DEPARTMENT OF NUTRITION AND FOOD SCIENCE
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THE EFFECT OF CONSUMPTION OF CASSAVA AND CASSAVA PRODUCTS ON BLOOD AND URINE GLUCOSE LEVELS IN ADULT DIABETIC PATIENTS

BY
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DECLARATION

I declare that this thesis represents my original work and has not been submitted to another university for an award of a degree.

Any help received in writing this thesis and all sources used have been duly acknowledged.

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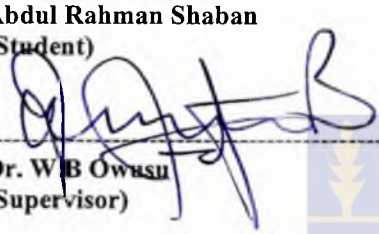

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DEDICATION

Dedicated to my wife Amina, mother and the Shaban Family.

ACKNOWLEDGEMENT

The successful production of this document would not have been possible without the help of the following personalities: Dr W. B. Owusu, a lecturer at the Department of Nutrition and Food Science, Legon (my supervisor), Dr (Col.) Wayo, a physician specialist, staff of the dietetic unit and the laboratory at 37 Military Hospital in Accra. I also wish to express my gratitude to the Nutrition and Food Science Department of the University of Ghana, Legon for their help.

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Last but not the least, is my family, for their moral and financial support. God bless every one of them.

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ABSTRACT

Diet is one of the very important components in diabetes treatment, and since its main problem is utilisation of glucose, diabetics are advised to carefully select foods rich in carbohydrates.

It is worth noting that cassava which has a comparable carbohydrate (wet weight) content (40.8g/100g) to plantain (39.3g/100g) and energy values of 171 cal/100g and 169 cal/100g (on wet-weight basis) respectively is avoided by many diabetics who eat mostly plantain. The belief is that cassava contains a lot of energy which can worsen their condition. However, no scientific work has been done to prove that.

This study therefore investigated the effect of the consumption of cassava or any of its products on the blood and urine glucose levels in diabetics under treatment. Each selected patient who consented to participate in the study was followed for a period of five weeks. Blood and urine samples were collected twice in the week for glucose analysis. Forty patients who participated in the study were all under the care of a physician specialist and a dietician. The mean fasting blood glucose when cassava was consumed compared to when not consumed and the mean urinary glucose when cassava was consumed compared to when not consumed were not significantly different ($p>0.05$).

Total urine and glucose excreted within the12-hour period in the night after supper were also determined. There was no correlation between urine volume and glucose excreted ($r=0.12$; p-value=0.99). The mean excretion of urine

when cassava was consumed and when not consumed was not statistically significant ($p>0.05$).

Energy consumed from various foods eaten by the patients within the day was also calculated. When the total energy consumed at supper was related to fasting blood glucose, the relationship was not statistically significant ($p>0.05$).

Patients' body weights were positively but not significantly correlated with blood glucose ($r=0.25$, $p>0.05$).

The univariate effects of age ($p= 0.41$), sex ($p = 9.9$) and energy ($p= 0.12$) on fasting blood and urinary glucose were not statistically significant. These variables [age ($p=0.67$), sex ($p=0.34$) and energy ($p=0.57$)] were found to have no effect on urinary glucose as well. Adjusting for these did not change the results.

In conclusion, as long as patients are on treatment, there appears to be no significant rise in blood and urinary glucose levels in adult diabetics who consumed cassava diets and products for a period of five weeks.

Consumption of cassava and its products does not appear to worsen the condition of the adult diabetic as long as he/she in on a hypoglycaemic drugs.

CHAPTER ONE
INTRODUCTION

Diabetes Mellitus is a syndrome characterised by an elevation of glucose concentration in the blood, due to deficiency or diminished effectiveness of insulin. The disease has many other symptoms but the most important ones, usually referred to as the cardinal symptoms, are: polydipsia (persistent thirst), polyuria (excessive volume of urine), polyphagia (increased appetite) and glucosuria (glucose in urine), weight loss.

In 1997, an estimated 124 million people world-wide had diabetes, 91% of whom were non- insulin dependent diabetes mellitus. By the year 2010 the total number of people with diabetes is projected to reach 221 million. The regions with the greatest potential increase are Asia and Africa, where the rates could rise 2 or 3 times what is experienced today (Zimmet and Amos, 1997).

Diabetes mellitus was thought to be rare in Africa, and its prevalence varies in different parts of the continent (Eho, 1984). Duodu and de Heer (1964) estimated the prevalence to be 0.2% to 0.4%. In Ghana, Acheampong *et al* (1995) estimated the prevalence rate at 2.0% with a mortality rate as high as 13%.

Diet therapy is the cornerstone of diabetes management. In insulin- dependent diabetes, stable glycaemic control is almost impossible unless insulin therapy is combined with diet.

Diabetes is an expensive disease to live with, and its treatment requires some dietary restrictions. There are two types of diet used in managing diabetes; measured and unmeasured. The measured diet is one in which the amount of food to be eaten at each time of the day is specified, compared to the unmeasured one in which there is no specification.

For years, the dietary recommendation for diabetics has been based upon the belief that all carbohydrate foods act in predictable ways and that complex carbohydrates cause a lower rise in blood sugar level than simple rapidly absorbable carbohydrates (Michelle *et al.*, 1987). Despite this belief, most health personnel and diabetic patients in Ghana appear to have a notion that cassava and its products, which are complex carbohydrates, can either cause diabetes or aggravate the disease. The reason sometimes attributed to this is that cassava contains more calories than other carbohydrate-containing foods like plantain, and when eaten can elevate blood sugar level and therefore worsen the patient's condition. However, the scientific basis of this is yet to be known. For example, the difference in calorie content between cassava (171cal/100g) and plantain (169/100g) (on wet-weight basis) is only 2 cal/100g. Also, the complex carbohydrate contents of these food items are comparable; 40.8/100g for cassava and 39.3/100g for plantain (Eyeson and Ankrah, 1975).

This perception about cassava often leads health personnel to advise diabetic patients to completely avoid cassava and its products in their diets, even though a few recommend its use in limited quantities.

A study conducted in Dar-es-salaam, Tanzania, by MacLartey *et al* (1989) in two communities, Nyambesi and Waswaa, where the consumption rates of cassava differed, found comparable prevalence of diabetes. This showed that cassava consumption may aggravate diabetes. In Ghana, cassava, which is avoided by diabetics, is one of the most important staple crops and a major affordable source of energy for a considerable proportion of the population.

Plantain is mostly mixed with cassava to make very good "fufu", but in many fufu-eating areas in the country most diabetics are made to eat only plantain fufu (sometimes called plantain diet) which is more expensive. "Kokonte", "banku" with cassava dough and "yakeyake" are all cassava products avoided by diabetics. The avoidance of these cassava foods in the diet of diabetics has been observed to cause extreme discomfort to them, and very inconvenient to their caretakers because of the cost involved in finding alternative food for their patients. Even though cassava consumption and the beliefs of its association with adverse effects on the diabetic patient have existed for a while in Ghana, little has been done to investigate this conception.

This study therefore sought to investigate the association between the consumption of cassava and/or its products on the plasma and urine glucose levels of adult diabetics.

1.0 OBJECTIVES

The objectives of the study were to:

1. Investigate the urinary and fasting plasma glucose profiles of adult diabetic patients.
2. Observe and compare the plasma and urinary glucose concentration of diabetic patients when they ate cassava or its products with concentration observed when they did not eat cassava or its products.

1.1 HYPOTHESIS

Ho = Fasting blood and urinary glucose are not increased by consumption of cassava and its product.

Ha = Fasting blood and urinary glucose are increased by consumption of cassava and its products .

CHAPTER TWO
LITERATURE REVIEW

Diabetes Mellitus is a disease resulting from a breakdown in the body's ability to produce or utilise insulin. It is a common chronic disease affecting many body organs and systems. Disturbances of carbohydrates, protein and lipid metabolism occur because of the deficiency of insulin.

2.1 INSULIN

Insulin is a hormone secreted by the beta cells in the islet of Langerhans of the pancreas. It plays a major role in the metabolic processes of the body by controlling the storage and metabolism of the ingested metabolic energy. When insulin production ceases, the metabolism of carbohydrates in most tissues of the body becomes considerably depressed (Brunner and Suddath, 1980).

Following a meal, the secretion of insulin facilitates the uptake, utilisation and storage of glucose, amino acids and fat. It promotes the storage of glucose in the liver and utilisation of glucose in the muscles and storage of fat in the adipose tissue by enhancing the transport of glucose across the cell membrane (Brunner and Suddath, 1980). Insulin regulates the level of blood glucose which is formed from the ingested carbohydrates and from the conversion of amino acid to glucose by the liver (gluconeogenesis).

Lack of insulin prevents insulin-sensitive cells from using glucose as a source of energy. Without insulin, the body enters into serious state of catabolism, glucose builds up in the body and hyperglycaemia results. Hyperglycaemia causes a series of fluid and electrolyte imbalances ultimately resulting in polyuria (excessive volume of urine), polydipsia (persistent thirst) and polyphagia (increased appetite). These are classic signs and symptoms of diabetes.

Although diabetes may occur at any age, its prevalence rises dramatically in older populations from less than 2 cases per 1000 children to almost 200 in their sixties (Davidson *et al.*, 1975).

Atherosclerosis is a leading complication of diabetes mellitus making coronary heart disease and cerebral vascular disease major causes of morbidity and mortality in diabetic patients.

Davidson *et al.* (1975) reported three methods of treatment and each involves an obligation for the patients to adhere to dietary regimen for the rest of their lives. These methods are dietary treatment, the use of diet and insulin and diet and hypoglycaemic drugs.

2.2 DIET

Diet therapy is the cornerstone of diabetes management. In insulin -dependent diabetes, glycaemic control is impossible unless insulin therapy is superimposed upon diet. The glycaemic instability observed in diabetics can be attributed to erratic diet, missing meals or poor dietary food choices.

Dietary measures are necessary in the management of diabetes mellitus, to optimise control of blood glucose level, to achieve ideal body weight and to reduce the risk of cardio-vascular diseases.

In the normal person, the pancreas has an ability to adjust the quantity of insulin produced in proportion to the intake of carbohydrate but in diabetic person this control function is compromised (Guyton, 1968).

Guyton, (1968) also reported that the insulin requirement of diabetics is established with the patient on a standard diet and any change in the quantity of carbohydrate intake changes the requirement for insulin.

The basic principle of dietetic therapy of the elderly who are mostly non-insulin dependent is essentially the same as for all other persons. Therapeutic modalities include diet, exercise, hypoglycaemic drugs and patient's education. Generally, it is best to alter the patient's usual diet as little as possible because it is desirable that diabetics eat with, and feel that they are part of, their family. It is often stressed that a good diet for a diabetic patient is generally a healthy and adequate diet for the entire family. The idea is that special diets made for a diabetic should be discouraged.

2.3 GLYCAEMIC INDEX OF FOODS

Jenkins and Wolever in 1981 introduced the concept of glycaemic index to rank foods according to their postprandial impact on plasma glucose levels. Since then the glycaemic index values of over 200 foods have been determined (Brand *et al.,* 1985; Jenkins *et al.,* 1988).

Sugars are an important component of diets in developed countries, providing about 20% of the total energy consumed, and nearly half the total carbohydrate (Clinsman *et al.*, 1986; Baghurst *et al.*, 1989). The glycaemic index of foods containing sugar should also be considered in the emergency treatment of hypoglycaemia.

The common assumption that foods containing sugar will produce more rapid glycaemic response than starchy foods has little scientific basis. To test this, 42 products were studied by Brand *et al.* (1985). Thirty-nine of these were significant sources of

simple sugars, cereals, fruits and confectionery. Each food was tested on eight subjects drawn from a pool of eighteen healthy volunteers with normal glucose tolerance. Their ages ranged from 19 to 59 years and the body mass index from 18-27kg/m^2. The subjects consumed portions of each food containing 50g of available carbohydrate portions. The gylcaemic and insulin indices were calculated using 50g carbohydrate as reference point. The glycaemic indices of various foods were multiplied by the factor 70g/100g in order to express the final result on a scale on which glucose was 100g (when glucose is reference point, the glycaemic index of white bread is 70).

When the foods were compared within categories (bakery products, dairy products, canned fruits, and beverages), there were no significant differences for cakes, muffins and most cookies made with or without sugar.

The study indicated that most foods containing sugars did not have high glycaemic index. The majority fell within the intermediate range of 50-70 on the glycaemic index scale where glucose is equal to 100. The results did not show that foods containing added sugars produce high glycaemic index and insulin responses than standard values. The glycaemic index of bread is about 70 and potatoes have 70-90 depending on the method of preparation (Jenkins and Wolever, 1981). Over 80% of sugary foods tested in the study had glycaemic index lower than 70.

Recently, Wolever *et al.* (1994) showed that the strongest determinant of whole glycaemic index in 340 individuals with non-insulin dependent diabetes was the intake of simple sugars which correlated inversely with glycaemic index. Their findings were further evidence that foods rich in simple sugars usually have lower glycaemic index values than most common starchy foods of the same weight.

The low mean glycaemic index foods studied is best explained by the composition of the individual sugars. Sucrose is a disaccharide composed of simple glucose and fructose so that only half of glucose equivalent is available compared with equal carbohydrate portion of bread or glucose.

The sweetness of fruits is determined by a mixture of glucose, fructose, sucrose and other sugars which do not affect plasma glucose equally. Fructose has a very small effect on the overall rate of glucose appearance (Delarue *et al.,* 1993).

Furthermore, the insulin requirement of individuals with insulin-dependent diabetes is presently based on carbohydrate and energy intake rather than on precise quantitative measurements of insulin responses to food. It suggests that many foods containing sugar(s), whether naturally occurring or refined, give glycaemic and insulin responses that are similar to or lower than those of many common starchy foods in western diets.

The glycaemic index classifies starchy carbohydrate foods into predictable post-prandial glycaemic responses, and it is thought to be a possible tool for the planning of a diabetic diet.

It is known that as long as proper adjustment of insulin or hypoglycaemic drugs is made, the type of carbohydrate in the single mixed diet does not appear to have a significant effect on the post prandial glycaemic responses. This was the result of the study conducted by Michelle *et al.* (1987) on glycaemic response in children with insulin-dependent diabetes mellitus after a high and low glycaemic index breakfast.

To examine the effect of various carbohydrate foods on post prandial glycaemia in diabetic children, 22 children with poorly controlled insulin-dependent diabetes mellitus were fed on mixed isocaloric diet containing high and low glycaemic index breakfast foods. The blood response was measured with or without adjustment for insulin doses. It was found that children fed on a high glycaemic index meal showed significantly higher serum glucose level than those fed on low glycaemic index meal. However, such differences were not seen when the pre-prandial dose of regular insulin was adjusted to the amount of carbohydrate in feeding. Thus, as long as proper adjustment of insulin is made, the type of carbohydrate in a single mixed meal does not appear to have a significant effect on the post–prandial glycaemic response of children with long-standing and poorly controlled insulin-dependent diabetes mellitus.

Roots and tubers (cassava, yam, cocoyam) form one of the staples eaten by Ghanaians except cocoyam which is grown in the forest area in southern Ghana. Cassava and Yams are found almost everywhere in Ghana.

Cassava is processed into many different products such as "gari", "kokonte", (Dovlo ,1975) and cassava dough. The fresh cassava roots can be prepared into "ampesi" or "fufu". Although nutritionally, cassava is comparable to plantain in energy and starch content (Eyeson and Ankrah, 1975), plantain is preferred by diabetics.

Two studies by Brakohiapa *et al.* (1991) investigated the glycaemic index of five common Ghanaian foods, namely: boiled white yam, white rice, Ga kenkey (from corn dough), green plantain and "gari" (cassava product). The first was in healthy young males. This study was repeated on non-insulin dependent diabetic males. In both studies rice exhibited the least mean incremental changes in glycaemic index during the first 90

minutes, with a value of (40.2 ± 6.0). This was followed by plantain (40.9 ± 5.1), Ga Kenkey (43.7 ± 5.7), "gari" (49.0 ± 2.9) and yam (64.9 ± 7.0).

It has been found that the same weight of carbohydrate in different foods can produce widely different blood glucose response (glycaemic index) (Irene *et al.,* 1988). The implication is that it will be helpful in planning meals for individuals with diabetes. The Nutrition Committees of America and the Canadian Diabetics Associations recommended the use of glycaemic index of food in planning diets for diabetic patients. The question naturally arises whether glycaemic index can be used to predict the glycaemic and insulin responses to mixed meals. Coulston *et al.* (1984) reported that glycaemic responses to mixed meals containing different types of carbohydrate sources did not differ significantly and concluded that the glycaemic index approach would have little clinical utility. His study involved 8 volunteers (7 women and 1 man) who satisfied the criteria for non-insulin dependent diabetes mellitus. Five subjects were treated with sulfonylureas and 3 by diet alone. Each subject consumed 4 test meals (Meal Tolerance Test = MTT) within a two-week period. The test meals provided 40% of each subject's calculated daily caloric requirement and contained (as percentage of total calories) 15% protein, 40% fat and 45% carbohydrate. The protein and fat sources were held constant while the test carbohydrate source (which provided 66% of the total carbohydrate) varied. The carbohydrate test food consisted of baked potato, rice, spaghetti, and lentil. Although the absolute amount of the test carbohydrate that was ingested varied with the food in question, they were equal in terms of carbohydrate content. In order to maintain a constant percentage of dietary protein, only 0.3 g of turkey per 400 kcal was added to the MTT containing lentil.

Subjects were instructed to fast from 10:00pm the evening before each MTT, and to consume a light breakfast consisting of white toast, margarine, fruit juice and tea or coffee before 8:00am. Subjects treated with oral sulfonylureas took their normal morning doses with breakfast on each test day. Nothing else was consumed before the MTT was performed at 12:00 noon. Test meals were consumed over a 20 to 25 minutes period. Blood samples were drawn for measurement of plasma glucose and insulin before and 30, 60, 120, and 180 minutes after the beginning of each test meal. There were no significant differences noted in glucose and insulin responses among the subjects treated with oral sulfonylureas and those on diet therapy only. Wolever *et al.* (1985) refuted these conclusions by demonstrating that the observed glycaemic index responses could be predicted by the glycaemic indices of component foods. His first study conducted with 4 different meals were fed to a group of 8 type II (non insulin dependent) diabetics. The meals contained 69 83g carbohydrate, 20 –29g protein and 13-21g fat (514 –610 calories). There were 9 different carbohydrate- containing foods (not all given in each meal). Venous plasma glucose was measured fasting and at ½ hour intervals for 4 hours after the start of the meals.

In a second separate study in the same year Wolever *et al.,*(1985) studied 5 different meals containing 84 to 89g carbohydrate, 31- 38g protein and 25-26g fat (682 – 742 calories) which were fed to 10 healthy subjects, 12 patients with type I (insulin dependent) diabetes and 10 patients with type II diabetes. One–half of the carbohydrates in each of these meals was rice, starch and lactose, and the other half either glucose, sucrose, fructose, potato starch or wheat starch. Venous plasma glucose concentration was measured at fasting and at 15, 30, 60, 90,120, 180 and 240 minutes after the start of

the meals. The contribution of each food to the total carbohydrate content of the meal was calculated. The proportion of carbohydrate in each food was multiplied by the glycaemic index of the food to give that item's contribution to the meal glycaemic index.

The study showed that there were significant differences in the glycaemic and insulin responses of healthy individuals to different mixed meals. Moreover, the glycaemic indices of mixed meal could be predicted from the glycaemic indices of the component carbohydrate foods. The results showed that the glycaemic index approach will be useful in planning diets for diabetic people.

The current nutrition recommendation of the American Diabetic Association represents a thoughtful synthesis of current data. They depart from tradition by not advocating specific figures for total fat and carbohydrate intake. They endorsed the principle of individuality and set the guideline accordingly. This principle covers the effect of altered meals frequency, viscous dietary fibres, low glycaemic index food and inhibitors of carbohydrate absorption (American Diabetic Association, 1984).

Studies showed that diets high in fibre improve the glycaemic index of diabetic patients (Eugenio *et al.,* 1988). In this study, 13 non-insulin dependent diabetic (NIDDM) subjects were recruited from the Diabetic Day Hospital of the Ospedale Forlanini, Rome, Italy . After the approval of the ethical committee of the hospital and after informed consent was obtained, 13 subjects (5 women and 8 men) aged 34 to 66 years (mean age 54± 12 year) who satisfied the criteria for NIDDM, participated in the study. With the exception of diabetes and being overweight, all the subjects were in good metabolic control and in good general health. The volunteers weighed 70.0 ± 8.8kg with mean BMI of 27.0 ± 3.4 kg/m^2 (range 22.45 – 35.23 kg/m^2).

Over a period, each patient ate one of the 2 meals; a low fibre diet, total with soluble and insoluble fibre of 6.7g per ration and high fibre diet with total soluble and insoluble fibre of 32.9g per ration given in random order during 2 test periods that were two weeks apart. Meals consisted of foods commonly consumed by the population and differed chiefly in amount and type of fibre. Both diets were designed to achieve the required proportion of carbohydrate, fat, protein and fibre (soluble and total) without altering total daily caloric intake. Carbohydrate was mainly in complex form and was kept constant in all subjects at 45% of total calories. Venous blood was collected via an indwelling needle during fasting and 15, 30, 45, 60, 90, 120 and 180 minutes after the start of the meal. Blood glucose was determined by the glucose oxidase method. Analysis of variance for cross-over experimental design was used to analyse the data. The results showed 250mg glucose /dl of blood sugar for low-fibre diet and 150mg glucose /dl of blood for high-fibre diet. This difference is statistically significant.

The beneficial effect of relatively higher proportion of carbohydrate in the diet on circulating glucose and lipid levels has been attributed to some of the fibre content of the complex carbohydrates. It has been shown that high fibre foods may slow absorption of carbohydrate thereby minimising blood glucose (Bierman, 1985).

There is no need to restrict disproportionally the intake of carbohydrate in the diet of most diabetic patients now because the distinction between complex and simple carbohydrate is becoming increasingly blurred. In insulin-treated diabetic patients, an increase of total calories does not appear to increase insulin requirement (Bierman, 1985). Glucose tolerance steadily improves with increasing proportion of carbohydrate in the diet and the basal glucose levels are lowered over a long term (Bierman, 1985).

It appears mild and moderately severe type II diabetes as well as type I diabetes can be controlled on a basic diet containing as much as 60% of calories as carbohydrate, with a reduction in saturated fat and cholesterol and with caloric intake adjusted so that body weight is reduced towards ideal body weight. Such a diet will lower blood glucose, cholesterol and triglycerides (American Diabetic Association, 1984).

2.4 BLOOD GLUCOSE

A person with diabetes needs to control his blood sugar as near normal as possible by striking a balance between food, exercise and medication. People with diabetes report that their quality of life improves when blood glucose levels are under control (Almond, 1986).

