codex alimentarius commission

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

WORLD HEALTH ORGANIZATION

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Agenda Item 11 **CX/NFSDU 00/11**

March 2000

JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON NUTRITION AND FOODS FOR SPECIAL DIETARY USES
Twenty-second Session
Berlin, Germany, 19-23 June 2000

DISCUSSION PAPER ON ENERGY CONVERSION FACTORS

(Prepared by Australia)

BACKGROUND

1. At the 21st Session of the Codex Committee on Nutrition and Foods for Special Dietary Uses (CCNFSDU) in 1998, Australia presented a proposal for new work to define the basis for the derivation of energy conversion factors in the Codex Guidelines on Nutrition Labelling. The Committee noted that the proposal paper was provided as a conference room document (CRD10) and as such, was too technical in nature to be considered in session. It was agreed that the paper be circulated prior to the 22nd Session for consideration at that meeting, with a view to making a decision about whether this matter would be supported as new work for the Committee (ALINORM 99/26 para 118).

2. This paper is a revised version of the CRD10 paper presented at the 21st Session and replaces the previous paper.

PROPOSAL

3. Australia proposes that the Committee determines the most appropriate system for defining energy to provide a consistent basis for the derivation of energy conversion factors for individual food components, for purposes of developing a harmonised approach to nutrition labelling.

4. Some energy factors for macronutrients are included in the Codex Guidelines on Nutrition Labelling (CAC 1983, Supplement 1 to Volume 1, General Requirements) but no factors are assigned to other food components, such as dietary fibre, polyols (sugar alcohols), other unavailable carbohydrates and novel food ingredients. Furthermore, the Codex Guidelines

do not give any indication of how energy factors for these food components should be derived.

5. Australia considers there is a need for the Committee to consider the problem caused by the current lack of guidance on this issue. In the absence of clear international guidelines, there is potential for countries to assign different energy factors to the same food component that would result in the calculation of a different total energy content for the same whole food.

6. Inconsistent labelling of the total energy content of whole foods may create trade barriers in the future for foods that are traded internationally. This would be particularly true where differences in total energy content causes differences in eligibility for low calorie/low joule claims for the same food in different countries. The success of introducing the proposed Codex criteria for low calorie/low joule claims will also depend on a consistent system for assigning energy factors to all food components.

7. A clear definition of energy yield of food components would also facilitate the international and national assessment of food components, such as reduced energy fats and sugars, by regulatory agencies.

