Development of a Malian food exchange system based on local foods and dishes for the assessment of nutrient and food intake in type 2 diabetic subjects

Coulibaly A, PhD **O'Brien HT,** PhD, RD **Galibois I,** PhD, RD

Département des sciences des aliments et de nutrition, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval Québec (QC) Canada

Correspondence to: Isabelle Galibois, email: isabelle.galibois@fsaa.ulaval.ca

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Abstract

Objective: To develop exchange lists for the assessment of food and nutrient intakes for people with diabetes in Mali.

Design: Based on North American exchange lists, a Malian food exchange system was developed using food composition tables for Mali. Dietary intakes were assessed by two 48-hour dietary recalls. Daily numbers of exchanges were determined for the whole sample and for each gender. Energy and macronutrient intakes obtained by a software-based nutritional analysis of the dietary recalls were compared with the average energy and nutrient values calculated with the exchange lists.

Setting: Centre National de Lutte contre le Diabète.

Subjects: Seventeen male and 40 female adults with type 2 diabetes.

Results: The analysis of food recalls using the Malian exchange system showed that subjects consumed the following numbers of exchanges per day: 2.6 ± 1.5 meat and substitutes, 0.5 ± 0.8 legumes, 0.7 ± 1.2 milk, 8.0 ± 4.1 fat, 8.3 ± 3.0 starch, 1.5 ± 0.9 vegetables, 0.2 ± 0.5 fruit, and 0.0 ± 0.2 sugar-added foods, totalling 1 854 ± 648 kcal, 260 ± 92 g carbohydrate, 56 ± 23 g protein and 63 ± 31 g fat. These results concerning energy and macronutrients did not differ significantly from those obtained from the nutritional analysis of food recalls with software using data from the Food Composition Table for Mali. Compared to women, men consumed significantly larger numbers of exchanges of meat and substitutes, fat, starch, and fruit. No significant differences were found for the intakes of legumes, milk, vegetables and sugar-added foods.

Conclusions: This study allowed the development of Malian food exchange lists and demonstrated their usefulness for the description of the dietary pattern and energy and macronutrient intakes of male and female Malian type 2 diabetic patients.

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Introduction

Diabetes poses an immeasurable threat to global health, health care structures and national economies.[1] Africa will not escape its impact. Although the exact magnitude of the problem in Africa is not well understood, diabetes is a serious threat to public health throughout the continent.[2] According to International Diabetes Federation estimates, the number of people with diabetes in Africa will have increased by almost 100% in the 15 years leading up to 2010.[1] For the vast majority of African people with diabetes, insulin and other anti-hyperglycaemic agents are simply out of reach, due either to their excessive cost or the unreliable and insecure supply chains that make these life-saving medications unobtainable even for those who have the means to buy them.[1] Considering the human and economic burden of diabetes, and the difficulty of purchasing the medication, it would be important to emphasise nutrition therapy. The primary goal of medical nutrition therapy for individuals with diabetes mellitus is to optimise their metabolic control through dietary choices that are attainable and sustainable within the culture, preferences and capacities of the patients themselves.[3,4]

In Africa, nutrition therapy is often put aside, due to the lack of training in nutrition of health care providers and to the inexistence of adapted tools for the assessment of dietary and nutrient intakes.

In 1950, a joint effort by the American Dietetic Association, the American Diabetes Association and the US Public Health Services was undertaken to prepare a set of food values for estimating the energy and nutrients of meal plans for persons with diabetes, a short method for calculating the diet, and several lists of foods of similar values. This resulted in the first edition of the Exchange Lists for Meal Planning.[5] Ever since, this meal-planning tool has proven to be useful, both to assess nutrient intake and to determine individualised meal plans for diabetic subjects. In the present study, inspired by the Samoan[6] and North American food exchange lists,[7,8] a food exchange system based on local West African foods was developed. Its adequacy to assess energy and macronutrient intake was tested using food recalls of Malian type 2 diabetic subjects.