Diabetics can only find out if their diabetes is well controlled by checking the levels of glucose in the blood. Testing blood is more useful than testing urine glucose level because urine testing does not reveal the level of glucose at the actual time of testing and most people do not show glucose in the urine until the blood glucose level is at least 10mmol/L. Testing urine also does not show whether glucose levels in the blood are low or a person is at risk of becoming hypoglycaemic (Seymour, 1995).

Fasting blood sugar determines the amount of glucose in the blood when the patient is fasting and no food is eaten for 12 hours prior to test (8pm to 8am). Serum glucose level of 80-120mg/100ml is normal while 200mg/100ml or more is abnormal, and has been used to diagnose diabetes (Brunner and Suddath, 1980).

2.5 URINARY GLUCOSE

In a normal person's urine, a small amount of glucose is present but not enough to be detected by an ordinary test. The presence of glucose in the urine is a signal of diabetes and calls for immediate blood glucose test.

The presence of glucose in the urine depends on the serum or plasma glucose level and the renal threshold for glucose (Brunner and Suddath, 1980). In diabetes, glucose may appear in the urine when blood glucose rises above 160-180mg/dl. Glucosuria may appear in a diagnosed diabetic when the patient is not following a prescribed diet, when the treatment is inadequate, when the patient is not getting enough exercise or when infection is present (Brunner and Suddath, 1980).

The basis of urinary glucose test is the fact that glucosuria is roughly correlated with hyperglycaemia. Urine testing is painless and less expensive but not reliable. For instance, fluid intake and urine concentration can affect urine test results. The test will reflect the average level of blood glucose during the interval, since the last voiding and not the level at the time of test and a negative urine test does not distinguish hyperglycaemia, euglycaemia and mild or moderate hyperglycaemia.

The determination of urinary glucose concentration has evolved as the most commonly used method for indirectly estimating blood glucose concentration and for providing quantitative data to guide alteration in insulin and dietary regimens.

In a study by Hayford *et al.* (1983) to estimate the validity of urinary glucose for plasma glucose concentration, they reported a correlation between plasma glucose concentration and urinary glucose concentration but re-emphasised the potential limitation of urinary glucose excretion data in the clinical management of insulin and

dietary programmes among diabetic subjects. The study population comprised of 24 diabetic subjects, 15 females and 9 males. With the exception of one subject who was an insulin-treated type II diabetic patient, all subjects had type I diabetes. The mean age at the time of study was 23.5 years (SD =4.7 years, range 14.5 – 35.5 years) and mean duration of diabetes was 10.9 years (SD 6.7 years, range 0-20.6 years). No subject had a history of chronic urinary tract infections to suggest defects in bladder function. Nevertheless, adequacy of bladder emptying during spontaneous voiding was not documented among the study subjects.

Subjects were admitted to the Clinical Research Centre of the University of Iowa, USA, on the day before the study, for history and physical examination, explanations of the protocol and their acclimatisation to the clinic facilities. They were maintained on their previous insulin regime with no attempt to optimise blood glucose control. Dietary intake while in the hospital was designed to mimic home dietary patterns with respect to total energy intake, schedule of meals and snack consumption, and composition of energy, protein, fat and carbohydrate.

Between 0700 and 0800 hours, after an overnight fast, a 24 hour of continuous blood withdrawal was started. An indwelling catheter, impregnated with an anti-coagulant binding resin, was inserted in a forearm vein under aseptic conditions and was connected to a constant speed, portable continuous withdrawal pump. Blood samples were collected at 30 minute cycle (half-hourly intervals) into iced 0.02M, EDTA-0.033M benzamidine solution (15µl/ml of blood). All samples were maintained at 4°C before centrifugation and harvested plasma was frozen for assay. During the 24-hour study, subjects remained ambulatory, except for nocturnal sleep.

During the 24-hour period of blood sampling, all urine output was collected in 2-hour fractions for determination of the concentration of glucose and urine excretion rate. Since all urine was collected by spontaneous voiding, no provisions were made to exclude the inadvertent retention of urine in the subject`s bladder. The 2-hour urine collections were coordinated with the half-hourly changes in the blood collection vessels. Plasma glucose was measured using a semi-automated glucose-oxidase system, whilst urinary glucose was measured by nurses using two-drop clinitest procedure and by a semi-automated glucose–oxidase system.

The observation showed a significant correlation ($P<0.0001$) between plasma glucose concentration and urine glucose excretion rate.

Differences among subjects in the renal re-absorption of glucose contributed to the wide variance observed in the estimate (SD=± 150mg/dl). The study re-emphasised the limitation of using urine glucose determinations for the estimation of plasma concentration.

2.6 BODY MASS INDEX (BMI)

Body mass index is commonly used to classify overweight and obesity in adults. It is calculated as the weight in kilogram divided by the square of the height in meters (Kg/m^2). The classification of overweight and obesity according to BMI is as follows: Underweight <18.5; Normal range 18.5-24.9; Overweight>25; Pre-obese 25-29.9, Obese class I 30-34.9; Obese class II 35-39.9; Obese class III ≥40 (WHO/NUT/NCD/98).

Although it can generally be assumed that individuals with BMI of 30 or above have excess fat mass in their body, BMI does not distinguish between weight associated with muscle and weight associated with fat. As a result, the relationship between BMI and body fat content varies according to body build and proportion. Also, it has been shown repeatedly that a given BMI may not correspond to the same degree of fatness across populations (Swinburn *et al.,* 1986).

Polynesians for example, tend to have lower fat percentage compared to Caucasian Australians at an identical BMI (Swinburn *et al.,* 1986). In addition, the percentage of body fat mass increases with age up to 60-65 years in both sexes (Forbes and Reina, 1970; Rolland-Cachera *et al.*, 1991), and is higher in women than in men of equivalent BMI (Ross *et al.,* 1994).

The health consequences of obesity are many and varied, ranging from an increased risk of pre-mature death to several non-fatal but debilitating complaints that have impact on immediate quality of life. Obesity is also a major risk factor for non-communicable diseases such as non-insulin dependent diabetes, cardio-vascular diseases and cancer which in many industrialised countries is associated with various psychological consequences.

A positive association between obesity and the risk of developing non-insulin dependent diabetes mellitus has been repeatedly observed in both cross-sectional (Hartz *et al.*,1983) and prospective studies (Tai *et al.*, 1992). The consistency of association across populations despite different measures of fatness and criteria for diagnosing non-insulin dependent diabetes reflects the strength of the relationship when women aged 30 to 55 years were monitored for 14 years (Colditz *et al.,* 1990). The additional risk of

developing non-insulin dependent diabetes for those who were obese was over 40 times greater than for women who remained slim (BMI <22) (Colditz *et al.*, 1990). The risk of non-insulin dependent diabetes increases continuously with BMI and decreases with weight loss.

Lack of physical activity and an unhealthy diet both of which are associated with life styles are important modifiable risk factors for overweight and obesity. The prevalence of non-insulin dependent diabetes mellitus is 2 – 4 fold higher in the least physically active individuals compared to the most physically active (Schranz., 1989). The relationship is independent of the level of body mass, although healthy diet can reverse deterioration in glucose tolerance commonly seen with diets high in fat and low in carbohydrate and fibre.

In reality, populations are not composed of two distinct groups (the obese and non-obese), but that distribution of body fatness ranges from underweight through normal to very obese and the risk of associated morbidity and mortality could begin at relatively low levels of BMI (WHO/NUT/NCD/98).

CHAPTER THREE
MATERIALS AND METHODS

3.0 STUDY DESIGN AND STUDY SUBJECTS

The study was an observational cohort and was both clinic and community-based. The population studied was selected based on the following inclusion criteria:

i. Adult diabetic patients between the ages of 25 and 60 years (The younger ones between the ages of 1 – 24 years, most of whom were insulin dependent, were excluded from the study because their glucose levels were mostly unstable for sometime even with treatment).

ii. Patients were either on dietary management alone or diet plus hypoglycaemic drugs.

iii. The patients were also under the regular care of a physician specialist.

The study population consisted of volunteers from a diabetic clinic at 37 Military Hospital in Accra (by a convenient sampling method) among patients who visited the hospital at the time of the study and were interviewed. Only those who agreed to participate in the study were admitted. This was done after permission was granted by the hospital authorities.

A structured questionnaire was used at the first contact to screen the patients for information on personal data, disease history, dietary habit and knowledge of diabetes mellitus (Appendix A). The purpose of this was to identify those who occasionally consumed cassava and would agree to take part in the study. There were those who had stopped cassava consumption but agreed to consume cassava in order to participate in the study. There were a few who indicated they would not consume cassava again once they had stopped eating it, despite the education given to them about the objective of the study. They were therefore excluded from the study.

3.1 SAMPLE SIZE CALCULATION

With a weighted standard deviation of 5.48 mmol/L (Burrin and Alberti, 1989) and at 1% level of significance, 35 diabetic patients were needed to detect a difference of 1.2 mmol/L in plasma glucose levels between when they consume or do not consume cassava and cassava products. This was, however, rounded up to 40 patients (Appendix B).

3.2 FOLLOW UP

Each patient selected was encouraged to follow his/her dietary habit for the whole period of study. Each of them was monitored for a period of five weeks. Each week, 2 fasting blood and 2 early morning urine samples were collected and analysed for glucose level. Each pair of samples was collected when the patient had consumed cassava as part of his/her meal for supper the previous day and when he/ she had not consumed cassava, respectively. Furthermore, collection of urine and blood samples for glucose analysis was made 12 hours after the previous day's supper. This gave a total of 10 fasting blood (Appendix C) and 10 urinary glucose determinations (Appendix D) for each subject. There were five measurements made on each subject when cassava was consumed and another 5 when cassava was excluded. Before blood and urine samples were collected, each patient was asked to recall all foods eaten over the past 24 hours. They were made to show the articles they used to measure the food items consumed at home. Some of these were milk tins used in measurement and different types of soup ladles. This was to help estimate the types of food and amount of energy consumed, and also to ascertain whether cassava was included in the diet of the patient within that period.

About half of the patients studied were also visited at home to see whether they complied with the advice given at the clinic on the diet. The initial weight and height of the patients were taken at the first contact in the hospital, using a weighing Salter scale for weight. Subsequently, the weights of each patient was taken on each day that urine and blood samples were collected. Patients' weights were taken while they stood upright on the scale with their shoes and sandals removed and in minimal clothing. The weight was recorded to the nearest gram. They were also made to stand against a graduated wall for their height to be taken at the perpendicular vertical axis (wall). Each subject was asked to provide information on the frequency of urination and the volume of urine passed 12 hours before the specimens were taken for analysis. The overnight urine collected was measured using a measuring cylinder. From these values, 12 hour urine volume and the urinary glucose concentration were estimated (Appendices E and F). The collection of blood and urine and the analysis of glucose levels were determined in collaboration with hospital laboratory technicians and the values obtained were recorded and statistically analysed.

3.3 LABORATORY BLOOD AND URINARY GLUCOSE

The accurate and precise measurement of glucose concentration in circulation is important in clinical practice and research on diabetes. Many methods are available for the determination of glucose levels in blood serum or plasma in the laboratory.

The methods are:-

i. Oxidation – reduction reaction. This includes the methods such as cupri-reduction and ferric cyanide (Burrin and Alb*erti,* 1989).

ii. Ortho-Toluidine – This method is more specific than the first one and depends on the property of glucose to condense with aromatic amines in hot-acetic acid

to form coloured glycosylamines (Burrin and Alb*erti*, 1989).

iii. Enzymatic method- Three main enzymatic methods are based on the following reactions

a. Glucose Oxidase (D-glucose + O_2 → D-gluconic acid + H_2O)

b. Hexokinase (D-glucose + O_2 + ATP → D-gluconic acid + ADP)

c. Glucose dehydrogenase (D-glucose + NADP → D-gluconic acid +NAD+H^+ (Burrin and Alb*erti,* 1989).

All the enzymes are highly specific for glucose and should therefore be equally useful for glucose analysis.

A new method using mass spectrometry, radioisotope measurements, infra-red spectroscopy had been described. Dry chemical reagent strips currently available for glucose measurements all use the glucose oxidase reaction.

Glucometers are used to test blood glucose but sometimes they are used with dextrostix.

3.4 ENZYMATIC OR COLORIMETRIC METHOD

Principle

For this study, glucose was determined after enzymatic oxidation in the presence of glucose oxidase (GOD). The formed H_2O_2 reacted under catalysis of peroxidase (POD) with phenol and 4 amino antipyrine to form quinoneimine. The intensity of the colour is proportional to the glucose concentration in the sample.

Reaction of blood

(glucose) + O_2 +2H_2O GOD⟶ gluconate + H_2O_2

2H_2O_2 + phenol + 4-amino- antipyrine POD ⟶ quinoneimine (colour complex) + 4H_20

3.5 METHOD

Sample

The samples used for the study were blood plasma and urine. The blood was collected from the veins on the left hand of the patients whilst sitting on a stool. Each of them was given specimen bottles to provide early morning urine before eating.

The skin of each patient was cleaned and dried with 70% Ethanol before blood (5cc) was collected with a 5cc syringe and needle into a specimen bottle. The specimen collected was kept in a wooden box and placed at a corner of the room away from sunlight. (The concentration of glucose in the blood sample will decrease immediately after collection due to glycolysis within the leukocytes and erythrocytes). Concentration falls by three to six percent after one hour at room temperature and by 10 to 30% after four hours (Uchida *et al.,* 1988). Although much higher rates of decline have been noted for capillary sample, the problem can be obviated by instant centrifugation of the whole blood (No change at 6 hours, at room temperature or storage at 0-4^{0}C. (0.4-3% fall at 6 hours) (Burrin and Alberti, 1989)].

The specimen collected was kept for 15 minutes just to allow the technician to organise himself for the analysis. No preservatives were added to the samples collected because analysis was done immediately.

Ten micro litres of the standard was also pipetted into another test tubes, and into each tube (including the blank) was added 1000 micro litres of the working reagent (Appendix G).

The test tubes were incubated in a water bath for 10 minutes. The colorimeter (Ciba-coring 252) was zeroed with the blank and the solution in each test tube was read and the corresponding absorbances recorded and used to calculate individual glucose concentration in the blood and urine samples (Appendix H).

3.6 STATISTICAL ANALYSIS

The results obtained were presented in a tabular form and also calculated appropriately as percentages, mean values and standard deviations.

A paired t-test was used to compare the means of the fasting blood glucose, urinary glucose level, urine volume and body weight when cassava was consumed and when not consumed.

The data obtained were analysed using M-Stat statistical package and EPI Info, version 6.

CHAPTER FOUR
RESULTS

In all, 40 diabetic patients (17 males and 23 females) were involved in the study. Table 1 is the background information on the subjects studied.

Table 1: Background Information on subjects

Age (years)		**%**
Mean (SD)	52 (± 8.5)	
Range	30-67	
Sex		
Male	17	42.5
Female	23	57.5
Marital status		
Married	33	82.5
Not Married	5	12.5
Divorced/Separated	2	5.0
Education		
Elementary	25	62.5
Secondary	9	22.5
Vocational	2	5.0
No Schooling	4	10.0
Body Mass Index		
Mean (SD)	28 (±5.2)	
Range	19.3-44.3	
Disease Information		
Doctor	29	72.5
Nurse	4	10.0
Diabetes sign	4	10.0
Others	3	7.5
History of diabetes in the subject family		
Yes[1]	20	50
No	20	50
Family Member affected		
Father	2	10
Mother	5	25
Brother	7	35
Sister	5	25
Other	1	5
Mode of Treatment		
Diet and Drugs	35	87.5
Diet	5	12.5

SD= Standard Deviation

The oldest patient was 67 years whilst the youngest was 30 years, with the average age being 52 years. More than half (57.5%) were females and almost all the subjects were married with about 83% of them having only elementary school education. The Mean Body Mass Index of the subjects was 28 kg/m^2 with a range of 19 kg/m^2 - 44.3 kg/m^2. (Individual weight and height measurements are in Appendix I).

Seventy-and a-half percent of the subjects in Table 1 knew about their disease conditions for the first time from their doctors. Sixty percent (60%) of the subjects who had family history of the disease indicated siblings as having the disease or had the disease and died. All the 40 subjects studied were on dietary treatment and 87.5% of them were on medication.

Table 2 shows the knowledge of the subjects about diabetes.

Table 2: Subjects knowledge about diabetes

Knowledge about signs	**N**	**%**
Having knowledge	35	87.5
Not having Knowledge	5	12.5
Cardinal Diabetes signs		
Polyuria	28	80.0
Polydipsia	17	48.6
Polyphagia	5	14.3
Glucosuria	8	22.9
Weight loss	11	31.2
Taste of Diabetic Urine		
Sugary	24	60.0
Salty	2	5.0
Acidic	1	2.5
Don't Know	13	32.5
Dietary Importance		
Having Knowledge	37	92.5
Not having Knowledge	3	7.5
Cassava Consumption		
Yes	21	52.5
No	19	47.5

Eighty-seven and-a-half percent of the subjects (Table 2) indicated having knowledge of the signs and symptoms of diabetes. Eighty percent and 48% indicated polyuria (excess urine production) and polydipsia (excessive thirst) respectively as a cardinal sign of the disease, while more than half (60%) also said the urine of diabetic patient tastes sugary.

Table 2 again shows subjects' knowledge on the usefulness of diet in the treatment of diabetes. About 93% of the subjects stated that diet is important in the treatment of diabetes. However, 47.5 % were not eating cassava and its products as part of their diet before the commencement of this study.

The various foods consumed by the subjects during the period of study is presented in Table 3. Ga kenkey, rice and banku were commonly consumed as foods made from cereals; Ga kenkey and bread topped the list. Cassava fufu and "gari" as well as Plantain and cocoyam were the foods from starchy roots and tubers. Beans were also consumed by the patients during the period of study. "Kontomire" was the most commonly consumed stew whilst groundnut and palmnut were mostly used for the diets consumed as soups. Fish was the most commonly used animal protein food, whilst Lipton tea was the popular beverage used as breakfast.

Table 3: Foods consumed by the subjects during the period of study

	FOOD TYPE	FREQUENCY (n = 40)	%
A	CEREAL AND CEREAL PRODUCTS	No. OF PATIENTS WHO CONSUMED THE FOOD	
1	Aboloo	2	5.0
2	Banku	27	67.5
3	Akpele	5	12.5
4	Koko/Porridge	21	52.5
5	Fante Kenkey	14	35.0
6	Ga Kenkey	31	77.5
7	Oblayo	4	10.0
8	Rice	30	75.0
9	Wheat Bread	31	77.5
10	Oats	1	2.5
11	Ekuegbemi	1	2.5
B	STARCHY ROOTS, TUBERS AND FRUITS		
1	Cassava Ampesi	3	7.5
2	Cassava Fufu	27	67.5
3	Gari	13	32.5
4	Cassava Kokonte	11	27.5
5	Biscuits	5	12.5
6	Cocoyam Mpotompoto	3	7.5
7	Cocoyam Ampesi	5	12.5
8	Cocoyam Fufu	29	72.5
9	Roasted Plantain	2	5.0
10	Plantain Fufu	9	22.5
11	Yam Ampesi	28	70.0
12	Yam Fufu	1	2.5
13	Fried Yam	2	5.0
14	Roasted Yam	2	5.0
C	LEGUMES		
1	Koose	3	7.5
2	Agawu	1	2.5
3	Beans	14	35.0
D.	VEGETABLES		
1	Cabbage	10	25.0
2	Nkontomire	28	70.0
3	Bokoboko	1	2.5
4	Ayoyoo	1	2.5
5	Garden Eggs	8	20.0
E	SOUPS		
1	Groundnut Soup	10	25.0
2	Light Soup	28	70.0
3	Okro Soup	19	47.5
4	Palmnut Soup	35	87.5
F.	MEAT		
1	Beef	24	60

G	FISHES		
1	Fish	40	100
H	DRINKS		
1	Malta	1	2.5
2	Coke	1	2.5
3	Lipton Tea	26	65.0
4	Coffee	2	5.0

The 24-hour energy intake by the subjects from the foods eaten is presented in Table 4.

Table 4 Energy (calories) intake from cassava and non-cassava foods consumed by the subjects within 24 hours.

S/No	Mean Energy (Cassava)	Mean Energy (Non Cassava)	Mean Energy (Difference)
1	486.3	502.4	-16.1
2	604.6	473.5	131.1
3	806.7	765.6	41.1
4	419.6	624.6	-205.0
5	586.9	450.2	136.7
6	849.8	546.4	303.4
7	753.8	631.7	122.1
8	495.5	395.2	100.3
9	1196.6	542.7	653.9
10	464.8	443.4	21.4
11	479.5	563.5	-84.0
12	434.3	465.2	-30.9
13	432.9	608.0	-175.1
14	558.4	608.0	-49.6
15	565.9	569.5	-3.6
16	543.6	580.8	-37.2
17	1166.6	1118.2	48.4
18	456.1	675.6	-219.5
19	479.3	438.2	41.1
20	579.8	617.6	-37.8
21	1159.2	781.7	377.5
22	1156.1	508.2	647.9
23	1086.4	705.9	380.5
24	504.1	678.6	-174.5
25	615.5	398.2	217.3
26	951.7	613.2	338.5
27	622.3	665.3	-43.0
28	773.9	525.6	248.3
29	449.9	470.2	-20.3
30	662.6	713.9	-51.3
31	992.8	560.2	432.6
32	821	544.6	276.4
33	459.4	435.9	23.5
34	683.6	539.2	144.4
35	619.8	576.9	42.9
36	795.1	799.0	-3.9
37	653.8	638.4	15.4
38	1269.7	604.4	665.3

39	556.1	589.7	-33.6
40	791.1	640.3	150.8
Mean	**690.6**	**590.3**	**100.3**
Standard Deviation	**249.1**	**132.6**	**116.5**

Individual values for the fasting blood and urine glucose measured from the patients when various diets in Table 3 were consumed is shown in Appendix J.

When the means of blood and urine glucose values were compared for cassava consumption and non-cassava consumption the p-values obtained are 0.30 and 0.20 respectively which were not significant (Table 5).

Table 5: Blood and Urine Glucose Profile of the 40 subjects when they consumed cassava and when they did not

Variables	**Cassava n = 40**	**Non Cassava n = 40**	**p-value**
Blood (mmol/l)			
Mean	8.45	8.26	0.30
SD	3.41	3.36	
Urine (mmol/l)			
Mean	10.43	8.66	0.20
SD	11.86	9.31	

SD= Standard Deviation

The fasting blood glucose values of subjects when cassava was consumed and avoided was compared for sexes. There was no significant difference between the two groups (p- values of 0.90 for males and 0.76 for females).

The mean fasting urinary glucose values of subjects when cassava was consumed and avoided was also compared for the sexes. There was no significant difference between the two groups. (P-values for males 0.20 and that of females 0.96 respectively).

