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ORIGINAL COMMUNICATION

Use of variety/diversity scores for diet quality measurement: relation with nutritional status of women in a rural area in Burkina Faso

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Objectives: To develop scores for food variety and diversity to assess the overall dietary quality in an African rural area; and to study their relationship with the nutritional status of women of childbearing age.
Design: Cross-sectional.
Setting: Sahelian rural area in the North-East Burkina Faso (West Africa).
Subjects: A total of 691 mothers with children below the age of 5 y, selected at random in 30 villages.
Methods: A qualitative recall of women's food consumption during the previous 24 h made it possible to calculate a food variety score (FVS = count of food items consumed) and a dietary diversity score (DDS = count of food groups, among 14 groups). These scores were then divided into terciles. Body mass index (BMI), mid-upper arm circumference (MUAC) and body fat percentage (BFP) were used to determine the women's nutritional status.
Results: The overall dietary quality was poor: mean FVS (s.d.) = 8.3 (2.9) food items; mean DDS = 5.1 (1.7) food groups. A clear relationship was shown between both FVS and DDS (in terciles) and most nutritional indices. Women with a FVS in the lowest tercile had a mean BMI of 20.1, while those in the highest tercile had a BMI of 20.9 ($P = 0.009$). Those in the lowest tercile of DDS had a 22.8% prevalence of underweight *vs* 9.8% in the highest tercile ($P < 0.0001$). The latter relationship remained significant even when the subjects' sociodemographic and economic characteristics were accounted for.
Conclusion: Dietary scores measured at the individual level are good proxies for overall dietary quality of women living in a poor rural African area. These scores were also shown to be linked with the nutritional status of women.
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Introduction

The scientific community has long been interested in the overall quality of diets, owing to the fact that it is important for each individual's health to meet his/her needs for different nutrients through a healthy, varied and balanced diet. Much research has been conducted on methods used to measure dietary quality, mainly in industrialized countries. These studies led to the determination of numerous indices, some very simple and some much more complex; in some cases these indices add quantitative elements to qualitative aspects, and some are based on thresholds or recommendations.

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Although all these indices aim to show the overall quality of diet, they often focus on specific food features, depending on the contexts and objectives of their usage. The large number and the diversity of the indices proposed in the literature led Kant to classify them in three categories as a function of their determination mode, in a now classical review (Kant, 1996): first, indices based on intakes of nutrients (or at least of certain nutrients), then indices based on the consumption of foods or of groups of foods, and, finally, indices that combine both approaches. The most popular among these indices is certainly the Diet Quality Index (DQI) which is based on the American nutritional recommendations (Patterson *et al*, 1994). A second element in Kant's classification refers to the way of using and of validating these indices. In most cases, the indices were studied to link the adequacy of intakes with the theoretical needs in nutrients, especially through nutrient adequacy ratios (NARs) and the mean adequacy ratio (MAR) and/or with respect to certain parameters of nutritional status (biochemical, anthropometric, and other measurements). Indices have rarely been studied in relation to their links with health status, but when they have, then using a more practical or applied approach (Haines *et al*, 1999; McCullough *et al*, 2002). In this context, since the indices were mainly developed in industrialized countries, the chronic diseases referred to are essentially pathologies linked to overweight, cardio-vascular diseases and cancers.

In developing countries great interest has also been paid to a balanced and diversified diet, especially in relation to problems caused by nutritional deficiencies and their consequences (WHO/FAO, 1996). It has been clearly stated that a nondiversified diet can have negative consequences on individuals' health, well-being and development, mainly by reducing physical capacities and resistance to infection, but also by impairing cognitive development, reproductive and even social capacities (Underwood, 1998). In addition, it is well known that in developing countries, the nutritional status of populations in urban areas is generally better than that in rural areas, one of the explanations for this difference being a more diversified diet in urban areas (Popkin & Bisgrove, 1988); though access to more diverse foods sometimes leads to diets higher in fats, and can result in other health problems (Drewnowski & Popkin, 1997).

Dietary problems may be primarily quantitative in the most underprivileged areas, such as rural areas during seasonal food shortages or urban areas under acute poverty. As a result, the dietary deficiency then appears to be chiefly energy related. However, even in these conditions it has been shown that the problem of dietary diversity is crucial and the measurement of the dietary quality is therefore essential (Allen *et al*, 1991). Yet, in developing countries, fewer studies have been conducted on dietary quality than in industrialized nations. This is undoubtedly at least partially due to the fact that these kinds of measurements are time-consuming, complex and costly. And although it is already quite difficult to collect information on individuals' dietary consumption in industrialized countries, it is even more difficult in an African context, particularly in rural areas. African rural populations generally eat from a common bowl and they sometimes obey very complex rules that make the measuring individual dietary consumption very difficult (Hudson, 1995). Moreover, due to the generally low level of education, it is quite difficult to estimate serving sizes and to use certain types of questionnaires.

It is thus important to develop simple methods and simple indicators to be used as proxies for measuring overall dietary quality in different contexts. Dietary variety and diversity indices are both good candidates for this purpose. A Norwegian team working in Mali proposed food variety and dietary diversity scores derived from a qualitative recall of food consumption based on the simple count of consumed food items and on the count of represented food groups, respectively. This method was then validated with regard to nutrient needs and a reference method, and in both cases, diversity and variety scores appeared to be simple tools, which clearly reflected the dietary quality (Hatloy *et al*, 1998; Torheim *et al*, 2003, 2004). Other teams also used this type of scoring system to assess whether dietary diversity could be used as an indicator of household food security (Hoddinott & Yohannes, 2002). In these examples, dietary variety and diversity were measured at the household level. Studies on the association of variety and diversity scores measured at the individual level, on the one hand, and nutrient adequacy, morbidity and socio-economic status, on the other hand, are even scarcer.

It is also important to study the association between proxies of overall dietary quality and nutritional outcomes. In developing countries, this has been the subject of many studies on children (Onyango *et al*, 1998; Hatloy *et al*, 2000; Arimond & Ruel, 2002), but rarely on adults.

The present study was conducted in a Sahelian area in West Africa (Burkina Faso) with two main objectives: (i) to add to the development of proxy indicators for assessing overall dietary quality; and (ii) to evaluate the importance of dietary quality for the nutritional status of women of childbearing age.

