

## Eating frequency: methodological and dietary aspects

BY SUSAN J. GATENBY\*

*Institute of Food Research, Earley Gate, Whiteknights Road, Reading RG6 6BZ*

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It is commonly stated that 'snack' foods provide 'empty calories' and, therefore elevate energy intake whilst providing insignificant quantities of other nutrients. The data presented in the present review suggest that foods which contribute to the pattern of 'snacking' contribute significantly to the nutrient quality of the diet. Those who 'snack' frequently tend to eat more food in general. Part of the difficulty in identifying the nutritional implications of 'snacking' is related to the definitions of 'meals' and 'snacks' and subsequent categorization of individual patterns. The physiological definitions typically relating to energy content or the time of eating do not necessarily coincide with colloquial, cultural or individual perceptions of what constitutes a 'meal' or 'snack'. Clearly, a more consistent approach would facilitate interpretation of the literature and enable more effective health education messages about 'snacking' to be delivered.

**Meal: Snack: Eating behaviour: Dietary pattern**

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An increasing body of research investigating the metabolic consequences of eating patterns has shown that increasing the frequency of eating throughout the day is associated with beneficial physiological changes such as a reduction in blood cholesterol and improved glucose tolerance (Debry, 1978; Kulesza, 1982; Jenkins *et al.* 1989, 1992; Arnold *et al.* 1993). Many epidemiological, clinical and experimental analyses have pointed to possible relationships between eating frequency, energy intake and body weight. It is often suggested that increasing eating frequency is associated with improved body-weight control and reduced likelihood of overeating and fat deposition. However, the literature is by no means clear or in agreement on these issues (Bellisle *et al.* 1997; V. J. Burley, S. J. Gatenby, O. A. Anderson and D. J. Mela, unpublished results). Despite these considerable physiological data there has, until recently, been very little information about habitual eating habits and in particular dietary patterns and their implications for nutrient intake and energy balance.

Part of the difficulty in identifying the nutritional implications of eating more frequently is related to the range of terminology used to describe eating patterns. Very few studies describe the eating pattern by the size and distribution of each eating occasion, most use instead the colloquial terms of 'meals' and 'snacks' which lack clear meaning and definition.

### DEFINITIONS OF EATING PATTERNS

Comparisons of periodic national surveys of eating habits suggest that foods eaten between 'meals' make a significant contribution to total food intake among all age-groups (Gregory *et al.* 1990, 1995; S. A. Gibson, unpublished results). It is clearly important, therefore, to clarify the terminology if the physiological data are to be translated into health

\*Present address: SmithKline Beecham Consumer Healthcare, 11 Stoke Poges Lane, Slough SL1 3NW.

promotion messages. Interestingly, the issue of what constitutes a 'meal' or 'snack' is not confined to the literature on human eating behaviour but also extends to research on eating patterns of the laboratory rat (Levitsky, 1974; Castonguay *et al.* 1986).

Published definitions of eating occasions are largely based on loose social and/or cultural norms of timing and size, and therefore give little quantitative information about specific eating occasions or individual practices. For human subjects the number, size and timing of 'meals' are clearly subject to many acute and chronic social influences and chronological trends. The majority of investigators have defined what constitutes a 'meal' and a 'snack', based on the criteria of time of consumption and/or nutrient composition of the eating occasions (Fabry *et al.* 1968; Metzner *et al.* 1977; Skinner *et al.* 1985; de Castro, 1990, 1993b; Basdevant *et al.* 1993; Lennernas *et al.* 1993). 'Meals' are generally described in a colloquial sense, that is, one of the main eating occasions of the day, nominally occurring at morning ('breakfast'), mid-day ('lunch') or evening ('dinner'). 'Snacks' refers to other eating episodes, generally smaller and less structured than 'meals', while 'snacking' refers to the patterns of frequency of these eating events consumed at times other than recognized 'meal' times. Summerbell *et al.* (1995), for example, defined very closely what time periods constitute 'meal' times and times appropriate for 'snacking' by dividing the day into six eating periods, three of which are defined as 'meals' and three as 'snacks'. Such an approach may bias towards a more regular and traditional eating pattern with 'snacks' becoming consolidated into the definition of a 'meal' or *vice versa* simply because of the time band in which the food was consumed. Morgan *et al.* (1988) also used time factors only to identify these eating occasions.

