Original Article

Contribution of complementary food nutrients to estimated total nutrient intakes for rural Guatemalan infants in the second semester of life

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Background: In developing countries, complementary foods are often introduced earlier or later than appropriate and the quality is frequently insufficient, particularly in rural areas where complementary foods have traditionally been based on starchy gruels. Adequate intakes of a number of nutrients are recognized to be problematic in traditional complementary feeding regimens in developing societies. Aim: To determine the contribution of the complementary feeding nutrients to the estimated total nutrient intake in Guatemalan infants. Methods: Three non-consecutive 24-hr recalls were collected from a convenience sample of mothers of 64 infants, aged 6-12 month on enrolment, in the rural Guatemalan highland village of Santo Domingo Xenacoj. Additional information on early introduction of pre- and post-lacteal feeds and on first foods and beverages was included. Human milk intakes were estimated by a model based on assumptions regarding satisfaction of weight-based daily energy needs by the combined diet. The 2004 WHO/FAO recommended nutrient intakes were used as the standard for adequate nutrient consumption. Results: We observed that exclusive breastfeeding up to 6 month is rare. Mean nutrient intakes and densities were above recommended intakes for all nutrients examined, except calcium, iron and zinc. Intakes of most nutrients were greater from the complementary feeding component of the diet. Vitamin A intake was excessive due to consumption of fortified sugar. Conclusions: We conclude that intakes of most micronutrients were near recommendation levels, unusual within the complementary feeding experience in scientific literature. Calcium, iron and zinc were identified as "problem nutrients" as persistently reported in developing countries.

Key Words: human milk, complementary foods, infant feeding, micronutrient intake, Guatemala

INTRODUCTION

The most important factor for normal growth and development of infants is adequate nutrition. The recommendations for infant feeding have been clearly enunciated by the World Health Organization (WHO): "Exclusive breastfeeding for 6 month is the optimal way of feeding infants. Thereafter infants should receive complementary foods with continued breastfeeding up to 2 years of age or beyond".[1] The term exclusive breastfeeding is used when all fluids, energy and nutrients are provided by breast milk with an exception provided for medicinal supplements.[2]

Complementary feeding (CF) is a challenging undertaking. When economic resources are limited, concerns for the affordability, hygienic quality and nutritional adequacy of the complementary foods surge to the fore. However, analysis of the nutritional needs of infants entering the 7th month of life demonstrate the fact that maternal milk cannot support the physiological demands of the infant for certain nutrients.[2, 3]

We conducted a survey in two low-incomes settings in Guatemala, with a common field team, research protocol and sample size to determine the intake of complementary foods and beverages in infants in their 7th through 12th month of life, along with an estimated intake of human milk. The findings with respect to estimated total water intake in the urban sample and the comparative features of dietary variety and diversity of the diets offered in the two sites have been presented elsewhere.[4,5] Here, we turn our attention to quantitative aspects of macro- and micronutrient intakes in rural infants. We surmised that current CF practices in rural Guatemala show appropriate timing of CF and inadequate nutrient intake from complementary foods and beverages.

MATERIALS AND METHODS

Study population

The study was conducted in the Republic of Guatemala, in the Mayan village of Santo Domingo Xenacoj, on the

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central highlands, 45 km from Guatemala City along the Pan American Highway. Most households have a per cap ita earning of less than two US dollars per day, and are thus classified as being poor.

Subjects

The mothers of 81 infants, aged approximately 6 to 12 month, visiting the local midwife, were initially recruited for the study. Inclusion criteria were: 1) the infant was at least 6 month old, but had not reached his or her 1st birthday; and 2) the infant had consumed both breast milk and CF the day before the first interview. Exclusion criteria included: 1) exclusive breastfeeding the day before the first interview; 2) no breastfeeding the day before the first interview; 3) congenital anomalies or chronic illness; and 4) failure to sign the study consent form.

Ethical approval was obtained from the Human Subjects Committee of the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) and the study conforms to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000). The study protocol was approved by the local authorities of the Ministry. The purpose and procedures of the study were explained and all mothers gave written informed consent; subject anonymity was preserved. Participants received a small compensation in kind after each interview.

Data collection

The first contact with the community was made through a midwife who lived and worked in the area. Two focus groups attended by mothers and other family members were held at local homes. There was always a Kakchiquel-language interpreter present. Based on these meeting, 3 data collection tools were designed and each mother was interviewed three times between August and November of 2007.

On the day of enrolment only, a structured questionnaire was administered, which queried socio-demographic characteristics and general breastfeeding and CF practices. These including colostrum feeding practices, early introduction of prelacteal feeds, termed ¨*aguitas*¨ in the local parlance, the use of formulas or whole milk, and early complementary food items. Mothers were asked what food or beverage items they introduced first, at what age and why they made the choices they made. This tool was administered only once, during the first interview.