Methodology

Context of the study

The study was conducted in the Gnagna province in the North-East Burkina Faso. This province covers an area of 8640 km^2 and has about 350 000 inhabitants. The majority of the population belongs to the Gourmantche ethnic group. This zone is particularly vulnerable from a food and nutritional standpoint due to its landlocked position, unfavourable climate and the low level of soil fertility. Each year, the population of this province faces a seasonal food shortage during which food availability is very limited (Janin, 2003).

Sample

A cross-sectional domestic survey, including questionnaires and anthropometric measurements, was carried out from January to March 2002 in 30 villages of the province. It was carried in a period assumed to be 'neutral' from a nutritional point of view, that is, far enough away from the food shortage season.

A two-stage sampling technique was used using the most recent available population census (1998): first the 30 villages were randomly selected with a probability proportional to size, and then six compounds were randomly chosen in each village. In this area, a compound can comprise from one to more than 20 households, all of them being ruled by a common 'head of compound' (HC), while each household is ruled by a 'head of household' (HH). The survey covered a final sample of 691 women living in the compounds selected, all having at least one child aged under 5 y. All of them gave their free and informed consent to participate in the study.

Dietary consumption

The dietary consumption was measured by a qualitative recall of all foods consumed by each woman during the previous 24 h, regardless of whether it was a weekday or a weekend day. Indeed, weekends do not have any special significance in this very rural province where there are several different religions. Moreover, the members of the same compound usually eat from common bowls in several groups, following very complex rules of food distribution (Sawadogo, 2002). To measure women's individual dietary consumption, it was first necessary to identify which collective dishes had been consumed by each woman within the compound. We then asked the woman in charge of preparing the meal to give us a complete list of the ingredients used. We also took into account other foods consumed by each woman outside the compound (meals, snacks, etc). The exact composition of all these foods was also noted. From a practical point of view, we first let the women spontaneously describe their food consumption, and then we prompted them to be sure that no meal or snack had been forgotten.

The interviews were conducted by 14 local fieldworkers with at least middle-school education who were trained by us. All of them spoke French and local languages (Gourmantchema, Moore and Fulfulde).

A preliminary survey made it possible to identify 116 known dietary items potentially consumed in the province. Two initially unidentified dietary items were added to this list, which remained open throughout the survey. We then used this list to distinguish 14 food groups so as to get closer to the food composition table proposed by FAO and commonly used in Africa (FAO, 1970): cereals, roots/tubers, pulses and nuts, green leafy vegetables, other vegetables, fruits, sugar, meat/poultry/insects, eggs, fish/sea food, milk/dairy products, oils and fats, condiments, drinks and miscellaneous. The information we collected in the list of dietary items and its organization in 14 groups enabled us to calculate two types of scores:

Food variety score (FVS). This refers to the number of different dietary items consumed by the woman the day before the survey. The frequency of consumption and the amount of food consumed were not taken into account.

Dietary diversity score (DDS). This refers to the number of the different food groups to which the above food items belong (irrespective of the number of representatives of each group).

These dietary scores were then divided into terciles in order to distinguish diets of 'high', 'medium' and 'low' quality, in terms of both variety and diversity (grouping observations that have many tied values can result in unbalanced groups because the SAS procedure used always assigns observations with the same value to the same group) (Figure 1).

Anthropometric measurements

The anthropometric measurements were carried out in a standardized way by trained surveyors who used procedures recommended by WHO (WHO, 1995). The women were weighed to the nearest 100 g on electronic scales with a weighing capacity of 10–140 kg. The height was measured to the nearest mm with locally made portable devices equipped with height gauges (SECA 206 Bodymeter). The mid-upper arm circumference of the left arm was measured to the nearest mm with a nonstretch measuring tape. Skinfold thickness (bicipital, tricipital, underscapular and suprailiac) was measured to the nearest 0.2 mm according to Lohman standard procedures (Lohman *et al*, 1988) with a Holtain calliper. The body mass index (BMI) was used to assess the women's corpulence. Moreover, the measurement of skinfold thicknesses enabled us to determine body density (BD), which made it possible to calculate the body fat percentage (BFP) of the women, by applying equations developed by Durnin and Womersley (1974) and Siri (1956) respectively.

Pregnant women ($n = 95$) and women with incomplete anthropometric measurements due to a physical handicap or to other causes ($n = 7$) were excluded from all analyses.

Other information

Sociodemographic, economic and sanitary information was collected at the compound level (number of households and composition of each household, compounds without or with plots, access to drinking water, etc), at the household level (dwelling quality, assets, hygiene practices, etc) and among the women (age, ethnic group, marital status, education, etc).

In some cases, we set up synthetic indicators in order to summarize information:

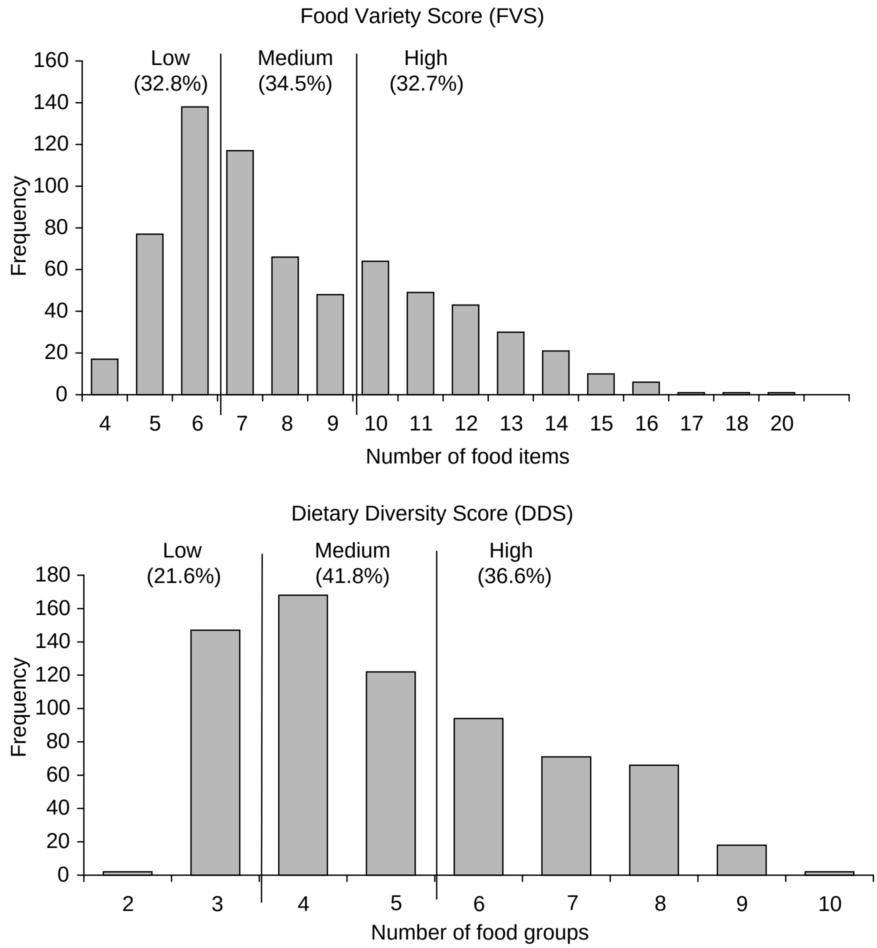

Figure 1 distribution of dietary scores.

