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TRADITIONAL AND *ACACIA COLEI* SEED-INCORPORATED DIETS IN MARADI, NIGER REPUBLIC

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ABSTRACT

A survey of dietary habits of 83 male and 35 female volunteers from rural villages around Maradi, southern Niger, revealed that fura and tuwo were basic staples, the former being consumed up to 21 times weekly and the latter about once daily. Local recipes were modified to incorporate a prospective new food, *Acacia colei* seed flour, at 0, 15 and 25% (w/w) and the resulting diets fed *ad libitum* to volunteers for three weeks under controlled conditions. *Acacia* incorporation at 25% increased the crude protein content of most meals and the *per capita* crude protein intake to 136 g/day, 56% above the control. Lipid intake was similar in the three trial groups. Dietary fibre intake and *per capita* energy consumption for the 25% acacia diet was 93% and 18% above the control respectively. Daily vitamin consumption was above RDA from all the diets. The results showed that the supplementation of the traditional foods of the people of Maradi with *acacia* increased the nutritional value of each food.

Key words: Proximate composition, energy, consumption, traditional diets, Niger

INTRODUCTION

Hunger, malnutrition and starvation are common in the semi-arid Sahelian region of tropical Africa with mean annual rainfall below 600 mm.[1] Project records of Maradi Integrated Development Programme (MIDP), a non-governmental rural development program, showed serious failures of the staple crops – millet and sorghum – and resulting food shortages have occurred in the Maradi region of southern Niger Republic in 1973–75, 1984,

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1998, 1994, 1996 and 2000 as a result of drought and other factors such as pest attack.

The seeds of some 50 Australian dry-zone Acacia species are known to have been a significant seasonal component of traditional Aboriginal diets.[2] One of these species, *Acacia colei*[3] has been widely planted in southern Niger Republic for windbreaks and fuel wood production. It yields heavy seed crops in the Maradi region, where local people associated with MIDP have developed palatable foods by incorporating *A. colei* seed flour into traditional recipes.

Chemical analysis indicates that *A. colei* seeds have high nutritional value.[2,4] Corn starch-based diets incorporating 42–50% (w/w) of *A. colei* seed flour supported moderate growth in laboratory rats and supplementation with methionine boosted the growth rate (Adewusi *et al.* Unpublished data).

These results suggested that acacia could be used as a human famine food and probably in regular diets if incorporated at not more than 20–25% of the whole diet. There are, of course, species differences between animals and man in their susceptibility to diets and chemical compounds. Accordingly, a three-week dietary trial of acacia-incorporated foods with human volunteers from villages around Maradi was conducted in 1995. Significant increases in body mass index and mid-arm circumference were obtained for the acacia-incorporated diets but not the control diet, showing the beneficial effects of incorporating acacia seed flour into the traditional diets (Adewusi *et al.* Unpublished result).

This paper reports the proximate composition and energy content of the control and acacia-incorporated foods used in the human volunteer trial. Based on this information and the weights of food eaten, the daily intake of crude protein, lipid, dietary fibre, some vitamins and total metabolisable energy was calculated. Information on the dietary preferences and habits of the volunteers, gathered during preparation for the trial, is also presented.

MATERIALS AND METHODS

The protocol for the human volunteer trial was approved by the Ethics in Human Experimentation Committee of the Australian National University, Canberra. Approval to proceed with the trial was also obtained from national and local government authorities in Maradi, Niger Republic. Danja, a village about 15 km from Maradi, was chosen as the study site.

Selection of Volunteers: The choice of volunteers was by purposive sampling. An appeal for volunteers was made to the local chiefs after the objective of the study had been thoroughly explained to the chiefs-in-council. Volunteers came from five rural villages within 30 km of Maradi; Bassarawa, Chadakori, Dan Indo, Dan Makao and Sarkin Hatsi. A common feature in the five villages was the presence of *A. colei* trees that had been planted either as windbreaks or as a potential source of firewood.

The rural villages from which volunteers had been invited had close collaboration with MIDP on improved farming techniques and the use of acacia trees in farm plantings. They were also subsistence farmers vulnerable to food shortage, and were therefore likely to benefit directly from the successful uptake of acacia seed flour into human diets. All villages invited to participate were to be represented in the selected group of volunteers. A total of 83 men and 35 women were available at the start of the project.

