

Dietary Diversity Scores and Nutritional Status of Women Change during the Seasonal Food Shortage in Rural Burkina Faso¹

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Abstract

In developing countries, dietary diversity is usually assessed during a single yearly period and the effects of seasonal variations remain unknown. We studied these variations in women living in a Sahelian rural area (Burkina Faso). A representative sample of 550 women was surveyed at the beginning and at the end of the seasonal cereal shortage in April and September 2003, respectively. For each season, a dietary diversity score (DDS) representing the number of food groups consumed over a 24-h period, was computed and nutritional status was assessed by the BMI. The DDS increased from 3.4 ± 1.1 to 3.8 ± 1.5 food groups between the beginning and the end of the shortage season ($P < 0.0001$), and the proportion of women exhibiting low DDS decreased from 31.6 to 8.1%. This was due to the consumption of foods available during the cereal shortage season and despite the decrease in the consumption of some purchased foods. The increase in DDS was lower in women for whom DDS was already high in April and vice versa. Over the same period, the percentage of underweight women (BMI < 18.5 kg/m²) increased from 11.1 to 17.1%. The relation between DDS and the women's socioeconomic characteristics or nutritional status was weakened in September. Thus, in April, fewer women were underweight when their DDS was high than when it was medium or low [odds ratio = 0.3 (0.2; 0.6)], but not in September [odds ratio = 0.6 (0.3; 1.0)]. In such a context, it would be useful to measure dietary diversity at the beginning of the cereal shortage season, when many women exhibit low DDS. J. Nutr. 136: 2625–2632, 2006.

Introduction

Seasonality is recognized as a key element of food availability in many developing countries, particularly in Sahelian countries. Each year, rural populations in these countries face a seasonal food shortage during the period between the depletion of cereal stocks and the next harvest. These shortages are particularly harsh in areas where people depend on the annual harvest of the staple crop after a single rainy season. In addition to the depletion of cereal stocks, this period is also characterized by intense agricultural work (1–3) and increased morbidity (4,5). The consequences of seasonal changes on the nutritional status of adults have been well documented. Many studies report seasonal weight loss and other anthropometric modifications during the food shortage period in both men and women (4–9). Other studies also report adverse seasonal changes in reproductive outcomes, such as insufficient weight gain during

pregnancy and low birth weight (10–12). Seasonality leads people to adapt their dietary consumption. Many studies have dealt with the effect of seasonality on dietary patterns, and especially on energy and nutrient intakes (4,9,13,14). On the other hand, few studies specifically address the effect of seasonality on overall dietary diversity. Yet a nondiversified diet can have negative consequences on individuals' health, well-being, and development, as this kind of diet is not likely to meet micronutrient requirements (15). However, in rural areas of developing countries, the measurement of dietary diversity is complex because populations often receive little education and generally share food from a communal bowl (16). Consequently, dietary diversity is frequently assessed by the use of simple tools such as diversity scores, i.e., the number of food groups consumed over a reference period. These scores are promising measurement tools in industrialized as well as developing countries, and several studies indicate that they are good proxies of overall dietary quality (17–22), they can be useful indicators of household food security (23), and they are also positively associated with the nutritional status of children (24–27). Recently, we found that a simple dietary diversity score was also associated with the nutritional status of adult women in rural Burkina Faso (28,29). Nevertheless, dietary scores are usually measured during a single

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period of the year and their seasonal variations remain largely unknown. Even if seasonal food shortages primarily affect the quantity of staple food, we assume that dietary diversity is also affected. In a report published by FANTA, Swindale et al. (30) took into consideration the potential effect of the food shortage season on the dietary diversity of households while assessing dietary diversity immediately prior to the harvest. The aim of the present research was to study variations in dietary diversity assessed by a simple dietary diversity score (DDS)⁵ in women living in rural Burkina Faso during the cereal shortage season. We also tried to identify the socioeconomic factors associated with these seasonal variations and to assess the effect of the cereal-shortage season on DDSs and their relation to the nutritional status of women.

Subjects and Methods

Study area. The study was conducted in Gnagna province, a rural area located in NE Burkina Faso. This province covers an area of 8640 km² and has ~350,000 inhabitants. The majority of the population belongs to the Gourmantche ethnic group. The province is particularly vulnerable because of its landlocked position, low-quality soils, and harsh climatic conditions, including scarce and erratic rainfall. Annual rainfall is ~610 mm and is concentrated during the period between June and September. The year is split into 3 distinct periods: the harvest season from October to December; the postharvest season from January to April, when food is relatively abundant; and the preharvest season from May to September, during which the population faces a cereal shortage and which is also characterized by hard agricultural work and increased morbidity.

