Original Article

Commercial 'ready-to-feed' infant foods in the UK: macro-nutrient content and composition

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Abstract

Quantitative analyses of the macronutrient content of eight popular commercial 'ready-to-feed' baby meals for 6–9-month old infants in the UK market have been undertaken in order to ascertain their nutritional suitability in relation to the total daily dietary intake as well as nutritional profiling of the products. The chemical analyses conducted included Kjeldhal for protein, acid hydrolysis and extraction for fat, phenol sulphuric acid for carbohydrate and Association of Official Analytical Chemists 985.29 for fibre. The only difference found between different varieties (meat- and vegetable-based) was with respect to the protein content ($P = 0.04$) per 100 g of food. The experimentally determined concentrations of macronutrients (g/100 kcal) were compared with the declared values provided by the manufacturers on the product labels and, despite some variations, the values obtained comply with regulatory requirements (Commission Directive 2006/125/EC). The total daily intake of fat (27.0 g per day) – based on the menu composed from commercial complementary food – is suggested to exceed the daily recommended values for fat (31%), *if the intake of snacks and desserts are incorporated*. These findings imply that the formulation of recipes, based on a standard commercial menu, is an important consideration in relation to the nutritional quality of the diet of infants.

Keywords: commercial, complementary, baby food, macronutrients, chemical analysis, nutritional profiling, labelling and legislation.

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Introduction

Early infant feeding provides nutrients for optimal growth and physiological development.

The current UK recommendation relating to infant feeding is exclusive breastfeeding for the first 6 months of infant life [Department of Health (DoH) 2008]. After the first 6 months of life, the utilisation of post-natal nutrient stores together with the need for rapid growth of an infant, creates further demand for energy and nutrients; milk alone

becomes inadequate (Barclay & Weaver 2006; Briefel *et al.* 2004; Hulzebos & Sauer 2007). This is the beginning of the weaning period, when complementary food is required to boost energy and nutrient intake (Briefel *et al.* 2004; Hulzebos & Sauer 2007). It is therefore important that complementary foods contain the necessary amount of energy, protein, fat, minerals and vitamins to fulfil the requirements needed for growth and development at this critical period of dietary transition (Barclay & Weaver 2006; Wells 2007).

Over recent decades, the modern lifestyle dynamic has led to an increased parental reliance on commercially marketed complementary foods in the UK (White & Hampson 2008), which may have potential implications for total energy and fat intake in addition to taste acquisition (Lobstein *et al.* 2004; Stang 2006). The effects of early nutritional imbalance are already evidenced, in part, as currently one in five children in the UK starts school overweight (DoH 2006). Data suggest that children who are overweight at an early age are likely to continue to be overweight (DoH 2006). This in turn, increases the risk of developing chronic diseases such as type 2 diabetes, heart disease and a variety of other co-morbidities at early adulthood (Skinner *et al.* 2002; Lobstein *et al.* 2004; Rudolf 2009; Wells 2009). The foregoing issues enhance the importance of a robust regulatory system, both in the areas of food safety and nutritional quality of commercially prepared food products relevant to their target age group.

To date, insufficient attention has been paid to the nutritional quality of 'ready-to-feed' complementary foods intended for infants during the period of weaning. Increased emphasis has been given to improving preparation methods for infant formula milk and also official guidelines have been declared in order to ensure the safety of baby food products [Commission Directive 2006/125/EC (The Commission of the European Communities 2006)]. The current nutritional information labelling formats for 'ready-to-eat' complementary food (Processed Baby Foods Regulations 1997/2042) are a duplicate of the legislative requirements for manufacturing 'ready meals' in general. The requirement concerning the essential nutrient composition of food marketed as

'ready meals' for adults are therefore, generally not particularly robust, because the nutritional value of these food products are not critical to their target group. For example, certain data have not yet been required to be included in the nutritional information content of infant-ready meals, such as mandatory classification of fat and carbohydrates or declaration of micronutrient content. This recommendation has already been adopted by the US Food and Drug Administration in relation to the nutrition fact label; i.e. mandatory declaration of saturated fat and dietary cholesterol as well as *trans* fats by the Nutrition Facts Panel (USA) has been included since 1 January 2006 (68 FR 41434). In Europe the inclusion of such information has been controversial and much disputed both within the European Community and by the stakeholders involved in the technical field [Commission Directive 90/496/EEC on Nutrition Labelling for Foodstuffs (The Commission of the European Communities 1990)].

