The contribution of breast milk to toddler diets in western Kenya

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Objective To understand the relative contributions of breast milk and the weaning diet to overall nutrient intake, with a view to designing and implementing appropriate programmes to improve complementary feeding in developing countries.

Methods Complementary food intake was measured in a sample of 250 toddlers (mean baseline age: 13.9 ± 2.4 months) using 24-h dietary recall interviews administered once every 3 weeks over a 6-month period. Breast-milk intake over a 24-h period was measured using the test-weighing method in a subsample of 50 children. Regression effects of age and sex on observed milk intakes were estimated and imputed to the whole sample to estimate mean intake over the observation period. Total energy and nutrient intakes were evaluated for adequacy with reference to published estimates of toddler requirements.

Findings Total energy intake (1029 kcal/day) was adequate, with breast milk supplying an average of 328 kcal/day (32%), but vitamin A, riboflavin, calcium, iron and zinc intakes were below current estimates of required intakes. Observed limitations in nutrient intake were consistent with the finding that almost half of the toddlers were stunted. The prevalence of wasting was 6% at baseline and 4% at final assessment. Although food consumption increased when breastfeeding stopped, it could not fully compensate for the fat and vitamin A previously supplied by breast milk.

Conclusions The nutritional role of mother's milk in the second year is inversely related to the adequacy of the complementary diet. In this study, breast milk was an irreplaceable source of fat and vitamin A. When the weaning diet is inadequate for key nutrients because of low intake or poor bioavailability, breast milk assumes greater nutritional significance in the second year of life but does not guarantee adequate nutrient intakes.

Keywords Milk, Human; Infant nutrition/physiology; Infant food; Weaning; Energy intake; Infant; Prospective studies; Kenya (*source: MeSH, NLM*).

Mots clés Lait femme; Nutrition nourrisson/physiologie; Aliments pour nourrisson; Sevrage; Ration calorique; Nourrisson; Etude prospective; Kenya (*source: MeSH, INSERM*).

Palabras clave Leche humana; Nutrición infantil/fisiología; Alimentos infantiles; Destete; Ingestión de energía; Lactante; Estudios prospectivos; Kenya (*fuente: DeCS, BIREME*).

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Voir page 298 le résumé en français. En la página 298 figura un resumen en español.

Introduction

When breast milk becomes inadequate to meet infants' needs for energy and nutrients, the complementary diet takes on an increasingly important role in maintaining optimal growth. If the combination of breast milk and dietary intake is adequate, this should be reflected in the nutritional status of the child population in the period of sustained breastfeeding, which may overlap with the second year of life. Few studies have examined the relative contributions of breast milk to overall energy and nutrient intakes during the period of complementary feeding (*1*). Studies from several developing countries indicate that children aged 12–23 months consuming average quantities of breast milk should obtain 750 kcal from the complementary diet to meet their daily requirements (*1*). However, there have been few analyses of nutrient intake in the second year of life (*2*, *3*). Our data provide a profile of energy and nutrient intakes in the second year and some insights into the nutritional implications of the continuation or termination of breastfeeding for toddlers being weaned on diets similar to the typical food selection in this study population.

Breastfeeding is sustained until at least the latter part of the second year for most children in the agricultural community of Marachi Central Location, Busia District in western Kenya. Most infants begin to receive cereal- and cassava-based gruel before the age of 3 months. Gruel remains the most important food item in complementary diets until toddlers are weaned onto the household staple, *ugali*, a stiff porridge prepared from the same flours used for making gruel, served with a limited variety of vegetable and animal food accompaniments. Our study prospectively followed a cohort of 264 children. The findings of our investigation of the association between breastfeeding and growth in the second year have been published elsewhere (*4*). This paper evaluates the relative contributions of breast milk and the complementary diet to the energy and nutrient intake of these children. It presents analyses of data from the 250 children who were breastfed for any duration between November 1995 (baseline) and May 1996 (final assessment). Data from the other 14 toddlers, who had stopped breastfeeding before baseline assessment, were not taken into account.

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Methods

During the study period, 24-h dietary recall interviews were administered once every 3 weeks. The data were processed using the Worldfood Program (WFP) to calculate intakes of energy and nutrients for each recall day (*5*). Daily nutrient and energy intakes written in D-Base IV format by the WFP were imported into SPSS 7.0 for further processing. Nutrient and energy intakes from all available records for each subject were aggregated to calculate estimated mean intakes over the follow-up period. A phytate:zinc molar ratio was computed using non-aggregated data according to the formula of Murphy et al. (*6*):

(phytate (g)/molar weight 660) ÷ (zinc (mg)/atomic weight 65.4).

