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Original Article

Excess sodium and insufficient iron content in complementary foods

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Abstract

Objectives: To determine, by chemical analysis, the macronutrient, energy, sodium, and iron contents of homemade foods prepared for infants in two socioeconomic classes in Belém, state of Pará, Brazil.

Methods: Cross-sectional study of 78 infants (aged 6 to 18 months) distributed into two groups according to socioeconomic status (high or low). Chemical analyses were performed on samples of homemade complementary foods prepared for each infant's lunch. Daily food intake was estimated on the basis of two 24-hour dietary intake recall.

Results: Chemical analyses showed that the energy content of some food samples was lower than recommended, both in the low socioeconomic status (SES) group (29.8% of samples) and in the high-SES group (43.0%; p = 0.199). The iron content of all samples, regardless of group, was lower than minimum recommended levels (6.0 mg/100 g). On the other hand, excessive sodium levels (200 mg/100 g) were found in 89.2 and 31.7% of samples in the low- and high-SES groups, respectively (p = 0.027). Dietary recalls showed that energy intake exceeded 120% of the Estimated Energy Requirement in 86.5% of infants in the low-SES group and 92.7% of those in the high-SES group (p = 0.483). Lunch and dinner provided 35.2±14.6 and 36.4±12.0% of daily energy intake in the low- and high-SES groups, respectively (p = 0.692).

Conclusion: Homemade complementary foods for infants were found to be low in iron. A significant portion of samples had excessive sodium content, most frequently those prepared for infants in low-SES families.

J Pediatr (Rio J). 2010;86(4):303-310: Infant food, food composition, food analysis, nutritional status.

Introduction

Human habits and customs have been changing in recent years, and may interfere with quality of life and life expectancy. An inadequate diet in the first year of life may have an influence on the onset of noncommunicable chronic diseases in adulthood.[1] Infant transition to solid foods is influenced not only by nutrient requirements, but also by the cultural habits of each region.[2] This transition is often conducted inappropriately; nonetheless, there have been few studies on the chemical composition of homemade infant foods.[3,4] These studies have shown that homemade infant foods contain excessive amounts of sodium and provide insufficient iron. Worthy of note, the sodium content of complementary infant foods may determine future preference for salty foods, and may also

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be associated with higher blood pressure in childhood and adulthood.[5,6] Furthermore, iron deficiency is highly prevalent among infants in several regions across the world,[7] and complementary foods should be iron-rich in order to prevent this nutritional deficit disorder. Iron deficiency is most frequent in low socioeconomic status (SES) populations; this suggests that the quality of transition foods may differ according to the socioeconomic status of a given region or population.[8]

In light of the above, this study sought to assess, by chemical analysis, the macronutrient, energy, sodium, and iron content of homemade infant lunches prepared by families from two distinct socioeconomic classes in Belém, state of Pará, in the eastern Amazon region of Brazil. We also assessed the quantitative role of complementary foods as a nutrient source in relation to the Dietary Reference Intakes.

Methods

In a cross-sectional study conducted between June 2005 and September 2006, 78 samples of homemade complementary foods were analyzed. The infant for whom the food was prepared had to meet the following criteria for inclusion into our convenience sample: 1) absence of clinical evidence of acute infectious disease or chronic or degenerative conditions; 2) age between 6 and 18 months; 3) diet including complementary foods prepared exclusively at homes located in the municipality of Belém. Free and informed consent forms were signed by the children's parents or guardians. The project was approved by the Research Ethics Committee of Universidade Federal de São Paulo – Escola Paulista de Medicina (UNIFESP-EPM), São Paulo, Brazil.

Iron content was chosen as the determinant of sample size, as iron deficiency is the most common nutritional deficiency in infants and was found to be one of the main inadequacies of complementary foods in a prior study of foods adapted for infant consumption from family meals.[9] We estimated that 65% and 35% of foods would provide insufficient iron content in the lower and higher socioeconomic groups respectively – that is, a 30% difference between groups – and estimated 33 children for each group. As a precaution, the study sample ultimately included 78 children and their respective food samples.

