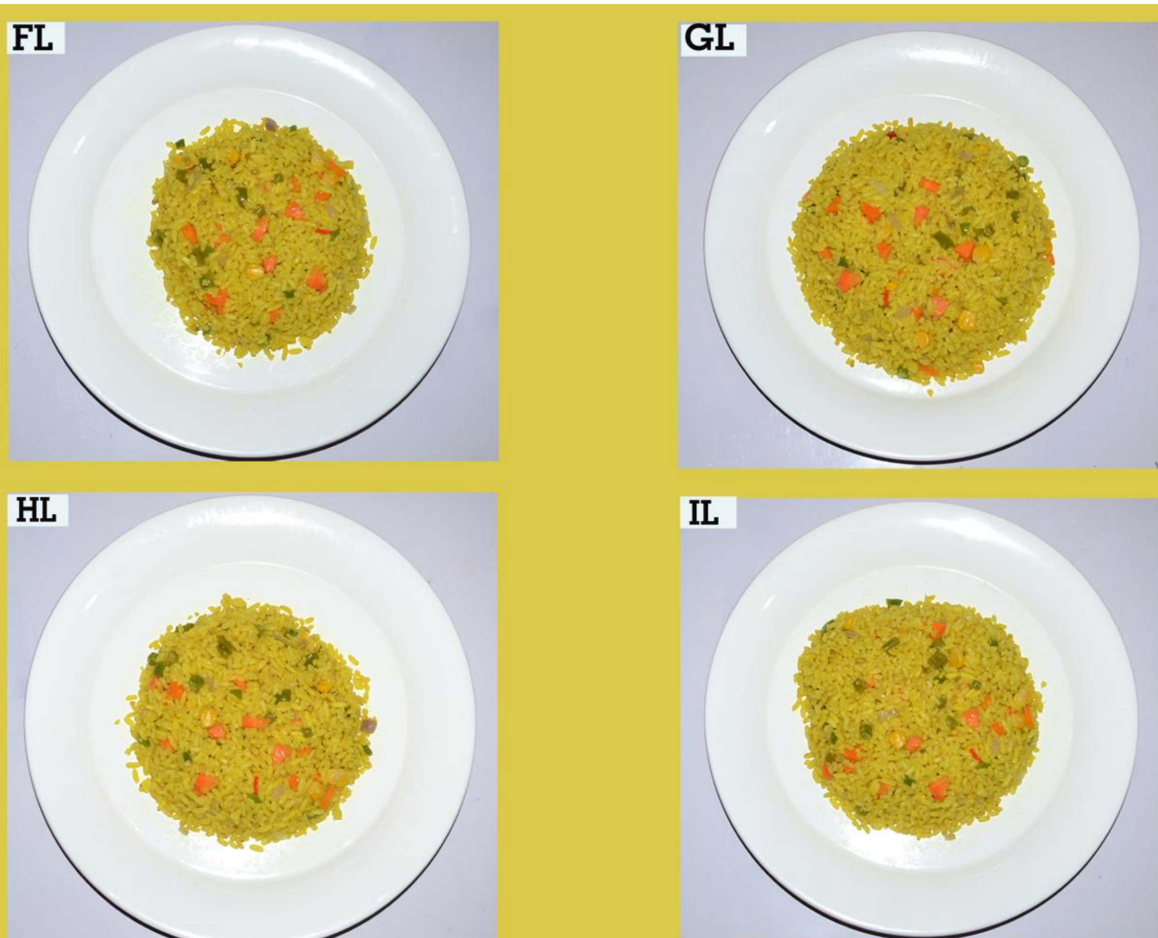


Figure 4.29a: Photographic atlas of DOM-M F to I of fried rice prepared with local rice (Abakaliki rice).

4.7.9 The proximate and energy content of domestic measures of jollof rice prepared with local rice

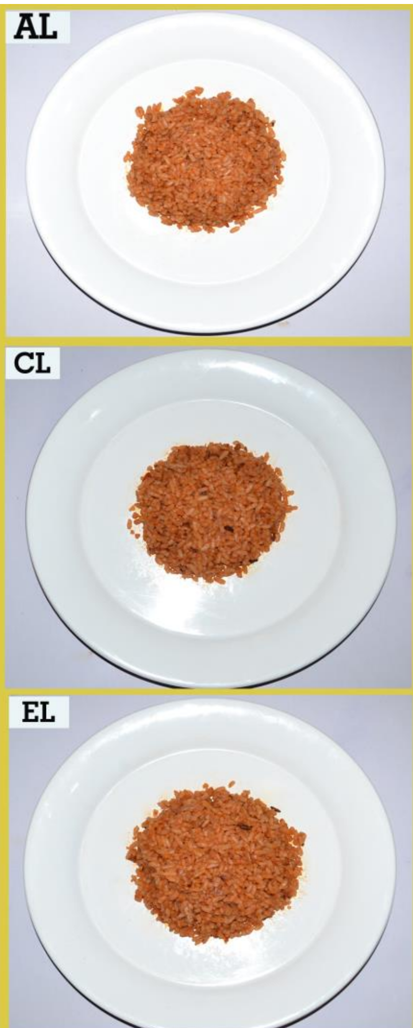
The proximate and energy composition of different domestic measures (DOM-M) of jollof rice prepared with local rice is presented in Table 4.31. DOM-M-I had a mean weight of 203g which is the highest while DOM-M – B contained the least (90g). The carbohydrates ranged from 14.7g in B to 33.1g in I. The energy content was 108.7 kcal in B to 245.2 kcal in I. The proximate composition per 100g shows that the moisture, ash, protein, crude fibre, fat and carbohydrates were 71.70g, 1.10g, 6.40g, 2.20g, 2.40g and 16.2g respectively.

Table 4.31: The proximate and energy composition of different domestic measures of jollof rice prepared with local rice

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	120.8	507.2	71.7	1.1	6.4	2.2	2.4	16.2
A	125.0	151.0	634.0	89.6	1.4	8.0	2.7	3.0	20.4
B	90.0	108.7	456.5	64.5	1.0	5.7	1.9	2.1	14.7
C	99.0	119.6	502.2	71.0	1.1	6.3	2.1	2.3	16.2
D	109.0	131.6	552.9	78.1	1.2	6.9	2.4	2.6	17.8
E	148.0	178.7	750.7	106.1	1.6	9.4	3.2	3.5	24.2
F	123.0	148.5	623.9	88.2	1.3	7.8	2.7	2.9	20.1
G	179.0	216.2	907.9	128.3	2.0	11.4	3.9	4.2	29.2
H	174.0	210.1	882.6	124.7	1.9	11.1	3.8	4.1	28.4

4.7.10 The photographic food atlas of domestic measures of jollof rice prepared with local rice

Figures 4.30a to 4.30b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of fried rice prepared with local rice.



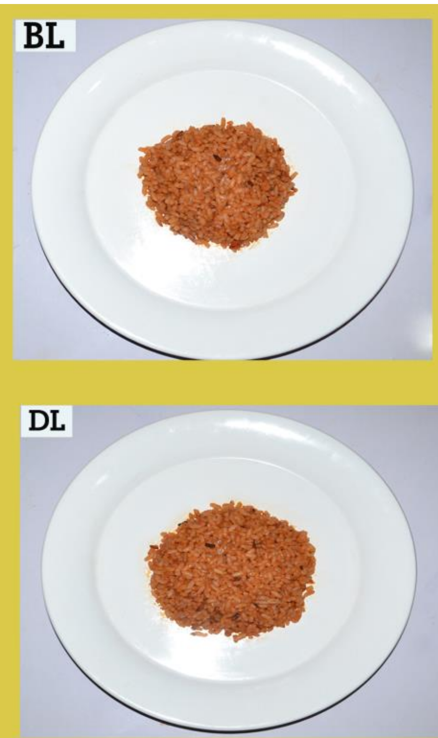


Figure 4.30a: Photographic atlas of DOM-M A to E of jollof rice prepared with Local rice (Abakaliki rice).

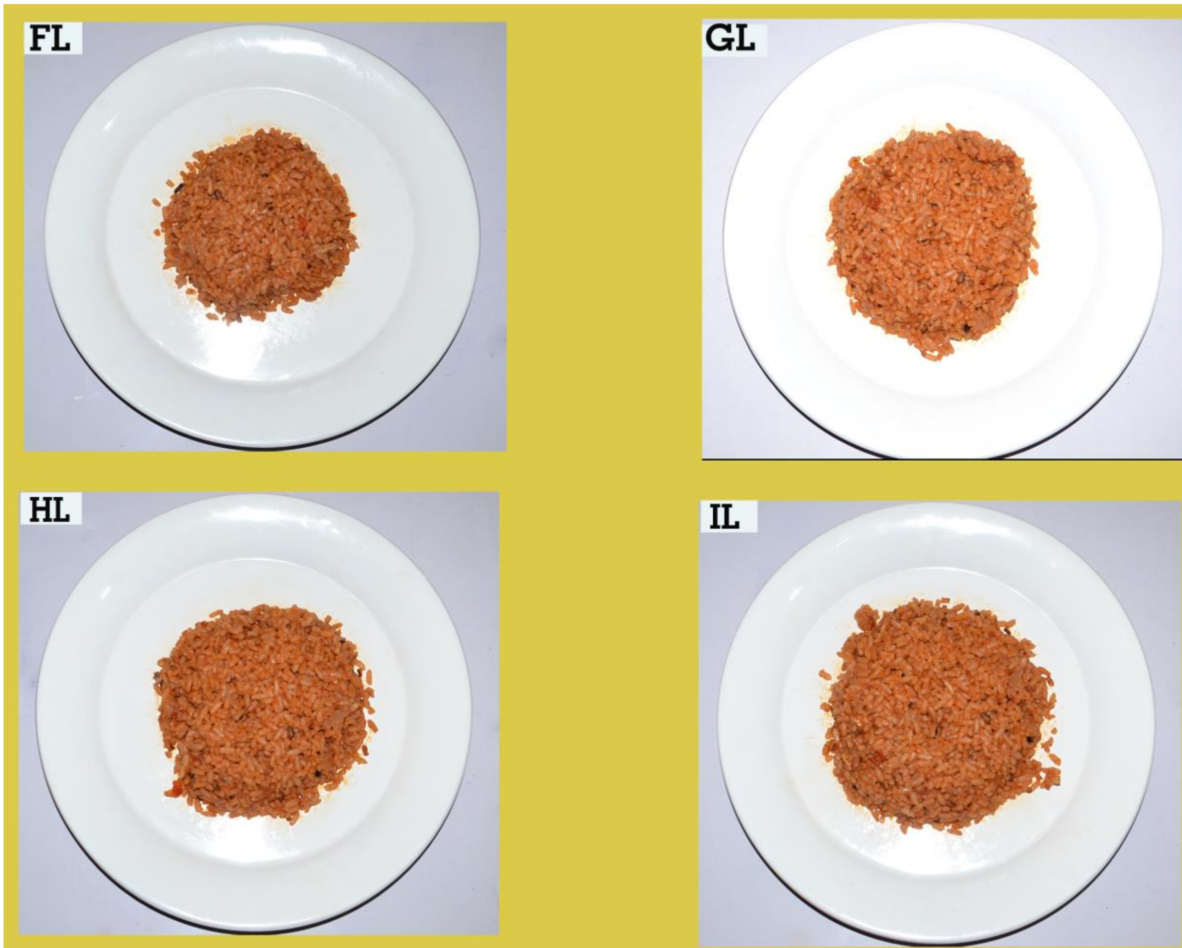


Figure 4.30b: Photographic atlas of DOM-M F to I of jollof rice prepared with Local rice.

4.7.11 The proximate and energy content of domestic measures of boiled rice and tomato stew prepared with local rice

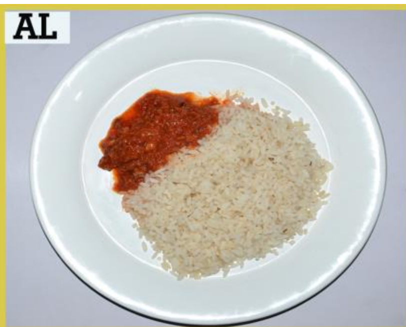
The proximate and energy composition of different domestic measures (DOM-M) of boiled rice and tomato stew prepared with local rice is presented in Table 4.32. DOM-M-G had a mean weight of 266g which is the highest while DOM-M – B contained the least (133g). The carbohydrates ranged from 21.9g in B to 43.7g in G. The energy content was 149.3 kcal in B to 298.7 kcal in G. The proximate composition per 100g shows that the moisture, ash, protein, crude fibre, fat and carbohydrates were 73.6g, 0.6g, 4.9g, 2.7g, 1.8g and 16.4g respectively.

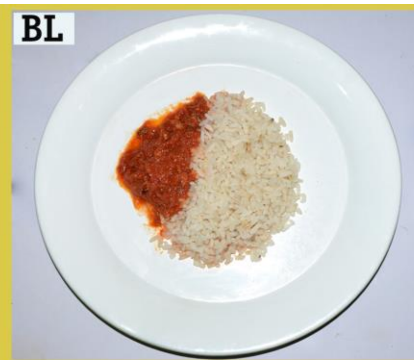
Table 4.32: The proximate and energy composition of different domestic measures of boiled rice and tomato stew prepared with local rice

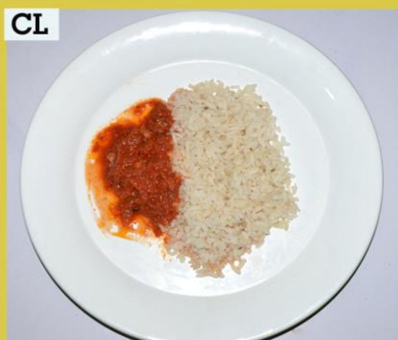
DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	112.3	471.6	73.6	0.6	4.9	2.7	1.8	16.4
A	209.0	234.7	985.6	153.8	1.3	10.3	5.6	3.8	34.4
B	133.0	149.3	627.2	97.8	0.8	6.5	3.6	2.4	21.9
C	154.0	172.9	726.2	113.3	0.9	7.6	4.1	2.8	25.3
D	173.0	194.2	815.8	127.3	1.1	8.5	4.6	3.1	28.4
E	233.0	261.6	1098.8	171.4	1.4	11.4	6.2	4.2	38.3
F	186.0	208.8	877.1	136.8	1.1	9.1	5.0	3.3	30.6
G	266.0	298.7	1254.4	195.7	1.6	13.1	7.1	4.8	43.7
H	209.0	234.7	985.6	153.8	1.3	10.3	5.6	3.8	34.4
I	211.0	236.9	995.0	155.2	1.3	10.4	5.6	3.8	34.7

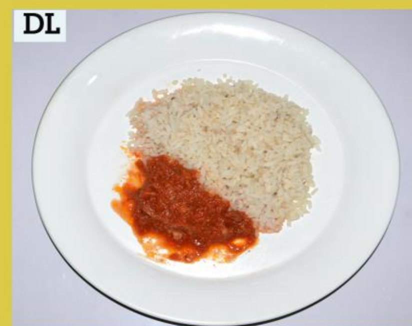
4.7.12 The photographic food atlas of domestic measures of boiled rice and tomato stew prepared with local rice

Figures 4.31a to 4.31b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of fried rice prepared with local rice.









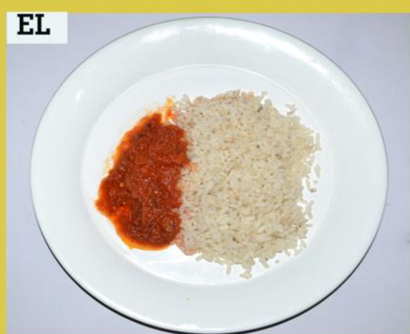


Figure 4.31a: Photographic atlas of DOM-M A to E of boiled rice and tomato stew prepared with local rice (Abakaliki rice).

Figure 4.31b: Photographic atlas of DOM-M F to I of boiled rice and tomato stew prepared with local rice.

4.7.13 The proximate and energy content of domestic measures of fried rice prepared with long grain rice

The proximate and energy composition of different domestic measures (DOM-M) of fried rice prepared with long grain (foreign) rice is presented in Table 4.33. DOM-M-G had a mean weight of 243g which is the highest while DOM-M – B contained the least (118g). The carbohydrates ranged from 15.6g in DOM-M – B to 32.1g in DOM-M – G. The energy content was 161.7 kcal in DOM-M – B to 332.9 kcal in DOM-M – G. The proximate composition per 100g shows the the moisture, ash, protein, crude fibre, fat and carbohydrates were 70.0g, 1.0g, 10.0g, 1.3g, 4.5g and 13.2g respectively.