A second structured questionnaire was administered on each data collection day. This included questions related to morbidity, exclusivity of breastfeeding, timing of breastfeedings, initiation of weaning, the use of formulas (including brand names), and dietary supplements. In addition, mothers were asked when they first introduced a predetermined list of 10 commonly consumed foods items (*Incaparina*®, oatmeal, rice, white rolls, sweet rolls, fruits, vegetables, potatoes, baby food desert, and coffee).

Three separate 24-hr dietary recalls were recorded on each data collection day for each infant. Mothers were asked to report all foods and beverages, excluding breast milk, consumed by their infant in the previous 24 hours. Portion sizes of complementary foods were recorded as estimated in common household measures and recipes for dishes and household preparations were queried in detail. The interviews were conducted by a team of 2 trained and standardized nutritionists.

Data were collected on 3 non-consecutive days, always on week days. The first interview took place on the day of enrolment. Most interviews took place within a calendar month. The minimum and maximum time interval between the three interviews was 7 and 104 days, respectively. A total of 15 children completed a first birthday before the final one or two recall interviews were completed. These children were retained in the analysis, and the reference standards for infants in their 12th month of life were used.

When an interview appointment was missed, efforts were made to contact and reschedule the mother for a future date. If the mother failed to return after multiple contact attempts, the infant data was excluded from entering into the final analyses.

Energy and nutrient analysis of complementary feeding

Each food or beverage item reported was coded and entered into a database. Dishes were disaggregated to the most elemental level possible. Household measures were converted to grams using standard reference tables. A total of 94 items were listed and their nutrient values were derived from USDA food composition table obtained on line from the USDA database.[6]

Modelled intakes of breast milk

Although breast milk consumption was a criterion for inclusion, quantitative consumption of breast milk was not evaluated. A simple approach to model the volume of breast milk intake was developed based on the assumption that the energy from breast milk intake is equal to the energy requirement of the infant minus the energy derived from complementary foods. Energy requirements for each age group were computed using the formula: $-95.4 + 88.3\times$body weight (kg) in addition to sex-specific daily energy requirement for growth.[7]

It was not possible to directly weigh the participants in the present protocol. Reference growth curves for infants in the 7th to the 12th month of life were constructed using archival data for infants who visited the local well-baby clinic for vaccinations, as described previously.[4] A total of 132 body weight measurements were taken (11 per month and gender) and median values were used for analysis. Data was collected over the span of the full calendar year (2008). Breast milk was assumed to provide 272 kJ/100 mL (67 kcal/100ml).[2]

Data analysis

Data were analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics used to estimate daily energy, protein, fat, carbohydrates, vitamins A, B_1, B_2, B_3, and C, folate, calcium, iron and zinc intakes in CF, breast milk and the total diet are presented for the pooled sample based on 3 data collection days for each infant (n=192). In addition, nutrient intakes for CF only are presented by age group (i.e. 7th-9th month and 10th-12th month). Estimated daily energy and nutrient intakes are presented as percentages of Reference Nutrient Intake (RNI) for CF only and for the total diet for each infant (n=64).[8] Descriptive statistics for the nutrient density of selected nutrients in the CF only are presented and compared to reference values from human milk.[2,9] The top 10 sources of energy, macronutrients and selected micronutrients are presented for the total diet, including breast milk.

RESULTS

Demographic characteristics

Of the original 81 mother-infant dyads recruited, 64 (79%) were available for analysis. Reasons for exclusion included, failure to complete the series of 3 interviews (n=13), full weaning (*n*=1), exclusive breastfeeding (n=1) and inappropriate age on enrolment (*n*=2). Table 1 provides demographic statistics on our sample on the 1st day of data collection. There were a total of 64 mother–infant pairs in which the full series of three interviews were completed, 36 boys and 28 girls. The median age of the sample was 8.0 month at entry into the study. Of these, 34 were in the 7th to 9th month range at the time of enrolment and 30 were in the 10th to 12th month range.

Qualitative aspects of feeding infants in the first semester of life

A total of 53 women (87%) reported having given colostrum to the index infant. According to our estimates, 9 of the 64 infants (14%) had received exclusive breastfeeding, as defined by the WHO criterion,[1] during the first 6 month of life, prior to becoming eligible to be entered into our protocol. The provision of "*agüitas,*" which include plain water or emulsions or infusions of various grains and herbs, had been given to children post-partum interval or early in life in 74% of instances. Ten infants (16%) had received some commercial replacement formula, generally NAN1®, at some point before their entry into the present study.