Diet diversity variables, including individual food and food group counts, were created in SPSS. The eight food groups counted were starch, vegetables, fruit, fats/oils, meat/fish/poultry/insects, nuts/seeds/pulses, sugars/sweets, and miscellaneous (including spice mixtures). Although consumed regularly in the sample, salt (miscellaneous) and tea (beverages) were not included in the food counts.

A test-weighing study in a subsample of 50 children was carried out to estimate breast-milk intake in a single 24-hour period. We began from the northern end of the location and moved systematically through the study area. The subsample comprised children of mothers who had indicated willingness to participate in the test-weighing component and who, when the test-weighing team was working in their local area, were still breastfeeding and were available for observation.

Two fieldworkers arrived in the home at 07:00 and conducted weighing throughout the day. A different fieldworker took over in the evening to continue the weighing until 07:00 the following day. The mother could choose whether she wished the night-time evaluation to be undertaken at home or at the local health centre, where a house had been set aside for the project. If they were going to the health centre, the mother and night-time fieldworker were driven to the centre once the former had completed her household chores. As anticipated, most babies normally slept with their mothers and nursed intermittently throughout the night without the mother waking up specifically to feed. Each mother was therefore asked to wear a T-shirt to prevent the baby's access to the breast while she slept, so that both mother and observer had to wake up for each feed.

Babies wore terry-cloth napkins and plastic pants before feeding to avoid losses of urine or faeces. Just before and immediately after each breastfeed, the baby was weighed on a DETECTO baby scale, model 6730 (Webb City, MO, USA), which has a precision of 5 g. The scale is equipped with a microcomputer that takes a series of weights in successive milliseconds and locks on a stable weight. This reading remains displayed even after the child has been lifted away from the pan, and is stored in memory until the next weighing. The difference between the two weights (in grams) was considered as the weight of milk consumed. Insensible water loss was not estimated.

The 24-h totals formed the basis for imputing daily breast-milk consumption for the whole sample. When the effect of age on breast-milk intake was estimated, the residual plot revealed that boys consumed more milk than girls of equivalent age. The imputation formula was therefore generated by regressing observed intake on age and sex (n = 50). The resulting equation was applied to the whole sample (n = 250), weighted by breastfeeding duration as a

Table 1. Breast milk composition estimates[a]

Nutrient factor	Country source	Age (months)	Content per dl	Content per 100 g[b]
Lactose (g)	Gambia	12–18	7.93	7.69
Total fat (g)	Gambia	12–18	3.53	3.42
Protein[c] (g)	Gambia	12–18	0.995	0.965
Energy[d] (kcal)	Gambia	12–18	67.47	65.44
Total iron (μg)	Côte d'Ivoire	12, 18	59.57	57.8
Calcium (mg)	Gambia	12–26	18.1	17.6
Phosphorus (mg)	Gambia	12–26	15.8	15.3
Zinc (mg)	Gambia	12–26	0.12	0.12
Vitamin A (μg RE)	Ethiopia	11.5–23.5	21.2	20.6
ß-carotene (μg)	Ethiopia	11.5–23.5	18.8	18.2
Thiamine (μg)	India	13–18, > 18	16	15.5
Riboflavin (μg)	India	13–18, > 18	15.2	14.7
Niacin (μg)	India	9–12	102	98.9
Pantothenic acid (μg)	India	9–12	103	99.9
Biotin (μg)	India	9–12	160	155.1
Vitamin B_{12} (ng)	India	9–12	7.7	7.5
Vitamin C (mg)	India	12–18, > 18	3.1	3
Folic acid (μg)	USA	1.5–3	0.83	0.8

[a] With the exception of folic acid, calculated from values presented by Prentice (*7*). Preferred samples were African, rural, low-income, not supplemented, children's age range including the second year or at least late infancy. If two reports were found, the one with the larger sample was chosen. When no African sample had late infancy or second-year estimates, Indian rural low-income non-supplemented samples were used. Kenyan data were available only for infants between birth and 6 months and were therefore not used. Means for specific age ranges were weighted by sample size before the final mean was calculated. The original references were not reviewed. The values for folic acid were taken from analyses using more modern techniques by O'Connor et al. (*8*).

[b] The per dl values were divided by 1.031, the specific gravity of human milk, to obtain the content per 100 g.

[c] Protein content was obtained by multiplying total nitrogen (mg) by 6.25.

[d] Energy (kcal) content was calculated by multiplying the lactose, fat and protein contents by the factors 4, 9 and 4, respectively (*14*).

percentage of the follow-up span, to obtain an estimate of each child's intake over the study period. The final imputation formula was as follows:

breast-milk intake (g/day) = {1081.15 g + 142.88 x male sex –

[34.75 g x age (months)]} x (% of time breastfed)

where age = the midpoint age in the period during which the child was breastfeeding.

The reference breast-milk content estimates used in estimating the energy and nutrient intakes from breast milk reported in this study are detailed in Table 1 (*7*, *8*).