The lack of recommendations in respect of complementary foods for infants and young children is also highlighted in the National Obesity Action Plan (Lobstein *et al.* 2004). This plan deals with a number of areas such as improved breastfeeding rates, clear and consistent food labelling, production of more nutritious and lower-energy food for children, healthier school meals, and advertising (Lobstein *et al.* 2004). There is, however, no mention about the weaning diet or products intended for infants during the progressive adaptation to ordinary foods. Furthermore the National Diet and Nutrition Survey Programme (NDNS), which is conducted every 5 years on behalf of the UK Department of Health, does not include the diet of children aged less than 18 months (DoH 2008).

Key messages

- There is a paucity of data in respect of the nutritional quality of 'ready-to-feed' complementary foods marketed in the UK for infants aged between 6 and 12 months.
- Experimentally determined concentrations of macronutrients (g per 100 kcal) are within the regulatory requirements [Commission Directive 2006/125/EC (The Commission of the European Communities 2006)].
- Total daily dietary intake of fat from the consumption of commercial complementary food may be in excess of the recommended guidelines if the intake of dessert and snacks are incorporated.
- Formulation of commercial infant meals is important in relation to the nutritional quality of the infants' diet and requires further investigations.

To date, there has been little discussion relating the nutritional composition of complementary foods in the UK, and there have been no controlled studies comparing the dietary intake from this food with reference to the recommended nutrient intake (RNI) in order to ascertain their suitability (DoH 1991). This study aims to address several important issues; (1) the macronutrient content of a series of commercially prepared 'ready-to-feed' meat and vegetable-based meals; (2) the discrepancy, if any, between the label claims and the actual macronutrient content of the infant foods; (3) a hypothetical, non-numerical format of labelling information is proposed; and (4) the role of these foods used within a hypothetical meal plan in meeting the dietary requirements of infants. The essential and trace element content of the same range of infant food products have already been reported by the same author (Zand *et al.* 2011) as consumption of the nutrient-dense food is essential part of the infants' diet.

Material and methods

Sample collection and preparation

Eight types of 'ready-to-feed' infant meals, representing four brands of two different varieties of meat- and vegetable-based products, were purchased from retail outlets in the UK between November 2010 and May 2011. The sampling plan was intended to reflect the main products and brands within the major categories of commercial infant foods on sale, taking into account available market share data. Two categories of commercial infant foods were sampled: (1) meat based; and (2) vegetable based with three jars from the same lot/batch for each individual product obtained. These products were semi-pureed and packed in glass jars. Exact corresponding recipes were not available for all the brands. The sample jars were stored unopened at room temperature, similar to their distribution and market environment. The main ingredients of the baby food samples and their characteristics are presented in Table 1. The samples were first homogenised using a blender (Multiquick 3 MR 300, Braun, Kronberg, Germany) prior to any analy-

sis. All samples were analysed in triplicate and the mean value reported for energy, protein, fat, carbohydrate and fibre.

Quantitative analysis of macronutrient content in the food samples

All the methods employed in this study are those approved by the Food Standards Agency (FSA) as well as UK Trading Standards and currently in use by public analysts (Kent Scientific Laboratories) (White & Hampson 2008).

Protein

The technique used in this study for protein quantification is based on the colorimetric analysis of Kjeldhal nitrogen (indophenol method; Mantoura & Woodward 1983). After determination of Kjeldhal nitrogen liberated by sodium hydroxide, the protein level was obtained by multiplying the nitrogen factor by 6.25 [Association of Official Analytical Chemists (AOAC) 1990].

Fat

Acid hydrolysis followed by organic solvent extraction was used for the determination of the fat content of the food samples (adapted from the AOAC Official method 922.06). The mass of the fat was obtained by evaporation of the solvent (AOAC 1990; Pomeranz & Meloan 1994). The fat content in the samples was calculated as follows:

$$\text{Fat content (\%)} = [\text{fat content (g)/weight of sample before extraction}] \times 100$$

Carbohydrate

Total carbohydrate was measured using the phenol-sulphuric acid method during which, carbohydrates are first hydrolysed to simple sugars by using diluted hydrochloric acid. In hot acidic medium,

