Dietary intakes of starch and non-starch polysaccharides in a West African village

BY GEOFFREY J. HUDSON AND HANS N. ENGLYST

MRC Dunn Clinical Nutrition Centre, Hills Road, Cambridge CB2 2DH

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Dietary intakes of starch and non-starch polysaccharides (NSP) have been estimated for a rural West African community. These people eat directly from shared bowls of cooked food, and so measurement of any individual's food intake is not possible. Recently developed methodology for estimating food intake under these circumstances and the analysis of samples for dietary polysaccharides are combined to yield estimates of intakes of about 375 g starch and 25 g NSP/d for adult males, with lower intakes for women and children, related to their smaller body weights. These intakes are not direct measurements but are extremely plausible when compared with values obtained for other societies where the complication of the shared food bowl does not impinge upon the measurements.

West Africa: Non-starch polysaccharides: Starch: Dietary intakes

Direct measurements of an individual's dietary intake cannot be made when groups of people eat from shared bowls of food but reasonable values for food intake may be obtained by the application of appropriate methodology (Hudson, 1992, 1995). The method consists of weighing and recording every ingredient during the preparation of cooked food, weighing the cooked food and weighing the people who are going to eat the food. Food-table values are then used to calculate the nutrient content of the meal. The division of food between the subjects is estimated, taking account of body weight and applying a mathematical weighting factor in recognition of the fact that intake is not directly proportional to body weight (Anderson *et al.* 1977). When energy intakes from two cooked meals per d are calculated in this way for subjects living in the village of Keneba in The Gambia, West Africa, they are shown to represent 80% of total energy expenditure as measured by the doubly labelled water technique (Hudson, 1992, 1995). The present paper presents the results of applying the same methodology for calculation of the intakes of starch and of non-starch polysaccharides (NSP, dietary fibre) in this rural West African community.

MATERIALS AND METHODS

The studies took place from 1987 to 1989 in the farming villages of Keneba, Kanton Kunda and Manduar in the West Kiang District of The Gambia, West Africa. All family members took part in the measurement of food intake but only those who were at least 13 years old took part in other parts of the study. Ethical permission for the work was granted by the joint Medical Research Council/Gambian Government Scientific Coordinating Committee and Ethical Committee. A detailed description of this work has been given elsewhere (Hudson, 1992, 1995). Qualitative and quantitative data were collected for the ingredients

Table 1. *Total starch* content (g/kg dry matter) of Gambian foods*†

	Starch (g/kg)		Starch (g/kg)
Vegetables		Cereals	
Bush cassava		Wheat flour	788
Raw	763	Maize	
Boiled	745	Whole	696
Cassava, raw	711	Dehusked	760
Beans (cowpea), raw	470	Flour	723
Potato, raw	720	Rice	
Aubergine, raw	80	Whole	616
Bitter tomato, raw	63	Dehusked	812
Okra, raw	114	Flour	825
Palm kernel, raw	4	Dempetengo	796
Groundnuts		Findo millet	
Raw	29	Whole	609
Roast	32	Dehusked	850
Fruit		Sanyo millet	
Locust beans, raw	7	Dehusked	681
Locust bean pod, raw	5	Flour	701
Mango unripe, raw	533	Sorghum	
Baobab flesh, raw	16	Whole	707
Pawpaw, raw	0	Flour	777
Bush mango, raw	126	Suno millet	
Tamba, raw	30	Whole	658
Tubabu ningkongo	365	Flour	711

* Starch is expressed as glucose × 0·89.
† For botanical names, see Table 2.

of cooked food and the weight of the cooked food was established. Food was weighed on portable electronic scales to the nearest 1 g. The people who were to eat the food were weighed, to the nearest 100 g on portable electronic scales, whenever possible, and their age and sex were recorded. These measurements were made in the subjects' compound and made minimal demands on their time.

Samples (approximately 150 ml) of raw and cooked food were collected in Keneba in exchange for rice, freeze-dried where appropriate, and sent to Cambridge for analysis. Total starch was measured by the method of Englyst & Kingman (1990). NSP were measured by the method of Englyst *et al.* (1992*b*). Data from the field records and from the food analysis are stored on the University of Cambridge mainframe computer and have been analysed in the SIR system using programs written under the guidance of Mr K. C. Day, Dunn Nutrition Unit, Cambridge. The compositional values are used in conjunction with the field records to calculate the nutrient content of the cooked food, and the distribution of it is estimated by dividing it between subjects, assuming a distribution of food that recognizes a non-proportional relationship between energy requirements and body weights (Anderson *et al.* 1977). Mathematical factors are calculated for each sex (X)/age (Y) classification using the algorithm:

$$X/Y \text{ factor} = {}^{\text{int}}((W_t - 10{\cdot}5)/10)) \times 0{\cdot}25 + 1{\cdot}5,$$

where $^{\text{int}}(x)$ is the integer of x and W_t is body weight (kg) for individuals who weigh more than 10·5 kg; subjects who weigh less than 10·5 kg are assigned a factor of 1·0.