Total and per kg body weight consumption was assessed on the basis of pooled intakes from breast milk and complementary foods. Mean nutrient intakes were compared to recommendations published in various reports from United Nations agencies (*9–12*); energy and protein intakes were evaluated in reference to requirement levels estimated by Torun et al. (*13*) and Dewey et al. (*14*), respectively. Intake estimates for protein from non-breast-milk sources were corrected for lower digestibility (85%) and quality (72%), since the weaning diet in this sample resembled the Nigerian cassava-based diet used in a FAO/WHO/UNU report as a reference to adjust digestibility (*15*).

Dietary intake records from the children who were weaned during the study (n = 77) were selected from the non-aggregated file. The pre- and post-weaning intakes of each subject were summed separately to calculate mean consumption for each of the two periods. These data were analysed by paired t test to examine intrasubject differences between pre- and post-weaning intakes.

The research protocol was reviewed and approved by the Ethical Review Committee of the Faculty of Agriculture and Environmental Sciences at McGill University, Montreal, Canada. Clearance to conduct research was obtained from the Government of Kenya before fieldwork took place. Informed verbal consent was obtained from each participating mother before enrolment in the study.

Results

Table 2 describes the age, attained growth and nutritional status of the 128 girls and 122 boys in the sample. All the children were already receiving some complementary foods. The average follow-up period was 5.6 months, during which the children gained 5.0 ± 1.8 cm and 1.4 ± 0.8 kg, on average. Almost half of the children were stunted, while wasting decreased from 6% at baseline to 4% at final assessment. In the course of the study, 77 toddlers stopped breastfeeding; thus 69% were breastfed throughout the observation period.

Participants had been advised not to change their work routines or child-feeding practices during test-weighing. Results from an interview administered at the end of the 24-h session indicated that mothers had indeed carried out their work as usual and that daytime breastfeeding patterns had not changed (the night-time feeding practices were modified as described above to permit measurement). For cultural reasons, however, the mothers treated the fieldworkers as their guests and prepared special meals. Therefore the weighed food record results did not reflect the babies' usual complementary food selection.

A comparison of the test-weighed sample (n = 50) with the 200 other children who were eligible for test weighing showed no significant differences other than that the former group were on average 1 month younger than the latter, and their mothers had more years of formal education (6.3 compared with 4.8 years). The age difference is related to the fact that younger children had a higher chance of participating in the test-weighing study, since they were less likely than older children to be weaned before the end of the study. The disparity in maternal education reflects some degree of self-selection, in that mothers with more formal education may have felt more confident about receiving the "guests" and having their home management observed. Despite this limitation, there is no evidence to suggest that the 50 babies were different from the rest of the sample in a way that systematically biases the breast-milk estimates.

The test-weighing results show wide variability in daily breast-milk intake (502 ± 239 g/24 h) (range 55–1005 g). The average child spent 1.25 out of 24 h at the breast. Mean time spent breastfeeding was longer at night than during the day (47 min compared with 28 min), hence total consumption at night was higher (271 ± 152 g compared with 231 ± 119 g during the day). An average feed at the breast lasted roughly 10 min (9.6 ± 3.8 min). Total number of feeds ranged from two to 13 (mean 7.9 ± 2.7), about evenly split between daytime (3.8 ± 1.6) and night-time (4.3 ± 1.4).

Correlations between child variables and feeding characteristics are summarized in Table 3. In univariate analysis, the associations between sex and feeding frequency, total duration and total milk intake were not statistically significant. However, when adjusted for age in regression, boys were shown to consume significantly more breast milk (β = 143 g) than girls of equivalent age (Fig. 1). Age alone

Table 2. Sample description (n = 250)

Characteristic	Baseline	Final assessment
Age (months)	13.9 ± 2.4	19.5 ± 2.3
Length (cm)	71.6 ± 3.5	76.6 ± 3.7
Weight (kg)	8.5 ± 1.3	9.8 ± 1.3
< –2 SD length for age[a] (n (%))	118 (47.2)	122 (48.8)
< –2 SD weight for age[a] (n (%))	95 (38.0)	57 (22.8)
< –2 SD weight for length[a] (n (%))	15 (6.0)	9 (3.6)

[a] Standard deviation (SD) from the NCHS-WHO reference population median.

Table 3. Correlations between age and weight of children and breastfeeding (n = 50)

	Age	Weight	No. of feeds	Total duration of breastfeeding
Weight	0.50[a]	–	–	–
No. of feeds	–0.37[a]	–0.37[a]	–	–
Total duration of breastfeeding	–0.23	–0.23	0.75[a]	–
Total milk intake	–0.34[b]	–0.13	0.67[a]	0.56[a]

[a] Two-tailed significance P = < 0.01.
[b] Two-tailed significance P = < 0.05.

or adjusted for sex was associated with a reduction in total milk intake and time spent at the breast. For every additional month in age, children spent on average 4 min less at the breast (95% confidence interval (CI) 0.1 to 8 minutes less), but child weight was not significantly associated with milk intake when age was included in these models (data not shown). Imputed daily average consumption in the sample (n = 250) was 501 g/day (range 15–792 g/day).