Rotenberg (1981) used a social definition of eating occasions: the presence or absence of fellow diners. In this way, a 'meal' was defined as a planned social interaction centred on food, whereas a 'snack' was identified as an eating event conducted individually. Bernstein *et al.* (1981), studying the eating patterns of free-living subjects living without time cues, defined 'meals' as eating episodes of greater than 375 kJ. Others have also used a series of energy-based definitions combined with an added time constraint. de Castro (1993a) has used this combination in his research on eating patterns describing a 'meal' as providing at least 210 kJ; or more stringently food providing 420 or 840 kJ, with a separation time from a preceding or following eating event of at least 15 min. The type of food consumed has also been used as the basis for the definition of eating occasions. In a study by Skinner *et al.* (1985) the criteria of time and both the types and quantity of foods consumed was used to distinguish between breakfast, lunch, evening 'meal' and a 'snack'.

It is apparent that the type of definition may significantly influence the outcome and interpretation of studies in which they have been used. McBride *et al.* (1990) found that relationships between energy intake and eating frequency were dependent on the definition of what constituted a 'meal'. A correlation between eating frequency and energy intake was only significant with 'meals' defined as being food(s) providing more than 375 kJ. Work from our laboratory using self-reports of 'meals' and 'snacks' highlights the conflicting views held by the general public about what constitutes a 'meal' and what constitutes a 'snack' (Gatenby *et al.* 1995). An example of this is where a beverage with a biscuit consumed at 12.30 hours might be regarded as a 'snack' or a 'meal' depending on whether the respondent uses time of day or food type as a means of classification.

It is important to note that accurate assessments of dietary intake are a prerequisite for assessing the relationships between frequency of eating and health. Even when an appropriate method has been selected it remains subject to random and/or systematic errors at each stage in data collection (Livingstone, 1995). It has been documented that people

admit that they would change their behaviour when asked to complete dietary records (Mela & Aaron, 1997).

This issue is clearly of concern, particularly with respect to under-reporting of dietary intake. Of particular relevance to the study of eating frequency is the tendency to under-report 'snack' foods consumed between 'meals' (Poppitt *et al.* 1995). In one study (V. J. Burley, S. J. Gatenby, D. A. Anderson and D. J. Mela, unpublished results) adolescents reported eating on 4.65 occasions throughout the day. This low value is at odds with the literature and may reflect the fact that these adolescent subjects, in contrast to the adults participating in the dietary survey, were asked to keep a duplicate diet, possibly leading to under-reporting of 'snacks'.

#### DIETARY IMPLICATIONS OF EATING FREQUENCY

A number of recent publications have raised concern about the nutritional quality and eating patterns of British children and adolescents with respect to the prevention of CHD and other chronic diseases (Department of Health, 1989; Anderson *et al.* 1994; Strain *et al.* 1994). Although these particular authors do not cite increasing eating frequency or 'snacking' behaviour as part of the problem, others have expressed concern about 'snacking' and so-called 'junk food' diets and poor nutrient intakes. There is a tendency to equate 'snacking' with 'snack' foods which may have a poor nutritional profile. Altered eating patterns (e.g. 'snacking') have been cited as one of the key influences on food intake in adolescents (Truswell & Darton-Hill, 1981). Because of these concerns the literature was until very recently heavily weighted towards this sector of the population, with much less information regarding the eating patterns of adults and the elderly. However, a number of large-scale studies of population groups have recently appeared in the literature facilitating the examination of eating frequency in relation to health in these age-groups.

#### EATING FREQUENCY AND NUTRIENT INTAKE IN CHILDREN AND ADOLESCENTS

Ezell *et al.* (1985) investigated the 'snacking' patterns of 225 adolescents selected from four metropolitan and three rural schools in eastern Tennessee. From data collected by 24 h recall these authors report that 89 % of the respondents ate at least one 'snack' (defined as foods consumed between conventional 'meal' times) on the day of the survey, over half consumed one or two snacks, one-third consumed three or four snacks, with only 5 % consuming from five to eight 'snacks'. Micronutrient densities of the 'snacks' were low in all time periods but lowest in morning 'snacks'. Such 'snacks' were typically candies and salty 'snack' foods. 'Snacking' patterns in boys and girls were similar, although boys' intake of energy, Ca and riboflavin were higher than those of girls.