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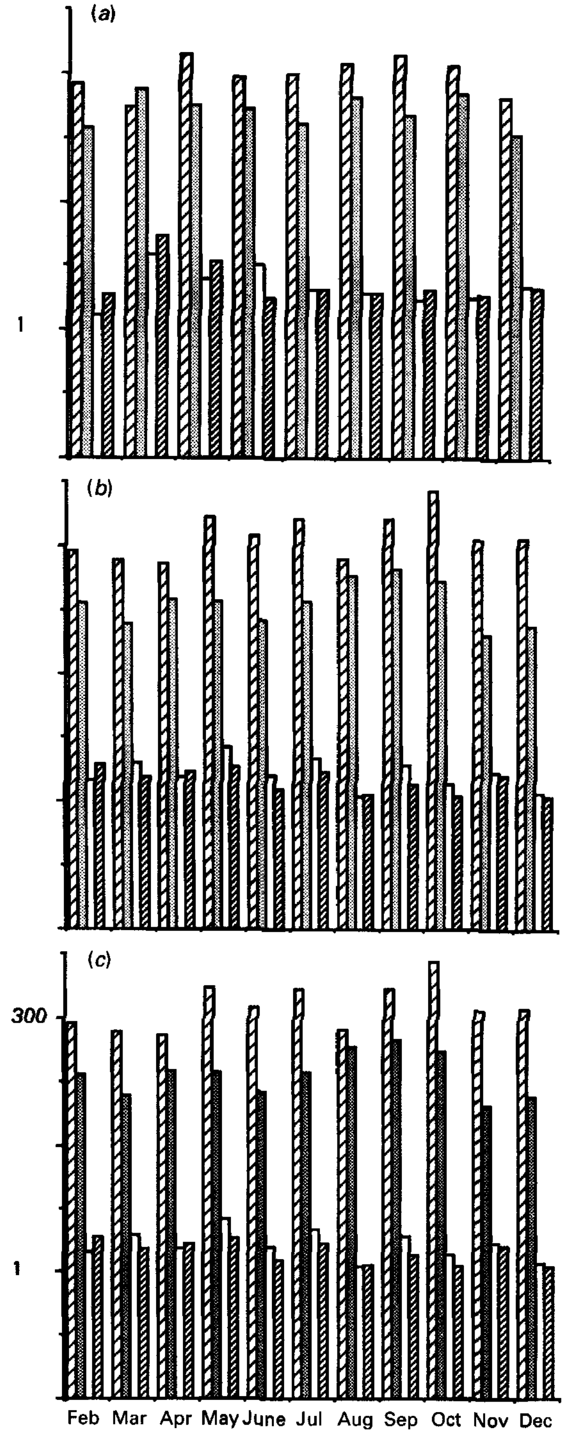

Fig. 1. Mean starch intakes from cooked food for men (▨), women (▩), boys (□) and girls (▦) in West Africa during the years (a) 1987, (b) 1988 and (c) 1989. Intakes are g starch/d, calculated as twice the mean over all observed meals for each month.

Table 2. *Non-starch polysaccharide (NSP) content of Gambian foods (g/kg dry matter)*

(Values are shown for total NSP, insoluble NSP separated into cellulose and non-cellulosic polysaccharides (NCP) and soluble NSP which is calculated as the difference between total and insoluble NSP)