Methods

Development of the Malian Food Exchange System: preliminary version

Based on North American models, the Malian exchange system was initially divided into seven food groups: meat and substitutes, milk, fat, starch, vegetables, fruit and sugar-added foods. For these groups, nutritive values (that is, number of grams of carbohydrate, proteins, lipids and energy content for one exchange) were similar to those of the American Dietetic Association/American Diabetes Association Exchange Lists for Meal Planning[7] and/or the Diabetes Quebec Meal Planning for People with Diabetes.[8] The milk group was an exception, as the nutritive values that were retained were those of whole cow's milk, as found in the Food Composition Table for Mali.[9] In addition, to make the Malian exchange system easier to use and because legumes are widely consumed in Mali, a specific food group was included for them in this first version of the Malian exchange system, which totalled eight food groups (Table I, V1).

Table I: Amount of energy and macronutrient content in one serving from each group in the preliminary (V1) and the second (V2a) versions of the Malian food exchange system.

Group	Nutrient values for one exchange							
	Carbohydrate (g)		Protein (g)		Fat (g)		Energy (kcal (KJoules))	
	V1	V2	V1	V2	V1	V2	V1	V2
Meat and substitutes [b]	0	0	8	7	3	6	60 (250)	90 (375)
Legumes	15	14	8	8	0	0	90 (375)	90 (375)
Milk	12	12	9	9	12	12	195 (815)	195 (815)
Fat [b,c]	0	0	0	0	5	5	45 (190)	45 (190)
Starch [b,c]	15	28	2	3	0	0	70 (290)	125 (520)
Vegetables [b,c]	5	5	2	2	0	0	25 (105)	25 (105)
Fruit [b,c]	15	15	0	0	0	0	60 (250)	60 (250)
Sugar-added foods [b,c]	15	15	varies		varies		varies	

[a] The second version (V2) was adapted from the preliminary version (V1).
[b] Amounts of energy and macronutrients for the preliminary version (V1) were based on reference 7.
[c] Amounts of energy and macronutrients for the preliminary version (V1) were based on reference 8.

Testing of the preliminary version with food recalls of Malian diabetic subjects

This study was part of a wider nutrition survey undertaken in a health care setting for diabetic patients: the Centre National de lutte contre le diabète (CNLD) in Bamako, Mali. Participants were recruited among the outpatients who attended primary health care services. Ethics approval for the study was obtained from Laval University's ethics committee. Written, informed consent was received from subjects prior to their inclusion in the study.

Patients visiting the clinics agreed to participate in the study after receiving information from their physician. In order to facilitate the patients' participation in the study, their physicians were responsible for explaining and checking the eligibility criteria (to be an adult diagnosed with type 2 diabetes; not treated with insulin), which were checked again by one of the research team members (AC). Each subject was seen individually and the interviews were conducted in a local dialect, Bamana.

The sample comprised 17 males and 40 females. The mean age of the subjects was 54.5 ± 9.4 yrs, and the mean body mass index (BMI) was 24.1 ± 3.8 kg/m^2 for men and 27.0 ± 5.3 kg/m^2 for women ($p = 0.043$).

In this study, the participants were asked to recall their previous 48-hour dietary intake of foods and beverages. Two 48-hour recalls were carried out on 43 subjects during two distinct interviews, whereas only one 48-hour recall was carried out on 14 other subjects who did not show up for a second interview. Based on the model of SU.VI.MAX,[10] food models and photographs, as well as a portion-size guide of locally consumed foods, were used during the interview to help participants better quantify the portions consumed. Various containers and local utensils (bowl, spoons and dishes) were also used, in particular the Sada Diallo bowl, a 400 ml container developed by the CNLD to help diabetic patients measure quantities of food consumed.

First, nutritional analysis software based on the Canadian Nutrient File,[11] completed by nutritive values obtained from the Food Composition Table for Mali,[9] was used to assess the mean intakes of each subject according to the 48-hour dietary recalls. The energy and macronutrient intakes of each participant were the means of all of his or her dietary recalls, expressed on a per-day basis. Secondly, all food items obtained from the 48-hour recalls were converted into numbers of food exchanges. The daily energy and macronutrient intake of each participant was calculated using the mean nutrient and energy values according to the preliminary version of the Malian exchange system. The two assessments of the macronutrient and energy intakes for the whole group were compared (Table II). There was no significant difference between energy intakes assessed by the two methods. However, carbohydrate ($p = 0.0002$) and protein ($p < 0.0001$) intakes were significantly higher when assessed by the exchange system, while fat intakes were lower ($p < 0.0001$).