The mean fasting blood and urinary glucose for male and female patients were compared for cassava and non-cassava consumers within the same sexes of subjects. These were also not significant (p-values obtained for males and females were 0.99 and 0.75 respectively for blood glucose and 0.28 and 0.90 for urine glucose).

This shows that there was no material changes when the energy derived from the various foods consumed in Table 3 was adjusted for age and sex.

Fasting blood glucose values correlated with urinary glucose values when cassava foods were consumed ($r = 0.78$, $p < 0.001$).

The weights of the foods eaten and the energy each food contributed to the total daily energy intake of each patients was also estimated and presented in Appendix K.

The 12 and 24 hour total energy intake from the diets consumed by each patient was calculated (Appendices L and M respectively) with the corresponding fasting blood and urine glucose.

Tables 6 and 7 show the mean fasting blood glucose and energy intake within 12 and 24-hour period when cassava was consumed. The mean energy intake at supper was significantly higher in those who consumed cassava than non-cassava consumers (p value = 0.0001). However, there was no correlation between the energy intake and fasting blood glucose within 24 hour period ($r = -0.15$, p-value = 0.34).

Table 6: Energy Intake (calories) and Fasting blood glucose (mmol/l) Concentration of cassava and non-cassava consumers at supper.

Variables	Cassava n = 40	Non-Cassava n = 40	p-value
Fasting Blood Glucose			
Mean	8.4	8.3	
SD	3.4	3.4	0.0001
Energy			
Mean	992.3	609.1	
SD	567.0	130.2	

SD= Standard Deviation

Table 7: Energy Intake (calories) and Fasting Blood glucose (mmol/l) concentration of cassava and non cassava consumers within 24 hours.

Variables	Cassava n = 40	Non Cassava n = 40	p-value
Fasting Blood Glucose			
Mean	8.4 3.4	8.3	0.34
SD		3.4	
Energy			
Mean	690.6	590.3	
SD	249.7	132.6	

SD= Standard Deviation

When the mean of urine volume and glucose excreted within 12 hour period at night were compared for cassava consumers and non cassava consumers there was no significant relationship (p-values were 0.18 and 0.07 respectively) (Table 8).

Table 8 Urine volume and urine glucose excreted within 12 hours at night by the diabetic patients

	Volume of Urine (m\l)			Glucose (mmo/l)		
	Cassava	Non Cassava	P value	Cassava	Non Cassava	P value
Mean	801	749	0.18	4.09	6.75	0.07
Standard Deviation	283	333		10.67	8.44	

Individual values of urine and glucose excreted within 12-hour period during the period of study are presented in Appendix N. There was no correlation between urine volume and glucose excreted by the subjects within 12 hour period at night ($r = 0.12$; p-value = 0.99) when cassava food was consumed by the patients.

There was also no significant difference in urine glucose excreted at night between sexes when cassava was consumed and when not consumed ($p=0.33$ and $p=0.55$ for males and females, respectively). When the means of urine glucose levels were compared with each other within the two sexes the p values obtained were 0.92 and 0.74, respectively, for cassava and non-cassava consumption.

There was no correlation between blood glucose and weight of the 40 subjects when cassava was consumed ($r=0.25$, $p=0.12$) (Table 9)

Individual weights and fasting blood glucose levels are presented in Appendix O.

Table 9 Blood Glucose and weight of the patients when cassava was consumed.

Variables	Cassava n = 40	r-value	p-value
Blood Glucose (mmol/l)			
Mean	8.45		
Standard Deviation	3.41	0.25	0.12
Body Weight (Kg)			
Mean	74.5		
Standard Deviation	14.1		

Table 10 is the correlation matrix of the various continuous variables measured in the study and their corresponding p-values. There is a significant relationship between weight and urine volume and between fasting blood glucose and urine glucose as shown by the respective p-values.

Table 10: Correlation Matrix of the following variables

	Weight	FBG	Energy	Urine glucose	Urine Volume	p-values
						1. p = 0.12
						2. p = 0.69
Weight	1.0	0.25[1]	0.07[2]	-0.06[3]	0.44[4]	3. p = 0.71
						4. p = 0.004
FBG		1.0	-0.15[5]	0.78[6]	0.11[7]	5. p = 0.34
						6. p = 0.001
Energy			1.0	0.00[8]	- 0.19[9]	7. p = 0.51
						8. p = 0.99
Urine Sugar				1.0	0.12[10]	9. p = 0.25
						10. p = 0.18
Urine Volume					1.0	

FBG = Fasting Blood Glucose

Superscripts indicate the corresponding p-values shown at the right side of the table.

Table 11 ANALYSIS OF VARIANCE TABLES

Variables Associated With a. Fasting Blood And b. Urine Glucose

a. FASTING BLOOD GLUCOSE

Variables	F	P-value
1. Age	0.69	0.411
2. Sex	0.00	0.995
3. Energy Intake	2.52	0.121
4. Age & Sex	0.40	0.676
5. Age & Energy Intake	1.47	0.243
6. Sex & Energy Intake	1.23	0.304
7. Sex & Age & Energy Intake	1.00	0.404

b. URINE GLUCOSE

Variables	F	P-value
1. Age	0.18	0.671
2. Sex	0.93	0.342
3. Energy Intake	0.32	0.573
4. Age & Sex	0.45	0.639
5. Age & Energy Intake	0.56	0.575
6. Sex & Energy Intake	0.24	0.791
7. Sex & Age & Energy Intake	0.37	0.778

CHAPTER FIVE
DISCUSSIONS, CONCLUSION AND RECOMMENDATION

5.1. DISCUSSIONS AND CONCLUSION

This study was undertaken at the diabetic clinic of the 37 Military Hospital, Accra where Physician specialists run the clinic on different days of the week. The patients who took part were all adult patients from one of the physician's clinic.

The participants were aged between 30 and 67 years and were all non-insulin dependent diabetics who were on diet alone or diet and hypoglycaemic drugs. There were more female patients (57.5%) than males (42.5%) (Table 1). The possible reason for this trend may be that more women sought medical treatment during the period of study.

Diet is very important in the management of diabetes. Diabetics need constant supply of food with the eating time well planned. Almost all the patients we saw were married (Table 1) and this may have enabled them to have regular supply of well-planned diets prescribed for them at the hospital.

Most study subjects had some level of education (Table 1). The implication of this on the disease is that diabetes is a chronic condition and for treatment to be effective, patients under management must be well informed about the condition, and this is easier and simpler when a patient has some education. Because many of them could read and write, it was not difficult for them to take simple dietary instructions. It can therefore be concluded that treatment of chronic conditions might be easier when patients can read simple instructions.

Diabetes mellitus can be hereditary or acquired at certain stages of an individual's life. Most of the time, people are not aware that they have the disease until they are taken ill and a health officer requests a routine laboratory investigation or specific investigation based on the signs and symptoms that the patient presents.

The results in Table 1 show that most patients were first told about their condition by their doctors. What can be inferred from this is that laboratory investigations will continue to be very important in the diagnostic management of diseases.

Body Mass Index (BMI) is commonly used to determine nutritional status in adults. Individuals with BMI above 25 kg/m^2 and those with BMI greater than 30 kg/m^2 are classified as overweight and obese patients respectively (WHO/NUT/NCD/98). There were quite a lot of patients who were overweight with BMI over $28kg/m^2$; very few (30%) were obese. However, the mean BMI was $28kg/m^2$ (Table 1).

Regardless of the type of diabetes one is suffering from, diet is important its [redacted] management. Increased awareness on the part of patients to the effect that diet is an important component in their treatment is necessary. Fortunately, all the study subjects appreciated that diet is important in diabetes management. This has encouraged compliance to the food prescribed. If, for instance, instructions on diet are not adhered to, one is likely to have fluctuations in blood glucose level which can either lead to hyperglycaemia or hypoglycaemia, the consequences of which can be fatal to the patient.

Polyuria (excessive urine production) is one of the cardinal symptoms normally experienced by diabetics. This is usually accompanied by polydipsia (excessive thirst). It was therefore not surprising that most of the patients reported these two cardinal symptoms (Table 2).

Out of the 40 subjects interviewed, 47.5% of them indicated they had stopped eating cassava and its products because of their condition. This was as a result of advice from various health personnel, friends and other diabetic patients (Table 2)

However, for the purpose of this study and in consultation with their physician, they agreed to consume cassava and its products after they had been educated.

The dietary recall technique enabled us to determine the type of foods each individual consumed (Table 3). The total energy intake from the various foods during supper and in 24 hours was calculated (Appendices L and M). Adjusting for energy for sexes and age did not show any significant change (Table 4). The mean energy intake was 383.2 kcal higher at supper when the patients ate cassava products than when they did not. The mean difference in energy intake at supper provided by individual foods was higher in cassava consumption than when cassava was not consumed (Table 6) (Appendix K). This observation was similar to the report of Brakohiapa et al, (1991). However, the mean energy intake for 24 hours period had no significant relationship ($r = -0.15$, $p = 0.34$) to the fasting blood glucose probably because the patients were on hypoglycaemic drugs. Michelle et al. (1984) made a similar observation when they examined the effect of various carbohydrate foods on diabetic children who were on treatment and those who were not. No appreciable increase in blood glucose level was observed in children who were on treatment.

Following a meal, the secretion of insulin facilitates the uptake, utilisation and storage of glucose, amino acids and fat (Brunner and Sudddath,1980). Insulin regulates the level of blood glucose which is formed from ingested carbohydrate and from the conversion of amino acid to glucose by the liver. In the normal person, the pancreas has the ability to adjust the quantity of insulin produced in relation to the intake of carbohydrate. However, for a diabetic person, this control function is completely lost (Guyton, 1968). To correct this defect, all patients were given well-planned and adequate diets and some received hypoglycaemic drugs which were found to be very effective in controlling the blood glucose level, irrespective of the

foods they ate at supper. The administration of hypoglycaemic drugs to the subjects might explain the similarity in glucose level despite the fact that the energy supplied by the foods was different. Therefore, it does not matter which food one eats; blood glucose level can be controlled with the correct medication (oral hypo-glycaemic drug or insulin) or by wise selection of the diet.

Even though the patients were allowed to choose foods freely for their diets, plantain fufu which is known to be preferred by diabetic patients was poorly patronised when compared with the number of people who ate fufu made from cassava (Table 3). Most Ghanaian homes normally mix plantain with cassava to prepare fufu and the patients studied patronised it during the period of the study because of the education they had, which gave them assurance for their safety. This might have accounted for the above observation made in this study. Cassava is processed into many different products such as gari, fermented and dried cassava and smoked cassava balls (Dovlo,1975). Some of these products were eaten by the subjects during the period of study. Thus, given proper guidance and encouragement, diabetic patients would like to eat every available cassava product to meet their energy requirement. This could have been an incentive to the patients, their relatives or caretakers, because cassava is cheaper and available.

Kontomire and bean stews (Table 3) were found to be regularly used by the patients whenever ampesi was eaten, irrespective of whether the ampesi was from cassava, yam, plantain or cocoyam. Vegetables supply fibre to the diet of the patients. Studies have shown that diets high in fibre improve the glycaemic balances of patients (Eugenio *et al.,* 1988). The physiologic effect of fibre is to delay gastric emptying and reduce absorption which consequently regulates the amount of glucose in the blood.

Some of the patients' diets were consumed with soups, but the most preferred was palm nut soup. Although fats and oil consumption by diabetics is treated with caution, the advice is mostly against the consumption of saturated fats and oils. This is because diabetes is often accompanied by blood vessel problems which worsen when a patient consumes fats and oils with saturated fatty acids (The American Diabetic Association, 1984).

The palm oil consumed by the majority of patients was from plant origin, which contains unsaturated fatty acids, and no cholesterol. The consumption of palm oil is less harmful to the patients and should be encouraged.

Meat, fish and beans were the main protein sources for the patients (Table 3). Fish was, however, more predominantly patronised by almost all of the patients (Table 3) because it was cheaper than meat.

Vegetables like kontomire, garden eggs, and tomatoes featured prominently in the patients' diets while fruits and raw sugar were lacking (Table 3). Fruits were avoided in the diets by the patients because of their sugar content. This observation was interesting because studies by Michelle *et al.* (1987) revealed that there is no need to restrict the intake of carbohydrate in the diets of diabetic patients, whether it is complex or simple carbohydrate. For instance, when the same weight of mono/disaccharides like glucose and sucrose, respectively, are taken, sucrose will lead to a higher elevation of glucose in the blood and will even be more when complex carbohydrates like starch is consumed (Wolever *et al.*,1994). Therefore, the distinction between complex and simple carbohydrates is becoming increasingly blurred especially when it relates to the management of diabetics on carbohydrate diets. Regular intake of prescribed drugs by the patients is what is required to control blood and urine glucose levels and not the type of food one eats.

The consumption of cassava and its products did not significantly increase fasting blood and urine glucose levels. This observation persisted irrespective of gender difference. Michelle *et al.* (1987) suggested that irrespective of the food one consumes, the blood glucose level will not be affected as long as the individual takes the prescribed drugs regularly.

The absence of differences in fasting blood glucose when cassava and non-cassava diets were consumed by the patients does not necessarily mean that cassava and other foods eaten at supper at different occasions do not contain different glycaemic indices. Comparison of the mean energy intake when cassava was consumed to the corresponding value when cassava was not consumed was significant ($p<0.0001$) indicating that the total energy content of the diet increased when cassava was consumed. However, the absence of a significant relationship between dietary energy intake and fasting blood glucose ($r= -0.15$ and p-value 0.34) of the subjects on treatment suggests that, when a diabetic patient is on treatment and the diet is properly planned, the effects of the type of foods consumed on the fasting blood and urinary glucose levels would be minimal.

Polyuria is normally associated with excretion of large amount of sugar in the urine. It was observed that in all the patients sampled, large amounts of urine were excreted. However, the amount of urine produced over 12 hour period at night was not directly related to the quantity of glucose in the urine ($r = 0.12$, p value >0.05). (Appendix N).

The study did not show any significant difference in the mean urinary glucose excreted within the 12 hour period in the night when cassava and non-cassava foods were consumed (p-value= 0.07). There were no significant differences among the males and females when cassava foods and non-cassava foods were consumed (p =

0.33 and p = 0.55 respectively). There were also no differences between the sexes when urinary glucose levels were compared with each other for cassava and non-cassava consumption (p = 0.92 and 0.74, respectively). There was no significant difference in the mean of urinary volume excreted (p -value = 0.18), which suggests that cassava consumption did not increase urine production when a diabetic patient is on drug.

The basis for urinary glucose test is the fact that glucosuria is correlated with hyperglycaemia (The American Diabetic Association, 1994) and indirect measurements of blood glucose may be obtained through urinary glucose excretion. The study showed a direct relationship between urinary glucose levels of individual and blood glucose levels (r= 0.78, p-value =0.001). This is similar to observations made by Hayford et al. (1983).

Cassava consumption does not bring about immediate changes in the body weight. This may be explained by the fact that within the period of study the mean weight of the patients when cassava was consumed (74.48kg) did not differ from the mean weight (74.49kg) when cassava was not consumed (p value =0.12).

There was also no change in fasting blood glucose when it was compared with the weights despite the consumption of different types of diets at supper (r = 0.25, p-value = 0.12). However, those who are already overweight or obese could be advised to reduce their energy intake or maintain their energy intake, but increase exercise in order to lose weight.

This study investigated the meal taken at supper and the energy content of the individual food within the meal consumed by the subjects. Energy values for some cassava products have been found to be very high. Notably among them was konkonte (Appendix K). However this did not bring about any appreciable rise in the

blood glucose level because of the hypoglycaemic drugs the patients were taking. Also, the multiple regressions models after adjusting for energy, sex and age, on the blood and urinary glucose (Tables 11), respectively, showed no significant differences.

The blood glucose and urinary glucose levels did not rise beyond normal irrespective of the food taken, because the patients were on treatment. On the other hand, if one eats cassava foods or other carbohydrate-rich foods as part of the diet without proper planning in accordance with the treatment, the blood glucose level could rise above normal.

5.2 RECOMMENDATION

Diet is very important in the management of diabetic patients and it is recommended that the best approach to dietary management should be to permit diet selection whilst the patient is on drug treatment. Permitting the consumption of free diet enables a diabetic to make a free choice of the variety of foods found in his or her environment.

Individual food products made from cassava have different energy content. Therefore eating the same quantity of different foods from the cassava source can provide different quantities of energy to the body. This does not mean that because these food products have high energy values they should be eliminated from the diet of a diabetic patient. The present study did not find any significant elevation of blood glucose level when the patients included cassava or its products in their diets while receiving treatment, compared to when they did not eat cassava products. Therefore, it can be recommended that diabetic can consume diets made of cassava as long as they are on hypoglycaemic drugs.

Nutrition and dietetics form a very minimal part of the medical and nursing curriculum. Health professionals, especially doctors, come into contact frequently with diabetic patients. Doctors often diagnose the disease and therefore are the first people who interact with patients on the management of diabetes. Nurses later take over from the doctors in the education of patients on required diet. It is therefore recommended that every health personnel who is involved in the education of diabetic patients should periodically have a chance of attending in-service training on nutrition and the management of diabetes.

Diabetes is a disease which is growing in the whole world, but sadly enough, very few studies have been conducted in diabetes management using local foods in Ghana. Since cassava is a cheap staple readily available most of the year, more studies are required on the effect of cassava and its products on diabetes. There is also the need for studies on the dietary management of diabetes to be widened to include the effect of both macro and micro-nutrients.

Hitherto, most studies have been based on foods which provide only energy.

Other studies should focus on nutrients which do not necessarily provide energy but tremendously influence the chemical processes of the body. It is hoped that such studies may adequately address the dietary problems of diabetics and bring relief to majority of them.

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APPENDIX A NUTRITION AND FOOD SCIENCE DEPARTMENT (LEGON)

STUDY QUESTIONNAIRE

A. PERSONAL DATA

1. Age:--------- 2. Sex: Male [ ] Female [ ]

3. Marital Status: Married [ ] Not married [ ] Divorced [ ] Other [ ]

Specify ----------

4. Educational Background

Elementary [ ] Secondary/Training College [ ] University [ ] Other [ ]

Specify ----------

5. Place of Residence/House Number: --------

6. With whom are you staying in the house?

Wife [ ] Children [ ] Sister/Brother [ ] Other [ ] (Specify) --------

B. ANTHROPOMETRIC MEASUREMENTS

7. Weight: -------- 8. Height: -------- 9. Body Mass Index (BMI): ----

C. DISEASE HISTORY

10. How did you know you have diabetes?

Was told by a doctor [ ] Was told by a nurse [ ] Through the signs and Symptoms [ ] Other [ ] (Specify) ---------

11. For how long now since you were diagnosed as a diabetic patient?

A week [ ] A month [ ] A year [ ] Other [ ] (Specify)-------

12. Do you have any family history of diabetes? Yes [ ] No [ ]

12b. Which member of the family?

Father [ ] Mother [ ] Uncle [ ] Other [ ] Specify -------

13a. Are you on treatment? Yes [ ] No [ ]

13b. If yes, what type of treatment?

Diet [ ] Diet and hypoglycaemic drugs [ ] Diet and insulin [ ]

D. KNOWLEDGE ABOUT THE DISEASE

14 Do you know any signs and Symptoms of diabetes? Yes [ ] No [ ]

15. Which of the following signs and symptoms do you experience?

i. Polyuria [ ] ii. Polydipsia [ ] iii. Polyphagia [ ]

iv. Glucosuria [ ] v. Weight loss [ ] vi. All of the above [ ]

16. Do you pass a lot of urine especially at night? Yes [ ] No [ ]

17. How many times do you wake up to pass urine at night? ----------

18. What will be the taste of diabetic urine?

i. Sugary [ ] ii. Salty [ ] iii. Acidic [ ]

19. Do you think diet can be very important in the treatment of diabetes?

Yes [ ] No [ ]

E. DIETARY HABIT

20. Who prepares your food in the house?

Wife [ ] Daughter [ ] Sister [ ] Other [ ]Specify _____

21. Do you eat or drink between meals? Yes [ ] No [ ]

21b. If yes what food or drink do you like in between meals? ----------

22. What foods do you dislike before you got to know that you have diabetes mellitus? ----------

23. Would you like to eat them now? Yes [ ] No [ ]

24. What foods do you usually eat at the following periods of the day?

Morning _____ Afternoon _____ Evening _____

25. What time of the day do you normally eat in-between meals?

After breakfast [ ] After lunch [ ] After supper [ ] Other [ ] Specify _____

26. Do you eat cassava or any of its products? Yes [ ] No [ ]

26b. If yes, give the name of specific cassava food you like eating. ----------

26c. If no, give reasons ----------

27. Would you like to continue to eat cassava or any of its products? Yes [ ]

No [ ]

27b. If no, what are your reasons for not eating cassava and its products.