	Soluble NSP	Insoluble NSP		Total NSP
		Cellulose	NCP	
Leaves				
Baobab (*Adansonis digitata*)	170	48	81	299
Bitter tomato (*Solanum incanum*)	75	42	33	150
Cassava (*Manihot esculenta*)	85	63	50	198
Groundnut (*Arachis hypogaea*)	87	68	67	222
Jambanduro (*Cassia tora*)	120	54	52	226
Kerenkerengo (*Corchorus olitorius*)	174	55	38	267
Kucha (*Hibiscus sabdariffa*)	117	69	62	248
Morongo (*Amaranthus* sp. (*caudatus/viridis*))	81	59	66	206
Nebedayo (*Moringo oleifera*)	104	42	43	189
Pumpkin (*Cucurbita maxima*)	100	48	37	185
Sweet potato (*Ipomaea batatas*)	118	67	49	234
Sobo (unidentified leaf)	186	48	62	296
Sora (*Leptadenia* sp. (*lancifolia/hastata*))	167	76	63	306
Vegetables				
Aubergine (*Solanum melongena*)	158	108	59	325
Bitter tomato	171	106	53	330
Bush cassava (*Dioscorea* sp. (*prahensalis/bulbifera*))	17	12	16	45
Cassava	46	25	24	95
Chilli pepper (*Capsicum frutescens*)	59	38	151	248
Green beans (cowpea; *Vigna unguiculata*)	29	18	38	85
Groundnuts				
Fresh	24	20	33	77
Roast	14	16	33	63
Okra (*Hibiscus esculentus*)	161	56	49	266
Onion (*Allium cepa*)	111	44	22	177
Potato (*Solanum tuberosum*)	19	19	10	48
Pumpkin	64	65	37	166
Spring onion	121	59	23	203
Tomato	82	47	45	174
Tomato paste	56	66	25	147
Wonjo (*Hibiscus* sp.)	170	107	88	365
Fruit				
Cashew apple (*Anaccerdium occidentale*) (s)	56	36	22	114
Locust bean seeds (*Parkia biglobosa*)	139	89	73	301
Locust beans, dehusked	42	19	12	73
Mango (*Mangifera indica*)				
Ripe flesh (s)	64	27	11	102
Ripe with skin (s)	102	25	13	140
Unripe flesh (s)	85	18	25	128
Unripe with skin (s)	80	23	53	156
Palm kernel (*Elaeis guineensis*)	36	25	190	251
Pawpaw (*Carica papaya*) (s)	121	74	41	236
Cereals				
Findo millet (*Digitaria exilis*)				
Whole grain	6	42	49	97
Dehusked	3	3	4	10
Maize (*Zea mays*)				
Whole kernels	36	3	121	160
Dehusked	10	17	44	71
Flour	8	10	27	45

Table 2. (*cont.*)

	Soluble NSP	Insoluble NSP: Cellulose	Insoluble NSP: NCP	Total NSP
Rice (*Oryza sativa*)				
Whole grain	3	70	55	128
Dehusked	13	6	7	26
Flour	2	3	5	10
Dempetengo	4	6	11	21
Sanyo millet (*Pennisetum typhoideum*)				
Whole grain	25	6	84	115
Dehusked	13	18	52	83
Flour	7	8	28	43
Sorghum (*Sorghum* sp. (*gambicum/margaritiferum*))				
Whole grain	4	17	44	65
Flour	2	3	13	18
Suno millet (*Pennisetum gambiense*)				
Whole grain	11	21	53	85
Flour	32	23	34	89
Wheat (*Triticum aestivum*), flour	14	3	14	31

(s), Snack food.

RESULTS AND DISCUSSION

Starch measurement

Representative samples of individual food types were collected in Keneba and were analysed for their total starch content by the method of Englyst & Kingman (1990). The analytical values are shown in Table 1. These total starch values were entered into the database and starch intakes from the two cooked meals were calculated using the same arithmetic as that used for the calculation of energy intakes (Hudson, 1992). The results for each month for men, women, boys and girls in 1987, 1988 and 1989 are illustrated by Fig. 1.

The mean starch intake (g/d for two cooked meals) in 1989, as the average over 10 months (excluding April and May), was 311·4 (SD 11·5) for men, 258·1 (SD 16·8) for women, 134·3 (SD 7·4) for boys and 122·9 (SD 5·4) for girls. Two meals, 'lunch' and 'dinner', were studied each day; considering only the intakes of starch for men, the mean intake over the 10 months was 177·7 (SD 9·0) g from lunch and 133·7 (SD 8·1) g from dinner, reflecting the calculated higher intakes of energy from lunch (see Hudson, 1992). During Ramadan, the ninth month of the Moslem year (April/May in 1989), when a strict fast is observed during daylight for 30 d, the average intake of starch from dinner was 159·4 (SD 0·4) g, which is more than 3 × SD above the mean for dinner in the other months, indicating that more food was cooked than usual at these meals to compensate for the daylight fasting.

The values given here are for total starch. Starch is not all digested and absorbed in the small intestine and, therefore, any calculation of the contribution of starch to energy intakes can be made properly only when measurements are made of the various types of starch with respect to their digestibility *in vivo* (Englyst *et al.* 1992*a*), but such measurements were beyond the scope of the present study. The presence of starch that escapes digestion and absorption in the small intestine (resistant starch; Englyst *et al.* 1992*a*) is often the result of food processing, and the amounts are not large in European diets (approximately 3–6 g/person per d; EURESTA, 1993). There is no reason to suppose that the values would be any higher for African diets.