Indicator of property level. Each household's property was evaluated according to the quality of the dwelling, the type and the number of nonagricultural assets as well as the number of cattle owned by each household. Correspondence analysis was performed on the matrix of indicator variables that code these characteristics (Lebart *et al*, 1984). The score of each household on the axis of the first principal component of this analysis was used as a summary index of household properties, and was then divided into terciles to define three categories of households: 'high', 'medium' and 'low' (Martin-Prével *et al*, 2001).

Hygiene index. From the variables reflecting hygiene practices and conditions (drinking water, presence of a latrine and bathroom, garbage and waste-water drains, yard cleanliness, etc) a score was established by giving positive or negative points based on favourable or unfavourable situations. This score ranged from -6 to $+4$ within the sample and thresholds were established according to the observed distribution to classify the households in three categories: 'high', 'medium' or 'low' hygienic conditions.

Care for women. The same method was used to evaluate the level of care for women. Care is here defined as 'the provision of time, attention and support to meet individuals' physical, mental and social needs within the household' (FAO/WHO, 1992). The care level was evaluated for each woman on the basis of the following information: obstetrical history, knowledge/use of family planning, prenatal care, improved diet and alleviation of physical tasks during pregnancy, postdelivery rest, decision-making power, physical or verbal abuse. The score values ranged from -1 to $+11$ within the sample and the women were again classified in three categories according to the level of care: 'high', 'medium' or 'low'.

Conceptual framework of the analysis

Our main objective was to study the relationship between dietary scores and women's nutritional status but this relation is obviously influenced by the women's environment. As a matter of fact, a wide range of social, demographic, economic or sanitary factors have an impact on women's nutritional status and/or on the quality of their diet. These factors could therefore play a mediating or a confounding role with respect to the relationship that was studied. In order to take these different factors into account and classify them hierarchically, we set up a conceptual framework for the analysis based on the diagram of the causes of malnutrition proposed by Unicef (1990) and widely validated by the international community (ACC/SCN, 2000). Thus, in the analysis, we considered 3 levels of factors (corresponding to the immediate, underlying and basic causes) while establishing, within each category, subsets of variables reflecting a same construct (Figure 2).

Analysis strategy

In the first phase, the raw relationships between dietary scores and anthropometric indices were studied, only adjusted on the so-called 'physiological' variables, that is, women's age and height that were found to be significantly linked to most of the anthropometric indices (model 0). These comparisons were then also adjusted on potential confounders identified among the underlying causes (model 1), and finally on those identified among basic causes (model 2).

The following strategy was used to identify the adjustment variables:

- Bivariate analyses were performed to study the links between sociodemographic variables and dietary scores, on the one hand, and between sociodemographic variables and anthropometric indices, on the other hand. The sociodemographic variables which were significantly linked to either the dietary scores or the anthropometric indices were selected as potential confounders. Type I error threshold was set to 0.05 for this phase.
- In the multivariate models, these variables were then introduced by subsets corresponding to the different constructs identified in the conceptual framework (Figure 2) in order to better identify the colinearities between variables. After this phase, only the variables linked to anthropometric indices with a type I error ≤ 0.15 were kept as adjustment variables for the ongoing analyses. The same strategy was independently reproduced with the FVS and with the DDS when establishing their relationship with each of the four anthropometric indices used in the study (namely mean BMI, percentage of women with a BMI $\leq 18.5\,kg/m^2$, mean MUAC and mean BFP). A final common set of adjustment variables, to be used in all the models, was finally established by selecting the variables that were kept at least twice among the adjustment variables in the eight analyses performed in the above process.

Data processing

The data were double entered with EPI-DATA software, version 2.1a. (Lauritsen *et al*, 2000). Their final quality was ensured by a check file associated with the data entry process and also by further data cleaning. The general linear model was used for the analyses in which the dependant variables were quantitative, and the logistic model when they were qualitative. All the analyses were performed taking into account the design effect of the study using appropriate procedures of the SAS System, version 8.0 (SAS, 1999) or SUDAAN software (SUDAAN, 1997).

Results

Sociodemographic characteristics of the sample (Table 1)

Our sample included compounds comprising three to 209 individuals divided into one to 18 households (mean $\pm$s.d. $= 3.5 \pm 3.1$), with an average of 10 people. Most of the heads of households and women surveyed belonged to the Gourmantche ethnic group (84%). The general education level was very low: only 24% of heads of households and 20% of women had received a basic education or literacy training or other kind of training. Finally, nearly half of the heads of households and 28% of women had a secondary activity other than agriculture.

Dietary variety and diversity

The usual local diet consists of a cereal paste (called 'tô', mainly cooked with sorghum) accompanied by a sauce of leafy vegetables. Since this meal is always cooked in the same way, we found that the common diet systematically included cereals (98.6%), leafy vegetables (87.1%) and condiments (100%). Oftentimes, another vegetable or some fish were added to the diet (in nearly half the cases). On the other hand, the women in our sample hardly ever consumed roots or tubers, milk or dairy products, eggs, fruit or drinks. Their diet was therefore very poor, which is also reflected by the fact that among the 116 (+2) identified food items, only 38 were found to have been consumed among the whole sample the day before the survey. This poverty is reflected in all the dietary scores: FVS distribution in the sample was quite broad and ranged from four to 20 items, but with a low mean (8.3 ± 2.9 items). In terms of food groups, the DDS ranged from 2 to 10, over 14 possible groups (mean DDS $= 5.1 \pm 1.7$ food groups) (Figure 1).