Sampling. A longitudinal domestic survey was carried out in 30 villages in the province at the beginning of the cereal-shortage season (April 2003) and at the end of the cereal-shortage season of the same year (September). The sample stemmed from a previous survey carried out in March 2002 (28) for which a 2-stage sampling technique was used: first, the 30 villages were randomly selected with a probability proportional to size, and then 6 compounds were randomly selected in each village. All the women living in the selected compounds that had a child <5 y of age were included in the study. The same women were surveyed again in April and in September of 2003. In April, the sample included 550 women; 67 were lost at follow-up in September because of migration away from the study area, refusal to take part in the study, or because they died. All the women included in the study, as well as the village, compound, and household heads, verbally gave their free and informed consent to participate.

Food consumption. A qualitative recall of all foods consumed by the women during the previous 24-h period was performed in both seasons (April and September 2003). Each woman involved in the study was asked to recall all the dishes, snacks, or other foods she had eaten during this period, regardless of whether the food was eaten inside or outside the compound. From a practical point of view, we first let the woman spontaneously describe her food consumption and then we prompted her to be sure that no meal or snacks had been forgotten. Next, a detailed list of all the ingredients of the dishes, snacks, or other foods mentioned, was collected from either the person in charge of their preparation or directly from the woman being interviewed. No distinction was made between recalls made on weekdays or on weekends, insofar as weekends did not have any special importance in the context of our study. We were careful not to include atypical days (such as local feast days or celebrations) in the recall, but market days were noted and accounted for in the analysis because food consumption was likely to be different on those occasions. The interviews were conducted by 2 carefully trained fieldworkers with at least a secondary-school education. Both of them spoke French and local languages (Gourmantchema, Moore, and Fulfulde).

The information collected allowed us to calculate a dietary diversity score for each season, which was defined as the number of different food groups consumed in the 24 h preceding the recall. Because there is no internationally acknowledged recommendation for the food group classifications to be used, we decided to use a 9 food-group classification derived from a proposal made at a workshop on dietary diversity in Rome in October, 2004 (31): cereals, roots, tubers; pulses, nuts; vitamin A-rich fruits, vegetables; other vegetables; other fruits; meat, poultry, fish; eggs; milk, dairy products; and oils, fats. Neither the frequency of consumption nor the amount of food consumed was taken into consideration. The scores were used as discrete quantitative variables and were also divided into terciles to distinguish diets of high, medium, and low diversity. The choice of cut-offs to define the terciles was based on the distribution of DDSs observed in April. The same cut-offs were applied to the DDSs measured in September.

Anthropometric measurements. The anthropometric measurements were performed using the standardized procedures recommended by WHO (32). The women were weighed to the nearest 100 g on electronic scales with a weighing capacity of 10 to 140 kg. Their height was measured to the nearest mm with locally made portable devices equipped with height gauges (SECA 206 Bodymeter). The BMI [weight/height² (kg/m²)] was calculated and the threshold of 18.5 kg/m² was used to identify underweight women. Bicipital, tricipital, subscapular, and suprailiac skinfold thicknesses were measured in duplicate to the nearest 0.2 mm with a Holtain caliper according to standard Lohman procedures (33). The measurement of skinfold thickness enabled us to determine body density by applying the equation developed by Durnin and Womersley (34). To calculate the body fat percentage from body density in black subjects, we accounted for their higher lean mass density by adapting the equation of Siri (35) according to the recommendation of Heyward (36). The mid-upper arm circumference (MUAC) of the left arm was measured to the nearest mm with a nonstretch measuring tape. Upper arm muscle area (UAMA) was calculated from the MUAC and tricipital skinfold measurements using the following formula (37): $UAMA = [(MUAC - (\pi \times \text{tricipital skinfold}))^2 / 4\pi] - 6.5$. Women who said they were pregnant ($n = 94$ in April and $n = 78$ in September) and women with unreliable measurements due to a physical handicap ($n = 6$ in April and $n = 5$ in September) were excluded from all analyses using anthropometric measures.