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Table 3. *Intakes of total and insoluble non-starch polysaccharides (NSP) from lunch (L) and dinner (D), by men, women, boys and girls in West Africa, during 1987**

(Mean values and standard deviations)

	Men					Women					Boys					Girls				
	Total		Insoluble			Total		Insoluble			Total		Insoluble			Total		Insoluble		
	Mean	SD	Mean	SD	n†	Mean	SD	Mean	SD	n	Mean	SD	Mean	SD	n	Mean	SD	Mean	SD	n
Feb																				
L	8·9	3·0	5·0	1·7	6	7·9	4·0	4·4	2·2	16	3·1	18·0	2·8	2·6	21	3·1	1·0	2·2	1·6	21
D	7·6	2·9	4·4	2·4	9	5·2	1·5	2·8	1·3	20	4·1	2·4	2·2	1·5	22	3·1	1·5	1·7	1·2	18
L+D	16·5		9·4			13·1		7·2			7·2		5·0			6·2		3·9		
Mar																				
L	10·6	4·5	7·1	3·4	14	11·3	4·5	7·0	2·8	19	5·9	2·0	4·4	1·9	20	5·8	2·2	4·4	2·1	18
D	6·1	3·2	3·6	1·8	15	5·6	2·1	4·0	3·1	21	3·6	2·3	2·1	1·3	22	3·9	1·7	2·6	1·6	14
L+D	16·7		10·7			16·9		11·0			9·5		6·5			9·7		7·0		
Apr																				
D	8·2	4·9	4·2	2·7	23	7·7	4·1	4·0	2·1	40	3·7	1·9	2·4	1·8	54	3·4	1·7	2·1	1·5	48
May																				
D	10·6	5·2	6·6	3·6	24	8·9	4·9	5·4	3·2	61	5·3	2·7	4·1	2·5	54	5·1	2·5	3·8	2·2	58
Jun																				
L	11·1	3·8	6·4	2·5	28	8·1	3·3	5·0	2·6	45	5·3	2·5	3·8	2·1	41	3·9	1·7	2·7	1·8	59
D	6·3	2·4	3·6	1·5	33	7·2	3·4	4·4	2·7	47	4·0	1·5	2·3	0·9	53	3·2	1·4	1·9	0·8	44
L+D	17·4		10·0			15·3		9·4			9·3		6·1			7·1		4·6		
Jul																				
L	11·2	4·3	8·0	3·3	24	8·0	3·2	5·5	3·1	52	4·4	2·3	3·3	2·3	78	4·3	2·1	3·0	2·1	92
D	7·3	3·3	4·5	2·2	30	6·7	3·7	4·2	2·3	39	3·4	1·7	2·6	2·1	49	3·1	1·9	2·0	1·3	43
L+D	18·5		12·5			14·7		9·7			7·8		5·9			7·4		5·0		
Aug																				
L	9·7	3·9	6·0	2·8	20	8·7	3·3	5·2	2·4	44	4·1	2·4	3·0	2·2	64	3·9	1·8	2·4	1·4	74
D	7·5	2·5	5·1	3·3	18	6·7	2·9	3·7	1·6	32	4·4	1·9	2·5	2·1	46	4·2	2·0	2·7	1·6	35
L+D	17·2		11·1			15·4		8·9			8·5		5·5			8·1		5·1		
Sep																				
L	8·8	3·1	5·5	2·6	25	10·0	3·9	6·0	3·0	34	3·6	1·7	2·3	1·5	46	4·2	2·0	2·7	1·7	46
D	9·3	3·6	5·4	2·6	18	7·9	4·4	4·3	2·2	39	4·0	2·4	2·6	1·7	36	4·0	2·1	2·3	1·3	43
L+D	18·1		10·9			17·9		10·3			7·6		4·9			8·2		5·0		
Oct																				
L	10·8	4·5	6·1	2·6	20	8·6	2·8	5·6	2·8	29	3·4	2·1	2·6	2·2	53	3·4	1·8	2·5	1·9	47
D	10·4	4·7	6·8	3·1	18	8·4	4·5	5·5	3·4	25	4·7	2·4	2·9	1·6	36	3·9	2·3	2·5	2·7	32
L+D	21·2		12·9			17·0		11·1			8·1		5·5			7·3		5·0		
Nov																				
L	11·1	3·9	7·5	3·2	20	8·4	3·2	5·6	3·0	33	5·2	2·0	3·5	2·0	33	4·8	1·8	3·7	2·2	29
D	5·4	4·8	3·2	2·7	20	3·8	1·3	2·3	1·5	32	2·4	1·0	1·5	0·9	26	2·5	0·8	1·6	1·2	28
L+D	16·5		10·7			12·2		7·9			7·6		5·0			7·3		5·3		

* Soluble NSP may be calculated as the difference between total and insoluble NSP.
† Number of people included at each meal.