Table II: Mean energy and macronutrient intakes in type 2 diabetic subjects as assessed by the preliminary version (V1) of the Malian food exchange system and by nutritional analysis software (n = 57).

Variable	Exchange system	Nutritional analysis	P
Energy (kcal (kJ))	1 899 (7 957) ± 657 (2 753)	1 872 (7 843) ± 637 (2 669)	0.318
Carbohydrate (g)	277 ± 98	260 ± 86	0.0002
Fat (g)	55 ± 28	65 ± 32	< 0.0001
Protein (g)	67 ± 26	58 ± 26	< 0.0001

Adjustment in nutrient values for the meat and meat substitutes and starch food groups

Since the Food Composition Table for Mali[9] indicated that meats are generally higher in fat and lower in protein, and as starchy foods are eaten in larger amounts and are, according to food composition tables,[9,11] generally lower in protein in Mali than in North America, the nutrient values for the meat and substitutes and starch groups were adjusted in a second version of the exchange system (Table I, V2).

As with the preliminary version, all food items obtained through the 48-hour recalls were converted into numbers of food exchanges based on the second version of the Malian exchange system. Energy and macronutrient intakes were calculated using the new sets of nutrient values and were again compared with results from the software-based nutritional analysis of the food recalls.

Elaboration of the exchange lists

Foods selected to be in the Malian exchange lists are those commonly eaten by a majority of individuals in Mali. To determine the serving size most appropriate for matching the exchange list mean values, the Food Composition Table for Mali[9] was used to obtain nutrient values for each individual food. Exchange lists for each food group are presented in Table III, indicating the serving sizes of commonly consumed foods that account for one exchange. Since many Malian dishes did not fit into single exchange lists, the exchange composition of various typical combination foods is also found in Table III. Many are core foods in Mali.

Table III:. Exchanges lists for common Malian foods

Meat and substitutes list: Each serving of meat and substitute on this list contains approximately 7 grams of protein, 6 grams of fat and 90 calories (380 kJ).

Food	Amount
Beef	30 g
Mutton	30 g
Chicken	30 g
Fish	30 g
Egg	1

Legumes list: One exchange has approximately 14 grams of carbohydrate, 8 grams of protein and 90 calories (380 kJ).

Food	Amount
Pulses	
Beans and peas, cooked (such as kidney, white, black-eye)	½ cup (125 ml)
Lentils, cooked	½ cup (125 ml)
Groundnut	
Groundnut, bambara, fresh, shelled[a]	60 g
Groundnut, grilled, salt, shelled[b]	60 g
Groundnut paste[b]	60 g

a = Also calculate ½ fat exchange
b = Also calculate five fat exchanges.

Milk list: Each serving of milk and milk products on this list contains about 12 grams of carbohydrate, 9 grams of protein, 12 grams of fat and 195 calories (820 kJ).

Food	Amount
Milk, cow, whole, fresh	1 cup (250 ml)
Milk, cow, whole, curdled[a]	1+½ cup (375 ml)
Milk powder, cow	30 g
Evaporated whole milk	½ cup (125 ml)

a = Also calculate 1 meat and 1 fat exchange

Fats list: Each serving on the fats list contains 5 grams of fat and 45 calories (190 kJ). Items on this list should be used sparingly.

Food	Amount
Peanut oil	1 tsp (5 ml)
Cottonseed oil	1 tsp (5 ml)
Red palm oil, fresh	1 tsp (5 ml)
Shea butter	1 tsp (5 ml)

Starch list: Each item on this list contains approximately 28 grams of carbohydrate, 3 grams of protein, a trace of fat and 125 calories (525 kJ).