All volunteers were given a medical check-up, certified fit and each signed or thumb printed a "consent for investigative procedures form" willingly. They were then interviewed with the aid of interpreters, using a prepared questionnaire, to obtain relevant personal data, and information on their normal diets. Twenty-eight male (aged 21–30 years) and 27 female (age range 15–30 years) volunteers were finally selected for the dietary trial. Nine male and nine female volunteers were randomly placed on diets incorporating 0, 15 and 25 % of *A. colei* flour (w/w) except for the 15 % acacia diet, which was assigned ten male volunteers.

Dietary regimes and conduct of the trial: The control diet comprised typical local foods based on millet, sorghum and maize flours as staple foodstuffs. *Acacia colei* seed flour was mixed with the millet, sorghum and maize flours in appropriate proportions to provide the acacia-incorporated diets as described in the next section.

For the duration of the three-week trial, three meals were served each day: breakfast before or by 9 am, lunch around 1pm and supper around 7pm. Volunteers were able to eat as much of most of the foods as they desired and were allowed free access to water at all times. Meat was also served once per week, following a request by the volunteers. The three groups were housed and ate separately but adjacent to one another at the Danja site for the duration of the trial. It was not possible to arrange double-blind conditions, so both volunteers and trial supervisors were aware of the diets they were consuming. Supervisors watched carefully during meal times to ensure that foods were not swapped between groups. The volunteers were on light duties during the course of the trial, their work activities being restricted to maintenance of their living areas and the surrounding compound.

Diet Preparation: *Acacia colei* seeds were collected around Maradi, milled to flour in a local grain mill and sieved through a wire mesh sieve with 0.6 mm aperture size to remove as much as possible of the seed coat fragments. Other foodstuffs were purchased in the local markets. The most important diet items were prepared as follows:

Fura: 415, 527 and 494 g flour was mixed with hot water and pounded to form one kg of thick paste which was then rolled into balls and heated in water for 30–60 minutes for the 0, 15 and 25% acacia incorporated fura balls respectively. 712 g of each ball was then mixed in a clean calabash with about 76 g sugar and fresh cow's milk to give one kilogram of thick fluid, which was taken with a wooden spoon.

Fura/Datun-Yanmaka: Fura was served as prepared above. Datun yanmaka was prepared (per kilogram product) by pounding 522 g Moringa (*Moringa pterygosperma* Gaertn) leaves (Yanmaka in Hausa language), 279 g kulikuli (a fried groundnut product), 10 g table salt and 189 ml water to form a paste which was taken with fura.

Fura/Dan Wake: Dan wake was prepared by mixing and pounding together about 365 g millet or its *acacia*-incorporated composite flour with 286 g kulikuli, 4 g table salt and water to give one kg of paste which was then steamed and served with fura.

Masulali: About 402 g of the different composite flours was thoroughly mixed with 163 g water, 225 g vegetable oil, 44 g onion, 65 g table salt and 100 g Moringa leaves and then steamed for about one hour. The resultant meal was then eaten with a spoon or by hand.

Tuwo Millet: A thick paste was prepared by mixing 182–282 g millet or its composite flour with boiling water to make one kilogram of the food. The paste was then eaten with gravy or stew. One kg of gravy was prepared by cooking together 74.5 g of dry tomato and pepper, 24.8 g of cowpea, 4.5 g of spices, 23.4 g of vegetable oil, 22.9 g table salt, 4.5 g Ajinomoto seasoning salt (99.5 % monosodium glutamate), 20 g of Maggi stock cube, and water to make up the difference.

Tuwo Massara: was prepared from maize and or composite flour as above.

Tuwo Sorghum: was prepared from sorghum or its composite flour as above.

Burabusko: About 400 g of the millet or composite flour was mixed with 600 g of water and steamed to give a crispy food similar to but not as coarse as rice. This food was eaten with gravy prepared per kilogram from water, 52 g sliced pumpkin, 30 g vegetable oil, 28 g cucumber, 20 g dry spices/pepper/tomatoes, 19.4 g table salt, 16 g lettuce, 13 g eggplant, 11 g carrot, 5.2 g onion, 4.0 g Maggi cube, 1.8 g green pepper and 1.0 g of Ajinomoto seasoning salt (99.5 % monosodium glutamate).

Spaghetti: Millet or composite flour was moistened with water, mixed thoroughly and extruded through a machine. The dry spaghetti was then steamed in water and served with gravy.