Food samples were collected at home from families seen at two pediatric care settings: 1) the public outpatient clinic at the Maternal and Child Health Unit of the Universidade do Estado do Pará (UEPA), Belém, Brazil; and 2) four private practices in Belém. This strategy was used to obtain children from different socioeconomic backgrounds for the sample.

Inclusion in the study was followed by an interview with the infant's mother, physical examination and measurement of weight and height, 24-hour dietary recall, and collection of a homemade complementary food sample for chemical analysis at the infants' homes.

A questionnaire on clinical information and feeding history of the child was filled out on the day of admission to the study. Socioeconomic status was determined according to the Brazilian Economic Classification Criterion developed by the Brazilian Association of Research Companies (Associação Brasileira das Empresas de Pesquisa, ABEP).[10]

Twenty-four-hour dietary recalls were conducted on the day of inclusion and upon collection of the food sample (approximately two weeks apart). Nutrient calculations were performed with the Nutrition Decision Support System (NutWin) software package. Intake values were compared to the dietary reference intakes (DRIs).[11] The following categories were taken into account: estimated energy requirements (EER); estimated average requirement (EAR), recommended dietary allowances (RDA); and adequate intake (AI).

During the initial interview, the researcher recorded the usual time of the infant's lunch; the study visit was then performed at this time, without prearrangement, to ensure collection of a sample of food prepared as usual. Samples were analyzed in duplicate at the UNIFESP Laboratory of Food Science and Microbiology, following standard methods for the determination of protein, fat, carbohydrate, and iron content, as well as total energy.

The energy density of each sample was compared to the values set forth in Brazilian Ministry of Health Ordinance no. 34[12] on complementary foods for infants and young children. Protein, fat, iron, and sodium contents of the analyzed samples were compared to the reference values established by European Community Commission Directive 2006/125/EC[13] on foods for infants and young children.

Assessment of compliance with acceptable macronutrient distribution ranges (AMDRs)[12] followed values established for the 1-to-3-year old children (5 to 20% of energy from protein; 30 to 40% from fat; and 45 to 65% from carbohydrate), as there are no recommended ranges for the first year of life.

Weight-for-age, height-for-age, and weight-for-height z scores were calculated with the WHO Anthro 2.0[14] software package. Assessment of the nutritional status were defined according to the cutoffs established in a preliminary document published by the Food and Dietary Surveillance System.[15]

Parametric and non-parametric statistical methods were employed depending on whether variables had a normal distribution. The significance level was 5%. Calculations were performed with the Epi-Info v.6.04 and SigmaStat for Windows v.2.0 software packages. Results are presented with their respective statistical tests.

Results

Of the 78 infants included in the study, 37 were assigned to the low socioeconomic status group (social classes C, D, and E as defined in the Brazilian Economic Classification Criterion) and 41 to the high socioeconomic status group (Brazilian Economic Classification Criterion classes A and B). In the low SES group, 19 infants were female (51.4%), whereas the high SES group comprised 15 girls (36.6%; p = 0.191, chi-square test). In the low SES group, 18 infants were between the sixth and twelfth month of life, and 20 were aged 12 to 18 months. In the high SES group, the number of infants in each of the above age ranges was 19 and 21 respectively (p = 0.990, chi-square test). Z scores were as follows, in the low and high socioeconomic status groups respectively: weight-for-age, +0.39±0.39 and +0.99±1.35 (p = 0.026); weight-for-height, +0.61±0.97 and +0.65±1.12 [p = 0.864, mean ± standard deviation (SD), Student *t* test for weight-for-age and weight-for-height]; and height-for-age, +0.03 and +0.94 (median, Mann-Whitney U; p = 0.014). No children with a weight-for-age or weight-for-height deficit (z score < -2.0 SD) were found in either group. A height-for-age deficit (stunting) was found in 10.8% of infants in the low socioeconomic status group and 2.4% of those in the high socioeconomic status group.