The first food item, other than *agüitas* or human milk, had been offered to the child from the 3rd to the 9th month (median, 5th month). Rural mothers often mentioned a number of different items in the category of "first food" when presented with the question. In descending order, the 10 most commonly named items among the 30 different items mentioned, were: 1) white bread rolls; 2) rice; 3) potato; 4) noodles; 5) green *chayote* squash; 6) *Incaparina*® gruel; 7) oat meal gruel; 8) commercial baby food (in jars); 9) cookies; and 10) sweet roll. The persons who were most influential in suggesting the timing and the nature of the first food was ranked as: maternal grandmother (38%), sister (23%), the mother herself (22%), a doctor (5%), and others, including the paternal grandmother (mother-in-law) (7%).

Quantitative aspects of estimated nutrient intakes in the second semester of life

Estimated 24-hr protein and selected micronutrient intakes from CF (derived from interviews); from human milk (derived from the modelling); and estimated total estimated intake (as the summation of the two components) are presented in Table 2 for the entire sample. For all nutrients, except vitamin C, the contribution from CF is greater than the contribution from human milk. Using the combination of both components of the diet estimated here, we compared the median of intakes with the reference standard for intake (RNI).[8] The sample's median met or exceeded the reference value for vitamins A, B_1, B_2, B_3, and C, and folate, whereas for calcium, iron and zinc, severe gaps were revealed.

Focusing in on the contribution of selected nutrients exclusively from CF, Table 3 tabulates estimated intakes

Table 1. Characteristics of the population sample on the 1st day of data collection

	n	Age (month)		Number sampled by month of age					
		mean±SD	Median	7th	8th	9th	10th	11th	12th
Total	64	8.3±2.0	8.0	20	7	7	6	12	12
Boys	36	8.1±1.8	8.0	11	5	6	2	9	3
Girls	28	8.6±2.1	9.0	9	2	1	4	3	9

Table 2. Estimated 24-hr intakes of selected nutrients from complementary feeding, human milk and both combined, based on 192 responses in 64 rural infants

	RNI†	Complementary feeding§		Human milk¶		Human milk and complementary feeding combined	
		mean±SD	median	mean±SD	median	mean±SD	Median
Protein (g)	10/11‡	12.2±8.2	11.1	4.2±2.9	4.5	16.4±6.0	14.7
Vitamin A (RAE)	400	299±468	172	200±137	213	499±431	414
Vitamin B_1 (mg)	0.3	0.4±0.3	0.4	0.1±0.1	0.1	0.5±0.3	0.4
Vitamin B_2 (mg)	0.4	0.4±0.3	0.3	0.1±0.1	0.1	0.5±0.3	0.4
Vitamin B_3 (mg)	4	4.7±3.3	4.3	0.6±0.4	0.6	5.3±2.9	4.8
Vitamin C (mg)	30	14.9±18.7	9.7	16.0±11.0	17.1	30.9±16.9	29.9
Folate (DFE)	80	126±83	113	34±23	36	160±64	147
Calcium (mg)	400	183±179	134	112±77	119	295±139	254
Iron (mg)	9.3	4.3±3.4	3.5	0.1±0.1	0.1	4.4±3.3	3.6
Zinc (mg)	4.1	2.4±1.9	2.0	0.5±0.3	0.5	2.9±1.7	2.5

RNI, Reference Nutrient Intake; RAE, Retinol Activity Equivalents; DFE, Dietary *Folate* Equivalent.
† RNI values for infants aged 7-12 mo old.[8]
‡ RNI for infants aged 7-9/10-12 mo old.[8]
§ Based on 3 non-consecutive 24hr recalls.
¶ Breast milk intakes were modelled based on age- and gender-specific energy requirements.[7]

Table 3. Estimated 24-hr intakes of selected nutrients from complementary feeding only, based on 192 responses in 64 rural infants, by age group

	Age-groups			
	7th - 9th month (n=34)		10th - 12th month (n=30)	
	mean±SD	median	mean±SD	median
Energy (kcal)	304±200	274	491±231	482
Protein (g)	9.3±7.4	7.3	15.6±7.8	14.9
Fat (g)	4.1±4.3	2.9	8.6±6.7	7.6
Carbohydrates (g)	58.2±38.5	52.3	89.5±45.8	79.4
Vitamin A (RAE)	211±252	141	399±616	230
Vitamin B_1 (mg)	0.3±0.3	0.3	0.5±0.3	0.5
Vitamin B_2 (mg)	0.3±0.3	0.2	0.4±0.3	0.4
Vitamin B_3 (mg)	3.9±3.1	3.3	5.7±3.2	5.0
Vitamin C (mg)	12.8±13.5	8.9	17.2±23.2	10.9
Folate (DFE)	100±74	87	156±83	132
Calcium (mg)	146±159	98	226±191	166
Iron (mg)	3.3±2.9	2.6	5.3±3.6	4.4
Zinc (mg)	1.9±1.8	1.4	3.1±1.9	2.8

