Research Article

An empirical pictorial guide to carbohydrate counting in Uganda: A resource for diabetes meal planning and education

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Abstract

Background: Carbohydrate counting has become a popular meal planning strategy in achieving optimal postprandial blood glucose control and dietary flexibility among people with insulin-requiring diabetes. Yet, this aspect of diabetes care has not been well embraced especially in low-resource countries like Uganda. This study aimed to develop an accessible, easy-to-use and context-specific meal planning resource for use in diabetes self-management education and to assist in clinical decisions as reference for clinicians in Uganda. It will also contribute to addressing the dearth in locally contextualised diabetes education resources.

Methods: We mapped common foods consumed in Uganda from a variety of sources which we congregated into food groups. Typical portion sizes of the selected foods and beverages served in the Ugandan context were measured and corresponding carbohydrate content calculated from available food composition tables of Uganda, Tanzania, Kenya and the US Department of Agriculture Food Data Central. We provided descriptive summary statistics and comparisons of carbohydrate content across food groups. All analyses were conducted in STATA version 16.0.

Results: Images of Ugandan foods and dishes with corresponding carbohydrate figures were compiled into an electronic document that is freely accessible online. It features information from 100 food sets categorised into 12 food groups.

Conclusions: This meal planning resource can provide important guidance to meal planning, food choices, clinical decision making and nutrition education in clinical practice.

Keywords: Carbohydrate counting; Diabetes mellitus; Meal planning; Diet; Diabetes education; Uganda

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Background

Carbohydrate-gram counting concept was coined in the 1950s and became a popular approach to nutrition management of diabetes since the completion of the Diabetes Complications and Control Trial (DCCT) in 1993.[1,2] Carbohydrate counting has become an integral component of medical nutrition therapy, and its popularity has been linked to the emergence of short-acting insulin analogues and continuous subcutaneous insulin infusion technologies that involve carbohydrate intake assessment for prandial dosing.[3,4] Carbohydrate counting or usually termed 'carb counting' involves estimation of carbohydrate grams in a given portion or serving of a food or meal.[5] The use of carbohydrate counting is based on the principle that carbohydrate among macronutrients is the primary nutrient with a direct and significant effect on post-prandial glycaemic response.[6] It draws from this principle that regulating and controlling for carbohydrate amount in a meal can provide better prediction and counter-control of postprandial blood glucose levels.[6] The use of carbohydrate counting as one of postprandial glycaemic control strategies has advanced to inform calculations such as insulin-to-carbohydrate ratios, insulin dose adjustments and insulin sensitivity that have been used to achieve control of glycaemic variability.[6]

The importance of carbohydrate counting in achieving and maintaining good glycaemic control has been well documented in landmark studies. For instance, the Dose Adjustment for Normal Eating (DAFNE) study reported 1% improvement in HbA1c among persons with type 1 diabetes, whereas 1%–2% improvement in HbA1c among persons with type 2 diabetes mellitus was reported by Pastors et al (2002).[7,8] Moreover, more studies have shown postprandial blood glucose as a better predictor of diabetes-related cardiovascular complications than glycated haemoglobin deeming carb counting an important strategy in the nutrition management of diabetes.[9,10]

The tasks of carbohydrate counting are basically, learning the foods containing carbohydrate and understanding how to choose and eat appropriate portions of such foods. Carbohydrate counting is more appropriate for individuals with type 1 diabetes, whose bolus insulin doses are usually matched to the meal carbohydrate content.[6] It can

also be used for individuals with type 2 diabetes especially those that control their diabetes through healthy eating and physical activity, with or without use of additional hypoglycaemic agents.[5] More advanced use of carbohydrate counting may involve establishment and adoption of individual-specific insulin-to-carb ratios, insulin sensitivity factor and insulin dose adjustment calculations.[6] Whereas the use of carbohydrate counting in meal planning and nutrition education for people with diabetes has been shown to improve postprandial glycaemic control, promote liberty in food choices as well as flexibility with meals, its use is yet to be well-embraced in most countries in sub-Saharan Africa.