Table 4. *Intakes of total and insoluble non-starch polysaccharides (NSP) from lunch (L) and dinner (D), by men, women, boys and girls in West Africa, during 1988**

(Mean values and standard deviations)

	Men					Women					Boys					Girls				
	Total		Insoluble			Total		Insoluble			Total		Insoluble			Total		Insoluble		
	Mean	SD	Mean	SD	n†	Mean	SD	Mean	SD	n	Mean	SD	Mean	SD	n	Mean	SD	Mean	SD	n
Feb																				
L	7·9	3·2	7·4	4·0	9	8·8	3·5	4·6	1·6	11	4·5	1·2	2·9	1·6	15	4·3	1·2	3·5	2·0	10
Mar																				
L	10·5	3·9	6·3	2·9	42	9·7	3·8	5·6	2·3	87	5·2	2·6	3·2	1·8	150	4·6	2·3	2·9	1·7	151
D	7·9	4·3	4·5	2·7	42	5·8	3·4	3·4	2·4	82	3·6	2·2	2·3	1·7	118	3·3	2·0	1·9	1·2	128
L+D	18·4		10·8			15·5		9·0			8·8		5·5			7·9		4·8		
Apr																				
D	8·3	4·7	5·4	3·5	35	7·1	3·6	3·9	1·9	64	3·9	2·5	2·5	2·0	122	3·9	2·3	2·3	1·6	119
May																				
D	9·9	5·7	7·2	4·0	10	8·0	3·1	5·1	2·6	21	4·6	2·6	3·5	2·4	29	4·2	2·6	2·7	2·1	41
Jun																				
L	9·4	3·9	5·5	2·3	29	8·3	4·2	5·2	3·0	48	4·2	2·6	3·0	2·3	84	3·4	2·4	2·6	2·3	109
D	7·4	4·2	4·1	2·4	26	4·8	2·2	2·9	1·8	52	2·9	1·8	1·6	1·0	79	2·8	1·6	1·6	1·0	87
L+D	16·8		9·6			13·1		8·1			7·1		4·6			6·2		4·2		
Jul																				
L	10·8	3·6	6·8	2·7	21	9·3	4·0	5·4	2·4	35	4·9	2·5	3·0	1·9	52	3·9	2·2	2·4	1·6	59
D	6·6	2·2	3·7	1·3	13	6·4	4·1	3·7	2·9	20	3·5	2·2	2·1	1·6	28	4·4	2·6	2·5	1·6	20
L+D	17·4		10·5			15·7		9·1			8·4		5·1			8·3		4·9		
Aug																				
L	11·6	4·7	7·7	3·5	19	11·9	3·6	7·2	2·4	36	4·0	2·2	3·2	2·4	63	4·5	2·5	2·9	1·8	115
D	7·0	4·9	4·1	3·2	24	5·3	3·8	3·0	2·3	38	2·6	2·0	1·7	1·6	64	2·4	1·7	1·5	1·6	90
L+D	18·6		11·8			17·2		10·2			6·6		4·9			6·9		4·4		
Sep																				
L	11·5	5·0	7·1	3·4	29	10·6	4·6	6·3	3·1	44	4·2	2·6	3·5	2·6	62	4·0	2·6	2·6	2·0	78
D	8·2	4·1	5·0	3·1	35	8·0	2·9	3·2	1·5	52	3·1	1·7	1·9	1·4	78	3·1	1·8	1·7	1·0	87
L+D	19·7		12·1			18·6		9·5			7·3		5·4			7·1		4·3		
Oct																				
L	11·2	4·8	6·8	3·3	17	7·9	4·0	5·1	3·1	30	3·5	2·0	2·3	1·8	49	3·0	1·6	1·9	1·5	81
D	9·0	3·4	5·8	3·1	19	6·1	3·5	3·7	2·8	43	3·1	1·9	2·1	1·9	48	2·8	1·8	1·8	1·7	75
L+D	20·2		12·6			14·0		8.8			6·6		4·4			5·8		3·7		
Nov																				
L	12·1	4·2	7·6	2·9	49	9·2	4·4	5·6	2·9	86	4·7	2·4	3·7	2·3	88	4·4	2·4	3·0	2·1	116
D	7·6	4·4	4·4	2·7	49	5·0	3·0	2·9	1·9	79	3·4	2·3	2·1	1·6	105	2·8	1·7	1·9	1·7	134
L+D	19·7		12·0			14·2		8·5			8·1		5·8			7·2		4·9		
Dec																				
L	11·8	3·3	6·9	2·1	43	8·8	4·0	5·5	2·9	63	4·3	2·9	3·1	2·3	98	3·3	2·1	2·7	2·3	120
D	6·2	3·8	3·5	2·2	38	5·6	37·0	3·9	3·3	59	2·7	2·0	1·6	1·2	117	2·4	1·5	1·4	1·2	115
L+D	18·0		10·4			14·4		9·4			7·0		4·7			5·7		4·1		

* Soluble NSP may be calculated as the difference between total and insoluble NSP.
† Number of people included at each meal.