Complementary diet

More than two-thirds of the sample completed eight dietary recall interviews (n = 176; 70%), 53 (22%) completed seven, 13 (5%) completed six, and eight had between two and five recalls (3%). This section describes the non-breast-milk diet with particular reference to macronutrient profiles (Table 4) and selected characteristics of diet quality (Fig. 2). Three-quarters of non-breast-milk energy was obtained from carbohydrate. In what was thus a bulky carbohydrate-based diet, only 13% of energy was obtained from animal source foods. Table 4 describes the baseline, end-point and period average energy profiles. Fig. 2 plots a more detailed pattern of consumption over the study period; baseline intakes are weighted as 1, and intakes thereafter fall below or rise above this reference level. Not surprisingly, vitamin A from animal food sources shows the most erratic intake pattern and, unlike the other nutrient factors, exhibits no consistent pattern of change during the 6 months of observation. Carbohydrate and total energy intake plots are very closely related, underlining the fact that the former was the most important source of dietary energy. Other qualitative factors — protein and energy from animal food sources; and protein and iron from the meat/fish/poultry group — increased only slightly from baseline to midway through the follow-up, and then more rapidly in the latter half of the study.

Of the actual foods selected, cereal-based gruel was consumed daily by over 90% of children throughout the study period. The household diet gained prominence, rising from daily consumption by 73% of toddlers at baseline to 94% at final assessment. Overall, only one-fifth of children received cow's milk daily, and 1% were reported to consume some egg almost daily. Fruit was consumed daily by 13% at baseline and 21% at final assessment. Diversity in the complementary diet increased from an average of six food items from four groups at baseline to seven items from five food groups at the end of the study.

Adequacy of estimated intakes and the contribution of breast milk to overall intake

At average energy intake per kg body weight, children were receiving 125% of average daily energy requirements, chiefly owing to the fact that the 250 children in this sample had lower mean weight than the samples on which Torun et al. (*13*) based their estimates (Table 5). Similarly, average protein intake was above the upper limit (average requirement + 2 standard deviations (SD)) of nitrogen per kg body weight (205%) for children in the latter half of the second year. Other nutrients whose daily intakes were above estimated requirements were vitamins B_1, B_{12}, and C, niacin, folic acid and phosphorus. Nutrients whose mean intakes fell short of estimated requirements were calcium (72%), iron (74%), vitamin A (78%), vitamin B_2 (63%), and zinc (33%). A phytate:zinc molar ratio exceeding 15 is believed to compromise zinc bioavail-

Table 4. Daily non-breast-milk energy profile (n = 250)

	Baseline	Final assessment	Period average
Total energy (kcal)	592 ± 280	829 ± 351	701 ± 320
Carbohydrate (g)	117 ± 53	159 ± 69	136 ± 61
Protein (g)	17 ± 12	26 ± 17	21 ± 14
Fat (g)	8 ± 7	13 ± 10	11 ± 9
Carbohydrate energy (%)	77	74	75
Protein energy (%)	11	12	11
Fat energy (%)	12	14	14
Animal food energy (%)	12	13	13

Fig. 1. **Estimated effect of age on breast-milk intake**

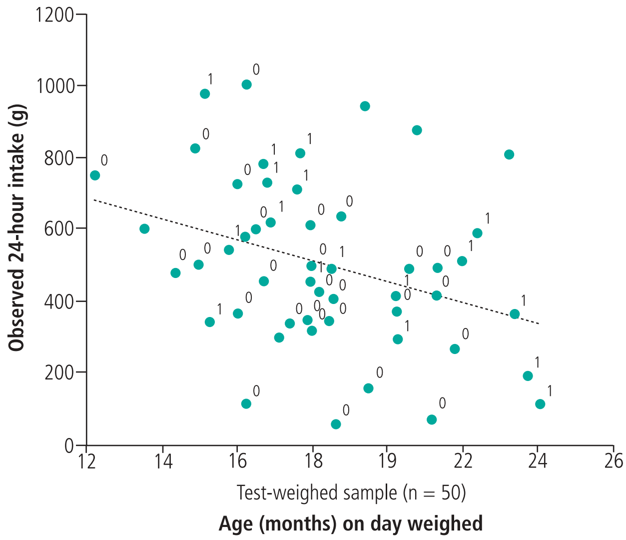

Fig. 2. **Change in energy intake and nutrient intakes from baseline (recall no. 1) to final assessment (recall no. 8).** Actual intakes at baseline (in parentheses for each component) are scaled to one as a reference for intakes thereafter