In sub-Saharan Africa, the use of carbohydrate counting in nutrition management of diabetes has been barely reported. Moreover, nutrition management of diabetes has been rather challenging for both the healthcare providers and patients with anecdotal citing of limited context-specific resources to guide recommendations, interventions and implementation. Uganda has not been exceptional to these challenges. From our experience, similar to what Sunni reported in Somali communities, this has mainly been due to lack of local contextuality of such resources, limited presence of diabetes-specialist nutritionists, and with the existing low literacy levels among patients and caregivers adding to the complexity.[11] The nutrition aspect of diabetes care has therefore remained underexplored in clinical settings. A few studies conducted in Uganda have shown the challenges in nutrition management among diabetes patients. For instance, Matovu, et al. found carbohydrate to contribute more than 75% of total energy intake among diet-conscious people with type 2 diabetes attending clinics in Uganda.[12] In another study, Kyokunzire et al. reported non-adherence to diet recommendations to be a popular experience among type 1 diabetes patients in diabetes clinics in Uganda.[13] These highlight the need to enhance nutrition consideration in diabetes management within health settings especially when poor metabolic control is still reported among young persons with type 1 diabetes.[14,15] There is need for context-specific nutrition support information and guidance to enable patients and caregivers to appropriately make informed food and dietary choices other than imposing unpopular dietary restrictions.

Given that the number of type 1 and type 2 diabetes in Uganda is growing proportionately over the years, it is imperative to step-up all aspects of diabetes care and management to improve diabetes outcomes and quality of life.[16,17] We therefore undertook to develop an update and expansion of a locally contextualised, easy to use and accessible meal planning resource, the first of its kind in Uganda to guide nutrition education and diabetes self-management for health workers, patients and caregivers.

Methods

This project is a continuation of the work done by Sseguya (2014) on carbohydrate content of common foods consumed in Uganda.[18] In this cross-sectional study, we transformed the descriptive information of his work into pictorial visual material. These revisions were informed by consideration of feedback information that had been reported by users of the earlier version. We compiled individual and group feedback information that we from healthcare workers, persons with diabetes and caregivers of people with diabetes under different diabetes care programmes of St Francis Nsambya hospital diabetes centre between 2017 and 2018. The feedback information informed modifications in presentation of content of the earlier material version into a more pictorial and visually illustrative presentation that provides more visual understanding and translation. An ethics waiver was granted by St. Francis Hospital Nsambya REC as the research project did not involve work on human research participants or animals.

Foods and dishes

Foods and dishes that we included represent most of the foods and beverages that are popularly consumed in Uganda. In addition to the foods and dishes covered in the earlier version of the material, we added extra dishes and foods to the revised version. The foods and dishes were presented in 12 groups i.e., plantain, starches and grain; Porridges; Dairy; Snacks and accompaniments; Fruits; Legume sauces; Vegetables; Juices; Sweeteners; Meat, eggs and edible insects; and Fats and oils. Where appropriate, various forms of foods and dishes were represented.

Measuring equipment and utensils

We used the following measuring materials and equipment to ensure standardisation across measurements; a calibrated measuring cup (measuring up to 250 ml), a digital food scale (Helect® model H1011, measuring range 1 g-5000 g) and a non-stretch measuring tape. We further used utensils that are typical of and popularly used in most households in Uganda to represent typical household food portions. These included different drinking mugs, drinking glass versions, plates, saucers, Ladle and tableware to match typical food portions commonly served in households.

Portion measurements

Food portion measurements were based on edible portion and typical hand portions or typical household servings. To arrive at food portion measurements that we used in

the guide, we took samples of a given food item from at least three sources, including local restaurants, street food stalls, local grocery outlets and households. We compared these samples to come up with an average food size or volume where appropriate. This informed the sizes and volumes that we attached to food items in the guide. Where appropriate, we presented different forms and or sizes of foods that are prepared, served or presented in various forms and sizes. Where a dish consisted of mixed foods, component carbohydrate containing foods were measured independently for purposes of estimating the carbohydrate content of the entire portion of the mixed dish. For mixed beverages, proportions were established from local recipes described by sellers or vendors.

