Ecology of Food and Nutrition, Vol. 37, pp. 339–353
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NUTRITIVE VALUE OF SELECTED MILK AND MILK-CEREAL BLEND BABY FOODS IN SAUDI ARABIA

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(Received December 6, 1997; in final form April 7, 1998)

The nutritional quality of six baby foods based on milk or milk-cereals consumed in Saudi Arabia, was evaluated by means of chemical and biological assays. The baby foods (milk-based vs milk-cereal) provided (per 100 kcal) protein (5.0–5.3 g vs 2.8–3.9 g), fat (5.5–5.6 g vs 2.0–4.5 g), carbohydrates (7.2–7.4 g vs 12.1–16.5 g), Ca (188–200 mg vs 115–180 mg), P (146–153 mg vs 80–105 mg) and Fe (0.18–0.20 mg vs 1.5–2.0 mg). Metabolizable energy (ME) varied between 476–480 kcal vs 390–454 kcal/100 g. The content of linoleic acid were lower and saturated fatty acids were higher in milk-based foods than milk-cereal blends. Most of the baby foods were inadequate in linoleic acid to meet the Codex requirements. An imbalance of calories from protein, fat and carbohydrates was found. The true protein digestibility (TD), net protein utilization (NPU) and net dietary protein calorie percent (NDp cal %) in milk-based vs milk-cereal blends ranged from 94–95% vs 92–95%, 0.72–0.74 vs 0.72–0.76 and 14.4–16.0% vs 8.4–11.9% respectively. Low protein quality reflects the influence of processing techniques and storage conditions.

KEY WORDS: Nutritional quality, milk-based food, milk-cereal blends, fatty acids, protein quality, Saudi Arabia

INTRODUCTION

In recent years there has been an increasing concern about the changing patterns of infant feeding particularly in societies in rapid transition. In Saudi Arabia, mothers breast feed their

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children traditionally for two years (Abdullah *et al.*, 1982). However, a successive decline in the duration of breast feeding with increasing affluence, and the late introduction of weaning foods have been reported (Serenius *et al.*, 1988). The energy vs protein intakes of Saudi children 1–3 years and 4–5 years have been reported to be 66% vs 150% and 64% vs 139% of RDA respectively (Sawaya *et al.*, 1985; Khan and Al-Kanhal, 1998), indicating energy deficiency in their diets. Under such situations, the protein in the diet provides energy and may become a limiting factor in the diet, resulting in the risk of protein energy malnutrition (Khan, 1990).

Several studies have indicated that breast fed infants may gain developmental and intellectual advantages over formula fed infants (Lucas *et al.*, 1992). An imbalance of food energy and nutrients, affecting the quality of commercial baby foods have been reported (Al-Othman *et al.*, 1997; Khan and Al-Kanhal, 1997). The order of limiting amino acids in infant formulas was methionine plus cystine, tryptophan and lysine (Khan and Al-Kanhal, 1997). The country has been importing 445,000 tons of milk and milk products every year (FAO, 1996). There were thirty-six different types of infant and weaning foods available in the market, consumed by 30% of the babies in the country (Al-Frayh, 1986; Sawaya *et al.*, 1985). About 90% of the bottle fed babies received powdered milk as a complete substitute or a supplement for breast milk/infant formula and dairy products, mainly milk, contributed (% of intake), energy 71%, protein 78%, calcium 90%, iron 39% and vitamin A (RE) 85% to Saudi infants (Sawaya *et al.*, 1985). Since adequate information on their nutritional quality was not available, the present study was planned to evaluate the nutritional quality of instant milk-based (powdered milk) and milk-cereal blends, chemically, including fatty acid analysis, and biologically in growing rats.

MATERIALS AND METHODS

Selection of Baby Foods

Two different types of baby foods i.e. milk-based (powdered milk as replacement for infant formula introduced during early infancy) and milk-cereal blends (weaning foods as supplement usually introduced at 6–12 months) were selected on the basis of their popularity and availability in Riyadh city. The full cream milk-based products: Klim (Denmark), Anchor (New Zealand) and Coast (Holland) and partially skimmed milk-cereal blends namely Cerevit with wheat (Holland), Cerevit with rice (Holland) with added fruits and Milupa 1, a blend of milk with rice (Germany) were purchased from the market.