Fura/Massa: The preparation of fura was as described earlier. Massa was prepared by mixing 324–374 g millet or its *acacia* composite flour with 140–151 g water, salt was added to taste and the mixture then fried in 487–525 g of vegetable oil.

Massa/Koko or Kunu: 139–167 g millet or composite flour was mixed with boiling water to give one kilogram of a thin watery paste called koko or kunu taken along with massa described earlier.

Chin-chin: was prepared by mixing 571 g wheat or composite flour with a small amount of yeast and water to form one kilogram of dough, which was allowed to rise to about twice its volume in about 15 minutes, rolled into tiny rods and fried in vegetable oil.

Massa/Damia: Damia was prepared from the following ingredients, per kg: 31 g eggplant, 90 g fluted pumpkin, 13 g lettuce, 11.5 g cucumber, about one gram green pea and 3 g green pepper were grated together, salt added to taste, 37 g vegetable oil added and the mix cooked with enough water to make one kilogram of damia (soup) which was then taken with massa.

Sampling Techniques: Food preference and consumption for 83 male and 35 female volunteers were estimated by a three-day dietary recall and direct questions in the survey instrument, and checked through interactions with the rural population during other survey programs. Weight of food consumed per person per meal during the dietary trial was estimated by a weigh-back technique during the middle one-week period of the experiment. During this period, weight of ingredients for the preparation of each diet was also taken and recorded. Samples from each diet were taken at source and from two individuals from each group and then stored frozen until analyzed for proximate composition. Food consumption was calculated as a mean and standard deviation of each type of food eaten by each group for the week.
Analytical Techniques: Crude protein (CP) – N × 6.25 was determined by the micro-Kjeldahl's method.[5] Ash content was determined on 2.0 g samples according to the AOAC method[5] Total lipid was soxhlet extracted for 12 hours using petroleum ether (b. p. 60–80°C) as the solvent. Dietary fibre was calculated from the values for individual foodstuffs determined earlier[4]. The daily intake of protein, lipid and carbohydrate was calculated from the food intake over one week and total energy was estimated by multiplying the three components by the Atwater factor (4, 9 and 4 Kcal/g respectively).

Estimation of Daily Vitamin Intake: The vitamin content of the each composite food stuff of each diet (as shown under Diet Preparation) was calculated using all the Food Composition Tables[4,6,7] (Table 8). Total daily vitamin intake was calculated from the food consumption for breakfast, lunch and supper of participants in the human dietary trial. The mean value for seven days is presented as the vitamin intake per day in Table 6. The value obtained was compared to RDA values.[7,8]

RESULTS AND DISCUSSION

Food Preference and Consumption: In rural villages around Maradi, the diet is almost exclusively from plant sources with roasted spiced meat (suya) eaten as a delicacy or during religious festivals. Table 1 shows the frequency of the main food items eaten in the sampled households. Fura was the food item most commonly consumed either alone or in combination with other food items. Eighty-three male and 35 female respondents interviewed indicated taking fura at least once daily, with some respondents taking it up to 21 times per week. Tuwo-millet was another favourite food also eaten alone or in combination with fura. As expected, fura and tuwo constituted the major breakfast, lunch and dinner food items while beans and bean products came next in order of priority (Table 2). Masulali was a preferred food for home use, and was the most favoured item during the dietary trial as determined by the solid mass intake, more being consumed by the females than the males. Masulali is rich in purchased ingredients such as oil and onions and therefore expensive which is why it would feature as an occasional diet item in poor rural households. Snacks (not shown in Table 2) consisting of

TABLE 1

The Most Commonly Eaten Foods of Volunteers from Five Rural Villages around Maradi, Niger Republic.

Male (83 respondents)		Female (35 respondents)	
Food Type	% Frequency	Food Type	% Frequency
Fura	36.4	Fura	48.6
Tuwo	29.0	Tuwo	30.0
Beans	10.7	Beans	10.0
Meat	6.3	Haiki[1]	4.3
Massa	3.3	Meat	1.4
Haiki	3.3	Kunu	1.4
Kunu	3.3	Rice	1.4
Rice	2.9	Waina	1.4
Cassava	1.5	Others[2]	1.5
Waina	1.1		
Others[3]	2.2		

[1]Haiki (Leaves in Hausa language) is a combination of many leafy vegetables eaten boiled and salted.
[2]Others included Ground nut, Yam, Massa, Round nuts and Bread.
[3]Others included Ground nut, Bread, Corn, Yam and Round nuts.