Excess weight for height (z score > +2.0 SD) was found in 10.8 and 16.9%, of infants in the low and high socioeconomic status groups respectively. Regarding maternal age, five (13.5%) mothers in the low SES group were younger than 20 years, whereas none in the high SES group fell within this age interval (p = 0.015, chi-square test). The percentage of mothers with more than 12 years of formal education was higher in the high SES group (65.8%) than in the low SES group (43.2%; p = 0.017, chi-square test).

Table 1 shows the results of macronutrient, energy, iron, and sodium analyses of the homemade infant food samples according to socioeconomic group. Water, protein, fat, carbohydrate, and iron content were similar in both groups. Foods prepared for infants in the low socioeconomic status group had higher carbohydrate content (10.9±4.3/100 g) than those prepared for infants in the high SES group (9.0±4.5/100 g); however, this finding did not reach statistical significance (p = 0.078). Furthermore, prepared for infants in the low socioeconomic status group contained higher amounts of sodium (p = 0.005) than did those prepared for infants in the high SES group.

Table 2 shows the energy and nutrient adequacy of homemade infant lunch samples, as determined by chemical analysis, in comparison with levels recommended by the Brazilian Health Ministry[12] and in European Community Directives.[13] Excessive sodium content was found more frequently (p = 0.027) in foods prepared at low-SES homes (89.2%) than in foods prepared for infants in the high SES group (31.7%). Iron content was below recommended levels in all samples from both socioeconomic groups. There was no difference between groups in the percentage of samples having adequate energy, protein, and fat content. However, 29.8 and 43.9% of samples in the low and high SES groups respectively were found to have energy density below the minimum recommended levels for complementary infant foods.

Table 2 also shows the mean percentage of total energy obtained from macronutrients. Only percentages of energy obtained from carbohydrates were within the expected range. In both groups, percentage of energy obtained from protein exceeded the recommended range; percentages were highest in the high SES group (p = 0.035). Percentage of energy obtained from fat, on the other hand, was lower than recommended in both groups.

Table 1 - Chemical composition of homemade infant lunches, as determined by laboratory analysis, according to socioeconomic status

	Socioeconomic status		
Content/100 grams of food	**Low (n = 37)**	**High (n = 41)**	**p**
Water (g)*	79.0±7.5	80.3±7.7	0.451
Protein (g)†	4.3 (3.1-7.3)	4.9 (2.7-7.9)	0.681
Fat (g)†	1.4 (0.6-2.4)	1.6 (0.6-2.4)	0.795
Carbohydrates (g)*	10.9±4.3	9.0±4.5	0.078
Energy (kcal)*	80.6±33.7	74.1±33.0	0.395
Iron (mg)†	1.3 (0.9-1.5)	1.5 (1.1-1.8)	0.184
Sodium (mg)*	363.2±148.3	269.3±138.0	0.005

* Mean and standard deviation, Student *t* test.
† Median and 25th and 75th percentiles, Mann-Whitney U.

Table 2 - Adequacy of measured energy, protein, fat, iron, and sodium content as compared with levels recommended by the Brazilian Ministry of Health[12] (energy) and European Community Directives[13] (protein, fat, iron, and sodium) and mean percentage of energy from macronutrients in homemade infant lunches according to socioeconomic status

	Socioeconomic status		
Nutrients	**Low (n = 37)**	**High (n = 41)**	**p**
Adequacy in comparison with recommended levels			
Energy (no less than 70 kcal/100 g)*	26 (70.2%)	23 (56.1%)	0.199
Protein (no less than 3.0 g/100 kcal)*	35 (95.0%)	40 (97.6%)	0.499
Fat (no more than 4.5 g/100 kcal)*	35 (95.0%)	40 (97.6%)	0.499
Iron (no less than 6.0 mg/100 g)	0 (0.0%)	0 (0.0%)	NA
Sodium (no more than 200 mg/100 g)*	4 (10.8%)	28 (68.3%)	0.027
Mean percentage of energy from macronutrients			
From protein (expected range: 5-20%)†	25.2±8.5%	29.5±9.1%	0.035
From fat (expected range: 30-40%)†	18.9±11.6%	21.6±9.7%	0.505
From carbohydrates (expected range: 45-65%)†	55.8±14.5%	49.9±13.2%	0.066

NA = not analyzable.
* Mantel-Haenszel chi-square test.
† Mean ± standard deviation, Student *t* test.