Considering the diet within each category of the diversity score, women with low scores had a very basic diet and consumed only three food groups at most. In most cases, these groups were cereals, leafy vegetables and condiments, which are the basic ingredients of the traditional dish (tô). Women with medium scores often consumed fish, and vegetables in addition to these groups, and also a little more meat, pulses or nuts, fat and sugar. Finally, in comparison with the two other DDS categories, women who had higher scores often ate more meat, pulses or nuts, fat, sugar as well as some fruits (Figure 3).

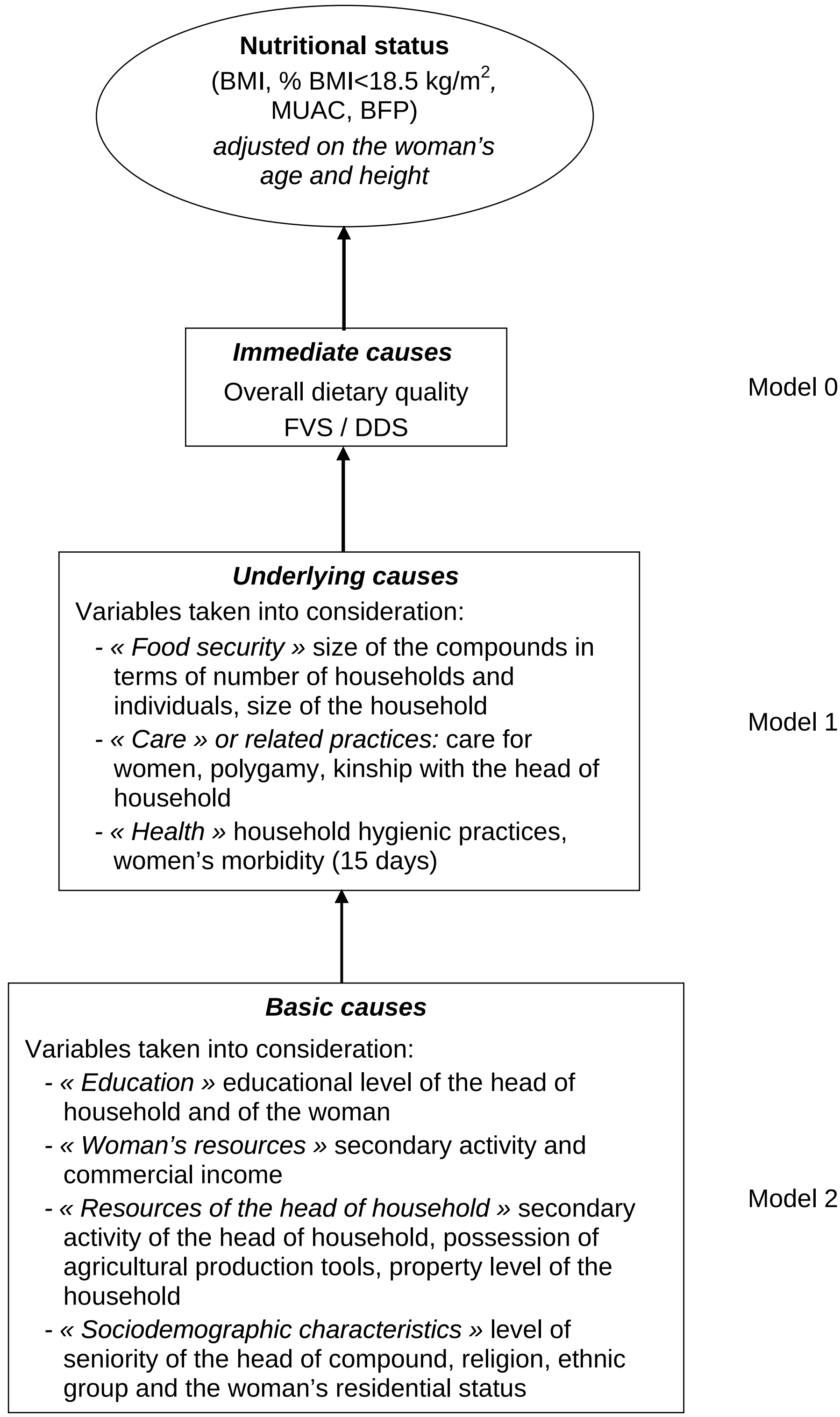

Figure 2 Conceptual framework of analysis (UNICEF, 1990).

Dietary scores and sociodemographic variables
We studied the distribution of dietary scores as a function of the sociodemographic characteristics of the sample through bivariate analyses, using either mean scores or the percentages of high, medium and low scores. Table 2 presents the main results of these comparisons. The comparisons made

Table 1 Sociodemographic characteristics of the sample

Statistic unit = compound	*% (n = 159)*
Size in number of households	
One	25.8
2–3	35.9
Four and more	38.4
Size in number of individuals	
<15 individuals	27.7
15–29 individuals	30.8
≥30 individuals	41.5
Seniority of the head of compound	
≥50 years, or born	73.6
<50 years in the compound	26.5
Statistic unit = household	*% (n = 428)*
Size	
≤6 persons	22.9
7–10 persons	35.3
>10 persons	41.8
Education of the head of household	
Educated[a]	24.1
Uneducated	75.9
Secondary activity of the head of household	
Yes	46.7
No	53.3
Agricultural production tools[b]	
Yes	54.9
No	45.1
Hygienic level	
High	14.0
Medium	55.4
Low	30.6
Statistic unit = woman	*% (n = 589)*
Age	
<20 years	14.9
20–29 years	48.7
30 years and more	36.3
Ethnic group	
Gourmantche	84.0
Fulani	9.0
Mossi	6.7
Polygamy	
Yes	45.6
No	54.4
Religion	
Animist	28.7
Muslim	27.1
Christian	44.2
Education	
Educated[a]	20.4
Uneducated	79.6
Secondary activity	
Yes	28.5
No	71.6

[a]Corresponds to 'at least a beginning of literacy, schooling or another training'.
[b]Other than basic agricultural tools.

on mean scores provided similar findings but are not shown on the table for reasons of simplicity (details of these results are available upon request). First, only the level of seniority of the head of compound appeared to have a real influence on dietary scores. We also noted that there were a larger number of women with high scores when the level of properties of the household was higher, when the hygiene index of the household was better, and when the head of the household had received a basic education. Furthermore, women's economic activities and the level of care for women clearly influenced their dietary scores. On the other hand, their level of education appeared to be insignificant, contrary to what one might expect. There was also an obvious difference in the dietary scores between the ethnic groups, with higher scores mainly among the Mossi, but the difference was not significant (which may be due to the huge proportion of Gourmantche people, about 80%, in our sample). Ultimately, religion was also an influencing factor, Muslim women having the lowest scores whereas Christian women had the highest.

