

# Animal Source Foods to Improve Micronutrient Nutrition and Human Function in Developing Countries

## School Snacks Containing Animal Source Foods Improve Dietary Quality for Children in Rural Kenya<sup>1,2</sup>

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**ABSTRACT** Provision of a snack at school could help alleviate the micronutrient malnutrition that is common among schoolchildren in developing countries. The Child Nutrition Project was designed to compare the efficacy of three school snacks in improving growth and cognitive function of children in rural Kenya. The snacks provided ~20% of the children's energy requirement, and were composed of equicaloric portions of githeri (a vegetable stew) alone (Energy group), githeri plus milk (Milk group) or githeri plus meat (Meat group). A fourth group of children served as Controls. When nutrient intakes from three, 24-h dietary recalls collected before feeding were compared to three, 24-h recalls conducted after feeding began, intakes of vitamin B-12, riboflavin, vitamin A and calcium increased more in the Milk group than in the Control group, whereas intakes of vitamin B-12, vitamin A, calcium, available iron and available zinc increased more than those of Controls for children in the Meat group. At most of the time points examined, total energy intake increased more for the Meat group than for the other two feeding groups, because the additional energy provided by the Milk and Energy snacks was partially balanced by a decrease in the energy content of foods consumed at home. This decrease did not occur to the same extent for the Meat group, so both dietary quantity and dietary quality improved. For the Milk group, only dietary quality improved. For the Energy group, there were no significant changes in the total day's diet compared to the Control group. *J. Nutr.* 133: 3950S–3956S, 2003.

**KEY WORDS:** • school feeding • animal source foods • nutrient intake • school children • Kenya

Although protein-energy malnutrition (PEM)<sup>4</sup> remains a concern for many of the world's children, micronutrient malnutrition has been recognized increasingly as an even widespread problem (1). Results from the Nutrition Collaborative Research Support Program showed that children in rural Kenya, Egypt and Mexico had poor dietary quality (2–5). In addition, intakes in Kenya appeared to also be low in energy (but not protein). Thus, the Child Nutrition Project (CNP) sought to provide snacks that would meet the recognized gaps

between recommended nutrient and energy intakes and the actual intakes of schoolchildren in rural Kenya.

To determine the effect of the snack on total daily nutrient intake, it was necessary to measure food intake across the full day. Although parents were asked not to alter the child's home intake, a quantitative measure of total nutrient intake was needed to determine if changes actually occurred. Furthermore, to determine the change in intake from baseline (the period before the feeding) to the intervention period, several days of intake (at least 3) were needed to provide stable estimates of usual nutrient intake for each child (6,7). Here we report data on multiple days of intake for the Kenyan schoolchildren before and during the school-based feeding program.

### METHODS

**Study design.** The study was a controlled feeding trial conducted in the Kyeni South Division of Embu District in Kenya, 150 km northeast of Nairobi. The study area is mostly rural, with farming the primary occupation. Twelve primary schools were randomized to one of four feeding groups, with all children in class 1 in a school receiving the same type of feeding. The feeding groups were: 1) Control: no food provided; 2) Energy snack: a vegetarian stew (githeri) of maize, beans and vegetables; 3) Milk snack: githeri plus 200 mL milk; and 4) Meat

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<sup>4</sup> Abbreviations used: ANOVA, analysis of variance; CNP, Child Nutrition Project; IML, International Minilist; PEM, protein-energy malnutrition; RAE, retinol activity equivalents; TE, tocopherol equivalents.

snack: githeri cooked with 60 g minced beef. The snacks were approximately equicaloric, ranging from 239 to 269 kcal/d (1000–1125 kJ). The nutrient content of the three snacks is shown in Table 1. The energy content of all three snacks was increased after the first 3 mo of the study to ~315 kcal/d (1318 kJ/d), by increasing the portion size of the energy snack (from 185 to 230 g/child), the milk content of the milk snack (to 250 mL) and the beef content of the meat snack (to 85 g) (8).

Baseline data for the children and their families were collected between June and August 1998. Feeding began in September 1998 and continued through November 2000. The snacks were provided on all school days, but not on weekends or school holidays. Schools were in session for 3 mo, followed by a 1-mo holiday, year-round. Mothers were encouraged to maintain the usual home diet for the children.

The study was approved by Human Subject Protection Committees at the University of California, Los Angeles, CA, and the University of Nairobi, School of Medicine, Kenya.

**Food intake measures.** Food intake was measured using 24-h recalls as reported by the child's mother. The recalls were administered in the child's home by trained enumerators, most of whom had also collected quantitative food intake data for the Nutrition CRSP. Recalls were collected proportionately on all days of the week except

Saturdays and Sundays, and thus reflect intake on Sundays through Thursdays throughout the study (including school holidays).

