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Proximate Composition, Energy Contents and Blood Sugar Responses of Stiff Porridge and Rice Meals Consumed in Kenya

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Abstract

The term glycemic index has been used to categorize carbohydrate-rich foods on the basis of their blood sugar raising potential. Despite the existence of a table of glycemic indices of some foods, the glycemic indices of staple foods consumed in Kenya is still very scanty. This study therefore was designed to evaluate the glycemic indices (GI) of rice and stiff or thick porridge (ugali), the most commonly consumed staple foods in Kenya. *Ugali* is usually served with side dishes of cowpea leaves or beef and rice is usually served with either beans or beef stews among other accompaniments. The foods were analyzed for proximate composition using the AOAC methods. Glycemic index was determined following FAO/WHO recommended methodology. From the results of proximate analyses, it was established that the content of carbohydrates varied in the order: U*gali* > rice > beans > cowpea leaves. Glycemic indices followed the order plain rice (77) > *ugali* and beef (71) > rice and beef (69) > rice and beans = plain *ugali* (62) > *ugali* and cowpea leaves (45) > plain beans (44). The GI values for these foods were significantly different (p<0.05). Despite this, all the foods had a high glycemic load (≥20). However, cowpea leaves and beans lowered the GI of *ugali* and white rice respectively. This GI lowering effect is especially important in the dietary management of diabetes mellitus.

Key words: proximate composition, energy content, glycemic index, glycemic load, Kenya

1. Introduction

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

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

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

Despite the much emphasis and benefits attributed to the GI concept especially with regard to management of metabolic conditions such as diabetes mellitus, GI of most traditional foods in Kenya is yet to be evaluated. GI knowledge will guide better the promotion of local foods to the community (Idril, Diana & Wargahadibrata, 2013). Experts have also alluded to the urgent need to pass the information on the GI and GL of foods to health professionals as well as the general public (Augustin et al., 2015). This study considered two major staple foods in Kenya which include stiff or thick porridge (*ugali)* which is mostly prepared from maize flour (Wanjala et al., 2016) and locally grown rice. These carbohydrate-rich foods are usually consumed with a side dish. This study therefore investigated the GI/GL of *ugali* and rice and the effect of side dishes on their GI/GL. To our knowledge this is the first paper investigating the GI of Kenya's staple foods and the effect of different accompaniments on the GI of these foods.

2. Materials and Methods

2.1 Experimental design and ethical approval

Eight healthy adults were given a single food/meal or standard glucose each day after a 10-12 hour overnight fast. Postprandial blood glucose were then measured at (time 0 before eating) and then after 15, 30, 60, 90 and 120 minutes after consuming the test foods. The study involved healthy adult volunteers 4 males and 4 female. Inclusion criteria included healthy males and females (normal BMI, blood pressure, blood sugar and not on medication), non pregnant, non lactating females; aged 18–75 years and did not suffer from diabetes. Exclusion criteria was known history of AIDS, diabetes, hypertension or heart disease; history of surgery within the last 6 months; BMI $\geq 25 kg/m^2$; those on medication and those who may not be comfortable with the procedures of the experiment (Robert et al., 2008; Wolever et al., 2008).

This study was approved by the Kenyatta National Hospital/University of Nairobi, Research and Ethics Committee. The participants signed an informed consent form before commencing the experiment.

2.2 Proximate Analyses

Dry maize, dry beans, beef and cowpea leaf vegetables were purchased from Kocholya market in Amagoro, Busia County. Rice (Mwea pishori) was purchased from Nice Rice Millers in Mwea town. Food samples were prepared using traditional methods as shown in Table 1.

Proximate composition of the foods was analyzed according to the AOAC official methods (AOAC, 2000) of analysis at University of Nairobi's Food Chemistry Laboratory. Proximate analysis was mainly carried out to help in the calculation of the available carbohydrates and various energies from the foods Analyses were carried out for moisture, protein, crude fat, crude fiber and total ash. Soluble or digestible carbohydrate content was calculated as the difference [100 – (moisture + crude protein + crude fat + crude fiber + total ash)].