Food	Amount
Maize, sorghum, millet (gruel with grain)	1 cup (250 ml)
Maize, sorghum, millet, rice (gruel)	1 cup (250 ml)
Yam	2/3 cup (175 ml)
Fonio (African cereal), grain steamed	1 cup (250 ml)
Maize, sorghum, millet (couscous, flour steamed)	1 cup (250 ml)
Maize, sorghum, millet (flour cooked)	2/5 cup (100 ml)

Vegetable list: Each vegetable on this list contains about 5 grams of carbohydrate, 2 grams of protein and 25 calories (105 kJ).

Food	Amount
Carrots	1 small (75 ml)
Onion	½ medium (75 ml)
Cucumber	2 cups (500 ml)
Eggplant	1 cup (250 ml)
Tomato	1 medium (125 ml)

Fruit list: Each item on this list contains about 15 grams of carbohydrate and 60 calories (250 kJ).

Food	Amount
Banana	½ medium
Pineapple (raw)	2 slices (90 g x 2)
Pineapple (canned)	½ cup (125 ml)
Watermelon	1 cup (250 ml)
Mango	½ medium (125 ml)

Sugar-added foods: Each item on this list contains about 15 grams of carbohydrate. Energy varies depending on the amount of fat and lipid.

Food	Amount
Lemon juice + sugar, boiled	2/3 cup (175 ml)
Rosell fruit + sugar, boiled	½ cup (125 ml)
Ginger + sugar	1/3 cup (85 ml)
Tamarind juice + sugar	1/5 cup (50 ml)

Combination dishes

Many dishes in Mali are combinations of foods that do not fit into only one exchange list. This list gives average values for some typical combination Malian foods.

Food	Amount	Exchanges
Sauces		
Fakouhoy leaves + meat + dates	½ cup (125 ml)	2 meat + 1 vegetable
Groundnut paste + green leaves	½ cup (125 ml)	½ legume + 1 fat
Amaranth leaves + groundnut paste + meat + okra + dry fish + palm oil	½ cup (125 ml)	½ meat + 1.5 fat + 1 vegetable
One-pot dishes		
Bean flour steamed	150 g	3 legume + 2.5 fat
Fonio + groundnut flour	1 cup (250 ml)	2 starch + 1 meat + 2.5 fat
Rice + groundnut oil + fish + soumbala	1 cup (250 ml)	1.5 starch + 2 fat
Rice + groundnut oil + fish	1 cup (250 ml)	1.5 starch + ½ meat + 1 fat

Statistical analysis

All statistical analyses were performed using SAS version 9.1 (SAS System for Windows, SAS Institute, Cary, NC). Results are expressed as mean values and standard deviations, unless stated otherwise. The comparison between the two dietary methods was undertaken using a Student paired t-test. Statistical significance was set at $p < 0.05$.

Results

In contrast with the preliminary version, no significant differences were found for energy and macronutrient intakes when comparing the results obtained from the second set of nutrient and energy values of the Malian food exchange system with those of the nutritional analysis software (Table IV).

Table IV: Mean energy and macronutrient intakes in type 2 diabetic subjects as assessed by the second version (V2) of the Malian food exchange system and by the nutritional analysis software (n = 57).

Variable	Exchange system	Nutritional analysis	P
Energy (kcal (kJ))	1 854 (7 768) ± 648 (2 715)	1 872 (7 844) ± 637 (2 699)	0.48
Carbohydrate (g)	260 ± 92	260 ± 86	0.97
Fat (g)	63 ± 31	65 ± 32	0.19
Protein (g)	56 ± 23	58 ± 26	0.09

The mean number of food exchanges consumed per day for all subjects and for each gender are presented in Table V. For the starch and fat groups, the consumption averaged about eight exchanges per day. The meat and substitutes group totalled 2.6 exchanges per day, and the vegetables group 1.5. Daily numbers of exchanges were much lower for sugar-added foods, fruit, legumes and milk. Differences in food intakes were found between male and female subjects, with the mean number of exchanges being significantly higher in men for meat and substitutes ($p = 0.04$), starch ($p = 0.003$) and fruit ($p = 0.03$). Finally, results (not reported in the tables) showed that foods from the meat and substitutes, fat, starch and vegetables groups were found in the dietary recalls of every subject. Foods from the milk and legumes groups were present in two-thirds and in more than half of the recalls respectively. Only 6% of men and 10% of women reported the consumption of foods from the sugar-added food group.