RAE, Retinol Activity Equivalents; DFE, Dietary *Folate* Equivalent

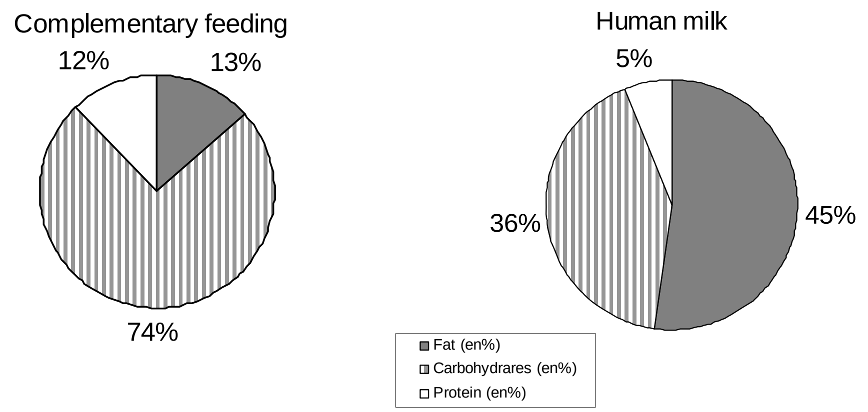

Figure 1. Analysis of the respective energy percent contributions of macronutrient inherent for each component of the diet of the infants

for infants in the 7th-9th and the 10th-12th month of life separately, conforming to the analysis level of Brown and colleagues.[2,10] As expected, the contribution of CF increased with age through the second semester of life. A similar calculation by 3-month bands was made for the modeled human milk calculations (*data not shown*).

Table 4. Percentage of infants meeting the Reference Nutrient Intake for selected nutrients, based on complementary feeding only and total estimated diet from total estimated 24-hr intakes, based on 3-day averages for 64 rural infants

	Percentage of infants meeting the RNI† (%)	
	Complementary feeding only‡	Human milk and complementary feeding combined§
Protein	59	97
Vitamin A	25	61
Vitamin B_1	63	83
Vitamin B_2	34	61
Vitamin B_3	61	70
Vitamin C	8	42
Folate	72	100
Calcium	6	11
Iron	6	6
Zinc	13	14

RNI, Reference Nutrient Intake
† RNI values for infants aged 7-12 mo old.[8]
‡ Based on 3 non-consecutive 24hr recalls.
§ Breast milk intakes were modelled based on age- and gender-specific energy requirements.[7]

Figure 1 shows pie-graph analysis of the respective macronutrient distributions inherent for each component of the diet of the infants. Almost three-quarters (75%) of the energy contribution of CF are from carbohydrates, whereas in human milk fat contributes almost half (45%) the energy. Analysis of the total estimated intake showed that CF contributed 67% of daily protein, 66% of daily carbohydrates and 36% of daily fat, with the remainder being contributed from the human milk.

As a second measure of nutrient adequacy, we took the nutrient estimates from the combined 3-day intake of complementary food and of estimated total consumption. From this standpoint, we assessed each child's values in relation to satisfying -- or not -- the corresponding RNI.[8] Table 4 shows the percentage of subjects who achieved the target intake just from their CF contribution, or including human milk. The ranking generally corresponded to the median analysis (above), but there was no nutrient for which 100% of the children achieved their RNI only with CF. The proportion of children achieving their RNI for calcium, iron and zinc was extremely low.

Finally, we took the convention of nutrient density as a point of comparison.[2,9] Table 5 shows that nutrient densities

Table 5. Nutrient density for estimated complementary foods based on 3-day averages for 64 rural infants, in relation to reference values from Dewey et al.[9] and human milk

