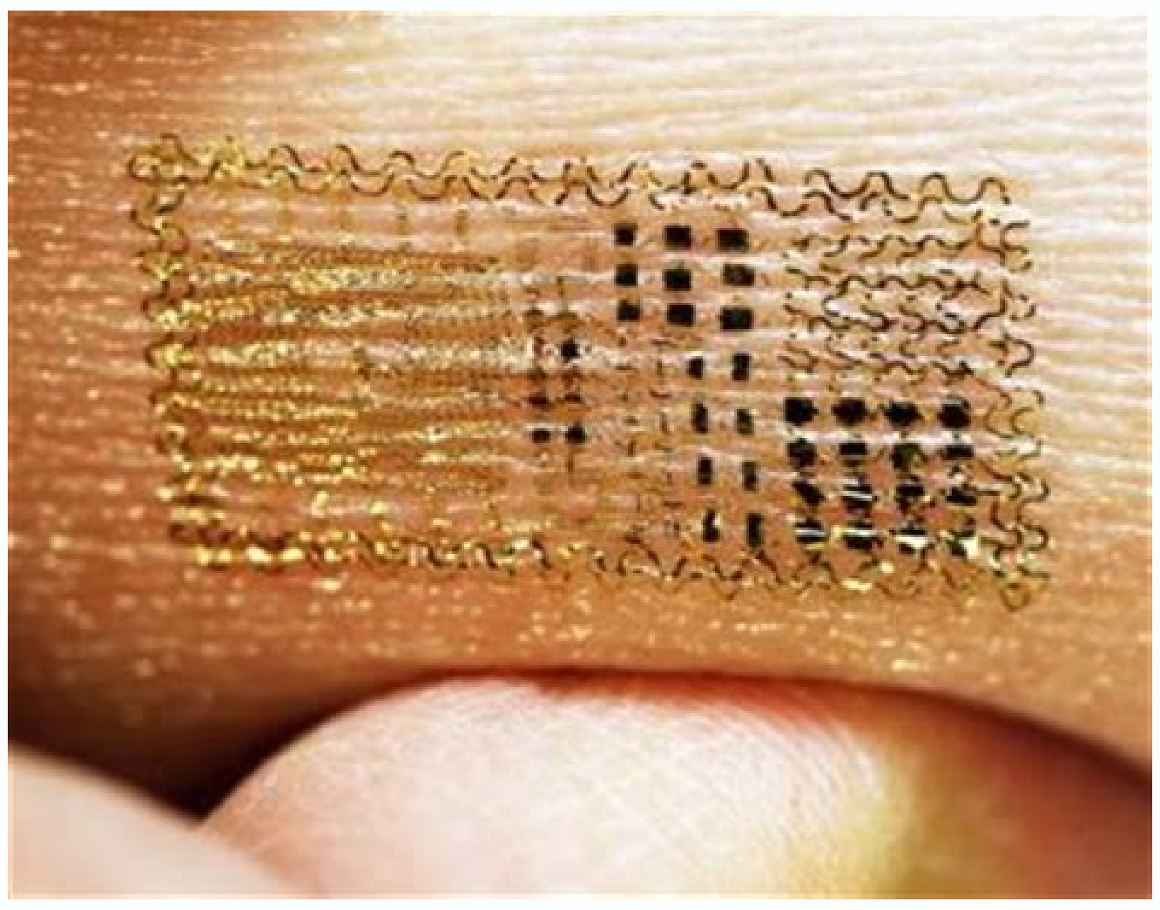
42265076.25641 16300788.910112 14492924.351351 84942236330 50060196676 39581097840 7714982.0208333 23301666352 2469920.1111111 20315082125 32380743512 50921946943 166847160748 9139071.2786885 36500011.782609 591922968 9311009565 6040505097 5349508.9104478 28434897456 21648040.9125 8735887.7887324 11311333.645833 1327690.7428571 10873338544 13933970.597015 1864842.5308642 59743806472 71790546.130435 9635615.047619 7202087.6727273 25063005663 483166.44615385 131652868060 23675283496

Metabolism food label lunch lab answer key pdf sheet free online



Metabolism food label lunch lab answer key. Metabolism food label activity.

Figure 3.4 clearly demonstrates that energy supply calculated through NME relates well with the application of general Atwater factors. Because of the importance of food and the broad-reaching effects of food regulations within a country's borders, and beyond as they affect trade, it is fair to say that whatever system is in use in a given country is likely to be entrenched, and there will be a great deal of inertia and resistance to change. Some energy is utilized during the metabolic processes associated with digestion, absorption and intermediary metabolism of food and can be measured as heat production; this is referred to as dietary-induced thermogenesis (DIT), or thermic effect of food, and varies with the type of food ingested. For example, if expressed as monosaccharide equivalent, 100 g of glucose, 105 g of most disaccharides and 110 g of starch each contain 100 g of anhydrous glucose. Values for fermentable fibre are believed to vary by 27 percent, i.e. ME 11 kJ/g (2.6 kcal/g) and NME 8 kJ/g (2.0 kcal/g). This change recognized the fact that different weights for available carbohydrate are obtained depending on whether the carbohydrate is measured by difference or directly. Whereas the normal state of the adult is "zero balance" - no net retention of energy or other nutrients - the normal state of infants and children is growth, which implies the retention of large amounts of energy and other nutrients as new tissue, although the energy cost of weight gain of tissue of similar composition does not differ appreciably from that of adults (Roberts and Young, 1988). For these individuals, use of NME factors in the clinical setting may be of value. The Atwater specific factor system appears to be superior to the original Atwater general system, which took only protein, fat, total carbohydrate and alcohol into account. "Energy balance is achieved when input (or dietary energy intake) is equal to output (or energy expenditure), plus the energy cost of growth in childhood and pregnancy, or the energy cost to produce milk during lactation" (FAO, 2004). This is the accepted standard unit of energy used in human energetics and it should also be used for the expression of energy in foods. For the current case study, as well as using these conversion factors, which also served as a baseline, additional variables were created. The energy values are 17 kJ/g (4.0 kcal/g) for protein, 37 kJ/g (9.0 kcal/g) for fat and 17 kJ/g (4.0 kcal/g) for carbohydrates.[9] The Atwater general system also includes alcohol with a rounded value of 29 kJ/g (7.0 kcal/g or an unrounded value of 6.9 kcal/g) (Atwater and Benedict, 1902). Relative to the first goal, the consistent application of a uniform system to all foods is likely to be the first step in yielding the greatest benefits to the most consumers. Application of NME factors resulted in expected variable decreases in the energy content of baby foods that ranged in the examples examined from a low of 2 percent, for apple sauce, to a high of 9 percent, for chicken with gravy. Since the use of ME factors of one type or another represents the status quo, a change to NME at this time would seem to have larger implications. Infant formulas and foods for infants and young children present a special situation, and in most regulatory frameworks are handled separately from foods in general. # Fibre content included in total carbohydrates by difference. It is likely that this segment will view any change as a burden. When the energy lost to microbial fermentation and obligatory thermogenesis are subtracted from ME, the result is an expression of the energy content of food, which is referred to as net metabolizable energy (NME). In addition, some countries use energy values for novel food ingredients such as polyols and polydextrose. 75) 15 (3.6) 17 (4.0) 15 (3.6) Lactose 16 (3. It would be both inaccurate and undesirable to convey such a message. The differences of importance between ME and NME factors are found primarily in estimating the energy content of protein, fermentable, unavailable carbohydrate, and alcohol (Table 3.3). However, the following points, which were made previously, should be kept in mind when interpreting these findings. By contrast, net metabolizable energy (NME) is based on the ATP-producing capacity of foods and their components, rather than on the total heat-producing capacity of foods. § Original data were published in kcal/g; values for kJ/g have been calculated from calorie values. Second, such a change would have broad-reaching implications for a wide range of interests, most of which have been considered only briefly here and some of which may not yet have been recognized. NME-System 2 = NME specific conversion factors (proposed), including energy from fibre. One example serves to illustrate these issues. 3.5.2 The extensive general factor system A more extensive general factor system has been derived by modifying, refining and making additions to the Atwater general factor system. ME factors appear to be reasonably valid for infants and small children; furthermore, neither ME nor NME factors have been specifically investigated in infants or young children. The United States Nutrition Labeling and Education Act (NLEA, see: www.cfsan.fda.gov/~lrd/CFR101-9.HTML) of 1990, for example, allows five different methods, which include both general and specific factors. Although all energy values in the database are derived using ME factors, it has not been possible to calculate the energy values for all foods using the same set of factors (i.e. specific or general). Most other food composition databases do not face this problem as they use only the general Atwater factors for all foods. Regulatory authorities benefit from a system that allows them to assure compliance with regulations at a reasonable cost. In fact, if the NME system were used, the energy requirements would be lowered approximately by the same percentage as food energy. Pragmatic consideration of the practical implications of standardizing on one set of energy conversion factors, including a critical evaluation of the possible change from the use of ME factors, leads to several conclusions. 2) Factors for dietary fibre vary widely and are not dependent on method. The SI is founded on seven SI base units, which are assumed to be mutually independent. (1997). In this regard, uniformity is perhaps a greater consideration than the energy conversion factor or system that is adopted. Furthermore, foods replace each other as energy sources in the diet and in intermediary metabolism on the basis of their ATP equivalence (which is reflected in NME), rather than on their ability to produce equal amounts of heat (which is reflected in ME). However, it may not be vastly superior to the more extensive general factor system, which takes into account the differentiation between available carbohydrate and dietary fibre, and recognizes sources of energy other than protein, carbohydrates and fat. For example, Codex (Codex Alimentarius, 1991) uses Atwater general factors with additional factors for alcohol and organic acids. § Concept diet 1: United Kingdom women's slimming diet (as tabulated), with further replacement of fat by protein. For the workshop, FBS data from nine countries were examined using the USDA data set for calculating energy availability. Energy values in centrally maintained databases are likely to be modifiable, some with less effort and cost than others. For example, separate factors were needed so that the division of total carbohydrate into available carbohydrate and fibre could be taken into account. ° The specific Atwater factors (Merrill and Watt, 1973) were applied and values of total carbohydrates by difference (CHOCDF)** were used with protein calculated with Jones factors. (However, as NME factors are derived from ME factors, the standardization of ME factors would still seem to be a logical first step to such a change.) The ultimate recommendation must take into account the scientific differences between metabolizable and net metabolizable systems, the need to provide useful information to consumers, and the practical implications of either staying with and standardizing one of the systems currently in use or moving to the other system. In the non-fasting state, this includes the heat of microbial fermentation and obligatory thermogenesis, which are the defining differences between ME and NME. It uses a single factor for each of the energy-yielding substrates (protein, fat, carbohydrate), regardless of the food in which it is found. Smaller food companies have fewer and limited capabilities. In considering the alternatives, there was general agreement on the following principles: 1) NME represents the biological ATP-generating potential and, as such, the maximum potential of individual food components and foods to meet energy requirements that require ATP; thus, NME represents a potential improvement in the description of food energy, especially when individual foods are to be compared. Relative to the second goal, however, NME conversion factors would appear to be preferable in at least two situations: comparisons of individual foods or food products when it is desirable to know their relative potential to support gains of weight, especially gains in fat; and, related to this, counselling of individuals with specific dietary needs that relate to weight control.