Table 4.33: The proximate and energy composition of different domestic measures of fried rice prepared with long grain (foreign) rice

DOM Measure Code	Serving Weight (g))	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	137.0	576.0	70.0	1.0	10.0	1.3	4.5	13.2
A	202.0	276.7	1163.5	141.4	2.1	20.1	2.6	9.0	26.7
B	118.0	161.7	679.7	82.6	1.2	11.8	1.5	5.3	15.6
C	151.0	206.9	869.8	105.7	1.6	15.0	2.0	6.7	19.9
D	156.0	213.7	898.6	109.2	1.6	15.5	2.0	6.9	20.6
E	224.0	306.9	1290.2	156.8	2.3	22.3	2.9	10.0	29.6
F	195.0	267.2	1123.2	136.5	2.0	19.4	2.6	8.7	25.8
G	243.0	332.9	1399.7	170.1	2.5	24.2	3.2	10.8	32.1
H	211.0	289.1	1215.4	147.7	2.2	21.0	2.8	9.4	27.9
I	209.0	286.3	1203.8	146.3	2.2	20.8	2.7	9.3	27.6

4.7.14 The photographic food atlas of domestic measures of fried rice prepared with long grain rice

Figures 4.32a to 4.32b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of Fried rice prepared with long grain (foreign) rice.

Figure 4.32a: Photographic atlas of DOM-M A to E of fried rice prepared with long grain (foreign) rice.

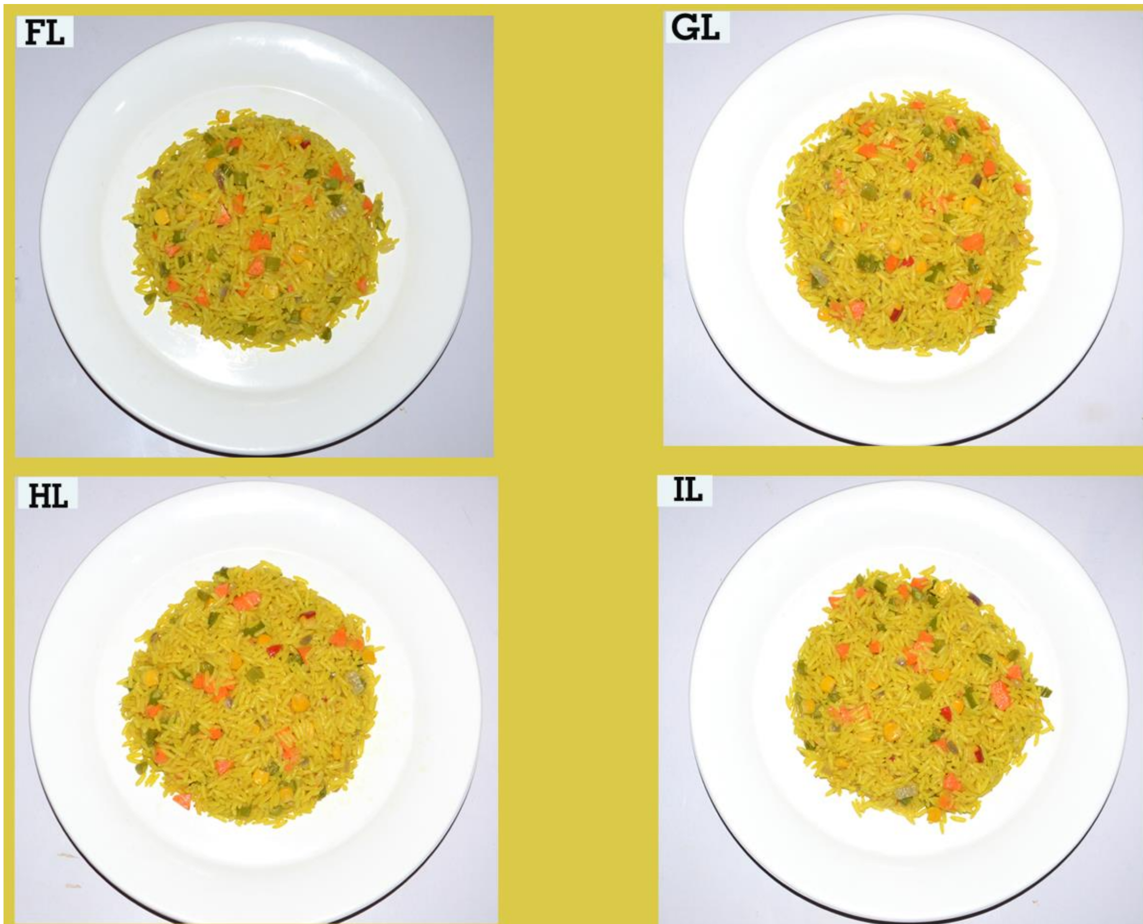


Figure 4.32b: Photographic atlas of DOM-M F to I of fried rice prepared with long grain (foreign) rice.

4.7.15 The proximate and energy content of domestic measures of jollof rice prepared with long grain rice

The proximate and energy composition of different domestic measures (DOM-M) of jollof rice prepared with long grain (foreign) rice is presented in Table 4.34. DOM-M-I had a mean weight of 189g which is the highest while DOM-M – B contained the least (92g). The carbohydrates ranged from 14.0g in B to 28.8g in I. The energy content was 127.0 kcal in B to 260.8 kcal in I. The proximate composition per 100g shows that the moisture, ash, protein, crude fibre, fat and carbohydrates were 69.0g, 1.8g, 8.0g, 1.70g, 4.4g and 15.1g respectively

Table 4.34: The proximate and energy composition of different domestic measures of jollof rice prepared with long grain (foreign) rice

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat g)	Carbohydrates (g)
	100.0	138.0	580.0	69.0	1.8	8.0	1.7	4.4	15.1
A	118.0	162.8	684.4	81.4	2.1	9.4	2.0	5.2	18.0
B	92.0	127.0	533.6	63.4	1.6	7.3	1.5	4.0	14.0
C	94.0	129.7	545.2	64.8	1.7	7.5	1.6	4.1	14.3
D	99.0	136.6	574.2	68.3	1.7	7.9	1.7	4.3	15.1
E	137.0	189.1	794.6	94.5	2.4	10.9	2.3	6.0	20.9
F	114.0	157.3	661.2	78.6	2.0	9.1	1.9	5.0	17.4
G	165.0	227.7	957.0	113.8	2.9	13.1	2.8	7.2	25.1
H	189.0	260.8	1096.2	130.3	3.3	15.0	3.2	8.3	28.8
I	189.0	260.8	1096.2	130.3	3.3	15.0	3.2	8.3	28.8

4.7.16 The photographic food atlas of domestic measures of jollof rice prepared with long grain rice

Figures 4.33a to 4.33b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of Jollof rice prepared with long grain (foreign) rice.

Figure 4.33a: Photographic atlas of DOM-M A to E of jollof rice prepared with long grain (foreign) rice.

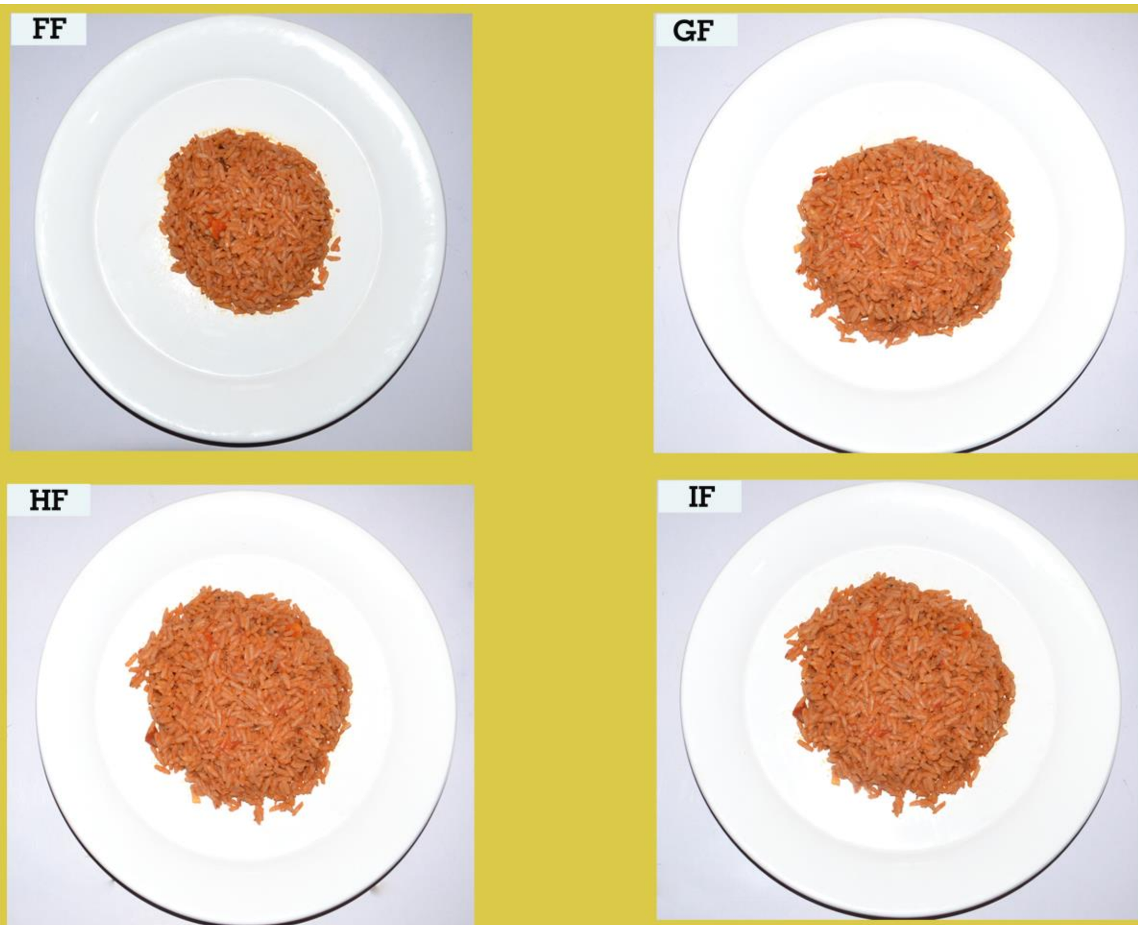


Figure 4.33b: Photographic atlas of DOM-M F to I of jollof rice prepared with long grain (foreign) rice.

4.7.17 The proximate and energy content of domestic measures of boiled rice and tomato stew prepared with long grain rice

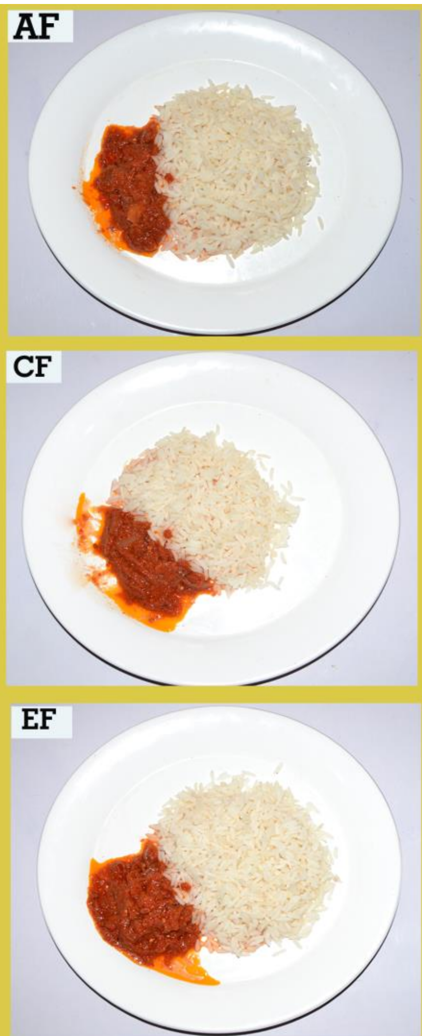
The proximate and energy composition of different domestic measures (DOM-M) of boiled rice and tomato stew prepared with long grain (foreign) rice is presented in Table 4.35. DOM-M-G had a mean weight of 238g which is the highest while DOM-M – B contained the least (128g). The carbohydrates ranged from 18.8g in B to 35.0g in G. The energy content was 165.1 kcal in DOM-M – B to 307.0 kcal in DOM-M – G. The proximate composition per 100g shows that the moisture, ash, protein, crude fibre, fat and carbohydrates were 70.80g, 1.30g, 8.80g, 0.08g, 3.6g and 14.7g respectively

Table 4.35: The proximate and energy composition of different domestic measures of boiled rice and tomato stew prepared with long grain (foreign) rice

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	129.0	541.0	70.8	1.3	8.8	0.8	3.6	14.7
A	193.0	249.0	1044.1	136.6	2.5	17.0	1.6	6.9	28.4
B	128.0	165.1	692.5	90.6	1.6	11.3	1.1	4.5	18.8
C	140.0	180.6	757.4	99.1	1.8	12.4	1.2	5.0	20.6
D	162.0	209.0	876.4	114.6	2.1	14.3	1.3	5.8	23.8
E	226.0	291.5	1222.7	159.9	2.9	20.0	1.9	8.0	33.3
F	191.0	246.4	1033.3	135.2	2.4	16.9	1.6	6.8	28.1
G	238.0	307.0	1287.6	168.4	3.0	21.0	2.0	8.4	35.0
H	171.0	220.6	925.1	121.0	2.2	15.1	1.4	6.1	25.2

4.7.18 The photographic food atlas of domestic measures of boiled rice and tomato stew prepared with local rice

Figures 4.34a to 4.34b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of boiled rice and tomato stew prepared with long grain (foreign) rice.



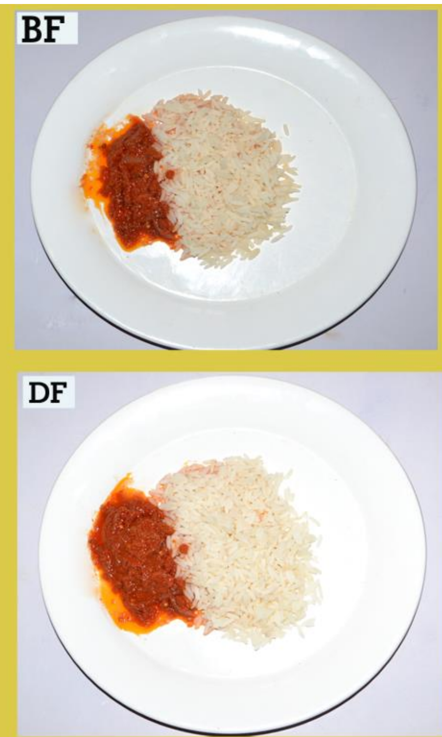


Figure 4.34a: Photographic atlas of DOM-M A to E of boiled rice and tomato stew prepared with long grain (foreign) rice.

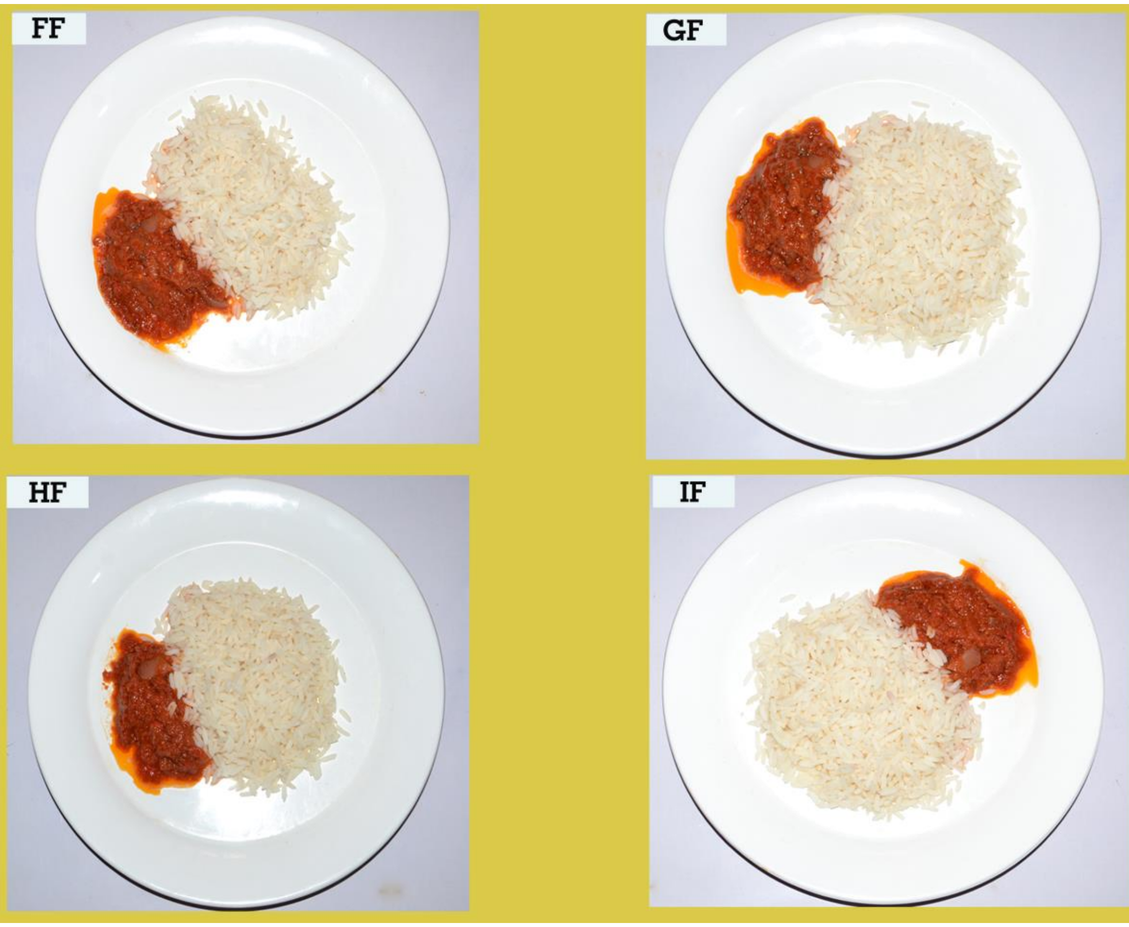


Figure 4.34b: Photographic atlas of DOM-M F to I of boiled rice and tomato stew prepared with long grain (foreign) rice.