The mother was asked to report all foods that the child consumed the previous day, and to estimate the amount in common household units (cups, spoons, etc.). Portion sizes were quantified using food models and by filling local plastic dishes and utensils with maize or coffee beans to the appropriate level specified by the mother. After listing all foods that the child had eaten, information on the recipe was collected for any mixed dish that had been consumed. The amount of each ingredient in the recipe was estimated using food models and household utensils. The final volume of the recipe was then estimated, usually from the size of the pot in which it was prepared and the height of the contents after the dish was cooked. The amount of each ingredient consumed by the child could thus be estimated from the child's portion as a fraction of the amount prepared.

If the child consumed a school snack on the recall day, the foods served were automatically added to the foods reported by the child's mother. Leftovers, if any, were subtracted from the standard portion size of the school snack for each child. If the mother included an estimate of the school snack as part of the 24-h recall, these foods were deleted before calculation of daily intakes.

Portion size of all foods and ingredients in grams was calculated using a density table developed for this purpose. This table contains the grams per milliliter for foods that were measured as volumes (e.g., in cups and pots) and the grams per small, medium, or large item for foods such as fruits and vegetables. The resulting list of foods and portion sizes was converted to daily nutrient intakes using the WorldFood Dietary Assessment System, version 2.0 (9). As necessary, the food composition databases were updated to include newer foods available in the area, new levels of fortification for some foods and a 50% lower vitamin A activity for provitamin A carotenoids (10). Intakes of available iron and available zinc were calculated using the approach described by Murphy et al. (4).

**Sample.** Of the 554 children enrolled in the study, 492 had at least one baseline 24-h recall plus at least one 24-h recall from the first 3 mo of feeding, and were included in the primary analyses. Because most children had multiple intake visits during these periods, all days of intake were averaged for each child for each period before comparisons among feeding groups were made. Of the 492 children, 116 were in the Control group, 135 in the Energy group, 125 in the Milk group and 116 in the Meat group. For analyses of energy intake across six time points, data were available for 524 children, with similar proportions in each of the four intervention groups.

**Statistical methods.** Intakes at baseline (average of 1–3 baseline visits) were calculated for each child. *F* tests on baseline differences were performed for eight nutrients of particular interest: energy, protein, vitamin B-12, riboflavin, vitamin A, calcium, available iron and available zinc. The multiple comparisons among groups were performed after the overall *F* test indicated a statistical significance at 5% (i.e., *P*-value < 0.05).

Change in intake between baseline and the first term of feeding (average of mo 1, 2 and 3) was also calculated. One-way analysis of variance (ANOVA) across the four feeding groups on each of the eight selected nutrients was performed. In addition, the pairwise comparisons among groups were performed after the overall *F* test indicated a statistical significance at 5%.

A repeated measures model was used to examine energy intakes at six time points during the feeding intervention (intake visits 1–3 collected in September, October and November 1998; visit 6 in February 1999; visit 13 in September 1999; and visit 17 in February 2000). Fixed effects were feeding group, visit number and treatment by visit interaction, and the random effect was the intercept for each individual child.

## RESULTS

**Baseline characteristics.** Across the four study groups, the average age of the children ranged from 86.0 mo (Energy group) to 93.5 mo (Meat group) at baseline (11). Average height ranged from 114.6 to 116.7 cm, and average weight was between 19.8 and 20.4 kg. Overall, 25.3% of the children were

TABLE 1

Nutrient content of the CNP snacks during the first term of feeding

Nutrient	Githeri-only snack <sup>1</sup>	Githeri <sup>1</sup> plus milk snack	Githeri <sup>1</sup> plus meat snack
<b>Macronutrients<sup>2</sup></b>			
Energy, kcal	239	262	259
kJ	1000	1096	1084
Protein, g	8.6	11.0	16.6
Fat, g	4.6	10.3	11.1
Carbohydrate, g	42.5	33.0	23.4
Dietary fiber, g	6.8	3.7	3.7
Phytate, mg	673	368	368
<b>Vitamins</b>			
Thiamin, mg	0.24	0.21	0.17
Riboflavin, mg	0.12	0.40	0.13
Niacin, mg	1.7	1.1	2.4
Folate, mg	97	64	55
Vitamin B-12, µg	0	0.80	0.90
Vitamin B-6, mg	0.20	0.23	0.27
Vitamin A, µg RAE	127	178	68
Vitamin C, mg	4	3	1
Vitamin E, mg α-TE	0	0	0
<b>Minerals</b>			
Calcium, mg	27	245	17
Phosphorus, mg	181	282	191
Magnesium, mg	77	63	52
Available iron <sup>3</sup> , mg	0.29	0.18	0.23
Available zinc <sup>3</sup> , mg	0.18	0.20	0.35
Copper, mg	0.23	0.12	0.16

CNP, Child Nutrition Project; RAE, retinol activity equivalents; TE, tocopherol equivalents.