Nutritional status

With a mean height of 161 cm and a mean weight of 54 kg, the mean BMI of the women in our sample was not exceptionally low (mean $= 20.8 \pm 2.0\,kg/m^2$); nevertheless it was well below the threshold of 23 which is likely to provide benefit to adults in developing countries (WHO, 1998). Even if most of the women (about 86%), regardless of their age, had a 'normal' BMI, almost 12% of them were underweight (BMI $< 18.5\,kg/m^2$). On the other hand, a very small number of them were overweight. The mean MUAC was relatively high (26.5 ± 2.0 cm) but the body fat percentage was low (mean BFP $= 20.9 \pm 3.9$%).

Study of the relationship between overall dietary quality and anthropometric indices

Table 3 shows the women's anthropometric characteristics as a function of dietary variety and diversity scores. There was generally a clear and positive statistical link between the overall dietary quality and women's nutritional status. In fact, the more varied and/or diversified the diet, as reflected by FVS and DDS, the higher the anthropometric indices, reflecting a better nutritional status. This relationship was very clear with the BMI and the mean BFP, but was less significant with respect to the mean MUAC. It was also apparent that the proportion of underweight women was much higher among women belonging to the category of low dietary scores (22.8 *vs* 7.3% for the 'medium' DDS category and 9.8% for the category of 'high' DDS). Finally, the links between dietary scores and anthropometric indices were generally more significant with the DDS than with the FVS.

Table 4 shows the relationship between overall dietary quality and women's nutritional status with adjustment on the set of underlying variables (model 1) and of basic variables (model 2) identified as potential confounders according to the method described above. Another analysis

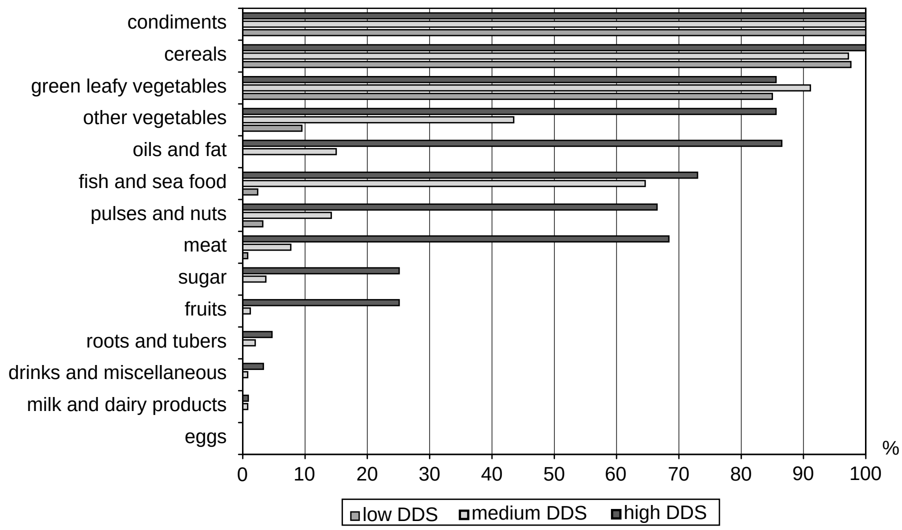

Figure 3 Percentage of women consuming each food group as a function of the category of dietary scores.

Table 2 Dietary scores as a function of sociodemographic characteristics of the sample

	n	FVS (%)			χ2	DDS (%)			χ2
		Low	*Medium*	*High*	(P)	*Low*	*Medium*	*High*	(P)
Compound									
Size in number of households									
One	588	41.5	43.4	15.1	8.9	26.4	52.8	20.8	8.2
Two to three		29.3	35.7	35.0	*(0.06)*	23.6	36.3	40.1	*(0.08)*
Four and more		33.1	32.8	34.1		20.1	42.6	37.3	
Size in number of individuals									
<15 individuals	588	42.3	40.4	17.3	7.4	32.7	44.2	23.1	11.7
15 to 29 individuals		35.8	32.5	31.7	*(0.12)*	28.3	37.5	34.2	*(0.02)*
≥30 individuals		30.8	34.4	34.9		18.3	42.8	38.9	
Seniority of the HC									
≥50 years, or born	575	30.6	33.5	35.8	11.5	20.0	39.6	40.4	14.8
<50 years in the compound		44.2	36.8	19.0	*(0.003)*	30.5	49.5	20.0	*(0.0006)*
Household									
Size									
≤6 persons	588	29.4	36.3	34.3	7.7	22.6	41.2	36.3	4.4
7 to 10 persons		40.8	30.4	28.8	*(0.11)*	26.1	41.3	32.6	*(0.35)*
> 10 persons		29.1	36.4	34.4		18.5	42.4	39.1	
Education of the HH									
Educated[a]	588	23.1	27.6	49.3	22.0	12.7	38.1	49.3	14.6
Uneducated		35.7	36.6	27.8	*(<0.0001)*	24.2	43.0	32.8	*(0.0007)*
Secondary activity of the HH									
Yes	588	28.5	32.3	39.2	11.6	16.3	39.9	43.8	15.7
No		37.0	36.7	26.3	*(0.003)*	26.7	43.7	29.7	*(0.0004)*
Agricultural production tools[b]									
Yes	588	26.4	38.0	35.7	15.7	16.8	43.5	39.7	11.7
No		42.0	29.6	28.4	*(0.0004)*	28.4	39.5	32.1	*(0.003)*
Property level									
High	553	25.5	36.5	38.0	16.1	14.6	42.7	42.7	17.9
Medium		31.4	38.2	30.4	*(0.003)*	21.3	42.5	36.2	*(0.001)*
Low		44.8	28.6	26.6		31.8	41.6	26.6	
Hygienic level									
High	588	15.9	34.2	50.0	18.8	2.4	42.7	54.9	30.2
Medium		34.0	36.5	29.5	*(0.0008)*	22.0	44.6	33.4	*(<0.0001)*
Low		38.5	31.0	30.5		29.9	36.2	33.9	