4.7.19 The proximate and energy content of domestic measures of *achicha*

The proximate and energy composition of different domestic measures (DOM-M) of *achicha* is presented in Table 4.36. DOM-M-I had a mean weight of 216g which is the highest while DOM-M – B contained the least (111g). The carbohydrates ranged from 9.5g in DOM-M-B to 18.6g in DOM-M-I. The energy content was 344.7 kcal in DOM-M-B to 670.7 kcal in DOM-M-I. The proximate composition per 100g shows that the moisture, ash, protein, crude fibre, fat and carbohydrates were 54.5g, 1.9g, 3.80g, 4.10g, 27.2g and 8.60g respectively.

Table 4.36: The proximate and energy composition of different domestic measures of *achicha*

OM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	310.5	1304.0	54.5	1.9	3.8	4.1	27.2	8.5
A	175.0	543.4	2282.0	95.3	3.4	6.6	7.1	47.6	15.0
B	111.0	344.7	1447.4	60.5	2.1	4.2	4.5	30.2	9.5
C	139.0	431.6	1812.6	75.7	2.7	5.3	5.6	37.8	11.9
D	125.0	388.1	1630.0	68.1	2.4	4.7	5.1	34.0	10.7
E	170.0	527.9	2216.8	92.6	3.3	6.4	6.9	46.2	14.6
F	137.0	425.4	1786.5	74.6	2.6	5.2	5.5	37.3	11.8
G	159.0	493.7	2073.4	86.6	3.1	6.0	6.4	43.2	13.7
H	163.0	506.1	2125.5	88.8	3.1	6.2	6.6	44.3	14.0

4.7.20 The photographic food atlas of domestic measures of *achicha*

Figures 4.35a to 4.35b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of *achicha*.

Figure 4.35a: Photographic atlas of DOM-M A to E of *achicha*

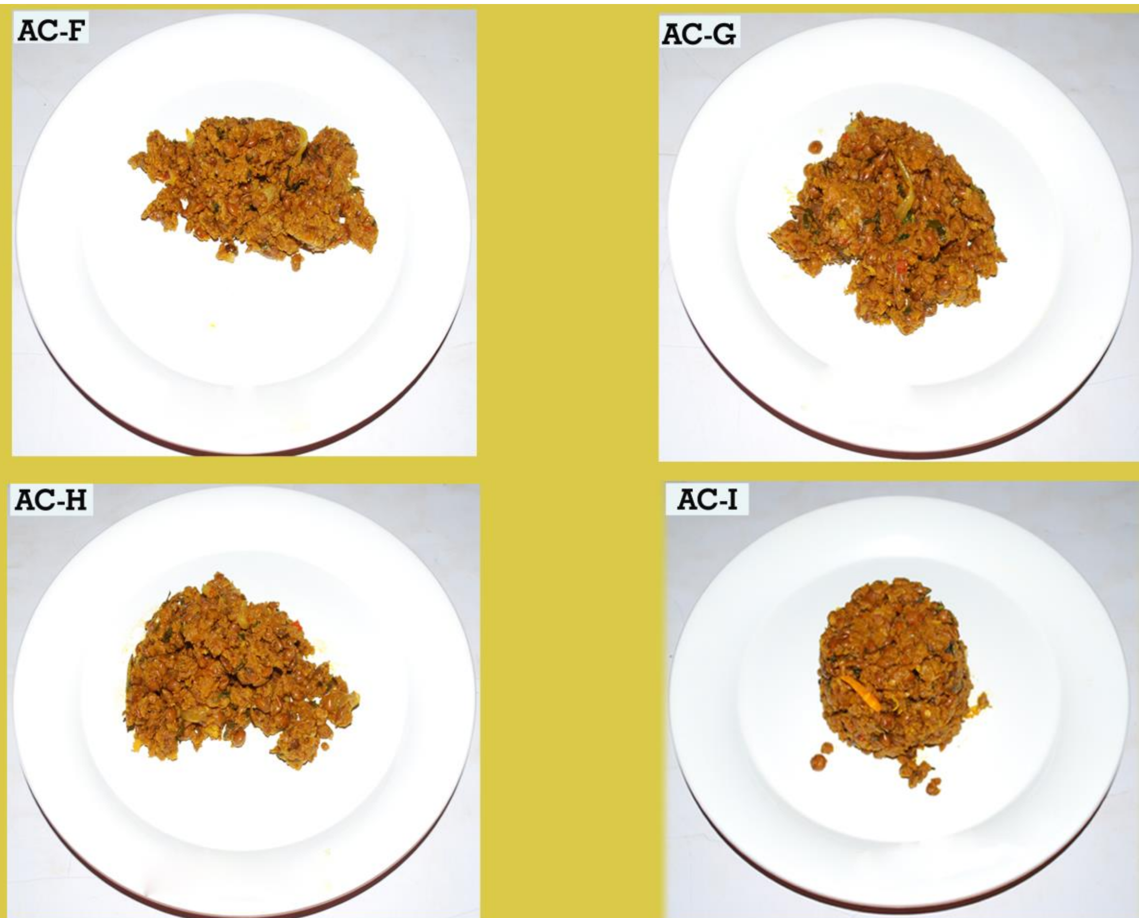


Figure 4.35b: Photographic atlas of DOM-M F to I of *achicha*

4.7.21 The proximate and energy content of domestic measures of *ayaraya-oka*

The proximate and energy composition of different domestic measures (DOM-M) of *ayaraya-oka* is presented in Table 4.37. DOM-M-E had a mean weight of 230g which is the highest while DOM-M – B contained the least (110g). The carbohydrates ranged from 7.9g in DOM-M – B to 16.5g in DOM-M – E. The energy content was 208.2 kcal in DOM-M – B to 405.0 kcal in DOM-M – I. The proximate composition per 100g shows that the moisture, ash, protein, crude fibre, fat and carbohydrates were 68.10g, 4.60, 3.70g, 0.60g, 16.00g and 7.00g respectively.

Table 4.37: The proximate and energy composition of different domestic measures of *ayaraya-oka*

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	189.2	795.0	68.1	4.6	3.7	0.6	16.0	7.0
A	170.0	321.7	1351.5	115.7	7.8	6.2	1.0	27.1	12.2
B	110.0	208.2	874.5	74.9	5.1	4.0	0.6	17.5	7.9
C	121.0	229.0	962.0	82.3	5.6	4.4	0.7	19.3	8.7
D	146.0	276.3	1160.7	99.4	6.7	5.3	0.8	23.3	10.5
E	230.0	435.2	1828.5	156.5	10.6	8.4	1.3	36.7	16.5
F	151.0	285.7	1200.5	102.8	6.9	5.5	0.9	24.1	10.9
G	181.0	342.5	1439.0	123.2	8.3	6.6	1.0	28.9	13.0
H	175.0	331.2	1391.3	119.1	8.1	6.4	1.0	27.9	12.6
I	214.0	405.0	1701.3	145.6	9.8	7.8	1.2	34.1	15.4

4.7.22 The photographic food atlas of domestic measures of *ayaraya-oka*

Figures 4.36a to 4.36b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of *ayaraya-oka*.

Figure 4.36a: Photographic atlas of DOM-M A to E of *ayaraya-oka*

Figure 4.36b: Photographic atlas of DOM-M F to I of *ayaraya-oka*

4.7.23 The proximate and energy content of domestic measures of *ayaraya-ji*

The proximate and energy composition of different domestic measures (DOM-M) of *ayaraya-ji* is presented in Table 4.38. DOM-M-A had a mean weight of 278g which is the highest while DOM-M – B contained the least (165g). The carbohydrates ranged from 35.1g in DOM-M B to 59.1g in DOM-M – A. The energy content was 339.9 kcal in DOM-M – B to 572.7 kcal in DOM-M – A. The proximate composition per 100g shows the moisture, ash, protein, crude fibre, fat and carbohydrates were 59.90g, 3.40g, 3.20g, 0.50g, 11.8g and 21.2g respectively.

Table 4.38: The proximate and energy composition of different domestic measures of *ayaraya-ji*

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy Kj	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	206.0	856.1	59.9	3.4	3.2	0.5	11.8	21.2
A	278.0	572.7	2380.0	166.5	9.5	8.8	1.3	32.8	59.1
B	165.0	339.9	1412.6	98.8	5.6	5.2	0.8	19.5	35.1
C	200.0	412.0	1712.2	119.8	6.8	6.4	1.0	23.6	42.5
D	206.0	424.4	1763.6	123.4	7.0	6.6	1.0	24.3	43.8
E	259.0	533.5	2217.3	155.1	8.8	8.2	1.2	30.6	55.1
F	259.0	533.5	2217.3	155.1	8.8	8.2	1.2	30.6	55.1
G	259.0	533.5	2217.3	155.1	8.8	8.2	1.2	30.6	55.1
H	260.0	535.6	2225.9	155.7	8.8	8.3	1.2	30.7	55.3
I	232.0	477.9	1986.2	138.9	7.9	7.4	1.1	27.4	49.3

4.7.24 The photographic food atlas of domestic measures of *ayaraya-ji*

Figures 4.37a to 4.37b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of *ayaraya-ji*.