Table 3 shows estimated daily intakes as determined by averaging the results of two 24-hour dietary recalls. There was no statistically significant difference between groups in terms of mean protein, carbohydrate, fat, and iron intake or observed intake as a percentage of DRI. Notably, intakes were within the expected range in most infants. Iron intake was found to exceed the DRI in most infants. Mean sodium intake was higher among infants in the low socioeconomic status group; the percentage of children whose sodium consumption was 120% or more of AI was higher in the low SES group, but the difference was not statistically significant (p = 0.089).

Table 4 shows the contribution of lunch and dinner meals to total daily intake. There was no statistically significant difference between socioeconomic groups in the percentage of daily intake obtained at lunch. Homemade lunch and dinner meals account for approximately 35% of total energy and 75% of sodium intake.

Discussion

As expected, the low socioeconomic group had a higher number of mothers younger than 20 years and with less than 12 years of formal education. Infant weight-for-age and weight-for-height were similar in both socioeconomic groups; mean z scores were lower in the low socioeconomic status group, though within expected values (+0.03). No infants with a weight-for-age or weight-for-height deficit (z score < -2.0 SD) were found in either group (results not shown). These data are consistent with the profound changes observed in the epidemiological profile of Brazilian diets, characterized by a transition from the malnutrition/infection complex to the obesity/chronic degenerative disease complex.[16] Even though we used a convenience sample, the two groups that provided food samples seemed to reflect the socioeconomic profile found in Brazil. Our purpose was to assess whether there were differences in the nutritional content of homemade foods according to socioeconomic class.

The difference in meal quality between both socioeconomic groups was apparent in one of the most compelling findings of this study, shown both by chemical analysis of complementary food samples and by dietary assessment: excess sodium intake. This issue was found to be even worse in the low socioeconomic status group. Chemical analysis showed that only 10.8 and 68.3% of samples in in the low and high SES groups respectively contained less than 200 mg sodium/100 grams, as recommended by the European Community for industrialized infant foods. This standard was adopted in the absence of reference levels for homemade infant foods. These results are similar to those few studies found in the international literature. Our review came upon three studies. One, conducted in the U.S., found that 64% of 70 samples of homemade infant foods destined for infants aged 3 to 14 months contained excessive amounts of sodium.[17] The other two, conducted

Table 3 - Estimated daily intake (average of two 24-hour dietary recalls) and Dietary Recommended Intakes, according to socioeconomic status

	Socioeconomic status		
Nutrients	**Low (n = 37)**	**High (n = 41)**	**p**
Energy			
Estimated daily intake (kcal)*	1,386±328	1,378±395	0.919
Intake as percentage of EER			
< 80%	01 (2.7%)	0 (0.0%)	
80-120%	04 (10.8%)	03 (7.3%)	0.483†
> 120%	32 (86.5%)	38 (92.7%)	
Protein (g)			
Estimated daily intake (g)*	56±16	60±21	0.462
Intake as percentage of RDA			
> RDA	37 (100.0%)	41 (100.0%)	NA
Fat			
Estimated daily intake (g)*	45±14	45±15	0.914
Carbohydrates			
Estimated daily intake (g)‡	200 (139-242)	177 (140-243)	0.631
Intake as percentage of EAR			
80-120% of EAR	7 (18.9%)	7 (17.1%)	NA
> 120% of EAR	30 (81.1%)	34 (82.9%)	
Iron			
Estimated daily intake (mg)*	9±4	11±6	0.267
Intake as compared to EAR and RDA			
< -2.0 standard deviations from EAR	2 (5.4%)	3 (7.3%)	
≥ -2.0 standard deviations from EAR to < EAR	2 (5.4%)	8 (19.5%)	0.150†
≥ EAR ≤ RDA	16 (43.2%)	10 (24.4%)	
> RDA	17 (46.0%)	21 (51.2%)	
Sodium			
Estimated daily intake (mg)‡	1,556 (1,094-2,241)	1,250 (738-1,868)	0.020
Intake as percentage of AI			
< 80%	3 (8.1%)	3 (7.3%)	
80-120%	0 (0.0%)	5 (12.2%)	0.089†
> 120%	34 (91.9%)	33 (80.5%)	