Table 5. *Intakes of total and insoluble non-starch polysaccharides (NSP) from lunch (L) and dinner (D), by men, women, boys and girls in West Africa, during 1989**

(Mean values and standard deviations)

	Men					Women				
	Total		Insoluble			Total		Insoluble		
	Mean	SD	Mean	SD	n†	Mean	SD	Mean	SD	n
Jan										
L	11·4	5·3	6·5	3·1	5	8·7	3·8	4·9	2·1	74
D	7·0	4·4	3·4	1·8	56	5·8	3·2	3·4	2·4	78
L+D	18·4		9·9			14·5		8·3		
Feb										
L	13·2	6·2	7·0	3·2	34	11·3	5·4	5·9	2·6	64
D	7·6	3·7	4·5	3·0	31	8·1	6·2	4·5	3·6	68
L+D	20·8		11·5			19·4		10·4		
Mar										
L	14·8	5·0	7·9	2·6	37	11·8	5·4	6·4	3·1	55
D	10·3	7·0	5·2	3·7	34	8·9	6·1	4·9	3·9	59
L+D	25·1		13·1			20·7		11·3		
Apr										
D	15·7	6·4	9·3	3·6	28	13·7	6·0	7·9	3·6	48
May										
D	11·8	6·3	6·7	4·0	33	10·6	6·5	5·6	3·4	46
Jun										
L	11·8	4·8	6·7	2·7	65	10·2	5·4	5·3	2·5	115
D	6·4	3·4	3·4	1·7	64	5·1	3·5	2·7	1·8	104
L+D	18·2		10·1			15·3		8·0		
Jul										
L	11·1	4·2	6·3	2·6	59	10·5	5·6	5·6	2·6	99
D	8·1	4·2	4·0	2·3	68	6·4	4·4	3·5	2·7	100
L+D	19·2		10·3			17·0		9·1		
Aug										
L	9·1	5·5	5·1	3·2	68	8·3	5·2	4·5	2·6	93
D	7·6	5·1	4·0	2·7	55	6·8	4·2	3·6	2·2	67
L+D	16·7		9·1			15·1		8·1		
Sep										
L	9·7	6·0	5·1	3·2	60	8·9	5·2	4·7	2·8	67
D	6·8	3·8	3·6	2·1	45	6·0	3·7	3·2	2·0	49
L+D	16·5		8·7			14·9		7·9		
Oct										
L	15·2	5·5	8·6	3·1	20	12·7	5·6	7·0	3·0	33
D	7·1	4·7	3·8	2·8	18	8·1	4·9	4·4	2·8	25
L+D	22·3		12·4			20·8		11·4		
Nov										
L	13·5	6·0	7·3	3·2	31	10·4	5·9	5·7	3·3	41
D	9·4	5·5	5·2	2·9	20	5·7	3·2	3·1	1·7	32
L+D	22·9		12·5			16·1		8·8		
Dec										
L	12·3	4·3	7·1	2·5	22	10·0	5·4	5·4	2·8	31
D	14·3	7·6	7·3	3·8	19	9·9	6·1	5·4	3·6	27
L+D	26·6		14·4			19·9		10·8		

Table 5. (*cont.*)