Other information. Socio-demographic, economic, and sanitary information was collected at the level of the household or of the individual. To summarize information, the following 3 indices were computed. 1) The *property level index* was constructed using a correspondence analysis performed on the matrix of indicator variables that code housing quality (walls, roof, and floor), possessions (electric lamp, petrol lamp, radio, bicycle, or moped), and ownership of cattle. For a given household, the value on the first principal component of the correspondence analysis gives a coordinate that is interpreted as a summary indicator of its economic level. This index was then divided into terciles (38). 2) The *hygiene index* provided information about hygiene practices and conditions in the household. It was constructed from information concerning the type of water and the distance to the water source, latrines, promiscuity with animals, garbage disposal, and a spot check of the cleanliness of the compound. Based on this index, the sample was divided into 3 classes of hygienic conditions: high, medium, and low. 3) The *care for women index* assessed the level of attention and support given to women by other members of the household. This index was constructed from the following information: knowledge and use of family planning, obstetrical background (history of stillbirth or infant death), level of prenatal care (number of visits, malaria prophylaxis, and iron supplementation), beneficial practices during pregnancy (improved feeding, alleviation of physical burden, and postpartum rest time), declared ill treatment, and power of decision and autonomy. The index was subsequently divided into terciles.

Data management and analyses. Data entry was performed with EpiData software, version 3.1 (39). Data quality was ensured by quality checks associated with the data entry process, double entry, and also by further data cleaning. Data management, including computation of DDS from the dietary recall and recipe databases, was performed with SAS

⁵ Abbreviations used: DDS, dietary diversity score; MUAC, mid-upper arm circumference; UAMA, upper arm muscle area; OR, odds ratio.

system, version 9.1 (SAS Institute). The analysis first assessed seasonal variations in the dietary diversity scores, the food consumption, and the nutritional status of women. The DDS, frequency of food group consumption, and the anthropometrics of the women were used as dependent variables and were examined as a function of the "season" variable that was coded for the surveys conducted in April and in September. Next, we identified the effect of socio-demographic and economic factors on DDSs and BMIs at each season. Models with BMI or DDS as the response variable and each economic factor as regressors were thus fitted for each season. Finally, we analyzed the modifying effect (40) of the season on the relation between the mean DDS and the socio-economic variables, the nutritional status and the socio-economic variables, and the nutritional status of women and DDS. For this purpose, an interaction term, season \times each variable, was included in the models. The first type error rate for interactions was set at 0.20 to account for the lower power of interaction tests compared with main effects (41). The general linear model was used for quantitative response variables, and the logistic model was used for dichotomous responses. For quantitative variables, unadjusted or adjusted means \pm SEM are given. Qualitative variables are expressed as unadjusted or adjusted percentages. All analyses took into account the longitudinal design (repeated measurements on the same women) by including in the model a covariance structure on the errors by means of GEE estimation, except for some special cases (zero percentages) for which analysis was stratified by subject (42). The clustered sample was also taken into account by including a village random effect in the models. Mixed models were fitted with SAS, version 9.1, using the MIXED procedure for quantitative response variables (BMI and DDS) and the GLIMMIX procedure for dichotomous response variables. Except where otherwise specified, the first type error rate was set at 0.05 for all analyses.

Results

Characteristics of the sample. The mean age of the women was 29 y, and the vast majority belonged to the Gourmantche ethnic group. Only 20% of them were literate, and \sim 30% had a secondary occupation in addition to their agricultural activity. The characteristics of the women who were no longer included in the September sample ($n = 67$) and those in the initial sample in April did not differ significantly.

Seasonal variations in dietary diversity. The distribution of the DDS was different between the beginning and the end of the cereal shortage period (Fig. 1). Indeed, by applying the same cut-offs for the terciles of DDS to both seasons, it turned out that, in September, a much lower proportion of women exhibited a low DDS (8.1 vs. 31.6%), and a higher proportion exhibited a high DDS (58.2 vs. 36.2%) than in April, although there were fewer women with a very high DDS (≥ 6 food groups) in September. This resulted in an increase in the mean DDS at the end of the cereal shortage season as compared with the beginning (3.8 ± 1.1 vs. 3.4 ± 1.5 food groups, respectively, $P < 0.0001$).