[15] Currently, NME factors do not seem to be well understood or to have been widely adopted for these purposes, even by health care professionals. Regulatory perspectives. Expressing these same recommendations in NME terms, energy from protein becomes 12 percent, and from fat 31 percent (see Table 3.8). 2) The 2001 human energy requirement recommendations are based on data derived from energy expenditure measurements, and hence equate conceptually to ME (FAO, 2004). Most of the energy that is absorbed is available to human metabolism, but some is lost as urinary energy (UE), mainly in the form of nitrogenous waste compounds derived from incomplete catabolism of protein. Regardless of the technique used, the energy values obtained are related to oxygen consumption or CO2 production and (through indirect calorimetry calculations) heat production. This is because NME factors reduce the energy content of a food or diet, so the application of such factors to foods but not to energy requirements would imply that an increased food intake is needed to meet those requirements. Energy content must include energy from protein, fat, carbohydrate and any ingredients for which specific food factors are known. There are clearly circumstances in which it is desirable to know with greater precision which specific foods will ultimately contribute to maintaining energy balance - for example: in the management of obesity through weight-loss diets that are high in protein or fibre, which will not be completely metabolized to yield energy; in diabetes mellitus with concomitant renal disease, when protein intake may be low, and therefore makes only a small contribution to total energy intake; or when using novel foods that may or may not be fully metabolized. In the case of fat, the Atwater general factor of 37 kJ/g (9.0 kcal/g) is commonly used. ME-System 1 = Atwater specific conversion factors, not including energy from fibre. The theoretical appeal of NME for the derivation of energy conversion factors rests on the following: substrates are known to differ in the efficiency with which they are converted to ATP, and hence in their ability to fuel energy needs of the body. On the basis of the theoretical discussion of energy flow through the body (see Section 3.1 and Figure 3.1), ME values can be modified further to account for energy that is lost as heat from different substrates via heat of fermentation and obligatory thermogenesis, i.e. energy that would not be available for the production of ATP to fuel metabolism. The Atwater general factors are used when specific factors are not known for all ingredients, or when the formulation is proprietary, and thus the amounts and proportions of ingredients are not known by the database compiler. The precise values for protein, fat, total carbohydrate and alcohol are, respectively, 16.7, 37.4, 16.7 and 28.9 kJ/g. This may result in apparent differences in the nutrient composition of infant formulas, especially when compared with human milk, for which nutrient content is always expressed per 100 g or 100 ml. Source: Adapted from Warwick and Baines (2000) and Livesey (in press [a]).Some energy is also lost as the heat produced by metabolic processes associated with other forms of thermogenesis, such as the effects of cold, hormones, certain drugs, bioactive compounds and stimulants. The countries represented different regions of the world and different diets: Afghanistan, Bangladesh and the Islamic Republic of Iran are characterized by a high rice and wheat supply; in Guatemala, Guinea and Mozambique maize and tubers are important, and also sorghum in Mozambique; and Italy, Tunisia and the United States observe a mixed diet. # The general Atwater factors and 8 kJ/g fibre were applied and values of available carbohydrates by difference (CHOAVDF +)** were used with protein calculated with Jones factors. Second, a single food usually represents the entire diet for infants in the first six months of life, and the differences between energy contents estimated by the ME and by the NME systems may be greater when single foods, rather than mixed diets, are involved. The effects of using various analytical methods with different energy conversion factors on the conclusions drawn from food consumption survey data. * Dietary fibre assumed to be 10 g. Source: ENDEF study, 1974-1975. The technical workshop participants addressed the specific issue of whether energy conversion factors should shift from their current system based on ME to one based on NME. Of the two principal differences between ME and NME factors (i.e. heat of fermentation and thermogenesis), heat of fermentation is a more significant factor in infants because of both the presence of non-digestible carbohydrates, such as oligosaccharides, in the infant's diet (breastmilk) and the inability to digest fully carbohydrates that are normally fully assimilated by the older child and adult (Aggett et al., 2003). If these are not known, Atwater general factors are used. 3.4 CONCEPTUAL DIFFERENCES BETWEEN METABOLIZABLE ENERGY AND NET METABOLIZABLE ENERGYME has traditionally been defined as "food energy available for heat production (= energy expenditure) and body gains" (Atwater and Bryant, 1900), and more recently as "the amount of energy available for total (whole body) heat production at nitrogen and energy balance" (Livesey, 2001). The lower NME values for dietary fibre are due to a higher assumed loss of energy through heat of fermentation, while those for alcohol seem to be due to thermogenesis following alcohol consumption. Among other applications, data in FBS are used to: 1) follow trends in food supplies; 2) compare available food supplies with estimated country requirements; 3) estimate shortages; and 4) evaluate the effectiveness of food and nutrition policies. 3.5.6 Resulting confusion This array of conversion factors, coupled with the multiplicity of analytical methods discussed in Chapter 2, results in considerable confusion. Codex specifies the use of general factors for energy conversion: 17 kJ/g (4 kcal/g), 37 kJ/g (9 kcal/g) and 17 kJ/g (4 kcal/g), for protein, fat and carbohydrate, respectively. In general, three systems are in use: the Atwater general factor system; a more extensive general factor system; and an Atwater specific factor system. It can be thought of as the "food energy available for body functions that require ATP". In more developed, industrial societies, consumers are increasingly interested in the effects of nutrition on health and longevity. Consumer interests. Nevertheless, any change in the food energy conversion factors that are used, be it standardization within the ME factor system or a shift to the use of NME factors, would have major implications. The energy content was also recalculated with Atwater general factors and NME conversion factors, applying them to the existing and the newly created variables. The conversion factors for joules and calories are: 1 kJ = 0.239 kcal; and 1 kcal = 4.184 kJ. [13] The National Study of Family Expenditure (Estudo Nacional da Despesa Familiar [ENDEF]) was conducted by the Brazilian Institute of Geography and Statistics. The degree to which labels are read and understood is not known with any certainty, and it is likely to be very variable. Values for oligosaccharides from McVeagh and Miller (1997) and Coppa et al. This results in the NME factors. The different calculation methods for protein (N x Jones factors, N x 6.25, or the sum of amino acids) have a minor impact on energy supply as they generate differences of less than 1 percent, or 4 to 80 kJ (1 to 20 kcal). Estimates of energy intake per adult-day were calculated using these approaches and when compared with the baseline (based on specific ME factor values) revealed values ranging from -3 to +1 percent (Figure 3.2).[14] Recalculated intake data were also compared with the baseline "energy requirement standard" to assess the effect of energy conversion factor on estimates of the apparent percentage of individuals with low energy intake. The recommended ME factor for dietary fibre in ordinary diets is 8 kJ/g (2.0 kcal/g); the corresponding NME value is 6 kJ/g (1.4 kcal/g) - a decrease of 25 percent. 