Table V: Daily consumption of food exchanges in Malian type 2 diabetic patients (n = 56)

Variable	Number of exchanges consumed per day (mean ± SD)			
	All subjects	Men (17)	Women (39)	P value
Meat and substitutes	2.6 ± 1.5	3.2 ± 1.8	2.3 ± 1.3	0.04
Legumes	0.5 ± 0.8	0.5 ± 0.5	0.5 ± 0.9	0.77
Milk	0.7 ± 1.2	1.0 ± 1.9	0.5 ± 0.5	0.27
Fat	8.0 ± 4.1	9.5 ± 4.4	7.2 ± 3.8	0.05
Starch	8.3 ± 3.0	10.6 ± 3.6	7.4 ± 2.1	0.003
Vegetables	1.5 ± 0.9	1.8 ± 1.2	1.3 ± 0.8	0.20
Fruit	0.2 ± 0.5	0.5 ± 0.7	0.1 ± 0.2	0.03
Sugar-added foods	0.0 ± 0.2	0.0 ± 0.1	0.1 ± 0.2	0.31

Discussion

The principle of a food exchange system for meal planning is that, within a given food group, one exchange is approximately equal to another in terms of calories, carbohydrate, protein and fat. That is why any food on a list can be "exchanged", or traded, for any other food on the same list.

The Malian food exchange system developed in this study was divided into the usual exchange categories, with the exception of the legumes group. In North American exchange systems,[7,8] legumes are included in both the meat and substitutes group and in the starch group because of their protein and carbohydrate content. Since they are staple foods in West Africa, legumes were put in a separate list in the Malian food exchange system. It has to be pointed out that this list included pulses (beans, lentils, etc.) that are virtually fat-free, as well as groundnut that, in its prepared forms (dried or grilled), contains significant amounts of oil. Hence, prepared groundnut counted for both legumes and fat exchanges.

Also, according to the food composition table data, starchy foods are generally lower in protein and slightly less dense in carbohydrates in Mali than in North America (for instance, 100 g of fonio flour, an African crop, contains 67 g of carbohydrate and 7 g of protein,[9] while 100 g of Canadian all-purpose white wheat flour provides 76 g of carbohydrate and 10 g of protein[11]). Because of this, and also because starchy foods are eaten in large amounts by Africans, the amount of carbohydrate for one starch exchange for the second and final version of the Malian system was increased from 15 to 28 g and the amount of protein from 2 to 3 g (Table I). As a result, the energy content of one starch exchange was set at 125 calories.

Another difference with the North American exchange lists is that, in the proposed system, there are no subgroups based on fat content for the milk and meat and substitutes categories. This is due to the fact that food items included in the Malian exchange lists were based on foods found in the Food Composition Table for Mali,[9] in which there were no subgroups such as whole or skim milk. Moreover, this reflects the actual situation in Mali, where food variety and availability are limited, making it difficult for diabetic patients to opt for lower fat choices in meats and milk.

In order to validate the proposed exchange lists, 48-hour dietary recalls of 57 type 2 diabetic outpatients recruited in a Bamako health care centre were used. It could be argued that a larger number of participants or a longer period of dietary assessment would have been preferable. Concerning the sample size, one must take into account that very few diabetes centres are found in Bamako. In addition, not all outpatients could or would participate in the study. Regarding the assessment length, it has to be pointed out that food consumption in Mali does not vary much from day to day. Also, the high prevalence of illiteracy among Malian people would have made it almost impossible to use a self-kept food diary. This is why recalls of the food intake for the previous two days administered by a trained interviewer seemed the best method under the circumstances.