The food consumption of women changed according to the season (Table 1). In September, more women consumed legumes, particularly peanuts, beans, and Bambara groundnuts. More women also consumed cow's milk and vegetables (other than vitamin A-rich vegetables); the latter difference was due to the higher consumption of okra; although tomatoes, cabbage, and onions were less consumed in September. On the other hand, fewer women consumed the meat/fish group; actually, far fewer women consumed meat, especially mutton, but a few more women consumed fresh fish. Also, fewer women consumed oils and fats due to a decrease in the consumption of peanut/cotton oil, despite a slight increase in the consumption of shea butter. Finally, there was no change in the frequency of consumption of cereals and of vitamin A-rich vegetables between the 2 seasons.

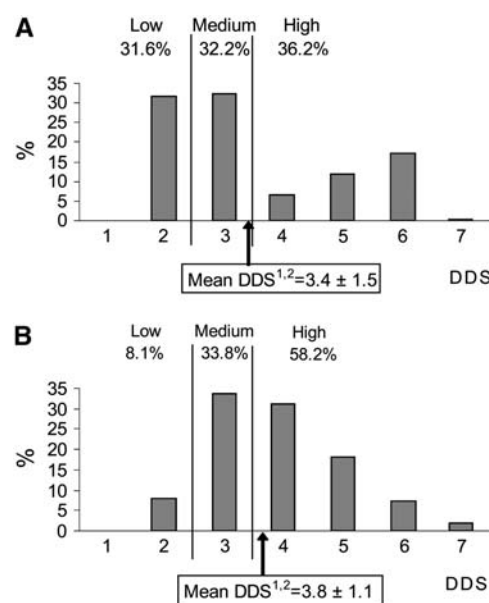


Figure 1 DDS distribution among women in April (A, $n = 550$) and September (B, $n = 483$). Means, adjusted for market days, differed between the 2 months, $P < 0.0001$.

However, the women did not consume exactly the same types of cereals (maize was consumed only in September) or the same types of leafy vegetables.

Factors associated with seasonal variations in dietary diversity. From April to September we observed differential changes in the relation between the DDS of women and socio-economic and demographic factors (Table 2). On the whole, differences in DDS between socio-economic categories were less marked in September than in April because the increase in DDS between these 2 rounds was lower for women who belonged to socio-economic categories in which the DDS was already high in April and vice versa. For example, in April, the DDS tended to be higher when the seniority of the compound head was higher, whereas it tended to be the reverse in September (P for interaction term = 0.009). In addition, in April, the DDS was notably higher for women living in households with a high level of hygiene but this advantage disappeared in September (P for interaction term = 0.2). The same phenomenon was observed when household heads had a secondary occupation (increase in DDS of +5.4% vs. when they had not (+22.6%, $P = 0.009$). On the other hand, when heads of household were literate, the DDS of women were higher in September, whereas this advantage was not apparent in April. Finally, the increase in the DDS between April and September was much higher for the Fulani women (+38.5% vs. +11.4% for the Gourmantche, and -8.6% for the Mossi, $P = 0.03$) and for the women who had personal incomes (thanks to ownership of animals).

To better understand the above differential changes in the DDS of women across socio-economic categories, we looked at seasonal variations in the consumption of food groups and food items as a function of these factors. Generally speaking, the increase in the frequency of consumption of legumes, fruits, and vegetables between April and September was higher for women from lower socio-economic categories (head of household without a secondary occupation, low or medium property level, etc., detailed results not shown). In addition, the increase in the frequency of milk consumption in September was much higher for the Fulani women than for the other ethnic groups (+50.9%

TABLE 1 Percentages of women that consumed food groups and food items as a function of season¹

Food groups and items	April, n = 550	September, n = 483	P-value
	%		
Cereals, roots, and tubers	100	100	1.0
White sorghum	84.5	62.0	<0.0001
Maize ²	0.2	39.4	<0.0001
Rice	23.3	7.7	<0.0001
Millet	24.0	24.1	0.9
Legumes	28.1	64.8	<0.0001
Peanuts	24.6	54.0	<0.0001
Beans	2.7	22.4	<0.0001
Bambara groundnuts	0.1	6.1	<0.0001
Vitamin A-rich fruits and vegetables	80.0	77.7	0.3
Baobab	64.3	52.3	0.0003
Bush okra	10.7	24.0	<0.0001
Wild leaf	0.3	2.5	0.0006
Mango ²	3.1	0	0.0005
Other vegetables	40.4	48.0	0.01
Tomatoes	21.0	3.0	<0.0001
Cabbage ²	27.4	0	<0.0001
Okra	22.7	43.8	<0.0001
Onions	20.8	2.4	<0.0001
Other fruits ²	0.9	0.2	0.3
Meat, poultry, and fish	61.7	44.3	<0.0001
Sheep	25.2	2.9	<0.0001
Poultry	1.1	0.4	0.1
Fresh fish	0.9	2.9	<0.0001
Dried fish	41.8	32.0	0.0009
Eggs	0	0	1.0
Milk and dairy products			
Cow's milk	1.0	23.2	<0.0001
Fats/oils	31.7	23.9	0.005
Peanut/cotton oil	30.2	16.1	<0.0001
Shea butter ²	0	6.4	<0.0001

¹ The analyses were adjusted for market days.