AI = adequate intake; EAR = estimated average requirement; EER = estimated energy requirement; NA = not analyzable; RDA = recommended dietary intake.
* Mean ± standard deviation, Student *t* test.
† Chi-square test.
‡ Median and 25th and 75th percentiles, Mann-Whitney U.

in Spain[4] and England,[3] found excess sodium levels in 24 and 31% of analyzed samples respectively.

According to dietary assessment, median daily sodium intake was 1,556 and 1,250 mg in the low and high socioeconomic status groups respectively (p = 0.020). Upon comparison of estimated intake to recommended AI, intake in both groups was found to exceed adequate levels; 51.4 and 31.7% of infants in the low and high SES groups respectively consumed amounts of sodium above the tolerable upper intake level (UL). In Finland, mean sodium intake in 13-month-old infants has also been found excessive (1,650 mg/day).[18] The only data available for Brazil showed high sodium content in all laboratory analyses of homemade meal samples.[9]

As shown in Table 4, lunch and dinner account for 73.0 and 79.2% of sodium intake in low and high socioeconomic status groups respectively (median values). Therefore, the importance of complementary food quality to the development of healthy eating habits and preferences cannot be overstated, as these habits are acquired early in life and the common preference for salty foods is probably not innate, but rather acquired.

When children are regularly offered salty foods, the habit of consuming such foods may persist into adulthood. Hence,

Table 4 - Percentage contribution of lunch and dinner to total daily intake, as determined by dietary recalls, in each socioeconomic group

	Socioeconomic status		
Nutrients	**Low (n = 37)**	**High (n = 41)**	**p**
Energy (kcal)			
% lunch*	18.7±8.2	18.5±7.2	0.829
% dinner*	17.0±7.2	17.9±6.3	0.593
% lunch + % dinner*	35.2±14.6	36.4 ±12.0	0.692
Protein (g)			
% lunch*	29.8±13.7	31.0±13.6	0.705
% dinner†	19.3 (16.1-30.5)	29.4 (20.0-36.2)	0.024
% lunch + % dinner*	53.4±19.2	59.2±20.0	0.191
Fat (g)			
% lunch†	13.5 (7.96-19.2)	14.8 (10.7-20.1)	0.136
% dinner†	12.8 (10.5-17.0)	16.2 (11.0-21.9)	0.040
% lunch + % dinner†	26.3 (20.1-35.7)	32.8 (22.7-42.5)	0.073
Carbohydrates (g)			
% lunch*	16.2±7.9	14.6±6.4	0.326
% dinner*	15.7±8.6	14.2±6.5	0.383
% lunch + % dinner*	31.9±15.4	28.8±11.2	0.308
Iron (mg/24 h)			
% lunch†	30.4 (21.1-48.0)	27.7 (18.2-41.5)	0.459
% dinner†	27.5 (11.9-41.5)	25.2 (18.4-32.9)	0.841
% lunch + % dinner*	62.8±26.4	59.1±23.9	0.512
Sodium (mg/24 h)			
% lunch†	42.2 (30.5-52.5)	39.4 (27.8-46.6)	0.423
% dinner*	28.3±15.1	30.8±13.4	0.428
% lunch + % dinner†	73.0 (55.2-86.4)	79.2 (57.4-84.8)	0.912

* Mean ± standard deviation, Student *t* test.
† Median and 25th and 75th percentiles, Mann-Whitney U.