5 NME-2: assumes 10 percent of protein is unavailable, leaving 8.01 g/litre of available protein. # Merrill and Watt (1973). Energy value for carbohydrate assumes weight of carbohydrate reflects weight of mono- and disaccharides. The dietary energy supply (DES) - average available kilocalories per person per day - can then be judged against requirements. Household food consumption surveys are an important tool used to estimate dietary adequacy of individuals and population groups. Source: Adapted from Livesey (in press [b]). The confusion stems from three main issues: The same weight of different carbohydrates (monosaccharides, disaccharides and starch) yields different amounts of hydrous glucose (expressed as monosaccharide), and thus different amounts of energy. First, in none of the areas examined is such a change infeasible - it is more difficult in some than others, but it is feasible in all. Clearly, the availability of data derived from different analytical methods, and the choice of energy conversion factors used to calculate energy content of the diet will affect the calculated intakes, and in turn the estimates of these numbers or the prevalence of inadequacy. Short-chain (volatile) fatty acids are also formed in the process, some of which are absorbed and available as energy. The ease or difficulty of that task will depend on how the secondary database was constructed. On the label however, nutrient composition is generally expressed per 100 g of the formula, even though manufacturers are permitted to express it per 100 kJ or 100 kcal. ** Tagnames - see footnote7 on page 17 for an explanation. It should be noted that in situations where NME conversion factors for food energy are used, guidance on "reduced" energy requirements based on NME factors must be provided so that requirements and intakes are expressed in the same fashion. This can be considered an obligatory energy expenditure and, theoretically, it can be related to the energy factors assigned to foods. In none of these cases is the amount of heat produced dependent on the type of food ingested alone; consequently, these energy losses have generally not been taken into consideration when assigning energy factors to foods. The primary database can be modified by changing factors in an algorithm in the system and using the new factors to recalculate the database. 3.5.1 The Atwater general factor system The Atwater general factor system was developed by W.O. Atwater and his colleagues at the United States Department of Agriculture (USDA) Agricultural Experiment Station in Storrs, Connecticut at the end of the nineteenth century (Atwater and Woods, 1896). Notes for Figure 3.4 * The general Atwater factors were applied and values of available carbohydrates by difference (CHOAVDF-)** were used with protein calculated with Jones factors. Briefly described, this study was a household, probabilistic sample of 53 311 families including more than 267 000 individuals. 3.8 OTHER PRACTICAL IMPLICATIONS RELATED TO THE USE OF FOOD ENERGY CONVERSION FACTORSThe participants at the technical workshop discussed a number of additional topics related to the interplay between different analytical methods and food energy conversion factors. These databases are used in a number of areas, including: 1) epidemiological and clinical studies; 2) formulation of menus, diets and food products; 3) food entitlement programmes; 4) nutrient labelling of food products; 5) regulation of international trade; and 6) generation of derivative, second-generation databases for special purposes. Relative to the baseline values, use of the Atwater general factors with available or total carbohydrates resulted in an apparent decrease of 1.8 percent. There are 22 derived SI units defined in terms of the seven base quantities. [15] As ME factors overestimate the ATP-producing potential of some foods, their continued use in these situations will not induce overconsumption; in fact, they will suggest an individual is eating more than he or she actually is. It integrates the results of 50 years of research and derives different factors for proteins, fats and carbohydrates, depending on the foods in which they are found. For more of the derivations of and differences between ME and NME see the detailed discussions of Warwick and Baines (2000) and Livesey (2001). It was important for at least two reasons to ask how the application of NME factors would affect the declared energy contents and relative amounts of other nutrients (i.e. per 100 kJ or 100 kcal) of currently available formulas: first, most health care professionals and consumers who use infant formula have a concept of the energy content (per 100 ml or per ounce); and second, regulatory frameworks (e.g. Codex Alimentarius, 1994) for infant formula specify the content of minimum and maximum nutrient levels per 100 available kilojoules or kilocalories. In these surveys, estimates of food intake, either by recall or weighing, are converted to the corresponding energy (and other nutrient values) to determine adequacy of intakes. TABLE 3.5 Differences in energy content of selected diets calculated using either modified ME or NME factors Difference using modified ME factors (%) Additional difference using NME factors (%) Total difference (%) Source of dietary composition Conventional/ representative diets Required protein + energy, children 4-6 years old* 1.0 1.1 2.1 WHO, 1985 Required protein + energy, women 50+ years old# 2.0 2.4 4.4 WHO, 1985 Tanzania, rural Ilala women 65+ years old 1.3 2.6 3.9 Mazengo et al., 1997 South Africa, rural Vendor people 2.6 4.1 6.7 Walker, 1996 Mexico, rural people 5.9 4.3 10.5 Rosado et al., 1992 United Kingdom, urban people 2.8 4.5 7.4 Gregory et al., 1990 Guatemala, rural people 8.7 4.7 13.8 Calloway and Kretsch, 1978 Inuit, traditional 1.1 11.4 12.7 Krogh and Krogh, 1913 Australia, Aborigine 4.6 13.3 18.5 Brand-Miller and Holt, 1998 Therapeutic diets - diabetes, weight loss Early diet - type II diabetes mellitus 11.4 6.5 18.6 Jenkins et al., 2001 Higher % protein replacing fat 2.9 7.9 11.0 Summerbell et al., 1998§ High % protein (90 g), fibre 5.4 12.5 18.5 Willi et al., 1998 United Kingdom, women slimming§ 2.9 5.4 8.4 Gregory et al., 1990 Notes to Table 3.5: Baseline values were obtained using Atwater general factors of 16.7 kJ/g protein, 37.4 kJ/g fat and 16.7 kJ/g carbohydrate. All kJ values are rounded. Application of general factors to the mixed diet common in the United States resulted in values that were on average about 5 percent higher than those obtained with specific factors. Conceptually, food energy conversion factors should reflect the amount of energy in food components (protein, fat, carbohydrate, alcohol, novel compounds, polyols and organic acids) that can ultimately be utilized by the human organism, thereby representing the input factor in the energy balance equation. These are not legally binding, and regulations must be developed and adopted at the national level in order to become binding. The following approach is used by USDA (Harnly et al., in press): For food commodities, specific Atwater factors are preferred. Protein 13 kJ/g (3.2 kcal/g), fat 37 kJ/g (9 kcal/g) and lactose/glucose 16 kJ/g (3.8 kcal/g). Issues related to standardizing nutrient databases on a single set of food energy conversion factors. Thus, the current estimates of energy requirements and dietary energy recommendations relate more closely to ME, and the use of ME conversion factors allows a direct comparison between the values for food intakes and the values for energy requirements. TABLE 3.3 Comparison of ME general factors and NME factors for the major energy-producing constituents of foods ME as general Atwater factors kJ/g (kcal/g) Modified ME factors# kJ/g (kcal/g) NME factors* 1 kJ/g (kcal/g) Protein 17 (4.0) 17 (4.0) 13 (3.2) Fat 37 (9.0) 37 (9.0) 37 (9.0) Carbohydrate Available -monosaccharides 16 (3.75)2 16 (3.75) 16 (3.75) Available - by difference, sum 17 (4.0) 17 (4.0) 17 (4.0) Total 17 (4.0) 17 (4.0) Dietary fibre Fermentable 11 (2.6)*** 1 8 (1.9) Non-fermentable 0 (0.0)*** 1 0 (0.0) In conventional foods** 8 (2)*** 3 6 (1.4) Alcohol 29 (7)* 29 (6.9)4 26 (6.3) Total polyols 10 (2.4)5 Organic acids+ 13 (3)6 9 (2.1) * Rounded values are used. However, it is likely that, because some of the changes to the important recommendations such as energy from fat in the diet are relatively minor, they may simply be ignored. The use of NME will result in a decrease in energy content (expressed per millilitre, decilitre or litre) of 3 to 5 percent in milk-based formulas, and of about 0 to 2 percent in soy protein-based formulas, using either specific or general Atwater factors. Simplicity would seem especially important for developing countries and smaller food companies. Current recommendations for a healthy diet suggest a distribution of protein, fat and carbohydrate in the range of 15, 30 and 55 percent of energy, respectively (based on ME factors). For this reason, it may be necessary to make corrections to the estimates of food energy requirements in circumstances where the diet has substantial amounts of protein or fibre. This is because the public health aspects of nutrition predominate for such countries, and these are the "tools of the trade" in the public health arena. ME with general Atwater factors always generates higher values than NME and, as expected, the difference between the two calculations increases linearly, from 2 to 5 percent, as the percentage of energy from protein increases. Hence, in this table, kcal values are given first, in italics, with kJ values following, in parenthesis. Furthermore, it was not considered pragmatic