2.3 Determination of Blood Glucose Responses

This was conducted *in vivo* using participants drawn from Amagoro division in Busia County of Western Kenya. Eight healthy subjects (4 females and 4 males) tested each food sample. The participants were sampled on voluntary basis. Foods were tested as they would typically be consumed except for the plain *ugali*. The portions were served in similar containers for each participant. The food samples were consumed with 250 ml of water. Test meals were consumed within 7 minutes. Timing for blood sampling started when the participants took the first bite of the test meal. The food portion size of each test food contained 50 g digestible carbohydrate (defined as total carbohydrate minus dietary fiber). The procedure on each occasion was as follows:

After an overnight fast (10-12 hours), fasting blood sample was taken (time 0); the subjects then ate the test meals or glucose (standard) and postprandial blood samples were drawn at 15, 30, 45, 60, 90, and 120 min after commencement of eating. Blood glucose levels were measured using a blood glucose monitoring system (*On-Call Plus* ACON Laboratories, USA). Participant's finger was pricked using a sterile lancet and blood sample applied directly to the end tip of the test strip which was connected to the glucose meter. The blood glucose level in mmol/L was read directly from the meter display and recorded.

The blood glucose responses against time were plotted in Microsoft Excel. Using the fasting blood sugar level as a baseline for each participant, the incremental area under curve (IAUC) was computed using trapezoidal rule (FAO/WHO, 1998, Wolever, 2003). The GI was then computed using the formula: GI= IAUC for the test food (50g) ÷ IAUC for reference food (50g) ×100. Glycemic load was computed by multiplying the available carbohydrate content with the GI of the food and dividing by 100. GI and GL results were then presented by means and standard deviation values. Mixed effects logistic regression analysis was conducted on glycemic indices of the test foods using the statistical package for social sciences (SPSS) version 20.0. The significance level of 5% ($p<0.05$) was adopted in these tests.

3. Results and Discussion

The GI concept has been used to rank carbohydrate-rich foods depending on how they raise the blood sugar after consumption. The concept is appropriate for foods that provide at least 15 to 20g available carbohydrates per serving (Arvidsson-Lenner et al., 2004). This study therefore considered the main carbohydrate-rich staple foods in the way they are normally prepared and consumed in Kenya as shown in Table 1. The study involved healthy male and female whose characteristics are shown in Table 2.

3.1 Proximate Composition and Energy Values

The results for the proximate analysis of ugali, rice, beans and cowpea leaves are shown in Table 3. Overall, the carbohydrate content followed the order: ugali > rice > beans > cowpea leaves. As expected of a legume, beans possessed the highest protein content as opposed to cereal grain products and cowpea leaves. The carbohydrate content of *ugali* in this study was found to be higher compared to that consumed in Malawi. This is attributable to the different cooking methods with Malawi's *ugali* having a higher moisture content of 76.54% (Mlotha et al., 2016) as opposed to 66.14% reported in this study. In Côte d'Ivoire, moisture content of 73.4% has been documented (Kouame et al., 2015). This means the consistency of *ugali* consumed in Kenya is different from that consumed in Malawi (Mlotha et al., 2016), Côte d'Ivoire (Kouame et al., 2015) or Tanzania (Ruhembe, Nyaruhucha & Mosha, 2014). The differences in carbohydrate content may possibly be due to different varieties used in the different studies. For example, the crude protein and crude fat content the Malawian variety was 2.84 and 7.07 % respectively as opposed to 0.56 and 0.93 respectively obtained in this study (Mlotha et al., 2016). Consequently, this study reported higher carbohydrate content. The fiber and ash contents were relatively similar among the two studies as well as the energy contents which were 128.47 and 136.71kcla/100g fresh weight for Malawi and Kenya respectively. It is however important to note that although the energy values are relatively similar, most of the energy is derived from fat in Malawi's study as compared to carbohydrates in the Kenyan case.