² The design effect could not be taken into account because of very low percentages in at least 1 season.

for the Fulani vs. +20.3% for the Gourmantche and +15.4% for the Mossi, $P = 0.02$). On the other hand, the percentage of women who consumed peanut/cotton oil decreased from 40.6 to 15.6% between April and September in households whose heads had a secondary occupation and from 25.3 to 10.3% when they had not (season \times secondary occupation interaction $P = 0.19$).

Seasonal variations in nutritional status and associated factors. Between the beginning and the end of the food shortage period the mean weight loss was 1.9 kg (Table 3). The mean BMI fell to <21 kg/m² and the percentage of underweight women (BMI <18.5 kg/m²) increased from 11 to 17% ($P = 0.001$). All the skinfold thicknesses decreased between both rounds, which resulted in a decrease in the body fat percentage (23.1% in April vs. 20.3% in September, $P < 0.001$). In contrast, there was no change in lean mass assessed by the UAMA (36.3 vs. 35.7 cm², $P = 0.1$). Very few socio-economic characteristics were associated with these nutritional modifications. Generally, women with higher anthropometric values in April underwent larger decreases. Thus, there was a greater decrease in the mean

BMI during the cereal shortage season for literate women (21.7 to 20.5 kg/m² vs. 20.9 to 20.4 kg/m² for illiterate women; P for interaction term = 0.09), for women with agricultural incomes (21.1 to 20.4 kg/m² vs. 20.0 to 20.2 kg/m²; P for interaction term = 0.10), and women who declared illness during the preceding fortnight (20.9 to 20.0 kg/m² vs. 21.1 to 20.7 kg/m²; P for interaction term = 0.10). Except for these categories, all the women underwent the same seasonal decrease in their BMI.

Seasonal effect on the relation between DDS and nutritional status. As the low DDS category almost disappeared in September, we decided to group it with the medium category of DDSs (Table 4). In April, the women's BMIs were higher when their DDSs were higher. There were also less underweight women in the high category of DDSs than in the medium and low category. This relation remained significant after adjusting for potential confounders. The same trends were observed in September, but the differences between the categories of DDSs were less marked and were not significant ($P = 0.08$ – 0.3). Indeed, in September, 11.0% of women were underweight when their DDS was high vs. 17.2% when their DDS was low. In April, the corresponding figures were 3.8 vs. 12.0% (P for the interaction = 0.10). The same analyses were performed with the MUAC and body fat percentage, and the same results were obtained (results not shown).

Discussion

In the context of our study, dietary diversity measured by a simple score over a 24-h period was sensitive to seasonal variations. Contrary to what might be expected, the women's DDSs were higher in September, even though this corresponded to the end of the cereal-shortage season and thus, presumably, to harder living conditions. Actually, scarcer financial resources at that time resulted in a decrease in the consumption of some purchased food products like meat and oil, but many other free or cheap foods were available in this rainy period, such as legumes, milk, or fresh fish. Similar seasonal changes in diet have been highlighted in other studies. Van Liere et al. (9) showed that when cereal stocks became depleted, the first change in the consumption patterns of Beninese adults was a shift to the consumption of pulses. They also pointed out that there was a higher consumption of wild foods, such as shea nuts and leafy vegetables. Consequently, the period of cereal shortage did not coincide with lower dietary diversity as measured by the DDS. Although it can be assumed that the quantity of cereals consumed is reduced during this period, the women manage to adapt their food consumption and take advantage of wild foods and other available foods. However, we showed that the increase in DDSs between April and September was not the same for all women. Indeed, the women who were more privileged in April were also those with better DDSs, partly because of their higher consumption of purchased foods, such as meat and oil. Their DDS did not increase much during the rainy season, probably because they could no longer afford to buy these foods in September. In comparison, the seasonal increase in the DDS was higher for women who had easy access to free or cheap foods in September. The most striking example was the case of the Fulani women, who, in April, had very low DDSs compared with other ethnic groups, whereas, in September, their mean DDSs had nearly caught up with the others'. This was mainly the result of a higher consumption of milk in September, given that the Fulani are cattle breeders and thus have easy access to milk. These differential changes in the DDS modified the relation between dietary