Chemical Analysis

Moisture, crude protein ($N \times 6.25$), crude fat, ash and mineral elements were determined by official methods (AOAC, 1990). Available carbohydrates were calculated by difference. The energy value was determined by using Gallenkamp Ballistic Bomb Calorimeter and metabolizable energy (M.E) was calculated (Miller and Payne, 1959). For the determination of minerals, 1–2 g samples were ashed in duplicate, dissolved in 20% HCl. The content of Ca, P and Fe were determined by using a Model 400 Perkin-Elmer atomic absorption spectrophotometer according to AOAC (1990). For the estimation of fatty acids, the solvent extracted oil was transesterified by sodium methoxide and the resulting fatty acid methyl esters were analyzed by gas liquid chromatography. The G.L.C. was performed by using Schimadzu Gas Chromatograph with flame ionization detector and adopting the following conditions according to Thies (1971). Column: glass column (2.1 meter/3.2 mm), packed with 3% sp 2310/2% sp 2300 coated chromosorb W AW, carrier gas: hydrogen at a flow rate of 20 ml/min, column temp 230°C, kept isothermal during the analysis, injector and detector temp were 260°C. Fatty acid methylesters were identified by comparing their relative retention times with those of the pure compounds analysed under the same conditions. Results are expressed as % wt/wt of all fatty acids detected.

Biological Evaluation

The experimental diets were prepared by mixing milk products with corn starch to calculate protein level of 10% and supplementing with 5% corn oil, 5% vitamin and mineral mixture. A protein free diet containing corn oil 5%, glucose 15%, vitamin and mineral mixture 5% and corn starch 75% was included to measure metabolic faecal nitrogen. A casein based diet served as control.

The experimental procedure has been described (Khan and Munira, 1978). Sixty four weaning Albino rats, 23 days old were used. The rats were given stock diet (20% protein) for 7 days and were randomly divided to groups of four rats each. The experimental diets containing 10% protein were randomly assigned to these groups in such a way that each diet was fed adlibitum to two groups of rats for a period of ten days. The true protein digestibility (TD), net protein utilization (NPU) and biological value (BV) were estimated (Miller and Bender, 1955). Net dietary protein calorie percent (ND pcal %) was calculated according to Miller and Payne (1961). The data were subjected to statistical analysis by applying Tukey's paired comparison Procedure (Daniel, 1987).

RESULTS AND DISCUSSION

The chemical composition of baby foods is given in Table I. The protein content (g/100 kcal) was higher ($P < 0.01$) in milk-based foods (5.0–5.3 g) than milk-cereal blends (2.8–3.9 g). According to FAO/WHO Codex Alimentarius Commission Standards for infants formulas, the protein content should range from 1.8–4.0 g/100 kcal (FAO/WHO, 1989). In the present study, the protein content of milk-based foods was higher than the upper limit of the standard (4.0 g/100 kcal), human milk (1.5 g/100 kcal) and protein content of 2.20–2.95 g, 2.20–2.62 g, and 2.24–2.83 g/100 kcal of baby foods consumed in Canada, Sweden and in Western European countries respectively (Sarwar *et al.*, 1989; Abrahamsson and Hambraeus, 1977; Pompei *et al.*, 1987). However, the protein levels of milk-based foods in the present study were similar to protein content of baby foods (3.2–6.0 g/100 kcal) used in Pakistan (Khan and Kissana, 1985). Data based on growth and plasma free amino acid levels

TABLE I
Chemical composition (per 100 kcal) of milk or milk-cereal blends

Products	g/100 kcal					kcal/100 g		mg/100 kcal		
	Protein (N × 6.25)	Fat	Carbo-hydrate	Crude fibre	Ash	Total	Meta-bolizable	Ca	P	Fe
Milk-based										
Klim	5.0	5.6	7.4	0	1.1	508	480	198	146	0.19
Anhor	5.3	5.5	7.2	0	1.1	505	477	188	148	0.20
Coast	5.0	5.6	7.2	0	1.2	505	476	200	153	0.18
Milk-cereal blends										
Cerevit (wheat)	3.8	2.0	16.5	0.2	0.7	416	393	146	97	2.0
Cerevit (rice)	3.9	2.2	16.2	0.2	0.8	412	390	180	105	1.9
Milupa 1	2.8	4.5	12.1	0.2	0.6	480	454	115	80	1.5