TABLE 2

Preference of Diets for Breakfast, Lunch and Supper in a 3-day Dietary Recall of the People of Maradi, Niger Republic.

Breakfast				Lunch				Supper			
Male		Female		Male		Female		Male		Female	
Food type	%	Type	%	Type	%	Type	%	Type	%	Type	%
Fura	32.8	Fura	43.2	Fura	40.3	Fura	41.0	Tuwo	62.9	Tuwo	34.6
Beans	14.4	Beans	17.7	Tuwo	23.8	Tuwo	23.8	Fura	12.5	Beans	29.8
Massa	11.5	Tuwo	12.8	Beans	14.9	Beans	18.1	Beans	10.5	Rice	21.3
Waina	11.1	Massa	12.8	Meat	7.7	Haiki	8.6	Kunu	3.7	Fura	7.7
Kunu	10.7	B'busko	5.9	Rice	6.5	Massa	2.9	Meat	2.8	Meat	3.9
Tuwo	7.8	Kunu	2.9	Kunu	3.2	Rice	2.9	Massa	2.4	Massa	0.9
Pancake	3.7	Pancake	2.9	Cassava	1.2	Waina	1.9	Rice	1.6	Yam	0.9
Burabusko	2.5	Waina	0.9	Haiki	1.2	Pancake	0.8	Haiki	0.8	B'busko	0.9
Meat	1.6	Bread	0.9	Waina	0.4	–	–	Yam	0.8	–	–
Rice	1.3	–	–	Massa	0.4	–	–	Masulali	0.8	–	–
Others	2.6	–	–	Roundnut	0.4	–	–	Others	1.2	–	–
Total	100		100		100		100		100		100
Respondents	83		35		83		35		83		35

fried/boiled groundnut, sugar cane, kola nut and round nut, usually bought outside the home, were taken by about half the male respondents, while the females ate very few snacks.

Weight and moisture content of the experimental diets: Food intake was generally higher for the 25% *acacia* diets (Table 3) though all volunteers seemed to eat about the same volume of food. The densities of the *acacia* incorporated recipes were higher due to a lower moisture content and/or lower swelling capacity of *acacia* seed flour.

Crude protein*:* Incorporation of *acacia* seed flour into the traditional diets generally increased the crude protein content (Tables 4 and 5). For instance, the crude protein content of burabusko increased by up to 45% when 25% (w / w) *acacia* seed flour was incorporated into this recipe while the crude protein content of tuwo, chin-chin and fura increased by 37, 29 and 26% respectively. Since food intake was also higher in the *acacia*-supplemented diets, total crude protein intake was higher in the group on 25% *acacia* supplemented diets than the control. Proteins from two or more plant sources usually complement one other,[9] so it might therefore be expected that *acacia* seed flour protein would also complement protein from other sources such as leaves, millet, sorghum etc. Rat bioassay studies (Adewusi *et al.,* unpublished data) indicated that protein from red sorghum complements that of *acacia* seed flour very well. Unfortunately, the tuwo-sorghum recipe made from the combination of these two flours had an unappealing and unappetizing dark brown/black colour, which was reluctantly eaten once per week during the trial and might not be eaten at all in the home environment.

The recommended daily protein intake for an adult is 55 g.[10] On a daily basis, male volunteers on 25% *acacia*-supplemented diet consumed 136 g crude protein (Table 6), 56% higher than that consumed from the traditional fare. Given a crude protein digestibility of about 70% (Adewusi *et al.* unpublished data), both *acacia* diets would supply more than the daily requirement while the traditional fare would barely meet the daily requirement.

Lipid Content: Sieved *acacia* seed flour contains about 12% ether extract (Table 9), a higher proportion than is present in most cereals. The predominant fatty acid in *acacia* seed flour is unsaturated linoleic acid, which accounts for about 50% of the total fatty acid component[4] (Table 7). As expected, ether extract was higher in the 25% *acacia*-supplemented burabusko, fura, danwake-millet, masulali and kunu than in the corresponding 15% *acacia*-supplemented foods, which in turn were generally higher in ether extract than the traditional fare (Table 4). However, lipid intake during the study period was about the same for all the groups on a daily basis (Table 6) due to a liberal addition of vegetable oil to the gravy or soup/stew and the oil used as a component of the diet or for frying purposes.