to recommend the use of NME for infant formulas only. 3 Values calculated using specific Atwater factors: 4.27 kcal/g for protein, 8.79 kcal/g for fat and 3.87 kcal/g for carbohydrates. The energy conversion factors and the models currently used assume that each component of a food has an energy factor that is fixed and that does not vary according to the proportions of other components in the food or diet. These new estimates were then compared with the baseline values (based on the specific ME conversion factors) to determine the effects of different systems on energy intake estimates. Thus, the complexity and costs of making changes must be clearly justified by the benefits to be derived from those changes. TABLE 3.8 Effect of using ME or proposed NME factors on apparent percentages of protein, fat and carbohydrate in the diet Factor ME-general Atwater kJ/g (kcal/g) Energy factor NME kJ/g (kcal) Energy ME- general Atwater kJ (kcal) Energy NME kJ (kcal) Energy ME- general Atwater % Energy NME % Protein 17 (4) 13 (3.2) 90 1 530 360) 1 170 (288) 15 12 Fat 37 (9) 37 (9) 80 2 960 (720) 2 960 (720) 29 30 Available carbohydrates as weight 17 (4) 17 (4) 330 5 610 (1 320) 5 610 (1 320) 55 56 Dietary fibre 8 (2)* 6 (1.4) 25 200 (50) 150 (35) 2 2 Total energy without fibre energy 10 100 (2 400) 9 740 (2 328) Total energy with fibre energy 10 300 (2 450) 9 890 (2 363) * Proposed new value from FAO, 1998.Conclusion. They will often need to rely on values in food tables that are derived from the databases generated by government agencies, or on outside laboratories for food analysis, and they may have to rely on regulatory and other consultants to help them to understand and implement changes. The energy that remains after subtracting these heat losses from ME is referred to as net energy for maintenance (NE), which is the energy that can be used by the human to support basal metabolism, physical activity and the energy needed for growth, pregnancy and lactation. In contrast, the United States Code of Federal Regulations allows any one of five ways to calculate energy content of foods. An overriding consideration to endorse the continued use of energy conversion factors based on ME is related to the way in which estimations of energy requirement recommendations are currently derived. Among the foods that provide substantial amounts of energy as protein in the ordinary diet, energy conversion factors in the Atwater specific factor system vary, for example, from 10.2 kJ/g (2.44 kcal/g) for some vegetable proteins to 18.2 kJ/g (4.36 kcal/g) for eggs. Although use of NME conversion factors does not present insurmountable problems, and could therefore be acceptable from an operational point of view, the fact that energy requirements for this age group have been estimated from measurements reflecting ME (as is also the case for adults) makes it seem logical to continue using the ME conversion factors for foods and formulas for infants and young children. 3.6 STANDARDIZATION OF FOOD ENERGY CONVERSION FACTORSThe previous section documented the need for harmonization and standardization of the definitions, analytical methods and energy conversion factors used to determine the energy content of foods. Many countries follow Codex standards. Currently these comprise data from more than 180 countries/territories, plus various aggregation categories on overall food supply and food use. Differences between general and specific Atwater factors result in relatively small differences in energy supply, of only 80 to 200 kJ (20 to 50 kcal). Estimates of the energy provided by "representative" mixed diets[11] showed that the use of NME instead of the Atwater general factors resulted in a decrease in estimated energy content of between 4 and 6 percent. The picture is very different for specific Atwater factors, where there is no linear relationship to NME. There is often a discrepancy between a country's food composition databases and its regulations for food labelling. The conversion factors related to carbohydrate present the greatest problems. A joule is the energy expended when 1 kg is moved 1 m by a force of 1 Newton. This exercise clearly shows that the harmonization of nutrient definitions, especially of carbohydrates, is as important as the energy factors applied. [12] Annex IV gives a more detailed discussion of this topic. Determining the energy content of foods depends on the following: 1) the components of food that provide energy (protein, fat, carbohydrate, alcohol, polyols, organic acids and novel compounds) should be determined by appropriate analytical methods; 2) the quantity of each individual component must be converted to food energy using a generally accepted factor that expresses the amount of available energy per unit of weight; and 3) the food energies of all components must be added together to represent the nutritional energy value of the food for humans. The effect of using NME rather than Atwater general factors on energy content and the labelling of infant formulas and foods destined for infants needs to be examined for several reasons. Source: Modified from Merrill and Watt (1973).3.5.4 Net metabolizable energy system All three of the systems discussed in the previous sections are based on ME. It would also encourage food labelling in those countries in which it is voluntary. Since recommended energy intakes are currently related to ME, consumers are best served in meeting this goal by food labels that reflect ME. This can be explained by the different compositions of the diet - especially the contribution of cereals and vegetable foods against that of animal foods, and the differences in their specific energy factors (see Table 3.1) - but not by the increasing protein content in the diets, as is the case in the comparison between general Atwater and NME factors. Thus, the comparison between energy intake and requirements would provide similar results within both the ME and the NME systems. Consumers are highly variable in their desire for and understanding of nutrition information. FAO maintains the FAOSTAT statistical databases (, which contain data on protein, fat and energy for 506 food commodities and aggregates of foods. At least 12 possible combinations of useful ways of calculating energy content were found. For all ME and NME systems, protein content calculated from an average of the three primary methods: N × 6.25, Jones specific factors and AA analysis. A general factor system based on NME has been proposed by Livesey (2001) as an alternative to these systems. Larger food companies generally have the capability to adapt readily to whichever system is adopted. that can be applied to all foods. Assuming a diet in which carbohydrate provides 50 percent of energy, the effect on total dietary energy would be between -3 and +1.5 percent. A change in the prescribed energy conversion factors is not likely to be viewed in the same way by all companies or segments. Hence, if a change in energy content is made by adapting NME factors, appropriate changes in minimum and maximum nutrient levels may be necessary. 1) The use of specific rather than general factors can introduce major differences, which are more than threefold for certain foods. Depending on the available data, the energy content of different foods may be calculated in different ways within a single database. When the average difference between general and specific factors was 2 percent. FAO has used FBS to estimate national food supplies for decades. Requirements for all ages are now based on measurements of energy expenditure, plus the energy needs for normal growth, pregnancy and lactation (FAO, 2004). Factors for fat vary from 35 kJ/g (8.37 kcal/g) to 37.7 kJ/g (9.02 kcal/g), and those for total carbohydrate from 11.3 kJ/g (2.70 kcal/g) in lemon and lime juices to 17.4 kJ/g (4.16 kcal/g) in polished rice. A detailed description of the derivation and uses of FBS is beyond the scope of this document, and fuller information is available from the FAO/ESS Web site (at www.fao.org/ES/ESS/index_en.asp; FBS_review.pdf; and www.fao.org/ES/ESS/menu3.asp). 3.2 THEORETICAL FRAMEWORK FOR AN UNDERSTANDING OF FOOD ENERGY CONVERSION FACTORSAs described in detail in the report of the most recent Expert Consultation on Energy in Human Nutrition (FAO, 2004), humans need food energy to cover the basal metabolic rate; the metabolic response to food; the energy cost of physical activities; and accretion of new tissue during growth and pregnancy, as well as the production of milk during lactation. The discrepancy between energy values calculated using ME and those using NME conversion factors will be greatest for diets that are high in protein and dietary fibre, as well as for some novel food components. Food labels, and in particular nutrition labelling, can help consumers identify the nutrient content of foods, compare different foods and make informed choices suitable for their individual needs. The Atwater system has been widely used, in part because of its obvious simplicity. 124, 125, 410. 75) 16 (3.7?) 