Table 1. Infant complementary food sample characteristics

Brand code	Product name (n = 8)	Ingredients	Nutritional information per 100 g
Meat based (6–9 months)	A Cottage pie	Organic vegetables (64%) (potato (22%), carrots, tomatoes, onions), water, organic cooked rice, organic beef (8%), organic sunflower oil, organic herbs (parsley, oregano), organic vegetable stock [salt, organic rice flour, organic vegetable (carrots, onions, celeriac), organic yeast extract, organic vegetable oil, organic spices]	Energy 278 kJ per 66 kcal, protein 2.8 g, carbohydrate 8.7 g of which sugars 1.9, fat 2.3 g of which saturates 0.6 g, fibre 1.6 g, sodium 0.05 g
	B Cottage pie	Vegetables (45%), [carrots (22%), potatoes (14%), onions (7%), peas (4%)] water, whole milk, beef (9%), corn flour, unsalted butter, natural flavouring, yeast extract, herbs, iron sulphate	Energy 253 kJ per 60 kcal, protein 2.8 g, carbohydrate 7.5 g of which sugars 1.8 g, fat 2.1 g of which saturates 1.2 g, fibre 1.3 g, sodium 0.8 g, iron 1.3 mg
	C Cottage pie	Baby grade vegetables (56%) (potato, green beans, carrot, peas), cooking water, beef (10%), white beans, wheat starch (gluten free), yeast extract	Energy 279 kJ per 66 kcal, protein 3.8 g, carbohydrate 7.6 g, of which sugars 0.7 g, fat 2.3 g of which saturates 0.9 g, fibre 2.3 g, sodium 0.07 g
	D Pasta & Lamb	Cooking water, potato, halal lamb (10%), pasta (10%), carrot, tomato, onion, rice flour, sunflower oil, herbs	Energy 272 kJ per 64 kcal, protein 3.1 g, carbohydrate 8.5 g, fat 2.1 g, sodium <50 mg
Vegetable based (6–9 months)	A1 Creamy vegetable pasta	Organic vegetables (50%) (carrot, sweet corn, cauliflower, fennel), organic wholemeal spaghetti(durum wheat) (18%), organic whole milk, water, organic cream (4%), organic sunflower oil, organic spice (pepper), rice, white beans, tapioca starch, oregano (0.5%), yeast extract	Energy 275 kJ per 65 kcal, protein 2.0 g, carbohydrate 8.5 g of which sugars 2.8 g, fat 2.6 g of which saturates 1.2 g, fibre 1.9 g, sodium trace
	B1 Cheesy tomato pasta star	Tomatoes (20%), pasta (18%) (water, drum wheat semolina), vegetarian cheddar cheese (8%), corn flour, natural flavouring (contain celery, celeriac), yeast extract, iron sulphite	Energy 283 kJ per 67 kcal, protein 2.9 g, carbohydrate 8.5 g of which sugars 0.7 g, fat 2.4 of which saturates 1.8 g, fibre 0.3 g, sodium 0.1 g iron 0.9 mg
	C1 Vegetable lasagne	Baby grade vegetables (64%) (tomatoes, aubergine (9%), courgette (9%), green paper, onion), pasta (18%) (drum wheat, egg albumin), full cream milk, cream (9%), cheese (3%), tapioca starch, basil, nutmeg	Energy 266 kJ per 63 cal, protein 2.9 g, carbohydrate 8.9 g, of which sugars 1.8 g, fat 1.8 g of which saturates 1.0 g, fibre 0.7 g, sodium 0.05 g
	D1 Garden vegetables	Vegetable (67%) (carrots, potato, peas, cauliflower), skimmed-milk, Sweet corn, cooking water, sunflower oil	Energy 247 kJ per 58 kcal, protein 2.2 g, carbohydrate 8.2 g, fat 1.9 g, sodium <50 mg

glucose is dehydrated to 5-hydroxymethylfurfural. The 5-hydroxymethyl-furfural forms a green coloured product with phenol that exhibits an absorption maximum at 490 nm (Pomeranz & Meloan 1994; Mecozzi *et al.* 2002; Masuko *et al.* 2005).

Energy

The energy content of the complementary food samples was determined by multiplying the protein

and carbohydrate content by 4 kcal (17 kJ) and the fat content by 9 kcal (37 kJ). These are values established by the European Union for the nutritional labelling declaration of foods.

Fibre

The percentage of total fibre was analysed by enzymatic-gravimetric method AOAC 985.29 (AOAC 1990).

Quality assurance

The accuracy of the methods mentioned earlier was verified by analysing the Certified Referenced Materials (CRM 8418: Wheat Gluten, Wheatex 2240) and the concentration for each of the samples were typically within the certified range or $\pm 5\%$ of the certified value. Blank samples of ultrapure water and reagents were also prepared using the same procedures as for the samples. All blank levels obtained were subtracted appropriately.