	Boys					Girls				
	Total		Insoluble			Total		Insoluble		
	Mean	SD	Mean	SD	n†	Mean	SD	Mean	SD	n
Jan										
L	4·6	2·5	2·9	1·8	117	3·9	2·2	2·4	1·5	136
D	3·3	1·8	1·8	1·2	124	2·8	1·8	1·5	1·0	127
L+D	7·9		4·7			6·7	3·9			
Feb										
L	5·0	2·7	3·4	2·2	95	5·0	2·7	3·3	2·1	111
D	3·8	2·5	2·4	2·1	80	3·0	1·9	1·7	1·3	70
L+D	8·8		5·8			8·0		5·0		
Mar										
L	5·7	2·7	4·0	2·3	87	5·8	2·6	3·7	2·2	134
D	3·8	2·3	2·4	1·9	79	4·1	2·5	2·9	2·5	104
L+D	9·5		6·4			9·9		6·6		
Apr										
D	6·7	3·2	4·9	2·7	56	6·3	2·7	4·4	2·3	73
May										
D	5·5	2·1	3·9	2·4	37	5·6	1·9	3·4	1·9	44
Jun										
L	5·1	2·8	3·0	1·9	127	4·4	2·1	3·0	1·9	179
D	3·0	1·8	1·7	1·3	105	3·0	1·9	1·7	1·2	132
L+D	8·1		4·7			7·4		4·7		
Jul										
L	4·9	2·8	3·0	2·0	121	4·9	3·0	3·0	2·0	180
D	3·4	2·5	1·9	1·5	89	3·3	2·2	1·8	1·4	153
L+D	8·3		4·9			8·2		4·8		
Aug										
L	4·5	2·7	2·5	1·6	112	3·8	2·3	2·2	1·5	162
D	3·6	2·7	2·1	1·9	76	3·7	2·6	2·0	1·4	113
L+D	8·1		4·6			7·5		4·2		
Sep										
L	5·1	2·6	3·1	2·0	63	5·1	2·8	2·8	1·6	99
D	3·8	2·4	2·2	1·8	47	3·0	1·7	1·6	1·0	83
L+D	8·9		5·3			8·1		4·4		
Oct										
L	5·2	3·2	3·6	2·5	37	4·9	2·9	3·1	2·2	86
D	3·3	1·8	1·9	1·3	34	3·4	2·6	2·0	1·7	53
L+D	8·5		5·5			8·3		5·1		
Nov										
L	5·9	3·0	3·4	1·7	61	5·7	2·8	3·2	1·7	85
D	2·8	1·6	2·3	2·2	32	3·2	1·8	2·0	1·5	58
L+D	8·7		5·7			8·9		5·2		
Dec										
L	5·0	2·6	3·6	2·4	45	5·2	2·6	3·1	1·8	85
D	4·2	2·9	2·9	2·3	39	5·0	3·0	3·3	2·3	60
L+D	9·2		6·5			10·2		6·4		

* Soluble NSP may be calculated as the difference between total and insoluble NSP.
† Number of people included at each meal.

Table 6. *Overall mean intakes of non-starch polysaccharides (NSP) from two cooked meals per day, by men, women, boys and girls in West Africa during the years 1987–1989**

	Men	Women	Boys	Girls
Total NSP				
1987	17·8	15·3	8·2	7·7
1988	18·6	15·3	7·5	6·9
1989	18·7	17·4	8·6	8·3
Insoluble NSP				
1987	11·0	9·4	5·6	5·1
1988	11·2	9·1	5·1	4·4
1989	11·2	9·4	5·4	5·0
Soluble NSP				
1987	6·8	5·9	2·6	2·6
1988	7·4	6·2	2·4	2·5
1989	7·5	8·0	3·2	3·3

* Values are intakes of NSP from lunch and dinner (g/d) calculated as the average of the mean monthly values in Tables 3–5 where there are values for both meals (1987, *n* 8; 1988, *n* 8; 1989, *n* 10).

Fibre measurement

Following the principles laid down by Southgate (1969*a*, *b*), methodology has been developed for the measurement of NSP, with identification and measurement of the constituent sugars by gas–liquid chromatography or high-pressure liquid chromatography (Englyst *et al.* 1982, 1992*b*, 1994; Quigley & Englyst, 1992, 1994), as the best index of the plant cell-wall material (dietary fibre) present in foods. The different physiological effects that result from the ingestion of NSP are related to the physical and chemical properties of the carbohydrates. For this reason it is appropriate to divide NSP into soluble and insoluble fractions, which have demonstrably different effects in man. For example, ingestion of apple pectin or oat bran, which are rich in soluble NSP, has only a small effect on faecal bulk. In contrast, ingestion of wheat bran, which is rich in insoluble NSP, results in a very substantial increase in faecal bulk (Kay & Truswell, 1980; Story & Kelley, 1982).

Samples of raw food were collected in Keneba, freeze-dried where appropriate, and sent to Cambridge for analysis by the Englyst *et al.* (1992*b*) GLC procedure. The values obtained for the soluble and insoluble NSP contents of these Gambian foods are given in Table 2. Values for the constituent neutral sugars and uronic acids will be published elsewhere.