Livingstone (1991) found that most of the forty-eight children (aged 5–12 years) who completed a detailed dietary history still conformed to the typical UK pattern, eating three traditional 'meals' per day with additional 'snacks'. In this study, most children had at least six eating and/or drinking episodes per day. This pattern of eating was also observed in young people (aged 11–25 years) in Brisbane, Australia (Dugdale *et al.* 1988). However, in a different culture, with diets of typically low energy density, eating frequency in young children may be much higher. Eastwood Garcia *et al.* (1990) reported that Mexican children ate up to thirteen times daily and consumed as much as 45 % of their energy as 'snacks'.

Ruxton *et al.* (1996) assessed 'snacking' habits in a study of 7–8-year-old children ( $n$  136). Although the frequency of 'snacking' was not reported, the subjects were divided into

'high snackers' and 'low snackers' according to the proportion of total energy accounted for by these 'snacking' events. Using this classification 13 % of children were classified as 'high snackers' receiving more than 35 % of mean daily energy from 'snacks' and 9 % of children as 'low snackers' receiving less than 15 % mean daily energy from 'snacks'. The majority of schoolchildren were therefore receiving between 15 and 35 % of food energy from 'snacks'. When overall energy and nutrient intakes were examined in the two 'snacking' groups, the only significant finding was that mean  $\beta$ -carotene intake was higher in the latter group. 'Snacks' eaten by the 'high' snackers were more dense in riboflavin, vitamin B<sub>12</sub> and vitamin D and these children received lower intakes of energy and nutrients at 'meal' times. There were no large differences in dietary patterns between the 'high' and 'low' 'snacking' groups except that breakfasts of children in the 'low' 'snacking' group contributed more energy, protein, carbohydrate, fat, total starch, total sugar, NSP, nicotinic acid, Ca and Fe to total intakes. In conclusion, the authors state that 'snacks', defined as food or drink not taken at a recognized meal time, made an important contribution to mean daily intakes, particularly to intake of energy, fat, carbohydrate, total sugars, NSP and vitamin C. Interestingly, for children who consumed low volumes of milk, 'snacks' were an important source of vitamin A and Ca and for children with a low consumption of breakfast cereal, 'snacks' were an important source of Fe and folate.

McCoy *et al.* (1986) calculated average daily nutrient intake provided by 'meals' and 'snacks' for 1224 girls participating in a dietary survey. The investigators defined 'snacks' as 'all foods (including liquids except water) not identified as part of a 'meal''. Of the girls, 9 % consumed one or more 'snacks' pre-breakfast, 56 % between breakfast and lunch, 91 % between lunch and evening meal and 80 % following the evening meal. Age was not related to the percentage who 'snacked' during any of the time periods, with the exception of the morning 'snack'.

In some studies an attempt has been made to examine the qualities of snacks which make them attractive to children. Cross *et al.* (1994) carried out a study to examine 'snacking' behaviour, including frequency, time of day, location and qualities sought in 'snack' choices in adults and fifth- and sixth-grade children in USA. The majority of children in all age-groups 'snacked' at least once daily. The modal 'snacking' frequency for all age-groups was two or three times daily. Of the students, 29 % reported that they 'snacked' four times daily. In common with previous studies the morning was the least common and afternoon was the most common time for 'snacking'. Almost all 'snacking' occurred at home. In the selection of 'snacks', taste outranked nutrition as the most important characteristic of a 'snack'. Fruits were popular with all age-groups, but overall they were chosen less often at 'snack' time than foods from other categories. Those who ranked nutrition or health as very important ate slightly more fruits and slightly less crisps, cookies and crackers than others in their respective age-groups. Among students who ranked nutrition as very important, however, there was no difference in frequency of candy consumption. Overall, salty crunchy foods dominated 'snack' preferences. More-nutritionally-sound 'snacks', such as fruits, led the list only in the morning.

It would appear from the literature that although most children and adolescents in Western developed countries regularly consume three meals per day, snacking behaviour is currently extremely common and possibly increasing (Morgan *et al.* 1983; Bull, 1988; Livingstone, 1991; Health Promotion Wales, 1993). However, it is difficult to say with certainty that there has been a real change in eating frequency with time as it may be that the distinction between 'snacks' and 'meals' has become somewhat blurred. Although there is much anecdotal information about changes in eating frequency amongst groups of the population, and in particular amongst adolescents, there are very few published studies

describing longitudinal data. There is clearly a need for well-designed comprehensive longitudinal surveys of eating behaviour and nutrient intake in all age-groups of the population. The Euronut SENECA study of the elderly is a good example of the nature of longitudinal data which might be collected on other age-groups (Schlettwein-Gsell & Barclay, 1996).