17 (4.0) 16 (3.87) # 16 (3.9) Starch 16 (3. These included two additional methods for estimating protein content - N × 6.25 and the sum of amino acid values - and also total and available carbohydrate by difference. Thus, changing energy conversion factors in the primary database is relatively easy from a purely mechanical point of view, and it need not be problematic for a database to hold and disseminate a variety of energy values for food. This energy is referred to as ingested energy (IE) or gross energy (GE). While the differences in energy intakes using different ME factors appear to be small (regardless of how the amounts of protein, fat, carbohydrate and fibre are calculated), the differences using NME factors appear to be relatively larger. Differences in thermogenesis are due to differences in size compared with adults, and are not due to the foods themselves. In many countries, the principal concern of the majority of the population is getting enough to eat at a reasonable cost, whereas in others it is to limit energy and fat intake in order to control body weight and conditions associated with obesity. Clearly, a more uniform system is needed. If NME factors were adopted, a decrease in energy requirement estimates would be needed in order to keep requirement and intake values compatible and comparable, i.e. to have both expressed in the same (NME) system. NME factors used were 13.3 kJ/g protein, 36.6 kJ/g fat, 16.7 kJ/g carbohydrate (or 15.7 kJ/g as monosaccharide equivalents) and 6.2 kJ/g dietary fibre. In addition, when comparing such results with other studies in the same or another country, a restatement of both intakes and the requirement standard using NME conversion factors would also be required. 2) Digestibility (and fibre content) of a grain may be affected by how it is milled. Third, the capture of energy (conversion to adenosine triphosphate [ATP]) from food is less than completely efficient in intermediary metabolism (Flatt and Tremblay, 1997). To improve understanding of these issues, a case study was undertaken using food intake data collected in a national food consumption and family budget survey in 1974-1975[13] (Vasconcellos, in press). The application of different specific Atwater conversion factors for the energy content of protein results in values for an individual food that differ from those obtained using the general factor by between -2 and +9 percent. As discussed in Chapter 2, the food composition databases are based on a variety of analytical methods, and as discussed earlier in this chapter, the energy content of different foods may be calculated in different ways (using different conversion factors) within the same database, depending on the analytical data available. The energy that remains after accounting for the energy content is known as "metabolizable energy" (ME) (see Figure 3.1). These differences are not considered significant, as the composition of human milk reported in the literature and using a variety of methods differs by more than this percentage (Fomon, 1993).[12] TABLE 3.6 Energy values of human milk Composition1 g/litre ME-ATW2 kJ/ml ME-specific3 kJ/ml (kcal/ml) NME-14, 6 kJ/ml (kcal/ml) NME-25,6 kJ/ml (kcal/ml) Protein - total 8.9 0.15 (0.04) 0.17 (0.04) 0.12 (0.03) 0.10 (0.03) Immunoglobulins 1.1 Fat 32 1.18 (0.29) 1.17 (0.28) 1.18 (0.29) 1.18 (0.28) CHO-lactose/ glucose 74 1.26 (0.30) 1.21 (0.29) 1.18 (0.28) 1.18 (0.28) Oligosaccharides 13 0.08(0.02) Energy 2.59 (0.63) 2.55 (0.61) 2.48 (0.60) 2.54 (0.61) 1 Values for all but oligosaccharides from Fomon (1993) pp. The NME factor for protein is 13 kJ/g (3.2 kcal/g) versus the Atwater general factor of 17 kJ/g (4 kcal/g). They also differ in heat loss and maintenance of body temperature owing to their greater body surface area relative to body weight and their lower heat-producing capacity (LeBlanc, 2002). Because nutritionists and food scientists are concerned with large amounts of energy, they generally use kiloJoules (kJ = 103 J) or megajoules (MJ = 106 J). Standardizing energy factors can lead to different values for the same food. Merrill and Watt (1973) compared the energy values for different representative foods and food groups derived using these new specific factors with those derived using general Atwater factors (Table 3.2). In the original survey, protein content was calculated as N × the specific Jones factor, while the Atwater specific energy conversion factors (from Merrill and Watt, 1973) were used to calculate energy content of proteins, lipids, alcohol and total carbohydrates (as well as total energy content) of the edible portions of foods. The precise value for available carbohydrate as monosaccharide is 15.7 kJ/g. Source: Livesey (in press [b]). Effects on health care professionals, educators and government staff. The use of Atwater general and specific factors was compared with the use of NME factors. Specifically, in the same infant formula, a change in the calculated energy content resulting from the use of NME conversion factors would lead to a corresponding change in the amounts of all other nutrients expressed per 100 kJ or 100 kcal. Even in such countries, the primary concern of a steadily increasing percentage of individuals is overnutrition. The current energy values on labels for foods must meet the regulations in force, and thus reflect some form of ME. [14] These differences are small owing to the nutrient definition adopted for fibre, i.e. crude versus dietary: the fibre value of the former is much smaller than that of the latter owing to incomplete recovery from the analysis method. Use of the NME rather than the Atwater general factor results in a 24 percent decrease in energy from protein. In other words, the amount (weight) of carbohydrate to yield a specific amount of energy differs depending on the molecular form of the carbohydrate. As originally described by Atwater, carbohydrate is determined by difference, and thus includes fibre. This was perceived as desirable for both professionals and consumers alike. Any change from the status quo will affect a number of stakeholders: food producers (both large and small), ingredient manufacturers, institutional catering companies, hospitals, restaurants in some countries, and specific sectors such as the weight-loss industry, to name but a few. Any derivative database would need to be modified accordingly. The use of NME factors resulted in an apparent increase in the prevalence of low energy intake of 3.3 to 4.1 percent compared with that of the use of specific ME factors (Table 3.7). 75) 16 (3.8) 17 (4.0) 17 (4.16) # 18 (4.2) * According to Southgate and Durnin (1970). In more developed countries, consumers seem best served by a system that allows them to: 1) compare food and energy intakes with recommended energy requirements that are based on the same standard; and 2) compare individual products with each other when making purchase or menu decisions. Each of these areas is discussed briefly in the following subsections. Depending on the diet, the difference in energy supply between the application of NME or specific Atwater factors varies from -1 to +5 percent. This obviates the need for extensive tables. Regulatory harmonization of both analytical methods and the energy conversion factors would be a great step forward, as regulations have major implications for international trade, and lack of harmonization represents a barrier to trade. First, there is a need to consider whether the NME values applied to foods for infants and small children differ from those for adults owing to differences in developmental physiology, such as the maturation of many enzyme systems and processes, and growth. The amount and type of nutrition information currently required on food labels vary from country to country. Also assumes presence of oligosaccharides, which are calculated as unavailable carbohydrate. It was established in 1960 by the 11th General Conference on Weights and Measures (CGPM - Conférence Générale des Poids et Mesures), which is the international authority that ensures wide dissemination of the SI and modifies it, as necessary, to reflect the latest advances in science and technology. Depending on the assumptions, use of the ME factors resulted in only very small changes (-0.6 to +0.2 percent). 