Dietary fibre: Sieved *acacia* seed flour is known to contain about 30% dietary fibre (Table 9), a much higher level than in cereals.[4] Incorporation of *acacia* seed flour into the traditional fare of the people of Maradi is therefore expected to increase their dietary fibre intake. Indeed, the fibre content of all diets (as calculated from the dietary fibre composition of the food components) increased with increase in the level of *acacia* seed flour incorporated into the diet (Table 6). The daily intake of dietary fibre from the 25% *acacia*-based food was estimated as 171 g in the male; about 80% higher than in the traditional fare (Table 6) and 170 g or 106% increase in the female volunteers. These levels are much higher than in Western diets. For example, the typical Australian consumption of dietary fibre is about 20 g per day.[10] The effect of high dietary fibre content is mainly in the energy requirement, which is increased by about 5%[10] and also in the protein digestibility of the food. It has been observed earlier[11–13] that a decrease between 0.93 and 1.65 occurred in crude protein digestion for each 1% increase in dietary fibre. Fortunately, the increase of up to 56% in the daily ingestion of crude protein content by incorporating *acacia* seed flour is expected to more than compensate for the reduction (less than 10%) in digestibility occasioned by the increase in the dietary fibre.

Carbohydrate: The carbohydrate content of each diet was calculated by difference to give the metabolisable carbohydrate excluding the dietary fibre content of each meal. The addition of *acacia* seed flour to the traditional diet at 25% level decreased the carbohydrate content by less than 12% in all the diet items (Table 4).

Calculated total metabolisable energy from the daily food intake: The total food energy calculated from the daily food intake was highest in the 25% *acacia* based diet in both male and female volunteers (Table 6), and was at least 65% in excess of the calculated food energy requirement (Adewusi *et al.,* unpublished results). Dietary intake and analysis of anthropometric measurements at the beginning and conclusion of the trial (Adewusi *et al.*, unpublished results) indicated clearly that the incorporation of *acacia* seed flour into the traditional diets of the people of Maradi had beneficial effects. There was a significant increase in body mass index and mid-arm circumference for volunteers on *acacia*-incorporated diets but not for the control diet presumably due to the food composition and consumption pattern of the volunteers.

DAILY DIETARY INTAKE OF SOME VITAMINS

Vitamin A: All the diets provided vitamin A about 300 % of the RDA for both male and female participants. The bulk of this vitamin is supplied by

TABLE 3

Moisture Content (% of wet weight) and Consumption per Meal of Experimental Foods (wet weight basis), ± standard errors.

Acacia flour substitution	0%	15%	25%
Recipe			
Burabusko			
Moisture content (% wet weight basis)	66.1 ± 0.5	68.4 ± 3.0	61.9 ± 3.5
Weight eaten/meal (kg), men	1.20 ± 0.02	1.05 ± 0.04	1.31 ± 0.03
Weight eaten/meal (kg), women	0.78 ± 0.02	0.95 ± 0.02	1.11 ± 0.02
Tuwo-millet			
Moisture content (% wet weight basis)	75.0 ± 3.1	66.2 ± 0.1	62.6 ± 0.4
Weight eaten/meal (kg), men	1.20 ± 0.06	1.00 ± 0.07	1.10 ± 0.15
Weight eaten/meal (kg), women	0.78 ± 0.08	1.10 ± 0.07	1.00 ± 0.08
Tuwo-sorghum			
Moisture content (% wet weight basis)	81.2 ± 0.1	64.8 ± 0.1	65.1 ± 0.1
Weight eaten/meal (kg), men	1.20 ± 0.05	1.00 ± 0.07	1.3 ± 0.05
Weight eaten/meal (kg), women	1.00 ± 0.14	1.20 ± 0.07	1.30 ± 0.03
Fura			
Moisture content (% wet weight basis)	76.0 ± 1.3	75.0 ± 3.0	72.0 ± 1.9
Weight eaten/meal (kg), men	1.00 ± 0.08	0.90 ± 0.08	0.80 ± 0.09
Weight eaten/meal (kg), women	0.95 ± 0.04	0.99 ± 0.12	0.90 ± 0.10
Chin-chin			
Moisture content (% wet weight basis)	11.2 ± 0.1	15.5 ± 0.1	13.9 ± 0.2
Weight eaten/meal (kg), men	0.19 ± 0.01	0.22 ± 0.01	0.25 ± 0.01
Weight eaten/meal (kg), women	0.16 ± 0.01	0.20 ± 0.02	0.21 ± 0.02