Cowpea leaves are important vegetables in the country and they help in improving food security since they are available in all seasons (Okonya and Maass, 2014). Cowpea leaves possess superior nutritional attributes (Chikwedu, Igbatim and Obizoba, 2014; Okonya and Maass, 2014). For example, this study has reported a protein content of 17.85% on dry weight basis. A study by Imungi and Potter (1983) in Kenya reported a protein content varying from 32.8 to 34.3% on dry weight. In Nigeria, cow pea tender and fresh leaves were reported to have a protein content of 21.98% (dry weight) and carbohydrate content at 39.11% (Chikwedu, Igbatim and Obizoba, 2014). These figures were higher compared to the findings in this study and this could be attributed to the differences in geographical locations, soil conditions, variety as well as seasonal variations (Samman et al., 1999; Okonya and Maass, 2014; Imungi and Potter, 1983). They further reported a fat content of 9% (Chikwedu, Igbatim and Obizoba, 2014) which was much lower than reported in this study (36.86%). This is because in this study the cowpea leaves were prepared using vegetable oil. Consequently the energy content was higher in this study (509.04 kcal/100g) than their study (357.58 kcal/100g dry weight) (Chikwedu, Igbatim and Obizoba, 2014). Beans on the other hand are important protein (27%) and carbohydrate source (56%) and accompaniment to rice. The results obtained were comparable to dry raw beans at 25% and 40% for protein and carbohydrate respectively (de Moraes & Angekucci, 1971).

Rice is generally rich in carbohydrates (Mohan et al., 2016). Locally grown *pishori* rice variety was used. Expressed on dry weight basis, the carbohydrate and protein contents were 86.6% and 8.9% respectively in this study which were comparable to 84.3% and 9.4% respectively reported for Basmati rice variety (Gunathilaka & Ekanayake, 2015). The fat content was 3.3% as opposed to Basmati's 1.4%. The moisture contents also differed among the studies, Pakistani Basmati rice reported 63% as opposed to 70% in this study. The differences in the composition could be attributed to the differences in varieties (Gunathilaka & Ekanayake, 2015) which may have influenced water uptake. However, the energy content of 397.33 kcal/100g in this study was comparable to Pakistani Basmati rice which had 393.2 kcal/100g.

3.2 Glycemic Responses

The sample size for glycemic index (GI) determination was calculated to provide 50 g available carbohydrate. The blood sugar response curves were then plotted and presented separately for *ugali* and for rice meals as shown in figures 1 and 2. The glycemic responses measured in terms of GI and GL are presented in Table 4.

3.2.1 Glycemic indices of stiff porridge meals

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

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

3.2.2 Glycemic indices of rice meals

Rice had the highest glycemic index (77). Combining rice with beans and beef reduced the GI to 62 and 69 respectively. Other studies on rice meals found a GI of 75 to 108 observed for different varieties of rice (Onimawo, Arukwe & Nzeagwu, 2010; Asinobi et al., 2016; Idril, Diana & Wargahadibrata, 2013; Gunathilaka & Ekanayake, 2015). The differences in the GI could be due to the difference in rice varieties, origin, processing and preparation methods (Miller, Pang & Bramall, 1992; Pi-Sunyer, 2002; Foster-Powell, Holt & Brand-Miller, 2002; Onimawo, Arukwe & Nzeagwu, 2010; Mohan et al., 2016). Asinobi et al., 2016, blended the rice with stew to prepare test meals. This means the particle size of the meal was considerably reduced which enhanced the accessibility by amylases. This might have led to the higher GI value in their study.

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

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

In general the differences in the GI among different studies could be attributed to the many factors that influence the GI of foods including the foods origin and variety (Pi-Sunyer, 2002; Foster-Powell, Holt & Brand-Miller, 2002; Allen et al., 2013; Idril, Diana and Wargahadibrata, 2013; Gunathilaka & Ekanayake, 2015; Atayoglu et al., 2016; Mohan et al., 2016), processing and preparation (Bahado-Singh et al., 2011; Allen et a., 2012; Gunathilaka & Ekanayake, 2015; Ogbuji et al., 2016), maturity of the food, other nutrients that are consumed with the food (Pi-Sunyer, 2002; Foster-Powell, Holt & Brand-Miller, 2002), as well as the physical/chemical characteristics of the foods (Pi-Sunyer, 2002; Foster-Powell, Holt & Brand-Miller, 2002; Atayoglu et al., 2016). It is therefore important to test the GI of local foods in the way that they are normally prepared and consumed instead of simply adopting the GI tested elsewhere especially when the food is to be recommended to individuals suffering from diabetes mellitus.