<sup>1</sup> Githeri is a stew containing maize and beans plus small amounts of oil, onion, kale and salt. Portion sizes for the first school term of feeding in 1998 were: 185 g githeri for the githeri-only snack; 100 g githeri plus 200 mL milk for the milk snack; and 185 g githeri containing 60 g minced beef for the meat snack. The energy content of the snack was increased to 313 kcal (1310 kJ) for each of the feeding groups in the second school term (January 1999).

<sup>2</sup> Nutrient values are calculated from the WorldFood 2 Dietary Assessment Program (9).

<sup>3</sup> Availability of the snack iron and zinc is assumed to be equal to the average availability across the day's intake (9% for iron and 13% for zinc). If the snack is consumed alone, availability would be higher for the meat snack, the available iron would be ~0.42 mg and the available zinc would be ~1.08 mg.

stunted (height for age Z-score below  $-2$  of the National Center for Health Statistics standard) and 4.6% were severely stunted (height for age below  $-3$  Z). Less than 2% were wasted (weight for height Z-score below  $-2$ ) (11). Although the children in the Meat group were  $\sim 6$  mo older than the children in the other groups, their average body weight was only slightly higher (20.4 vs. 19.8–20.0 kg for the other three groups).

At baseline, intake of three of the eight nutrients examined was significantly different among the four study groups: vitamin A, calcium and available zinc. For vitamin A, the Control group's intake was greater than that of the Milk group by 93  $\mu\text{g}/\text{d}$  ( $P = 0.03$ ), whereas the Energy group's intake was greater than the Milk group's intake (by 119  $\mu\text{g}/\text{d}$ ,  $P = 0.004$ ) and the Meat group's intake (by 85  $\mu\text{g}/\text{d}$ ,  $P = 0.04$ ). For calcium, the Control group's intake was higher than that of all three of the other groups, by up to 39  $\text{mg}/\text{d}$  ( $P$ -values were 0.01–0.04). Available zinc intake was significantly higher for the Meat group compared to the Milk or Control groups (by 0.11 and 0.14  $\text{mg}/\text{d}$ , respectively;  $P$ -values = 0.02 and 0.006).

**Intake from the snacks fed at school.** Table 2 shows nutrient intake from the school snacks. These values are lower than the actual nutrient content of the snacks shown in Table 1 because some children were absent, some did not eat all of their snacks and some recall days were for weekends when the children were not in school. Daily snack intake for the children in the Energy group averaged 181 kcal/d (757 kJ/d) [compared to 239 kcal/d (1000 kJ/d) if a complete snack had been consumed every day], 234 kcal/d (979 kJ/d) for the Milk group [compared to a possible 262 kcal/d (1096 kJ/d)] and 241 kcal/d (1008 kJ/d) for the Meat group [compared to a possible 259 kcal/d (1084 kJ/d)]. Thus, after considering leftovers, absences and weekends, energy intakes averaged 76% of the possible value of the snack for children in the Energy group, 89% for children in the Milk group and 93% for children in the Meat group.

**Change in home intake during the first 3 mo of the intervention.** Table 2 also shows changes in the food eaten at home during the first 3 mo of the intervention. The overall

TABLE 2

Mean nutrient intakes (mean  $\pm$  sd) during baseline and the first term of feeding, and changes in intakes during feeding