TABLE 2 Relation between DDS and women's socio-demographic and economic characteristics and season¹

	April			September			<i>P</i> -value ⁴
	<i>n</i>	DDS	<i>P</i> -value ²	<i>n</i>	DDS	<i>P</i> -value ³	(interaction)
Compound characteristics							
Size in number of households							
Single	46	3.3 ± 0.2	0.1	39	3.7 ± 0.2	0.2	0.4
2 or 3	136	3.2 ± 0.2		115	3.8 ± 0.1		
4 or more	364	3.5 ± 0.2		325	3.9 ± 0.1		
Size in number of persons							
<15	44	3.4 ± 0.2	0.01	40	3.7 ± 0.2	0.2	0.6
15 to 29	112	3.1 ± 0.2		93	3.8 ± 0.1		
≥30	390	3.5 ± 0.1		346	3.9 ± 0.1		
Seniority of the head of compound							
≥50 y or born	450	3.5 ± 0.1	0.07	391	3.8 ± 0.1	0.08	0.009
<50 y in the compound	82	3.2 ± 0.2		79	4.1 ± 0.1		
Household characteristics							
Size of the household							
≤6 persons	97	3.3 ± 0.2	0.1	87	3.9 ± 0.1	0.3	0.4
7 to 10 persons	178	3.3 ± 0.2		154	3.8 ± 0.1		
>10 persons	271	3.5 ± 0.2		238	3.9 ± 0.1		
Property level							
Low	141	3.2 ± 0.2	0.08	120	3.6 ± 0.1	0.006	0.8
Medium	192	3.5 ± 0.2		168	4.0 ± 0.1		
High	179	3.5 ± 0.2		162	4.0 ± 0.1		
Hygienic index							
Low	162	3.3 ± 0.2	0.02	143	3.9 ± 0.1	0.7	0.2
Medium	305	3.3 ± 0.1		264	3.8 ± 0.1		
High	79	3.8 ± 0.2		72	4.0 ± 0.2		
Possession of agricultural tools							
Yes	310	3.5 ± 0.2	0.06	285	3.9 ± 0.1	0.3	0.5
No	236	3.3 ± 0.2		194	3.8 ± 0.1		
Secondary occupation of the head of household							
Yes	271	3.6 ± 0.1	0.0003	237	3.9 ± 0.1	0.3	0.009
None	275	3.2 ± 0.1		242	3.8 ± 0.1		
Education							
Literate	121	3.5 ± 0.2	0.4	102	4.1 ± 0.1	0.02	0.8
Illiterate	425	3.4 ± 0.2		377	3.8 ± 0.1		
Women's characteristics							
Age, y							
<20	32	3.6 ± 0.2	0.7	24	4.1 ± 0.2	0.5	0.9
20 to 29	288	3.4 ± 0.2		255	3.8 ± 0.1		
≥30	225	3.4 ± 0.2		195	3.9 ± 0.1		
Matrimonial status							
Polygamist	233	3.3 ± 0.2	0.2	207	3.8 ± 0.1	0.2	0.5
Not polygamist	315	3.5 ± 0.1		276	3.9 ± 0.1		
Ethnic group							
Gourmantche	464	3.5 ± 0.1	0.0007	414	3.9 ± 0.1	0.2	0.03
Fulani	47	2.6 ± 0.3		39	3.6 ± 0.2		
Mossi	34	3.5 ± 0.3		26	3.8 ± 0.2		
Religion							
Animist	162	3.2 ± 0.2	0.02	138	3.7 ± 0.1	0.2	0.2
Moslem	147	3.3 ± 0.2		123	3.9 ± 0.1		
Christian	234	3.6 ± 0.2		217	4.0 ± 0.1		

(Continued)