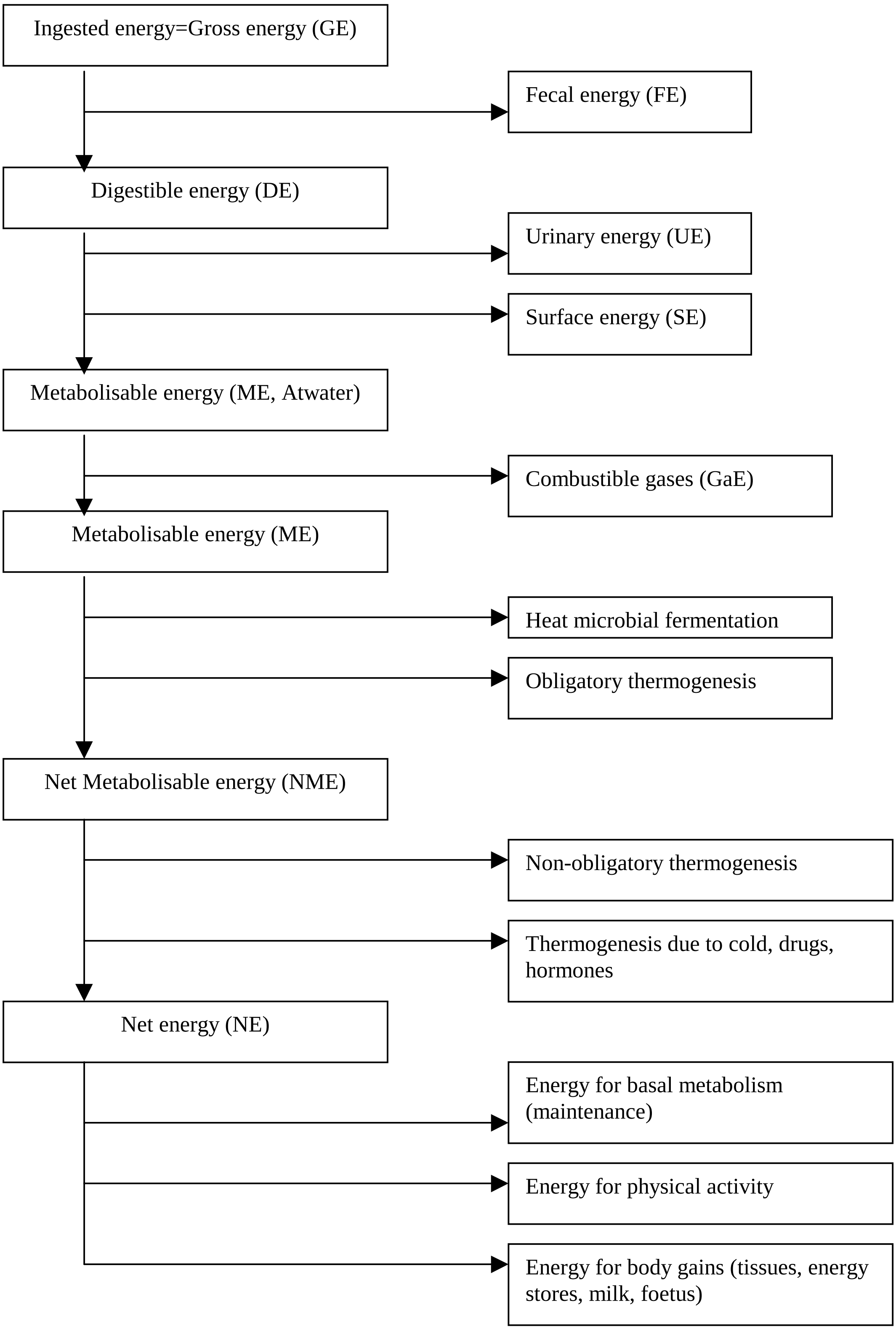
8. Australia considers the following principles to be important in developing this proposal:

- sound scientific rationale to underpin the definition of energy for food labelling purposes;
- consistent approach to applying energy definitions to the derivation of energy factors for all food components, including novel food ingredients;
- definitions of energy to be consistent with other non-labelling uses of energy factors, for example, dietary guidelines, energy balance studies and food composition tables; and
- maintenance of links with relevant sections of the Codex Guidelines on Nutrition Labelling, for example, criteria for low calorie/low joule claims.

ENERGY FACTORS USED IN INTERNATIONAL AND NATIONAL FOOD STANDARDS

9. There are several definitions of energy yield of food components in the scientific literature that account for energy losses from a range of sources in the human body on ingestion of the food component. In general, food components are assumed to have an energy yield based on a metabolisable energy (ME) definition or a net metabolisable energy (NME) definition (see Figure 1, Annex 1 for definitions). The difference in terms is that ME describes the amount of food energy in the food component available for physiological processes (heat production and body gains) but does not account for the efficiency with which food components are metabolised in the body. NME includes the obligatory costs of energy metabolism (Livesey 1995) and will therefore be lower than ME.

Figure 1: Overview of energy utilisation (adapted from FASEB 1994)



10. The energy factors for the macronutrients listed in the 1983 Codex Guidelines on Nutrition Labelling appear to be derived from Atwater's definition of metabolisable energy[1]. The Codex Guidelines state that the amount of energy to be listed in nutrition declarations should be calculated using the following conversion factors (CAC 1983, sec 3.2.7.1):

Carbohydrates (excluding dietary fibre)	4 kcal/g - 17 kJ/g
Protein	4 kcal/g - 17 kJ/g
Fat	9 kcal/g - 37 kJ/g
Alcohol (Ethanol)	7 kcal/g - 29 kJ/g
Organic acid	3 kcal/g - 13 kJ/g

11. To estimate the total energy yield of a whole food, energy factors derived for each food component are then substituted in a factorial equation:

The average energy yield of a food per 100 grams is determined by multiplying the average amount of each food component per 100 grams of the food by the energy factor for that food component and summing the amounts calculated for each:

Average energy (kJ/100 g) = $\sum W_i \times F_i$

Where
W_i is the average weight (mass) of food component (g/100g food)
F_i is the energy factor assigned to that food component (kJ/g)

12. It is now recognised that the Atwater definition of ME for food components that are not digested or only partially digested is inadequate because potential energy losses from gas or fermentation processes are not subtracted in determining the energy yield. In addition, the unabsorbed material may undergo fermentation by bacteria in the lower gastrointestinal tract, producing short chain fatty acids that can be absorbed and metabolised as a source of energy.

13. For example, for undigested or partially digested carbohydrates, such as polyols, the assigned energy factor will depend on the precise definition of energy yield used to derive an appropriate energy conversion factor, and whether a ME or NME definition is used. The same would be true for many novel food components, such as reduced energy fats or sugars, that are developed by the food industry for use in 'low joule/calorie foods' because they are undigested or partially digested in the human body and therefore yield less energy than their normal counterparts.

14. At the moment, many countries have adopted the energy factors for macronutrients listed in the Codex Guidelines on Nutrition Labelling in national food standards. A limited number of energy factors for other food components are listed in some food standards at a national level, for example NME factors for polyols and polydextrose are the only ones adopted in

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1 Atwater factors represent the metabolisable energy (ME) yield for macronutrients in a mixed diet. The Atwater factors are derived from the gross energy (GE) of the macronutrient minus energy lost from the urine (UE) and faeces (FE) only. Atwater factors for fat are 9 kcal/g (37 kJ/g), for protein 4 kcal/g (17 kJ/g,) and for alcohol 7 kcal/g (29 kJ/g). The Atwater factor for carbohydrate is for monosaccharide equivalents (16 kJ/g) and is often expressed for general carbohydrates as 4 kcal/g (17 kJ/g).

regulations in the United States (US), Canada and the European Union (EU). However, in some cases, different NME factors are assigned to the same polyol by different jurisdictions.

METABOLISABLE VERSUS NET METABOLISABLE ENERGY?

15. It is critical that the question of whether ME or NME definitions are suitable for deriving energy factors for the purposes of nutrition labelling is addressed. One of the current difficulties is that NME data are not available for all food components. If a NME definition is adopted for some food components, then the Committee should consider the issue of whether individual NME factors should be adopted into food standards as they become available or whether regulators should adopt ME values for all food components, until such time as NME values are available for all food components.

16. If adoption of a NME definition for deriving energy factors for some or all food components is considered in the future, the following issues would also need to be debated at an international level between nutritionists and food labelling regulators:

- the potential impact of extending the system of assigning NME factors to polyols and polydextrose, currently adopted in some countries, to other food components, for example, novel foods, unavailable carbohydrates and protein;

- the potential impact of adopting NME factors for all food components on other nutritional parameters, for example, the expression of energy requirements, energy expenditure measurements and food composition tables;

- the question of whether, in humans, the NME equation applies, for example whether all the heat generated as heat of fermentation and by thermogenesis (obligatory and non-obligatory) is wasted. This issue is not resolved, with little up to date research being undertaken; and

- if it is practical in practice because the additional energy losses that are required to be measured to determine NME factors (heat of fermentation and obligatory thermogenesis) are hard to measure experimentally, in particular, to separate obligatory from non-obligatory thermogenesis (refer Figure 1).

CONCLUSIONS

17. There is a pressing need to develop a clear system for defining the energy yield of food components to promote a harmonised approach to assigning energy factors to food components. This will achieve consistency in labelling of the energy content of whole foods, thus reducing the potential for creation of trade barriers based on different labelling standards.

18. A clear definition of energy content of food components would also facilitate the international and national assessment of food components, such as reduced energy fats and sugars, by regulatory agencies. Further, a clear definition is critical to the future derivation of energy factors for novel foods and novel food ingredients.

19. The adoption of a harmonised approach to defining energy is also important for regulators developing criteria for low calorie/low joule foods or for reduced energy claims for labelling purposes.