Nutrient	Group <sup>1</sup>	Intake at baseline	Intake during feeding period, mo 1–3			Change in intake	
			Snacks <sup>2</sup>	Food at home	Total intake	At home	Total
Energy, kcal kJ	Control	1689 $\pm$ 456 7067 $\pm$ 1908	0 0	1885 $\pm$ 609 7887 $\pm$ 2548	1885 $\pm$ 609 7887 $\pm$ 2548	196 <sup>3</sup>	196 <sup>3</sup>
	Energy	1771 $\pm$ 470 7410 $\pm$ 1966	181 $\pm$ 58 757 $\pm$ 243	1646 $\pm$ 449 6887 $\pm$ 1879	1827 $\pm$ 444 7644 $\pm$ 1858	–126 <sup>3,4</sup>	55
	Milk	1746 $\pm$ 513 7305 $\pm$ 2146	234 $\pm$ 53 979 $\pm$ 222	1617 $\pm$ 491 6766 $\pm$ 2054	1851 $\pm$ 499 7745 $\pm$ 2088	–129 <sup>3,4</sup>	105
	Meat	1733 $\pm$ 457 7251 $\pm$ 1912	241 $\pm$ 47 1008 $\pm$ 197	1872 $\pm$ 606 7832 $\pm$ 2536	2114 $\pm$ 603 8845 $\pm$ 2523	140 <sup>3</sup>	381 <sup>3,4</sup>
	Control	50.7 $\pm$ 15.0	0.0	54.0 $\pm$ 34.3	54.0 $\pm$ 34.3	3.3	3.3
Protein, g	Energy	53.5 $\pm$ 16.2	6.4 $\pm$ 2.1	45.2 $\pm$ 15.4	51.6 $\pm$ 15.2	–8.3 <sup>3,4</sup>	–1.9
	Milk	53.3 $\pm$ 18.3	9.8 $\pm$ 2.3	44.7 $\pm$ 16.8	54.4 $\pm$ 17.1	–8.6 <sup>3,4</sup>	1.1
	Meat	54.6 $\pm$ 16.8	15.1 $\pm$ 3.3	50.7 $\pm$ 17.6	65.8 $\pm$ 17.9	–4.0 <sup>4</sup>	11.2 <sup>3,4</sup>
	Control	0.54 $\pm$ 0.52	0.00	0.49 $\pm$ 0.60	0.49 $\pm$ 0.60	–0.05	–0.05
Vitamin B-12, $\mu\text{g}$	Energy	0.73 $\pm$ 2.81	0.00	0.42 $\pm$ 0.82	0.42 $\pm$ 0.82	–0.31 <sup>3</sup>	–0.31 <sup>3</sup>
	Milk	0.39 $\pm$ 0.35	0.68 $\pm$ 0.22	0.41 $\pm$ 0.63	1.09 $\pm$ 0.65	0.02	0.70 <sup>3,4</sup>
	Meat	0.37 $\pm$ 0.51	0.80 $\pm$ 0.23	0.27 $\pm$ 0.25	1.07 $\pm$ 0.33	–0.10	0.70 <sup>3,4</sup>
	Control	1.03 $\pm$ 0.30	0.00	1.11 $\pm$ 0.39	1.11 $\pm$ 0.39	0.08 <sup>3</sup>	0.08 <sup>3</sup>
Riboflavin, mg	Energy	1.04 $\pm$ 0.30	0.09 $\pm$ 0.03	0.95 $\pm$ 0.28	1.04 $\pm$ 0.27	–0.08 <sup>3,4</sup>	0.00
	Milk	1.02 $\pm$ 0.31	0.35 $\pm$ 0.10	0.96 $\pm$ 0.31	1.31 $\pm$ 0.33	–0.06 <sup>4</sup>	0.29 <sup>3,4</sup>
	Meat	1.06 $\pm$ 0.29	0.13 $\pm$ 0.02	1.07 $\pm$ 0.37	1.20 $\pm$ 0.37	0.01	0.14 <sup>3</sup>
	Control	324 $\pm$ 202	0	361 $\pm$ 195	361 $\pm$ 195	37	37
Vitamin A, $\mu\text{g}$ RAE <sup>5</sup>	Energy	349 $\pm$ 542	112 $\pm$ 36	334 $\pm$ 212	446 $\pm$ 213	–16	96 <sup>3</sup>
	Milk	235 $\pm$ 145	167 $\pm$ 39	318 $\pm$ 197	485 $\pm$ 207	83 <sup>3</sup>	249 <sup>3,4</sup>
	Meat	270 $\pm$ 220	76 $\pm$ 20	395 $\pm$ 381	471 $\pm$ 380	125 <sup>3</sup>	201 <sup>3,4</sup>
	Control	307 $\pm$ 146	0	285 $\pm$ 110	285 $\pm$ 110	–22	–22
Calcium, mg <sup>5</sup>	Energy	268 $\pm$ 117	21 $\pm$ 7	230 $\pm$ 93	251 $\pm$ 93	–38 <sup>3</sup>	–17
	Milk	270 $\pm$ 111	209 $\pm$ 64	249 $\pm$ 106	458 $\pm$ 130	–22	187 <sup>3,4</sup>
	Meat	274 $\pm$ 122	16 $\pm$ 4	278 $\pm$ 158	295 $\pm$ 158	5	21 <sup>4</sup>
	Control	1.40 $\pm$ 0.65	0.00	1.66 $\pm$ 0.77	1.66 $\pm$ 0.77	0.26 <sup>3</sup>	0.26 <sup>3</sup>
Available iron, mg	Energy	1.44 $\pm$ 0.63	0.18 $\pm$ 0.12	1.34 $\pm$ 0.54	1.51 $\pm$ 0.56	–0.10 <sup>4</sup>	0.07 <sup>4</sup>
	Milk	1.39 $\pm$ 0.61	0.13 $\pm$ 0.11	1.40 $\pm$ 0.60	1.53 $\pm$ 0.63	0.01 <sup>4</sup>	0.14 <sup>3</sup>
	Meat	1.52 $\pm$ 0.57	0.26 $\pm$ 0.16	1.74 $\pm$ 0.71	2.00 $\pm$ 0.69	0.22 <sup>3</sup>	0.48 <sup>3,4</sup>
	Control	0.99 $\pm$ 0.35	0.00	1.10 $\pm$ 0.84	1.10 $\pm$ 0.84	0.12 <sup>3</sup>	0.12 <sup>3</sup>
Available zinc, mg <sup>5</sup>	Energy	1.08 $\pm$ 0.46	0.07 $\pm$ 0.09	0.90 $\pm$ 0.32	0.97 $\pm$ 0.30	–0.18 <sup>3,4</sup>	–0.11 <sup>3,4</sup>
	Milk	1.02 $\pm$ 0.35	0.15 $\pm$ 0.09	0.90 $\pm$ 0.37	1.05 $\pm$ 0.37	–0.11 <sup>3,4</sup>	0.04
	Meat	1.13 $\pm$ 0.39	0.37 $\pm$ 0.16	1.04 $\pm$ 0.43	1.41 $\pm$ 0.47	–0.09 <sup>4</sup>	0.27 <sup>3,4</sup>

RAE, retinol activity equivalents.