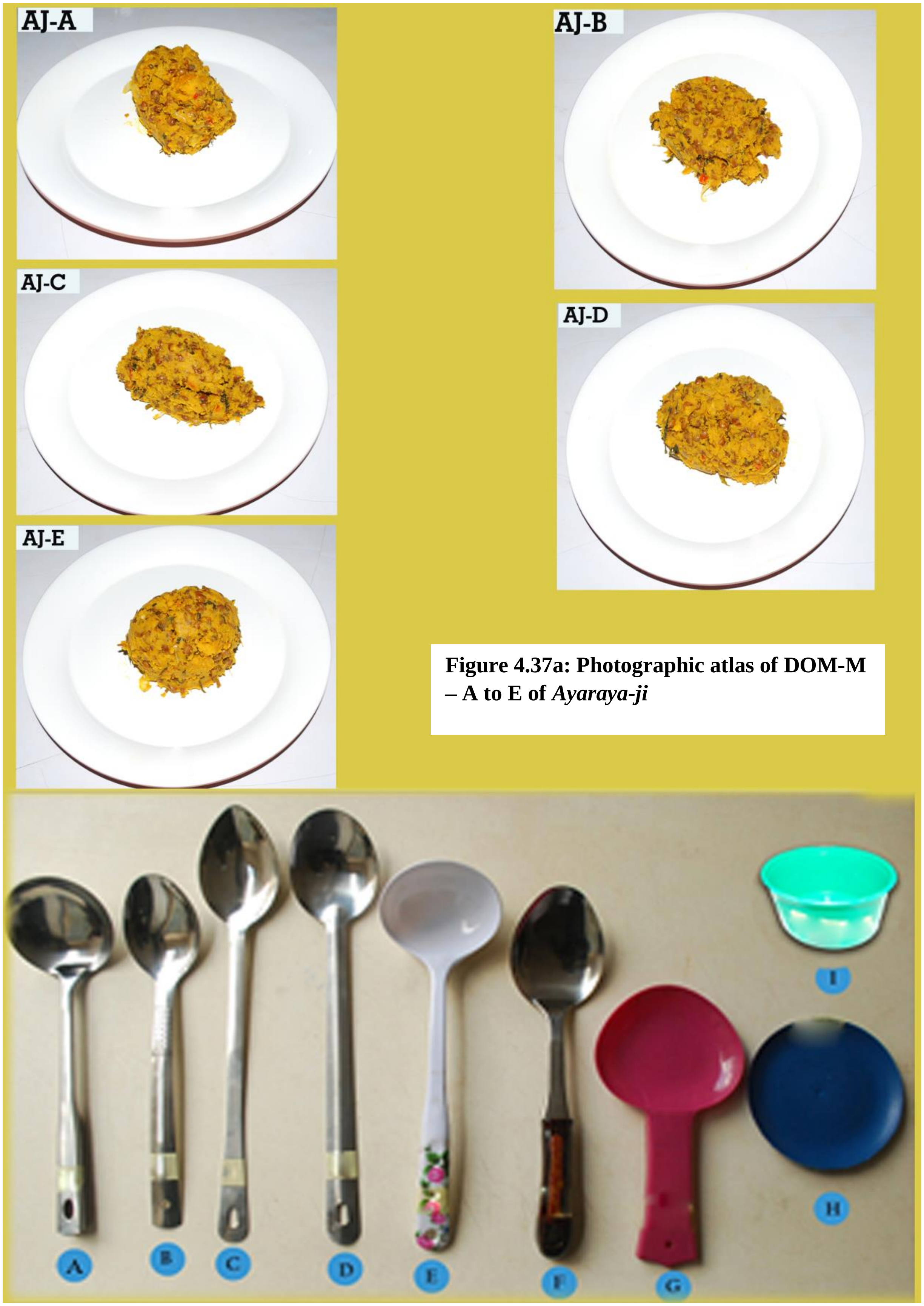


Figure 4.37a: Photographic atlas of DOM-M – A to E of *Ayaraya-ji*

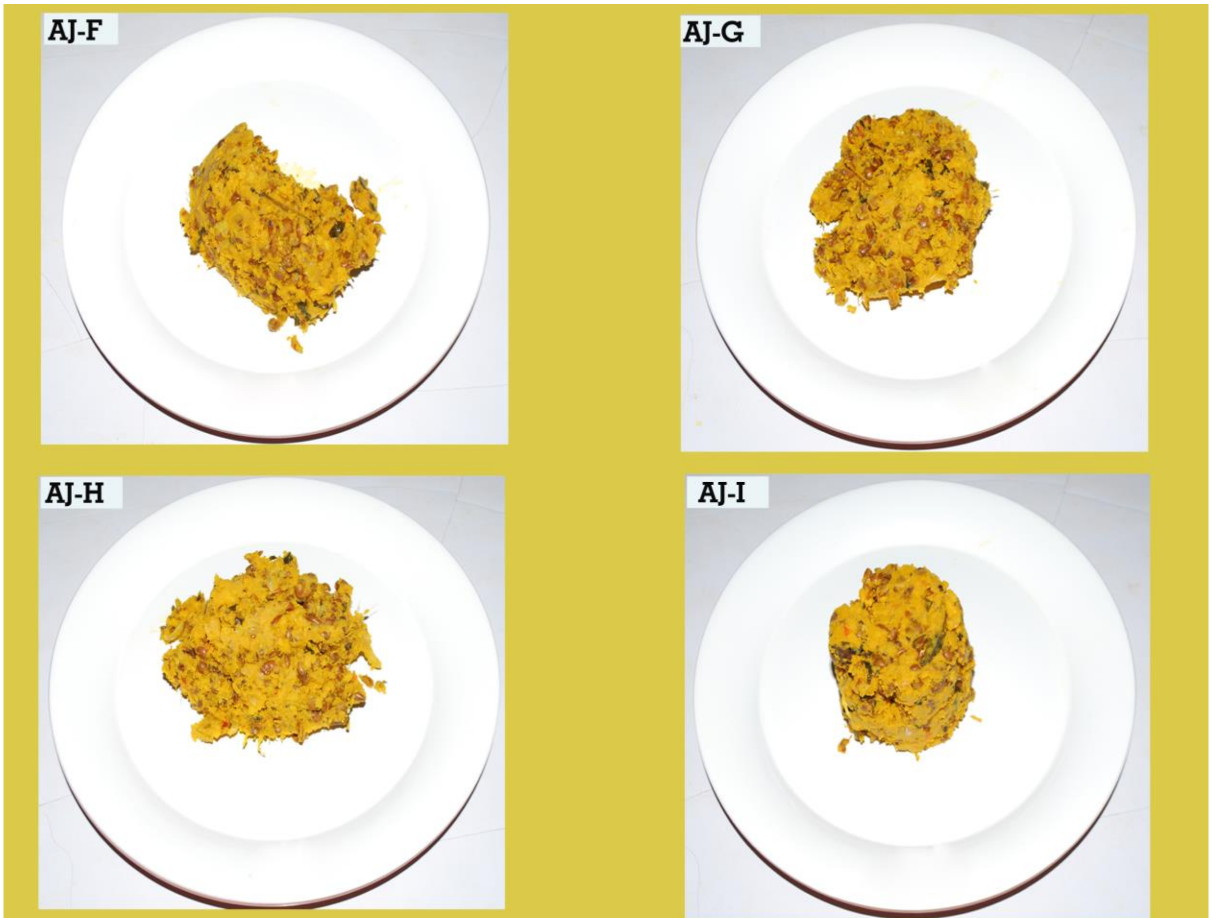


Figure 4.37b: Photographic atlas of DOM-M- F to I of *Ayaraya-ji*

4.7.25 The proximate and energy content of *abacha*

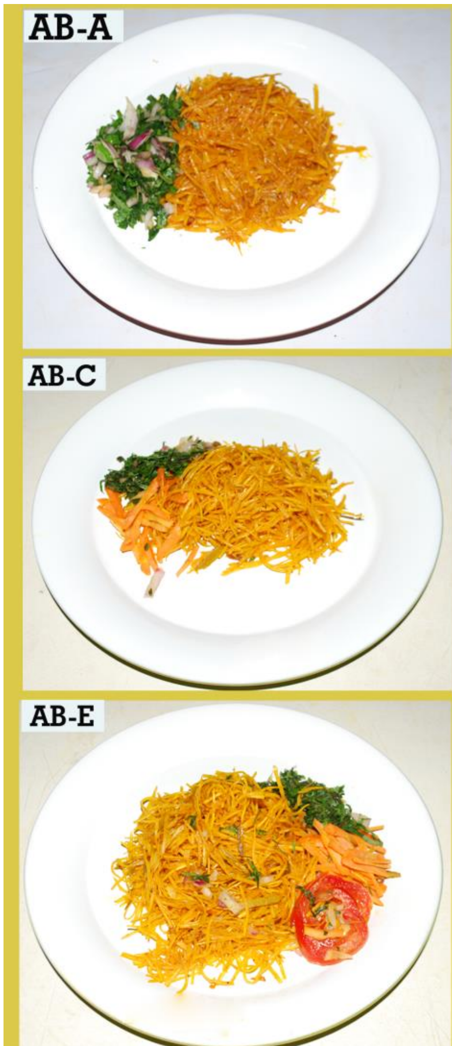
The proximate and energy composition of different domestic measures (DOM-M) of *abacha* is presented in Table 4.39. DOM-M-I had a mean weight of 161g which is the highest while DOM-M – B contained the least (92g). The carbohydrates ranged from 6.7g in DOM-M – B to 11.6g in DOM-M – I. The energy content was 187.6 kcal in DOM-M – B to 328.3 kcal in DOM-M – I. The proximate composition per 100g shows the moisture, ash, protein, crude fibre, fat and carbohydrates were 56.80g, 1.1g, 12.0g, 2.9g, 4.4g and 22.8g respectively.

Table 4.39: The proximate and energy composition of different domestic measures of *abacha*

DOM Measure Code	Serving Weight (g)	Energy Kcal	Energy KJ	Moisture (g)	Ash (g)	Protein (g)	Crude fiber (g)	Fat (g)	Carbohydrates (g)
	100.0	190.2	799.0	56.8	1.1	12.0	2.9	4.4	22.8
A	97.0	184.5	775.0	55.1	1.0	11.6	2.8	4.3	22.1
B	92.0	175.0	735.1	52.3	1.0	11.0	2.7	4.0	21.0
C	97.0	184.5	775.0	55.1	1.0	11.6	2.8	4.3	22.1
D	98.0	186.4	783.0	55.7	1.1	11.8	2.8	4.3	22.3
E	137.0	260.6	1094.6	77.8	1.5	16.4	4.0	6.0	31.2
F	113.0	214.9	902.9	64.2	1.2	13.6	3.3	5.0	25.8
G	155.0	294.8	1238.5	88.1	1.7	18.6	4.5	6.8	35.3
H	111.0	211.1	886.9	63.1	1.2	13.3	3.2	4.9	25.3
I	161.0	306.2	1286.4	91.5	1.7	19.3	4.7	7.1	36.7

4.7.26 The photographic food atlas of domestic measures of *abacha*

Figures 4.38a to 4.38b present the photographic atlas of different portions of domestic measures (Fig. 4.25a) of *abacha*.



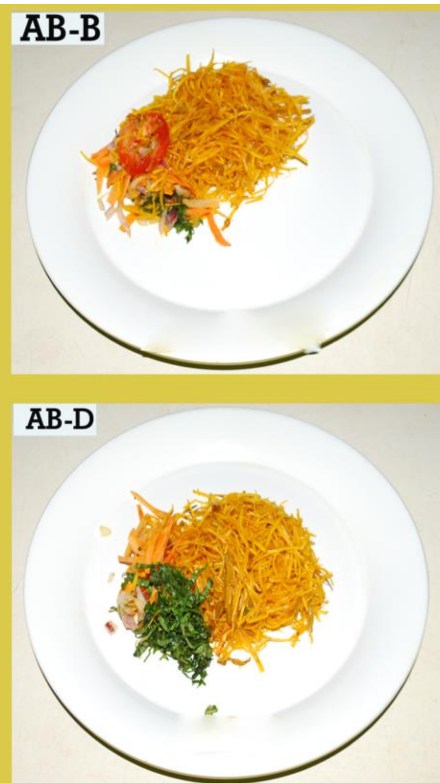


Figure 4.38a: Photographic atlas of DOM-M A to E of *abacha*

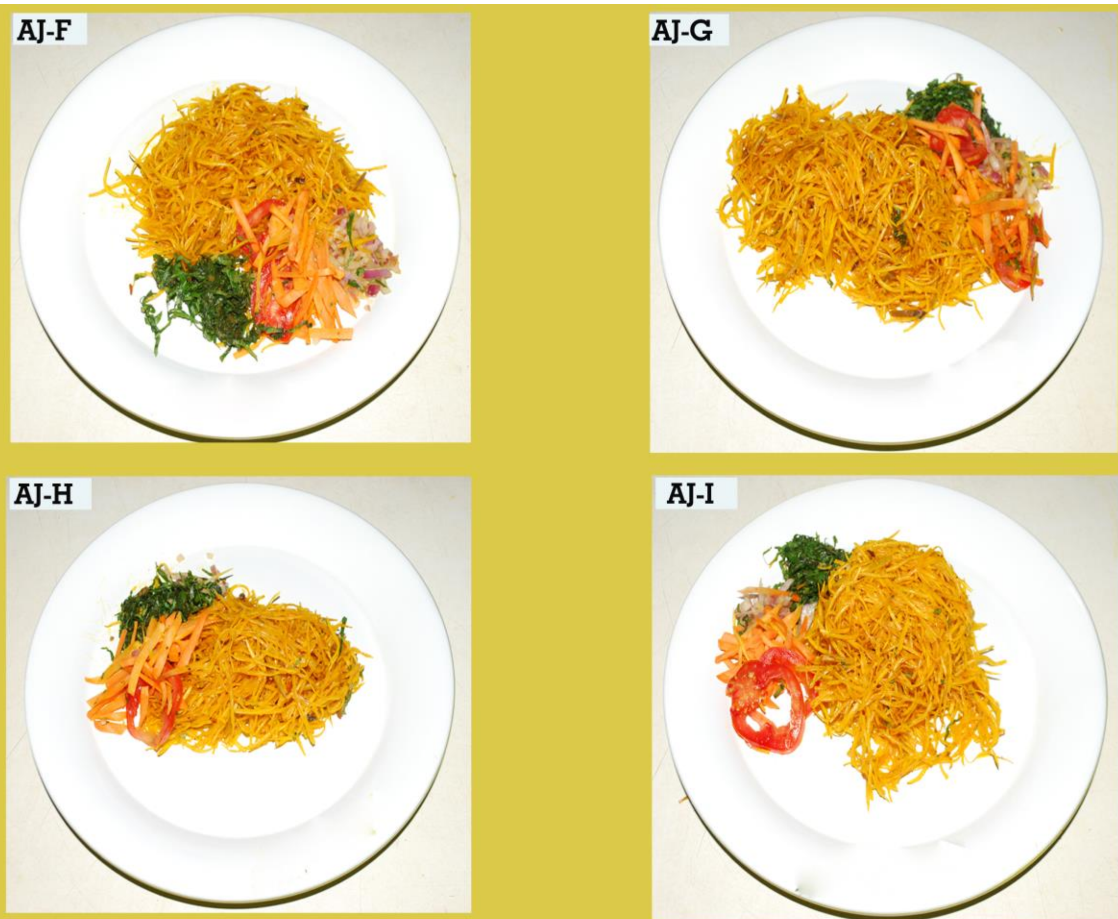


Figure 4.38b: Photographic atlas of DOM-M F to I of *abacha*

4.8 Validation of photographic food atlas, of carbohydrate servings of selected fruits and foods consumed by diabetic patients in Enugu State

4.8.1 The socio-demographic characteristics of the validators

Table 4.40 presents the socio-demographic characteristics of the validators. They were 66.7% males and 33.3% females, 25% had no formal education while 33% received tertiary education. Only 33.3% were still in active service of doing business/trading, 25% were farmers while the rest were either retired (33.3%) or unemployed (8.3%). Their marital status data shows that 25% were widows, 8.3% divorced and 8.3% single while others were living together with their spouse (58%). The area of residence of the respondents were distributed between the urban (41.7%) and rural areas (58.3%) respectively.

Table 4.40: Socio-demographic characteristics of the validators

Variables	Frequency	Percentage
Sex		
Male	8	66.7
Female	4	33.3
Total	**12**	**100.0**
Educational Qualification		
No Formal Education	3	25.0
Primary	4	33.3
Secondary	1	8.3
Tertiary	4	33.3
Total	**12**	**100.0**
Occupation		
Farmer	3	25.0
Trader/Business	4	33.3
Retired	4	33.3
Unemployed/Housewife	1	8.3
Total	**12**	**100.0**
Average Monthly Income		
<18000	3	33.3
18000 – 30000	5	41.7
31000 – 50000	2	16.7
81000 – 100000	1	8.3
Total	**12**	**100.0**
Marital Status		
Single	1	8.3
Currently Married/Cohabiting	7	58.3
Separated/Divorced	1	8.3
Widow/Widower	3	25.0
Total	**12**	**100.0**
Residential Area		
Urban	5	41.7
Rural	7	58.3
Total	**12**	**100.0**

4.8.2 The anthropometric characteristics of the validators

Table 4.41 presents the anthropometric indices of the validators. The waist circumference of the respondents showed that 50% had high risk developing cardiovascular disease, 8.3% were obese and 33.3% were overweight only 58.3% had normal weight.

Table 4.41: Anthropometric indices of the validators

Variable	Frequency	Percent
Waist Circumference		
Low risk	6	50.0
High risk	6	50.0
Total	**12**	**100.0**
Body Mass Index Classification		
Normal	7	58.3
Overweight	4	33.3
Obese	1	8.3
Total	12	100.0

4.8.3 The validation result

Table 4.42 presents the validation result of the validators. Only 33.3% of the respondents had a poor mean score (<40%), 41.7% had good scores from 50% to 59% while 8.3% scored 60% and above.

Table 4.42: Validation result of the validators

Validation Classification	Frequency	Percent
Poor (<40%)	4	33.3
Fair (40-49%)	2	16.7
Good (50-59%)	5	41.7
Very good (60-69%)	1	8.3
Total	12	100.0

4.8.4 The association of validation result with socio-demographic and anthropometric characteristics of the validators

Table 4.43 presents the association of validation classification with socio-demographic and anthropometric categorical variables. Validation class had significant relationship with sex (p=0.035) of the validators and their occupation (p=0.015) of the validators, while the other variables tested had no significant (p>0.05) relationships.

Table 4.43: Association of validation classification with socio-demographic and anthropometric categorical variables

Variable	χ2	p-value	Remarks
Sex	**8.625[a]**	**0.035**	**S**
Educational Qualification	7.975[a]	0.537	NS
Occupation	**20.550[a]**	**0.015**	S
Residing Area	3.977[a]	0.264	NS
Waist circumference class	4.800[a]	0.187	NS
Body Mass index class	12.450[a]	0.053	NS

4.8.5 The association of validation result, age, and anthropometric characteristics with gender of the validators

Table 4.44 presents the association of numerical variables between the male and female validators. There was no significant ($p>0.05$) difference in all the numerical variables compared between male and female respondents. The average age of the validators were 67 years, the mean body mass index (BMI) was 25.1kg/m^2 which was within the overweight category.

Table 4.44: Association of numerical variables between the male and female validators

Variable	Male (Mean±SD)	Female (Mean±SD)	t-value	p-value	Total (Mean±SD)
Validation score (%)	46.1±12.7	47.3±17.0	-0.134	0.896	46.5±13.5
Weight (kg)	71±12.28	68.5±9.25	0.356	0.729	70.2±11.0
Height (m)	1.69±0.1	1.59±0.1	1.893	0.088	1.65±0.1
Waist Circumference (cm)	95.9±11.0	98.5±6.2	-0.431	0.675	96.7±9.4
BMI (kg/m^2)	23.9±2.8	27.5±4.87	-1.666	0.127	25.1±3.8
Age (years)	66.5±6.0	68.7±9.0	-0.469	0.65	67.1±6.5

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Commonly consumed locally available foods consumed by adult diabetic patients

This study revealed that rice with tomato stew had the highest points (46) among the commonly consumed foods. This was expected because rice is a common staple consumed in most households in Enugu state. Rice dishes are consumed in different forms in Enugu State, it is prepared as jollof rice where all the ingredients including oil (mostly vegetable oil) are mixed and cooked together in the cooking pot. Rice is also cooked and fried (called fried rice) with vegetables such as carrots, green beans, sweet corn, green pepper, green peas and other optional vegetables like cabbage, cucumber among others. Chicken stock is mostly used for fried rice preparation. Another common method of preparing rice in Enugu State is cooking boiled rice alone by adding only salt to it and making tomato stew or vegetable sauce or egg sauce to eat them together. The variety introduced in the different methods of preparing rice which gives it differing organoleptic attributes contributes to its frequent consumption among diabetic clients in the study. Another study among diabetics in Owo, Ondo state, Nigeria, showed that majority (70.0%) of the respondents consumed cereals (made of rice, corn, wheat and others) once per day implying that cereal based diet is at least consumed in the household everyday which is comparable to this study where majority of the households consumed rice dishes more than 3 times a week (Oladapo, Jude-Ojei, Koleosho & Roland-Ayodele, 2013).

Refined carbohydrates and highly processed foods are not recommended for diabetic patients because it poses risk of hyperglycaemia due to their low glycaemic indices when the fibre is removed from the food during processing (Augustine, Kendall, Jenkins & Willet, 2015; Brand-Miller, Marsh, Barclay & Colagiuri, 2011; Mirrahimi, de Souza & Chiavaroli, 2012; Sadler, 2011). However, there are exceptions when enough roughages such as vegetables are added during preparation to increase the fibre content which reduces the glycaemic index (Brand-Miller et al., 2011; Sadler, 2011). Report of another research among adult persons with diabetics who received medical care at the Out-patient clinics of two Teaching Hospitals in Lagos, Nigeria showed that processed cereals were mostly (27.2%) consumed by the respondents more than other food groups (Olatona, Airede, Aderibigbe & Osibogun, 2019) which is not similar to the result in this study where highly processed foods such as macaroni were the least (6.5 points) consumed. This could be attributed to the patients visit to Dietitian – Nutritionist in the selected hospitals Enugu State where they must have received counselling in the previous visits. Also, different factors affects the frequency of consumption of a particular food in any locality which include the availability of foods in the area, the cost of the food, food habits formed from childhood, religion, culture and the different ways the food is prepared such as rice dishes that are cooked as jollof, fried and boiled rice and tomato stew/ofeakwu/vegetable source (Mahan, Escott-Stump & Raymond, 2012; Sizer & Whitney, 2014).

Okpa (bambaranut pudding) is second in the most frequently consumed foods among the respondents. *Okpa* is a legume based meal commonly sold by vendors early hours of the morning around all parts of Enugu State. Most households eat it in different form, either with pap (maize porridge) or alone or with sugar sweetened drink. Thus, due to its availability, many persons leave their house in the morning without eating breakfast planning to buy *okpa* from a food vendor which will serve as their breakfast, which could be the reason for its high score in the study. Ayogu et al. (2017) reported *okpa* as one of the common staple consumed in Enugu State in their study in rural setting in southeastern Nigeria. This, therefore corroborated with the study that *okpa* is commonly consumed among diabetics in Enugu State.