TABLE 2 *Continued*

	April			September			<i>P</i> -value ⁴ (interaction)
	<i>n</i>	DDS	<i>P</i> -value ²	<i>n</i>	DDS	<i>P</i> -value ³	
Education							
Literate	111	3.5 ± 0.2	0.3	100	4.0 ± 0.1	0.3	0.6
Illiterate	439	3.4 ± 0.1		383	3.8 ± 0.1		
Agricultural income							
Yes	498	3.4 ± 0.1	0.05	428	3.9 ± 0.1	0.2	0.6
No	38	3.0 ± 0.3		43	3.7 ± 0.2		
Commercial income							
Yes	39	3.6 ± 0.2	0.2	34	3.9 ± 0.1	1.0	0.5
No	497	3.4 ± 0.1		437	3.9 ± 0.1		
Income from animals							
Yes	80	3.0 ± 0.2	0.09	81	4.2 ± 0.2	0.08	0.02
No	456	3.4 ± 0.1		390	3.9 ± 0.1		
Care for women index							
Low	193	3.2 ± 0.2	0.004	162	3.7 ± 0.1	0.006	0.8
Medium	195	3.5 ± 0.2		182	3.9 ± 0.1		
High	158	3.7 ± 0.2		136	4.1 ± 0.1		
Morbidity (15 d)							
Yes	148	3.5 ± 0.2	0.2	214	4.0 ± 0.1	0.04	0.9
No	402	3.4 ± 0.1		269	3.8 ± 0.1		

¹ Values are means ± SEM. Analyses are adjusted for market days.

² DDS in April between categories of factors in first column.

³ DDS in September between categories of factor in first column.

⁴ Interaction term = season × factor.

diversity and certain socio-economic characteristics of the women in September compared with April. Indeed, the differences between mean DDSs across socio-economic categories were generally less marked in September. There may be specific explanations for some of the observed changes. For example, in April, a higher DDS was associated with the fact that the head of household had a secondary occupation (other than agricultural work), but this was no longer the case in September. We assume that in September these heads of household devoted most of their time to agricultural work. The secondary activities of women may also have decreased in September, which could have contributed to the weakening of the association. Unfortunately, we could not verify these assumptions insofar as the corresponding data were collected in April only. In contrast, the education of the head of household appeared to positively influence the

DDS of the women in September, whereas this was not the case in April, suggesting that the level of education is more protective when times are more difficult. The DDS was associated with morbidity in September only, probably because of the higher prevalence of some diseases, especially malaria, in September than in April. Indeed, in our study 27% of women claimed to have been ill during the 15 previous days in April, vs. 44% in September. However, generally speaking, it seems that the DDSs measured at the end of the cereal shortage season were less likely to discriminate the women from a socio-economical standpoint than the DDSs measured before the shortage season.

As expected, seasonal changes in body weight and fat mass were observed among the women in our study. These weight changes were moderate, but not negligible: a mean of −1.9 kg, corresponding to a mean weight loss of 3.5%. Similar seasonal weight changes were reported in women living in other developing countries (4,6–8,43). The mobilization of body fat stores constitutes a response to a negative energy balance that is caused by low energy intakes combined with heavy agricultural work (4,13). In contrast, we did not observe seasonal change in lean tissue mass, which agrees with the results of other studies (4,44). This would mean that, in years when the food shortage is not exceptional, seasonal stress has no effect on the muscle mass of women, which is probably maintained by the physical demands of agricultural work.

Very few socio-economic factors were found to be associated with the seasonal decrease in the women's nutritional status in our sample, as was the case in other studies (7,9). In our study, only educational levels, morbidity rates, and agricultural incomes of the women were associated with a decrease in their BMI. In fact, it seems that the decreases in BMI were larger in more privileged women because their initial values were also higher. Thus, the relative advantage of some women in April

TABLE 3 Seasonal variations in women's nutritional status^{1,2}

	April, <i>n</i> = 450	September, <i>n</i> = 400	<i>P</i> -value
Weight, <i>kg</i>	54.9 ± 7.3	53.0 ± 6.9	<0.0001
BMI, <i>kg/m</i> ²	21.1 ± 2.2	20.4 ± 2.0	<0.0001
Mid-upper arm circumference, <i>cm</i>	26.7 ± 2.1	26.1 ± 2.1	<0.0001
Bicipital, <i>mm</i>	5.0 ± 1.7	4.2 ± 1.9	<0.0001
Tricipital, <i>mm</i>	11.3 ± 4.1	9.9 ± 3.8	<0.0001
Underscapular, <i>mm</i>	10.5 ± 3.4	8.4 ± 2.7	<0.0001
Suprailiac, <i>mm</i>	5.7 ± 2.6	4.3 ± 1.6	<0.0001
Body fat, %	23.1 ± 4.0	20.3 ± 4.1	<0.0001
Upper arm muscle area, <i>cm</i> ²	36.3 ± 5.6	35.7 ± 5.8	0.1
BMI <18.5 <i>kg/m</i> ² , %	11.1	17.1	0.001

¹ Values are means ± SD or %.