Carbohydrate gram figures

Food portion measurements were used to calculate the respective carbohydrate content in grams (g). Carbohydrate grams were calculated using figures from the previous material version and from food composition tables; Uganda food composition tables, Tanzania food composition tables, Kenya food composition tables, USDA Food Data Central, and food labels.[18-21] Since many of the foods prepared and the ingredients used were typical of east Africa regional cuisines, we were able to ascertain their carbohydrate content from the food composition tables compiled for Uganda, Tanzania and Kenya. Foods that were prepared using internationally documented recipes as well as packaged foods had their respective carbohydrate content were derived from USDA Food Data Central and use of food labels where appropriate. Local recipes were obtained for the few food and beverage items that were missing in the food databases and compositions tables. Their carbohydrate content was estimated by individually considering the carbohydrate content of component carb-containing ingredients.

Food composition tables for Uganda, Tanzania and Kenya took precedence over any other data source. Food labels however took overall precedence over other data sources for food items with nutrition information labels. All carbohydrate calculations were based on edible portion and 'available' carbohydrate. Carbohydrate grams were rounded off to the nearest round number for simplicity. This was only performed for numeric figure calculations that returned decimal numbers. Numeric figures were rounded down for the decimal number <5 and rounded up for the decimal number ≥ 5. Where a similar food item featured in more than one set of food composition tables with varying carbohydrate figures, precedence was given to Uganda food composition tables (because of origin), Kenya food composition tables (because of recency in compilation) and then Tanzania food composition tables.

Foods that are known to contain insignificant quantity of carbohydrate were labelled as "zero carbohydrate." These included all foods in the groups of Meat, poultry and edible insects; fats and oils; and for cheese in the Dairy group.

Statistical analysis

This paper provides a summary of selected food items assessed and their carbohydrate content per 100 grams or millilitres of food portion (Table 1). The selected food items represented 9 food groups basing on their nutrient profiles. These food groups included:

- diary,
- fruit juices and cold beverages,
- fruits,
- legumes and pulses,
- mixed dishes,
- porridges,
- snacks and accompaniments,
- starchy tubers, plantain and cereals, and
- vegetables

Table 1: *Summary of Carbohydrate content per food item as assessed in this study*[5]

Food Items	Carb (g)†	Food Items	Carb (g) †	Food Items	Carb (g) †	Food Items	Carb (g) †	Food Items	Carb (g) †
1. Starchy tubers, plantain and Cereals		**3. Snacks and Accompaniments**		**4. Legumes and pulses**		**6. Porridges***		**8. Fruit Juices and Cold Beverages***	
Rice	34	Bread	50	Dry Beans	17	Millet porridge	7	Apple juice	11
Kivuvu	29	Chapatti	42	Dry garden peas	11	Maize porridge	8	Bushera	8
Sweet Potato	17	Mandazi	20	Groundnut sauce	9	Rice porridge	8	Mango juices	13
Cassava	30	Banana pancake	20	Simsim paste	20	Cassava porridge	7	Munananansi	11