Other legumes and tuber based dishes (moimoi [beans pudding], yam pottage and beans/yam) also ranked high in the frequency of commonly consumed foods which is similar to findings from other researchers (Ntui, Udoh, Esiere, Essien & Egbe, 2006; Oladapo et al., 2013; Olatona et al., 2019). Legume and tuber based dishes such as beans, *okpa*, African yam bean and black eye bean, *achicha* (cocoyam and pigeon pea), *ayaraya-oka* (maize, pigeon pea and leafy vegetables) and *ayaraya-ji* (yam and pigeon pea) are traditional foods common in Enugu State which many persons suffering from diabetes mellitus consumed these foods because they attribute it to be low in carbohydrates due to the legumes in them. Although, legumes are known to be rich source of plant proteins, they also contain carbohydrate as one of the highest nutrient in them after moisture (Ayogu et al., 2017; Davidson et al., 2017; Fadupin, 2009; Food Basket Foundation International, 1995; Platt, 1962). When legume based dishes are consumed without quantifying them, especially for diabetics, it could result in glycaemic spike. Portion control in any type of meal is key to proper dietary management of diabetes. In this study, the respondents were drawn from diabetic clients who had come to consult the Dietitian-Nutritionist who will provide expert counselling especially for those that were consulting for the first time. Management of diabetes mellitus in interdisciplinary involving medicines, lifestyle and dietary modification for a good glycaemic control (British Dietetic Association, 2014; International Diabetes Federation, 2019; Nelms et al., 2011).

The least consumed dish from this study was consuming macaroni together with rice where macaroni is a processed cereal. This is expected as most individuals with diabetes are careful with their meals to ensure that there is no spike in the blood glucose, thus, they tend to consume foods that contain lower glycaemic index. However, misconceptions surrounding consumption of high carbohydrate foods must have been cleared by the Dietitians providing dietary counselling to the respondents as most of them had been coming to receive dietary counselling from the Dietitians and must have obtained correct information. However, when high glycaemic index food are consumed as a mixed dish especially with appreciable quantity of vegetables, their glycaemic index reduces making it suitable for consumption by persons with diabetes (Nelms et al., 2011). The diet of persons living with diabetes in Nigeria is most times influenced by the information they received from non-diet professionals before they consult a Dietitian. However, proper dietary counselling is an integral part of diabetes management which enhances better self-management, prevents early onset of long term complications of diabetes, and prevents monotony in dietary intake as well as excessive dietary restrictions (International Diabetes Federation, 2019; Nelms et al., 2011; Rolfes et al., 2006).

5.1.2.1 Proximate composition of selected foods

The foods analysed in the study included both single foods including fruits (banana of different varieties, watermelon, pawpaw, pineapple, apple, African salad [*abacha*] and bambaranut pudding [*okpa*]), also mixed dishes (*ayaraya-ji*, *ayaraya-oka*, igbangwuoka, jollof rice, fried rice, boiled rice with tomato stew) were analysed in the study. The macronutrients (total carbohydrates, fats and protein) content of the dishes which are the energy giving food nutrients were used to calculate the energy content of the foods using the appropriate Atwater factor (Food and Agriculture Organization, 2012).

5.1.2.2 Moisture content of selected foods consumed in Enugu State

Moisture content of selected foods consumed in Enugu State in the study is high because these foods are not usually consumed as dry foods. Fruits analysed in this study contained moisture ranging from 74.45% in red dacca banana varieties to 93.93% in watermelon. Studies have shown that red (red delicious) and green (golden delicious) apples contained moisture ranging from 82.68% to 84.5% (Jasia et al., 2017; Lee, 2012). This is similar to the 79.9% and 81.45% reported for red apple and green apple respectively. The moisture content of pineapple in this study was 76.95%, which was lower than the value (86.3%) reported for pineapple in a study on the nutrient content of edible fruits in oil producing communities of River State, Nigeria (Ogoloma, Nkpaa, Akaninwor & Uwakwe, 2013). Another study as well reported higher value (87.3%) in pineapple pulp (edible portion) (Hossain, Akhtar & Anwar, 2015). The Nigerian food composition table also reported a higher value (84%) of moisture for pineapple (Sanusi et al., 2017). The difference in the levels of moisture could be attributed to the seasonal changes and variations in moisture content of the soil at the period of the study.

Watermelon is one of the fruits that is widely consumed in Nigeria and it is generally known to contain high moisture. The study showed that it contained the highest moisture (93.93%) among all the fruits. The result was similar to findings from other studies that reported moisture in watermelon to range from 93.4% to 94.6% for different species of watermelon (Inuwa et al., 2011; Olayinka & Etejere, 2018). The moisture level (82.87%) reported for pawpaw in the study was lower than the level (88.75%) reported in another study on pawpaw pulp (Nwofia et al., 2012). Sanusi et al. (2017) reported 85% moisture in ripe pawpaw pulp which is similar to the study. Three varieties of banana analysed in this study showed that the moisture content ranged from 75.49% to 78.5%. The values reported in the study is slightly higher than the values

(60.06% to 75.25%) reported in other findings in banana, although these studies were not Nigerian based but Indian varieties (Ashokkumar et al., 2018; Kookal & Thimmaiah, 2018). However, in the West African food composition table, the moisture content reported for banana (73.5%) was similar to the result of the study. The Nigerian food composition table reported similar value (74.9%) to the findings of the study (Sanusi et al., 2017). The moisture content of fruits could vary depending on the season, variety and level of exposure of the fruits before the moisture determination. The region where the fruit was harvested or sold, the freshness of the fruit as well as the degree of ripeness of the fruit could affect the moisture content significantly (Ashokkumar et al., 2018; Hossain et al., 2015; Inuwa et al., 2011; Kookal & Thimmaiah, 2018; Lee, 2012; Nielson, 2010; Nwofia et al., 2012; Ogoloma et al., 2013; Olayinka & Etejere, 2018).

Igbangwu-oka (maize meal added African oil bean and vegetables such as eggplant leaves, scent leave, fluted pumpkin, bitter leave and other leaves) was analysed in the study. The moisture reported for *igbangwu-oka* meal was 73.8% in the study. This result was similar to 73.1% reported by Ayogu et al. (2017). Three varieties of rice (basmati, local [Abakiliki], and long grain [foreign] rice) prepared as jollof rice, boiled white rice with tomato stew and fried rice respectively were analysed differently in the study. The moisture content reported for the various rice dishes ranged from 63.6% to 73.6%. This was similar to 69.25% and 60.05% for jollof and fried rice respectively reported in the Nigerian food composition table (Sanusi et al., 2017). Ayogu et al. (2017) reported similar range for rice dishes (70.2% for jollof rice and 66.2% for boiled rice without stew). The slight variation observed in the moisture levels of the rice dishes could be associated with the varieties, amount of water used in cooking them, duration of cooking and degree of absorption of moisture during cooking. *Achicha* (cocoyam and pigeon pea based meal) contained 54.5% moisture in the study. There is paucity of data on the nutrient content of *achicha* because it is an indigenous staple food in Enugu State. Ayogu et al. (2017) reported a moisture level of *achicha* in her study on the common staples consumed in the southeastern Nigeria to be 62.7%. This is slightly higher that the value in this study. The moisture content of *ayaraya-oka* in the study was 68.1% which is similar to value (70.4%) reported by Ayogu et al. (2017). *Ayaraya-ji* (yam and pigeon pea based meal) is an indigenous meal in Enugu State. The moisture concentration in the study (59.9%) was slightly lower than 63.1% reported in a previous study in Enugu State (Ayogu et al., 2017). *okpa* (steamed bambara groundnut paste pudding) has moisture of 49.1% in the study which was lower the 57.0% reported in another study (Ayogu et al., 2017). *Abacha* (local cassava salad) were had 56.8% moisture concentration which is similar to the range (53.8% to 65.6%) reported in another study that varied the recipes used in preparing the *abacha* (Davidson et al., 2017).

The differences observed in the moisture concentration of foods is mainly credited to the variations in the recipes of the meal (Ayogu et al., 2017; Davidson et al., 2017). All these foods reported have moisture high moisture content with *okpa* as the lowest (49.1%) and watermelon and the highest (93.93%). The high moisture concentration signifies that the foods highly perishable if not preserved in refrigerator/freezer due to the microbial activities (Maduforo, 2016; Nielson, 2010; Onuoha et al., 2015). However, these foods are usually eaten as soon as they are cooked in most homes except for some households that cook food in bulk and store in their freezer. Water added to food during preparation add up to the higher moisture concentration (Ayogu et al., 2017; Davidson et al., 2017). The fruits could be stored in the freezer but it might suffer freezer burn, thus, once they are opened, the high moisture content do not support long storage but rather forms a good substrate for microbial growth.

5.1.2.3 Protein content of selected foods consumed in Enugu State

Protein is an essential nutrient needed all humans in the body for repair of worn-out tissues, synthesis of hormones, enzymes and the cells of the immune system (British Dietetic Association, 2014). Protein is also a source of energy supplying 4 kilocalories per gram (Nielson, 2010). Fruits are not known to be rich sources of protein, however, there are few reports on the protein content of various fruits used in this study. The protein content of ripened Red Dacca and Gross Michel banana varieties were 1.4% and 2.2% respectively are comparable with similar range reported in several studies 1.09% to 4.2% (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Kookal & Thimmaiah, 2018; Sanusi et al., 2017). However, the protein content of green mutant banana (0.3%) was lower than the range of protein concentrations in banana reported in literatures (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Kookal & Thimmaiah, 2018; Sanusi et al., 2017). Although, none of the studies reported protein concentration in green mutant banana in their study. Pawpaw had protein (0.87%) similar to the range (0.47% to 4.1%) of protein content reported for different species of ripe pawpaw pulp (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Marfo et al., 1986; Nwofia et al., 2012; Santana et al., 2019; Sanusi et al., 2017; Vij & Prashar, 2015). Green apple and red apple contained 0.86% and 1.04% protein respectively which was higher than previous studies on apple varieties which reported a range of 0.19% to 0.44% protein concentration in apples (Jasia et al., 2017; Lee, 2012; Platt, 1962). The reported protein content of ripe pineapple pulp ranged from 0.35% to 3.7% which was similar to 1.03% reported in this study (Ackom & Tano-Debrah, 2012; Food and Agriculture Organization, 2012; Food Basket

Foundation International, 1995; Hossain et al., 2015; Ogoloma et al., 2013; Platt, 1962; Sanusi et al., 2017). Although most of the values in literatures were within the range of 0.35% to 0.55% (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Hossain et al., 2015; Ogoloma et al., 2013; Platt, 1962; Sanusi et al., 2017), only one study reported higher value of protein (3.7%) in pineapple (Ackom & Tano-Debrah, 2012). Thus, the 1.03% reported in this study was slightly higher what was reported in most studies (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Hossain et al., 2015; Ogoloma et al., 2013; Platt, 1962; Sanusi et al., 2017), but low that the 3.7% reported by Ackom and Tano-Debrah (2012). Watermelon is not a good source of protein in our daily meal but studies have found small proportion of protein in watermelon ranging from 0.34% to 0.60% (Inuwa et al., 2011; Olayinka & Etejere, 2018). This was not different from the concentration of protein (0.58%) reported in the study.

Achicha contained 3.8% protein in this study. This was lower that 7.9% reported in the study by Ayogu et al. (2017) where they standardized the recipes of *achicha* after a focused group discussion in rural communities. This is attributed to the recipes. The *achicha* analysed in the study was based on food sold by food vendors and restaurants in Enugu. Commercial food sellers pay more attention to proceeds to their business instead of the food quality. It is important to note that protein sourced foods are not cheap, thus the more they increase the protein sources, the higher the cost of the food which might deter customers from buying from them. The result of *achicha* in this study is a reflection of the average intake of most *achicha* consumers because many individuals eat *achicha* sold by these food sellers. The protein reported for *ayaraya-ji* in the study was 3.4% which was comparable with 3.1% reported in another study (Ayogu et al., 2017). Also, other authors that studies on the nutrient and glycaemic response of *ayaraya-ji* reported 3.8% protein similar to this study (Davidson, Eze, Onyeke & Owoh, 2019). *Igbangwu-oka* contained 4.3% protein, similar to the report of Ayogu et al. (2017), but lower than 3.4% reported in another study in Enugu State (Davidson, Eze, et al., 2019). The protein in *okpa* (6.0%) is very low when compared with 15.1% reported by Ayogu et al. (2017). The difference in the protein content of *okpa* could be attributed to the adulteration of *okpa* flour with cassava flour by many *okpa* seller in order to make more profit. Thus, differences in the recipes might be the reason for the disparity in the protein level. Also, another study reported protein content of 13.5% in *okpa* which was as well higher than the result of this study (Emelike & Barber, 2018). Another study on the nutrient and glycaemic response of *okpa* reported a higher concentration of protein (10.5%) (Davidson, Eze, et al., 2019). These reports standardized and produced the *okpa* in their study which differed from the mean value of five vendors used in this study. Rice dishes had protein ranging from 0.6% in boiled rice and tomato stew prepared with local rice to 1.8% in jollof rice prepared with foreign rice. This is similar to 2.0% reported for jollof rice in the same region (Ayogu et al., 2017), but lower than 2.64% reported for jollof rice and 2.56% reported for fried rice (Sanusi et al., 2017). The range of protein concentration reported for *abacha* (2.21% to 10.45%) when vegetable and protein sources were varied was than 1.1% reported in the study (Davidson et al., 2017). The result of the study is similar to the values (0.9% to 1.6%) reported by many other researchers (Ekwu, Uvere & Chinwero, 2012; Jonathan et al., 2017; Thomas & Oriaku, 2010).

5.1.2.4 Ash content of selected foods consumed in Enugu State

The ash content of foods reflects the sum of all the minerals in that particular food (Nielson, 2010). The ash content of *achicha* was 1.9%, this is comparable with 2.3% recorded by Ayogu et al. (2017). *Achicha* is made from cocoyam and oil-bean seed commonly called *ugba* or *ukpaka* by the Igbo people in Nigeria. Vegetables such as scent leaf, spinach, and unripe pepper are also added. These ingredients added to the cocoyam which is a root high in carbohydrate could be the reason for the appreciable level of ash in *achicha*. The ash content of *ayaraya-ji* reported in the study was 3.4% which is similar to 4% reported by Ayogu et al. (2017). However, a lower value (1.2%) was reported by another study in Enugu State (Davidson, Eze, et al., 2019). *Ayaraya-ji* is made from yam, pigeon pea, and oil-bean seed. The legume (pigeon pea) and the oil-bean seed could be the reason for higher ash content when compared with that of *achicha*. Yam is also known to contain appreciable quantity of potassium which is a mineral that could contribute to the increase in the ash content (Food and Agriculture Organization, 2012; Sanusi et al., 2017). The variations in the ash content among the different studies reported could be as a result of the recipes for the dish.

Ayaraya-oka contained 4.6% ash slightly below 5.2% reported in the study by Ayogu et al. (2017). *Ayaraya-oka* is prepared with maize, pigeon pea, oil-bean seed and vegetables (bitter leaf or spinach and with optionally adding eggplant [garden egg]). This recipes contribute to the higher ash content of *ayaraya-oka.* The ash content of *igbangwu-oka* reported in the study was 2.8% comparable with 3.0% in another study (Ayogu et al., 2017), but higher than 1.0% reported by Davidson et al. (2019). The ash content in jollof rice prepared with different rice dishes ranged from 0.9% to 1.8%. The jollof rice prepared with basmati rice variety contained the least quantity of ash which is a reflection of the total mineral in the rice dish. Ayogu et al. (2017) reported a higher ash content (3.2%) in jollof in their study. Ayogu et al. (2017) standardized and prepared the rice in their study which probably contained more ingredient higher in minerals than the rice samples used for this study which was drawn from food vendors/restaurant. However, the result of this study is similar to the 1.39% reported in the Nigerian food composition table (Sanusi et al., 2017). Fried rice contained ash ranging from 0.9% in fried rice prepared with local rice variety to 1.4% fried rice prepared with basmati rice variety. The result is similar to 1.48% reported in the Nigerian food composition table (Sanusi et al., 2017). The ash content of boiled rice with tomato stew ranged from 0.6% to 1.3%. This is higher than 0.3% reported for white rice without stew in Ayogu et al. (2017). The reason for the higher value in the study is due to the tomato stew which contained tomatoes, pepper, fish/meat stock and other ingredients in addition to the boiled rice. The tomato stew which serves as a sauce increased the ash content in the study. *Okpa* contained 1.9% ash which is lower than 4% reported by Ayogu et al. (2017) but higher than 1% ash reported for *okpa* by Davidson et al. (2019). The variation in the ash content of *okpa* by the different studies is attributed to the recipe of the food. *Abacha* contained 1.1% ash which is similar to the range of 0.87% to 1.44% ash reported in another study (Davidson et al., 2017).