Table 2 *Continued*

	n	FVS (%)			χ2	DDS (%)			χ2
		Low	Medium	High	(P)	Low	Medium	High	(P)
Woman									
Age									
< 20 years	588	27.3	35.2	37.5	1.8	19.3	42.1	38.6	0.6
20 to 29 years		33.9	34.6	31.5	(0.78)	21.7	42.7	35.7	(0.97)
30 years and more		33.6	34.1	32.2		22.4	40.7	36.9	
Residential status									
Permanent	588	34.8	32.8	32.4	4.5	24.7	39.1	36.3	14.1
Other		25.4	41.0	33.6	(0.11)	9.8	52.5	37.7	(0.0009)
Ethnic group									
Gourmantche	587	32.3	35.7	32.1	8.1	20.5	42.6	36.9	13.3
Fulani		45.3	26.4	28.3	(0.09)	39.6	34.0	26.4	(0.01)
Mossi		22.0	31.7	46.3		12.2	41.5	46.3	
Polygamy									
Yes	587	32.8	29.9	37.3	6.4	22.0	37.7	40.3	3.8
No		32.6	38.7	28.8	(0.04)	21.3	45.1	33.5	(0.15)
Kinship with the HH									
Wife	588	34.3	33.3	32.4	1.8	23.7	39.7	36.5	5.5
Other		28.7	38.0	33.3	(0.41)	15.3	48.0	36.7	(0.06)
Religion									
Animist	585	32.7	38.7	28.6	16.5	17.9	50.0	32.1	23.3
Muslim		43.4	28.9	27.7	(0.003)	31.5	40.3	28.3	(0.0001)
Christian		26.0	35.3	38.8		17.1	38.0	45.0	
Education									
Educated[a]	588	23.5	37.0	39.5	6.3	18.5	40.3	41.2	1.6
Uneducated		35.2	33.9	30.9	(0.04)	22.4	42.2	35.4	(0.45)
Secondary activity									
Yes	586	24.6	29.9	45.5	*17.8*	16.8	33.5	49.7	*17.1*
No		36.0	36.3	27.7	(0.0001)	23.6	44.9	31.5	(0.0002)
Commercial incomes									
Yes	575	23.9	29.4	46.7	*9.9*	12.0	37.0	51.1	*11.6*
No		34.6	35.2	30.2	(0.007)	23.6	42.4	34.0	(0.003)
Care level									
High	588	44.0	33.0	23.0	*23.3*	36.4	35.9	27.8	*43.0*
Medium		26.7	37.6	35.6	(0.0001)	14.9	45.1	40.1	(<0.0001)
Low		26.6	32.8	40.7		11.9	45.2	42.9	
Morbidity (15 days)									
Yes	587	28.9	34.6	36.5	*2.0*	21.8	32.7	45.5	*9.1*
No		34.3	34.3	31.3	(0.37)	21.6	45.2	33.2	(0.01)

FVS, food variety score; DDS, dietary diversity score; HC, head of compound; HH, head of household.
[a]Corresponds to 'at least a beginning of literacy, schooling or another training'.
[b]Other than basic agricultural tools.

with specific adjustment variables for each model led to the same conclusions (results not shown).

In model 1, the adjustment variables used referred to the size of the compound (in terms of number of individuals), care for women and the hygiene index at the household level. This last variable was the one that remained most closely linked to anthropometric indices. The introduction of these variables reduced the strength of the relationship between dietary scores and anthropometrics. Considering the FVS, this relation nevertheless remained significant for the mean BMI ($P = 0.03$) and nearly significant for the mean BFP ($P = 0.05$), but not for the percentage of low BMI or for the mean MUAC.

As regards the DDS, the relationship still persisted for all the anthropometric indices except the mean MUAC ($P = 0.03$ for the mean BMI; $P = 0.001$ for the percentage of low BMI and $P = 0.04$ for the mean BFP).

In model 2, the adjustment variables used referred to the head of household's secondary activity, the household's agricultural production tools and the women's ethnic group. The variable that remained the most closely linked to anthropometric indices was the head of household's secondary activity. The introduction of the adjustment variables further reduced the strength of the relationship between dietary scores and anthropometrics, and this even became nonsignificant in most cases. As for the DDS, the relationship

Table 3 Relationship between dietary scores and anthropometry, adjusted on women's age and height (model 0)

	Mean BMI (n = 588)		% BMI < 18.5 kg/m^2 (n = 588)			Mean MUAC (n = 587)		Mean BFP (n = 581)	
Dietary scores	Values	P	%	OR [95% CI]	P	Values	P	Values	P
FVS									
Low	20.1		16.1	1.9 [1.0;3.7]		25.7		19.9	
Medium	20.7	0.009	9.4	1.0 [0.6;1.7]	0.08	26.1	0.10	20.3	0.02
High	20.9		9.4	1.0		26.2		21.2	
DDS									
Low	19.9		22.8	2.9 [1.5;5.6]		25.6		19.4	
Medium	20.6	0.006	7.3	0.7 [0.4;1.5]	<0.0001	26.0	0.04	20.5	0.02
High	21.9		9.8	1.0		26.2		21.2	

BMI, body mass index; MUAC, mid upper arm circumference; BFP, body fat percentage; FVS, food variety score; DDS, dietary diversity score.

remained significant for the percentage of low BMI (OR = 1.9 for the 'low DDS' category with the 'high DDS' category taken as reference; $P = 0.004$).

Finally, the introduction in the models of the variables that reflect basic causes of malnutrition also entailed a reduction in the level of significance for the effect of underlying causes on anthropometrics. This reinforces the conceptual diagram used since it is assumed that part of the effect of basic causes has already been taken into account by underlying causes.

Discussion

As underlined in the introduction, many indices of overall dietary quality have been proposed in the literature. We obviously recognize that the development of methods for measuring dietary quality is a progressive process that recent research is trying to improve by including strong points and avoiding the limits of previous methods (Dixon *et al*, 2001). Owing to the fact that information is particularly difficult to collect in developing countries, it is clear that the indices proposed should be simple and adapted to the context. Nevertheless, up to now, little research has been done in this area and, as Ruel stressed, there is no homogeneity in measurement methods used either in developing countries or in industrialized ones (Ruel, 2002). Consequently, there are still many points that should be tested and clarified in the methods used for measurement and for the determination of these indices.