<sup>1</sup> Sample sizes: Control group = 116; Energy group = 135; Milk group = 126; Meat group = 116.

<sup>2</sup> Snack intake is averaged across school days (when snacks were received) and nonschool days (weekends and absences, when snacks were not received).

<sup>3</sup> Significantly different from baseline ( $P < 0.05$ ).

<sup>4</sup> Significantly different from change in the control group ( $P < 0.05$ ).

<sup>5</sup> Significant differences among groups at baseline ( $P < 0.05$ ).

*F* test comparing intake at baseline to home intake during the intervention was significant for six of the eight nutrients of interest, indicating significant differences among the feeding groups for energy, protein, riboflavin, vitamin A, iron and zinc, but not for calcium and vitamin B-12. For both the Energy group and the Milk group, energy intakes were lower than at baseline, whereas energy intakes for the Control and Meat groups were higher than baseline. Thus, children in the Energy and Milk groups are apparently receiving less food at home as a result of the snacks given at school, whereas no such reduction was seen for the children in the Meat group. However, intakes of protein, vitamin B-12 and available zinc from home food decreased for the Meat group.

**Change in total intake during the first 3 mo of the intervention.** In addition, Table 2 shows changes in total mean intakes for each of the four groups between baseline and the first term of feeding for each nutrient. The overall *F* test comparing intake at baseline to total intake during the intervention was significant for all eight nutrients of interest, indicating significant differences among the feeding groups. Total daily energy intake increased for the Control, Milk and Meat groups, but not for the Energy group. However, the increase in the Meat group's energy intake was significantly greater than the increase for the Control group, whereas the changes for the Milk and Energy groups were not significantly different from those for the Control group. For all nutrients except calcium, the Meat group's increases in intake were significant. Even though calcium intake increased only slightly in the Meat group (21 mg/d), this change was significantly different from the decline in intake by the control group (-22 mg/d). Although the Milk group significantly increased their energy intake, this change was actually less than the change for the Control group, and not significantly different from the change for the Control group. However, the Milk group had greater increases in intake than the Control group for four of the seven micronutrients: vitamin B-12, riboflavin, vitamin A and calcium. The Energy group had a significant increase only in vitamin A intake, but significant decreases in vitamin B-12 and available zinc intakes.

To further examine changes in energy intake as a result of the feeding, we compared intakes at six points in time during the feeding period, and calculated total daily intake from the school snacks, from food at home and from all food (Table 3). On average, intake from the snacks was 220 kcal/d (920 kJ/d) for the Energy group, 239 kcal/d (1000 kJ/d) for the Milk group and 242 kcal/d (1013 kJ/d) for the Meat group. When averaged across these 6 d, daily energy intake from home food followed the same pattern that was seen for the first 3 d that intake was measured during the intervention: intake declined for both the Energy and Milk groups and increased for the Control and Meat groups. Total daily energy intake (from the school snack plus home foods) increased, on average, for all four groups of children, with the largest increases for the children in the Meat group. However, repeated measures analyses showed a significant interaction between the feeding groups and the time the intake was measured, implying that the effect of the feeding groups is different across visits. Thus, statistical tests of the effect of the feeding group (the main effect) cannot be performed on these averages. Further examination of the data showed that the intake measure in September 1999 (intake visit 13) was different from the other visits in that energy intake from food at home was very similar for children in all four feeding groups (Figs. 1, 2). When change in total intake from baseline to visit 13 was examined (home food plus school snacks), energy intakes for the three intervention groups were not different from each other, and all were higher than energy intake by the Control group.

## DISCUSSION

**Energy, protein and fat intakes.** Although energy intakes increased during the study for children in all four groups, including the Control group, increases were greatest for the Meat group. When the data were examined separately for sources of energy (at home versus from the snack), it was clear that intake at home declined for children in the Energy and Milk groups. Some of the decline may reflect less food carried by the children to school, as well as less food served at meals

TABLE 3

Mean energy intake (mean  $\pm$  SD kcal/d; kJ/d in parentheses) at baseline and across 2 y of the feeding intervention