Fruits are rich sources of micronutrients including minerals which sum up to form the ash content of foods (Nielson, 2010; Sizer & Whitney, 2014). Three banana varieties analysed in this study contained ash ranging from 0.67% in green mutant banana to 1.26% in Gross Michel banana. This was comparable with 0.82% reported in the Nigerian food composition table (Sanusi et al., 2017). Although the variety of banana reported in the Nigerian food composition table was not describe for better comparison. Another study reported a higher (4.5%) ash content in ripe banana (Food Basket Foundation International, 1995). A slightly higher ash content was reported in a study on the nutritional composition of staple food bananas of three cultivars in India (Kookal & Thimmaiah, 2018). The study reported ash content of ripened banana varieties in their study to range from 1.61% to 2.22% (Kookal & Thimmaiah, 2018) The concentration of ash in red and green apple in the study were 0.22% and 0.23% respectively. This was not dissimilar with 0.14% reported for red delicious apple in the Nigerian food composition table (Sanusi et al., 2017). Another study reported higher values of 1.1 – 1.7% in golden delicious apple, and 1.8 – 5.0% in red delicious apple (Mukhtar et al., 2010). A study reported a similar result (0.26%) with the findings of this study on the ash content of fresh apples with skin (Lee, 2012). Apple is common fruit in markets in Nigeria, and it has a longer shelf life when compared with most fruits making it a fruit of choice for many persons who cannot go out every day to purchase fresh fruits. Paw-paw is a common fruit consumed in Enugu state and many households have a paw-paw tree in their homes. The ash composition of paw-paw reported in this study was 0.55%. This was higher than 0.12% reported for ripened peeled paw-paw in the Nigeria food composition table (Sanusi et al., 2017). A similar result was reported for different paw-paw morphotypes which contained ash ranging from 0.31% to 0.61% (Nwofia et al., 2012). A study on nutrient content of edible fruits grown in oil producing community of Rivers State and Benue State, Nigeria reported comparable result on the ash content of paw-paw as 0.64% and 0.46% respectively (Ogoloma et al., 2013). Ash in pineapple pulp in this study was reported to be 0.32% which was comparable with most of the values in literatures which ranged between 0.22% to 0.76% (Ogoloma et al., 2013; Sanusi et al., 2017). However, one study reported higher value (3.16%) of ash in pineapple (Ackom & Tano-Debrah, 2012). Ash content of watermelon reported in this study was 0.24% which corroborates with many other studies which reported ash content of watermelon ranging from 0.31 to 0.59% (Inuwa et al., 2011; Olayinka & Etejere, 2018; Sanusi et al., 2017). The variability of the ash content in fruits could be as a result of the soil where the fruits were cultivated, moisture content of the fruit, and the variety of fruits analysed in the various studies.

5.1.2.5 Carbohydrate and fibre content of selected foods consumed in Enugu State

Carbohydrates is the primary source of energy to human containing 4kcals in one gram (Gropper et al., 2009; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010). Fibre is a type of carbohydrate which the body do not have enzyme to digest but the activities of microorganisms in the large intestine digest it and make the nutrients available to humans (Gropper et al., 2009; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010). Most plant based foods are rich sources of carbohydrates such as the local staples consumed in Enugu State. The most abundant nutrient in fruits is water and carbohydrates.

The carbohydrate content of *achicha* in this study was 8.5%. This was lower than 22.4% reported in another study (Ayogu et al., 2017). The lower carbohydrate content in this study could be due to the recipes used in the different studies being compared. Ayogu et al. (2017) standardized the recipes used in cooking *achicha* analysed in their study while the recipes used in this study is unknown as the samples were drawn from five different food vendors selling *achicha* in Enugu State and the mean of the analysed sample was reported. This report probably presented a better carbohydrate content of *achicha* consumed in households in Enugu State. The crude fibre content reported for *achicha* in the study was 4.1% which was higher than 0.2% reported in Ayogu et al. (2017). This higher value could be attributed to the quantity of vegetables used as part of the ingredients in the preparation of *achicha*. Thus, the addition of 4.1% crude fibre to 8.5% carbohydrate sums the total carbohydrate content of *achicha* to 12.6% in the study. This 12.6% was used in the calculation of the total energy content in *achicha* per 100g in addition to fat and protein contribution to energy. This method was used in calculating the energy of the foods in this study. The *ayaraya-ji* analysed in this study contained 21.2% carbohydrate and 0.5% crude fibre. The carbohydrate content is similar to 23.7% reported in another study as well as 0.3% reported for crude fibre in *ayaraya-ji* (Ayogu et al., 2017). A study in Nsukka however, reported a similar value of carbohydrate (22.4%) in *ayaraya-ji* when compared with this study (Davidson, Eze, et al., 2019). The total carbohydrate therefore was 21.7% (21.2 +0.5%) which was utilized in the calculation of the energy content by multiplying with 4kcal per gram (Atwater factor of carbohydrate) (Nielson, 2010). The similarity in the carbohydrates content of the two studies connotes that their recipe for carbohydrate containing ingredients is similar as well. Carbohydrate and crude fibre in *ayaraya-oka* was 7.0% and 0.6% respectively. The carbohydrate reported for this study was higher than 4.8% reported in a similar study implying that the recipes might have differed (Ayogu et al., 2017). Similarly, the crude fibre in this study was also higher than the crude fibre in the same similar study that reported 0.3% crude fibre (Ayogu et al., 2017). This could also be attributed to the quantity of vegetables used in the preparation of the different *ayaraya-oka* in the different studies. Leafy vegetables contain roughages which increases crude fibre content of foods. Higher fibre in foods lowers glycaemic index of foods and prevents glucose spike for patients with diabetes mellitus (Atkinson, Froster-Powell & Brand-Miller, 2008; Augustine et al., 2015; Brand-Miller et al., 2011; Mahan et al., 2012). Carbohydrate content of *igbangwu-oka* in this study was 5.0% and crude fibre was 0.4% making total carbohydrate to be 5.4%. The carbohydrate reported for *igbangwu-oka* in this study was less than 7.1% reported by Ayogu et al. (2017) and 15.5% in another similar study (Davidson, Eze, et al., 2019). However, it is worthy to mention that all the studies did not utilize same recipes but this study analysed food samples from different sources which could be a more reliable to estimate the average nutrient intake of individuals or groups from the food samples analysed. A higher sample size tend to reduce errors and increases accuracy of the data (Nielson, 2010). A lower crude fibre content of *ayaraya-ji* (0.2%) was reported in another study (Ayogu et al., 2017). *Okpa* contained 32.1% carbohydrates and 0.1% crude fibre. The carbohydrates was higher than 16.7% but similar to 0.2% reported in a similar study (Ayogu et al., 2017). Another similar study in Nsukka, Enugu State also reported 18.7% carbohydrate in *okpa* which is lower than the value (32.1%) in this study (Davidson, Eze, et al., 2019). The differences in the carbohydrate content could be attributed to many reasons. Sometimes, food vendors that sell *okpa* add cassava flour to *okpa* flour in other to make more profit, thus when this is purchased, inexperience person will not be able to detect the difference. Addition of cassava flour to the recipes will increase the carbohydrate content of the foods. However, these other studies that reported lower carbohydrate value, the researchers standardized and prepared the *okpa* by themselves and thus they were sure of the purity of the flour used in the study (Ayogu et al., 2017; Davidson, Eze, et al., 2019).

The rice dishes prepared in the study contained varying carbohydrate content ranging from 13.2% to 27.9%. Ayogu et al. (2017) reported similar values in rice dishes where 16.6% carbohydrate was found in jollof rice and 30.1% in boiled white rice without stew. The Nigerian food composition table also had a comparable result where 27.51% of carbohydrate was in their jollof rice and 32.55% in their fried rice (Sanusi et al., 2017). Cooking of rice in different forms and with different recipes usually result to variations in the nutrient content including the carbohydrates. Rice as a staple food in Enugu State is prepare in the form of jollof, fried and boiled and eaten with stew or sauce. All these various methods introduces variety and interest in individuals to consume it. Rice is from a cereal food group which is known to contain higher carbohydrates when compared with legumes, thus the level of carbohydrate in the samples analysed was expected. The crude fibre content differed ranging from 0.2% to 2.7% in the rice dishes analysed in the study. Ayogu et al. (2017) reported 0.2% in jollof rice and 0.5% in boiled rice without stew which are similar to the result of this study. The Nigerian food composition table reported 1.10% fibre in fried rice similar to the result of this study (Sanusi et al., 2017). The crude fibre concentration of fried rice can vary significantly depending on the amount of vegetables used in cooking it. This study however, analysed prepared food samples of unknown recipes sold by restaurants and food vendors which makes it difficult to cook exactly the same thing but provides an average level of nutrients in the food.

Abacha contained 22.8% carbohydrates and 4.4% crude fibre. The high level of carbohydrate is expected being from roots and tuber food group. The crude fibre in it could also be attributed to the vegetables used in the preparation as well as the method of processing where all the roughage in the cassava tuber was not removed but was part of what constitutes *abacha.* Davidson et al. (2017) reported carbohydrates in *abacha* prepared with different recipes to range from 17.42% to 28.34% similar to the result of this study. However, Davidson et al. (2017) reported crude fibre of their *abacha* prepared with different recipes to be lower than result from this study. The crude fibre in their study ranged from 1.49% to 1.67%. Variations in recipes affected the crude fibre content (Davidson et al., 2017).

Fruits are known to contain carbohydrate as the major energy giving food nutrient in it. Green and red apples analysed in the study contained 16.84% and 15.18% of carbohydrate respectively. This is in similar to 14.06% reported for red delicious apple in the Nigerian food composition table (Sanusi et al., 2017). Another study reported comparable result of 15.3% carbohydrate in apples analysed with the skin as it the case in this study (Lee, 2012). Generally, studies have reported varying values for carbohydrate content of apples ranging from 9.25% to 19.35% (Jasia et al., 2017; Lee, 2012; Mukhtar, Gilani & Bhatty, 2010; Sanusi et al., 2017). The crude fibre content of apples in this study ranged from 1.91% in red apple to 2.04% in green apple. The crude fibre content of varieties of apple as reported in previous studies were 0.77% (Lee, 2012) and 2.3% (Sanusi et al., 2017). This result was in tandem with the 2.30% reported in the Nigerian food composition table (Sanusi et al., 2017).

The carbohydrate reported for pineapple in this study was 18.75% while the crude fibre was 2.80%, thus the total carbohydrates was 21.55%. The result of carbohydrate reported for pineapple was higher than some research report on carbohydrate content of pineapple ranging from 6.75% to 13.7% in previous reports (Ackom & Tano-Debrah, 2012; Hossain et al., 2015; Ogoloma et al., 2013; Sanusi et al., 2017). The higher carbohydrate in this study could be as a result of lower moisture compare to the similar studies reported. An example is the report in the Nigerian food composition table that reported about 84% moisture while this study reported about 77% moisture (Sanusi et al., 2017). The lower the moisture content, the higher the concentration of other proximate values (Nielson, 2010). The value of crude fibre reported in various studies in pineapple include 1.2% (Food Basket Foundation International, 1995; Sanusi et al., 2017); 1.4% (Food and Agriculture Organization, 2012; Hossain et al., 2015); 2.25% and 7.21% (Ogoloma et al., 2013). This studies therefore has results different from many of the previous studies for crude fibre content of pineapple but similar to the study by Ogoloma et al. (2013).

Watermelon in this study contained 4.51% carbohydrate and 0.64% crude fibre. The result of this study is corroborates with previous studies that reported carbohydrate content of watermelon that ranged from 4% to 6.5% (Inuwa et al., 2011; Olayinka & Etejere, 2018; Sanusi et al., 2017). The crude fibre reported in this study is also similar with the crude fibre content of watermelon reported in previous studies which ranged from 0.29% to 0.40% (Food and Agriculture Organization, 2012; Inuwa et al., 2011; Olayinka & Etejere, 2018; Sanusi et al., 2017). The carbohydrate and crude fibre content of pawpaw in this study was 13.75% and 1.91% respectively. Thus, the total carbohydrate in pawpaw is 15.66%. Similar studies reported wide range but lower values of carbohydrate in pawpaw ranging from 2.9% to 9.51% (Marfo et al., 1986; Nwofia et al., 2012; Ogoloma et al., 2013; Santana et al., 2019; Sanusi et al., 2017). The wide range in the carbohydrate is mostly due to the moisture content which was as high as 88.3% and 91.4% in pawpaw harvested at Rivers State and Benue State respectively (Ogoloma et al., 2013). But the moisture in this study was lower (82.87%) which could be the reason for higher carbohydrate recorded in this study. Different varieties of pawpaw pulp contained crude fibre ranging from 0.77% to 0.93% (Nwofia et al., 2012; Santana et al., 2019). However, other studies reported different values ranging from 2.47% to 2.93% (Ogoloma et al., 2013); 6% (Food Basket Foundation International, 1995; Sanusi et al., 2017); 1.9% (Food and Agriculture Organization, 2012). This study therefore reported similar crude fibre content with what 1.9% reported in West African food composition table (Food and Agriculture Organization, 2012).

Different banana varieties used in the study showed that the carbohydrate content ranged from 12.3% in green mutant banana variety to 19.2% in Gross Michel banana variety, while the crude fibre in Red Dacca banana variety was the least (0.01%) while Gross Michel banana variety had the highest (0.04%) crude fibre. The result of this study on the carbohydrate content was lower than previous studies that reported a range of 21.8% to 22.84% for different banana varieties (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Sanusi et al., 2017). The degree of ripeness of the fruits could affect the carbohydrate content significantly (Ashokkumar et al., 2018; Hossain et al., 2015; Inuwa et al., 2011; Kookal & Thimmaiah, 2018; Lee, 2012; Nielson, 2010; Nwofia et al., 2012; Ogoloma et al., 2013; Olayinka & Etejere, 2018). Also, the moisture content of banana used in this study was higher than the moisture content reported in the comparable studies (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Sanusi et al., 2017). The fibre content of banana is affected by the degree of ripeness of the banana. The more the ripeness, the higher the simple sugars and lower crude fibre content (Nielson, 2010). A study showed that the crude fibre content of banana was higher in the unripe species than in the ripe ones of similar species (Kookal & Thimmaiah, 2018). The crude fibre reported for all the banana varieties in this study was lower than the crude fibre content of ripe banana of different varieties reported in some studies which ranged from 1.58% to 2.6% (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Kookal & Thimmaiah, 2018; Sanusi et al., 2017).

5.1.2.6 Fat content of selected staple foods consumed in Enugu State

One gram of fat contain more than twice the energy a gram of protein or carbohydrate (Nelms et al., 2011). Fat is a high energy source in food. The Atwater factor 9kcal per kilogram (Nielson, 2010). There is consideration of fat content of foods during dietary counselling of diabetic patients (Mahan et al., 2012). Fat is usually recommended to contribute 25% to 30% of the total energy in foods daily (Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010). High fat foods lowers glycaemic index of foods but they could contribute to increased weight and obesity for diabetic patients (Augustine et al., 2015; Mirrahimi et al., 2012; Sadler, 2011).

Fat in foods is useful in the body in a variety of ways and it is involved in many body processes. Some of the functions of fat include synthesis of steroid hormones, cholesterol, insulation of organs, formation of cells of the immune system especially the essential fatty acids and production of energy for the body (British Dietetic Association, 2014; Gropper et al., 2009; Rolfes et al., 2006; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010).

The fat content of *achicha* was 27.2% in this study. Among all the food samples in the study, *achicha* contained the highest percentage of fat per 100g. The reason for the high fat content is due to the amount of oil used in the cooking. Usually, some of the local foods indigenous to Enugu people are high in fat as seen in this study due to the amount of palm oil added to the foods during preparation. Lower values of fat was however reported in other studies that standardized the preparation of *achicha* using different legumes. The values reported by the authors ranged from 4.5% to 8.3% fat (Ayogu et al., 2017; Davidson, EneObong, & Nnawuihe, 2019). The higher content of fat in *achicha* in this study is attributed to the quantity of palm oil added by the food sellers during the preparation of the samples. *Ayaraya-ji* in this study contained higher fat (11.8%) than the range (3.9% to 5.8%) reported in previous studies (Ayogu et al., 2017; Davidson, Eze, et al., 2019). The fat content (16%) in *ayaraya-oka* in this study is similar to 15.4% reported in another study (Ayogu et al., 2017) but higher than 11.8% reported in a recent study (Davidson, EneObong, et al., 2019). *igbangwu-oka* sampled in this study contained slightly higher fat (13.7%) than 12.0% reported in a previous study (Ayogu et al., 2017) but higher than 1.7% reported in a recent research (Davidson, Eze, et al., 2019). Rice dishes sampled in this study contained fats ranging from 1.6% to 5.3%. The result of fat in rice dishes was lower than 7.7% reported by Ayogu et al. (2017) for jollof rice, but similar to 2.67%

and 3.36% reported for jollof rice and fried rice respectively (Sanusi et al., 2017). *Okpa* contained 10.8% fat in this study. The result of fat in *okpa* was higher than 7.0% and 8.7% reported in an earlier studies (Ayogu et al., 2017; Davidson, Eze, et al., 2019). The *abacha* sampled in this study contained 4.4% fat which was within the range (1.54% to 14.15%) reported in a previous study (Davidson et al., 2017).