3.7 THE RELATIONSHIP Between FOOD ENERGY CONVERSION FACTORS AND RECOMMENDATIONS FOR ENERGY REQUIREMENTSBecause energy factors are used to assess how well foods and diets meet the recommended energy requirements, it is desirable that values for requirements and those for food energy be expressed in comparable terms. The issues raised for these foods do not differ specifically from those concerning food for adults, and it is therefore recommended that the same energy conversion factors used for foods in general be applied to baby foods. With these stipulations, any of the following approaches can be used: 1) specific Atwater factors; 2) general factors that are identical to Codex standards for protein, fat and carbohydrate; 3) general factors in which carbohydrate is defined as total carbohydrate minus fibre; 4) specific factors for particular foods or ingredients that have been approved by the Food and Drug Administration (FDA); and 5) bomb calorimetry data, subtracting 1.25 kcal per gram of protein to correct for incomplete digestibility. Sources: ¹ Livesey (in press [b]); ² Southgate and Durnin (1970); ³ FAO (1998); 4 Merrill and Watt (1973); 5 EC (1990); 6 Codex Alimentarius (2001).3.5.5 Hybrid systems Although ME factors are generally in use, there is a lack of uniformity in their application within and among countries. In theory, there are 975 combinations for the major energy-containing components in food (13 definitions for protein, times three for fat, times five for carbohydrates, times five for fibre), each leading to different nutrient values (Charrondière et al., in press). These variables were subjected to a number of tests to see how their results compared with each other, and in some cases it was decided to merge some of the methods because the results were similar. In tables, values for kilocalories are given in italic type. 3.3 FLOW OF ENERGY THROUGH THE BODY - A BRIEF OVERVIEWFood that is ingested contains energy - the maximum amount being reflected in the heat that is measured after complete combustion to carbon dioxide (CO2) and water in a bomb calorimeter. Figure 3.1 Overview of food energy flow through the body for maintenance of energy balance1 1 Additional energy is needed for gains of body tissue, any increase in energy stores, growth of the foetus during pregnancy, production of milk during lactation, and energy losses associated with synthesis/deposition of new tissue or milk. All intakes were judged against the same energy requirement. Table 3.4 ME and proposed rounded NME factors for available carbohydrate, as monosaccharide equivalent or by weight ME-general* kJ/g (kcal/g) NME kJ/g (kcal/g) ME-specific kJ/g (kcal/g) NME-specific kJ/g (kcal/g) Glucose monohydrate 16 (3.8) 17 (4.0) 14 (3.4) Glucose 16 (3. Thus, different energy conversion factors have to be used to convert carbohydrate expressed as weight (16.7 kJ/g, usually rounded to 17 kJ/g) and available carbohydrate expressed as monosaccharide equivalents (15.7 kJ/g, rounded to 16 kJ/g) in order to account for the weight difference between the values of these two expressions of carbohydrate (Table 3.4). FIGURE 3.4 Percentage differences in energy supply between ME and NME with increasing protein content in the diet The figures in parenthesis after the country name indicate the percentage of energy from protein. Despite the recommendation of more than 30 years ago to use only joules, many scientists, non-scientists and consumers still find it difficult to abandon the use of calories. The effect of any manner of calculation was similar across all socio-economic groups (Figure 3.3). The convention of expressing data and recommendations for protein, fat and carbohydrate as percentages of energy in the diet is deeply entrenched and widely used by health professionals. It should also be recognized that some of the energy generated by fermentation is lost as gas and some is incorporated into colonic bacteria and lost in the faeces. As a result, any change in the way energy content is calculated would change the apparent content of product formulation for all other nutrients. [8] The SI (from the French Système International d'Unités) is the modern metric system of measurement. In 1970, Southgate and Durnin (1970) added a factor for available carbohydrate expressed as monosaccharide (16 kJ/g [3.75 kcal/g]). *** Proposed factors. NB: NME-Systems 1 and 2 in these figures are not the same variables, labelled as NME-1 and NME-2, that appear in Table 3.6 and in Annex IV. These were: 1) the effect of using NME factors rather than Atwater general factors on the energy content and the labelling of infant formulas and foods for infants and young children; 2) the issues related to standardizing nutrient databases on a single set of food energy conversion factors; 3) the effects that using various analytical methods with different energy conversion factors have on the conclusions drawn from food consumption survey data; 4) the effects of using different food energy conversion factors on data in food balance sheets; 5) regulatory perspectives; 6) effects on industry; 7) consumer interests; and 8) effects on health care professionals, educators and government staff. The current disparities in the energy conversion factors specified in Codex (Codex Alimentarius, 1991) and in the United States Code of Federal Regulations (FDA, 1985) provide an example of this regulatory dissonance. Energy expenditure data have been obtained by a variety of techniques, including the use of doubly labelled water, heart rate monitoring and standard Basal Metabolic Rate (BMR) measurements. In large countries, such as Brazil, wide regional variations in the amounts and types of foods that comprise the diet may affect significantly the interpretation of the food intake, and may not be appreciated when mean values only are considered. (The maximum differences for protein and fibre supplements would be 24 and 27 percent, respectively.) The use of NME rather than ME factors has less effect on the estimation of energy content for most mixed diets than it has for individual foods, because about 75 percent of the energy in mixed diets derives from fat and available carbohydrate, which have the same NME and ME factors (Table 3.3). However, it must be recognized that the cost and complexity of a wholesale change to a new system would not be small. Many companies may view any change as an undue burden, while a few - e.g. those involved in weight-loss products - might see change as an opportunity, especially if the use of NME factors results in a label with a lower declared energy content. TABLE 3.7 Per adult-day energy consumption and prevalence of low energy intake according to nine different methods for determining energy content of foods Methods for determining energy content of foods Per adult-day energy consumption Difference in prevalence of low energy intake Energy conversion factor Description Protein based on Carbohydrates by difference Energy from fibre Kcal % Atwater Jones Total # 2 739 101.2 -1.8 ME2 Jones Available Included 2 714 100.3 -0.6 Merrill and Watt* Jones Total # 2 706 100.0 0.0 ME1 Jones Available Ignored 2 698 99.7 0.2 NME2AA Total AA Available Included 2 634 97.3 3.3 NME2Jones Jones Available Included 2 632 97.3 3.4 NME26.25 6.25 Available Included 2 631 97.2 3.5 NME1AA Total AA Available Ignored 2 621 96.9 4.1 NME1Jones Jones Available Ignored 2 619 96.8 4.0 NME16.25 6.25 Available Ignored 2 618 96.7 4.1 * The baseline values for the survey used the values from Merrill and Watt (1973). Any increased cost would almost certainly be passed on to the consumer and hence, to justify the increase in cost, the consumer should derive real benefit from the proposed change. A small amount of energy is also lost from the body surface (surface energy [SE]). Effects on industry. TABLE 3.2 Average percentage differences in energy values for selected foods, derived using general and specific Atwater factors Food group Ratio of general to specific factor values Animal foods: Beef 98% Salmon, canned 97% Eggs 98% Milk 101% Fats: Butter 102% Vegetable fats, oils 102% Cereals: Cornmeal - whole, ground 103% Cornmeal - degermed 98% Oatmeal 102% Rice, brown 99% Rice, white or milled 97% Whole wheat flour 107% Wheat flour, patent 98% Legumes: Beans, dry seeds 102% Peas, dry seeds 103% Vegetables: Beans, snap 120% Cabbage 120% Carrots 107% Potatoes 102% Turnips 109% Fruits: Apples, raw 110% Lemons, raw 138% Peaches, canned 110% Sugar - cane or beet 103% Source: Adapted from Merrill and Watt (1973). The protein supply ranges from 35 g in Mozambique (or 7.2 percent of energy from protein) to 101 g in Italy and the United States (or 11.2 percent of energy from protein). Thus, while the use of joules alone is recommended by international convention, values for food energy in the following sections are given in both joules and calories, with kilojoules given first and kilocalories second, within parenthesis and in a different font (Arial 9). This would assure that scientists in a variety of disciplines, regulators, and policy-makers have an opportunity to explore more thoroughly the merits and implications of making such a change when it is deemed appropriate. In recent years, an energy factor for dietary fibre of 8.0 kJ/g (2.0 kcal/g) (FAO, 1998) has been recommended, but has not yet been implemented. 75) 16 (3.8) 17 (4.0) 15 (3.68) # 16 (3.8) Fructose 16 (3. Based on these considerations, a system - or rather a set of tables - was created with substantial variability in the energy factors applied to various foods (see examples in Table 3.1). 