The first question concerns the reference period during which information should be collected. This period should be sufficiently long so as to better reflect the population's usual dietary consumption (Palaniappan *et al*, 2003), but it should also be sufficiently limited to minimize the memory bias (Swindale & Ohri-Vachaspati, 1999); in addition, a too long questionnaire may cease to interest the interviewee who may therefore not give appropriate answers. This is particularly true in developing countries. We consequently decided to use simplified scores based on a single 24-h recall, although we are conscious that this simplicity has some drawbacks. Mainly, a single 24-h recall is not sufficient to accurately reflect the usual intake of an individual, since the lack of variety on a given day does not mean that there is no day-to-day variation. Nevertheless, such proxy indicators are very useful at the scale of the population to monitor progress on the dietary situation or to target interventions to groups who are in need.

One way of improving the estimation of the usual dietary intake and of collecting more information about day-to-day variability is to make repeated 24-h recalls on the same subjects over a period of several days, and if possible, also over different seasons (Sempos *et al*, 1985; FNB, 1986). Indeed, seasonality is another important issue, especially in an African rural context, and it has been clearly shown that food consumption and nutrient intake can vary from one season to the next (Kigutha, 1997; Rose & Tschirley, 2003). Consequently, one may wonder whether a particular individual or household would be classified in the same terciles of FVS or DDS in different seasons. Additional studies are needed to clarify this point.

One may also wonder whether it is better to determine scores from food items (FVS) or from food groups (DDS). Several studies have used both types of scores and have shown that they both adequately reflect dietary quality in terms of meeting nutrient needs; however, with a stronger relationship between outcomes and the scores built up from food groups (Hatloy *et al*, 1998; Ogle *et al*, 2001). Other authors also proposed the use of DDS because of its greater simplicity (Krebs-Smith *et al*, 1987; Hatloy *et al*, 2000). In our study, we observed that the DDS provided more information to describe the type of diets and their nutritional quality. In addition, this score had a stronger link with women's nutritional status. However, even if there is a preference for DDS indices, the issue of the number of food groups that should be taken into account to determine such indices, which so far has ranged from 4 to 14 (Ruel, 2002), has not yet been resolved. However, this is an important point if international comparisons are to be made. To our knowledge, there is no international recommendation concerning

Table 4 Relationship between dietary scores and women's nutritional status (linear and logistic regressions)

	Relationship with the variety score (FVS)								*Relationship with the diversity score (DDS)*							
Nutritional status	*Mean BMI (kg/m²)*		*OR [95% CI] BMI < 18.5 kg/m²*		*Mean MUAC (cm)*		*Mean BFP*		*Mean BMI (kg/m²)*		*OR [95% CI] BMI < 18.5 kg/m²*		*Mean MUAC (cm)*		*Mean* BFP	
Models	*1*[a]	*2*[b]	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*
n	*588*	*587*	*588*	*587*	*587*	*586*	*581*	*580*	*588*	*587*	*588*	*587*	*587*	*586*	*581*	*580*
Dietary scores																
Low	20.2	20.2	1.5 [0.8;2.8]	1.3 [0.7;2.5]	25.7	25.6	20.1	20.0	20.1	20.1	2.3 [1.2;4.2]	1.9 [0.9;3.8]	25.6	25.6	19.7	19.6
Medium	20.7	20.6	0.8 [0.5;1.5]	0.8 [0.5;1.5]	25.9	25.8	20.3	20.1	20.6	20.5	0.7 [0.3;1.3]	0.6 [0.3;1.2]	25.9	25.7	20.4	20.2
High	20.8	20.7	1.0	1.0	26.0	25.8	21.1	20.9	20.8	20.7	1.0	1.0	26.0	25.8	21.1	20.9
P	*0.03*	*0.10*	*0.16*	*0.42*	*0.28*	*0.61*	*0.05*	*0.12*	*0.03*	*0.13*	*0.001*	*0.004*	*0.25*	*0.63*	*0.04*	*0.12*
Underlying variables								P-*value*								
Size of compounds in individuals	0.29	0.53	0.12	0.46	0.06	0.29	0.93	0.98	0.33	0.55	0.15	0.47	0.07	0.32	0.94	0.96
Care of women	0.26	0.32	0.32	0.55	0.22	0.24	0.14	0.23	0.32	0.36	0.58	0.75	0.25	0.25	0.28	0.37
Hygiene of household	0.01	0.03	0.15	0.40	0.02	0.07	0.18	0.34	0.01	0.04	0.19	0.41	0.02	0.07	0.23	0.41
Basic variables								P-*value*								
Secondary activity of the HH		0.13		0.01		0.04		0.06		0.17		0.008		0.04		0.07
Agricultural production tools		0.04		0.08		0.12		0.12		0.03		0.07		0.10		0.13
Woman's ethnic group		0.44		0.11		0.07		0.67		0.50		0.14		0.09		0.74

[a]Model 1: nutritional status = *f* (age and height, dietary scores, underlying variables).
[b]Model 2: nutritional status = *f* (age and height, dietary scores, underlying variables, basic variables).
HH, head of household.

the number of food groups to be used upon which the whole scientific community currently agrees. Additional work on this point is urgently required. It is worth noting that, in our study, the use of another classification (11 groups) did not alter our conclusions but did slightly modify the degree of significance of some comparisons (results not shown). This was mainly due to different cutoffs used to distinguish terciles, which resulted in some individuals moving from one group to the next.

Other discussions have raised the question of whether to take into account the minimum quantity consumed, or a weighing system based on the frequency of food consumption. Still other studies, for example, the one made in Mozambique (Rose *et al*, 2002), used more complex scoring systems which focused more on certain foods. The problem arose in our study particularly with respect to dried/smoked fish, which is added in the sauce in very small quantities to enhance its flavour, and also with respect to condiments (salt, spices, aromatic plants) which are systematically added to the dishes in small quantities. However, the fact that condiments are used by 100% of the individuals (Figure 3) means that not taking them into account does not modify the results. Nonetheless, the case of dried/smoked fish raises the question of the significance of the diversity score in relation to real dietary quality. Diversity should not be confused with quality because ensuring a certain degree of diversity does not mean that the dietary quality will match people's intrinsic needs (Krebs-Smith *et al*, 1987; Brown *et al*, 2002). However, both in industrialized and developing countries, the literature shows that diversity indices clearly reflect overall dietary quality (Guthrie & Scheer, 1981; Hatloy *et al*, 1998; Torheim *et al*, 2004). A similar problem concerns the choice of thresholds to determine poor, medium and satisfactory scores. In most studies these thresholds are determined according to the score distribution in the sample by the use of terciles or quintiles, thereby permitting comparisons within the same sample. However, regarding the problem of adequacy of diets to meet needs, thresholds should be based on more functional criteria.