Nutrient density (ND)

Because the consumption of nutrient-dense food (those foods that provide substantial amounts of nutrients with relatively few calories) is critical during infancy, the ND (amount of nutrient per 100 kcal of food) for both meat- and vegetable-based food samples was also calculated.

Transparency of the labels

In order to ascertain the transparency of the labelling, the experimentally determined concentrations of different nutrients in the samples (g/100 kcal) were compared with the content declared by the manufacturers on the product labels and validated against the legislative requirements [Commission Directive 2006/125/EC (The Commission of the European Communities 2006)]. According to this legislation, the minimum requirement for protein is 3 g per 100 kcal of food and for fat the maximum is 4.1 g per 100 kcal of food.

Proposed nutritional profiling of the products based on the FSA 'front of pack traffic light signpost labelling' guidelines (FSA 2007)

A nutritional profiling model, using data from the traffic light signpost labelling on the product label is hypothetically proposed as a tool to categorise the food samples analysed in this study based on their nutrient content. The colour coding of the nutritional criteria, is based on EC n°. 1924/2006 and recommendations by the Committee of Medical Aspects of Food and Nutrition Policy (COMA) and the Scientific

Advisory Committee on Nutrition for fat, sugar and salt using 25% of the recommended intake level per 100 g. Based on the traffic light colour approach to nutritional signpost labelling, criteria are defined as the green/amber (low/medium) and amber/red (medium/high) boundaries for the key nutrients fat, saturated fat, sugars and salt. One of the main benefits of the non-numerical labelling format of food products is to help consumers to make judgements on the nutritional information presented on the food labels. Approaches used for estimation of total daily dietary intake from a diet based on commercially prepared complementary foods.

In order to estimate the total daily dietary intake of an infant from the consumption of manufactured infant foods and formulas, it was necessary to adopt the following approaches in combination. In the first approach, an example menu based on the manufacturer's feeding recommendations was composed (Heinz Meal Planner, available at: <http://www.heinzbaby.co.uk/advice/first-foods-advice/baby-nutrition/starting-weaning-plan.aspx>), which included the ready-to-feed-type foods, such as jars of semi-solid meals and ready-made formulas. Based on this approach, the daily recommended intake of energy and macronutrients by an infant aged between 6 and 9 months, was calculated by taking into account the medium recommended daily intake of milk (600 mL per day) [DoH 1980; World Health Organization (WHO) 2004].

The second approach was then introduced to estimate the gastric capacity (30 g kg⁻¹ body weight per day) based on data from the WHO Expert Consultation on Complementary Feeding (Dewey & Brown 2003). The average weight for infants of different age ranges have been taken from the report by COMA: 'Weaning and The Weaning Diet' (1994). The methods mentioned earlier have been used by the Scientific Committee on Food for assessing the maximum level of residue of pesticides in food. The estimated amount for milk consumption however, was set at 600 mL, as advised by COMA, for infants up to 12 months old.

As a starting point, the energy provided from recommended total protein intake of the target population (13.7 g day⁻¹) is calculated (DoH 1991). Next, the fat content is calculated to ensure that the diet

Table 2. Comparison between the experimental values of protein content (g per 100 g) of meat and vegetable-based samples and the declared values on the labels

Brand (<i>n</i> = 8)	Experimental (mean)	SD $\pm$	Declared	% variation*	ND [†]	%RNI [‡]
A	2.7	0.02	2.8	4	16.4	19.7
B	3.2	0.01	2.8	-14	21.3	23.4
C	3.6	0.02	3.8	5	21.8	26.3
D	3.3	0.01	3.1	-6	20.6	24.1
Mean	3.2	0.37	–	–	–	–
A1	1.8	0.03	2.0	10	11.1	13.1
B1	3.0	0.01	2.9	-3	17.9	21.9
C1	2.5	0.02	2.9	14	15.9	18.2
D1	1.9	0.03	2.2	14	13.1	13.9
Mean	2.3	0.56	–	–	–	–
CRM	1.18	0.02	1.25	95.4	–	–

CRM, certified reference material; ND, nutrient density; RNI, recommended nutrient intake; SD, standard deviation. *Percentage difference between the experimental values vs. declared. [†]ND = [percentage of energy (kcal) derived from protein (experimental values) per 100 kcal of food; Lee & Nieman 2003]. [‡]The % of daily intake (experimental values) from 100 g of the food towards the RNI (DoH 1991).

contains at least 31% of energy as fat for an infant who consumes 600 mL of milk per day. The remaining energy requirement not provided by fat or protein is then used as the basis for calculating the diet's carbohydrate content (Lutter & Dewey 2003). Hence, the daily dietary energy and macronutrient requirements for the diet of an infant 6–9 months old are mainly calculated based on the Daily Reference Values (DRVs) for protein and fat, yielding 6% (13.7 g) and 31% (27.3 g) of the Estimated Energy Requirement (EER) from protein and fat, respectively (DoH 1991; WHO 2004). The remaining 63% of the EER needs to be provided by 131.7 g of carbohydrate.