#### EATING FREQUENCY AND NUTRIENT INTAKE IN ADULTS

There is a paucity of data on eating frequency in adult populations, although the issue of shift work and its effect on dietary patterns received some considerable attention in the 1970s (Tagaki, 1972). Much of the dietary data which has been collected more recently does not permit analysis of eating frequency due to inappropriate and insufficiently detailed information and, if eating frequency has been examined, investigators have tended to define specific eating periods (for example, Summerbell *et al.* 1995) which may mask the actual level of eating frequency in these age-groups.

In a very comprehensive study the British Nutrition Foundation (1984) reported an average consumption of 1.68 'meals' (defined by the respondent as a 'meal' as opposed to a 'snack') and 4.76 non-meals (defined as anything other than a 'meal') per d in over 1000 UK adults, based on a 24 h recall technique, giving an average eating frequency of about 6.5 times daily. An unpublished analysis of dietary intake records at our laboratory indicates that adults eat on average 6.5 times daily with smaller frequencies reported by the elderly (6.02) and the very elderly (5.60) and this reduction in meal frequency with advancing age concurs with the data of Summerbell *et al.* (1995) and Schlettwein-Gsell (1992).

In a study where adult subjects were asked to self-define eating occasions as 'meals', 'snacks', or drinks we found that adults reported eating 4.9 (range 3.0–8.2) times daily, which is lower than most estimates of the number of eating occasions for this age-group. The classification of beverages consumed without food (i.e. at a time interval of at least 30 min from food consumption) as a 'drink' rather than a 'snack' may have led to this lower than average value. The mean number of drinks consumed daily in isolation from either a self-defined 'meal' or 'snack' was 2.55 (Gatenby *et al.* 1995).

In a study to compare dietary patterns in different age-groups Summerbell *et al.* (1995) collected data on eighty-eight elderly, forty middle-aged and fifty-nine young adults. In this study daily food intakes were divided into six feeding periods: breakfast (1), mid-morning 'snacks' (2), lunch (3), mid-afternoon 'snack' (4), evening 'meal' (5), evening 'snacks' (6). A feeding period was defined as the consumption of any food or drink which provided energy. Two consecutive feeding occasions were considered as separate if the time interval between them was greater than 1 h. Feeding periods 1, 3 and 5 were defined as 'meals', while feeding periods 2, 4 and 6 were defined as 'snacks'. In this study, therefore, the maximum number of potential eating occasions was six. As has already been noted this division of eating periods does not permit an analysis of actual eating frequency in terms of the number of daily eating occasions. The data are presented as the percentage contribution to total dietary intake by 'meals' and 'snacks'. The middle-aged group (39–59 years) received 25.8% (males) and 21.4% (female) of their total daily energy intake during those periods defined as 'snacks', whereas the elderly group (65–91 years) received only 16.6% (males) and 17.9% (females) of their total energy intake at these time periods.

The snacking habits of European university students were assessed using a standardized questionnaire and by asking subjects to self-define their eating occasions



(Bellisle *et al.* 1995). Students reported to consume, on average, 2.8 (SD 0.9) 'meals' and 1.6 (SD 1.2) 'snacks'. In agreement with other data (Gatenby *et al.* 1995), women reported slightly but significantly fewer 'meals' (2.7 v. 2.8) and more 'snacks' (1.7 v. 1.6) than men. Those respondents reporting to be on a diet to lose weight reported fewer 'snacks' and 'meals' than non-dieters.

S. Drummond, T. Kirk and N. Crombie (unpublished results) examined the eating patterns of ninety-six adults. The total group was divided into frequent (those having four or more eating occasions daily; males *n* 26, females *n* 26) and infrequent eaters (those eating less than four times daily; males *n* 23, females *n* 21). A 'meal' was defined as one of the main eating occasions of the day occurring in the morning (breakfast), midday (lunch) and in the evening (dinner). Any food taken outside these eating times was a 'snack'. This is a similar classification to that employed by Summerbell *et al.* (1995) and is consistent with the commonly used definition of a 'snack' being food eaten at a time other than a conventional 'meal' time (Rugg-Gunn *et al.* 1986). If a subject habitually consumed a breakfast food (e.g. cereal, toast, bacon and/or egg sandwiches, etc.) 1 h or so after rising, this was still considered to be his or her breakfast 'meal'. When foods were taken at an habitual 'meal' time but consisted of a food commonly regarded as a 'snack' food (e.g. packet of crisps, chocolate, biscuits, fruit) this eating occasion was defined as a 'snack', that 'snack' being taken in place of a 'meal'. This is an interesting methodological approach which highlights the difficulties inherent in the use of 'meal' and 'snack' terminology. Using this method male subjects eating at least four times daily consumed 2.17 'snacks', whereas those eating fewer than four times in the day consumed only 0.88 'snacks' per day. Consistent with other data the level of 'snacking' in females was slightly greater, with 2.32 'snacks' per day being consumed by those eating frequently and 1.22 'snacks' per day in those eating fewer than four times daily. In total the mean number of eating occasions per day was 4.11 and 4.31 in males and females respectively. In infrequent female eaters 'snacks' contributed 21% of total food energy; the corresponding value for infrequent male eaters was only 14%. The 'snacks' consumed by the female population tended to be higher in fat as a percentage of energy, about 38% v. 33% in the male group.