Potato fries	45	Doughnut	50	**5. Fruits**		Soya Porridge	4	Orange Juice	10
Karo	20	Samosa peas	15	Apple	14	**7. Vegetable**		Passion Juice	12
Potatoes	22	Samosa Rice	20	Avocado	8	Entula	1	Watermelon juice	7
Matooke	30	Samosa Meat	10	Mango	17	Aubergine	1	**9. Dairy**	
Yam	23	Cookie	65	Jackfruit	24	Bitter berries	2	Yoghurt	4
Cassava Bread	28	Daddies	50	Oranges	9	Cabbage	2	Milk*	5
Posho	23	Popcorn	50	Passion Fruit	10	Carrots	10	-	-
2. Mixed dishes		Gonja	30	Pawpaw	10	Cucumber	4		
Cassava+Beans	36	Maize cob	27	Pineapple	13	Bugga	1		
Mpengere	36	Groundnut kernels	13	Yellow banana	30	Doodo	1	†Carbohydrate content assessed per 100g (or mls*) of food item. ⁶Data is derived for carbohydrate-containing food items	
Potatoes+Gnuts	20	Soyabeans	30	Watermelon	8	Okra	1		
Matooke+Gnuts	24	Hardcorn	80	Sugarcane	7	Nakati	2		
Matooke+Beans	26	-	-	Tangerine	13	Pumpkin	4		
Potatoes+Beans	20	-	-	-	-	-	-		

Given the fact that the authors thought it necessary to characterize the carbohydrate content of each food group, mean estimates together with their corresponding 95% confidence intervals of carbohydrate content of all foods in a given food group were computed and reported. The minimum and maximum expected carbohydrate content per food group was simultaneously reported. A box plot was also presented to illustrate and compare differences in median carbohydrate content per food group in order to enable better interpretation of results and assist decision making when choosing carbohydrate foods from certain food groups.

Results

A total of 100 food items including foods and beverages have been included in this version. The names, visual portions and carbohydrate content of the food items are well displayed. Some local names of certain food items have been provided with English translations. The images provide more ease in visual estimation and recognition of foods. The guide also has additional text information related to diet, diabetes and insulin that is relayed in simple and understandable language. This meal planning resource is available as supplementary material to this publication.

Summary and comparisons of carbohydrate contents across food groups as assessed from our pictorial guide

A summary of all food items assessed and their carbohydrate content per 100 grams or millilitres of food portion is shown in Table 1. Comparisons with illustrations of carbohydrate estimates across selected food groups are shown in Table 2 and Figure 1 respectively. Briefly, results from our pictorial carbohydrate counting guide illustrate that snacks and accompaniments; starchy tubers, plantain and Cereals; and mixed dishes had the highest mean carbohydrate content, all with figures above 20 g per 100 g of food portion. On the other hand, vegetables, diary and porridges had the lowest mean carbohydrate content per 100 g or millilitres of food portion, all below 10 grams.

Table 2: *Estimated Carbohydrate content per selected food group**

Food group	Number of food items assessed	Mean	(95% C.I)	Min	Max
Dairy	2	4.5	3.50, 5.5	4	5
Fruit Juices and Cold Beverages	7	10.3	8.7, 11.9	7	13
Fruits	12	13.6	9.5, 17.6	7	30
Legumes and Pulses	4	14.3	9.1, 19.4	9	20
Mixed Dishes	6	27	21.0, 33.0	20	36
Porridges	5	6.8	5.3, 8.3	4	8

Snacks and Accompaniments	16	35.8	25.7, 45.8	10	80
Starchy tubers, plantain and Cereals	11	27.4	22.7, 32.0	17	45
Vegetables	11	2.7	1.1, 4.30	1	10
*Data is derived for carbohydrate-containing food items					