Statistical analysis

The experimental results were subject to statistical analysis using Excel 2007 and the Statistical Package for the Social Sciences (SPSS) package v.17.0 (SPSS Inc., Chicago, IL). The mean differences between meat and vegetable-based varieties were compared using a 2-sided unpaired *t*-test at *P* = 0.05 level of significance, in addition to standard error of the mean and CI at 95% level of confidence.

Results

Macronutrient content and labelling discrepancies

Protein

The results of the protein analyses (Table 2) indicate that there is a significant difference (*P* = 0.04) between the meat- and vegetable-based recipes with respect to protein content. The mean protein content of meat- and vegetable-based recipes were 3.2 (± 0.37) and 2.3 (± 0.56) g/100 g, respectively. With respect to the protein density (Table 2), all the products were found to be a good source of protein with a ND of >12% as recommended by the nutritional guidelines for composition of complementary food (DoH 1980; WHO 2004). The meat-based recipes were found to provide, on average, 23.4 (± 2.7)% of the RNI of protein for 6–9-month old infants (DoH 1991), which is 6.6% i.e. higher than the percentage of RNI provided by the vegetable-based recipes at $16.8 \pm 4.09\%$. The results show a greater variation, on average 10–14%, between the experimental and declared values of vegetable-based varieties. These observations confirm that the protein content of the commercial infant foods is within the

Table 3. Comparison between the experimental values of fat content (g per 100 g) of meat and vegetable-based samples and the declared values on the labels

Brand (<i>n</i> = 8)	Experimental (mean)	SD ±	Declared	% variation*	ND [†]
A	1.9	0.02	2.3	17	25.9
B	2.0	0.02	2.1	5	30.0
C	2.4	0.02	2.3	−4	32.7
D	2.2	0.01	2.1	−5	30.9
Mean	2.1	0.02	—	—	—
A1	3.5	0.03	2.6	−35	48.5
B1	3.0	0.01	2.4	−25	40.3
C1	1.4	0.02	1.8	22	20.0
D1	1.8	0.03	1.9	8	27.2
Mean	2.5	0.2	—	—	—
CRM	1.4	0.02	1.5	95	—

CRM, certified reference material; ND, nutrient density; SD, standard deviation. *Percentage difference between the experimental values vs. declared. [†]ND = [percentage of energy (kcal) derived from fat (experimental values) per 100 kcal of food; Lee & Nieman 2003].

regulatory requirements established for complementary food.

Fat

The mean fat content of meat- and vegetable-based recipes (Table 3) were found to be 2.1 g (± 0.02) and 2.5 g (± 0.2) per 100 g, respectively and there was no difference ($P = 0.5$) between meat- and vegetable-based recipes regarding the fat content. The fat density in both meat- and vegetable-based food samples was calculated and all the products were found to have relatively high percentage of fat specifically in two of the vegetarian brands with a fat density higher than the recommended 31% for nutritional composition of complementary food, as demonstrated in the data presented in Table 3. The data (Table 3) show greater variations between the experimental and declared values of fat content in vegetable-based (min. 8%–max. 35%) recipes than meat-based (min. 4%–max. 17%). However, the average fat content (g 100 kcal^{−1}) of the food samples in both varieties were found to be compliant with the maximum permitted level established. These results, however, reveal that the fat content in the vegetarian products is almost at the maximum regulatory requirements established for complementary food.

Carbohydrate

The results of the carbohydrate analyses are presented in Table 4. The mean carbohydrate content of meat- and vegetable-based recipes were found to be 8.1 g (± 0.02) and 7.4 g (± 0.02) per 100 g, respectively. No difference in carbohydrate content ($P = 0.3$) was found between the meat- and vegetable-based recipes. The carbohydrate density for both meat- and vegetable-based food samples was satisfactory and was below the recommended 57% for nutritional composition of complementary food intended for infants with medium intake of milk (DoH 1980; WHO 2004). The percentage variation between the experimental and declared values of carbohydrate in the meat- and vegetable-based products (Table 4) shows the same variation in both vegetable- and meat-based recipes. Because there is no legislative requirement defined for the carbohydrate content (g 100 kcal^{−1}) of food [Commission Directive 2006/125/EC (The Commission of the European Communities 2006)], this cannot be validated.