APPENDIX B

SAMPLE SIZE DETERMINATION

PROCEDURE

$$N = \frac{(Z1-\beta + Z1-a)^2 6}{(\mu_1 - \mu_2)^2}$$

n = The sample size to be calculated

$Z_1 - \beta$ = Power

$Z_1 - \alpha = 1$ – type one error

$\mu_1 \quad \mu_2$ = The expected difference if any in blood or urine sugar levels when diabetic consumes cassava

$1 - \beta = 80\%$ power of the study

α- level = 1%

Desired Difference = 1.2 mmol/L

Weighted standard deviation (6)= 5.1

$$N = \frac{5.1 (Z_{0.8} + Z_{0.99})^2}{(1.2)^2}$$

$$\frac{5.1(0.84 + 2.33)^2}{(1.2)^2}$$

$$= (3.17)25.1$$
$$\frac{(10.05)5.1}{1.44}$$

$$= \frac{51.26}{1.44}$$

$$= 35.6$$

APPENDIX C - FASTING BLOOD GLUCOSE (MMOL/L)

(Y=CASSAVA CONSUMPTION N=NON-CASSAVA CONSUMPTION)

S/No.	Fby1	Fbn1	Fby2	Fbn2	Fby3	Fbn3	Fby4	fbn4	Fby5	fbn5
1	29.6	13.8	10.7	12.5	11.2	10.7	8.0	9.0	9.0	8.0
2	4.9	6.0	4.8	6.1	4.4	4.6	5.2	4.6	4.6	4.6
3	9.2	7.6	9.5	7.4	8.3	7.8	6.6	7.0	6.2	7.1
4	16.1	16.6	14.3	18.8	16.6	21.5	22.9	18.5	22.9	18.5
5	16.1	15.7	6.9	11.5	15.7	10.4	7.0	10.4	15.7	7.0
6	5.0	6.2	5.5	5.5	6.5	4.9	7.1	7.4	7.2	7.3
7	6.2	6.6	5.2	7.6	7.9	7.4	7.5	7.0	7.5	7.0
8	4.8	6.1	7.5	5.6	5.2	6.1	5.2	7.3	7.0	7.2
9	12.9	12.1	13.6	13.4	12.9	10.1	10.4	12.2	12.0	11.2
10	7.8	4.6	9.5	11.3	10.7	7.5	9.6	6.6	7.0	6.6
11	6.2	6.4	5.6	3.7	5.5	5.7	5.5	4.6	5.8	5.5
12	13.3	11.2	10.2	6.4	10.4	8.7	8.1	7.4	7.0	7.5
13	4.9	4.5	10.7	10.9	5.9	6.1	6.7	6.1	6.7	6.0
14	5.1	5.5	7.5	5.8	3.9	6.5	5.2	4.4	4.4	4.5
15	6.1	6.9	8.4	5.5	3.7	3.5	5.5	3.0	3.9	5.1
16	11.2	10.1	15.2	11.1	10.5	11.3	11.2	10.2	11.2	10.2
17	10.1	7.2	8.4	13.4	11.1	5.7	7.4	9.6	7.0	9.0
18	6.4	6.8	6.1	8.2	6.4	7.3	7.4	6.8	6.8	7.0
19	7.0	8.6	10.1	8.6	8.3	7.8	7.8	9.6	7.0	7.1
20	15.7	9.7	11.7	10.4	3.5	7.4	6.5	8.5	7.0	7.0
21	3.7	12.9	3.7	3.7	5.3	5.5	3.7	7.4	3.7	6.5
22	5.0	3.5	4.3	4.4	5.3	4.8	4.5	4.4	4.4	4.5
23	7.5	5.5	6.1	6.8	7.3	6.1	6.4	6.4	6.4	6.5
24	5.3	6.0	6.4	8.0	7.2	8.5	7.0	7.4	7.4	7.0
25	4.8	5.3	4.7	6.1	5.5	7.2	5.5	4.4	4.4	5.0
26	8.6	8.6	8.6	8.0	9.0	8.3	10.2	8.3	9.0	10.1
27	11.1	9.3	11.4	9.9	20.3	12.9	11.4	16.1	11.1	12.2
28	10.2	6.4	5.9	8.7	14.8	6.2	10.7	3.4	6.9	8.5
29	11.1	5.2	9.4	9.3	8.3	8.8	8.3	8.4	8.1	9.1
30	11.1	14.0	9.8	10.7	9.0	9.1	8.8	9.8	10.7	11.1
31	8.8	9.2	10.3	9.0	8.3	8.5	5.2	3.9	5.1	4.0
32	3.5	6.2	7.2	7.2	4.8	1.6	1.6	6.1	6.6	6.1
33	15.0	20.3	20.7	17.5	17.5	15.7	17.2	23.5	20.0	23.0
34	13.1	13.3	11.1	12.1	11.4	12.1	12.0	11.1	12.0	11.9
35	4.4	7.1	6.9	7.5	6.8	5.1	6.6	7.1	6.0	7.1
36	7.4	4.1	4.2	6.4	6.3	5.9	6.0	6.2	6.0	6.9
37	6.9	6.7	8.5	6.5	8.1	8.9	7.0	7.4	7.0	7.4
38	4.5	4.1	4.4	4.6	8.3	4.8	4.8	4.1	4.7	4.6
39	9.3	7.0	9.2	9.6	8.5	7.4	7.0	6.6	7.2	7.0
40	11.5	8.8	8.8	11.5	9.2	10.2	9.2	11.3	9.0	10.1

FBY=Fasting blood glucose (Cassava) FBN=Fasting blood glucose (No cassava)

APPENDIX D URINARY GLUCOSE (MMOL/ML)

(Y=CASSAVA CONSUMPTION N=NON-CASSAVA CONSUMPTION)

S/No.	Usy1	Usn1	Usy2	Usn2	Usy3	Usn3	Usy4	Usn4	Usy5	Usn5
1	8.80	32.90	46.7	5.10	35.10	8.30	7.10	1.00	5.10	7.00
2	4.10	0.80	1.0	8.80	0.30	0.74	0.89	0.30	0.30	0.30
3	5.30	0.70	0.6	0.50	0.50	0.71	0.55	0.56	0.54	0.55
4	17.00	17.60	32.2	35.60	44.40	31.20	47.60	21.40	47.60	21.40
5	17.90	37.80	2.8	5.30	5.20	25.30	10.70	5.20	5.20	25.30
6	1.80	0.90	37.0	0.60	1.10	0.90	4.90		4.50	7.30
7	1.10	1.50	0.5	0.70	0.60	0.50	1.80	0.90	1.90	0.90
8	4.60	1.40	7.0	0.55	0.60	0.30	1.00	1.10	1.10	1.20
9	10.20	32.90	14.8	14.70	17.60	10.30	41.50	26.30	25.60	31.10
10	7.70	9.20	12.1	0.60	0.30	0.70	5.00	1.10	1.70	1.20
11	3.30	1.50	0.6	0.30	0.90	0.70	0.60	0.70	0.60	0.70
12	9.80	8.10	4.4	13.60	11.50	1.10	24.10	1.10	5.90	25.90
13	1.40	1.00	4.5	0.70	0.40	3.90	35.10	0.70	36.00	0.80
14	10.90	41.50	1.1	0.70	0.20	0.60	0.40	0.90	0.40	0.90
15	1.60	0.30	4.8	0.70	0.74	0.60	0.40	0.80	1.10	0.70
16	24.40	8.10	34.0	18.20	2.50	37.30	17.70	16.60	17.60	16.20
17	24.00	35.10	32.2	26.00	0.38	3.90	28.80	16.60	28.00	17.00
18	7.50	15.70	1.5	2.50	1.70	1.90	3.30	1.10	1.10	3.30
19	0.09	1.00	1.3	4.80	2.20	1.50	1.30	0.40	1.20	0.50
20	35.10	25.80	76.5	16.20	33.30	6.80	17.60	17.60	8.00	17.00
21	0.37	0.37	0.7	0.90	0.92	2.20	4.50	1.30	4.40	1.20
22	0.37	0.37	0.7	2.00	0.92	0.90	1.10	0.60	0.60	1.20
23	1.40	1.10	2.8	2.10	0.57	0.90	0.40	0.00	0.60	0.10
24	0.37	0.10	3.5	40.20	1.20	9.20	21.10	12.90	1.60	1.80
25	0.37	0.57	4.4	0.37	1.50	2.80	0.93	0.37	0.30	0.92
26	6.00	3.10	10.5	5.50	6.10	22.20	25.90	22.00	10.10	25.90
27	30.30	16.40	35.1	16.60	33.30	1.50	35.10	17.90	30.30	52.90
28	35.10	4.20	1.1	16.60	49.90	2.20	15.90	0.92	0.92	1.10
29	2.60	5.90	0.7	1.10	0.92	1.50	0.91	0.17	0.90	1.10
30	33.30	33.30	11.5	16.60	11.00	16.50	10.00	16.00	15.00	15.90
31	35.10	4.90	22.8	0.70	33.30	8.30	10.20	1.70	9.00	1.20
32	6.00	6.60	2.1	2.70	1.20	35.10	0.30	49.30	0.89	49.30
33	31.20	8.30	51.9	25.80	35.10	35.10	42.90	1.20	8.30	1.20
34	35.10	17.50	35.1	38.90	40.30	46.70	33.30	27.80	34.00	27.00
35	4.80	1.00	1.0	2.50	0.74	0.50	2.10	2.50	1.10	2.00
36	0.50	0.90	0.7	0.70	0.40	0.40	0.40	0.40	0.50	0.70
37	1.00	0.37	0.4	0.70	0.70	0.40	0.50	0.40	0.40	0.60
38	1.00	0.55	1.0	0.90	0.90	0.70	0.70	0.40	0.80	0.50
39	1.00	0.55	0.4	0.90	0.50	0.50	0.60	0.50	0.60	0.60
40	4.90	40.50	1.1	2.20	3.50	1.50	1.60	6.80	1.50	1.70

FUSY =Fasting urinary glucose (Cassava)

FUSN=Fasting urinary glucose (No cassava)

APPENDIX E URINE VOLUME (MLS)
(Y=CASSAVA CONSUMPTION N=NON-CASSAVA CONSUMPTION)

S/No	Uvy1	Uvn1	Uvy2	Uvn2	Uvy3	Uvn3	Uvy4	Uvn4	Uvy5	Uvn5
1	720	620	1280	500	1120	640	880	660	770	860
2	700	700	880	640	820	560	540	780	780	540
3	440	400	700	540	640	640	820	400	800	300
4	920	840	960	940	900	860	920	460	920	640
5	520	1200	400	820	820	800	900	820	800	900
6	800	960	880	1100	1100	780	980	880	980	880
7	1520	1320	1820	1500	1220	1820	1240	1960	1240	1960
8	1020	720	940	660	680	600	920	480	400	480
9	650	650	860	900	480	1080	920	910	650	920
10	440	460	400	360	710	440	500	500	440	500
11	920	780	720	360	720	640	1000	880	980	840
12	900	900	910	1520	1200	142	1180	880	1000	960
13	840	1020	740	640	860	160	880	600	610	480
14	280	820	840	760	300	700	580	1080	980	900
15	820	500	500	500	500	760	820	450	460	500
16	160	1260	520	2040	2020	1200	3010	2060	2060	3010
17	510	640	840	740	800	580	740	880	700	800
18	620	260	220	260	220	280	260	220	250	230
19	780	520	680	680	180	630	860	740	800	820
20	800	1320	560	740	540	400	580	420	520	400
21	1680	440	540	380	540	540	540	540	500	530
22	880	740	620	960	800	800	920	460	450	400
23	1000	300	320	120	820	390	440	740	720	720
24	1320	500	240	260	480	480	400	720	600	550
25	284	260	300	760	300	380	420	400	420	400
26	340	630	350	600	640	360	360	340	400	520
27	1440	1340	1280	780	1040	780	700	900	900	840
28	1100	660	640	760	880	1200	860	460	400	350
29	1480	1380	1040	1120	1020	1400	1025	1022	1450	1200
30	800	680	460	100	470	150	200	270	500	300
31	240	440	400	340	300	420	580	300	480	350
32	760	900	960	860	880	980	860	980	850	840
33	980	440	860	720	840	1000	800	840	800	770
34	1060	1260	840	840	460	560	580	560	570	550
35	1500	1080	700	1160	110	1140	1500	860	800	900
36	900	740	1200	960	920	920	920	900	900	920
37	500	580	420	580	600	600	480	600	500	450
38	1200	1320	780	1120	1440	1100	1280	1020	1270	1010
39	1460	700	720	1060	1280	1260	1120	1040	1130	1040
40	420	1320	620	640	400	400	450	400	4500	400

UVY = Urine Volume Excreted (Cassava) UVN = Urine Volume Excreted (No Cassava)

APPENDIX F URINARY GLUCOSE CONCENTRATION MMOL/MLS

			(Y=CASSAVA	CONSUMPTION	N=NON-CASSAVA	CONSUMPTION)				
S/No.	Uscy1	Uscn1	uscy2	Uscn2	Uscy3	Uscn3	Uscy4	uscn4	Uscy5	uscn5
1	6.3	20.4	59.8	2.6	39.3	5.3	6.1	0.7	3.9	6.0
2	28.7	5.6	8.8	56.3	2.5	4.1	4.8	2.3	2.3	4.0
3	2.3	0.3	0.4	0.3	0.3	0.4	0.5	0.2	0.4	0.2
4	15.6	14.8	30.9	33.5	40.0	26.8	43.8	13.7	43.8	13.7
5	9.3	44.4	1.1	4.3	4.3	20.2	9.6	4.3	4.2	22.8
6	1.4	0.9	32.6	0.6	1.2	0.7	4.8	6.5	4.4	6.4
7	1.7	2.0	0.9	1.1	0.7	0.7	2.2	1.8	2.4	1.8
8	4.7	1.0	6.6	0.4	0.4	0.2	0.9	0.5	0.4	0.6
9	21.4	21.4	12.0	13.2	8.4	11.3	38.2	24.4	16.6	28.6
10	3.4	4.2	4.8	0.2	0.2	0.3	2.5	5.5	0.7	0.6
11	1.4	1.2	0.4	0.1	0.6	0.5	0.1	0.7	0.5	0.6
12	9.0	8.4	4.0	20.7	13.6	1.6	28.4	1.0	5.9	24.9
13	1.2	1.0	3.3	4.7	0.3	0.6	30.9	0.4	22.0	0.4
14	3.1	34.0	0.9	0.6	0.1	0.4	0.2	1.0	0.4	0.8
15	1.3	0.2	2.4	0.4	0.4	0.1	0.3	0.4	0.5	0.4
16	10.2	10.2	17.7	37.1	5.1	40.4	53.3	34.2	24.2	53.3
17	12.2	33.0	27.0	19.2	0.3	2.3	21.3	14.6	19.6	13.6
18	4.1	4.1	0.3	0.7	0.4	0.5	0.9	0.2	0.3	0.8
19	0.1	0.5	0.9	3.3	0.4	0.9	1.1	0.3	1.0	0.4
20	28.1	34.1	42.8	11.6	18.0	2.7	10.2	7.4	3.1	2.4
21	0.6	0.2	0.4	0.3	0.5	1.2	2.4	0.7	2.2	0.6
22	0.3	0.3	0.5	1.9	1.7	0.7	1.0	0.3	0.3	0.5
23	1.4	0.3	0.9	0.3	0.5	0.4	0.2	0.0	0.0	0.1
24	0.1	0.1	0.8	10.4	0.6	4.4	8.6	5.4	1.0	1.0
25	0.1	0.2	1.3	0.3	0.5	1.1	0.4	0.1	0.1	0.4
26	2.0	1.9	3.7	3.3	2.1	8.0	9.3	7.5	4.0	10.8
27	43.6	22.0	45.0	13.0	34.6	1.4	24.6	16.1	27.3	44.3
28	38.6	2.8	0.8	12.6	43.9	2.6	13.6	0.4	0.4	0.4
29	3.8	8.1	0.7	1.2	0.9	2.4	0.9	0.2	1.3	1.3
30	26.6	22.6	5.3	1.7	5.2	2.5	2.0	4.3	7.5	48.0
31	8.4	2.2	9.1	0.2	1.0	3.5	5.9	0.3	4.3	0.4
32	5.0	1.9	2.6	1.1	30.9	0.3	42.4	0.9	41.9	0.8
33	30.6	3.7	49.8	18.6	39.5	35.1	34.3	1.0	6.6	0.9
34	37.2	22.1	24.5	29.5	18.4	26.6	19.3	15.6	19.4	14.7
35	7.2	1.1	0.7	2.9	0.8	0.6	3.2	2.2	0.9	1.8
36	0.5	0.7	0.8	0.7	0.4	0.4	0.4	0.4	0.5	0.7
37	0.5	0.2	0.2	0.4	0.4	0.4	0.2	0.3	0.2	0.3
38	1.2	0.7	7.8	1.0	1.3	0.8	0.9	0.4	1.0	0.5
39	1.5	0.4	0.3	1.0	0.6	0.6	0.6	0.5	0.7	0.6
40	2.1	0.2	0.7	1.5	1.4	0.6	0.7	2.7	0.7	0.7

USCY = 12 hour urine sugar (Non fasting) Cassava.
USCN = 12 hour urine sugar (Non fasting) No Cassava

APPENDIX G PLASMA OR SERUM/URINE

Pipette into test tube	Reagent Blank	Standard	Sample
Standard	-	10 µl	
Sample		-	10 µl
Working Reagent	1000 µl	1000 µl	1000 µl

The solutions, the sample, standard and reagents as shown in the table above.

Ref: Trinder PA (1969). Clinical Biochemistry. Vol.6 p.24

APPENDIX H CALCULATION OF GLUCOSE IN THE SAMPLE

$$\frac{\text{A sample}}{\text{A standard}} \times \text{Standard Concentration} = \text{Glucose concentration}$$

The expected values of glucose in the serum or plasma (fasting) are as follows:

4.2 – 6.1 mmol/L
76 –110 mg/dl

Ref: Trinder PA (1969). Clinical Biochemistry. Vol.6 p 24.

APPENDIX I WEIGHT, HEIGHT AND BMI OF SUBJECTS

Rec. No.	WEIGHT Kg	HEIGHT m^2	BMI kg/m^2
1.	90	2.6	34.6
2.	60	2.6	23.1
3.	64	2.6	24.6
4.	61	2.6	23.5
5.	76	2.9	26.2
6.	74	2.6	28.5
7.	67	2.3	29.1
8.	76	3.2	23.6
9.	75	2.6	28.8
10.	73	2.6	28.2
11.	71	2.3	30.9
12.	61	2.6	23.5
13.	79	2.9	27.2
14.	56	2.9	19.3
15.	74	2.9	25.5
16.	50	2.3	21.7
17.	110	2.9	37.9
18.	87	2.9	30.0
19.	79	2.3	34.3
20.	79	2.3	34.3
21.	62	2.9	21.4
22.	68	2.6	26.2
23.	61	2.6	23.5
24.	73	2.9	25.2
25.	84	2.6	32.3
26.	68	2.6	26.2
27.	63	2.9	21.7
28.	65	2.9	22.4
29.	76	2.9	26.6
30.	124	2.8	44.3
31.	175	2.6	28.8
32.	83	2.8	29.6
33.	92	3.2	28.8
34.	88	2.7	35.5
35.	81	3.2	25.3
36.	78	2.3	33.9
37.	72	2.9	24.8
38.	68	2.6	26.2
39.	91	2.6	35.0
40.	59	2.3	25.6
Mean	**76**	**2.7**	**28.0**
Standard Deviation	**22**	**0.3**	**5.2**
Range	**125**	**1.6**	**18.6**

APPENDIX J FASTING BLOOD AND URINARY GLUCOSE MEASUREMENT FOR DIABETIC PATIENTS

FASTING BLOOD GLUCOSE (mmol/l)				URINARY GLUCOSE (mmol/l)		
S/No	Mean fby^1	Mean fbn^2	Mean (fby^1-fbn^2)	Mean usy^3	Mean usn^4	Mean (usy^3-usn^4)
1	13.70	10.80	2.90	20.56	10.86	9.70
2	4.78	5.18	-0.40	1.32	2.19	-0.87
3	7.96	7.38	0.58	1.50	0.60	0.90
4	18.56	18.78	-0.22	37.76	25.44	12.32
5	12.26	11.00	1.28	8.36	19.78	-11.42
6	6.26	6.26	0.00	9.86	3.42	6.44
7	6.86	7.12	-0.26	1.18	0.90	0.28
8	5.94	6.46	-0.52	2.86	0.91	1.95
9	12.36	11.80	0.56	21.94	23.06	-1.12
10	8.92	7.32	1.60	5.36	2.56	2.80
11	5.72	5.18	0.54	1.20	0.78	0.42
12	9.80	8.24	1.56	11.14	9.96	1.18
13	6.98	6.72	0.26	15.48	1.42	14.06
14	5.22	5.34	-0.12	2.60	8.92	-6.32
15	5.52	4.80	0.72	1.73	0.62	1.11
16	11.86	10.58	1.28	19.24	19.28	-0.04
17	8.80	8.98	-0.18	22.70	19.72	2.98
18	6.62	7.22	-0.60	3.08	4.90	-1.82
19	8.04	8.34	-0.30	1.22	1.64	-0.42
20	8.88	8.60	0.28	34.10	16.68	17.42
21	4.02	7.20	-3.18	2.19	1.19	1.00
22	4.70	4.32	0.38	0.74	1.01	-0.27
23	6.74	6.26	0.48	1.15	0.84	0.31
24	6.66	7.38	-0.72	5,50	12.84	-7.34
25	4.98	5.60	-0.62	1.44	1.01	0.43
26	9.08	8.66	0.42	11.72	15.74	-4.02
27	13.06	12.08	0.98	32.82	21.06	11.76
28	9.70	6.64	3.06	20.59	5.00	15.59
29	9.04	8.16	0.88	1.21	1.95	-0.74
30	9.88	10.94	-1,06	16.16	19.66	-3.50
31	7.54	6.92	0.62	22.08	3.36	18.72
32	4.74	5.44	-0.70	2.10	28.60	-26.50
33	18.08	20.00	-1.92	33.88	14.32	19.56
34	11.92	12.10	-0.18	35.56	31.58	3.98
35	6.14	6.78	-0.64	1.95	1.70	0.25
36	5.98	5.90	0.08	0.50	0.62	-0.12
37	7.50	7.38	0.12	0.60	0.49	0.11
38	5.34	4.44	0.90	0.88	0.61	0.27
39	8.24	7.52	0.72	0.62	0.61	0.01
40	9.54	10.38	-0.84	2.52	10.54	-8.02
Mean	**8.45**	**8.26**	**0.19**	**10.43**	**8.66**	**1.77**
Standard Deviation	**3.41**	**3.36**	**0.05**	**11.86**	**9.31**	**2.54**

fby^1 = fasting blood sugar (cassava) **usy^3 = urine sugar (cassava)**
fbn^2 = fasting blood sugar (no cassava **usn^4 = urine sugar (no cassava)**
fby^1-fbn^2 = Mean Difference **usy^3-usn^4 = Mean Difference**