Danwake millet			
Moisture content (% wet weight basis)	65.4 ± 0.2	65.8 ± 0.5	65.2 ± 0.1
Weight eaten/meal (kg), men	0.36 ± 0.02	0.32 ± 0.02	0.60 ± 0.04
Weight eaten/meal (kg), women	0.33 ± 0.01	0.30 ± 0.02	0.38 ± 0.02
Masulali			
Moisture content (% wet weight basis)	54.0 ± 1.1	55.3 ± 0.4	57.0 ± 0.7
Weight eaten/meal (kg), men	0.5 ± 0.07	0.5 ± 0.03	0.6 ± 0.05
Weight eaten/meal (kg), women	0.8 ± 0.15	0.7 ± 0.11	0.7 ± 0.08
Kunu/Koko			
Moisture content (% wet weight basis)	82.2 ± 0.1	78.8 ± 0.1	74.2 ± 0.1
Weight eaten/meal (kg), men	1.00 ± 0.04	0.90 ± 0.08	0.90 ± 0.09
Weight eaten/meal (kg), women	0.96 ± 0.03	1.20 ± 0.07	1.10 ± 0.06
Massa-Damia			
Moisture content (% wet weight basis)	21.0 ± 3.1	20.0 ± 1.4	35.0 ± 1.7
Weight eaten/meal (kg), men	0.40 ± 0.09	0.40 ± 0.06	0.50 ± 0.08
Weight eaten/meal (kg), women	0.30 ± 0.05	0.40 ± 0.08	0.50 ± 0.09

TABLE 4

The Proximate Composition of Traditional and Acacia-incorporated Foods (% dry weight basis). Mean ± standard errors shown.

Food type and % acacia	Crude protein %	Ether extract %	Ash %	Dietary fibre %	Carbohydrate %[1]
Burabusko					
0	6.5 ± 0.3	5.0 ± 0.4	3.7 ± 0.3	9.5	75.3
15	7.4 ± 0.5	5.4 ± 0.4	4.8 ± 0.4	12.5	69.9
25	9.4 ± 0.3	6.5 ± 0.3	4.0 ± 0.6	14.4	65.7
Tuwo-Millet					
0	9.3 ± 0.2	5.1 ± 1.0	5.4 ± 1.0	9.5	70.7
15	10.7 ± 0.1	5.5 ± 0.5	4.7 ± 0.2	12.5	66.6
25	12.7 ± 0.4	4.1 ± 1.0	4.3 ± 0.5	14.4	64.5
Fura					
0	9.1 ± 0.4	1.3 ± 0.1	1.6 ± 0.2	9.5	78.5
15	9.7 ± 0.6	2.2 ± 0.4	1.8 ± 0.2	12.5	73.8
25	11.5 ± 0.7	2.4 ± 0.2	2.3 ± 0.2	14.4	69.4
Chin-Chin					
0	8.4 ± 0.0	13.9 ± 0.5	1.6 ± 0.1	5.2	67.8
15	9.1 ± 0.4	16.1 ± 0.7	2.4 ± 0.1	8.8	61.4
25	10.8 ± 0.2	12.3 ± 1.7	2.3 ± 0.0	11.2	64.3
Danwake Millet					
0	21.1 ± 0.3	1.8 ± 0.1	3.4 ± 0.1	9.5	64.2
15	23.0 ± 0.6	2.4 ± 0.3	5.1 ± 0.2	12.5	57.5
25	19.0 ± 0.8	4.5 ± 0.3	5.2 ± 0.4	14.4	56.7
Masulali					
0	9.0 ± 0.4	8.0 ± 0.5	4.5 ± 0.1	9.9	67.6
15	9.6 ± 0.3	9.0 ± 0.7	4.9 ± 0.1	12.9	63.5
25	10.0 ± 0.6	13.0 ± 1.4	5.5 ± 0.1	14.8	56.1
Kunu/Koko					
0	11.0 ± 0.6	4.6 ± 0.1	2.2 ± 0.1	9.5	72.7
15	15.4 ± 0.4	5.2 ± 0.1	3.3 ± 0.1	12.5	63.6
25	15.1 ± 0.1	5.4 ± 0.2	3.3 ± 0.2	14.4	61.8
Massa-Damia					
0	5.0 ± 0.6	35 ± 1.7	2.5 ± 0.4	8.6	48.9
15	6.6 ± 0.4	27 ± 0.9	3.3 ± 0.2	11.7	51.4
25	7.2 ± 0.7	25 ± 1.0	3.3 ± 0.2	13.7	50.8
Tuwo-sorghum					
0	11.0 ± 0.0	4.5	7.7 ± 0.3	9.6	67.2
15	11.5 ± 0.2	3.5	5.0 ± 0.5	12.5	67.5
25	12.8 ± 0.1	3.7	3.8 ± 0.2	14.5	65.2