Nutrient		Nutrient density as nutrient unit per 100 kcal			
		Infants' complementary foods†		Reference Value‡	Human Milk§
		Mean ±SD	median		
7th-9th mo (n=34)	Protein (g)	3.1±0.8	3.1	1.0	1.6
	Vitamin A (RAE)	68.2±57.9	53.5	31.0	74.5
	Vitamin C (mg)	4.7±4.1	3.8	1.5	6.0
	Vitamin B_1 (mg)	0.10±0.04	0.10	0.08	0.03
	Vitamin B_2 (mg)	0.08±0.05	0.07	0.08	0.05
	Vitamin B_3 (mg)	1.2±0.4	1.2	1.5	0.2
	Folate (DFE)	33±6	34	11	13
	Calcium (mg)	47±25	42	105	42
	Iron (mg)	1.1±0.4	1.0	4.5	0.04
	Zinc (mg)	0.6±0.2	0.5	1.6	0.2
10th – 12th mo (n=30)	Protein (g)	3.2±0.5	3.2	1.0	1.6
	Vitamin A (RAE)	80.7±66.5	54.0	30.0	74.5
	Vitamin C (mg)	3.2±2.3	2.8	1.7	6.0
	Vitamin B_1 (mg)	0.10±0.03	0.11	0.06	0.03
	Vitamin B_2 (mg)	0.09±0.03	0.09	0.06	0.05
	Vitamin B_3 (mg)	1.2±0.3	1.2	1.0	0.2
	Folate (DFE)	32±6	33	9	13
	Calcium (mg)	44±15	40	74	42
	Iron (mg)	1.1±0.4	1.0	3.0	0.04
	Zinc (mg)	0.6±0.2	0.6	1.1	0.2

RAE, Retinol Activity Equivalents; DFE, Dietary *Folate* Equivalent
† Based on 3 non-consecutive 24hr recalls; ‡ Recommended density for complementary feeding[9]; § Derived from the values for human milk nutrient content.[2]

Table 6. The ten leading sources of energy, protein, fat and carbohydrates of the total estimated diet, based on 192 responses in 64 rural infants

Rank	Energy	%†	Cum %‡	Protein	%†	Cum %‡	CHO	%†	Cum %‡	Fat	%†	Cum %‡
1	Human milk	40.7	40.7	Human milk	25.6	25.6	Human milk	28.4	28.4	Human milk	71.5	71.5
2	Table sugar	9.0	49.7	*Incaparina®*	13.0	38.6	Table sugar	15.0	43.4	Sweet rolls	3.2	74.7
3	White rolls	6.5	56.2	White rolls	8.4	47.1	Maize tortilla	8.2	51.6	Hard-boiled eggs	2.9	77.6
4	Maize tortilla	6.1	62.3	Pasta	6.5	53.5	White rolls	8.1	59.7	White rolls	2.2	79.7
5	*Incaparina®*	5.0	67.3	Maize tortilla	6.2	59.8	Rice	6.7	66.4	Maize tortilla	2.1	81.8
6	Pasta	4.8	72.0	Hard-boiled eggs	4.5	64.3	Pasta	6.2	72.7	Scrambled eggs	1.7	83.5
7	Rice	4.7	76.8	Beef broth	3.7	68.1	*Incaparina®*	5.7	78.4	Sausage	1.6	85.1
8	Sweet rolls	2.4	79.2	Rice	3.5	71.5	Oatmeal	2.3	80.7	Beef broth	1.3	86.5
9	Oatmeal	1.7	80.9	Scrambled eggs	2.9	74.5	Sweet rolls	2.1	82.8	Whole milk powder	1.6	88.1
10	Hard-boiled eggs	1.4	82.3	Whole milk powder	2.1	76.6	Potato	2.1	84.9	Vegetable oil	0.9	89.0
		82.3			76.6			84.9			89.0	

† Percent contribution ; ‡ Cumulative percent contribution.

Table 7. The ten leading sources of selected micronutrients of the total estimated diet, based on 192 responses in 64 rural infants