4. Conclusion

Kenya's *pishori* rice can be classified as a high GI food; stiff porridge had moderate while beans had low GI. Consuming rice and beans lowers the GI of rice as opposed to rice and beef. Generally, beans and cowpea leaves have the potential of lowering the GI of a carbohydrate meal. They can therefore be considered in the prevention and management of diabetes mellitus type 2. Future research may focus on the effect of other legumes and green leafy vegetables' ability to influence postprandial blood sugar levels.

Conflict of Interest

The authors wish to declare no conflict of interest in the writing of this paper.

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Table 1: Preparation of various foods/meals

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

Table 2: Characteristics of the study subjects

Subject	Age (years)	Body mass index (kgm^{-2})	Fasting blood sugar (mmol/L)	Blood pressure (mmHg)	
				Systolic	Diastolic
1	35	24.8	5.1	121	71
2	29	21.78	4.7	125	78
3	22	18.99	4.4	144	79
4	40	19.33	5.3	118	70
5	32	18.75	4.8	131	67
6	33	23.72	4.9	110	74
7	36	20.28	4.4	115	78
8	27	19.8	4.6	133	78
9	35	19.15	4.9	129	72
10	37	20.28	4.9	117	77
Mean ±SD	32.6±5.32	20.69±2.08	4.8±0.29	124.30±10.14	74.40±4.20

The subjects were aged 22 to 40 years with a mean age of about 32.6±5.32 years. They were of normal BMI with a mean of 20.69±2.08kg/m^2. The average fasting blood sugar was 4.8±0.29 while the mean systolic and diastolic blood pressure was 124.30±10.14 and 74.40±4.20 mmHg respectively.

Table 3: Proximate composition of the meals

Food	Moisture	Fat	Protein	Fibre	Ash	CHO	Energy
1. Whole maize *ugali*	66.14±1.50	0.93±0.05	0.56±0.35	0.69±0.50	0.50±0.05	31.18±0.27	136.71
2. Cowpeas leaves stew	80.17±0.25	7.31±0.05	3.54±0.25	3.02±0.12	2.22±0.06	3.74±0.05	100.95
3. Boiled white rice	70.00±1.00	0.99±0.05	2.67±0.44	0.32±0.35	0.36±0.02	25.98±0.12	124.15
4. Bean stew	71.43±0.50	2.16±0.20	7.78±0.30	1.48±0.50	1.12±0.02	16.03±0.15	117.64

The values in Table 3 were expressed on % fresh weight basis and energy was presented in kcal/100g. The proximate composition of the meals were calculated as grams per 100 g on "as is basis" and energy values were expressed as Kcal/100g. All analyses were performed in duplicate. Means and standard deviation values were then computed. The energy values were calculated from the available carbohydrates, protein, fat, and fibre values by multiplying with their respective empirical conversion factors of 4, 4, 9 and 2 respectively (Stadlmayr et al., 2012). Plain u*gali* had the highest carbohydrate content, while cowpea leaves had the lowest following the order *ugali* > rice > beans > cowpea leaves. Protein content was in the order of beans > cowpea leaves > rice > *ugali* while fibers followed the order, cowpea leaves > beans >ugali > rice.

Table 4: Food ration sizes, glycemic indices and glycemic loads of the meals

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

The GI values for these foods were significantly different (p<0.05). The GI was highest in rice and lowest in beans. Meals containing beef had higher GI as opposed to meals composed of beans and cowpea leaves. Although incorporating beef in rice seem to have lowered the GI of rice, beef seems to have increased the GI of *ugali*.