[1]calculated by difference

TABLE 5

The Proximate Composition[1] of Some Food Components of the Meals. (Mean ± standard errors).

	crude protein %	ether extract %	ash %	Moisture %
Fluted pumpkin	4.6 ± 0.3	6.0 ± 0.3	7.7 ± 0.3	91.5 ± 0.4
Green pepper (tatase[1])	12.3 ± 0.1	2.3 ± 0.2	Nd	90.2 ± 0.8
Egg-plant (purple)	12.3 ± 0.5	nd[4]	Nd	93.4 ± 0.3
Lettuce	15.1 ± 1.9	3.8 ± 0.4	Nd	91.2 ± 0.2
Cucumber	10.5 ± 0.6	0.6 ± 0.1	Nd	94.6 ± 0.3
Fura balls made from:				
millet + 0% acacia flour	8.2 ± 0.1	0.3 ± 0.0	1.6 ± 0.1	58.5 ± 1.0
millet + 15% acacia flour	9.6 ± 0.1	1.4 ± 0.1	1.5 ± 0.2	46.3 ± 0.5
millet + 25% acacia flour	9.3 ± 0.1	2.3 ± 0.1	1.6 ± 0.1	50.6 ± 0.5
Nunu (fresh cow milk)	34.4 ± 0.2	13.9 ± 0.2	7.6 ± 0.1	95.3 ± 0.1
Mix of spices	25.2 ± 1.4	36.1 ± 3.9	7.9 ± 0.2	17.2 ± 0.1
Damis[2] (Soup)	9.0 ± 0.8	21.3 ± 1.8	18.6 ± 0.5	86.3 ± 0.2
Damia[3] (Gravy)	29.8 ± 0.6	15.1 ± 0.6	7.8 ± 0.1	69.1 ± 0.1
Damia	3.5 ± 0.1	4.5 ± 0.3	16.2 ± 0.1	89.6 ± 0.1
Spices/tomato/pepper mix	10.3 ± 0.3	Nd	12.6 ± 0.1	20.2 ± 0.1

[1]Means ± standard errors.
[2]Damia can be soup, stew or gravy eaten with solid meals.
[3]Damia made from cowpea.
[4]nd – not determined.

the vegetable oil while the contribution from *acacia* was not significant (Table 8).

Vitamin B_1: All diets provided three times the RDA of Vitamin B_1 and the contribution of *acacia* towards this excess supply was substantial (Table 6).

Vitamin B_2: All diets again supplied more than the RDA for both male and female participants with the contribution from *acacia* seed component being above 21%.

Niacin: All diets again supplied above the RDA for both male and female volunteers. The contribution from *acacia* to the daily niacin intake was at least 23% of the total niacin content of the food.

The introduction of some new foods could result in vitamin deficiency such as beriberi, pellagra, dermatitis and dementia but this can not occur with the introduction of *acacia* seed into the diet of the people of Maradi. Indeed, the supplementation of the traditional foods of the people of Maradi with *acacia* tends to increase the level of the vitamins above those in the

TABLE 6

Daily Intake of Dietary Crude Protein, Lipid, Fibre, Carbohydrate (g/day)[1], and Total Food Energy (TFE) (mJ / day)[2]