KEY TO APPENDIX K

Weight = Gramme Energy = Calories

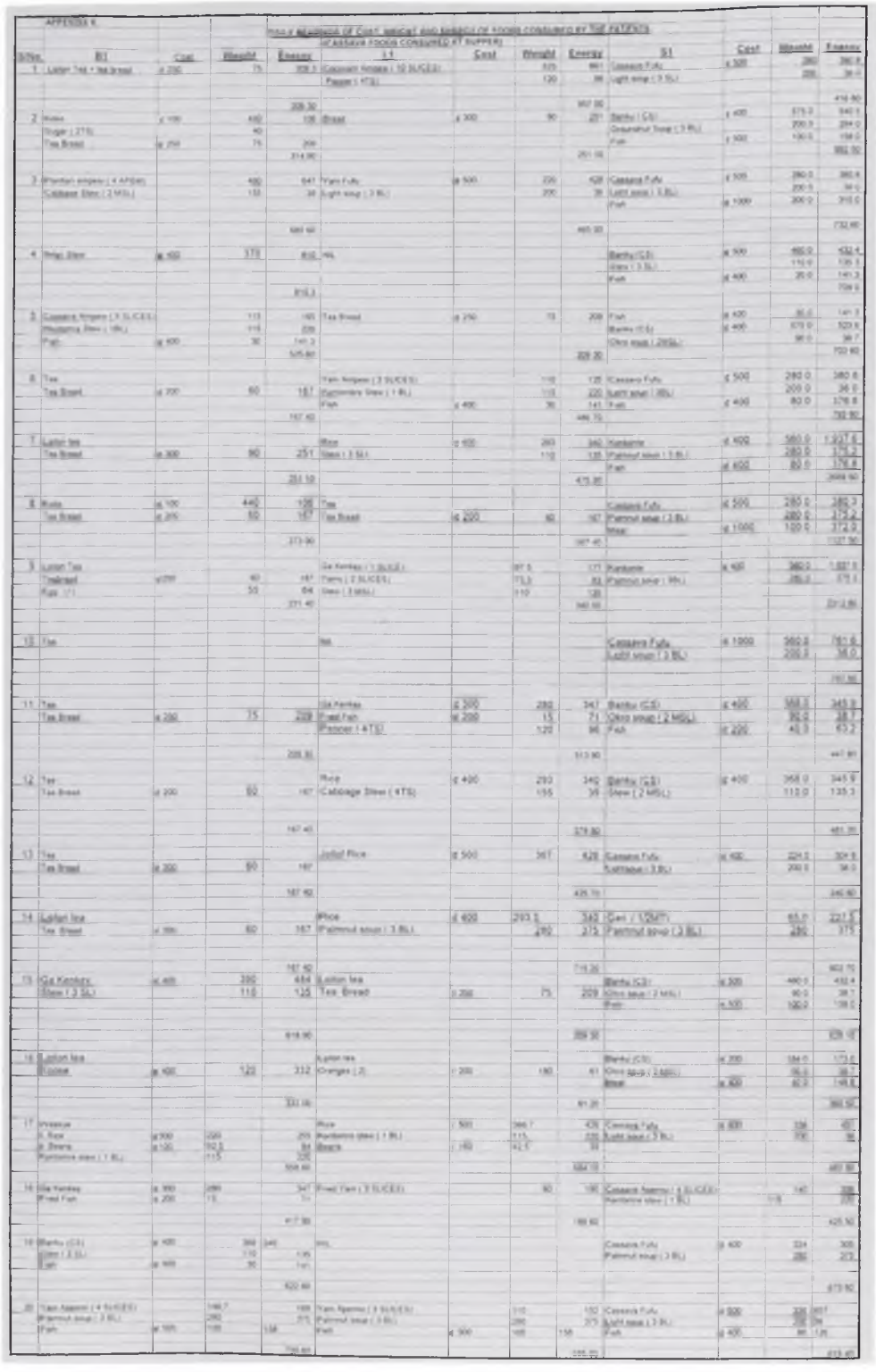
B = Breakfast L = Lunch S = Supper

1 = Day 1 2 = Day 2 3 = Day 3 4 = Day 4 5 = Day 5

BL = Big Ladle SL = Small Ladle TS= Teaspoon

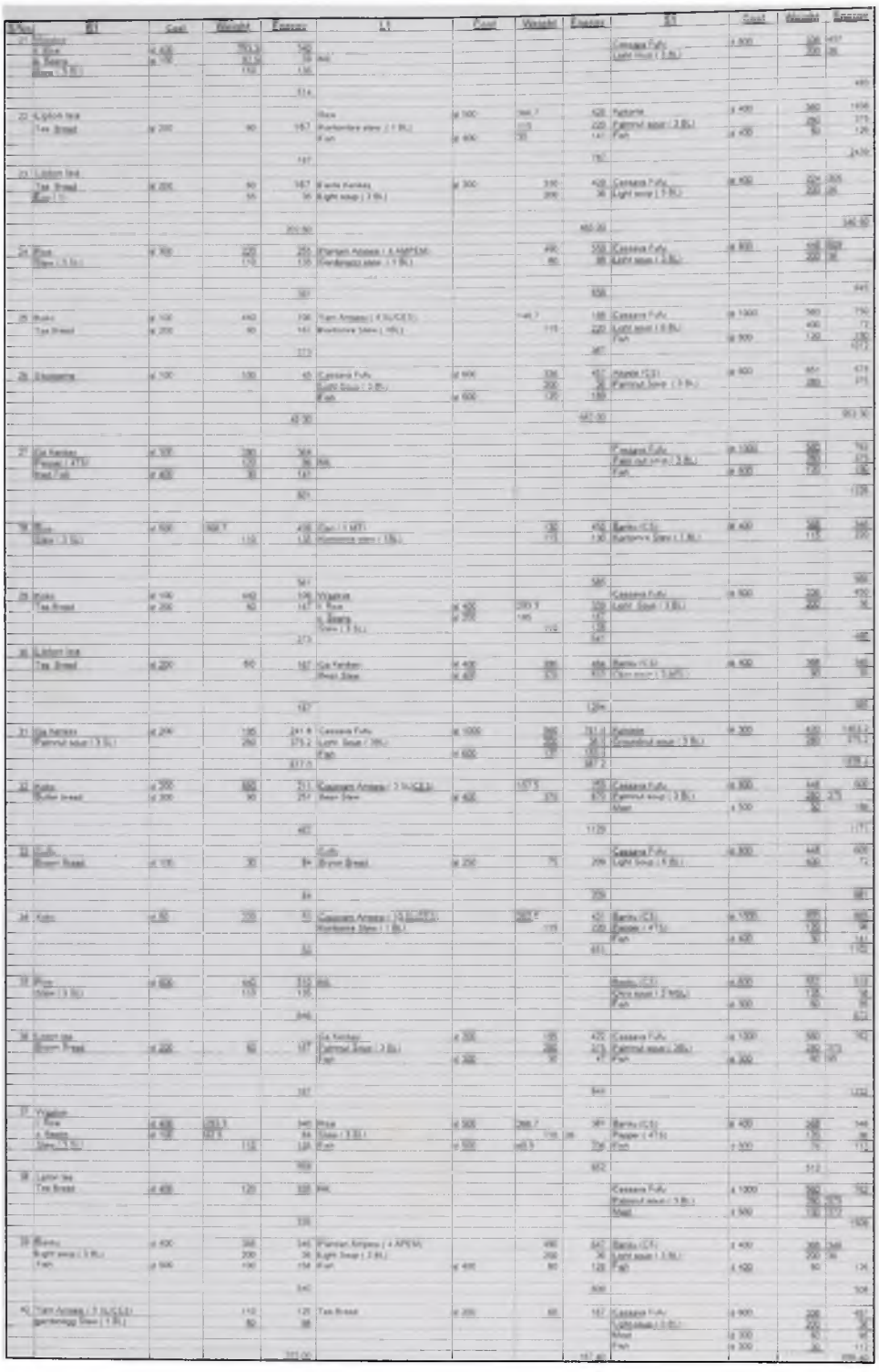
MSL = Medium Size Ladle MT = Milk Tin

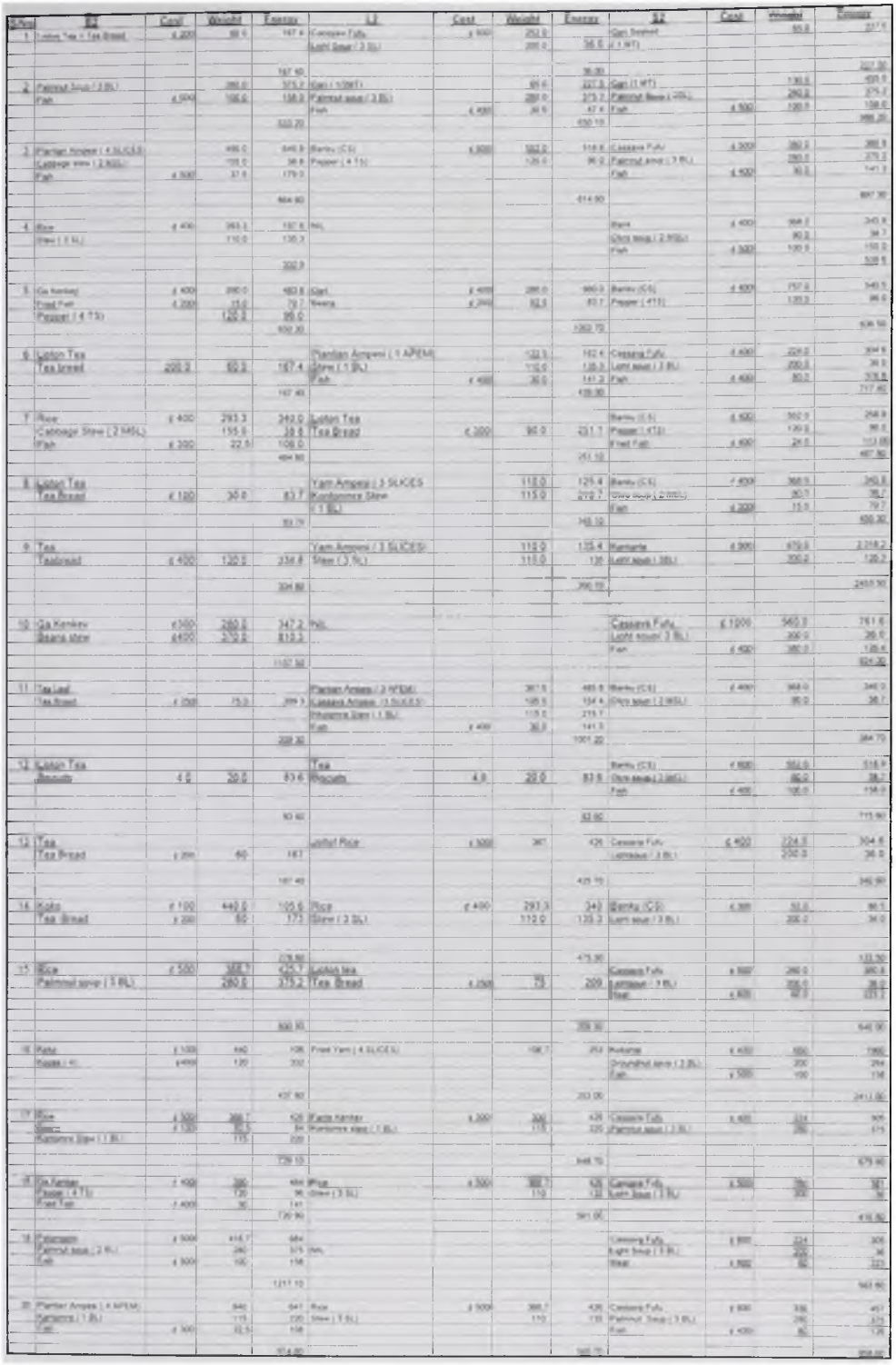
APPENDIX K

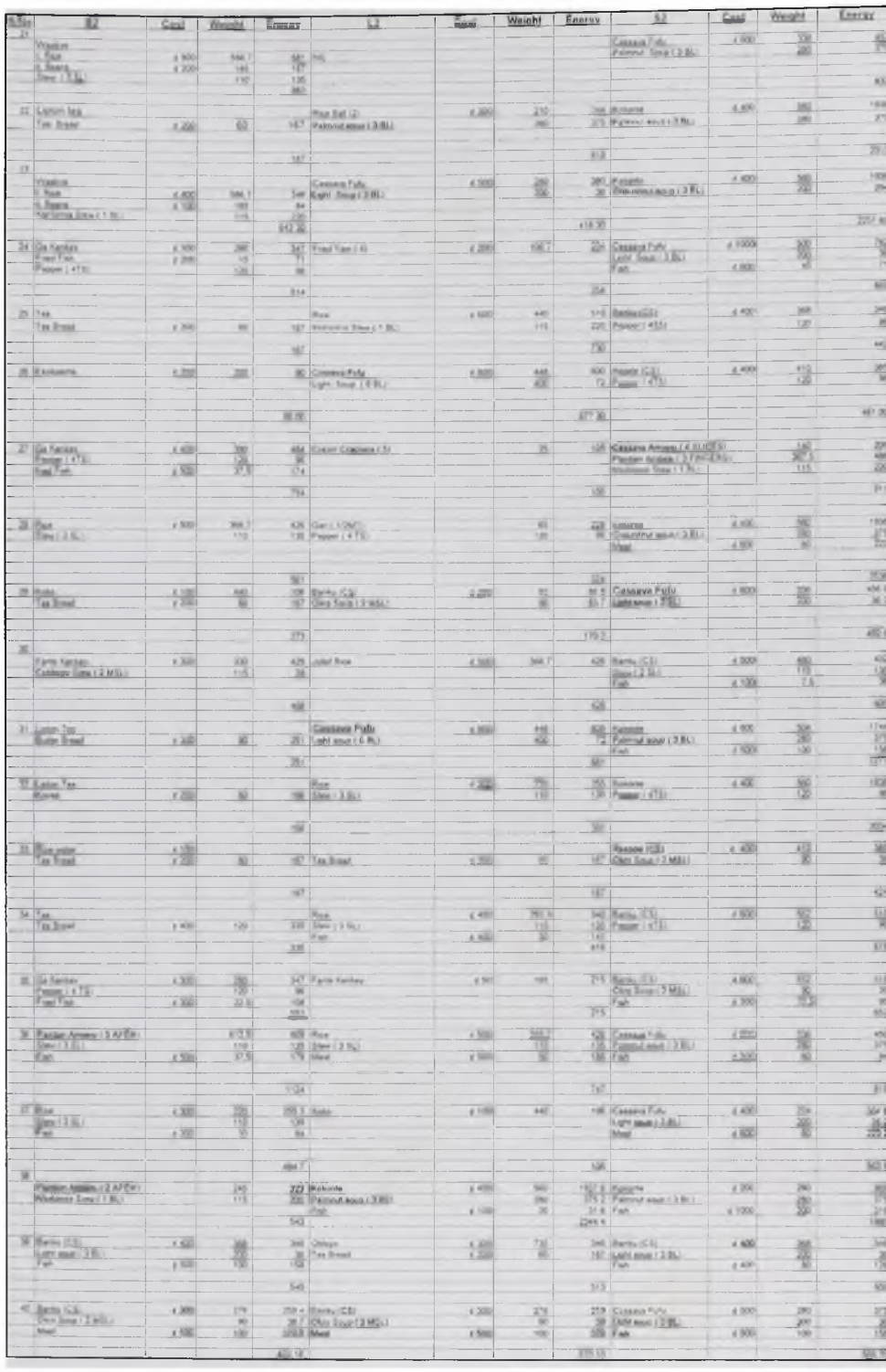


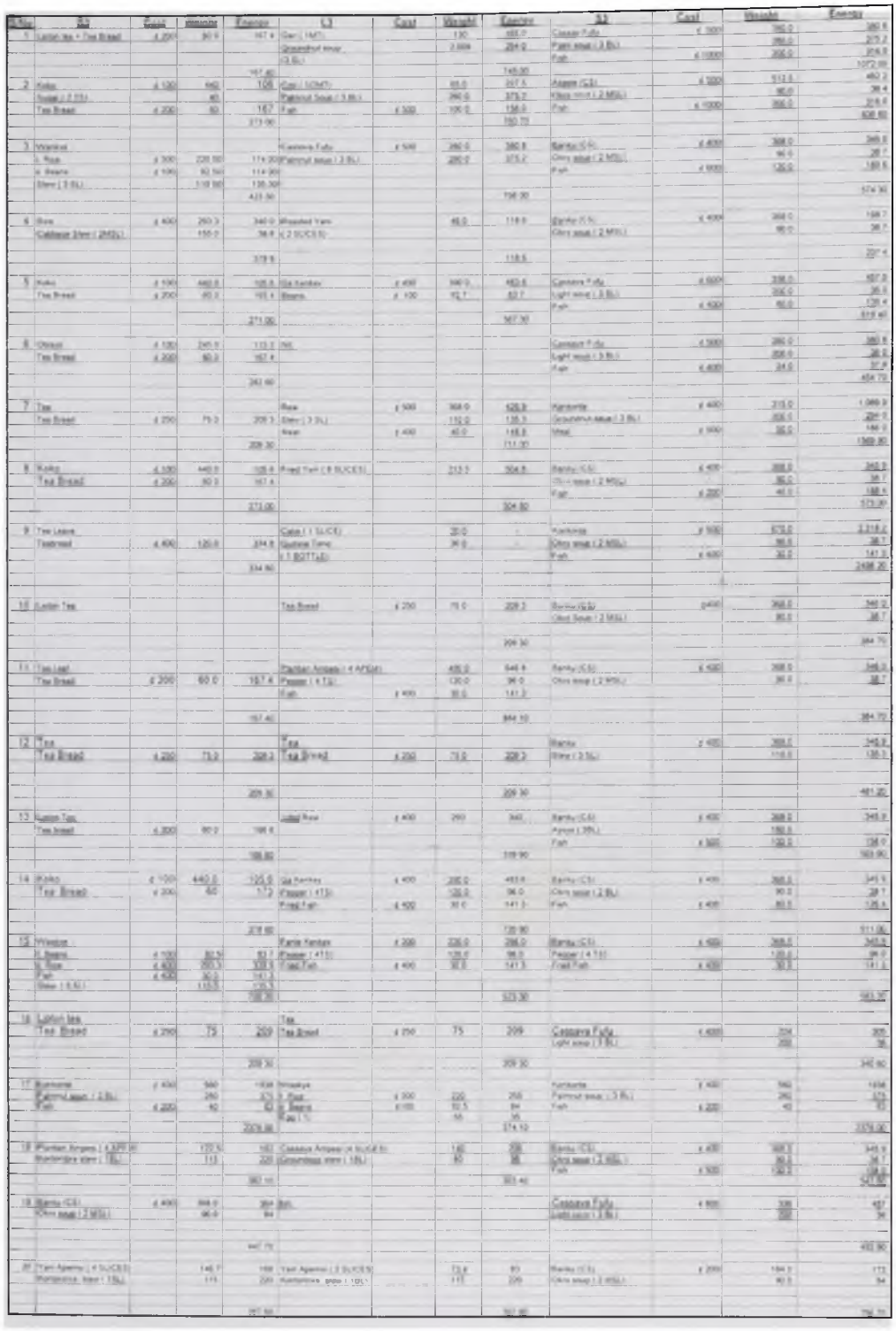
PRICE MEASURE OF COST (MEDIAN AND RANGE) OF FOODS CONSUMED BY THE PATIENTS
OF ASSAWA FOODS CONSUMED AT SUPPER)

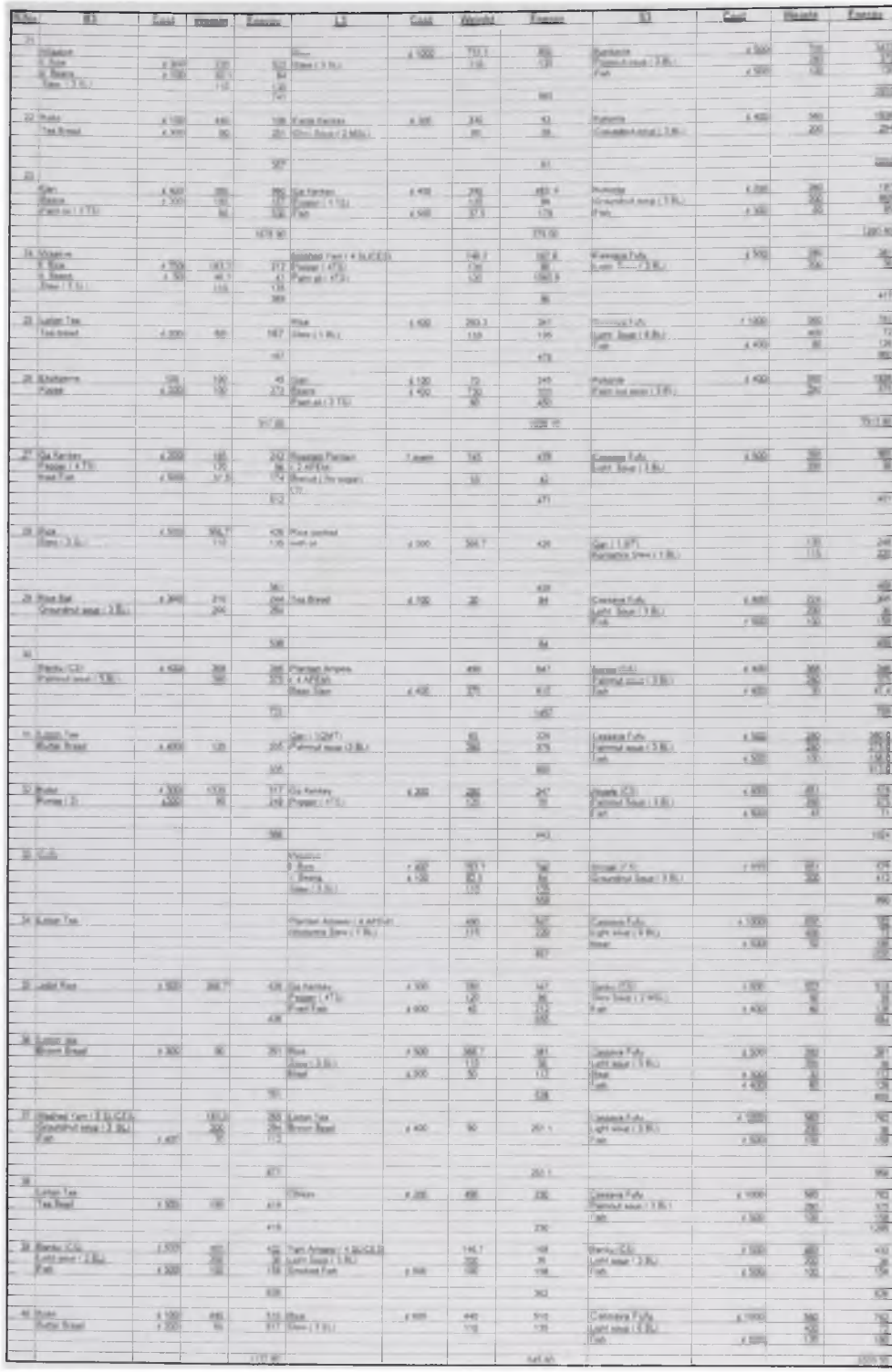
S/No.	B1	Cost	Weight	Energy	L1	Cost	Weight	Energy	S1	Cost	Weight	Energy
1	Latori Tea + Tea bread	@ 250	75	309.1	Coconut Kenkey (10 SLICES)		525	861	Cassava Fufu	@ 500	280	280.8
					Pepper (4TS)		120	98	Light soup (3 SL)		200	34.0
				309.10				957.00				414.80
2	Water	@ 100	440	176	Bread	@ 300	90	251	Banku (Cs)	@ 400	375.0	540.0
	Sugar (2TS)		40						Groundnut Soup (3 BL)		200.0	294.0
	Tea Bread	@ 250	75	209					Fish	@ 500	120.0	156.0
				314.90				251.10				992.50
3	Plantain Kenkey (4 APEM)		400	647	Yam Fufu	@ 500	220	428	Cassava Fufu	@ 500	280.0	280.8
	Cabbage Stew (2 MS)		110	38	Light soup (3 BL)		200	39	Light soup (3 BL)		200.0	34.0
									Fish	@ 1000	200.0	318.0
				685.90				467.30				732.80
4	Wagi Stew	@ 400	370	410	Rice				Banku (CS)	@ 500	400.0	432.4
									Stew (3 SL)		110.0	135.3
									Fish	@ 400	35.0	141.3
				810.3								708.9
5	Cassava Kenkey (5 SLICES)		110	165	Tea Bread	@ 250	75	209	Fish	@ 400	30.0	141.3
	Mushanya Stew (3BL)		110	220					Banku (CS)	@ 400	370.0	520.8
	Fish	@ 400	30	141.3					Okro soup (2MS)		90.0	38.7
				525.80				209.30				700.80
6	Tea				Yam Kenkey (3 SLICES)		110	135	Cassava Fufu	@ 500	280.0	280.8
	Tea Bread	@ 200	60	167	Palmnut Stew (3 BL)		110	220	Light soup (3BL)		200.0	34.0
					Fish	@ 400	30	141.3	Fish	@ 400	80.0	376.8
				167.40				496.75				782.80
7	Latori tea				Rice	@ 400	260	340	Kenkenie	@ 400	560.0	1,927.6
	Tea Bread	@ 300	90	251	Stew (3 SL)		110	135	Palmnut soup (3 BL)		280.0	376.8
									Fish	@ 400	80.0	376.8
				251.10				475.80				2680.80
8	Water	@ 100	440	176	Tea				Cassava Fufu	@ 500	280.0	280.2
	Tea Bread	@ 200	60	167	Tea Bread	@ 200	60	167	Palmnut soup (3 BL)		280.0	376.8
									Meat	@ 1000	120.0	372.0
				373.90				167.40				1027.00
9	Latori Tea				Ga Kenkey (3 SLICES)		187.5	177	Kenkenie	@ 400	360.0	1,927.6
	Thakrapal	@ 250	40	167	Tilapia (2 SLICES)		113	83	Palmnut soup (3BL)		280.0	376.8
	Rice (1)		50	64	Stew (3 MSs)		110	120				
				231.40				380.50				2304.80
10	Tea				Tea							
									Cassava Fufu	@ 1000	560.0	761.6
									Light soup (3 BL)		200.0	34.0
												795.60
11	Tea				Ga Kenkey	@ 300	280	347	Banku (CS)	@ 400	560.0	345.9
	Tea Bread	@ 250	75	209	Fried Fish	@ 200	15	71	Okro soup (2 MS)		90.0	38.7
					Pepper (4TS)		120	96	Fish	@ 200	40.0	63.2
				208.90				513.90				447.80
12	Tea				Rice	@ 400	260	340	Banku (CS)	@ 400	360.0	345.9
	Tea Bread	@ 200	60	167	Cabbage Stew (4TS)		155	39	Stew (2 MS)		110.0	135.3
				167.40				379.30				481.30
13	Tea				Jollof Rice	@ 500	367	428	Cassava Fufu	@ 400	224.0	304.8
	Tea Bread	@ 200	60	167					Kontomire (3 BL)		200.0	34.0
				167.40				428.70				340.80
14	Latori tea				Rice	@ 400	293.5	342	Gari (1Cup)		65.0	221.5
	Tea Bread	@ 200	60	167	Palmnut soup (3 BL)		330	275	Palmnut soup (3 BL)		280	375
				167.40				716.20				602.70
15	Ga Kenkey	@ 400	330	464	Latori tea				Banku (CS)	@ 300	440.0	432.4
	Stew (3 SL)		110	125	Tea Bread	@ 250	75	209	Okro soup (2 MS)		90.0	38.7
									Fish	@ 300	120.0	158.0
				618.90				359.50				629.10
16	Latori tea				Latori tea				Banku (CS)	@ 300	184.0	173.0
	Cocoa	@ 400	120	332	Oranges (2)	@ 200	180	61	Okro soup (2 MS)		90.0	38.7
									Meat	@ 400	80.0	149.8
				331.00				61.20				360.50
17	Waakye				Rice	@ 500	366.7	428	Canning Fufu	@ 800	336	457
	S. Rice	@ 300	220	255	Kontomire stew (3 BL)		115	220	Light soup (3 BL)		200	34
	B. Beans	@ 100	92.5	84	Shorts	@ 40	42.5	39				
	Plantaine stew (3 BL)		115	220								
				559.00				684.10				491.80
18	Ga Kenkey	@ 300	280	347	Fried Yam (3 SLICES)		80	190	Cassava fufu (3 SLICES)		140	336
	Fried Fish	@ 200	15	71					Kontomire stew (3 BL)		110	220
				417.90				88.60				425.50
19	Banku (CS)	@ 400	360	345	Rice				Cassava Fufu	@ 400	224	305
	Stew (3 SL)		110	135					Palmnut soup (3 BL)		280	373
	Fish	@ 400	80	141								
				620.40								673.50
20	Yam Apomo (4 SLICES)		146.7	169	Yam Apomo (3 SLICES)		110	152	Cassava Fufu	@ 500	336	457
	Palmnut soup (3 BL)		280	373	Palmnut soup (3 BL)		280	373	Light soup (3 BL)		200	34
	Fish	@ 100	100	158	Fish	@ 300	105	158	Fish	@ 400	80	126
				700.80				683.30				613.80