supported a recommendation for lowering the upper limit value to 3.5 g/100 kcal (Young and Pelletier, 1989). According to Beaton and Chery (1988) a formula containing 1.45–1.70 g protein/100 kcal would cover protein needs of 90–97.5% of infants. The protein levels in milk-based foods in the present study, on comparing with these recommendations, appear to be very high for the young, healthy infant. Feeding high protein levels to infants did not offer advantage in terms of growth (Jeans *et al*., 1985) and may result an imbalance and disturbance in plasma and tissue amino acids concentration (Raiha, 1989) leading to increase glomerular filtration rate (Herin and Zetterstorm, 1987), increase urinary excretion of Ca (Hegsted *et al*., 1981), negative effect on plasma Zn levels (Lonnerdal and Chen, 1990) renal glomerular sclerosis (Brenner *et al*., 1982) and influence neurochemistry and development during infancy (Patridge, 1986; Jarvenpaa *et al*., 1982). The protein content in milk-cereal blends ranged from 2.8 g/100 kcal in Milupa 1 to 3.9 g/100 kcal in Cerevit with rice (Table I) and agree well with the protein content (3.0–5.5 g/100 kcal) of weaning foods as recommended by Codex Commission (FAO/WHO, 1989).

The concentration of fat (Table I) ranged from 2.0–4.5 g/100 kcal in milk-cereal blends to 5.5–5.6 g/100 kcal in milk based foods and the difference was statistically significant ($P<0.05$). The fat content in all milk-based and Milupa 1 (milk-cereal blend) was adequate to meet the Codex requirement of 3.3–6.0 g/100 kcal. However, both Cerevit (wheat) and Cerevit (rice) had low fat content (2.0–2.2 g/100 kcal) and could not meet the Codex requirement. Fats contribute the major portion of food energy for infants and quality of dietary fat also has structural and functional effects for the developing tissues of growing infants, especially for the lipid rich nervous system (Koletzko and Bremer, 1989).

The carbohydrates were lower (7.2–7.4 g/100 kcal) in milk based foods and were higher (12.1–16.5 g/100 kcal) in milk-cereal blends than human milk (10.4 g/100 kcal). Infants on high carbohydrate diet could only synthesize non-essential fatty acids resulting in an unfavourable composition of stored fat (Flatt, 1977). The ME values were higher ($P<0.01$) in milk-based foods (476–480 kcal) due to high concentration of fat than milk-cereal blends (390–454 kcal/100 g).

The ash content varied between 1.1–1.2 g and 0.6–0.8 g/100 kcal in milk-based and milk-cereal blends respectively (Table I). The Ca content was significantly ($P < 0.01$) lower in milk-cereal blends (115–180 mg) than milk based foods (188–200 mg/100 kcal). Similar trends of P in both types of milk products were observed. The Fe content was highest (2.0 mg/100 kcal) in Cerevit (wheat) and was lowest (0.18 mg/100 kcal) in Coast. According to Codex Standard (FAO/WHO, 1989), the recommended levels of Ca, P and Fe for infant foods are 50 mg, 25 mg and 1 mg/100 kcal respectively. The milk based vs milk cereal products supplied (% of the standard) Ca (376–400% vs 230–360%), P (584–612% vs 320–420%) and Fe (18–20% vs 150–200%). A high Ca intake may inhibit the intestinal absorption of Fe, Zn and other essential minerals (Greger, 1988). High P consumption may contribute to the occurrence of hypocalcemia tetany in early infancy (Mizraki *et al*., 1968). It is evident (Table I) that all the milk-based products are poor in iron and cannot meet the requirement of the standard. However, milk-cereal blends were adequate to meet the requirement. Similar high levels of Ca, P and Fe have been reported in commercial baby foods used in Pakistan and India (Khan and Eggum, 1979; Dodd and Ratnani, 1991). The daily recommended allowances for Ca, P and Fe for 6 months old infant are 600 mg, 500 mg and 10 mg respectively (NRC 1989). One hundred gram of baby foods (milk-based vs milk-cereal blends) tested in the present study can meet the daily requirement (% of RDA) of Ca (158–167% vs 92–125%), P (148–154% vs 76–87%) and Fe (9–10% vs 70–85%) respectively.