Overall, females ate more chocolate bars, biscuits, cakes and crisps as 'snacks'; while males consumed more fruit, soft drinks and sandwiches and this is reflected in the higher percentage energy derived from fat in 'snacks' consumed by women. Eating frequency was positively correlated with total energy intakes for men and women, positively correlated with percentage energy from carbohydrates in men and positively correlated with both percentage energy from carbohydrates and sugars in women. When sugars were expressed in grams there was a positive correlation with eating frequency for males and females. There were no significant correlations between eating frequency and age in either male or female subjects.

Using the same data set S. Drummond, T. Kirk and N. Crombie (unpublished results) examined the association between breakfast eating and 'snacking' habits. Overall, habitual breakfast consumers had higher eating frequencies, indicating that those who do not eat breakfast do not make up for a lack of breakfast by consuming more 'snacks' throughout the day. This is corroborated by the fact that women eating breakfast have higher energy intakes. However, those eating breakfast are no fatter or heavier than those not eating breakfast, despite this increase in energy intake. Male breakfast eaters tend to have a higher percentage energy from carbohydrate, but whether this is entirely attributable to breakfast eating is not clear as those eating breakfast more frequently are higher-frequency eaters overall. It could, therefore, be that other 'snacks' and 'meals' consumed are high carbohydrate.

Table 1. Summary of studies examining the macronutrient composition of 'meals' and 'snacks'

Reference	No. of subjects	Subjects	Meal definition	Meal (% energy)			Snack definition	Snack (% energy)			%TDI from snacks:		
				Fat	CHO	Protein		Fat	CHO	Protein	Male	Female	All subjects
Children and adolescents													
Summerbell <i>et al.</i> (1995)	33	Adolescents 13-14 years	According to time period in which food consumed	40.7	46.1	13.1	According to time period in which food consumed	37.7	55.0	8.1	29	23.6	26.3
Ruxton <i>et al.</i> (1996)	136	Children 7-8 years	Food eaten at a recognized meal time	36.0	50.1	13.6	Food not eaten at a recognized meal time	42.6	51.4	6.0	-	-	25.6
Robson <i>et al.</i> (1991)	1015	Adolescents 12-15 years	All foods and drinks consumed at meal times	-	-	-	All foods and drinks not consumed at meal times	-	-	-	30.9	31.4	31.2
McCoy <i>et al.</i> (1986)	1224	Adolescents 12-16 years	Not stated	39.6	43.1	15	Not stated	32.2	55.1	7.0	-	-	23
Adults and elderly													
Gatenby <i>et al.</i> (1995)	75	Adults 18-60 years	Self defined	37	45	16	Self defined	38	50	10	-	-	25
Summerbell <i>et al.</i> (1995)	59	Young adult 17-60 years	According to time period in which food consumed	39.0	43.9	14.5	According to time period in which food consumed	31.5	47.8	8.9	18.9	19.4	19.2
Summerbell <i>et al.</i> (1995)	40	Middle-aged 39-59 years	According to time period in which food consumed	42.6	41.7	15.1	According to time period in which food consumed	37.7	4.2	11.5	25.8	21.4	23.6
Summerbell <i>et al.</i> (1995)	88	Elderly 65-91 years	According to time period in which food consumed	39.8	46.3	13.7	According to time period in which food consumed	34.4	48.8	10.6	16.6	17.9	17.3

CHO, carbohydrate; %TDI, % total dietary energy intake.