	Control group (n = 123)	Energy group (n = 140)	Milk group (n = 137)	Meat group (n = 124)
Baseline, 1998 <sup>1</sup>	1707 $\pm$ 472 (7142 $\pm$ 1975)	1787 $\pm$ 478 (7477 $\pm$ 2000)	1758 $\pm$ 508 (7355 $\pm$ 2125)	1744 $\pm$ 472 (7297 $\pm$ 1975)
Intervention period, 1998-2000 <sup>2</sup>				
Intake from snacks	0	220 $\pm$ 52 (920 $\pm$ 218)	239 $\pm$ 62 (1000 $\pm$ 259)	240 $\pm$ 63 (1004 $\pm$ 264)
Intake from home	1784 $\pm$ 344 (7464 $\pm$ 1439)	1687 $\pm$ 374 (7058 $\pm$ 1565)	1650 $\pm$ 371 (6904 $\pm$ 1552)	1813 $\pm$ 375 (7586 $\pm$ 1569)
Total intake	1784 $\pm$ 344 (7464 $\pm$ 1439)	1907 $\pm$ 380 (7979 $\pm$ 1590)	1889 $\pm$ 371 (7904 $\pm$ 1552)	2053 $\pm$ 377 (8590 $\pm$ 1577)
Change in home intake from baseline	77 (322)	-100 <sup>3</sup> (-418)	-108 <sup>4</sup> (-452)	69 <sup>5</sup> (289)
Change in total intake from baseline	77 (322)	120 (502)	131 (548)	310 <sup>6</sup> (1297)
School holiday, 1999 <sup>1</sup>	1732 $\pm$ 647 (7247 $\pm$ 2707)	1668 $\pm$ 562 (6979 $\pm$ 2351)	1798 $\pm$ 736 (7523 $\pm$ 3079)	1796 $\pm$ 796 (7514 $\pm$ 3330)

<sup>1</sup> No feeding occurred during this period. Baseline intake is the average of three intake visits before the feeding began. The school holiday was in August 1999.

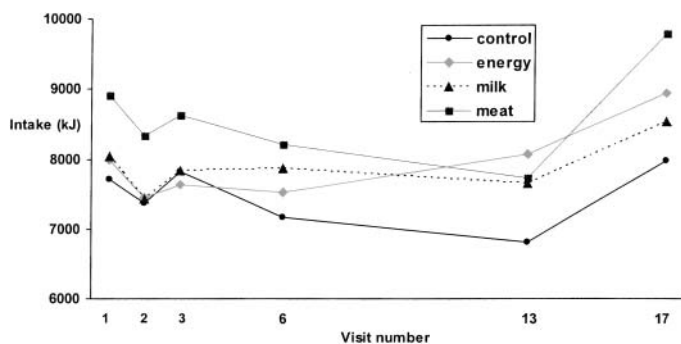
<sup>2</sup> Average of six intake measures (home visits 1, 2, 3, 6, 13 and 17) during the school terms. A significant interaction between the school feeding group and the time of the intake measure precludes testing the effect of the type of feeding on energy intakes overall.

<sup>3</sup> Significantly different from change in the Control group for four of six intake measures ( $P < 0.05$ ).

<sup>4</sup> Significantly different from change in the Control group for three of six intake measures ( $P < 0.05$ ).

<sup>5</sup> Significantly different from change in the Energy group for five of six intake measures, and from change in the Milk group for four of six measures ( $P < 0.05$ ).

<sup>6</sup> Significantly different from change in the Control group for all intakes examined, from change in the Energy group for four of six intake measures, and from change in the Milk group for five of six measures ( $P < 0.05$ ).

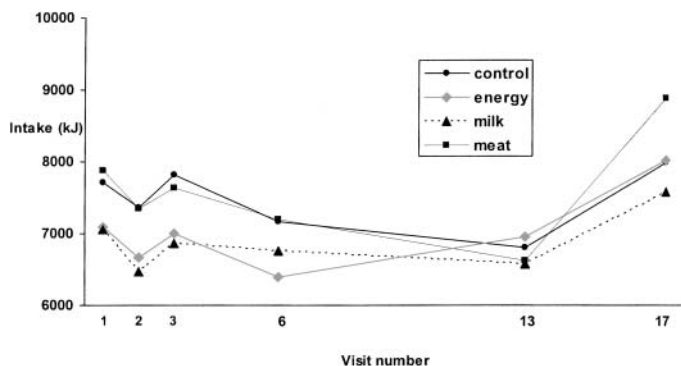


**FIGURE 1** Mean total energy intake (kJ) for schoolchildren at six times during the feeding period. Intake visits 1–3 collected in September, October and November 1998; visit 6 in February 1999; visit 13 in September 1999; and visit 17 in February 2000.

consumed at home. From this study, it is not possible to determine if the adults in these families purposely redistributed food within the household, or if the child simply was not as hungry and therefore chose to eat less. Because the children in the Meat group did not eat less at home, it seems likely that intakes were driven more by the child's hunger perhaps as a result of increased activity and growth. Other evidence supports an increased energy requirement by the children in the Meat group. Activity during the playground breaks appeared to be higher, and anthropometric measures showed a greater increase in arm muscle mass for these children compared to children in the other feeding groups (11,12). Thus, an overall increase in physical activity and in growth may provide an explanation for the increased total daily energy intake.