In our study, we were inspired by Hatloy *et al*'s work (Hatloy *et al*, 1998) leading to the simple measurement of overall dietary quality derived from a qualitative dietary recall of the previous 24 h. This process used a scoring system that sums all foods and food groups consumed thereby giving the same weight to all items. However, if one compares our results with those of the study conducted in Mali, it is surprising to see that the mean FVS is clearly lower in Burkina Faso (8.3 *vs* 14.2 food items) although the information was collected from similar lists of food items (respectively 118 and 104 items). A possible explanation is that in the Malian study, dietary consumption was measured at the household level by noting the foods consumed by all the individuals, whereas in our study it was measured at the level of each individual. This highlights the more general problem of the significance of diversity indices measured at the household level, which are supposed to better reflect the food security level and even the socioeconomic level of households, *vs* indices measured at the individual level, which are more strongly linked to dietary quality and to people's nutritional status (Ruel, 2002). This also raises the question of relationships between the two measurement levels, which are obviously interlinked as shown, for example, in Ghana (Leroy *et al*, 2003), but also underlines the problem of intrafamilial food distribution (Okeke & Nnanyelugo, 1989; Gittelsohn & Vastine, 2003). However, the difference observed between our study and the one conducted in Mali, despite relative geographical proximity, is probably due to the fact that one region is much more underprivileged than the other, with a poorer and less diversified diet in Burkina Faso. This highlights the need for research to establish tools which will make it possible to compare dietary quality between different countries. This problem was in fact recently addressed but with a much more complex index (Kim *et al*, 2003).

In our study, we were able to observe that the distribution of dietary scores among the women of the sample was strongly linked to some sociodemographic characteristics both at the individual and household levels, which suggests a certain degree of sensitivity and of discriminating power of this type of index, even within a rural population usually considered to be very homogenous. As shown by Hatloy with the same indices (Hatloy *et al*, 2000), and as expected, women living in a better economic context had higher dietary scores. However, a number of particularities were also observed, especially that the head of household's educational level clearly influenced the quality of women's diet whereas the women's educational level did not. However, this is perhaps not that surprising given men's position in African societies in general, and particularly in the province where we conducted our study, where men have a direct influence on the family's diet since they make decisions about food expenses and choices concerning the family's dietary consumption (Idrac, 2003). On the other hand, in a context with such a low level of education, it is also possible that the educational level of the women is not the best way of evaluating women's knowledge (Bhargava & Fox-Kean, 2003). We showed that women's diet is closely linked to the care they receive. This confirms the fact underlined by many researchers that gender issues should be included in nutritional programmes (Beckerleg, 1995; Quisumbing & Meinzen-Dick, 2001) and that the concept and measurement of care should be explored at greater depth.

Nonetheless, our study did show that variety and diversity scores can be considered as good proxies of overall dietary quality, and that these scores also reflect the social and economic contexts of the populations concerned.

Finally, one of the most important results of our study was to show a significant link between dietary scores and nutritional outcomes, which means that these simple indicators, namely FVS and DDS, adequately predicted the nutritional status of adult women. Our results also showed that, in addition to diet, other underlying factors affected nutritional status. When these factors, which reflected the sociodemographic and economic context of the people surveyed, were taken into account in the analyses, they tended to reduce the strength of the link between dietary scores and nutritional status. However, in adjusted comparisons the link between the dietary diversity score and the percentage of underweight women persisted. In developing countries in general and particularly in Africa, a relationship between dietary diversity scores, similar to the one we have used here, and individuals' nutritional status has already been shown several times (Onyango *et al*, 1998; Tarini *et al*, 1999; Hatloy *et al*, 2000; Arimond & Ruel, 2002), but the socioeconomic factors were not always adequately controlled in these studies (Ruel, 2002) which focussed on the nutritional status of young children, especially growth indices. As far as we know, only Torheim and her team have studied the relationship between diversity scores and adult women's nutritional status in a developing country (Mali), but in contrast to our study, these authors did not find a link between them (Torheim *et al*, 2004). In our case, some women clearly had lower dietary scores than in Mali, and these women were those who also had the worst nutritional status. Generally speaking, since adult women's nutritional status is much more stable than that of growing children, one can assume that it is more difficult to show this kind of relationship, especially in a comprehensively homogenous environment. Consequently, the differences that we observed may reflect a real influence of the degree of dietary diversity on the anthropometric characteristics studied, such as the percentage of $BMI < 18.5\,kg/m^2$. Nevertheless, this relationship could raise other questions since these anthropometric indices are essentially the outcome of an energetic balance in which the quantity of food, which was not addressed in our study, appears to be more important than the quality of the food. Besides, our study was conducted during a period during which an adequate supply of food was available. However, depending on the types of dietary groups that are consumed at an increasing rate when the dietary diversity score rises (pulses and nuts, meat and fish, fat, sugar, etc cf. Figure 3), one can assume that this score reflects both the energetic density of consumed food and its better micronutrient content. Global energy intake is also likely to be linked to the level of dietary diversity, as shown by other authors (Allen *et al*, 1991). In this context, the dietary diversity score can therefore be considered as an indicator of overall dietary quality. However, it should be noted that the differences observed between diets with low and high scores typically refer to dietary changes that happen during the nutritional transition process, especially with increasing consumption of fat, animal products and sugar (Popkin, 1999). In a transitional context, these dietary changes can quickly turn into a phenomenon of excess which, in turn, can lead to chronic diseases related to nutrition. In a poor region like the one in which our study was conducted where very few women are overweight, it would of course be a good thing to consume more food items from these groups; but it is also necessary to inform and educate the rural populations on adequate food habits — especially if their economic conditions improve — in order to avoid the occurrence of the above-mentioned problems. These actions are also necessary to further improve the overall dietary quality while insisting especially on fruits and vegetables, which are currently not sufficiently consumed even though they are highly recommended in all societies.

Dietary diversity scores are very useful to evaluate overall dietary quality. Research in this field is still limited in developing countries. Our study showed that a relatively simple method allows a satisfactory description of the dietary quality, and also demonstrated the link between dietary quality and adult women's nutritional status. This easy-to-use method thus has great potential as a tool to rapidly determine the diet quality in different contexts and to monitor or evaluate intervention programmes.

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