Energy

Data for the energy level of the food samples tested are presented in Table 5. The average energy density (kcal g^{−1}) of the food samples was found to be at

Table 4. Comparison between the experimental value of carbohydrate content (g per 100 g) of meat and vegetable-based samples and the declared values on the labels

Brand (<i>n</i> = 8)	Experimental (mean)	SD±	Declared	% variation*	ND [†]
A	7.8	0.02	7.8	–	47.3
B	7.9	0.02	8.7	26	42.7
C	8.5	0.02	7.6	12	40.6
D	8.0	0.01	8.5	2	54.4
Mean	8.1	0.02	–	–	–
A1	7.9	0.03	8.5	7	48.5
B1	8.9	0.01	8.5	4	52.1
C1	7.2	0.01	8.9	19	45.9
D1	5.7	0.03	8.2	31	39.3
Mean	7.4	0.02	–	–	–
CRM	10.2	0.02	10.3	98.8	–

CRM, certified reference material; ND, nutrient density; SD, standard deviation. *Percentage difference between the experimental values vs. declared. [†]ND = [percentage of energy (kcal) derived from carbohydrate (experimental values) per 100 kcal of food; Lee & Nieman 2003].

Table 5. Energy content of the food samples based on the nutrient values (g per 100 g) obtained in this investigation

Brand (<i>n</i> = 8)	Protein (g)*	Fat (g)*	Carbohydrate (g)*	Energy kJ kcal ⁻¹	ED (kcal g ⁻¹) [‡]	Sodium (mg) [§]	Fibre (g)*
A	2.7	1.9	7.8	247/59.1	0.59	0.05	1.5
B	3.2	2.0	6.4	236/56.4	0.56	0.8	1.8
C	3.6	2.4	6.7	263/62.8	0.62	0.07	1.1
D	3.3	2.2	8.7	284/67.8	0.67	<50	0.9
Mean	3.2	2.1	7.4	257/61.5	0.58		1.3
SD±	0.37	0.2	1.1	4.9	0.01		0.4
95% CI	2.8–3.6	1.9–2.3	6.4–8.4	56.7–66.4	0.57–0.59		0.9–1.7
A1	1.8	3.5	7.9	294/70.3	0.70	Trace	1.6
B1	3.0	3.0	8.9	312/74.6	0.75	0.1	0.5
C1	2.5	1.4	7.2	215/51.4	0.51	0.05	0.8
D1	1.9	2.0	5.7	353/48.4	0.45	<50	1.0
Mean	2.0	2.5	7.4	256/61.2	0.61		1.0
SD±	0.56	0.95	1.35	13.2	0.13		0.5
95% CI	1.75–2.85	1.54–3.41	6.11–8.78	48.24–74.11	0.48–0.74		0.5–1.4
<i>P</i> value [†]	0.04	0.5	0.3	0.9	–		0.3

CI, confidence interval; ED, energy density; SD, standard deviation. *Based on the analytical results obtained in this study (g per 100 g). [†]To examine the differences (*P* = 0.05) between meat and vegetable-based varieties. [‡]Energy density = amount of energy per g of food (kcal g⁻¹).

	Low (green)	Medium (amber)	High (red)
Fat (g per 100 g)	≤3	>3	>20
Sugar (g per 100 g)	≤5	>5	>12.5
Salt (g per 100 g)	≤0.30	>0.30	>1.50

[§]The information on the sugar and sodium content are obtained from the label, the data have not been available for those not declared.

the recommended level of 0.6 kcal g⁻¹ (Dewey & Brown 2003; Monte & Giugliani 2004). There was no difference (*P* = 0.9) between the meat- and vegetable-based varieties, regarding the energy content.

Fibre

The mean fibre content of meat- and vegetable-based recipes were found to be 1.3 g (±0.4) and 1.0 g (±0.5) per 100 g, respectively (Table 5). No difference in

fibre content ($P = 0.3$) was found between the meat- and vegetable-based recipes.

Nutritional profiling of the products based on the FSA 'front of pack traffic light signpost labelling' guidelines (FSA 2007)

The data in Table 5 were also categorised based on a hypothetical nutrient profiling model (FSA 2007), and products were found to be within the green (low) boundaries for most of the nutrients in each category as defined in the legend to Table 5. The level of fat in two of the vegetarian-based meals, however, was in the amber/medium zone.