Recommended energy intakes for children of this age are ~80 kcal/kg (335 kJ/kg) (13). At baseline, the children weighed ~20 kg, suggesting an energy requirement of ~1600 kcal/d (6694 kJ/d). At baseline, the children's intake averaged 1717–1797 kcal/d (7184–7519 kJ/d), indicating that energy intake may have been adequate. However, it is difficult to evaluate true adequacy without knowing activity levels, because these children often walk long distances to and from school and participate in many household chores. In addition, because a number of the children are small for their age (11), it is possible that additional energy would contribute to catch-up growth. Finally, a high infection and malaria burden may further contribute to an increased energy requirement for these children (8).

By the end of the study, children had gained 3–4 kg (11), increasing their energy needs by 240–320 kcal/d (1004–1339 kJ/d) if the requirement is 80 kcal/kg (335 kJ/kg) (13). These



**FIGURE 2** Mean energy intake (kJ) from food at home for schoolchildren at six times during the feeding period. Intake visits 1–3 collected in September, October and November 1998; visit 6 in February 1999; visit 13 in September 1999; and visit 17 in February 2000.

increases in body weight agree closely with the actual increases in energy intake that were seen at the intake measure taken in February 2000: 162 kcal/d (678 kJ/d) for the children in the Control group (who gained 3.5 kg); 383 and 292 kcal/d (1602 and 1222 kJ/d) for children in the Energy and Milk groups, respectively (who gained 3.9 kg). However, the increase by the children in the Meat group (591 kcal/d, 2473 kJ/d) was more than would have been predicted from weight gain alone (3.9 kg) and thus may have reflected an increase in activity level.

Although dietary protein also increased the most for the children receiving the meat snack, there is little evidence of low protein intakes by any of the children. Recommended intakes for children of this age and weight are ~17 g/d (14), whereas actual intakes averaged over 50 g/d. Even after adjusting for lower protein quality, protein intakes were found to be adequate for both toddlers and schoolchildren in a previous study (5,15).

All snacks contained fat, ranging from 4.6 g/serving (energy snack) to 11.1 g/serving (meat snack) during 1998. Saturated fat levels were low, with only 0.7 g in the energy snack and 5.1 g in the milk snack. Given the very low fat intakes of these children (~15% of energy), the additional dietary fat probably represented a desirable dietary change and served to increase both energy density and satiety.

**Mineral intakes.** As previously reported, the bioavailability of iron and zinc in children's diets in the study area is low: 8% for iron and 11% for zinc in the former study (4,5) and 9% and 13%, respectively, in this study. The snacks did not substantially increase the percent availability of either mineral, although the actual amounts of available iron and zinc increased significantly in the diets of the children in the Meat group. As we have done in the past (4), we calculated a single availability percentage for iron and zinc across the full day because of uncertainties about the timing of meals and snacks. As a result, the energy snack, with very low mineral availability, could decrease the average availability across the day, whereas the meat snack, with very high mineral availability, could increase availability across the day. Correspondingly, the available iron and zinc content of the snacks, as reported in Table 1, were assumed to have the same availability percentage as the overall diet. This approach substantially underestimates the availability that would be calculated for the meat snack if it was known to be consumed alone (16% for iron and 35% for zinc). Furthermore, we have used the absorption percentages that are assumed for a person to maintain a basal iron status; if a person is in poorer iron status, verging on anemia, absorption can be assumed to increase by 50% (16), which would further increase the amount of available iron in the snacks. These increases in available iron and zinc intakes may have functional importance related to the school performance outcomes that were measured.

Improved mineral intakes may increase children's appetites. For example, improved zinc status has been associated with better appetites in young, stunted children (17). Children in the Meat group increased their available zinc intakes by 0.27 mg/d, compared to much smaller increases in zinc intake for the other groups. Iron supplementation also improved appetites of Kenyan schoolchildren (18). Available iron intakes improved for children in the Meat group by 0.48 mg/d, which was substantially greater than the improvement for children in the other groups. The meat snack was the only one of the three snacks containing highly available heme iron. Thus, another explanation for increased intakes by the children in the Meat group may be an increase in appetite.

**Vitamin intakes.** Intakes of two vitamins were specifically targeted by the feeding: vitamin B-12 and riboflavin. Both the

milk and meat snacks contained substantial amounts of vitamin B-12, and intakes increased by 0.7  $\mu\text{g}/\text{d}$  in both groups, to 1.11  $\mu\text{g}/\text{d}$ . The recommended vitamin B-12 intake for a schoolchild is 1.2  $\mu\text{g}/\text{d}$  (19), so the snack increased intakes by 64% of this recommendation. As reported by Seikmann et al. in this supplement (20), plasma levels of this vitamin improved significantly, and mirrored the improvement in dietary intakes. Riboflavin intakes were increased by the milk snack, but all groups reported adequate riboflavin intakes at baseline [slightly over 1 mg/d, on average, compared to a recommended intake of 0.6 mg/d (19)].