Fruits are considered to contain low or negligible fat values. The fat content (1.4% to 8.2%) of ripened banana of different varieties reported in this study was higher than reports in some literatures (0.3% to 0.5%) (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Sanusi et al., 2017); but some had similar values with a previous study which presented fat ranging from 1.63% to 2.59% in banana varieties (Kookal & Thimmaiah, 2018). The differences in the fat content of banana could be as a result of the variability in the varieties and location of cultivation as well as moisture content (Nielson, 2010). The fat content of ripened pawpaw pulp in this study (0.5%) is similar to report of most studies reported which ranged from 0.1% to 0.7% (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Marfo et al., 1986; Nwofia et al., 2012; Santana et al., 2019; Sanusi et al., 2017; Vij & Prashar, 2015), however, higher values were reported in a single study in Rivers State were pawpaw pulp varieties were contained fat values ranging from 1.11% to 1.85% (Ogoloma et al., 2013). Red and green apple had 0.13% and 0.2% fat respectively. These values are similar to reported values fat in apple varieties (0.2% to 0.36%) reported by different authors (Lee, 2012; Sanusi et al., 2017). Another study reported a higher value of 1.95% of fat in red delicious and 2.21% in golden delicious apple respectively (Mukhtar et al., 2010). Pineapple contained 0.15% fat in this study. This was lower than few studies that reported fat in pineapple. The fat contained in ripe pineapple pulp as reported by various authors include 0.47% (Ackom & Tano-Debrah, 2012), 2.0% to 3.5% (Ogoloma et al., 2013), 0.3% (Food and Agriculture Organization, 2012). However, it was similar to 0.12% reported in the Nigerian food composition table (Sanusi et al., 2017). Watermelon sampled in this study contained 0.1% fat. This was similar to the fat content reported for watermelon in various literatures ranged from 0.1% to 0.24% (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Inuwa et al., 2011; Olayinka & Etejere, 2018; Sanusi et al., 2017).

5.1.3 Energy content of selected staple foods consumed in Enugu State

The energy in food is measured in kilocalories (kcal) or kilojoules (kj) (British Dietetic Association, 2014; Nielson, 2010; Rolfes et al., 2006). The energy giving food nutrients are fat, carbohydrates and protein supplying 9kcal, 4kcal and 4kcal per gram respectively (Gropper et al., 2009; Sizer & Whitney, 2014; Smolin & Grosvenor, 2010). These factors were used in calculating the energy present in the sampled foods after the analysis of the proximate composition of foods. The Atwater factor of fat (9kcal/g), total carbohydrate (4kcal/g), and protein (9kcal/g) were utilized to calculate the energy content of the sampled foods (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Platt, 1962; Sanusi et al., 2017).

Achicha contained 310.5 kcal/100g of energy in this study which was higher than 161.6kcal/100g reported in another study (Ayogu et al., 2017). The energy in *ayaraya-ji*, *ayaraya-oka*, *igbangwu-oka*, and *okpa* in this study was 206.6kcal/100g, 189.2kcal/100g, 163kcal/100g and 249.9kcal/100g respectively. These were all higher than values reported for *ayaraya-ji* (159.5kcal/100g), *ayaraya-oka* (175.6kcal/100g), *igbangwu-oka* (154.3kcal/100g), and *okpa* (190.1kcal/100g) reported in a previous study (Ayogu et al., 2017). The energy reported for *abacha* (190.2kcal/100g) in this study was within the range (152kcal to 263kcal) reported in another study (Davidson et al., 2017). Rice dishes sampled in the study contained energy ranging from 112.3kcal/100g in boiled rice with tomato stew prepared with local rice to 166.4kcal/100g in boiled rice with tomato stew prepared with basmati rice. Ayogu et al. (2017) reported similar energy content of 143.5kcal/100g and 134kcal/100g for jollof rice and boiled rice without stew respectively in their study. The Nigerian food composition table reported 144.55kcal/100g for jollof rice which was similar to the result of this study, but they reported higher values for fried rice (172.88kcal/100g) (Sanusi et al., 2017).

The major source of energy in fruits is its carbohydrate content. Fruits are good sources of vitamin and minerals as well as water but they are not relied upon to supply fat and protein except for few of them such as avocado pear and coconut which are not considered as fruit though (Sanusi et al., 2017).

Ripened banana varieties in the study contained similar energy value (95kcal/100g – 125kcal/100g) with some of the literatures reporting 89kcal to 103.89kcal per 100g of different banana varieties (Ashokkumar et al., 2018; Food and Agriculture Organization, 2012; Sanusi et al., 2017). The energy content per 100g reported for pawpaw (66.57kcal) was higher that the range (32kcal to 53.48kcal) reported in other studies (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Santana et al., 2019; Sanusi et al., 2017). Sample apples contained higher energy (74.32kcal/100g and 80.13kcal/100g) than the range of values (59kcal to 69.54kcal) presented in other literatures per 100g of apple varieties (Jasia et al., 2017; Lee, 2012; Sanusi et al., 2017). Energy in sample pineapple was higher (91.63kcal/100g) than the reported range (46kcal -56kcal) in other studies (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Hossain et al., 2015; Sanusi et al., 2017). Other authors reported similar energy content per 100g in watermelon (22kcal - 30.9kcal) with the findings of this study (23.82kcal) (Food and Agriculture Organization, 2012; Food Basket Foundation International, 1995; Olayinka & Etejere, 2018; Sanusi et al., 2017). Most of the fruits analysed in this study contained higher energy when compared with reported values in literatures. This could be as a result of the differences in the energy giving food nutrients in the food.

The proximate and energy content of these staple foods formed the basis of calculation the proximate and energy content of

5.1.4 Development of photographic food atlas with portion sizes of domestic measures and carbohydrate servings of the selected foods

Photographic atlas which have been developed in various studies in some developed and developing countries but however, not including Nigeria yet was developed for commonly consumed staple foods in this study (Abu Dhabi Food Control Authority, 2014; Ali et al., 2018; Boateng, 2014; Foster et al., 2008; Huybregts et al., 2008; Nelson et al., 1996; Rasekhala, 2016; Robinson et al., 1997; Small et al., 2010). Different approaches have been utilized by different authors in the presentation of their photographic food atlas, however, the major goal was to increase the accuracy of the photographs in the estimation of portion sizes of food during dietary assessment in the clinical settings or surveys (Boateng, 2014; Huybregts et al., 2008; Nelson & Haraldsdólttir, 1998). This study presented photographic food atlas using two different approaches. The first approach was targeted at providing dietary counselling to diabetic patients especially those with type 1 diabetes mellitus as well as those with other type of diabetes but have been placed on a specific amount of carbohydrate daily, thus those counting their carbohydrates. This approached utilized carbohydrate servings to present foods containing specific amount of carbohydrate ranging from the amount of food/fruit that will supply 10 grams of carbohydrates to 45 grams of carbohydrates. The amount of food that will supply 15 grams of carbohydrates is generally considered as one serving of carbohydrate, which is estimated to match one unit of insulin for patients on insulin medications (Mahan et al., 2012; Nelms et al., 2011). However, due to the variations in individual response in carbohydrate metabolism, some persons need 10 grams of carbohydrates to match one unit of insulin while others require as much as 20 grams of carbohydrates to match one unit of insulin, thus one serving of carbohydrates was considered to range from 10 to 20 grams depending on the individual response by some authors (American Diabetes Association, 2009; Daly et al., 2003; Geil, 2008; Nelms et al., 2011; Souto & Rosado, 2010). The presentation of five photographs supplying varying amount of carbohydrates ranging from 10 to 45 grams of carbohydrates makes rooms for more accuracy in estimation because the more the photographs, the better individuals can estimate the portion size (Abu Dhabi Food Control Authority, 2014; Boateng, 2014; Nelson et al., 1994, 1996). Also, the number of photographs in an A4 page is in line with the definition of photographic food atlas which presents food pictures ranging from 3 to 8 in an A4 page (Boateng, 2014; Byrd-Bredbenner & Schwartz, 2004; Jayawardena et al., 2018; Nelson et al., 1994, 1996; Nelson & Haraldsdólttir, 1998b, 1998a).

The second approach used in the presentation of photographic food atlas in this study have been used by another researcher in Ghana, although with different foods (Boateng, 2014). This approach was the use of domestic measures in other words called household measures. In a typical Nigerian homes, foods are dished out into the serving plates (dishes) before they are consumed. The art of dishing out foods into the serving plates/dishes utilizes domestic measures such as spoons, and flat plats as shown in figure 25. Domestic measure “I” which is not a common household measure was incorporated into the study because it is the common measure/standard cup used by Dietitian-Nutritionist in hospitals in the south-eastern Nigeria for counselling patients on the amount of foods they will consume. This study is not just intended for use in the dietary counselling the hospital alone, but was also designed to be applied in the house. The number of the household measures used in the study was informed by the commonly purchased ones in the major market in Enugu after sampling the opinion of the sellers in the market in other to be as elaborate as possible. Domestic measure “E”, “G” and “H” are more commonly used by food vendors and restaurants in Enugu to sell food to customers. This was also incorporated because many persons eat foods outside their homes in recent time due to job demands and travelling. This will aids proper estimation by individuals even when they are eating outside their homes (Popkin, 2002, 2006). The use of domestic measure is recognized as a modern and innovative portion size estimation aid to be used in dietary assessment and counselling (FAO, 2018).

The details contained in this photographic food atlas differs from most studies that only reported the amount of foods, types, recipes and the weight, whereas in this study, each photograph was presented with the proximate and energy content which minimizes the labour of calculating further for the nutrient content once similar recipes are utilized (Abu Dhabi Food Control Authority, 2014; Ali et al., 2018; Boateng, 2014; Faggiano et al., 1992; Foster et al., 2014; Frobischer & Maxwell, 2003; Huybregts et al., 2008). In this study as well, the domestic measures used in dishing out the foods into serving plates were well identified and presented alongside the foods so that there will be much more ease in identification and accuracy in estimating portion size. Individuals could easily use the domestic measure used in dishing out the foods for their estimation. The way the foods were heaped on the domestic measures were also shown visually to help in the estimation. The foods in the domestic measures were not leveled because individuals do not usually level the foods when dishing it out. However, four measures of the same domestic measures were heaped and the mean weight was utilized in calculating the nutrients present in them. The study utilized and incorporated as much as possible, the natural household practices so that there will be immediate applicability of the study by the target group.

5.1.5 Validation of photographic food atlas with portion sizes carbohydrate servings of the selected foods

The validation of the photographic foods atlas was conducted. Out-patient diabetic patients participated in the validation. The carbohydrate serving portions were the photographs used in the validation because there is no standard measure that was used in measuring out the amount of food in the serving dishes but rather, it was purely based on the weight measured in a kitchen weighing scale which is not available in most homes and some persons with diabetes may not be able to buy personal one. Also, most individuals will hardly weigh their food after dishing it out before they eat it. Thus, the validation was necessary to assess the applicability of the photographs in dietary assessment and counselling. Some studies have as well validated their photographic food atlas using different population groups (Boateng, 2014; Elwood & Bird, 1983; Faggiano et al., 1992; Foster et al., 2014, 2008; Huybregts et al., 2008). The accuracy of photographic food atlas have varied in different studies. In a study in Ghana, the validation of the photographic food atlas reported that 52.45% of the population correctly estimated portion sizes using the photographs (Boateng, 2014). Similarly, in this study, 66.7% percent had good estimation of portion sizes of the food using photographs developed in this study for the carbohydrate serving portion. The accuracy of usage will increase as the frequency of usage increases. The validators were made up of middle aged and elderly persons on diabetes mellitus treatment. Some studies have validated photographic food atlas with children, adolescents, and adults of different gender respectively (Ali et al., 2018; Boateng, 2014; Foster et al., 2014, 2008; Frobischer & Maxwell, 2003; Godwin et al., 2004).

The result of this study showed that the validation score categorization of the respondents had significant relationship with sex (p=0.035) of the validators and their occupation (p=0.015). Some studies have identified gender as a significant factor in the correct estimation of portion size using photographic food atlas (Boateng, 2014; Frobischer & Maxwell, 2003; Ovaskainen et al., 2008). Females were attributed to better estimate portion sizes more than their male counterpart with the photographs. This is expected as females in the Nigeria setting play the role of serving and distribution of food in the households and thus will be more accurate in estimating portion sizes. This was supported by other researchers (Boateng, 2014; Frobischer & Maxwell, 2003; Ovaskainen et al., 2008). Some other factors attributed to affect correct estimation of portion size in various studies are body mass index, weight, gender, occupation, age and colored pictures (Ali et al., 2018; Boateng, 2014; Frobischer & Maxwell, 2003; Godwin et al., 2004; Huybregts et al., 2008; Jayawardena et al., 2018; Ovaskainen et al., 2008).

5.2 CONCLUSION

The study developed a photographic food atlas of selected foods consumed by diabetic patients in Enugu State. Domestic measures which are majorly different types of dishing spoons used in the households were used to dish out portions photographed in this study. The proximate content of each portion size measured out with the domestic measure were recorded and tabluted for ease of dietary counselling. The method of presentation of the photographic food atlas will ease the work of the Dietitans and Nutritionist during dietary counselling session with patients in illustrating with abstract unfamilier food models unlike the one used in this study. Also, patients who are on insulin therapy are usually required to count their carbohydrates to match with the amount of insulin dosage of the patient. This study as well provided photographs that could be used during dietary counselling session.

The pictures were also validated which demonstrated a higher accuracy when compared with previous studiess (Fisher, Rolls, & Birch, 2003; Rolls, Roe, Meengs, & Wall, 2004). Over 50% of the respondents had a good score in the validation. This was their first time of using such counselling aid. It is an indicator that continuous use will increase the accuracy.

5.3 RECOMMENDATION

The study recommends the following:

1. The photographic food atlas produced in this study should be used in counselling diabetic patients that consume these foods.
2. This photographic food atlas could be employed in large surveys where these foods are consumed for dietary assessment.
3. More foods from different part of Nigeria should be included in the photographic food atlas to make it more comprehensive.
4. There should be further studies to assess the level of dietary fibre in the dishes.
5. The result should be translated to a booklet of pictures that will be accessible to both the dietitians and nutritionist as well as to the patients for effective communication during dietary counselling and self-management of diabetes mellitus.

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APPENDIX

Jollof rice recipes

Equipment used

Pots, plates, knives, trays, cooking spoons, tablespoons, teaspoons, colanders, bowls, sieves, measuring cylinders, blender, mortar, pestle, weighing scale (manual and electronic), grater, wooden spoon, clock, gas cooker.

Table 1: Rice varieties and ingredients used for the jollof rice preparation

Ingredients	Foreign rice (Weights)	Local rice (Weights)	Basmati rice (Weights)
Rice	660g	660g	660g
Fresh tomatoes	690g	690g	690g
Tomato paste	149g	149g	149 g
Red onions	190 g	190 g	190 g
Groundnut oil	122.5mls	122.5mls	122.5mls
Chicken stock	100mls	100 mls	100 mls
Crayfish	20g	20g	20g
Curry powder	2g	2g	2g
Thyme	2g	2g	2g
Stock cubes	8g	8g	8g
Nut meg	2g	2g	2g
Ginger	25g	25g	25g
Garlic	6g	6g	6g
Salt	3g	3g	3g
Red pepper	20g	20g	20g
Red chilli peppers (Shombo)	17g	17g	17g
Red bell peppers (Tatase)	20g	20g	20g

Bay leaves	4leaves	4leaves	4leaves

Table 2 Amounts of water used in the cooking

	Foreign rice(mls)	Local rice(mls)	Basmati rice(mls)
Water for washing the rice	1000	1000	1000
Water after washing the rice	710	690	750
Water absorbed after washing the rice	290	310	250
Water for parboiling the rice	1250	1250	1250
Water remaining after parboiling the rice	550	470	650
Water used for final cooking	1000	1150	800

Method of preparation

Ingredients were weighed. The chicken was cut and washed three times with salt and enough water and set in pot. The chicken was seasoned with a portion of the spices: sliced onions, pepper, salt to taste and some quantity of water were added afterwards. The main food was prepared with the stock. The fresh tomatoes and also pepper(s) were blended. In a clean pot, the blended tomatoes were heated to dryness (do not stir to prevent burning). When almost dry, groundnut/vegetable oil, sliced onions, blended pepper(s), nutmeg, ground ginger and garlic were added and heated for about 2 minutes. About a quarter of the stew was brought out and set aside.