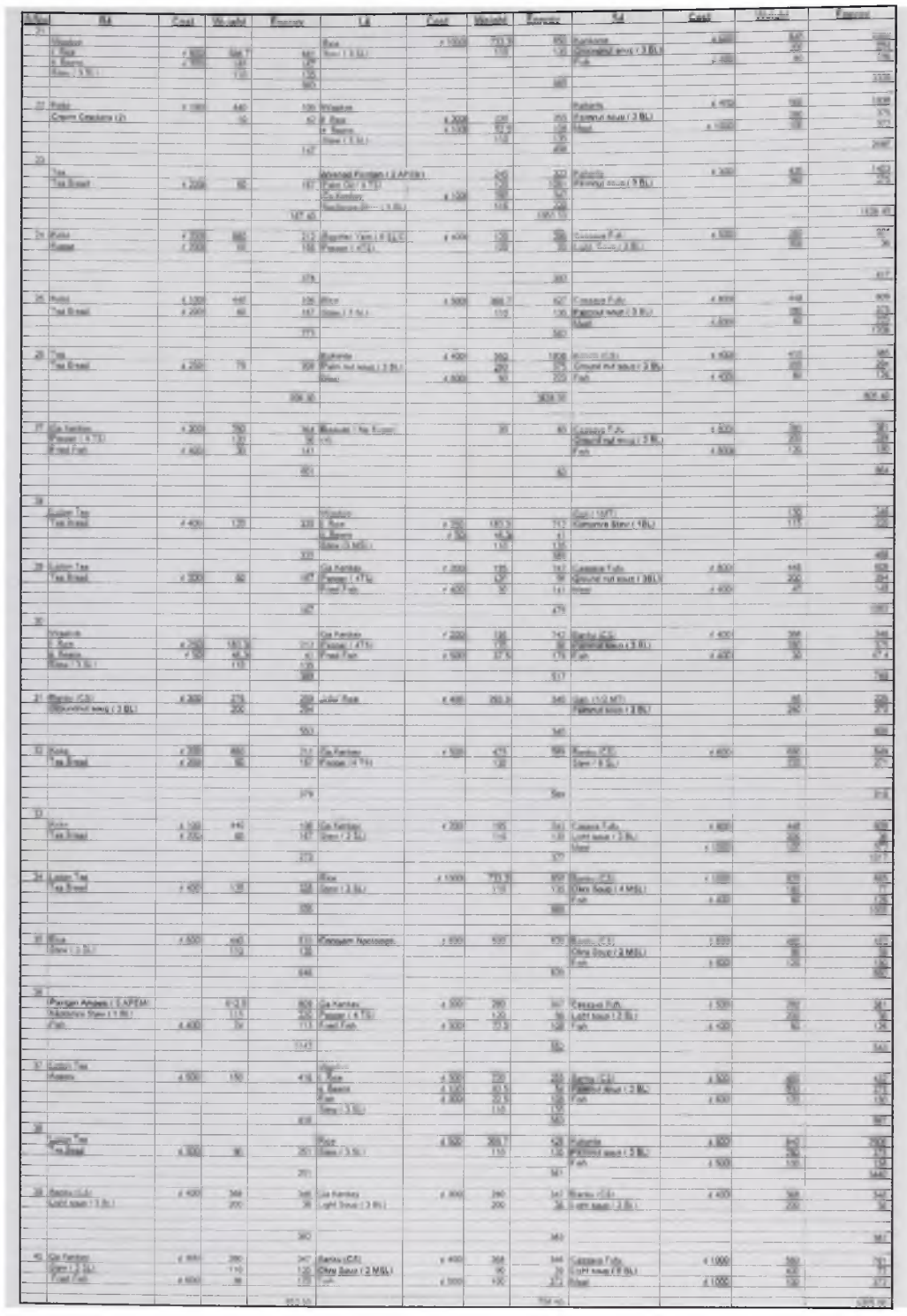


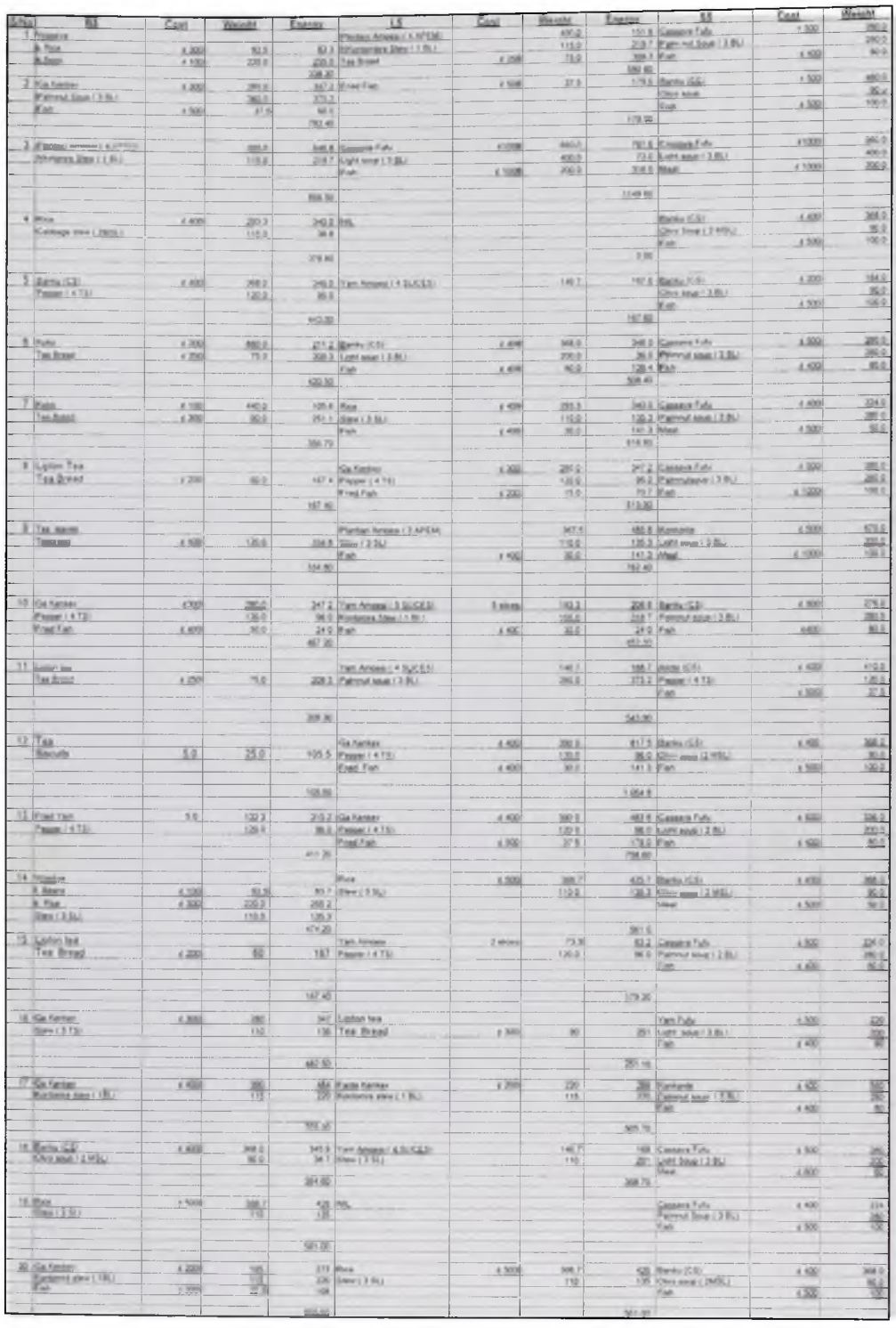


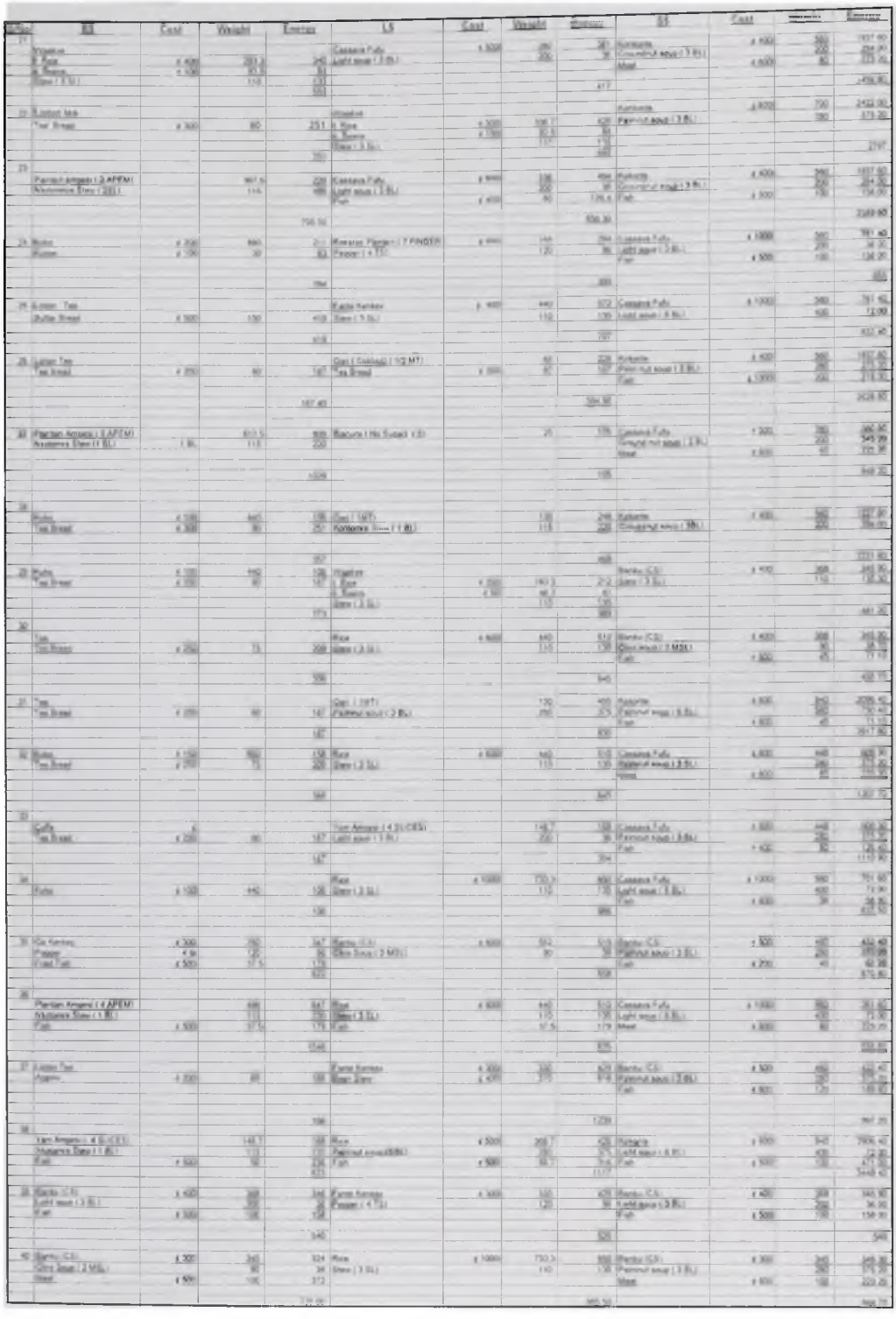


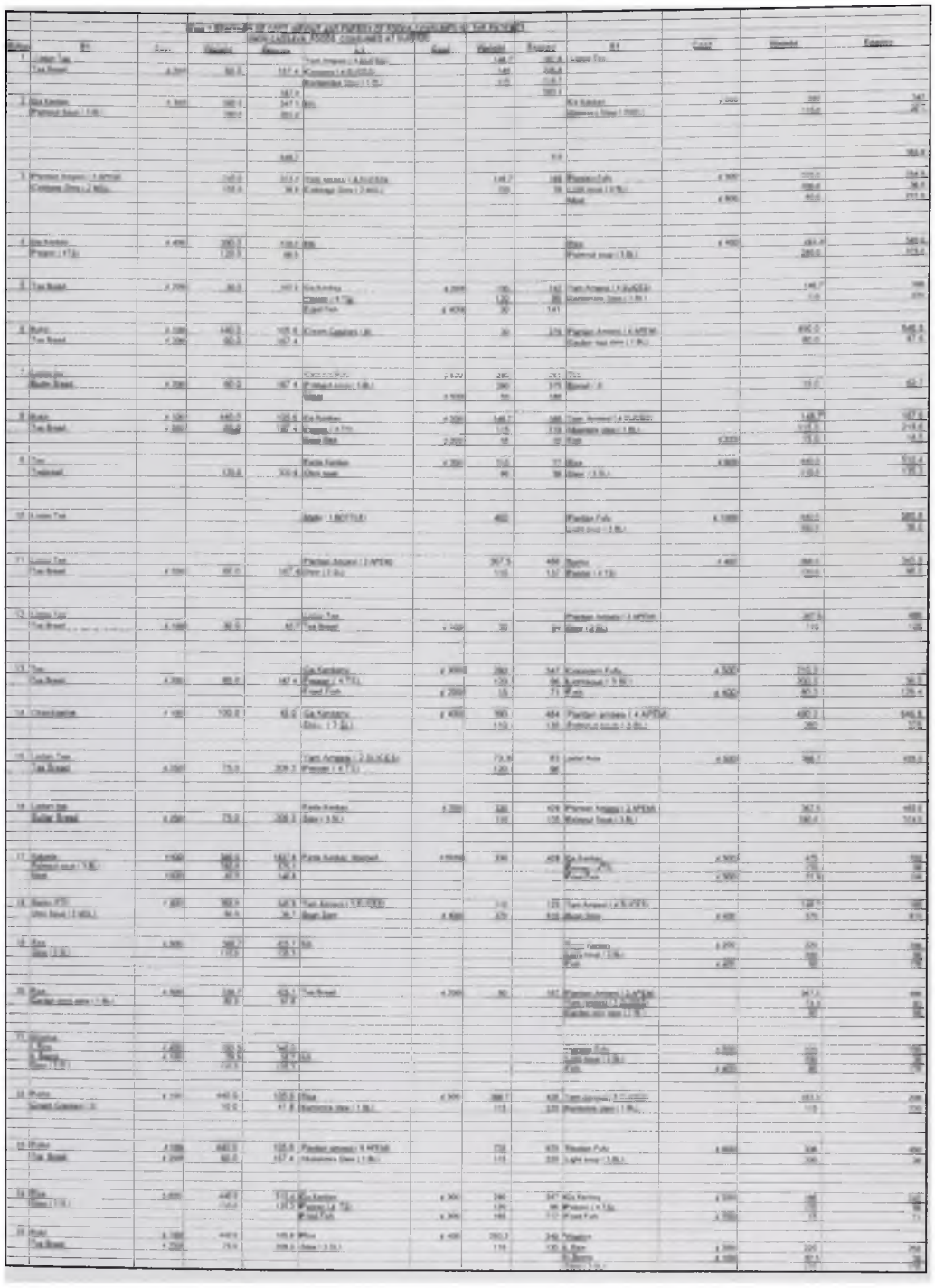


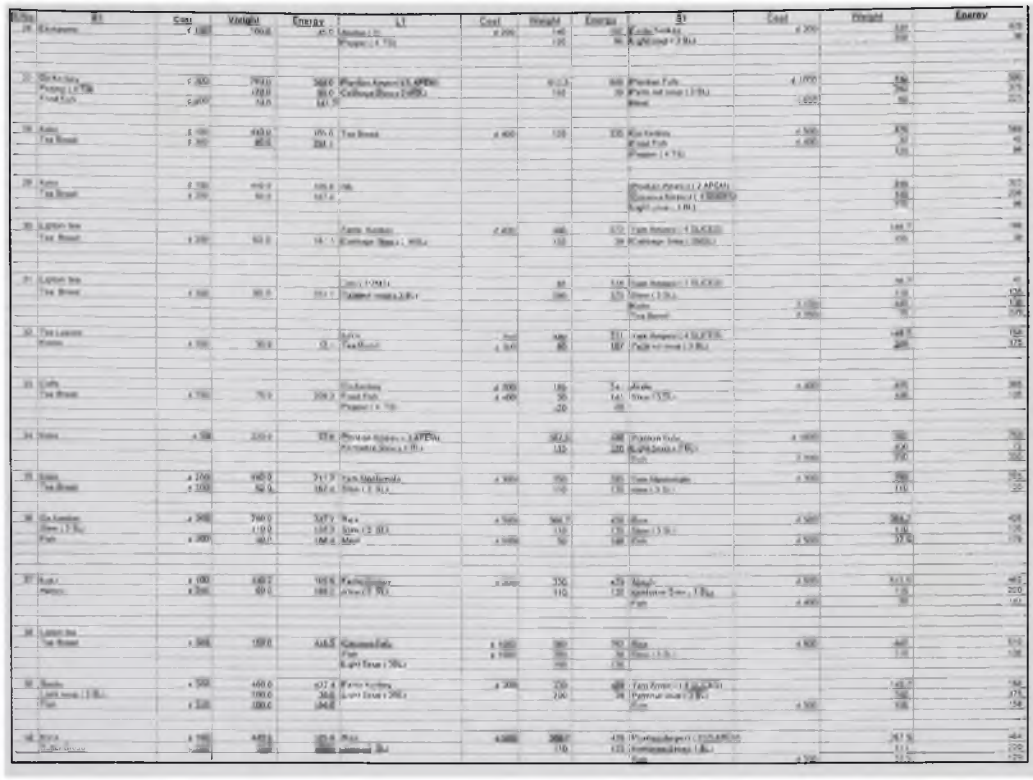


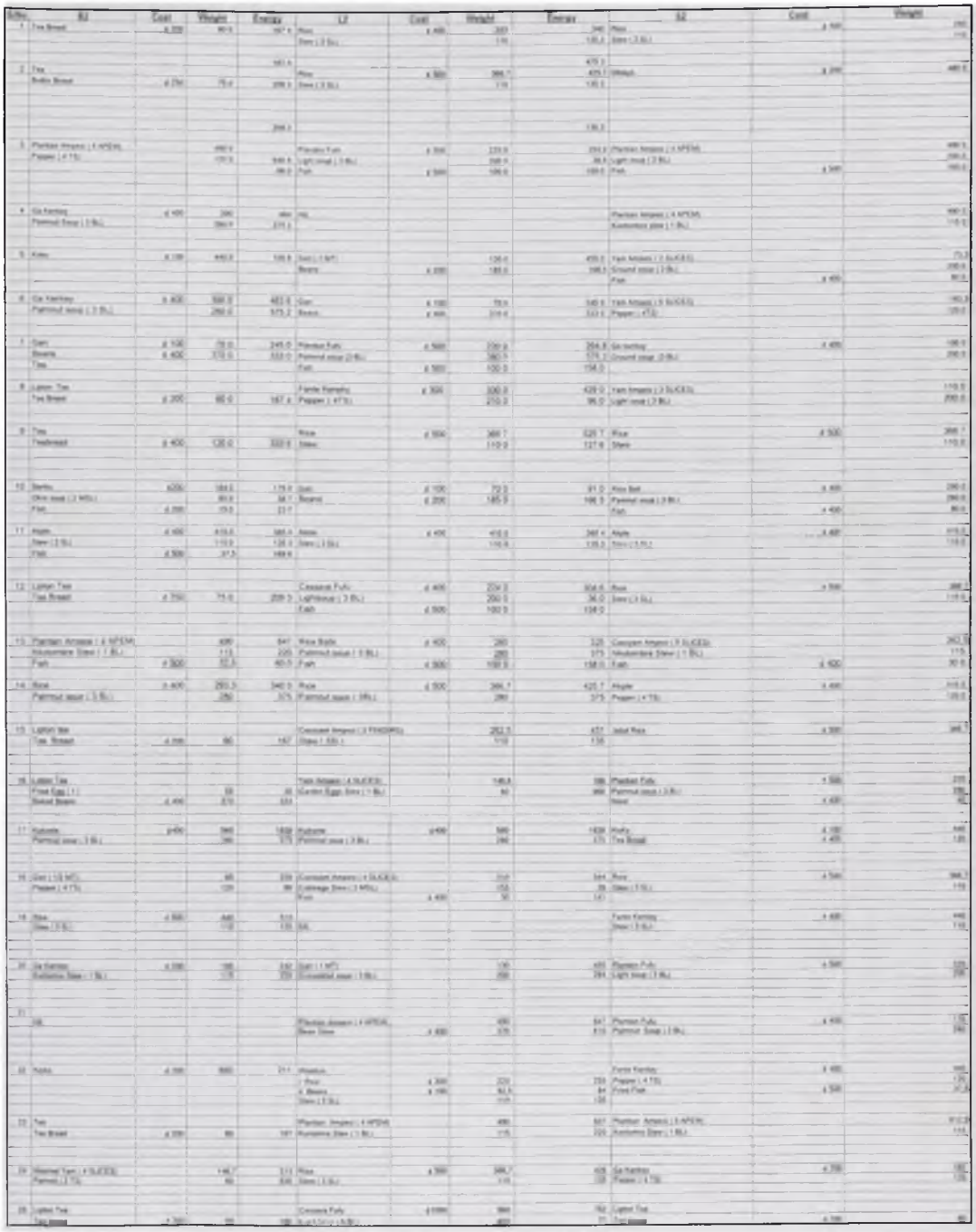


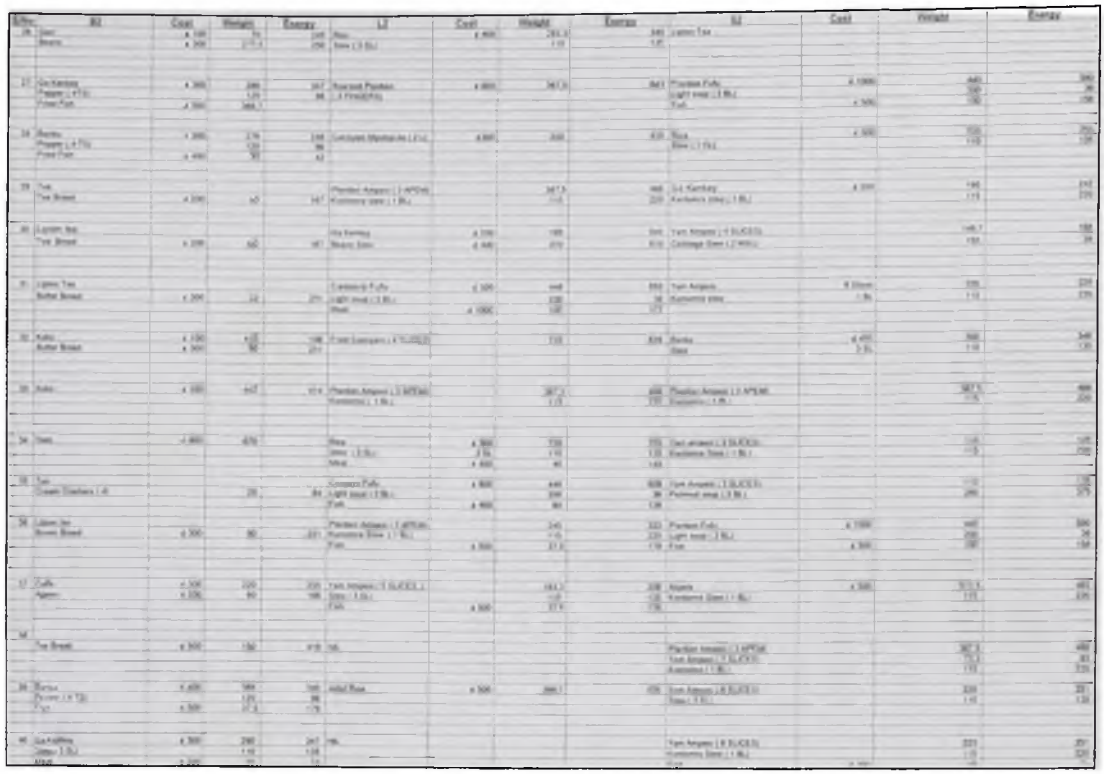


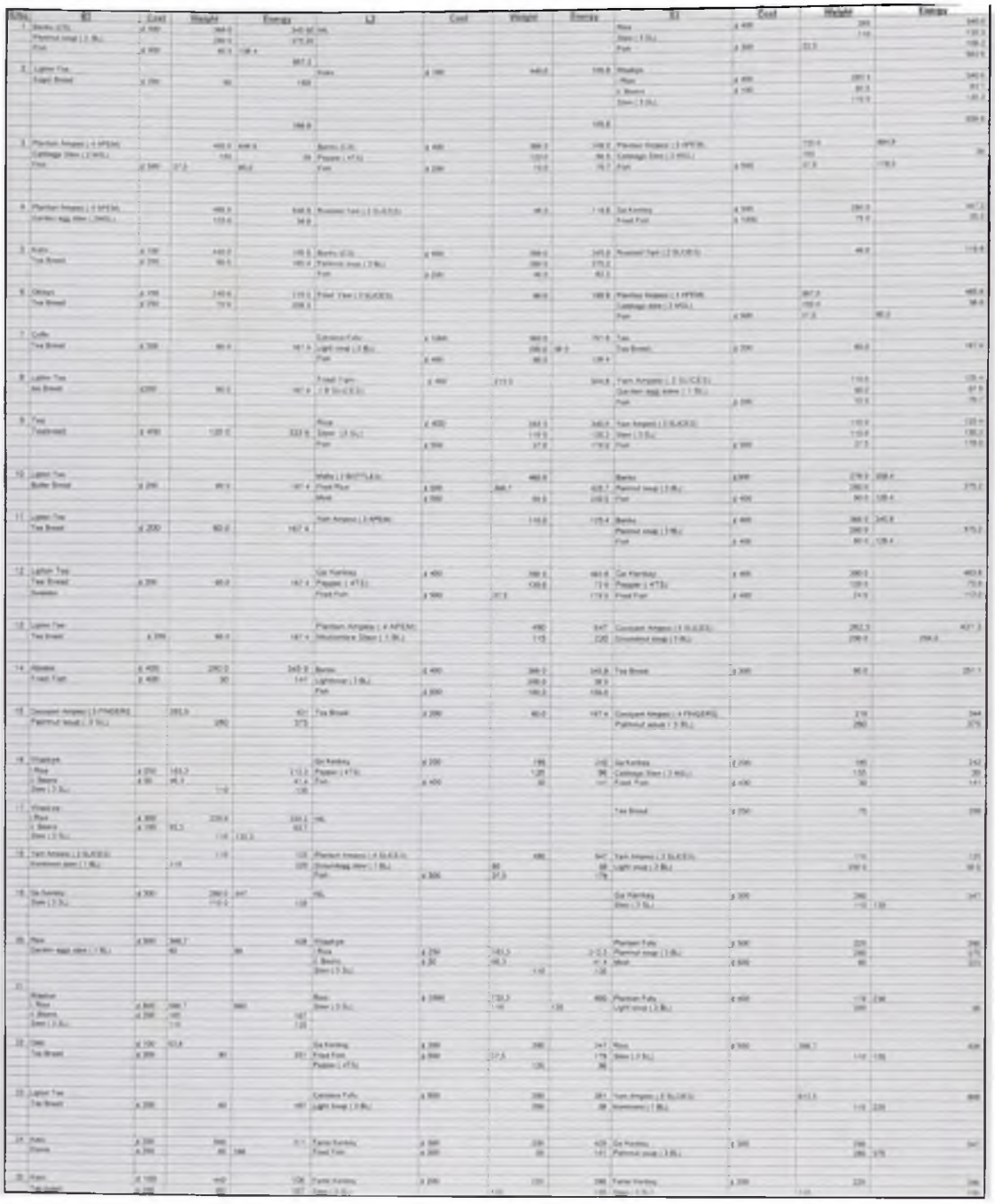


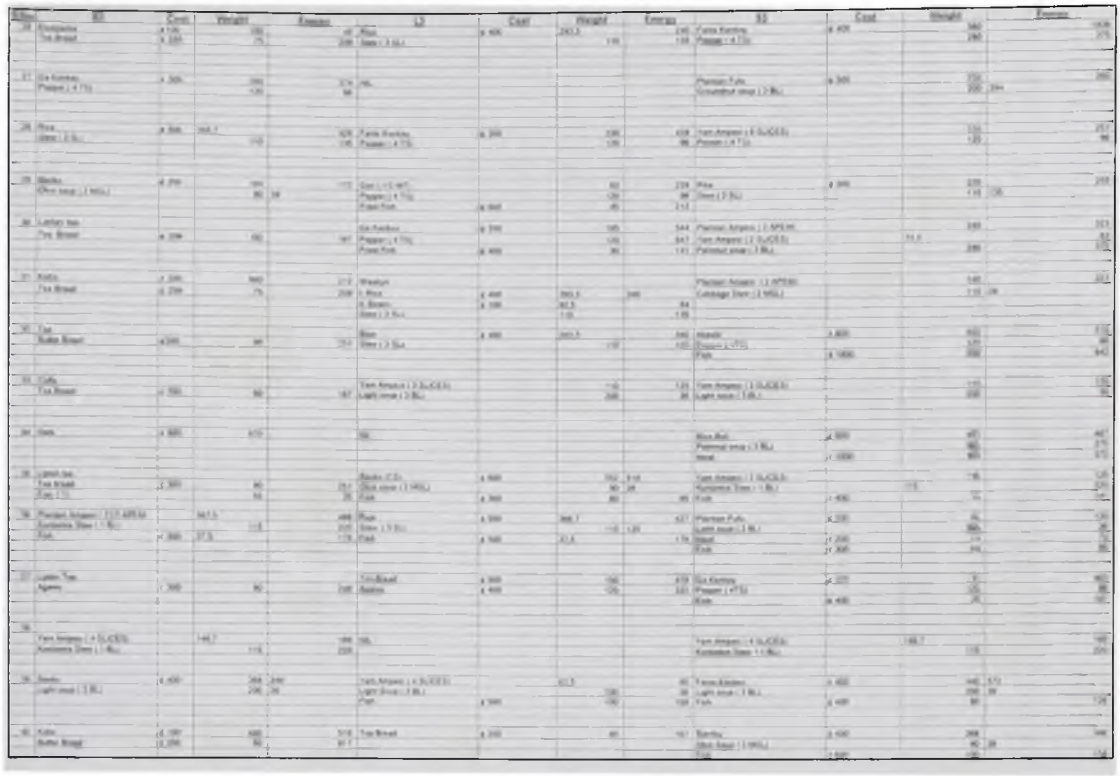


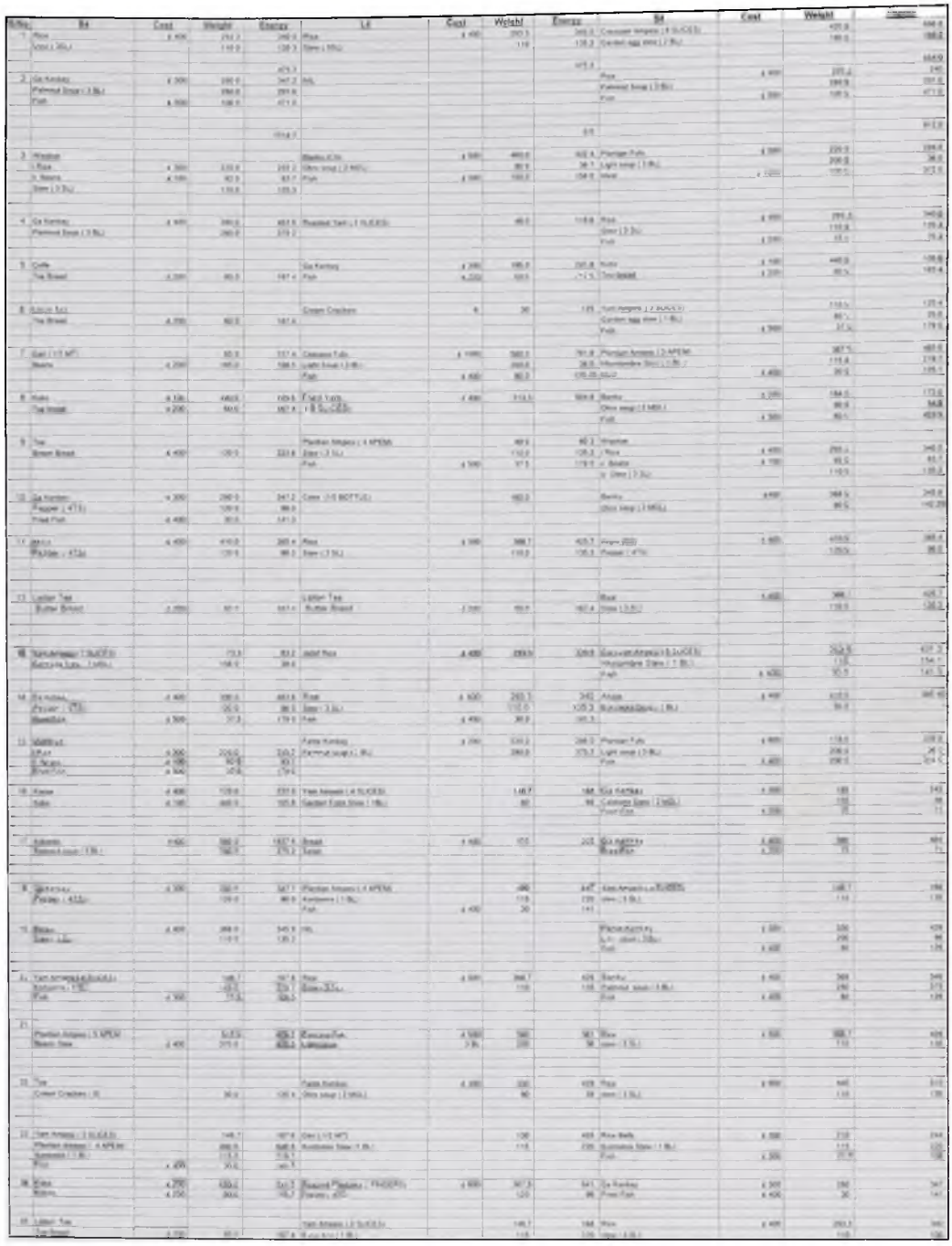


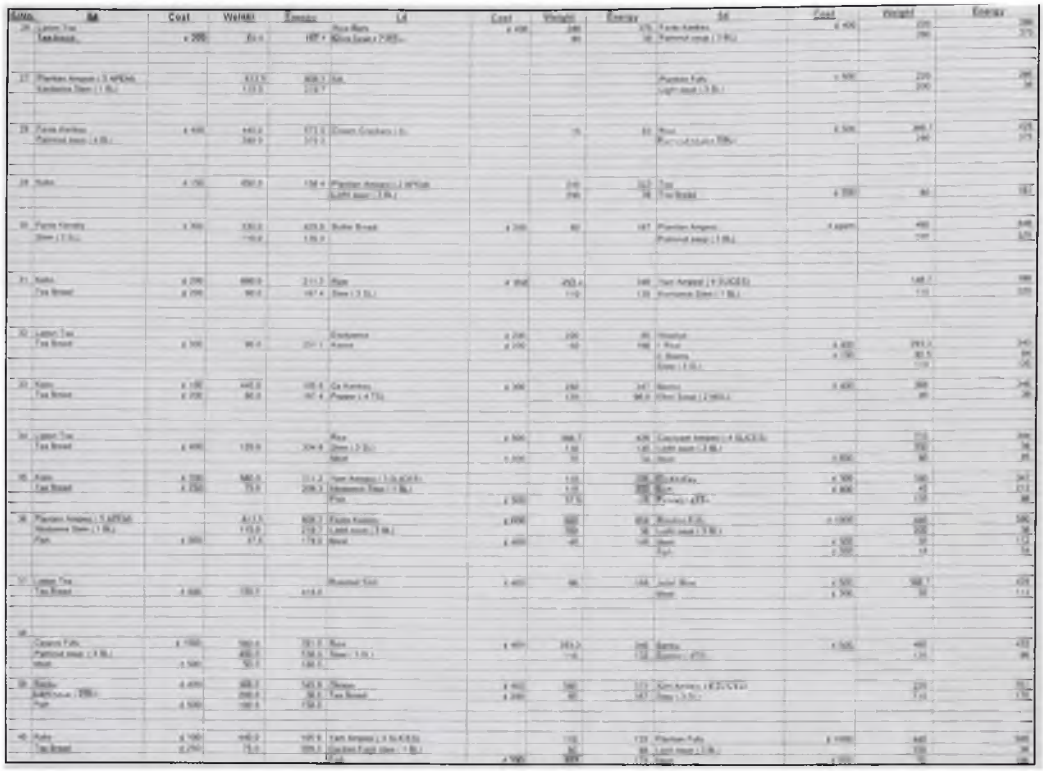


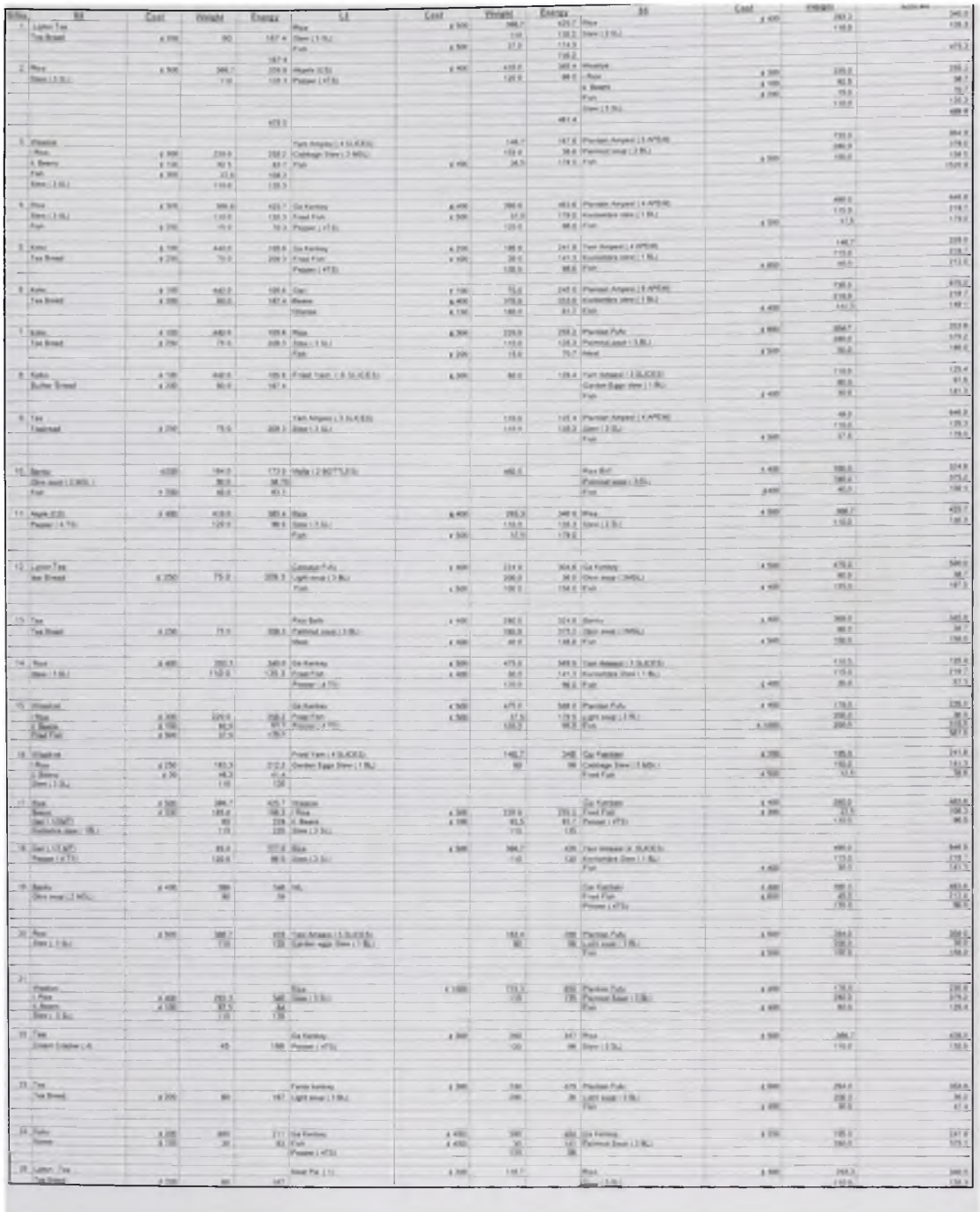


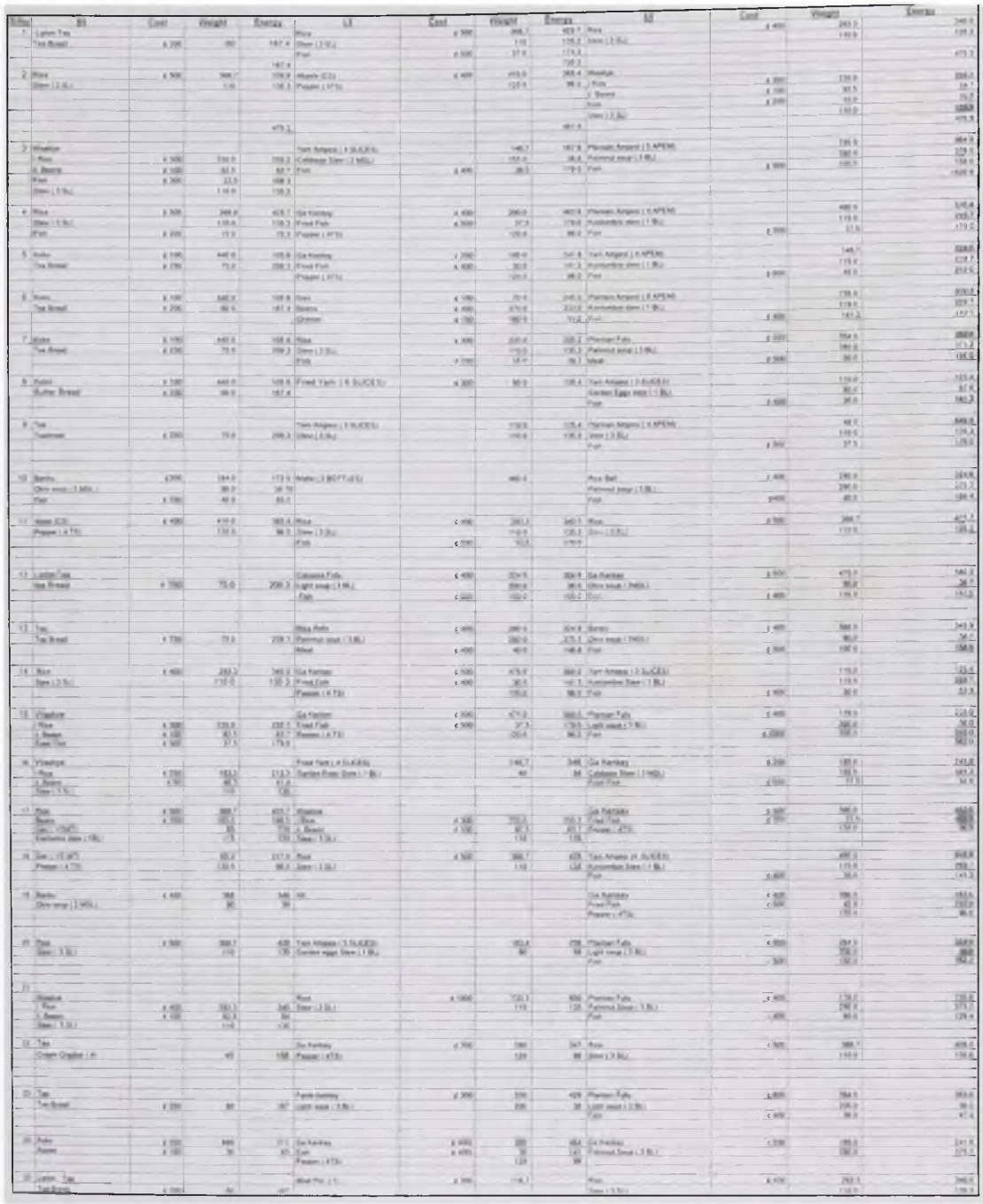












APPENDIX L: ENERGY (CALORIES) INTAKE COMPARED WITH FASTING BLOOD GLUCOSE (MMOL/L) WHEN CASSAVA WAS CONSUMED AND WHEN NOT CONSUMED AT SUPPER

S/No	Mean Energy	Mean fby^1	Mean Energy	Mean fbn^2	Mean Energy (y^1-n^2)
1	623.7	13.7	483.6	10.8	140.1
2	652.4	4.8	517.4	5.2	135.0
3	828.5	8.0	964.0	7.4	-135.5
4	582.4	18.6	711.1	18.8	-128.7
5	652.8	12.3	388.1	11.0	264.7
6	646.1	6.3	659.6	6.3	-13.5
7	1311.6	6.9	502.3	7.1	809.3
8	728.6	5.9	383.4	6.5	345.2
9	2611.2	12.4	651.8	11.8	1959.4
10	708.3	8.9	716.1	7.3	-7.8
11	507.6	5.7	570.5	5.2	- 62.9
12	575.4	9.8	645.6	8.2	-70.2
13	481.5	7.0	576.7	6.7	-95.2
14	537.2	5.2	508.4	5.3	28.8
15	772.9	5.5	549.3	4.8	223.6
16	881.2	11.9	573.5	10.6	307.7
17	1691.7	8.8	477.0	9.0	1214.7
18	453.9	6.6	602.2	7.2	-148.3
19	676.1	8.0	628.2	8.3	47.9
20	626.7	8.9	658.2	8.6	-31.5
21	2012.3	4.0	528.6	7.2	1483.7
22	2493.1	4.7	608.8	4.3	1884.3
23	1610.2	6.7	722.6	6.3	887.6
24	660.6	6.7	514.8	7.4	145.8
25	891.0	5.0	393.7	5.6	497.3
26	1436.3	9.1	921.9	8.7	514.4
27	890.5	13.1	757.4	12.1	133.1
28	1253.8	9.7	569.0	6.6	684.8
29	602.2	9.0	544.6	8.2	57.6
30	596.5	9.9	616.5	10.9	-20.0
31	1707.3	7.5	521.1	6.9	1186.2
32	1271.1	4.7	752.0	5.4	519.1
33	844.7	18.1	497.6	20.0	347.1
34	927.5	11.9	775.2	12.1	152.3
35	707.9	6.1	546.7	6.8	161.2
36	781.2	6.0	685.1	5.9	96.1
37	702.7	7.5	806.0	7.4	-103.3
38	2270.5	5.3	560.1	4.4	1710.4
39	513.0	8.2	555.9	7.5	-42.9
40	882.3	9.5	719.5	10.9	162.8
Mean	**992.3**	**8.4**	**609.1**	**8.3**	**383.2**
Standard Deviation	**567**	**3.4**	**130.2**	**3.4**	**436.8**

fby^1 = fasting blood glucose (cassava) fbn^2 = fasting blood glucose (no cassava)
y^1-n^2 = Mean Energy Difference

APPENDIX M: ENERGY (CALORIES) INTAKE COMPARED WITH FASTING BLOOD GLUCOSE (MMOL/L) WHEN CASSAVA WAS CONSUMED AND WHEN NOT CONSUMED WITHIN 24 HOURS

S/No	Mean Energy	Means fby[1]	Mean Energy	Mean fbn[2]	Mean Energy (y^1-n^2)
1	486.3	13.7	502.4	10.8	-16.1
2	604.6	4.8	473.5	5.2	131.1
3	806.7	8.0	765.6	7.4	41.1
4	419.6	18.6	624.6	18.8	-205.0
5	586.9	12.3	450.2	11.0	136.7
6	849.8	6.3	546.4	6.3	303.4
7	753.8	6.9	631.7	7.1	122.1
8	495.5	5.9	395.2	6.5	100.3
9	1196.6	12.4	542.7	11.8	653.9
10	464.8	8.9	443.4	7.3	21.4
11	479.5	5.7	563.5	5.2	-84.0
12	434.3	9.8	465.2	8.2	-30.9
13	432.9	7.0	608.0	6.7	-175.1
14	558.4	5.2	608.0	5.3	-49.6
15	565.9	5.5	569.5	4.8	-3.6
16	543.6	11.9	580.8	10.6	-37.2
17	1166.6	8.8	1118.2	9.0	48.4
18	456.1	6.6	675.6	7.2	-219.5
19	479.3	8.0	438.2	8.3	41.1
20	579.8	8.9	617.6	8.6	-37.8
21	1159.2	4.0	781.7	7.2	377.5
22	1156.1	4.7	508.2	4.3	647.9
23	1086.4	6.7	705.9	6.3	380.5
24	504.1	6.7	678.6	7.4	-174.5
25	615.5	5.0	398.2	5.6	217.3
26	951.7	9.1	613.2	8.7	338.5
27	622.3	13.1	665.3	12.1	-43.0
28	773.9	9.7	525.6	6.6	248.3
29	449.9	9.0	470.2	8.2	-20.3
30	662.6	9.9	713.9	10.9	-51.3
31	992.8	7.5	560.2	6.9	432.6
32	821.0	4.7	544.6	5.4	276.4
33	459.4	18.1	435.9	20.0	23.5
34	683.6	11.9	539.2	12.1	144.4
35	619.8	6.1	576.9	6.8	42.9
36	795.1	6.0	799.0	5.9	-3.9
37	653.8	7.5	638.4	7.4	15.4
38	1269.7	5.3	604.4	4.4	665.3
39	556.1	8.2	589.7	7.5	-33.6
40	791.1	9.5	640.3	10.4	150.8
Mean	**690.6**	**8.4**	**590.3**	**8.3**	**100.3**
Standard Deviation	**249.1**	**3.4**	**132.6**	**3.4**	**116.5**

fby^1 = fasting blood glucose (cassava) fbn^2 = fasting blood glucose (no cassava)
y^1-n^2 = Mean Energy Difference

APPENDIX N: MEAN VOLUME OF URINE AND URINARY GLUCOSE EXCRETED WITHIN 12 HOURS AT NIGHT BY THE DIABETIC PATIENTS

	URINE VOLUME (ml)			URINARY GLUCOSE (mmol/ml)		
S/No	**Cassava Food Consumed**	**Non cassava Food Consumed**	**Difference**	**Cassava Food Consumed**	**Non cassava Food Consumed**	**Difference**