There is increasing evidence of cross-cultural differences in eating frequency. The SENECA longitudinal study of the elderly (Schlettwein-Gsell *et al.* 1991) shows that the number of eating occasions varies from one country to another. In the twelve towns surveyed eating frequency varied from three times daily (Poland and Hungary) to six or more eating occasions (Netherlands and Switzerland). The large proportion of energy which is consumed at midday in the elderly population is a common characteristic of their more-stable eating patterns (Davies, 1981), but is also probably the most important characteristic of the Southern and Eastern European pattern.

#### THE NUTRITIONAL COMPOSITION OF 'MEALS' AND 'SNACKS'

As the nutritional composition of eating occasions is likely to be at least, if not more physiologically important, than eating frequency *per se* it is important to examine the macronutrient distribution within eating occasions termed 'meals' and 'snacks'. Such compositional data have been reported in a number of studies examining eating patterns of different age-groups (see Table 1). Gatenby *et al.* (1995) instructed adult consumers to self-define eating occasions as either 'meals' or 'snacks'. The bases for these definitions were not investigated and it is likely that the subjects used a variety of criteria to define each eating event. These self-defined eating occasions were then analysed to examine any differences in nutritional composition in those termed 'meals' and those described as 'snacks'. Interestingly there was no difference in total fat content as a percentage of energy (although 'snacks' were higher in saturated fat), but 'snacks' were higher in carbohydrate (49% *v.* 44% energy) and lower in protein content (10% *v.* 16% energy) than meals. McCoy *et al.* (1986) also reported that 'meals' were significantly higher in fat and lower in carbohydrate than 'snacks'. When Summerbell *et al.* (1995) examined the nutritional content of 'meals' and 'snacks' in adolescents, adults, elderly and very elderly individuals a similar nutrient distribution was observed. There does appear to be reasonable agreement within the published studies that, in adolescents and adults, eating events described as 'meals' are higher in fat and lower in carbohydrate than those described as 'snacks'. As under-reporting of 'snacks' is likely to be frequent amongst overweight, obese and restrained individuals this selective under-reporting may confuse the interpretation of studies relating macronutrient intake to body weight regulation.

In contrast to the data in adolescents and adults the work of Ruxton *et al.* (1996) in 7–8-year-old schoolchildren found that the percentage of energy from fat was higher in 'snacks' (defined as foods consumed outside a conventional 'meal' time) than 'meals' (defined as foods consumed at conventional 'meal' times) and there were no significant differences in the percentage of energy from carbohydrate derived from these two types of eating occasion. In the work of Ruxton *et al.* (1996) 'snacks' had a significantly lower density of protein, vitamin A, thiamin, riboflavin, vitamin C, folate, nicotinic acid equivalent and Fe compared with meals. However, the densities of carbohydrate, total starch and total sugar were similar.

'Snacks' eaten by children from manual social classes were higher in energy and percentage energy from fat and made a greater contribution to daily intakes of energy, protein and some micronutrients than 'snacks' eaten by children from non-manual families. This does suggest that 'snacks' may be a more important nutrient source for lower social class than for higher social class children.



## CONTRIBUTION OF 'SNACKS' TO NUTRIENT INTAKE

*Children and adolescents*

As a 'snacking' pattern is common among adolescents and they receive a significant proportion of their daily energy intake from 'snacks', the types of food selected for these eating occasions can determine the overall nutritional quality of the adolescent diet. The types of foods selected and the subsequent impact on the nutritional quality of the diet may be related to when and where the 'snack' occasion occurs (Hruban, 1977). Rugg-Gunn *et al.* (1986) and other researchers in this area (for example, Musgrave *et al.* 1981) have defined the term 'snack' as a food not eaten at a recognized 'meal' time and one which made a minor contribution to the day's intake. However, there is increasing evidence that foods commonly referred to as 'snack' foods have more than a minor contribution to nutrient intake, particularly in younger age-groups.

The UK National Diet and Nutrition Survey of children aged 1.5–4.5 years (Gregory *et al.* 1995) provided information on the percentage contribution of certain food types to average daily energy intake. Fried potatoes and savoury snacks provided on average across the age-groups 4% each of total energy intake. Sugar confectionery and chocolate confectionery contributed 10% each towards food energy. Non-low-energy soft drinks provided 32% of non-milk extrinsic sugars intake. Savoury 'snacks' and chips contributed significantly to total, saturated and cis-monounsaturated fat intakes.