The data in Table 6 provides an illustration of the daily dietary macronutrient requirements of a 6–9-month old infant and compares it with the DRV values (DoH 1991; Lutter & Dewey 2003; WHO 2004). Based on this comparison, the average daily intake of protein (20.8 g) is suggested to be in excess of the DRVs (13.7 g per day) and for carbohydrates (86.6 g) below the recommendations (131.7 g per day). Based on the WHO Expert Consultation on Complementary Feeding (Dewey & Brown 2003), the percentage EER provided from milk (407.2 kcal from 600 mL per day) can be estimated to be approximately 50%, and the remaining 50% is expected to be provided by complementary food at, e.g. breakfast, lunch and dinner. A typical 200 g jar of infant food will usually provide ~16% of the EER of an infant. Two jars a day will therefore provide 32% which is just short of the total energy requirements when milk at 600 mL per day is factored in. Between the energy provided from milk (50%) and two jars of infant food at 32% the total energy in the food ingested is 82%. The short fall would need to be made up from breakfast and snacks during the day. A menu based on the complementary jar foods should, therefore, be within the recommended limits providing on average 32% of the EER. On the other hand, the borderline intake of fat (27.0 g) based on this menu could also be a cause for concern as the fat intake will be in excess of the guidelines if the contribution made from intake of snacks and desserts are also incorporated.

Table 6. Total daily intake of nutrients by a 6–9-month old infant* (based on gastric capacity of an 8-month old infant and the standard feeding regime composed of commercially prepared infant food products)

Meals	Infant formula		Breakfast porridge†		Lunch (meat-based)		Dinner (vegetable-based)		Total daily intake ^e (a+b+c+d)	DRV [§]
Amount	100 mL	600 mL ^a	100 g	(83 g/2 ¹) ^b	100 g	83 g ^c	100 g	83 g ^d		
Macronutrient					Mean	SD	Mean	SD		
Energy	68	407.4	394.5	163.7	61.3	4.9	61.3	13.2	672.9	795
Protein	1.8	10.8	13.2	5.5	3.2	0.4	2.3	0.6	20.8	13.7
Fat	3.5	21	5.3	2.2	2.1	0.2	2.5	1.0	27.0	27.3
Carbohydrate	7.3	43.8	73.5	30.5	7.4	1.1	7.4	1.3	86.6	131.7

DRV, daily reference value; SD, standard deviation. *Weight about 8.3 kg. †Prepared using warm water (50:50, w/v) as advised by the manufacturer. ‡DRVs are based on an energy requirement of 795 kcal day⁻¹ and the recommendation for energy from protein (6%) and fat (31%), yielding 13.7 and 27.3 g per day, respectively (DoH 1991; WHO 2004). ^aRecommended volume of milk intake for a 6–9-month old infant. ^{b, c & d} The portion size is calculated based on the gastric capacity of a 6–9-month old infant aged (30 g kg⁻¹ per body weight per day) divided by three to make up for breakfast, lunch and dinner. ^eTotal Daily Intake is calculated from the sum of milk and non- milk intake to compare with the DRV.

Discussion

This study has attempted to address several important issues with respect to the macronutrient content of commercially prepared 'ready-to-feed' meat- and vegetable-based meals. Based on the findings of this study, there is a significant difference between the protein content in meat- and vegetable-based products with meat-based products providing a higher percentage (6.6%) of RNI. It is important to note that the protein in vegetable-based varieties could also be of less 'biological significance' because of the lack of particular amino acids in vegetable sources if the recipes are not carefully designed. This could be an issue especially where the vegetarian diet is concerned and requires further investigation (Iqbal *et al.* 2006).

With respect to fat, the vegetarian products do not provide a lower fat option in comparison with meat-based varieties. The surprisingly high level of fat in some vegetable-based recipes was further investigated and the reason was found to be the inclusion of cream, cheese and whole milk powder, declared by the manufactures in almost all the vegetarian options available for purchase (Table 1). This finding is in contrast to reports on parents' perceptions of vegetable-based products being a low-fat choice (Davies & O'Hare 2004). Davies & O'Hare (2004) further noted that parents in the UK tend to limit the dietary fat intake of infants and children, and this phenomenon is not limited to commercial infant foods. In a comparison of the nutritional composition of home-prepared baby meals in Spain and England, Boom *et al.* (1997) found that Spanish home-made food had a low-energy density and high fat/salt content. In contrast, English home-made baby food had higher energy density, lower protein and fat content, and wider variation in micronutrient content. There are, however, concerns that, because fat is the major source of energy for infants as well as the only source for essential fatty acids (EFAs) and fat soluble vitamins, such diets may limit growth (Garrow *et al.* 2000; Shils *et al.* 2006; Ells *et al.* 2008; Siri-Tarino *et al.* 2010). Although there are debates over the optimal amount of fat in the diet of infants and young children, the current recommendations suggest a range of 31–45%

of the energy from fat, based on the low or average amount of energy intake from milk (WHO 2004).