2 ME using the Atwater conversion factors: protein 17 kJ/g (4 kcal/g), fat 37 kJ/g (9 kcal/g), carbohydrate 17 kJ/g (4 kcal/g). The highest difference in energy supply calculations occurs as a result of different carbohydrate definitions (i.e. total or available carbohydrates) and ranges from 1 to 5 percent, or 80 to 500 kJ (20 to 120 kcal). FIGURE 3.2 Percentage differences in estimates of Brazilian daily mean energy consumption, calculated as the difference between each method and the estimate based on Merrill and Watt method (1973), by reference adult Notes for Figures 3.2 and 3.3: Atwater = Atwater general conversion factors with total carbohydrate determined by difference, i.e. fibre is included. These differences in efficiency are reflected in the differences between heat production from each substrate and that from glucose; they can be determined stoichiometrically and can be measured. Since infant formulas are patterned on human milk, it was important to understand how the application of NME factors to the contents of protein, fat and carbohydrate in human milk alters its apparent energy content relative to current values in the literature. It is clear from this discussion that the lack of standards for measuring and expressing energy-yielding components is problematic for both ME and NME. The weights of foods were expressed as nutrients using food composition tables compiled from 40 national and international sources. Not all metabolizable energy is available for the production of ATP. Not all combustible energy is available to the human for maintaining energy balance (constant weight) and meeting the needs of growth, pregnancy and lactation. While dietary fibre content plays a role in determining the differences between ME and NME, its impact on energy supply depends on whether any energy is attributed to dietary fibre or not. Standardization of specific methods of analysis and use of energy conversion factors may improve this situation. As part of the process for this recommendation, the magnitude of the effect of using NME instead of ME factors was examined in relation to individual foods and mixed diets. 6 NME-1 and NME-2 in this table are not the same variables that appear in Figure 3.2 and Table 3.7Third, Codex (Codex Alimentarius, 1994) and many other regulatory codes specify minimum and maximum nutrient levels in infant formulas based on energy content. Failure to make such an adjustment to energy requirements could lead to erroneous dietary energy recommendations. These ranges for protein, fat and carbohydrate are, respectively, 44, 7 and 35 percent. § The general Atwater factors were applied and values of total carbohydrates by difference (CHOCDF)** were used with protein calculated with Jones factors. 3.1 JOULES AND CALORIESThe unit of energy in the International System of Units (SI)[8] is the joule (J). 3.5.3 The Atwater specific factor system The Atwater specific factor system, a refinement based on re-examination of the Atwater system, was introduced in 1955 by Merrill and Watt (1955). 3.5 CURRENT STATUS OF FOOD ENERGY CONVERSION FACTORSJust as a large number of analytical methods for food analysis have been developed since the late nineteenth century, so have a variety of different energy conversion factors for foods. The value per 100 g of human milk is 253 kJ (61 kcal) using Atwater specific factors (USDA, 2003), 259 kJ (63 kcal) using Atwater general factors, and 248 kJ (60 kcal) using NME factors (Table 3.6). And they differ in growth. The effect of using NME factors rather than Atwater general factors (ME) on the labelling of "baby foods" (food designed to be fed specifically to infants and small children) was also examined. FIGURE 3.3 Differences in estimates of the prevalence of low energy intake based on each method in relation to Merrill and Watt method (1973), according to nine income expenditure categories The effects of using different food energy conversion factors on data in food balance sheets. Specific factors range from 35 kJ/g (8.37 kcal/g) to 37.7 kJ/g (9.02 kcal/g), a range of -5 to +2 percent relative to the general factor. TABLE 3.1 Atwater specific factors for selected foods Protein kcal/g (kJ/g)§ Fat kcal/g (kJ/g)§ Total carbohydrate kcal/g (kJ/g)§ Eggs, meat products, milk products: Eggs 4.36 (18.2) 9.02 (37.7) 3.68 (15.4) Meat/fish 4.27 (17.9) 9.02 (37.7) * Milk/milk products 4.27 (17.9) 8.79 (36.8) 3.87 (16.2) Fats - separated: Butter 4.27 (17.9) 8.79 (36.8) 3.87 (16.2) Margarine, vegetable 4.27 (17.9) 8.84 (37.0) 3.87 (16.2) Other vegetable fats and oils -- 8.84 (37.0) -- Fruits : All, except lemons, limes 3.36 (14.1) 8.37 (35.0) 3.60 (15.1) Fruit juice, except lemon, lime# 3.36 (14.1) 8.37 (35.0) 3.92 (15.1) Lemon, limes 3.36 (14.1) 8.37 (35.0) 2.48 (10.4) Lemon juice, lime juice# 3.36 (14.1) 8.37 (35.0) 2.70 (11.3) Grain products: Barley, pearled 3.55 (14.9) 8.37 (35.0) 3.95 (16.5) Cornmeal, whole ground 2.73 (11.4) 8.37 (35.0) 4.03 (16.9) Macaroni, spaghetti 3.91 (16.4) 8.37 (35.0) 4.12 (17.2) Oatmeal - rolled oats 3.46 (14.5) 8.37 (35.0) 4.12 (17.2) Rice, brown 3.41 (14.3) 8.37 (35.0) 4.12 (17.2) Rice, white or polished 3.82 (16.0) 8.37 (35.0) 4.16 (17.4) Rye flour - whole grain 3.05 (12.8) 8.37 (35.0) 3.86 (16.2) Rye flour - light 3.41 (14.3) 8.37 (35.0) 4.07 (17.0) Sorghum - wholemeal 0.91 (3.8) 8.37 (35.0) 4.03 (16.9) Wheat - 97-100% extraction 3.59 (14.0) 8.37 (35.0) 3.78 (15.8) Wheat t - 70-74% extraction 4.05 (17.0) 8.37 (35.0) 4.12 (17.2) Other cereals - refined 3.87 (16.2) 8.37 (35.0) 4.12 (17.2) Legumes, nuts: Mature dry beans, peas, nuts 3.47 (14.5) 8.37 (35.0) 4.07 (17.0) Soybeans 3.47 (14.5) 8.37 (35.0) 4.07 (17.0) Vegetables: Potatoes, starchy roots 2.78 (11.6) 8.37 (35.0) 4.03 (16.9) Other underground crops 2.78 (11.6) 8.37 (35.0) 3.84 (16.1) Other vegetables 2.44 (10.2) 8.37 (35.0) 3.57 (14.9) * Carbohydrate factor is 3.87 for brain, heart, kidney, liver; and 4.11 for tongue and shellfish. [11] This is assuming that the diet derives about 15 percent of energy from protein and contains a modest amount (~20 g) of fibre. For commercial, multi-ingredient foods, the database generally relies on manufacturers' data for composition. ** Assumes that 70 percent of the fibre in traditional foods is fermentable. One approach would be to work towards the uniform application of one of the currently used ME systems. A factor of 29 kJ/g (7 kcal/g) is specified for alcohol, and one of 13 kJ/g (3 kcal/g) for organic acids. The system is based on the heats of combustion of protein, fat and carbohydrate, which are corrected for losses in digestion, absorption and urinary excretion of urea. Specific energy conversion factors are used when all ingredients have a known specific factor and the exact proportion of ingredients is also known. # Based on general Atwater factors. United Kingdom food regulations require that carbohydrates must be expressed as the weight of carbohydrate, thus corresponding to Codex. All food composition databases and tables, textbooks, planning guides, etc. This argues against the benefits of a wholesale change in more developed countries at this time, given the conflicting goals. The degree of incomplete absorption is a function of the food itself (its matrix and the amounts and types of protein, fat and carbohydrate), how the food has been prepared, and - in some instances (e.g. infancy, illness) - the physiological state of the individual consuming the food. To address this last point - i.e. the inability to extrapolate conclusions based on data from one country to other countries - food balance sheets (FBS) data from different countries were examined relative to the different methods used to calculate food energy. The interaction of these two "terms in the equation" results in an unacceptably large number of possible values for energy of any food. Government organizations, universities and the food industry organize and maintain databases of the nutrient composition of foods. Finally, the values for alcohol are 29 kJ/g (7.0 kcal/g) for ME, and 26 kJ/g (6.3 kcal/g) for NME - a difference of 10 percent. [10] In addition, Merrill and Watt used Jones (1941) factors for nitrogen in determining protein content. Energy values are drawn from what is judged to be the most appropriate regional or national food composition table. In the case of individual foods, the difference between the use of NME and ME factors for the estimated energy content is minimal for foods with low protein and fibre contents, but can be quite large for foods that are high in protein and/or fibre. The EU (EC, 1990) mirrors Codex with the addition of a factor for polyols, 10 kJ/g (2.4 kcal/g). Energy values for dietary fibre are: 0 kJ/g (0 kcal/g) for non-fermentable fibre; 0 to 17 kJ/g (0 to 4.0 kcal/g) for fermentable fibre; and 0 to 8 kJ/g (0 to 1.9 kcal/g) for commonly eaten foods that contain a mixture of fermentable (assumed to be on average 70 percent of the total) and non-fermentable fibre (FAO, 1998). The USDA Nutrient Database for Standard Reference (USDA, 2003) was examined in order to look at the variations that result from the use of different methods and energy conversion factors. There are differences among countries depending on which regulatory framework predominates. For diets in which protein provides about 15 percent of energy, the resulting error for total dietary energy is small, at about 1 percent. This range is narrower when mixed diets rather than specific foods are being assessed. In arriving at this factor, fibre is assumed to be 70 percent fermentable. Thus, the available energy from equal amounts (weight) of whole-wheat flour (100 percent extraction) and extensively milled wheat flour (70 percent extraction) will be different. Alternatively, if changes are to be made, a move to an NME factor system could be considered. Second, compounds derived from incomplete catabolism of protein are lost in the urine. Nevertheless, in most cases the error incurred will be about 5 percent, which is within the usually accepted limits of measurement error or biological variation. First, foods are not completely digested and absorbed, and consequently food energy is lost in the faeces. 