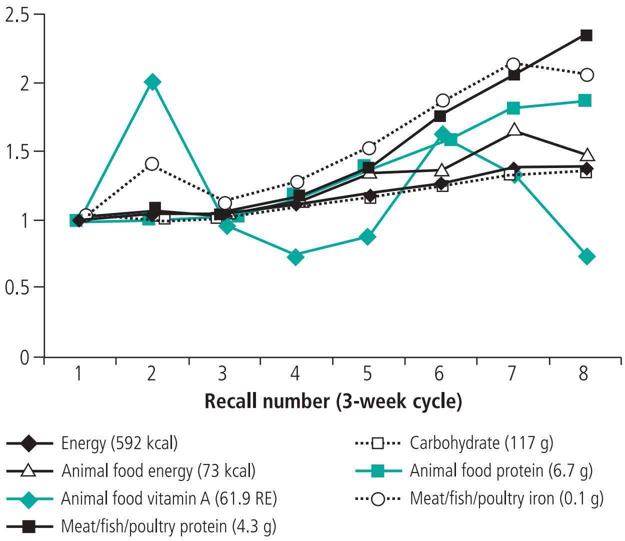

Table 5. Energy and nutrient intakes: adequacy of total intake (period average) and the relative contributions of breast milk and complementary diet (n = 250)[a]

	Estimated requirement (intake as % of requirement)	Nutrient sources (mean ± SD)		Percentage contributed by breast milk
		Complementary food	Breast milk	
Energy (kcal)	825 (125)[c]	701 ± 212	328 ± 118	31.9
Carbohydrate (g)	–	136 ± 39	39 ± 14	22.3
Protein (g)	12.5 (205)[d]	20.8 ± 8.8	4.8 ± 1.8	18.8
Fat (g)	–	10.5 ± 5.8	17.1 ± 6.2	62.0
Vitamin A (RE)	400 (78)[e]	209 ± 206	103 ± 37	33.0
Preformed vitamin A (RE)	–	73 ± 186	103 ± 37	58.5
Vitamin B_1 (mg)	0.5 (140)[f]	0.6 ± 0.2	0.1 ± 0.03	14.3
Vitamin B_2 (mg)	0.8 (63)[f]	0.4 ± 0.2	0.1 ± 0.03	20.0
Niacin[b]	9.0 (267)[f]	14.2 ± 5.1	9.8 ± 1.1	40.8
Folic acid (μg)	50 (182)[e]	90 ± 43	4.0 ± 1.6	4.2
Vitamin B_{12} (μg)	0.6 (260)[e]	1.2 ± 1.4	0.4 ± 0.1	25.0
Vitamin C (mg)	20 (330)[g]	51 ± 28	15 ± 5	22.7
Calcium (mg)	450 (72)[g]	237 ± 176	88 ± 32	27.1
Phosphorus (mg)	450 (129)[g]	504 ± 189	77 ± 28	13.3
Iron (mg)	8.0 (73)[e]	5.5 ± 1.7	0.3 ± 0.1	5.2
Zinc (mg)	11.0 (33)[e]	3.0 ± 1.0	0.6 ± 0.2	16.7

[a] Only children who were breastfed for at least part of the study were included. Intake estimates are the average for the period from baseline to final assessment.
[b] Calculated as preformed niacin + (tryptophan (mg) ÷ 60).
[c] Torun et al., 1996 (*13*).
[d] Dewey et al., 1996 (*14*).
[e] FAO/WHO, 1988 (*11*).
[f] FAO/WHO, 1967 (*9*).
[g] FAO/WHO, 1970 (*10*).

ability (*16*). In the complementary diet of the study sample, the phytate:zinc ratio of the average diet was 29 (range 10–43). When breast-milk zinc was included in the equation, the mean ratio dropped to 23 (range 5–38). Breast milk accounted for almost one-third of energy intake, 41% of niacin and greater proportions of total fat (62%) and preformed vitamin A (59%) intakes. Its contribution to other nutrient intakes ranged from 4% for folate to 27% for calcium (Table 5).

Pre- and post-weaning intakes and compensation for breast milk

Analyses were restricted to the 77 children who stopped breastfeeding during the study. Estimated energy and nutrient intakes from breast milk in the pre-weaning period were lower than the period means for the sample as a whole (Table 5) because these children had a higher average age, and breast-milk intake decreased as children grew older. Only 21 (27%) of the mothers who weaned their children during the study introduced an additional food item to the child's usual diet following the termination of breastfeeding. However, 59 (77%) mothers reported increasing the amounts of food offered and 74 (96%) reported that their children "accepted food better" after weaning. Paired t-test results (data not shown) indicated that post-weaning intakes were higher than pre-weaning intakes for energy and all nutrients except vitamin A. We estimated the extent of post-weaning dietary compensation for breast milk (Table 6) on the basis of differences between post- and pre-weaning non-breast-milk nutrient intakes.