Polysaccharide intakes

The analytically determined values for NSP were included in the database for food composition, and dietary intakes from two cooked meals/d were calculated by the same arithmetic as that used for the calculation of energy intakes (Hudson 1992, 1995). The results are given in Tables 3–5 and are summarized in Table 6. There remains the question of interpretation of these intake values. No attempt was made to measure total food intake in this study; two cooked meals/d were included but no record was made of snack foods. The values calculated for the energy intake of adult males were about 80% of the values recorded for total energy expenditure in January, April and July, when there was little change in either of these values or in body weight (Hudson, 1992). The calculated value for energy intake in October was little different but energy expenditure was increased with concomitant loss of body weight.

Comparison of total energy expenditure, as measured by the doubly labelled water technique, and estimated energy intake from cooked meals suggests that the intake estimates are of the order of 80% of total energy intake (Hudson, 1992, 1995). Estimation of polysaccharide intakes, however, is problematic in the absence of both data for the intake of snack foods and an independent measurement of total intake for reference.

The difference between energy intake and total energy expenditure is of the order of 2100 kJ/d for men, and it is possible to calculate the consequences for NSP intake if that amount of energy was to be provided by a single snack food. The energy density of fruit and vegetables is generally low, so that substantial amounts would have to be eaten to provide 2100 kJ, e.g. about 900 g ripe mango or more than 1·5 kg raw carrot would have to be eaten every day for a year. These are unrealistically large amounts; these foods are available only at certain times of the year and then not in these quantities.

Only a very few of the families in Keneba can afford to buy bread from the village baker or milk from the local cattle herders. If bread were the sole source of the extra energy intake, the NSP contribution to the diet would be of the order of 3 g total NSP/d, and if milk were the sole source of the extra energy there would be no increase in NSP intake. If groundnuts were the sole source of the extra energy, 2100 kJ/d would be provided by about 90 g nuts, and this would contribute about 6 g total NSP/d.

Most people eat a variety of snack foods throughout the year. For example, women make dempetengo (pounded and roasted rice) in the fields for immediate consumption when they are harvesting their rice crops. They may eat considerable quantities of this dempetengo at a time, but the consumption is limited to a few days each year. Maize is one of the first crops to mature, and whole cobs are roasted and eaten immediately. Again, individuals may eat considerable quantities, but this food is available only from about the middle of August to the middle of September. Vegetables are grown in gardens but most of these are cooked; carrots are eaten raw but are available only from March to May, and then not in large quantities. Some foods are taken from the bush, but these foods are available only seasonally, e.g. mangoes are available from March to July and bush cassava from the end of September to the end of November. Bread, milk and the home-made pastries of various sorts that are sometimes available for purchase in the village are available only to the comparatively wealthy few. Groundnuts, however, are grown by almost every family in Keneba, both for food and as a cash crop. The groundnuts are harvested, dried and stored for long periods, and are available as snack food throughout the year.

No reliable data exist for the consumption of snack foods in this community. However, groundnuts offer the commonest source of snack food, and these could supply the extra 2100 kJ/d if consumed in realistic amounts. Other snack foods are available, but only seasonally and in small quantities, so it seems unlikely that they will contribute significant amounts of NSP over the course of a year. It seems reasonable to suggest that the contribution from snack foods is therefore of the order of 6 g total NSP/d for an adult male.

Intake values of the order of 12 g total NSP/d have been reported for UK adults (Bingham *et al.* 1990) and the insoluble:soluble NSP ratio in the UK diet is not far removed from unity; by comparison, intake values for total NSP from cooked food alone are close to 19 g/d for adult males in the present study, and there is a preponderance of insoluble NSP in the diet. If groundnuts were to represent the majority of snack foods, then the preponderance of insoluble NSP would remain and intakes would be estimated to be of the order of 25 g total NSP/d for an adult male. Consumption of fruit and vegetables, where insoluble:soluble NSP ratio approaches 0·5, would tend to decrease the overall insoluble:soluble NSP ratio in the whole diet, which was close to 1·5 for cooked foods (1·6 in 1987; 1·5 in 1988; 1·5 in 1989). However, this effect of fruit and vegetables is likely to be small for the whole diet over the course of a year because of the small amounts eaten.

The contribution of snack foods to total starch intakes is not expected to be quantitatively significant. The cereals in cooked food are the components of the diet with the highest starch contents. The consumption of 90 g groundnuts/d would contribute about 30 g starch, i.e. of the order of 10 % of the estimated starch intake from cooked food. A few of the other snack foods could individually contribute rather more starch, e.g. bush cassava contains about 750 g starch/kg on a dry matter basis, but these foods are available for only brief periods and in very limited quantities.

These are believed to be the first detailed data for polysaccharide intake in West Africa, and are certainly the first West African data where the intake methodology has been validated by field use of the doubly labelled water method for the measurement of total energy expenditure.

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