Although vitamin A was not originally a targeted nutrient, low serum retinol levels indicated widespread deficiency (20). When designing the snacks, we estimated that only the milk snack would provide meaningful amounts of vitamin A,  $\sim 110 \mu\text{g}$  of retinol. The vitamin A activity of the 5 g of kale included in the githeri was assumed to be negligible due to the low conversion of provitamin A carotenoids to vitamin A (10). However, the cooking fat that we chose was fortified with retinol, and laboratory analyses indicated high levels of retinol: 37  $\mu\text{g}/\text{g}$  fat. The fat added to the snacks prepared in 1998 ranged from 1.6 to 3 g per serving, adding 60–112  $\mu\text{g}$  of retinol. In 1999, the amount of fat was raised by 2 g in the energy and milk snacks (but not in the meat snacks), providing an additional 74  $\mu\text{g}$  in these two snacks. A schoolchild's recommended intake of vitamin A is 400 retinol activity equivalents per day (where 1  $\mu\text{g}$  of retinol = 1 RAE) (10), so the cooking fat contributed substantially toward this recommendation.

**Accuracy of the collection and analysis of food intake.** The food intake data for this study were collected using a detailed 24-h recall methodology (21). Because many of the foods consumed in these villages are mixtures, and their ingredients and proportions can change both within and between households (22), we also collected detailed information on the recipe for each mixture that was reported. Others have compared data from 24-h recalls to more detailed food intake collection methods, such as weighed records, and found that the recalls give acceptable estimates of total intake in rural Kenya (23). Although we cannot exclude the possibility that the recall method introduced biases into the daily intake estimates, the levels appear to be consistent with expected intakes. Compared with schoolchildren's intakes in this same region of Kenya in 1984–1985, as determined by weighed intakes in the home (5), energy and nutrient intakes were somewhat higher at baseline in the current study. For example, energy intake averaged 1434 kcal/d (6000 kJ/d) in the former study and 1791 kcal/d (7494 kJ/d) in this study. This increase reflects an apparent improvement in dietary quantity over the 14 y between the studies, although a drought in 1984 reduced average intakes in the earlier study. The differences could also be an artifact of differing collection methods, reflecting an underconsumption of food when enumerators were present in the home or an over-reporting of intake on the 24-h recalls. However, Kigutha (23) found no significant differences between weighed food records and food recalls for either preschoolers or elderly adults in rural Kenya. We will be performing similar analyses for schoolchildren living in the area of the CNP study to see if intakes from dietary recalls differ from those obtained from weighed intakes.

The intakes reported here for the feeding periods are the sum of food consumed at home (based on the 24-h recall) and the calculated nutrient content of the snacks. Thus, the accuracy of the nutrient intake values is dependent on the accuracy of the food composition table. The WorldFood Dietary Assessment System has been used to estimate intakes in a variety of developing country settings (9) and appears to pro-

vide intake estimates with greater accuracy than country-specific databases (24). Specificity for local foods is obtained by using an index that matches a local food to one or more foods on the WorldFood food composition table [the International Minilist (IML)], using adjustment factors as appropriate. For example, a high fat type of beef can be described as a mix of leaner beef and beef tallow. Because there are no missing nutrient values on the IML, intake estimates are not artificially reduced. However, there remains the possibility that the nutrient profile of one or more foods is incorrectly estimated. For example, the fat content of the minced beef that was used for the meat snack is not certain. We assumed a relatively low fat content (14.4% by weight), but the provider of the beef estimated it was only 10–12% fat by weight. Thus, it is possible that we overestimated the fat in the meat snacks (which contained 60 g of raw minced beef initially, and was later increased to 85 g) by up to 3.3 g, representing up to 34 kcal/d (142 kJ/d). This relatively small error would have little effect on the estimated total intake of children in the Meat group and would have no effect on their estimated intake from home foods.

Based on the data analyzed to date, the meat snack was overall the most successful in improving both dietary quality and dietary quantity. However, the results from visit 13 show that the increased energy intake by the children in the Meat group was not uniform across visits. Both the milk and meat snacks improved vitamin B-12 and vitamin A intakes, but the milk snack also improved riboflavin and calcium intakes, whereas the meat snack also improved available iron and available zinc intakes.

Because less than half the intake data have been processed, further analyses will be needed to determine if the increased intakes by the Meat group children are seen consistently throughout the study. Results from a similar study conducted among toddlers, many of whom are younger siblings of the schoolchildren, will also be available soon. The mechanisms that might promote increased daily energy intakes among the children in the Meat group are unknown, but may be related to increased activity levels and/or increased hunger. One hypothesis is that the substantially higher mineral intakes by the Meat group children resulted in improved mineral status, which in turn promoted appetite, growth of muscle and more active playground activities. Further studies should particularly focus on the efficacy and effectiveness of snacks containing meat or milk, or a combination of the two, for children with low intakes of animal source foods.

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