Average energy intake from complementary foods increased from 679 kcal/day before weaning to 941 kcal/day in the post-weaning period. Since breast-milk energy intake prior to weaning was 212 kcal/day, the 262 kcal/day increase in post-weaning dietary energy compensated for the former by 124%. Protein intake increased by 10 g/day, at least three times more than the estimated pre-weaning intake from breast milk. On the other hand, the post-weaning diet replaced only 32% of the fat previously supplied by breast milk, 45% of total vitamin A (with an estimated net loss of 20 retinol equivalents (RE) of preformed vitamin A), and 55% of niacin. There appeared to be ample compensation for all other nutrients in the post-weaning diet. It should be noted that, despite post-weaning increases in intake of 275% for zinc and 800% for iron, the levels supplied still fell below estimated requirements for these nutrients.

Discussion

Breast milk made an important contribution to the fat and vitamin A intakes of toddlers in this community. The proportion of energy from fat was closer to the recommended levels (30–40%) required by young children for optimal growth when children were still receiving breast milk (24%) than with the local diet alone (14%). Upon termination of breastfeeding, the amount of food offered (and accepted) increased, but the composition of the diet did not change to compensate qualitatively for the loss of breast milk.

The limitations of a descriptive study of this type are obvious. As it was not feasible to collect data that could precisely describe the change in breast-milk consumption over the observation period, we were limited to imputing a crude period average intake for the sample. In addition, we did not analyse any milk samples to obtain more representative estimates of

Table 6. Adequacy of compensation for breast milk loss in the post-weaning diet (n = 77)

	Pre-weaning	Post-weaning	
	Intake from breast milk[a]	Increase in nutrient intake from diet[b]	Percentage compensation[c] for breast milk
Energy (kcal)	212 ± 111	262	124
Carbohydrate (g)	22 ± 2	49	114
Protein (g)	3.1 ± 1.6	10	325
Fat (g)	11.1 ± 5.8	3.5	32
Vitamin A (RE)	67 ± 35	30	45
Preformed vitamin A (µg)	67 ± 35	–20	
Vitamin B_1 (mg)	0.05 ± 0.03	0.2	400
Vitamin B_2 (mg)	0.05 ± 0.03	0.1	200
Niacin[d]	7.5 ± 0.8	4.1	55
Folic acid (µg)	23.7 ± 11.9	27	114
Vitamin B_{12} (µg)	0.2 ± 0.1	0.8	400
Vitamin C (mg)	10 ± 5	28	280
Calcium (mg)	57 ± 30	147	258
Phosphorus (mg)	49 ± 26	222	453
Iron (mg)	0.2 ± 0.1	1.6	800
Zinc (mg)	0.4 ± 0.2	1.1	275

RE = retinol equivalent.

[a] Estimated amount/day (mean ± SD) obtained from breast milk while still breastfeeding.

[b] Obtained by subtracting pre-weaning intake (from complementary food only) from the same nutrient intake after cessation of breastfeeding, without correction for age.

[c] Calculated according to the formula: {(post-weaning intake — pre-weaning intake from complementary diet) ÷ (estimated daily intake from breast milk in pre-weaning period)}X100.

[d] Calculated as preformed niacin + (tryptophan (mg) ÷ 60).

nutrients whose content in breast milk depends on maternal food intake and nutritional status. To safeguard against overestimating the contribution of breast milk to overall intake, we used reference values from non-supplemented low-income women similar to the mothers participating in our study. The method used to collect food intake data is reliable for estimating group mean rather than individual intakes. Despite the fact that multiple diet recalls were available for each child, the data were collected over a period of transition from partial breastfeeding to exclusive dependence on the household diet. They therefore provide a good estimate of the period average but not of individual usual intake over the study period.

Despite these limitations, the data provide a good description of overall toddler diets, the nutritional benefits of continued breastfeeding given a bulky carbohydrate-based complementary diet, and the possible nutrient deficiencies entailed by the final withdrawal of breast milk.

Our estimate of breast-milk volume consumed in 24 h (502 g, standard error 34 g) is not unreasonable. In Machakos, eastern Kenya, Steenbergen et al. (*2*, *17*) observed reduced milk production in the lean season compared with the harvest season. Our data were gathered during a lean season, including the two driest months of the year (January and February) and the planting–weeding season (March–May) when food supplies are low in Marachi Central. However, observed breast-milk intake was higher in our study than in the Machakos sample in the lean and harvest seasons by 162 g and 70 g, respectively. The greater difference for the lean season may reflect different levels of severity of this season in the two geographical locations. Our average was closer to the observed intakes in two Bangladeshi samples of comparable ages (12–23 months), which were 532 g/day (*3*) and 548 g/day (*18*).