Rank	Vitamin A	%†	Cum %‡	Vitamin C	%†	Cum %‡	Vitamin B_1	%†	Cum %‡
1	Human milk	40.1	40.1	Human milk	52.2	52.2	Human milk	16.7	16.7
2	Table sugar	18.4	58.5	*Incaparina*®	10.5	62.7	White rolls	16.3	33.0
3	Carrot	11.8	70.3	Tomato	4.9	67.5	*Incaparina*®	13.6	46.6
4	Pumpkin	4.9	75.2	Papaya	4.4	71.9	Pasta	9.1	55.7
5	*Incaparina*®	4.6	79.8	Oatmeal	4.2	76.0	Rice	8.0	63.6
6	Beef broth	3.7	83.5	Squash	2.8	78.9	Oatmeal	7.3	70.9
7	Oatmeal	2.8	86.3	Potato	2.6	81.4	Chicken and noodle soup	4.6	75.5
8	Chicken broth	2.6	88.9	*Gerber*, apple-compote	2.5	84.0	Maize tortilla	4.0	79.5
9	Tomato	1.2	90.1	Banana	2.3	86.3	Sweet rolls	2.7	82.3
10	Squash	1.1	91.2	*Nestum*® whole wheat-milk	1.8	88.1	Potato	2.1	84.4
	Vitamin B_2			Vitamin B_3			Folate		
1	Human milk	28.5	28.5	*Incaparina*®	20.1	20.1	Human milk	21.2	21.2
2	White rolls	10.5	39.0	White rolls	14.1	34.2	*Incaparina*®	13.4	34.6
3	Oatmeal	8.4	47.4	Human milk	11.3	45.5	Maize tortilla	12.8	47.4
4	*Incaparina*®	6.3	53.8	Oatmeal	9.2	54.6	Pasta	9.7	57.1
5	Hard-boiled eggs	6.2	60.0	Rice	8.3	62.9	White rolls	9.3	66.4
6	Pasta	4.4	64.4	Pasta	7.0	69.9	Rice	8.7	75.1
7	Scramble egg	3.9	68.2	Maize tortilla	5.1	75.0	Oatmeal	6.1	81.2
8	Whole milk powder	3.2	71.5	Beef broth	3.1	78.1	Beef broth	2.4	83.6
9	Maize tamale	2.7	74.2	Potato	2.6	80.7	Squash	2.0	85.6
10	Beef broth	2.7	76.9	Chicken broth	2.3	83.1	Hard-boiled eggs	1.6	87.3
	Calcium			Iron			Zinc		
1	Human milk	38.0	38.0	*Incaparina*®	22.1	22.1	*Incaparina*®	23.6	23.6
2	*Incaparina*®	25.9	63.9	Oatmeal	17.5	39.6	Human milk	16.5	40.1
3	Maize tortilla	10.7	74.5	White rolls	9.1	48.7	Oatmeal	10.8	50.9
4	Whole milk powder	4.1	78.6	Rice	8.2	56.9	Maize tortilla	5.8	56.7
5	White rolls	4.0	82.6	Pasta	7.2	64.0	White rolls	4.7	61.4
6	Wheat-milk *Nestum*®	1.9	84.5	Maize tortilla	5.8	69.8	Pasta	4.1	65.5
7	Oatmeal	1.6	86.2	Human milk	2.8	72.6	Beef broth	3.7	69.2
8	Squash	1.5	87.6	Wheat-milk *Nestum*®	2.4	74.9	Rice	3.5	72.6
9	Fresh cheese	1.4	89.0	Beef broth	1.9	76.9	Wheat-milk *Nestum*®	2.4	75.0
10	Scrambled eggs	1.2	90.2	Chicken broth	1.9	78.8	Hard boiled egg	2.1	77.1

† Percent contribution.
‡ Cumulative percent contribution.

of the CF diet of this sample were above the required densities for most nutrients, but well below for calcium, iron and zinc.

As a final perspective on latter infancy feeding, we looked at the foods that made the principle contributions of the nutrients of interest to the intakes of this sample. Table 6 ranks foods and beverages as total energy and the individual macronutrients. Table 7 performs a similar contribution ranking for the 9 micronutrients.

DISCUSSION

Although exclusive breastfeeding is the prescribed and recommended mode of feeding for infants in the first 6 month of life,[11] there comes a time when the nutrient needs of the growing baby cannot be satisfied by maternal milk alone.[3] For that reason, the WHO calls for "*adequate, safe, and appropriate* CF".[1] An example of how far from satisfying the recommendation for exclusive breastfeeding during the first 6 month of life is found in a corner of the Guatemalan highlands. The village of Santo Domingo Xenacoj lies 11 km from the town, which was the site of the noted longitudinal growth study by Leonardo Mata in the 1960s and 1970s, *The Children of Santa Maria Cauque*.[12] The way of life in this Mayan region has undoubtedly changed through the introduction of electrical current, change in housing construction, and intra-domiciliary water.

A prudent interpretation of the qualitative and quantitative findings of this study can only be made with a proper appreciation of the limits and caveats of the design, methods and assumptions of the study. Two previous publications involving the same protocol have provided a detailed discussion of the limitations and their implications.[4, 5] The salient issues relate to the representativeness of the sample, the validity of the nutrient values for consumed foods, and the procedures and assumptions related to estimation of contribution of maternal milk to energy intake, and consequently to macro- and micronutrient consumption.

As a convenience sample, the universality of the findings for the entire community is in question. Intakes were recorded after both days of infant wellness and illness, the later of which could suppress appetite or alter caretakers' offering of food to the child. An estimation of nutrient intake from recall inquiries is only as good as the estimates of portion sizes and the food composition data upon which it is based. Three days of dietary record, moreover, may be insufficient to provide estimates of "habitual" nutrient intake, stable for the individual infant level. Finally, in the absence of access to full-day test weighing – or even of taking weights of infants on the days of interviews -- modeling of milk intake involving assumption of infant mass and satisfaction of daily energy requirements was required to formulate a full-diet estimation of nutrient intake. We feel that the findings for complementary food, both in aggregate mean contribution of nutrients and ranking various items' for their differential contribution are more robust.