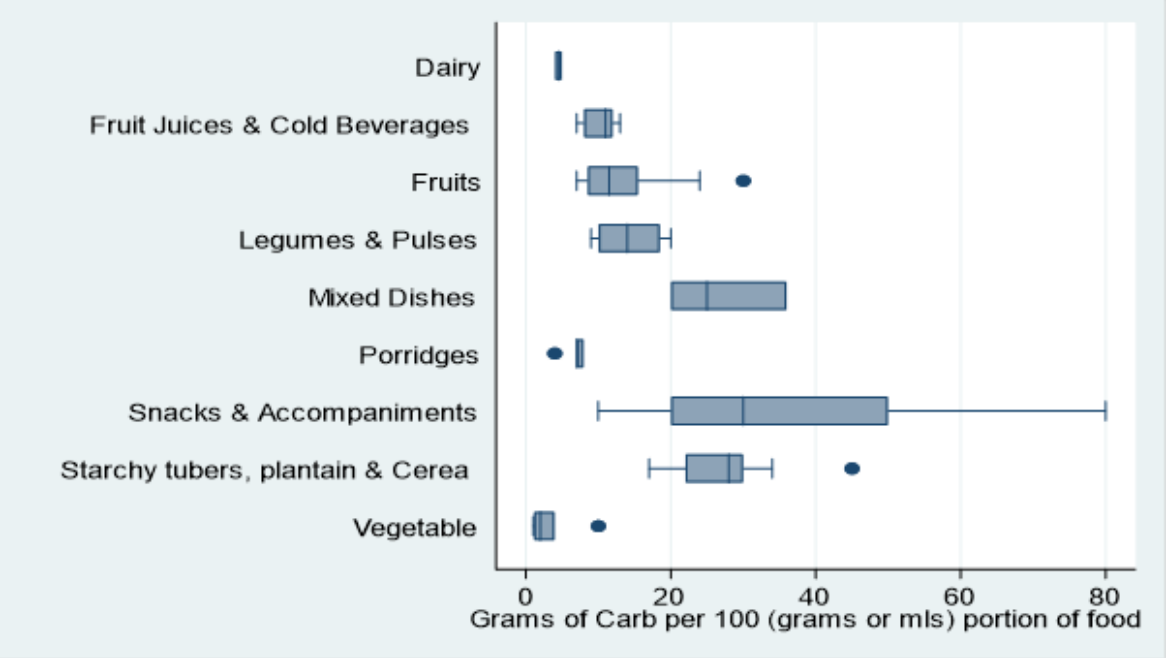

Figure 1: *Graphical comparison of median carbohydrate content per selected food group as assessed in the study (derived for carbohydrate-containing food items).*

Discussion

Carbohydrate counting is a popular meal planning method in diabetes management especially for children, adolescents and young adults with type 1 diabetes mellitus. It focuses on carbohydrate as the primary nutrient with significant effect on postprandial blood glucose levels. Accurate information on carbohydrate content of foods is thus crucial in guiding on food portion choices and corresponding insulin calculations for persons with insulin-requiring diabetes. This underscores the integral role of nutrition Information Education and Communication (IEC) resources in successful dietary education programs for diabetes management. Our project aimed to develop an accessible, easy-to-use and context-specific meal planning resource for use for Diabetes Self-Management Education (DSME) in Uganda. The resource presents information that can assist patients and caregivers in meal planning and making informed food and diet choices under guidance of their diabetes care team.

The use of IEC materials in patient education has gained popularity in chronic care programmes in sub-Saharan Africa, including their importance in delivering comprehensible information messages to predefined individuals or groups.[22] Mahapatra (2014) emphasises that IEC materials need to be designed with simple language and content. He further argues that they should also be aligned to address local needs and conform to cultural contexts if they are to realise their intended purpose.[22] Our resource was designed to address the dearth in locally-contextualised diabetes-specific nutrition resources in Uganda. Moreover, the need for such a meal planning resource among health workers, patients and caregivers had been indicated through their shared lived experiences. The western IEC resources that were previously intended to fill the gap in diabetes management became unpopular as they fell short of featuring several local foods that are well-known to the population. For a country like Uganda that is characterised by a rich diversity in cuisine and foods, availability of food information becomes very crucial for individuals whose disease management demands strict diet observation as the case is with diabetes.[23] Limited information on foods makes nutrition planning and advice for diabetes management difficult for health workers and caregivers. This may explain why many health workers resort to imposing strict food restrictions for patients as reported elsewhere and the poor adherence to dietary recommendations reported among type 1 diabetes patients.[7,13]