In addition to energy, Steenbergen et al. (*2*) reported on intakes of protein, iron, calcium and vitamins A, B_1 and B_2, while Brown et al. (*3*) reported on intakes of macronutrients, vitamin A and iron. We are unable to compare our results on the relative contribution of breast milk with findings from earlier studies that also measured complementary food intake because of differences in age categorization (*3*, *19*), or because reports did not disaggregate contributions from breast milk and other sources (*2*, *3*, *17*).

The nutrient profile of the complementary diet in Marachi was remarkably similar to that reported in Embu, eastern Kenya (*6*). The diet lacked certain qualities that have been positively associated with improved growth, such as a relatively high percentage of energy from animal foods (*20*, *21*) and overall diversity (*22*). Being cereal-based, the diet's high phytate content would limit the bioavailability of zinc and iron (*23*). With breastfeeding, an estimated 24% of energy was obtained from fat, a definite improvement on the 14% estimated from the local diet, but still below the range recommended (30–40%) for children in the first 2 years of life (*24*). Our analyses suggest that breast milk was an irreplaceable source of fat and preformed retinol. The importance of breast milk as a source of vitamin A for breastfed toddlers has been discussed recently, estimating that it contributes 164 µg of preformed retinol per day (*18*). Our data support the argument that breast milk is indeed important in this respect during the second year of life, although our estimate of its contribution was a more conservative 103 RE/day.

Published analyses suggest that there is a high risk of inadequate intake of vitamins A and B_2, and calcium, iron and zinc from cereal-based diets (*23*). Our finding that consumption of all five of these nutrients was inadequate is therefore not surprising. Although there appeared to be adequate compensation for iron and zinc upon termination of breastfeeding, the new levels of intake still could not match estimated toddler requirements. Considering the low bioavailability of these micronutrients from this type of diet (*23*), the relative contribution of breast milk to their consumption in Marachi and similar settings is probably underestimated. The fact that intakes of these micronutrients were inadequate even while breastfeeding continued does not question the value of breast milk but rather challenges any complacency about the overall nutrient intake breastfed toddlers in the second year.

A study on malnourished Ghanaian toddlers reported increased energy intake after weaning. It suggested that prolonged breastfeeding predisposed to malnutrition and that malnourished children should be weaned so as to increase their food intake (*25*). We also observed increased intakes of energy and several nutrients among the 77 children who stopped breastfeeding during the study, yet we have published what might be considered a contradictory finding in this same cohort: namely, a positive association between prolonged breastfeeding and growth (*4*). However, age was associated with increased energy intake independently of breastfeeding status, as illustrated in Fig. 2, implying that the higher post-weaning energy intake among the 77 toddlers was partly a function of their increased age. Furthermore, overall energy intake was estimated to be adequate — and therefore not a limiting factor for growth — although the quality of the complementary diet in this population was too poor to meet requirements for a number of nutrients that are understood to be important for optimal growth (*26*). In a review of nutrient deficiencies that could contribute to deficits in linear growth, Allen & Uauy (*26*) highlight vitamins B_2, B_{12}, retinol, iron, zinc and essential fatty acids. Apart from vitamin B_{12}, intakes of all the other nutrients in our sample were below estimated requirements (dietary fat as proxy for essential fatty acids). It is therefore not surprising that almost half of the children in our sample were stunted, or that despite increased energy consumption post-weaning, longer breastfeeding was associated with improved child growth (*4*).

The highest levels of stunting, wasting and underweight in Kenyan children have been reported in the age group 12–23 months (*27*). Given the high prevalence of stunting at baseline (47%) in the present study, it is clear that growth faltering begins in infancy, and perhaps earlier, for most children in this population. More than four-fifths of infants begin to receive low-quality complementary foods before the minimum recommended age for their initiation. This practice has been associated with growth deficits that are evident in the second and third years (*22*). The observed energy intake would be inadequate to support catch-up growth in a sample experiencing linear growth retardation, and the nutrient profile was such as might be expected to foster continuing suboptimal growth.

The complementary diet provided only 701 kcal/day, which appeared to be adequate considered as per kg body weight intake, and approximated the published amount of energy (750 kcal/day) that children aged 12–23 months should obtain from complementary foods (*1*). However, the diet does not meet the shortfall in intakes of vitamins A and B_2, calcium, iron and zinc for children receiving 500 g of breast milk or less per day. Children aged 18–30 months in Embu, Kenya, had similar inadequacies in nutrient intakes (*6*). Our data extend this observation to a younger age, demonstrating that, like older children, toddlers breastfed in the second year also receive inadequate amounts of specific micronutrients. Programmes to improve toddler nutrition should therefore encourage continued breastfeeding in the second year but complementary interventions, such as supplementation and the promotion of fortified food, are required for all toddlers who receive weaning diets similar to that described in this study. ■

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Conflicts of interest: none declared.