1	954	656	298	23.08	7.0	16.08
2	744	644	100	9.42	14.46	-5.04
3	680	456	224	0.78	0.28	0.50
4	924	748	176	34.82	20.5	14.32
5	688	908	-220	5.70	19.2	-13.50
6	948	920	28	8.88	3.02	5.86
7	1408	1712	-304	1.58	1.48	0.10
8	792	588	204	2.60	0.53	2.07
9	172	892	-720	19.32	19.78	-0.46
10	498	452	46	2.32	2.16	0.16
11	868	700	168	0.60	0.26	0.34
12	1038	880	158	12.18	11.32	0.86
13	786	580	206	11.54	1.42	10.12
14	596	852	-256	0.94	7.36	-6.42
15	620	542	78	0.98	0.30	0.68
16	1554	1914	-360	22.10	35.04	-12.94
17	718	728	-10	16.08	16.54	-0.46
18	914	250	664	1.19	1.26	-0.07
19	660	678	-18	0.70	1.08	-0.38
20	600	656	-56	20.44	11.64	8.80
21	760	486	274	1.22	0.60	0.62
22	734	672	62	0.76	0.74	0.02
23	660	454	206	0.60	0.22	0.38
24	608	502	106	2.22	4.26	-2.04
25	345	440	-95	0.48	0.42	0.06
26	418	490	-72	4.22	6.30	-2.08
27	1072	928	144	35.02	19.36	15.66
28	776	686	90	19.46	3.76	15.70
29	1203	1224	-21	1.52	2.64	-1.12
30	486	300	186	9.32	15.82	-6.50
31	400	370	30	5.74	1.32	4.42
32	862	912	-50	24.56	1.00	23.56
33	856	754	102	32.16	11.86	20.30
34	702	754	-52	23.76	21.70	2.06
35	922	1028	-106	2.56	1.72	0.84
36	968	888	80	0.52	0.58	-0.06
37	500	562	-62	0.30	0.32	-0.02
38	1194	1114	80	2.44	0.68	1.76
39	1142	1020	122	0.74	0.62	0.12
40	1278	632	646	1.21	1.14	0.07
Mean	**801**	**749**	**52**	**9.09**	**6.75**	**2.34**
Standard Deviation	**283**	**333**	**-50**	**10.67**	**8.44**	**2.23**

APPENDIX O FASTING BLOOD GLUCOSE COMPARED WITH THE WEIGHT OF DIABETIC PATIENTS

	FASTING BLOOD GLUCOSE (MMOL/L)			WEIGHT (KG)		
S/No	Mean fby^1	Mean fbn^2	Mean (fby^1-fbn^2)	Mean wy^3	Mean wn^4	Mean (wy^3-wn^4)
1	13.70	10.80	2.90	91.2	90.8	0.4
2	4.78	5.18	-0.40	61.4	61.6	-0.2
3	7.96	7.38	0.58	64.2	64.2	0.0
4	18.56	18.78	-0.22	59.8	60.4	-0.6
5	12.28	11.00	1.28	74.0	75.0	-1.0
6	6.26	6.26	0.00	74.0	73.8	0.2
7	6.86	7.12	-0.26	66.2	67.8	-1.6
8	5.94	6.46	-0.52	75.6	70.6	5.0
9	12.36	11.80	0.56	73.6	73.6	0.0
10	8.92	7.32	1.60	70.6	70.6	0.0
11	5.72	5.18	0.54	61.2	60.2	1.0
12	9.80	8.24	1.56	78.6	79.0	-0.4
13	6.98	6.72	0.26	69.8	68.8	1.0
14	5.22	5.34	-0.12	56.6	56.4	0.2
15	5.52	4.80	0.72	50.2	50.4	-0.2
16	11.86	10.58	1.28	109.0	109.2	-0.2
17	8.80	8.98	-0.18	85.2	85.2	0.0
18	6.60	7.22	-0.62	79.4	79.0	0.4
19	8.04	8.34	-0.30	78.6	78.4	0.2
20	8.88	8.60	0.28	60.6	60.4	0.2
21	4.02	7.20	-3.18	67.8	68.2	-0.4
22	4.70	4.32	0.38	60.2	60.2	0.0
23	6.74	6.26	0.48	72.6	73.2	-0.6
24	6.66	7.38	-0.72	85.4	85.4	0.0
25	4.98	5.60	-0.62	68.0	67.2	0.8
26	9.08	8.66	0.42	65.4	64.6	0.8
27	13.06	12.08	0.98	63.8	64.0	-0.2
28	9.70	6.64	3.06	74.8	75.2	-0.4
29	9.04	8.16	0.88	124.4	124.4	0.0
30	9.88	10.94	-1.06	78.0	77.6	0.4
31	7.54	6.92	0.62	71.8	72.0	-0.2
32	4.74	5.44	-0.70	67.6	67.8	-0.2
33	18.08	20.00	-1.92	91.2	91.2	0.0
34	11.92	12.10	-0.18	59.0	58.8	0.2
35	6.14	6.78	-0.64	71.6	71.8	-0.2
36	5.98	5.90	0.08	79.0	79.0	0.0
37	7.50	7.38	0.12	88.2	88.4	-0.2
38	5.34	4.44	0.90	91.6	91.6	0.0
39	8.24	7.52	0.72	83.6	83.8	-0.2
40	9.54	10.38	-0.84	75.6	76.0	-0.4
Mean	**8.45**	**8.26**	**0.19**	**74.5**	**74.5**	**0.0**
Standard Deviation	**3.41**	**3.36**	**0.05**	**14.1**	**14.2**	**-0.1**

Fby^1 = fasting blood glucose (cassava)
Fbn^2 = fasting blood glucose (no cassava))
Fby^1-fbn^2 = Mean Difference

wy^3 = weight cassava
wn^4 = weight (no cassava)
Wy^3-wn^4 = Mean Difference

APPENDIX P WEIGHT KG

(Y=CASSAVA CONSUMPTION N=NON-CASSAVA CONSUMPTION)

S/No.	Wy1	Wn1	Wy2	Wn2	Wy3	wn3	Wy4	wn4	Wy5	Wn5
1	91	91	91	92	91	91	92	90	91	90
2	62	62	62	63	61	60	61	61	61	62
3	64	63	64	66	64	64	64	64	65	64
4	60	60	60	61	59	60	60	61	60	60
5	75	74	69	75	74	74	78	74	74	78
6	74	73	74	74	74	74	74	74	74	74
7	61	65	68	68	68	68	67	69	67	69
8	75	74	75	74	78	75	75	75	75	75
9	74	73	74	73	73	75	73	74	74	73
10	70	70	70	70	71	70	71	72	71	71
11	62	60	61	60	60	61	62	60	61	60
12	78	79	78	78	79	80	79	79	79	79
13	69	68	73	70	70	69	68	68	69	69
14	56	56	57	56	56	56	57	57	57	57
15	50	51	50	50	50	50	51	51	50	50
16	109	110	109	109	109	109	109	109	109	109
17	85	85	84	85	85	85	86	85	86	86
18	83	80	79	79	78	79	78	79	79	78
19	79	79	79	78	79	79	78	78	78	78
20	62	61	60	60	60	60	61	60	60	61
21	68	69	68	68	67	68	68	68	68	68
22	61	61	60	60	60	60	60	60	60	60
23	74	74	72	73	73	72	72	74	72	73