As reported elsewhere, misperceptions and misconceptions related to diabetes and food are still widespread in Uganda.[24,25] Surprisingly, these are not only limited to patients and caregivers but exist among some health workers too. This has contributed to widespread misinformation regarding the effect of certain foods on diabetes with various tagging of certain foods "diabetic foods." With majority of foods that make up the affordable diets of Ugandans being carbohydrate-rich, information aimed at restricting intake of carbohydrate-containing food would risk young persons with type 1 diabetes being undernourished.[12,23] This is because type 1 diabetes commonly manifests in children and young adolescents, the two population groups that require critical nutritional consideration to address critical nutrient needs for their growth and development.[26] The observation from our summary statistics that nutrient-rich foods contain carbohydrate further highlights the need to focus on portion control rather than elimination of certain foods from the diet. Food choices from carbohydrate-dense food groups such as 'snacks and accompaniments,' 'starchy tubers, plantain and cereals' and 'mixed dishes' need to be controlled to moderate portions while leveraging on the low carbohydrate-dense food choices from 'Vegetables' to provide controlled overall meal carbohydrate intake. The role of food variety in controlling meal carbohydrate intake while enriching the nutrient profile of the meal should not be forgotten when making food choices. Dairy and fruits provide moderate carbohydrate intake with additional nutritional benefits, making these 2 groups of nutritional significance for persons with diabetes unlike the popular belief associating them with poor diabetes outcomes. The information further shows that typical school meals in the Ugandan settings can still be manipulated to achieve good control of blood glucose levels for learners with type 1 diabetes as long as they are assisted in understanding portion control and their insulin regimen appropriately adjusted. The common costly practice of arranging special meals is therefore not a necessary requirement or a guarantee for achieving good blood glucose at school as there is no justifiable supporting evidence that has been documented. We have experienced several unfortunate accounts of misperceptions, including individuals living on bland and bitter foods and avoiding sweet-tasting foods to achieve good diabetes control.

Our meal planning resource will therefore: Serve to create an understanding of the carbohydrate load of foods that were otherwise locally considered light loaded; assist in planning of meals and promoting liberal and flexible food choices; address common misinformation related to foods and diabetes; serve as additional education materials for individual and group diabetes self-management education during clinic days; assist and guide clinical decisions and as well serve as resource for use in continuous training of healthcare professionals. We also envisage the resource to provide opportunity and impetus for future similar diabetes-related research in Uganda and the Eastern Africa region.

We plan to evaluate the impact of use of this resource among patients and health workers-a process that will inform necessary future revisions to this resource material.

Strengths and Limitations

This carbohydrate-based meal planning resource is the first of its kind to feature locally available foods and traditional dishes from the different regions of Uganda. Its picture-based design and free online accessibility renders easy usability and availability. However, the foods and dishes represented in the resource material does not cover all foods and dishes available countrywide but rather the commonly consumed foods.

Conclusion

The availability of this meal planning resource for Uganda presents a huge milestone in the management of diabetes especially among young persons with type 1 diabetes whose numbers continue to grow in Uganda. Its use will contribute significantly to addressing misinformation and misperceptions related to food and diabetes especially with foods that have always been perceived to have no effect on postprandial blood glucose. We believe that the fit into local context, simplicity and accessibility of this resource will provide more uptake, utilisation and continued support to clinical and self-care decision making around food and diabetes.

What is already known on this topic?

A 1% improvement in A1C among persons with type 1 diabetes using carbohydrate counting was reported by the DAFNE study[7]

Carbohydrate counting in persons with type 2 diabetes was reported to contribute to a 1%-2% improvement in HbA1c[8]

What this study adds

- Carbohydrate counting centred on locally available foods and dishes in Uganda
- Locally contextualised pictorial meal planning resource that is free and electronically accessible to users

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Author's Contribution

WS conceived the research project idea. WS and NM were directly involved in design, acquisition of data, analysis and interpretation of results. Both WS and NM drafted, revised and approved the manuscript version to be published.

Competing Interests

The authors declare that they have no competing interests.

Supplementary Material

The material generated during this study is available as a supplementary material submitted to the editorial office.

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