Parameter	Male			Female		
% acacia in diet	0 %	15 %	25 %	0 %	15 %	25 %
Protein	87 ± 2.2	100 ± 3.1	136 ± 3.6	78 ± 2.8	109 ± 3.8	132 ± 3.5
Lipid	99 ± 7.0	81 ± 4.2	93 ± 4.1	79 ± 5.5	90 ± 5.1	91 ± 4.5
Fibre	100 ± 1.4	130 ± 3.8	171 ± 2.8	82 ± 2.1	137 ± 3.2	170 ± 2.9
Carbohydrate	715 ± 9.7	657 ± 9.3	751 ± 12.5	623 ± 15.7	716 ± 15.0	736 ± 13.9
TFE	17 ± 0.8	17 ± 0.7	19 ± 0.7	15 ± 1.1	17 ± 1.0	18 ± 0.9
Vitamin A	11801 ± 104	13669 ± 120	9981 ± 113	10221 ± 114	10473 ± 114	10872 ± 105
(IU / day)	(352 %)[3]	(408 %)	(298 %)	(305 %)	(312 %)	(324 %)
Vitamin B_1	3.8 ± 0.7	3.9 ± 0.1	4.1 ± 0.9	3.2 ± 0.1	4.1 ± 0.9	4.0 ± 0.9
(mg / day)	(313 %)	(323 %)	(340 %)	(263 %)	(338 %)	(333 %)
Vitamin B_2	1.9 ± 0.5	2.3 ± 0.6	2.6 ± 0.7	1.7 ± 0.5	2.5 ± 0.6	2.7 ± 0.7
(mg / day)	(145 %)	(177 %)	(198 %)	(130 %)	(190 %)	(205 %)
Niacin	21.2 ± 2.1	25.3 ± 2.3	32.4 ± 3.1	18.6 ± 2.5	28.5 ± 2.7	31.1 ± 2.8
(mg / day)	(133 %)	(158 %)	(203 %)	(116 %)	(178 %)	(194 %)

[1]Weight of food eaten per person per meal was recorded over one week and proximate composition of sample meals determined. Each value for protein, lipid, fibre and carbohydrate is a mean and standard error calculated from the food eaten by 9 male or female volunteers over a 7 day period (i.e. each mean value is based on 63 meals).
[2]Total food energy per individual was calculated by multiplying the individual volunteer's protein, lipid and carbohydrate intakes by the Atwater value (4, 9 and 4 Kcal/g respectively).
[3]Values in parentheses represent the intake of the volunteers above the RDA.

TABLE 7

Fatty acids composition (percentage of total) of *Acacia colei*

	A. colei whole	*A. colei sieved*
Palmitic acid C16:0	11.4	14.4
Palmitoleic acid C16:1	0.30	0.8
Stearic acid C18:0	3.7	3.5
Oleic acid C18:1, (n-9)	18.0	23.5
Vaccenic acid C18:1 (n-7)	1.1	1.4
Linoleic acid C18:2	55.9	49.1
Arachidonic acid C20:0	1.4	1.2
Behenic acid C22:0	4.1	3.5
Lignoceric acid C24:0	1.2	1.0
Saturated: Unsaturated ratio	1:3.5	1:3.2
Saturated: Monounsaturated: Polyunsaturated ratio	1.1:1:2.9	–

Source: Adewusi *et al,*[4]

TABLE 8

The vitamin content of whole and water-processed *Acacia colei* seed flour

	Whole seed	Water-processed
Moisture % m/m	10.0	7.6
Alpha carotene mg/100g	<5	<5
Beta-carotene mg/100g	<5	<5
Cryptoxanthin mg/100g	5.6	<5
Thiamin (B_1) mg/100g	0.34	0.30
Riboflavin (B_2) mg/100g	0.36	0.21
Niacin mg/100g	4.2	2.9
Pantothenic acid mg/100g	1,500	390
Ergocalciferol (D_2)	*	<5
Alpha-tocopherol (E) mg/100g	0.30	0.74

*Unable to identify due to a large number of interferences.
Source: Adewusi *et al.*[4]

TABLE 9

Crude protein, dietary fibre and ether extract content of *Acacia colei* seeds
(% dry weight)

	Crude protein	Dietary fibre	Ether extract
A. colei whole	23.4 ± 1.2	39.9 ± 0.3	10.9 ± 0.2
A. colei sieved	21.4 ± 0.4	29.1 ± 1.8	12.1 ± 0.6

Source: Adewusi *et al.*[4]

traditional diets and would therefore be beneficial to incorporate to *acacia* into their diet from every perspective.

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