Qualitative Feeding Pattern

The rate of offering of colostrum (87%) is very high as community studies go. Typical rates found were 69% in Giza, Egypt,[13] and 74% in Gwalior, India.[14] Other locations where more than 75% of children were offered colostrum were Pokhara, Nepal where 89% of the mothers feed colostrum,[15] Iraq where 93% of the women believed colostrum was good for their babies,[16] and 92% in Matlab, Bangladesh.[17] Other communities, such as the villages of the West Bengal State of India, demonstrate that generally, colostrum was discarded before putting the infant to the breast.[18]

The first violation of exclusive breastfeeding in Guatemala comes from the custom of offering prelacteal or postlacteal feedings of water or herbal teas, so-called *agüitas*, early in life, around the time of birth. This use of prelacteal feeds had a prevalence of three-quarters in our sample. This compares with 76% in Gwalior,[14] 57% in Eastern Uganda,[19] 52% in KwaZulu-Natal, South Africa,[20] 15% in Pokhara Nepal,[15] and 8% in Matlab, Bangladesh. In India, the first prelacteal food is generally hot water a few hours after birth.[18]

Aside from pre- or post-lacteal water and solutions, some mothers delayed introduction of a true complementary food up to the 9th month of life, but half of the infants had received their first food by 5 month of age. This compares to complementary food introduction to 73% of South African children having received solids by 2.5 month,[20] 50% of the infants in Phnom Penh, Cambodia were fed solids before 6 month,[21] and 65% were given food in their first month in Malawi.[22] Supplementary foods were given to a majority of infants within the first six month of life, in India.[18] Three percent of the infants had been given plain water by 1 month, in rural Bangladesh.[17] In the same sample 2% of the infants were given semisolid foods at 1 month, the median age of introducing complementary foods was 4 month of age. By this latter age in the Infant Feeding Practices Study II of U.S. infants, 40% of the infants had consumed infant cereal and 17% had consumed fruit or vegetable products, but less than 1% had consumed meat.[23] In Pohkara, Nepal, 40% of the mothers started CF before the recommended age of 6 month, whereas 22% delayed introduction of CF beyond the recommended age.[24] A subsample of the mothers in the Infant Feeding Practices Study II reported that 21% introduced solid foods before 4 month; and 20% fed juice before 6 month, whereas 7% introduced solids after 6 month.[25]

A wide variety of food items were mentioned as the first offering in our sample. Rural mothers often responded to the questionnaire query about first food with more than one item in response, as if when it came to the day to initiate CF, they explored a variety of options with their infants. Except for the two gruels and the commercial baby food, most of the top ten first foods were items from the family diet. Typical first foods in other settings are: porridge were the first foods offered to infants in Malawi,[22] in Phnom Penh, Cambodia the first solids was rice porridge.[21] In Matlab, Bangladesh, 7% of the infants were given fruit juices as first food and 13% of the infants were given cow milk at 1 month.[17] In rural Malawi, it is generally the grandmother of an infant who dictates what food is given to break the exclusivity of lactation.[22] In this community of Guatemala, a host of personages, related and unrelated to the mothers, were the counsellors related to the first food.

Commercial infant formulas represent a specific complementary food. Only 16% of our infants had ever been offered this item in our rural sample. This is well below frequencies seen in other settings such as 76% in KwaZulu-Natal by 14 weeks,[20] 52% of the mothers enrolled in the Infant Feeding Practices Study II, reported that their infants receive formula while in the hospital.[23]

Quantitative Nutrient Intake Considerations

The early, first-semester pattern of infant feeding of this rural community is far less than the ideal, but the concern that brought us to the study was related to the eminently quantitative issue of adequacy of nutrient intake in the CF phase. Specifically focusing on the CF intake estimates, it is difficult to make strict quantitative comparisons with other published literature. The uncertainties surrounding the contribution of human milk are the responsible factor. We have documented a number of publications presenting the conclusion that CF or total intakes were inadequate for second-semester infants, especially for calcium, iron and zinc but the judgment is subjective, lacking clear quantitative criteria in the majority.[17,26,27] In a 2008 study from Owino and collaborators[26] in Lusaka, Zambia similar to our own, in which modeling of breast milk intake was attempted, assuming medium breast milk intake, concluded that although the mothers or caretakers had wide knowledge of optimal infant feeding practices, they were constrained by food costs and time availability.