There were no significant differences found between the meat and vegetable varieties in relation to energy, carbohydrate and fibre content. In the case of carbohydrate and fibre in particular, there is no legislative requirement defined (g per 100 kcal), which made validation difficult.

With respect to the overall discrepancy between the label claims and the actual macronutrient content (g per 100 kcal) of the infant foods, although the variations in both varieties were found to be in line with the legislative requirement, it is important to note that in some cases, e.g. fat content in some of the vegetarian products, the level was found to be at the maximum regulatory requirements established for complementary food. This may have implications when considering the total daily intake as discussed further.

Currently, non-numerical labelling information of commercial infant foods is not required and is not practised. From the consumer point of view, it may be useful to present such information as a quick and easy to understand rule in making an informed choice. It is, however, important to note that the current categories may need to be reviewed for application to food intended for infants and young children, given the importance and differences in their dietary requirement. Furthermore, the quantification of different classes of lipid in terms of fatty acid content is not required under current legislation; the inclusion of such information could be helpful with respect to consumer's right to a healthy dietary choice when full knowledge of the facts are provided.

Finally, the role of complementary foods used within a hypothetical meal plan in meeting the dietary requirements of infants has also been assessed. It is important to note that the rationale for choosing formula instead of breast milk in the sample menu refers to the purpose of the evaluation being the intake from commercial infant foods. In addition, breast milk quality differs through the course of lactation and as a result of differences in maternal diet, in which case formula allows some uniformity when considering the commercial infant food contribution.

As mentioned earlier, in some cases, the macronutrient content (g per 100 g), e.g. the fat content in some of the vegetarian products, was found to be at the maximum regulatory requirements established for complementary food. Because the current UK recommended intake of milk at 600 mL per day provides an average energy of 396 kcal per day (energy density of 0.66 kcal g⁻¹), 31% of energy from fat (27.3 g fat per day) seems a reasonable compromise between inadequate intake of EFAs and risks associated with excessive intake (DoH 1991). One of the limitations with this study is that it does not take into account any contribution derived from breast milk, snacks or home-made food as well as the food wastage. The borderline daily intake of fat (27.0 g) based on the menu could, therefore, be a cause for concern as the fat intake will be in excess of the guidelines if the contribution made from intake of snacks and desserts (yogurt and fromage frais) are also incorporated. This particular aspect of the results, which relates to the excess daily intake of fat based on the commercial feeding menus, should be investigated further.

Conclusions

The primary aim of this study was to examine the macronutrient content of complementary infant foods currently for sale in the UK market. Quantitative analysis of eight different food products representing four popular commercial brands (meat- and vegetable-based) indicated that, despite the presence of some variations between actual content and the information provided on the labels, the concentration of macronutrients (g per 100 kcal) in complementary food were satisfactory and were within the regulatory requirements [Commission Directive 2006/125/EC (The Commission of the European Communities 2006)]. The selected infant food products were also hypothetically categorised on the basis of a traffic light-based nutrient profiling model (FSA 2007). This system has proved to be useful in highlighting the high fat content of some products, which otherwise, may have gone unnoticed. Examples of nutrient profiling are already in practice in helping consumers

make an informed choice with respect to the nutritional quality of food for children and adults.

Finally, the role of commercially prepared infant food products in meeting the dietary requirement of their relevant target group with reference to the RNI based on a sample menu, as advised by the complementary food manufacturers (available at: <http://www.heinzbaby.co.uk/advice/first-foods-advice/baby-nutrition/starting-weaning-plan.aspx>), was ascertained. The total daily intake of fat (27.0 g per day) based on the menu composed in this study from commercial complementary food are suggested to exceed the DRV of fat (27.3 g per day), if the intake of snacks and desserts are incorporated in the menu. The results of the current study suggest that the formulation of infant recipes are of significant importance in relation to the nutritional quality of an infants diet in which the consumption of nutrient-dense food (those foods that provide substantial amounts of vitamins and minerals with relatively few calories) is critical.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

NZ, BZC and MJS formulated the scientific ideas. NZ, LVP, FSP and FBZ conducted the experiments. NZ, BZC and MJS wrote the manuscript.

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