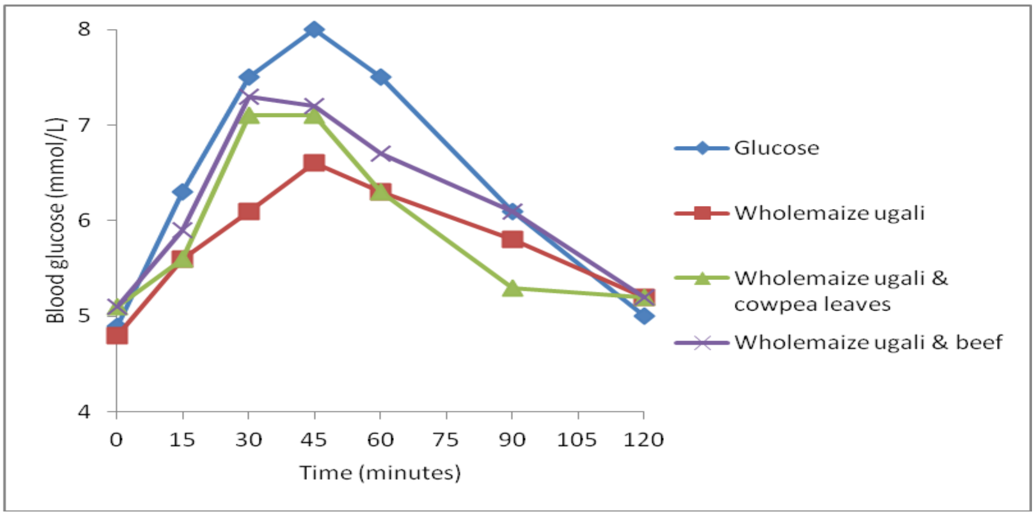

Figure 1: Average blood sugar response curves for ugali meals

There was a sharp rise in blood sugar in the first 30 minutes of consuming each meal except for plain *ugali*. The reference glucose presented the highest rise each time. *Ugali* meals reached peak at 30th minute as opposed to glucose and plain *ugali* that peaked at 45th minute. Although plain *ugali* showed lower response, it is rarely consumed alone, but with a relish. Cowpea leaves give lower response as opposed to beef. These two are some of the commonly used accompaniments to *ugali*. These results are shown in Figure 1.

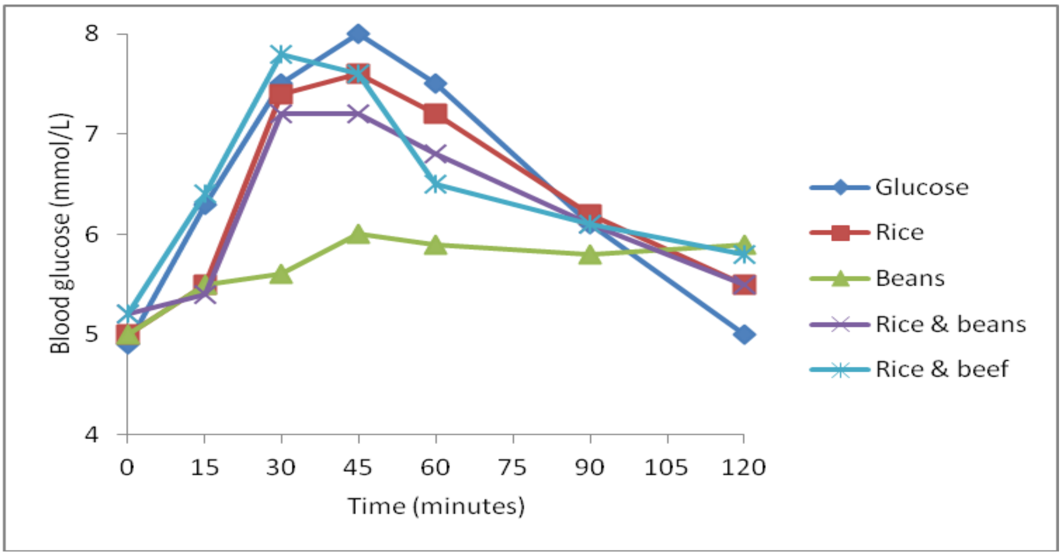

Figure 2: Average blood sugar responses to rice meals

Rice and beef meal and glucose resulted in a sharp rise in blood sugar as opposed to other test foods. Stewed beans seem to have a considerably lower blood sugar response than glucose and other rice meals. Beans seem to lower the blood sugar response of rice as opposed to beef. Rice and beef as well as rice and beans reached a peak at 30th minute while other test foods reached peak at 45th minute. It's also evident that beans sustains blood sugar levels above fasting levels for longer as opposed to other foods that showed sharp drop in blood sugar. These results are shown in figure 2.