Several studies suggest that children and adolescents have the most even distribution of energy across the day compared with other age-groups (Skinner *et al.* 1985; Summerbell *et al.* 1995), and it seems this may be partly attributed to high levels of 'snacking'. A number of recent surveys have estimated that 'snacks' contribute between 20–39% of dietary energy in this sector of the population (Thomas & Call, 1973; Robson *et al.* 1991; Ene-Obong, 1993; Ruxton *et al.* 1994). Estimates of the energy contribution from 'snacking' in adults are rare, but lower 'snacking' frequency has been found in adults compared with adolescents (Monello *et al.* 1965).

In a study of adolescents by McCoy *et al.* (1986) 'snacks' provided the following percentages of daily nutrient intake: 23% of energy, 14% of protein, 27% of carbohydrate, 22% of fat, 15% of cholesterol. 'Snacks' on average provided 15–20% of the mineral intakes and 13–17% of the vitamin intakes. 'Snacks' contributed greatly to the intake of riboflavin, vitamin C and thiamin providing 52, 43 and 39% of the recommended daily allowance (RDA) respectively and exceeding suggested recommended nutrient densities (Hansen & Wyse, 1980) which are consistent with the USA RDA. The nutrients which 'snacks' contributed in the lowest amounts relative to recommended were folate, vitamin D, Zn, Fe providing 8, 9, 10 and 11% of the RDA respectively and falling below the recommended density of these nutrients.

More recently, Robson *et al.* (1991) studied the 'snacking' habits of 1015 randomly selected adolescents. The majority of 'snacks' (defined as foods consumed between 'meals') was derived from cakes, puddings and biscuits. In addition to contributing significant proportions of energy as sugar, 'snacks' also contributed significant amounts of other important nutrients.

Spyckerelle *et al.* (1992) found that snacks provided 20% of the total energy intake of their adolescent sample, while Livingstone (1991) reported that 'snack' foods supplied one-third of British primary schoolchildren's energy intakes. In an Australian survey (Magarey *et al.* 1987) 'snacks' consumed by 8 year olds contributed 22% of energy, 13% of protein, 38% of total sugar, 22% of dietary fibre, 20% of total fat, 21% of Ca, 17% of Fe, 27% of vitamin C and 16% of thiamin to daily intakes. Rugg-Gunn *et al.* (1986) in

a study of adolescents in 1980, demonstrated that 'snacks' provided a significant proportion of children's total sugar intakes (66 % of added sugar and 57 % of natural sugar). In a follow-up study of a new cohort of adolescents in 1990 Rugg-Gunn *et al.* (1993) observed that confectionery contributed 30 % of non-milk extrinsic sugars, although the contribution of 'snacks' as a whole was not reported.

In a re-analysis of the data collected from 1705 British schoolchildren (Department of Health, 1989), Gibson (1996; unpublished results) studied relationships between the level of consumption of biscuits, cakes and sugar and chocolate confectionery (commonly known as 'snack' foods) and various nutritional variables. The distribution of intakes of each of the food groups was divided into thirds corresponding to low, medium and high levels of consumption within each of the four age and/or sex groups (boys aged 10–11 years; boys aged 14–15 years; girls aged 10–11 years; girls aged 14–15 years), and differences in energy and nutrient intakes between the thirds were then evaluated. Children in the highest third of consumption of each food had significantly higher intakes of energy, but also of many nutrients, compared with children in the lowest third. Those reportedly consuming high levels of bakery and confectionery products were apparently also consuming more food overall. In girls in the older age-groups there was some evidence of higher BMI among those consuming fewest biscuits and least confectionery, a finding which may reflect sugar-restricting habits among those with higher relative body weights. The data obtained by S. A. Gibson (unpublished results) do not support the hypothesis that high intakes of 'snack' foods of this nature are associated with poor intakes of vitamins and minerals. Whilst these foods undoubtedly contribute to dietary sugars, biscuits, chocolate and sugar confectionery do not appear to contribute to raising the proportion of fat in these children's diets.

### Adults

Data from two large American surveys (Human Nutrition Information Service, United States Department of Agriculture, 1985; Food and Nutrition Board, National Research Council, 1986) indicate that the proportion of total energy intake provided by 'snacks' in adults varies from 15 to 20 %. Similar frequencies were observed in a smaller survey (Dreon *et al.* 1988) which reported that a group of middle-aged sedentary men consumed on average 4.5 'meals' per day, with 82.4 % of daily energy consumed as 'meals' and 17.6 % consumed as 'snacks' (defined by time of day), with subjects consuming 48 % of their daily energy intake during and after the evening meal.