Using data from these food recalls, an excellent correspondence was found between the assessment of mean energy and macronutrient intakes calculated with the second and final version of the food exchange system and that performed with a nutritional analysis based on food composition tables. This gives a good indication that the proposed Malian Exchange Lists could be a valid and useful tool for the rapid assessment of nutrient intakes in diabetic patients, which is of special interest considering that nutritional analysis software is rarely available for African diabetes educators. The analysis of dietary recalls using the Malian food exchange system also allowed for describing the participants' food consumption patterns. It has been reported that there are two types of diets in Mali: 1) the pastoral diet, which is found in the nomadic population (Peuhls, Touaregs and Maures of the North) and characterised by large amounts of curded milk, dates, tea and sugar; and 2) the sedentary diet, which is composed essentially of cereals (millet, sorghum, maize and rice) and some legumes (niébé [black-eyed bean], groundnut and voandzou [African legume]).[12] The sedentary diet prevails in urban zones such as the city of Bamako. Indeed, the food consumption patterns of diabetic participants in this study showed a greater resemblance to the sedentary than the pastoral diet, since the most consumed food group was that of starch, which includes all cereal foods. Legumes were consumed in much smaller amounts, possibly because foods are seasonal in Mali and, during the study period, pulses were not abundant at the market or they were too expensive to purchase. The same applies to vegetables, another food group that was found in this study not to be consumed in large amounts.

With an average of 8.3 exchanges per day, foods from the starch group made up the major part of the participants' diets. Although starchy foods accounted for 56% of the total energy intake, this is lower than what has been reported for the general Malian population, in whom cereals (millet, maize, sorghum and fonio) provide about 80% of the total calories.[12,13] Consequently, the energy from carbohydrates for the participants (56% of total energy intake) was in the range of the distribution recommended for carbohydrates,[3,4] but was lower than the consumption of the general African population (80% of total energy intake)[12,13,14] and that in the diet of black diabetic patients in South Africa.[15]

The relatively low consumption of carbohydrates in this study could be explained by the advice given to patients by the CNLD to use a measuring bowl in order to limit their daily intakes of starchy foods.

Contrary to other studies of African diabetic patients,[14,15] where the fat consumption was found to be low (12% and 12.5% of the energy intake respectively), lipids accounted for 31% of the total energy intake in this study. By themselves, with an average of eight exchanges per day, foods from the fat group accounted for 19.4% of the total energy intake. This quite large number of fat exchanges could be related to a high intake of groundnuts, as shown by Torheim et al in a study carried out in a Malian village.[16] Indeed, groundnuts constitute one of the major foods consumed in Mali. The large overall consumption of fat exchanges could also be due to a high consumption of domestic oils and butter, as shown by Diagana et al.[17]

Regarding the meat and substitutes group, the relatively low number of exchanges in this study was expected, considering the high cost and the poor availability of these foods. Differences were also expected between men and women for the intake of all major food groups. Factors contributing to these gender disparities (e.g. women's position in the family, polygamy, privileged access to food for men) have been discussed elsewhere.[18]

The low consumption of fruit and the avoidance of added sugars in both men and women are possibly related to the nutritional advice that the diabetic participants had received at CNLD. Unfortunately, some health professionals in African diabetes dispensaries may have little training in nutrition and, in addition, may have poor knowledge with respect to the foods that are traditionally eaten. Consequently, the dietary advice given to patients may in some cases be inconsistent, confusing or even incorrect.[15]

It has been suggested that nutrition therapy for black patients is unsuccessful when the diet prescription does not relate to the patient's cultural environment and economic situation, and is presented in ways that are difficult for low-literacy patients to understand and implement.[19] So, it is important to develop educational tools for African diabetic patients that would provide uniformity in meal planning and allow for the inclusion of a wider variety of foods. Hopefully, the food exchange system developed in this study could become a useful educational tool.

Conclusion

This study allowed the development of a new food exchange system based on local West African foods. This exchange system could be used by West African diabetes educators as a tool for research, nutrition education and meal planning for diabetic individuals. Notably, this exchange system could serve for the rapid evaluation of energy and macronutrient intakes. However, continual updates and revisions of this work will be necessary.

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Declarations

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