RECOMMENDATIONS

20. That the Codex Committee on Nutrition and Foods for Special Dietary Uses accept in the future work program of the Committee the development of a consistent approach to the derivation of energy factors, for inclusion in the Codex Guidelines on Nutrition Labelling.

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ANNEX 1

DEFINITIONS OF ENERGY and associated terms (adapted from FASEB 1994)

Atwater factors: Atwater factors are metabolisable energy values for macronutrients which take into account energy loss in the urine (UE) and faeces (FE) only, that is, potential energy losses from gas or fermentation processes are not subtracted from the determined energy value.

Atwater factor: ME = GE - FE - UE

Where,
Faecal energy (FE): fraction of gross energy lost in faeces, determined by bomb calorimetry.
Urinary energy (UE): fraction of gross energy lost in urine, determined by bomb calorimetry.
Gross energy (GE) or ingested energy (IE): total energy content or heat of combustion expressed in kJ/g, determined by bomb calorimetry.

Metabolisable energy (ME) Metabolisable energy describes the amount of food energy available in the food component for heat production and body gains. An energy factor derived from a ME definition accounts for energy losses after ingestion of a food component from the urine, faeces, surface areas and sometimes from microbial fermentation processes, depending on the ME definition chosen.

ME (proposed for use in Australia and New Zealand)*:* that amount of dietary energy which is absorbed into the body and not excreted as energy containing organic compounds via the faeces, urine and other routes, for example, breath or skin.

ME = GE - FE - UE –GaE -SE

Where GE is gross/ingested energy, FE faecal energy, UE urinary energy, GaE is the energy used in microbial metabolism in the large intestine and lost as fermentation gases (eg hydrogen, methane), and SE represents energy surface losses (eg, skin) and other losses if measurable (sweat, breath).

There are several other definition of ME in the literature, some of which are inconsistent (FASEB 1994):

ME = GE - (FE + UE + GE gases) (Sentko 1992, various sources)
ME = DE - UE (British Nutrition Foundation 1990, Barr 1992)
ME = RE (Allison and Senti 1983)
Corrected ME = DE- (UE + heat losses due to fermentation in gut).

Where,
Digestible energy (DE): gross energy minus energy in faeces where DE = GE - FE.
Retained energy (RE): digestible energy that is retained in the form of protein, fat or glycogen. RE may or may not include the energy derived from metabolism that becomes available for use outside the body (eg production of milk or eggs).

Net metabolisable energy (NME): Net metabolisable energy describes the amount of energy in the food components that is available for conversion to ATP energy within the body, where faecal (FE), urinary (UE) and obligatory heat losses are subtracted from the gross energy (GE) to derive a net (metabolisable) energy. An energy factor derived from a NME definition accounts for all these losses as well as the energy the body is obliged to use to metabolise the food component (obligatory thermogenesis).

Net energy (NE): term used in animal nutrition to describe the energy derived from GE that is deposited or mobilised on the body plus the energy derived from metabolism that becomes available for use outside the body (eg production of milk or eggs). Net energy content offsets the energy required to metabolise the food, which is supplied by the body, against ME.

Other terms

Available carbohydrates: carbohydrates that reach the small intestine and are fully absorbed there.

Obligatory thermogenesis: obligatory component of the thermic effect of food related to the metabolic cost of processing the nutrients or other food components (Ravussin and Swinbourne 1993, p102).

Non-obligatory thermogenesis: non-obligatory component of the thermic effect of food, part of which may be mediated through the sympathetic nervous system (Ravussin and Swinbourne 1993, p102).

Short chain fatty acids (SCFA): volatile fatty acids, such as butyric, propionic or acetic acids, produced by fermentation of carbohydrates that are transported to the colon.

Unavailable carbohydrates: carbohydrates that are not absorbed in the small intestines and pass to the large intestine, where they are largely undigested, unabsorbed, unfermented or are not absorbed but fermented by resident bacteria to produce SCFAs. Absorption of the SCFAs provides some energy for the host. They appear to supply little energy overall to the body, but may account for some of the variance of ME or NE estimated from the energy value of diets (Livesey 1988).

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