Data from the Dietary and Nutritional Survey of British Adults (Gregory *et al.* 1990) show that micronutrient intakes are not compromised with increased consumption of bakery and confectionery products which are traditionally consumed as 'snacks'. At the highest level of consumption such products do contribute significantly to energy intake (between 1 % and at the highest level of intake 17.5 %) and to fat and sugar intakes. Across all male consumers the proportion of fat obtained from bakery and confectionery products was 9.8 and 3.7 % respectively whereas across all female consumers the corresponding values were 11.4 and 4.7 %. In the high-consuming groups the proportion of fat obtained from bakery products rose to 18.4 and 17.1 % in females and males respectively and for confectionery the corresponding values were 9.1 and 7.4 %. Micronutrient densities were reduced in those individuals who were classified as high consumers of bakery and confectionery products, but absolute intakes were still above those currently recommended (Department of Health, 1991).

Data from the 3rd Scottish MONICA cross-sectional study (Bolton-Smith & McCluskey, 1997) showed that increased frequency of confectionery consumption in men and women was associated with significantly greater consumption of total energy, percentage energy from carbohydrate and total sugars. The percentage energy from protein and alcohol (men only) was significantly lower with high confectionery intakes. For men, mean daily intakes of vitamin C, Fe and fibre increased with the increased frequency of confectionery. Nutrient density of  $\beta$ -carotene, vitamin A and fibre decreased significantly with increasing confectionery consumption for males but this was unrelated to relative intakes of other micronutrients. For women,  $\beta$ -carotene decreased and Fe increased significantly with increasing frequency of confectionery consumption. Nutrient densities of all the micronutrients (and fibre) were inversely related to the frequency of confectionery consumption for females. The Aberdeen Osteoporosis study of females (New & Grubb, 1996, 1997) clearly indicates that a high frequency of consumption of sweet biscuits, sugar confectionery and chocolate confectionery is not associated with obesity, although a high frequency of consumption of savoury biscuits was associated with increased body weight.

### CONCLUSIONS

A major difficulty in eating-frequency research is the selection of the appropriate tools with which to conduct the dietary aspects of the research and the assessment of validity of the resulting data. As has been noted in the present paper and in others in this supplement (Bellisle *et al.* 1997; Chiva, 1997) the potential for individuals to under-report their food (and particularly 'snack') intake is a major issue and not easily overcome. To enhance the interpretation of studies examining food and nutrient intake in relation to eating frequency it is imperative that investigators validate energy intake data with published cut-off points for energy intake in relation to estimated BMR (Black *et al.* 1991; Goldberg *et al.* 1991). It would also facilitate interpretation of studies if subjects were characterized in terms of their eating behaviour, in particular, their level of dietary restraint.

Part of the difficulty in identifying the nutritional implications of 'snacking' is related to definitions of 'meal' *v.* 'snack' and subsequent categorization of individual patterns. Physiological definitions, typically relating to energy content or time of the eating, do not necessarily coincide with colloquial, cultural or individual perceptions of what constitutes a 'meal' *v.* a 'snack', these being the definitions which dominate the literature. Thus, self-reports of 'meals' can reveal strong individual biases, and may be ambiguous and inconsistent. The methodological issue of how to incorporate drinks into the assessment of eating frequency remain unresolved. Clearly, a more consistent approach to the defining of eating occasions would facilitate appropriate interpretation of the available literature and future research.

There is clearly a need to examine dietary patterns using both cross-sectional and longitudinal approaches. Good data on longitudinal changes are scarce. The increasing availability of large national dietary surveys provides the ideal opportunity to examine changes in eating frequency over time.

It is commonly stated that 'snack' foods provide 'empty calories' and, therefore, elevate energy intake whilst providing insignificant quantities of other nutrients. The data presented in the present review suggest that in fact 'snack' foods, or at least foods consumed by the population between conventional main 'meals' contribute significantly to the nutrient quality of the diet. Those who 'snack' frequently tend to eat more food in general (presumably because of increased energy requirement related to increased physical activity levels; see Hawley & Burke, 1997).

It is important to recognize that many 'snack' foods may be eaten irregularly as spontaneous additions to the diet. It has been proposed that there may be poor compensation for the insertion of additional eating occasions and this may be particularly true if such additions are high in fat. Such hypotheses have not been empirically tested.

Future work in this area would benefit from a more consistent approach which includes precise descriptions of the methodologies employed. This would facilitate inter-study comparisons and enable more effective health education messages about 'snacking' to be delivered to the general public.

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