4 NME-1: applying values to total protein, fat and lactose/glucose. They may be derived from direct analysis of some individual components or by difference, and are mainly based on specific Atwater energy conversion factors. surrounding food and dietary energy. There were several foods (for example, snap beans, cabbage and lemons) for which the differences ranged from 20 to 38 percent. This is evident in that both joules (kJ) and calories (kcal) are used side by side in most regulatory frameworks, e.g. Codex Alimentarius (1991). The calculated energy values for carbohydrates are similar in most cases because the difference in energy conversion factors balances with the difference in carbohydrate values. would need to be changed, and an extensive (re-)education programme to bring professionals up to an acceptable level of understanding would be necessary. The same factors listed in footnote 3 were used, plus a factor for oligosacccharides of 6 kJ/g (1.5 kcal/g). It is clear from this that the analytical definition of energy-yielding components of the diet and the choice of energy conversion factors may have major effects on the analysis and interpretation of food consumption data. The application of "accepted" energy conversion factors increases the number of different energy values. The total combustible energy content (or theoretical maximum energy content) of a food can be measured using bomb calorimetry. In a number of countries, labelling regulations are kept simple so that they can be implemented at a reasonable cost by all segments of the food industry. As already mentioned, there are also general factors in use for alcohol (29 kJ/g [7.0 kcal/g]), organic acids (13 kJ/g [3.0 kcal/g]) (Codex Alimentarius, 2001) and polyols (10k J/g (2.4 kcal/g]), as well as individual factors for specific polyols and for different organic acids (Livesey et al., 2000; for an example of a national specification, see Canada's at: . In a diet in which 40 percent of energy is derived from fat, the effect of using specific factors on total energy content would range from -2 to +0.8 percent. On balance, the participants did not endorse changing at this time, because the problems and burdens ensuing from such a change would appear to outweigh by far the benefits. The factors outlined in Box III.1 of Annex III may be used to facilitate these corrections. The different results most likely reflect the fact that the standard for adequacy of intake - "the requirements" - against which intakes are judged is based on data that reflect ME and not NME. It can therefore be concluded that ME is generating between 1 percent (or 80 kJ [20 kcal]) less and 5 percent (or 630 kJ [150 kcal]) more energy supply than NME. Thus, any shift to the use of NME conversion factors for the determination of energy intake in food consumption surveys would have to be accompanied by a simultaneous change in expressing energy requirements. Third, if changes are to made, they will need to be made "simultaneously" across a number of different sectors. Whereas Atwater used average values of protein, fat and total carbohydrate, Merrill and Watt emphasized that there are ranges in the heats of combustion and in the coefficients of digestibility of different proteins, fats and carbohydrates, and these should be reflected in the energy values applied to them.[10] The following two examples help to make this clearer: 1) Because proteins differ in their amino acid composition, they also differ in their heats of combustion. This is owing to the water of hydration in different molecules. Thus, while resorting to the use of different energy conversion factors increases the nutrient declarations per 100 kJ or 100 kcal on the label, there should be no need to reformulate existing standard formulas to meet current regulations. There was uniform agreement, however, that the issue should continue to be discussed in the future, and that it could profitably be revisited during workshops and expert consultations involving recommendations, assessment of adequacy, public health policy, etc. Different factors are used for different foods depending on the availability of either analytical information on the composition of protein, fat and carbohydrate, or specific information on the ingredients and their amounts. Labels have life spans of their own and, given time, they can be modified to reflect changes in regulations; changes have been successfully implemented in some countries with an adequate period of transition. 3) The difference between ME and NME values is greater for certain foods than for most of the habitual diets that are commonly consumed.3.6.1 Recommendation With the above in mind, the participants at the FAO technical workshop reached consensus that the continued use of ME rather than NME factors is recommended for the present. These are based on international values for most foods, although there are country-specific values in some instances. The reasons for this are discussed in detail in the following sections. # Unsweetened. Infants differ from adults in particular in their ability to digest and absorb nutrients, although absorption of protein, fat and carbohydrate is at or near adult levels after six months of age (Fomon, 1993). Incomplete digestion of food in the small intestine, in some cases accompanied by fermentation of unabsorbed carbohydrate in the colon, results in losses of energy as faecal energy (FE) and so-called gaseous energy (GaE) in the form of combustible gases (e.g. hydrogen and methane). The NME system retains a general factor approach, i.e. a single factor each for protein, fat, available carbohydrate, dietary fibre, alcohol, etc. # Dietary fibre assumed to be 20 g. Different countries, communities and regions are in different states of development regarding food regulations and labelling. For most individual foods that are major sources of energy in the diet, use of a specific rather than a general factor results in differences that range from -6 to +3 percent. For many decades, food energy has been expressed in calories, which is not a coherent unit of thermochemical energy. [9] The figures given for kilojoules are the commonly used rounded values. 75) 16 (3.7) 17 (4.0) 16 (3.87) # 16 (3.9) Sucrose 16 (3. As stated in Chapter 1, the translation of human energy requirements into recommended intakes of food and the assessment of how well the available food supplies or diets of populations (or even of individuals) satisfy these requirements require knowledge of the amounts of available energy in individual foods. Neither modification may be possible, depending on the source of the analytical data. It is common to estimate the prevalence or numbers of individuals in a population who are not achieving energy (or nutrient) adequacy based on the ratio of actual intake to the optimum requirement. NME-System 1 = NME specific conversion factors (proposed), not including energy from fibre. Analysis carried out by Vasconcellos (in press). Depending on the source and quality of the analytical data, standardizing on a single set of ME factors is likely to be no easier than adopting NME factors. This results in different regulations in different parts of the world (e.g. Australia and New Zealand, the EC, the United States, Taiwan Province of China), which may be at odds with each other in specific areas (e.g. allowable ingredients, labelling requirements, etc.). In countries where the major nutritional problem is assuring adequate intakes, the vast majority of consumers would be best served by harmonization on factors that take into account the issues relative to energy requirements, how they are expressed, and how well food supplies meet these needs: food databases, food consumption surveys, and FBS. As previously discussed, however, these differences can be greater in some diets (Table 3.5). Finally, it may not be appropriate to extrapolate the magnitude of change induced by different food energy conversion systems in the Brazilian data to other countries with other diets, where different intakes of protein, fibre, carbohydrates and alcohol are likely. Although nutrient composition is generally expressed per 100 g of the formula on the label, those values will be derived from, and will reflect the changes per, 100 kJ or 100 kcal. Intake data were obtained by weighing the food items consumed and wasted in each household during a period of seven consecutive days. The SI derived unit for energy, as work or quantity of heat, is the joule (m2·kg·s-2), the symbol for which is J. The value for carbohydrate energy in chocolate is an extreme example - the factors range from 5.56 kJ/g (1.33 kcal/g) to 17 kJ/g (4.0 kcal/g). Thus, the heat of combustion of protein in rice is approximately 20 percent higher than that of protein in potatoes, and different energy factors should be used for each. Modified general factors used were 16.7 kJ/g protein, 37.5 kJ/g fat, 16.7 kJ/g carbohydrate (or 15.7 kJ/g carbohydrate as monosaccharide equivalents) and 7.8 kJ/g dietary fiber. The use of ME food conversion factors conceals the fact that energy expenditure derived from assessments of heat production varies with the composition of the diet that is being metabolized. ME-System 2 = Atwater specific conversion factors, including energy from fibre. It is important to note that all of these systems relate conceptually to (ME) as defined in the previous section.

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