The concept of nutrient densities of complementary foods in breastfeeding children was first introduced by Brown *et al*. in 1998 and later updated in 2003 using more recent energy requirements.[2,9] These critical nutrient densities make it possible to explore the nutrient adequacy of several diet and feeding practices, even when breast milk intakes are not quantified. Since then, several authors have used this principle to identify '*problem nutrients*' in CF schemes across poulations.[21, 28-39] The overall consensus across these studies is the observation of low nutrient densities for calcium, iron and zinc.

Leading Sources of Nutrients

With respect to ranking of the leading sources of macro- and micronutrients, the only comparative article found was a publication for the U.S. population of infants and toddlers,[40] which is disaggregated to show the top 5 to 15 sources of foods for 6 to 11 month American infants. With respect to energy, Xenacoj infants showed human milk followed by sugar as the top two sources, compared to infant formula and human milk as the leading pair in the US The leading protein source at the Guatemalan site was human milk gruel compared to infant formula for North America. First among sources of carbohydrate in the highland village was human milk, followed by sugar, whereas in the US, these places were occupied by infant formula and infant cereal respectively. In terms of total fat, the number one Guatemalan source was breast milk, whereas infant formula filled that spot in the US.

In our sample human milk was the primary source of the selected micronutrient analyzed, with the exception of vitamin B_3, iron and zinc for which *Incaparina*® gruel was the main source. In the US study, infant formula was the primary source for micronutrients. The top sources for the '*problem nutrients*' were predominantly plant-based. The top 3 sources of calcium were human milk, *Incaparina*®, and maize tortilla, and these 3 foods covering almost three-quarters of daily requirements. Main sources for iron were *Incaparina*®, oatmeal and white rolls with human milk in the 7^{th} place and beef and chicken broth as only animal sources are numbers 9 and 10, respectively. Main sources of zinc were *Incaparina*®, human milk and oatmeal with beef broth at number 7.

Onyango *et al*. demonstrate in their study in Kenya that 32% of the total energy intake was supplied by breast milk.[41] Other nutrients studied, whose daily intakes were above estimated requirements were vitamins $B_{1,}$ B_3 and C and folic acid. Nutrients whose mean intakes fell short of estimated requirements were calcium (72%), iron (74%), vitamin A (78%), vitamin B_2 (63%), and zinc (33%). Lander and collaborators showed in Mongolia that the energy intakes from complementary diets, primarily from cereals and non-nutritious snacks, were above WHO-estimated needs;[36] whereas less than 1% of energy was from meat and eggs or fruits and vegetables.

CONCLUSIONS

In conclusion, early infant feeding in this rural, Mayan village seems to be combining traditional practices, such as the offering of pre- and post-lacteal water and solutions and predominant maternal milk. By 6 month, we could find an ample number of infants consuming one or more complementary foods to constitute a sample; within this selection, more energy and micronutrients came from CF than breast milk. The degree of satisfaction of recommended nutrient intakes supported by CF proved to be superior to that which has generally been reported in the international literature, although deficits for the traditional '*problem nutrient*' of calcium, iron and zinc were dramatically manifested in rural Guatemala as well.

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AUTHOR DISCLOSURES

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Original Article

Contribution of complementary food nutrients to estimated total nutrient intakes for rural Guatemalan infants in the second semester of life

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瓜地馬拉鄉村嬰兒輔食品攝取對整體營養的貢獻

背景：在發展中國家，添加嬰兒輔食品的時機經常太早或太遲，且輔食品品質普遍不良，尤其是鄉村地區，傳統上是以澱粉類粥食為主。從這些傳統的輔食品中較不易攝取充足的營養素。目的：探討瓜地馬拉嬰兒的輔食品對整體營養素攝取的貢獻。方法：以便利取樣方式從 Santo Domingo Xenacoj 的瓜地馬拉高原村落中，抽出 64 位 6-12 個月的嬰兒的母親，挑非連續的三天實施 24 小時飲食回憶問卷。並額外調查哺乳前後餵食的食物及首項添加的輔食品和飲料。根據體重計算嬰兒熱量需求，並假設除輔食品外，是由母乳滿足其餘熱量需求，由此估算母乳攝取量。依據 2004 年 WHO/FAO 的營養素建議攝取量判定營養素是否攝取足夠。結果：完全哺餵母乳達六個月的母親非常稀少。大多數營養素平均攝取量和密度皆達標準，除了鈣、鐵和鋅。營養素攝取量較多來自輔食品。由於強化糖的關係，維生素 A 攝取量過多。結論：大多數營養素攝取量接近標準，這與多數文獻的輔食品添加經驗不相同。而鈣、鐵和鋅的不足和過去發展中國家的研究結果一致。

關鍵字：母乳、輔食品、嬰兒餵食、微量營養素攝取、瓜地馬拉