² Pregnant and handicapped women were excluded.

TABLE 4 Association between DDS and women's BMI as a function of season¹

	<i>n</i>	Mean BMI, kg/m ²		% BMI <18.5 kg/m ² and OR [0.95 CI]	
		Unadjusted ²	Adjusted ³	Unadjusted ²	Adjusted ³
DDS, April	450				
Low + medium	286	20.8	20.9	14.4%, 1.0	12.0%, 1.0
High	164	21.6	21.5	4.3%, 0.3 [0.2; 0.5]	3.8%, 0.3 [0.2; 0.6]
<i>P</i> -value ⁴		0.0007	0.02	0.0007	0.001
DDS, September	400				
Low + medium	164	20.1	20.3	22.2%, 1.0	17.2%, 1.0
High	236	20.5	20.5	13.7%, 0.6 [0.3; 1.0]	11.0%, 0.6 [0.3; 1.0]
<i>P</i> -value ⁴		0.07	0.2	0.2	0.08
<i>P</i> -value ⁵		0.2	0.3	0.08	0.1

¹ Values are means, % BMI, and OR.² Adjusted only for market days.³ Adjusted for market days, size of the compound (in number of persons), hygienic index of the household, secondary occupation of the head of household, age, agricultural incomes, education, ethnic group and morbidity of the women, care for women index.⁴ For effect of DDS on BMI or BMI <18.5 kg/m² (for each season).⁵ For DDS × season interaction term.

disappeared in September because the cereal-shortage season somewhat levels out the nutritional status. Except for these characteristics, all the other women underwent a similar decrease in their nutritional status during the cereal-shortage period. As for DDSs, the season modified the relation between BMI and the socio-economic characteristics of the women. In April, the BMI was significantly associated with several socio-economic factors, such as the hygienic level of the household, the ethnic group, the level of education, women's agricultural incomes, or the care for women index, but these associations were no longer significant in September (results not shown). On the whole, it appears that the relation between BMI and socio-economic factors was weakened over the period of cereal shortage. As previously discussed, some of the socio-economic characteristics of the women and households may have changed between the 2 seasons. Furthermore, the anthropometric indices decreased between April and September, probably because of dietary factors but also because of an increased workload for women in September. All these changes may have modified the relation between BMI and socio-economic factors.

Finally, we found no significant relation between the DDS and BMI at the end of the cereal-shortage season, whereas we did observe a relation when the DDS was measured before the shortage (28,29). This may be because in September, there was less difference in the DDS and in nutritional status among the women. Gnagna province is a typical Sahelian rural area that is very poor and rather homogenous, and the cereal shortage affects everyone but, as we have shown, without reducing dietary diversity. However, the lack of association of the DDS with the BMI in September may also reflect the limited ability of a simple DDS to represent changes in the energy balance because as it does not take portion size or amount of food into consideration. Global energy intake is likely to be linked to the level of dietary diversity (46), but this assertion may not hold for adults during a cereal-shortage season. Indeed, even if the number of food items increased in September because women made use of a variety of alternative food resources, the consumption of staple foods declines during the seasonal shortage (8,9).

Consequently, DDSs can help identify vulnerable individuals from a socio-economic and nutritional standpoint when measured before the cereal shortage season and are less likely to do so when measured after. In such a context, the usefulness of measuring DDSs at the end of the cereal shortage season is,

therefore, questionable, especially when conducted in a yearly or single-round cross-sectional survey. As discussed in the introduction, Swindale et al. (30) recommended, at the household level, measuring the DDS at the end of the food-shortage season to more effectively identify vulnerable households. They also recommended repeating surveys at the same season to avoid seasonal differences when assessing changes over time (for evaluation purposes notably). Our results are in line with their second recommendation, as we have shown that DDSs change across the seasons. However, at least at the individual level and in Sahelian rural contexts, to more accurately target people with the greatest needs, we also recommend measuring the dietary diversity scores before the cereal shortage season, when there are more women with low DDSs.

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