Table II shows the fatty acid composition (%) of baby foods. Total saturated fatty acids were higher ($P < 0.01$) in milk-based foods (59.7–67.5%) than milk-cereal blends (44.6–55.6%). The oleic acid content was highest (36.6%) in Cerevit (wheat) and was lowest (25.7%) in Coast. The content of linoleic acid was higher in milk-cereal blends (7.3–16.4%) than milk-based foods (4.4–7.0%). Total saturated fatty acids in all baby foods were higher than human milk (41.1%). High levels of saturated fatty acid in such foods are less absorbed and may inhibit calcium absorption (Chapell *et al*., 1986). All the baby foods except Cerevit (wheat) and Milupa 1 had lower contents of linoleic acid that human milk (10.8%). The American Academy of Pediatrics

TABLE II
Fatty acid composition (%) of milk or milk-cereal blends

Products	Saturated					Unsaturated		
	Lauric acid	Myristic acid	Palmitic acid	Stearic acid	Total	Oleic acid	Linoleic acid	Linolenic acid
Milk-based								
Klim	3.6	14.1	39.1	10.7	67.5	27.8	4.4 (245)	0.3
Anchor	—	14.5	32.1	13.1	59.7	32.3	7.0 (385)	0.6
Coast	5.2	15.1	40.6	5.6	66.5	25.7	5.1 (285)	0.8
Milk-cereal blends								
Cerevit (wheat)	—	11.5	31.3	10.4	53.2	36.6	10.2 (208)	0.2
Cerevit (rice)	—	15.2	30.6	9.8	55.6	31.2	7.3 (159)	0.3
Milupa 1	1.3	3.9	36.6	2.8	44.6	32.9	16.4 (734)	1.6

Data in parentheses indicate values in mg/100 kcals.

(AAP, 1985) has recommended that baby foods must provide at least 2.7 percent of energy as linoleic acid. Linoleic acid is a dietary essential and its deficiency may result poor growth and lowered resistance to infections in infants (Mahan and Escott-Stump, 1996). In the present study linoleic acid levels (% of total calories) were adequate in Anchor (3.4%) and Milupa 1 (6.5%) except Klim (2.2%), Coast (2.5%), Cerevit with wheat (1.9%) and Cerevit with rice (1.4%). Similar trends were observed (Table II) when linoleic acid contents (mg/100 kcal) were compared with FAO/WHO Codex Standard (300 mg/100 kcal).

The contribution of food energy (% of the total calories) from protein (20–21%) and fat (50–51%) was higher in milk-based foods whereas protein (11–16%) and fat (18–40%) were lower in milk-cereal blends. In a well-balanced baby food, 7–18% of the total food energy are usually derived from protein, 30–55% from fat and 35–50% from carbohydrates (AAP, 1976). In the present study, milk-based foods provided protein calories (20–21%) higher than the standard. According to Khan (1991) the levels of protein required in terms of protein and energy requirement ratios (PE%) for infants and children (1–3 year) are 7.3 and 7.4% respectively. All the baby foods in the present study were more than adequate to meet the protein requirement of infants and children (1–3 years). Both Cerevit with wheat (18%) and Cerevit with rice (20%) had low energy density. Similar results in milk-cereal blends used in Saudi Arabia have been reported (Al-Othman *et al.*, 1997). Feeding such foods to infants may lead to a deficient intake of food energy (Abrahamsson and Velarde, 1978). On the other hand, high fat intake (40% or more of the calories) as observed in milk based food (50–51%) may result poor digestibility of fat in infants (Mahan and Escott-Stump, 1996). The contribution of food energy from carbohydrates (29–30%) was lower in all milk-based and was higher in Cerevit with wheat (67%) and Cerevit with rice (64%) than the recommended values. Such an imbalance of food energy from different nutrients may effect the quality of diet (Khan, 1989).