24	85	85	85	86	86	86	87	86	84	84
25	69	66	68	68	67	68	68	67	68	67
26	65	64	64	64	67	64	66	66	65	65
27	64	64	63	64	64	64	64	64	64	64
28	75	76	65	75	75	74	74	76	75	75
29	125	123	124	125	124	124	124	125	125	125
30	78	78	78	76	78	78	78	78	78	78
31	73	73	72	74	72	71	71	71	71	71
32	67	67	67	68	68	68	68	68	68	68
33	90	90	92	92	92	92	91	91	91	91
34	59	59	59	59	58	58	60	59	59	59
35	72	73	72	73	71	71	71	71	72	71
36	79	79	79	79	79	79	79	79	79	79
37	89	88	88	89	88	89	88	88	88	88
38	91	91	91	93	92	91	92	92	92	91
39	82	84	84	83	84	84	84	84	84	84
40	76	76	74	76	76	76	76	76	76	76

WY = Weight (Cassava consumed) WN = Weight (No cassava consumed)

Appendix Q Age, Sex, Energy, Fasting Blood glucose and Urine glucose of the subjects

S/No	Age (Years)	Sex	Energy (Calories)	Fasting Blood Glucose (mmol/l)	Urine Glucose (mmol/l)
1	59	F	489.3	13.70	20.56
2	52	F	604.6	4.78	1.32
3	54	F	86.7	7.96	1.50
4	50	F	419.6	18.78	37.76
5	56	M	583.9	11.00	8.36
6	57	F	489.8	6.62	9.86
7	50	F	753.8	7.12	1.18
8	60	M	495.5	6.46	2.86
9	54	F	1196.6	11.80	21.94
10	41	F	464.8	7.32	5.36
11	40	F	479.5	5.18	1.20
12	60	M	434.3	8.24	11.14
13	51	M	432.9	6.72	15.84
14	51	F	558.4	5.34	2.60
15	60	M	565.9	4.80	1.73
16	41	F	543.6	10.58	19.24
17	67	M	1166.6	8.98	22.68
18	58	F	456.1	7.22	3.08
19	66	M	479.3	8.34	1.22
20	49	M	579.8	8.60	34.10
21	52	F	1159.2	7.20	2.18
22	32	M	1156.1	4.32	0.74
23	48	F	1086.4	6.26	1.15
24	57	M	504.1	7.38	5.49
25	54	M	615.5	5.60	1.44
26	64	M	951.7	8.66	11.72
27	67	F	622.3	12.08	32.82
28	41	F	773.9	6.64	20.58
29	54	F	449.9	8.16	1.21
30	59	M	662.6	10.94	16.16
31	58	M	992.8	6.29	22.08
32	45	F	821.0	5.44	2.10
33	49	M	459.4	20.00	33.88
34	47	F	683.6	12.10	35.56
35	56	M	619.8	6.78	1.94
36	30	F	659.1	5.90	0.50
37	48	F	653.8	7.38	0.60
38	49	F	1269.7	4.44	0.88
39	47	F	556.1	7.52	0.62
40	48	M	791.1	10.80	2.52

APPENIDIX R ANALYSIS OF VARIANCE TABLES EFFECTS OF THE FOLLOWING VARIABLES ON THE FASTING BLOOD GLUCOSE

Variables	Sum of Squares	Df	Mean sum of Squares	F	P-value
1. Age	8.166711 449.905917 458.072628	1 38 39	8.16671 11.83963	0.69	0.411
2. Sex	0.000560 458.072068 458.072628	1 38 39	0.00056 12.05453	0.00	0.995
3. Energy	28.475485 429.591223 458.072628	1 38 39	28.47549 11.30519	2.52	0.121
4. Age & Sex	19.581405 448.491223 458.072628	2 37 39	4.79070 12.12138	0.40	0.676
5. Age & Energy	33.701476 424.371152 458.072628	2 37 39	16.85074 11.46949	1.47	0.243
6. Sex & Energy	28.538115 429.534513 458.072628	2 37 39	14.26906 11.60904	1.23	0.304
7. Sex & Age & Energy	35.227985 422.844643 458.072628	3 36 39	11.74266 11.74568	1.00	0.404

APPENIDIX S ANALYSIS OF VARIANCE TABLES EFFECTS OF THE FOLLOWING VARIABLES ON THE FASTING URINE GLUCOSE

Variables	Sum of Squares	Df	Mean sum of Squares	F	P-value
1. Age	131.387636 5381.594981 5512.982617	1 38 39	131.38764 141.38129	0.18	0.671
2. Sex	26.493770 5486.488847 5512.982617	1 38 39	26.49377 141.62092	0.93	0.342
3. Energy	46.463247 5466.519370 5512.982617	1 38 39	46.46325 143.85577	0.23	0.573
4. Age & Sex	131.905033 5381.077584 5512.982617	2 37 39	65.95252 145.43453	0.45	0.639
5. Age & Energy	162.663397 5350.319220 5512.982617	2 37 39	81.33170 144.60322	0.56	0.575
6. Sex & Energy	69..540035 5443.440582 5512.982617	2 37 39	34.77102 147.12002	0.24	0.791
7. Sex & Age & Energy	163.110096 5349.872521 5512.982671	3 36 39	54.37003 148.60757	0.37	0.778

APPENDIX T

NUTRITION AND FOOD SCIENCE DEPARTMENT (LEGON)

NAME ----------

WEIGHT AT FIRST CONTACT---------- HEIGHT ----------

WEEKLY READINGS

VARIABLES	1ST WEEK YES	NO	2ND WEEK YES	NO	3RD WEEK YES	NO	4TH WEEK YES	NO	5TH WEEK YES	NO	MAIN VALUES YES	NO
1. Weight g (only mornings)												
2. fasting blood Glucose (mmol/L)												
3.Fasting Urine Glucose Concentration (mmol/L)												
4.Urine Volume (mls)												
5. urine glucose concentration (mls/L)												

Note: Yes - when cassava/cassava product is consumed

No - when cassava/cassava product is not consumed

APPENDIX U

NUTRITION & FOOD SCIENCE DEPARTMENT (LEGON)

24-HOUR DIETARY RECALL CHART

PATIENTS NAME:----------

A. BREAKFAST:----------

ANY OTHER FOOD:----------

B. LUNCH:----------

ANY OTHER FOOD: ----------

C. SUPPER:----------

ANY OTHER FOOD:----------