intervention at the early stages of life plays an important role in preventing the acquisition of undesirable dietary habits.[19,20] A study analyzing maternal behavior and child feeding practices with regard to sodium intake found that 40% of mothers had salted foods without first tasting them at least once, and that 19% did so every time.[20]

Excessive amounts of dietary sodium reflects the adult Brazilian population's habit of favoring salty foods. Studies conducted in Brazilian populations have detected high salt intake, in excess of 12 g/day. Salt intake is markedly influenced by socioeconomic status, and may explain, at least in part, the high prevalence of hypertension among those in the lower socioeconomic class.[21,22] The relation between excess sodium in infant diets and hypertension has been pointed out in some studies, which have shown an association between excessive sodium consumption in early life and higher blood pressure in the first year of life[23] and during adolescence.[5]

In addition to sodium, protein is also consumed in quantities superior to those recommended, as shown by the dietary assessments performed in the present study (Table 3). Chemical analysis of complementary foods showed that at least 95% of samples met the minimum recommended protein content, with protein accounting for more than 20% of total energy intake. Excess protein intake may lead to renal overload and hypertension.[24] One study has reported an association between high protein intake in the first years of life and obesity during school age and adulthood.[25] Other studies conducted in Brazil[26] and elsewhere[27] have shown, on the basis of estimated intake, that infants consume more protein than recommended.

As far as other macronutrients are concerned, chemical analysis of complementary food samples showed that mean energy obtained from carbohydrates was within the recommended range, whereas the percentage of energy obtained from fat was below recommended levels. Food energy density was inferior to that recommended by European Community directives in 70.2 and 56.1% of samples from the low and high SES groups respectively. Nonetheless, dietary assessment showed that total energy intake exceeded recommended levels, which may be explained by high levels of carbohydrate in milk feeding bottles[28] or excessively large servings of complementary foods.[29] Unhealthy or junk foods are also a possible energy source, as found in a recent study by the Brazilian Ministry of Health.[30] In this report, in the 24 hours prior to assessment, 71.7% of infants aged 9 to 12 months in the sample had eaten biscuits, cookies, or processed snack foods, 11.6% had consumed soft drinks, and 8.7% had drunk coffee.[30] The contribution of these unhealthy foods toward total energy intake warrants future investigation.

On chemical analysis, all samples were found to have iron levels below the recommended minimum of 6 mg/100 g. Dietary assessment of both groups found that iron intake exceeded RDA in roughly half of infants, and fell somewhere between iron EAR and RDA in another portion of subjects.

Complementary foods provided at lunch and dinner accounted for 60% of dietary iron intake in both study groups. These data contradict the prevalence of iron deficiency in this age range detected at the same basic health unit – 70% of infants were affected, with 55% having iron deficiency anemia, the most severe stage of this deficiency.[31]

The content and bioavailability of iron in complementary foods should be investigated further, in light of the importance of these foods as a source of iron from the second semester of life onwards. One example of the importance of varying iron bioavailability across different foods is the poor intestinal absorption of iron when it is added to whole cow milk.[32]

Caution is recommended in extrapolating the results of this sample to a broader universe of infants. Nonetheless, data obtained from the study populations seem to reflect those found in several regions throughout the world in which overweight has superseded malnutrition,[33] as found in part of both groups included in the present study. Taking into account that sample size was calculated exclusively on the basis of prevalence of iron deficiency, our results suggest that a larger sample size would have shown a statistically significant difference in carbohydrate values, both those measured in laboratory analyses and those derived from dietary assessment, between the two groups.

In conclusion, in both groups, complementary foods prepared for lunch and dinner account for roughly 35% of total daily energy, 60% of daily iron, and 75% of daily sodium intake. Chemical analysis revealed low iron content in these complementary foods. A significant portion of samples, particularly those prepared for low socioeconomic status infants, had excessively high levels of sodium.

Educational strategies that foster the preparation of nutritionally adequate complementary foods must be developed, as the transition to solid foods occurs at a stage that is particularly important to the development of healthy eating habits and the prevention of chronic diseases in adulthood.

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