The true protein digestibility (TD), net protein utilization (NPU), biological value (BV) and net dietary protein calorie percent (NDp cal %) of baby foods and casein (control diet) are presented in Table III. All the foods had TD of above 90%. Highest TD (95%) was found in Klim and Milupa 1 and while the lowest (92%) was found in Cerevit (wheat). There was no difference between the digestibility values of both types of baby foods. The results are in line with the TD values (95–97%) of baby foods reported by Khan and Kissana (1985). The low TD in some infant formulas used in Western Europe has been attributed to severe heat treatment (Sarwar *et al.*, 1989). There was no significant difference in NPU values between milk-based foods (0.72–0.74) and milk-cereal blends (0.72–0.76). The protein quality of a diet depends on balance of amino acids as well as the digestibility of the protein (Khan and Eggum, 1978), heat processing (Bender, 1972; 1978), storage conditions (Pompei *et al.*, 1987) and types of carbohydrates (Khan and Munira, 1978; Khan, 1975).

According to FAO/WHO Codex Alimentarius Commission (1989) the protein quality of infant foods based on milk should be equivalent to that of casein. The NPU values (0.72–0.74) of milk based foods (Table III) were higher than that of casein (0.70), however, these values were lower than cow whole milk (0.82) and human milk (1.0). The present results agree well with NPU values

TABLE III
Protein quality of milk or milk-cereal blends

Products	True digestibility (%)	Net protein utilization	Biological value (%)	Net dietary protein calorie (%)
Milk-based				
Klim	95.0	0.74	78.0	15.5
Anchor	94.0	0.73	78.0	16.0
Coast	94.0	0.72	77.0	14.4
Milk-cereal blends				
Cerevit (wheat)	92.0	0.72	78.0	10.8
Cerevit (rice)	94.0	0.74	79.0	11.9
Milupa 1	95.0	0.76	80.0	8.4
Casein (control)	96.0	0.70	73.0	—

of 0.75–0.78 and 0.68–0.75 of baby foods used in Sweden and Pakistan respectively (Abrahamsson and Hambraeus, 1977; Khan and Kissana, 1985). However, the present NPU values were higher than NPU (0.50) of infant foods reported in Demnark (Eggum, 1968). According to the early guidelines of the Protein-Calorie Advisory Group (PAG, 1972) of the United Nations System, the NPU of protein rich weaning foods should never be less than 0.60. The NPU values of milk-cereal blends (0.72–0.76) in the present study (Table III) were higher than this standard. Similar results have been reported by Al-Othman *et al*. (1997). However, according to Khan and Eggum (1979) the NPU of some home made milk-cereal blends (0.65–0.81) were better than those of industrially produced baby foods (0.57–0.60). The high NPU of Milupa 1, a product of milk with rice (0.76) as compared to Cerevit with wheat (0.72) in the present study may be due to the better quality of rice protein, having better digestibility and utilization of essential amino acids than wheat protein (Khan, 1981).

According to FAO (1965) the protein allowances in terms of NDp cal % are 8.0 and 7.8% for infants and toddlers respectively. All the milk based foods and milk-cereal blends in the present study have NDp cal % between 14.4–16.0 and 8.4–11.9 respectively (Table III) and can meet the protein requirements of infants and toddlers.

According to Khan and Al-Kanhal (1998), the RDA for reference protein for 6 months old healthy Saudi infant is 14 g per day. Based on their NPU values, a 100 g sample of Klim, Anchor, Coast, Cerevit (wheat), Cerevit (rice) and Milupa 1 can meet 133%, 140%, 131%, 81%, 85% and 73%, respectively of daily protein requirement of the infant.

In conclusion, the high protein levels particular in milk based foods, when used as replacement for infant formula must be adjusted to simulate human milk to prevent the young infant from metabolic stress. The low energy density in some milk-cereal blends needs improvement. The protein quality of baby foods may be improved by controlling processing and storage conditions and by adding limiting essential amino acids. An imbalance of food energy and nutrients in baby foods demands to recognize breast milk as the preferred food for infants at least during the first six months.

ACKNOWLEDGEMENT

The authors wish to thank to Dr. Ihsan Ullah and Mr. Omar Karrar for technical assistance, to Mr. Abdur Rahman F. Karim for typing the manuscript and acknowledge the financial assistance of the Research Centre, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia.

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