The raw rice was washed, parboiled, drained and set aside. To the stew, the chicken stock was added and brought to a boil. Crayfish and the remaining spices and salt to taste were added and boiled. The already parboiled rice was added and stirred thoroughly. The water and rice were made to be at the same level in the pot. Some bay leaves were dropped on top of the rice, covered and cook on low to medium heat. The quarter of stew that was set aside was added. The pot was covered and the food cooked until the liquid was all absorbed by the rice. The jollof rice was tasted for doneness.

Fried rice recipes

Equipment used

Gas cooker, pots (4.4 by 8” and 4.5 by 9”), mortar, pestle, chopping boards, Kitchen scale colanders, kitchen knives, cooking spoons, bowls, flat plates.

Table 3: Rice varieties and ingredients used for the fried rice preparation

Foreign rice (Weights)	**Local rice (Weights)**	**Basmati rice (Weights)**
600g of rice 750ml of chicken stock. 218g cow liver 228g of carrot 95g of green peas or runner beans 45g of green pepper 199g onion bulb 18g of ginger 8g of garlic 48g of stock cube or bouillon cube 7g of curry powder 35g of red pepper 168g of chicken 7g of fish 5g of thyme	600g of rice 750ml of chicken stock. 218g cow liver 228g of carrot 95g of green peas or runner beans 45g of green pepper 199g onion bulb 18g of ginger 8g of garlic 48g of stock cube or bouillon cube 7g of curry powder 35g of red pepper 168g of chicken 7g of fish 5g of thyme	600g of rice 750ml of chicken stock. 218g cow liver 228g of carrot 95g of green peas or runner beans 45g of green pepper 199g onion bulb 18g of ginger 8g of garlic 48g of stock cube or bouillon cube 7g of curry powder 35g of red pepper 168g of chicken 7g of fish 5g of thyme

117g of sweet corn 150ml 0f vegetable oil Salt 3 bay leaves.	117g of sweet corn 150ml 0f vegetable oil Salt 3 bay leaves.	117g of sweet corn 150ml 0f vegetable oil Salt 3 bay leaves.

Table 4: Amounts of water used in the cooking the fried rice

Purpose	Foreign rice(mls)	Local rice (mls)	Basmati rice(mls)
Water for washing the rice	2000	2000	2000
Water after washing the rice	1000	500	1750
Water absorbed after washing the rice	1000	1500	250
Water for parboiling the rice	1500	1500	1500
Water remaining after parboiling the rice	950	800	500
Water used for final cooking	1000	700	800

Method of preparation

The chicken was placed in a pot and 5g of thyme, curry, 16g stock cube and onion slices. 750ml of water was added to cook the chicken for 15minutes. The stock was poured into a strainer to remove tiny chicken bones and any other particles in it then about 500ml of the stock remained after cooking. The stock was set aside for later use. The cow liver was washed and placed in a pot and seasoning cube, salt was added for taste then the liver was cooked for 10 minutes in 500ml of water after cooking the liver, the stock remained 250ml and then it was allowed to cool and cut into cubes and set aside.

The rice was parboiled in 2000ml of water and placed in a sieve to drain out remaining water after 10 minutes. The remaining water was weighed and was found to have reduced to 750ml. All vegetables were washed, onions were diced and set aside; the carrots were peeled and cut into small cubes. The reserved chicken stock and liver stock was placed into a large pot and made up to 2000ml and then was brought to a boil. The parboiled rice was added into the boiling stock and the remaining stock cubes, curry powder, garlic, ground pepper, onions and salt and bay leaves were added. Then it was left to cook on medium heat for 30 minutes. 150ml of vegetable oil was heated up, carrots, peas, green pepper and diced liver meat and diced onions were put in the heated oil. seasoning cube were added to taste and stir fried for one minute and poured into a bowl. The rice was fried in small batches. A portion of the stirred fried mix was poured into the frying pan and the cooked rice was added and stirred fried for about 3minutes. After cooking the four rice samples gave different yields. Ofada rice gave 2462g, foreign rice gave 2578g, basmati gave 2585g and finally adani gave 2812g of rice. All cooked dishes were prepared with moderate heat (mark 4 of gas cooker)

Recipes for tomato stew

Equipment used

Pots, plates, knives, trays, cooking spoons, tablespoons, teaspoons, colanders, bowls, sieves, measuring cylinders, blender, mortar, pestle, weighing scale (manual and electronic), grater, wooden spoon, clock, gas cooker.

Table 5: Ingredients used for the preparation of tomato stew consumed

Ingredients	Raw weight
Onions	202g (whole)
Knorr cubes	8g
Ginger	18g
Chicken	310g
Groundnut oil	225ml
Curry	7g
Thyme	3g
Crayfish	22g (whole)
Pepper (yellow)	36g
Pepper	4g
Fresh tomatoes	1168g
Tin tomatoes (past)	140g
Salt	4g

Method of preparation

1. Wash and blend the fresh plum tomatoes.

2. If you’re using the thick tinned tomato paste mix it with cold water to get a softer consistency. If you are using the watery tinned tomato puree, open the tins or packets and set these aside.

3. Cut 2 onions into small pieces.

4. Pour the fresh tomato blend into a pot and cook at high heat till almost all the water has dried.

5. If you have the watery tinned/boxed tomato puree, add these to the pot and reduce the heat to low. Cook till the water in the tomato puree have dried as much as possible.

6. Add the vegetable oil in a pot and the chopped onions, stir fry for 3 minutes and add the thick tomato puree that you mixed in above (if it's the puree you are using). Stir very well.

7. Fry at very low heat and stir at short intervals till the oil has completely separated from the tomato puree. A well fried tomato puree will also have streaks of oil, unlike when you first added the oil and it was a smooth mix of the tomato puree and oil. Taste the fried tomato puree to make sure that the raw tomato taste is gone.

8. Put a clean pot and cook the beef cuts with 2 onions, 2 seasoning cubes, add curry powder and thyme to get the meat stock

9. Boil the fish with onions and 1 seasoning cube to get the fish stock.

10. Add the meat and fish stock to the well fried tomato stew.

11. Stir very well and add salt if necessary.

12. Cover and leave to simmer and it’s done!

Recipes for *igbangwu-oka*

Equipment used

Pots, plates, knives, trays, cooking spoons, tablespoons, teaspoons, colanders, bowls, sieves, measuring cylinders, blender, mortar, pestle, weighing scale (manual and electronic), grater, wooden spoon, clock, gas cooker.

Table 6: Ingredients used for the *igbangwu-oka* preparation

Ingredients	**Quantity (g)**
Dried whole corn (yellow)	740g
Garden egg leaves (coarsely sliced)	450g
Pumpkin leaves (whole)	130g
Fermented oil been seeds (finely sliced)	130g
Scent leaves (coarsely sliced)	90g
Stock/buillon cubes	10g
Palm oil	170ml
Onion (coarsely sliced)	90g
Water	410ml
Bouillon cube	10g
Salt	21g

Method of preparation

- Soak the dried corn in hot water overnight
- Drain, wash and drain again , cut some onions and pepper inside
- Mill the corn finely with local grinder/milling machine
- Add your oil and mix them together, use warm water while mixing (it must not be too

watery)

- Add other ingredients, except vegetables and mix properly
- Add all the vegetables and wrap in a nylon and steam for 1hour and serve hot

Recipes for *ayaraya-oka*

Equipment used

Pots, plates, knives, trays, cooking spoons, tablespoons, teaspoons, colanders, bowls, sieves, measuring cylinders, blender, mortar, pestle, weighing scale (manual and electronic), grater, wooden spoon, clock, gas cooker.

Table 7: Ingredients used for the *ayaraya-oka* preparation

Ingredients	**Quantity (g)**
Corn (yellow variety)	640g
Pigeon pea (cream colour)	560g
Ukpaka' (fermented African oil bean seed)	110g
Bitter leaves (sliced)	200g
Scent leaves (coarsely sliced)	90g
Palm oil	410ml
Onion (coarsely sliced)	90g
African spinach (Amaranthus spp)	450g
Bouillon cube	10g
Salt	25g
Uziza' (Piper guineense)	10g
Fresh pepper (ground)	35g
Water	4litres

Method of Preparation

- Soak the dry corn in hot water (for 6-8hrs)
- Sieve out the corn from the water

- Grind without adding water
- Boil the pigeon pea for 2hrs 30mins
- Slice bitter leaves and add to the pigeon pea when it is about to be done
- Drain the water in the pot when it is done to the level below the pigeon pea
- Mix the corn with 100g of oil
- Spread it on top of the pigeon pea
- Cook for 8mins
- Add the vegetables on top of the corn
- Cook for 3mins
- Bring the food down and gradually remove the food from the pot
- Set the pot back on fire and allow it to dry
- Heat the oil
- Add onions, fresh pepper, ‘ukpaka’, salt, ‘uziza’ to the oil and cook for 5mins
- Bring down and mix the pigeon pea, corn and vegetables properly
- Serve hot

Recipes for *ayaraya-ji*
Equipment used

Pots, plates, knives, trays, cooking spoons, tablespoons, teaspoons, colanders, bowls, sieves, measuring cylinders, blender, mortar, pestle, weighing scale (manual and electronic), grater, wooden spoon, clock, gas cooker.

Table 8: Ingredients used for the *ayaraya-ji* preparation

Ingredients	**Quantity (g)**

A tuber of yam	500g
Pigeon pea (*fio-fio*)	800g
Ukpaka' (fermented African oil bean seed)	100g
Palm oil	350ml
Onion	120g
Bouillon cube	10g
Salt	15g
Fresh pepper (ground)	20g

Method of preparation

1. De-stone the pigeon peas and put in a pot of boiling water.
2. Allow to cook until soft
3. Cut your yam and put into the pot of boiling *fio-fio* and allow the water to cook the yam. Add salt to it so that it will penetrate into the *fio-fio.*
4. When cooked, set aside
5. For the sauce, pour the quantity of palm oil you need into a pot. When it is hot (not bleached), put the already sliced onion and blended pepper into it.
6. After 1 minute, add salt (bearing in mind that you have added salt to the yam and *fio-fio*), seasoning. Add your *ukpaka/Ugba* and stir.
7. Pour the sauce into the *ayaraya ji* and stir. Allow to cook for 5 minutes and serve.

Recipes for *okpa*

Equipment used

Pots, plates, knives, trays, cooking spoons, tablespoons, teaspoons, colanders, bowls, sieves, measuring cylinders, blender, mortar, pestle, weighing scale (manual and electronic), grater, wooden spoon, clock, gas cooker and tough transparent plastic bags that can withstand high heat

Table 9: Ingredients used for the *okpa* preparation

Ingredients	**Quantity**
Okpa flour	150g
Red Palm Oil	5 tablespoons
Habanero pepper	10g
Salt	3g
lukewarm/tepid water	400ml

Method of preparation

1. Sift the *okpa* flour into a big enough bowl. Add salt and the Mix very well.
2. Add the palm oil. Mix the palm oil and flour very well till the palm oil is well incorporated into the flour. You will have a nice even yellow colour when done.
3. Pour a generous quantity of water in a big pot and set on the stove to boil.
4. Start adding the lukewarm water to the *okpa* flour and mix till there are no lumps.
5. Add salt and the Mix very well.
6. Add the sliced habanero pepper. Check for salt and add more if necessary and it's ready to be scooped into the wrappers!
7. Now the water in the pot should be boiling. If not, wait for it to boil and add some spare wrappers or plastic bags before moving on to the next step. These wrappers and plastic bags act as a base for the *okpa* wraps.

8. After tying one end of the banana leaves, stir the *okpa* mix very well and scoop into the leaf/plastic bag. Tie the other end with a string and place the wrapped *okpa* in the pot of boiling water. It is important that the *okpa* is completely immersed in the hot water.

9. Repeat the above step for the rest of the mix. Make sure you stir the mix, scoop into the wrapper, tie with the string and put in the pot of boiling water before wrapping another one.

10. When done, cover the wraps with more leaves or plastic bags. Cover the pot and start cooking medium to high heat.

11. Cook for at least 1 hour before checking it.

12. The *okpa* is done when it is solid all over.

Recipes for *abacha* (African salad)

Equipment used

Pots, plates, knives, trays, cooking spoons, tablespoons, teaspoons, colanders, bowls, sieves, measuring cylinders, blender, mortar, pestle, weighing scale (manual and electronic), grater, wooden spoon, clock,

Table 10: Ingredients used for the *abacha* preparation

Ingredients	**Quantity**
Abacha	600g
ugba (ukpaka)	256g
red palm oil	300 ml
Onion	80g
Salt	2g
ground crayfish	4 tablespoons

Maggi/Knorr	10g
ground Ehu seeds (Calabash Nutmeg)	1 teaspoon
Ogiri / Iru	1 teaspoon
Fresh *utazi* leaves (*Gongronema latifolium*)	3pcs
Garden Egg leaves	200g
Dry pepper	5g

Method of preparation

1. Prepare the *ehu* seeds by roasting, peeling and grinding them with a dry mill.
2. Wash and cut the vegetables into tiny pieces. Cut the big bulb of onion into tiny pieces and cut the medium one in circles. Wash the garden eggs and set aside.
3. Grind the crayfish and pepper
4. Soak the Abacha in cold water. Once the *abacha* has softened, put in a sieve to drain.
5. Pour the palm oil into a sizeable pot. You need all that oil so that your *abacha* will not have a dry feel in the mouth when done.
6. Add the ground pepper, ground ehu, crushed stock cubes, crayfish, then stir very well. Please not that we are doing everything off the stove.
7. Add the iru/ogiri and make sure it is mixed very well.

8. Now add the soaked and drained *abacha* and stir till it is well-incorporated in the palm oil paste.

9. Add salt to taste and stir well. It is important that you add salt last because after adding all that seasoning, your *abacha* may not even need salt any more.

10. Add the sliced garden egg leaves and sliced Utazi, fish and onions and serve

Recipe for *achicha*
Equipment used

Pots, plates, knives, trays, cooking spoons, tablespoons, teaspoons, colanders, bowls, sieves, measuring cylinders, blender, mortar, pestle, weighing scale (manual and electronic), grater, wooden spoon, clock, gas cooker

Table 11: Ingredients used for the *achicha* preparation

Ingredients	Quantity
achicha ede (cocoyam flakes)	350g
Pigeon pea	200g
Red Palm Oil	60ml
Habanero pepper	10g
Salt	7g
lukewarm/tepid water	400ml
Oil bean seed (*ukpaka/ugba)*	256g
Red onions	150g
Fluted pumkin leaves (*ugu*)	400g

Method of preparation

1. Rinse the *achicha* and soak in water overnight.
2. The next morning, rinse the *achicha* and remove from the water.
3. Crush into pieces
4. Wrap the crushed *achicha ede* with uma leaves, banana leaves or aluminium foil and cook in a pot with some water for 20 to 30 minutes.
5. While that is cooking, rinse and chop the following ingredients: green amaranth or *ugu* or spinach, scent leaves, onions and peppers.
6. When the *achicha ede* is very soft, remove from the pot and set aside.
7. In another clean dry pot, pour the red palm oil and heat it up. When the oil is hot,stir fry the onions for 2 minutes.
8. Add the *ukpaka* and pepper and fry for another 2 minutes.
9. When the content of the pot heats up, add the cooked *achicha*, stir very well and add salt to taste.
10. Add the chopped leafy vegetable and stir till it heats up
11. Stir very well and it's done.

Ethical clearance certificate

UNIVERSITY OF NIGERIA TEACHING HOSPITAL

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Chairman Medical Advisory Committee

Our Ref: UNTH/CSA/329/VOL.5

Date: 30th September, 2019

NHREC/05/01/2008B-FWA00002458-1RB00002323

ETHICAL CLEARANCE CERTIFICATE

TOPIC: DEVELOPMENT OF PHOTOGRAPHIC FOOD ATLAS OF DOMESTIC MEASURES AND CARBOHYDRATE SERVINGS OF SELECTED FOODS CONSUMED IN ENUGU STATE FOR DIETARY COUNSELLING OF DIABETIC PATIENTS.

BY: ALOYSIUS NWABUGO MADUFORO

FOR: A Ph.D THESIS IN NUTRITION AND DIETETICS OF THE DEPARTMENT OF NUTRITION AND DIETETICS, FACULTY OF AGRICULTURE, UNIVERSITY OF NIGERIA.

This research project on the above topic was reviewed and approved by the University of Nigeria Teaching Hospital Health Research Ethics Committee. This certificate is valid for **one year** from date of issue. Please note that the Committee Reserves the Right to monitor the Conduct of the study at any time for strict Compliance to the Protocol.

Prof. R.E. Umeh
Chairman, Health Research Ethics Committee

Date: 30/9/2019