Résumé

Contribution du lait maternel à l'alimentation des jeunes enfants dans l'ouest du Kenya

Objectif Comprendre la contribution relative du lait maternel et des aliments de sevrage à l'apport alimentaire total en vue d'élaborer et de mettre en œuvre des programmes destinés à améliorer l'alimentation de complément dans les pays en développement.

Méthodes L'apport d'aliments de complément a été mesuré sur un échantillon de 250 jeunes enfants (âge moyen au début de l'étude : 13,9 $\pm$ 2,4 mois) au moyen d'enquêtes alimentaires portant sur les dernières 24 heures réalisées toutes les 3 semaines pendant 6 mois. La quantité de lait maternel absorbée en 24 heures a été déterminée par pesée sur un sous-échantillon de 50 enfants. L'effet de régression de l'âge et du sexe sur la consommation de lait maternel observée a été estimé puis imputé à la totalité de l'échantillon pour calculer l'apport moyen sur la période d'observation. L'apport total en énergie et en éléments nutritifs a été évalué par comparaison avec des estimations publiées sur les besoins des enfants de cette classe d'âge.

Résultats L'apport énergétique total (1029 kcal/jour) était suffisant, avec une contribution moyenne du lait maternel de 328 kcal/jour (32 %), mais les apports de vitamine A, de riboflavine, de calcium, de fer et de zinc étaient inférieurs aux estimations actuelles concernant les besoins nutritionnels. L'insuffisance observée des apports nutritionnels concordait avec le fait que près de la moitié des enfants présentaient un retard de croissance. La prévalence de l'émaciation était de 6 % au début de l'étude et de 4 % lors de l'évaluation finale. La consommation alimentaire augmentait à l'arrêt de l'allaitement au sein, mais ne compensait pas entièrement les quantités de matières grasses et de vitamine A apportées par le lait maternel.

Conclusion Le rôle nutritionnel du lait maternel au cours de la deuxième année est inversement proportionnel à la qualité de l'alimentation de complément. Dans la présente étude, le lait maternel était une source irremplaçable de matières grasses et de vitamine A. Lorsque les aliments de sevrage ne suffisent pas à apporter les quantités nécessaires d'éléments nutritifs clés en raison soit d'un apport insuffisant, soit d'une mauvaise biodisponibilité, le lait maternel joue un rôle nutritionnel accru pendant la deuxième année, mais sans garantir un apport suffisant en éléments nutritifs.

Resumen

Papel de la leche materna en la alimentación de los niños de corta edad en Kenya occidental

Objetivo Conocer el peso relativo de la leche materna y la alimentación de destete en la ingesta global de nutrientes, con miras a formular y aplicar programas apropiados para mejorar la alimentación complementaria en los países en desarrollo.

Métodos Se midió la ingesta de alimentos complementarios en una muestra de 250 niños de corta edad (edad inicial media: 13,9 $\pm$ 2,4 meses), empleando para ello encuestas alimentarias por interrogatorio administradas una vez cada tres semanas a lo largo de un periodo de 6 meses. La ingesta de leche materna de 24 horas se midió mediante pesaje en una submuestra de 50 niños. Se estimaron los efectos de regresión de la edad y el sexo en la ingesta de leche observada, que se atribuyeron a la totalidad de la muestra para estimar la ingesta media a lo largo del periodo de observación. La idoneidad del aporte calórico y nutricional total se evaluó a partir de las estimaciones de las necesidades de los niños de corta edad aparecidas en la literatura.

Resultados El aporte energético total (1029 kcal/día) fue suficiente; la leche materna aportaba como promedio 328 kcal/día (32%), pero la ingesta de vitamina A, riboflavina, calcio, hierro y zinc se situaba por debajo de las actuales estimaciones de las necesidades diarias. Las deficiencias observadas en el aporte de nutrientes concordaban con el retraso del crecimiento que presentaban casi la mitad de los niños. La prevalencia de emaciación fue del 6% en la situación inicial y del 4% en el momento de la evaluación final. Aunque el consumo de alimentos aumentó al interrumpir la lactancia natural, no llegó a reemplazar por completo las grasas y la vitamina A aportadas previamente por la leche materna.

Conclusión La contribución nutricional de la leche materna durante el segundo año de vida está inversamente relacionada con la idoneidad de la dieta complementaria. En este estudio, la leche materna constituía una fuente irremplazable de grasas y vitamina A. Cuando los alimentos de destete aportan una cantidad insuficiente de nutrientes clave, debido ya sea a una ingesta baja o a una escasa biodisponibilidad, la leche materna adquiere una mayor importancia nutricional durante el segundo año de vida, pero no garantiza un aporte suficiente de nutrientes.

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