INCAP Publication PCI/035

Dietary protein/energy ratios for various ages and physiological states

B. TORUN (Chairman), J.V.G.A. DURNIN, C. GARZA, E. JÉQUIER and P.S. SHETTY

In: "Protein-Energy Interactions"
N.S. Scrimshaw & B. Schürch (Eds.)
Lausanne, Switzerland:International.
Dietary Energy Consultancy Group
(IDECG), 1992.

1. Definition, interpretation and uses

Nutrient/energy ratios have been used as indices of dietary quality in relation to several specific nutrients, and to express nutrient goals which, in turn, are the basis for dietary guidelines. The reasoning behind this is that energy requirements are the main driving force for food intake and, consequently, for the intake of nutrients present in that food. Therefore, a diet is adequate if it satisfies the requirements for all nutrients when it is eaten in amounts that will satisfy energy requirements. Thus, the protein/energy ratio is often used to describe the 'protein quality' of a diet. That ratio is generally expressed as the percentage of protein energy in the diet, that is, the ratio of protein energy to total dietary energy, where 1 g protein provides 4 kcal or 16.7 kJ of metabolizable energy. It is abbreviated P/E ratio or Pcal%.

The use of the P/E ratio has led to much controversy, but this is mainly due to inadequate application or misinterpretation of the ratio. To avoid these problems, the following must be clearly understood:

(a) The P/E ratio only gives information about one aspect of a diet's quality, namely that of protein concentration or density. It does not indicate the biological value or quality of the proteins.

(b) A 'recommended P/E ratio' indicates the amount of protein that the diet should provide relative to total energy, and it does not denote a constant relationship between protein requirements and energy requirements. In fact, recommended P/E ratios vary with changes in protein or energy requirements. This is illustrated by the following example, where two different P/E ratios can be calculated due to the fact that physical activity has a strong influence on energy requirements and little or none on protein requirements:

The protein requirement of men who weigh 60 kg and eat mixed proteins with adequate amino acid composition and digestibility of 80% is 56.2 g/d, equivalent to 225 kcal (939 kJ) of protein energy. If they have a sedentary lifestyle, their energy requirement would be 1.5 times their basal metabolic rate (BMR) or 2362 kcal (9.9 MJ), and the P/E ratio of their diet should be 225/2362, or 9.5%. If, on the contrary, their occupations involve heavy physical work, their energy re-

quirement would be 2 times BMR or 3150 kcal (13.2 MJ), while their protein requirement would remain virtually unchanged. In this case, the P/E ratio of their diet should be 225/3150, or 7.1%.

(c) A high P/E ratio does not necessarily imply a high protein requirement. From the example given above, it does not follow that men with a recommended P/E ratio of 9.5 need more protein than men for whom a P/E ratio of 7.1 is recommended.

(d) Most populations eat diets with P/E ratios between 10 and 15%, but this is mainly a consequence of the food that is available and does not reflect a biologically optimal ratio. There is no reason to believe that a diet with a P/E ratio of 15 has better nutritional value than one with a P/E ratio of 10 or 12.

With these considerations in mind, the P/E ratio can be used as one of the descriptors of overall dietary quality. An adequate P/E ratio suggests that the diet will not produce protein deficiency and that it will provide the micronutrients that are usually present in protein sources.

Excessive protein intake, within reasonable limits, does not have deleterious biological effects. However, recommendation of an unnecessarily high P/E ratio may divert food policy resources toward procuring excessive, and usually expensive, protein supplies.

P/E ratios should be used in reference to diets of population groups and not of specific individuals. They may be useful to evaluate the protein adequacy of family diets (assuming that all family members over one year of age eat 'from the same pot') or of population diets, based on average protein and energy requirements. They can also be targeted to satisfy the needs of specific age groups, such as infants, pregnant women or elderly persons, or of institutional diets, such as those of nursing homes, child care centers and hospitals that treat malnourished patients.

2. Calculation of recommended P/E ratios

The following must be taken into account to calculate a P/E ratio:

Protein requirements. These vary with age, sex and physiological state (i.e., pregnancy and lactation). Since the goal of the P/E ratio is the evaluation or recommendation of a diet that will satisfy protein requirements of a population when mean energy requirements are satisfied, the safe level of protein intake (i.e., the amount of dietary protein that will satisfy the needs of the whole population) must be used in the calculations. An increment of 25% of the mean protein requirement should be used, as recommended by the FAO/WHO/UNU Expert Consultation on energy and protein requirements (1985).

Protein quality and digestibility. Protein recommendations are based on the intake of animal proteins (milk, egg, beef), with a reference value of 100% for digestibility and a pattern of indispensable

amino acids where none is limiting. Diets that include mostly vegetables or mixtures of vegetables and animal foods have lower protein digestibilities, and their chemical composition may or may not have limiting amino acids. A correction must be applied to increase the protein component (numerator) in the P/E ratio of those diets and compensate for the lower digestibility. Usually, no correction is required for their amino acid composition, since it is assumed that the intake of adequate amounts of the diet will satisfy the needs for total nitrogen and all indispensable and conditionally indispensable amino acids. This is true of diets based on certain vegetable mixtures, or adequate combinations of animal and vegetable foods. However, diets of low-income families in many developing countries may require modifications to improve their protein quality, particularly for children under 5 years of age. This is further discussed elsewhere in this chapter and in the recommendations of Panel 3 (see pp. 399–413).

Energy requirements. In addition to age, sex and physiological state, energy requirements are strongly influenced by the physical activity associated with lifestyle and occupation. This must be considered to define the total energy component (denominator) of the P/E ratio, as illustrated by the example given in a preceding section of this chapter. To calculate a range of values, two extremes of habitual activity should be used, corresponding to sedentary and very active populations. Table 1 shows the mean daily energy expenditure under those conditions. The calculation of total energy expenditure and requirements as multiples of BMR has the advantage of accounting for genetic variability in basal energy expenditure.

Dietary energy availability. The FAO/WHO/UNU Expert Consultation on energy and protein requirements (1985) suggested an increment of 5% in energy intake to compensate for the reduced digestion and absorption of energy in diets with a high content of fiber. This correction may not be necessary for populations whose habitual diets do not have a high fiber content.

Table 1. Daily energy expenditure of sedentary and very active individuals, expressed as multiples of basal metabolic rate

Sex and age*	Energy expenditure	
	Sedentary	Very active
Either sex: 7–12 years	1.6	2.0
Male: > 12 years	1.5	2.0
Female: > 12 years	1.5	1.9
Either sex: elderly	1.5	1.8

* Children under 7 years are not included due to insufficient information about their daily energy expenditure.

Based on the preceding considerations, a variety of P/E ratios were calculated for population groups with different ages, dietary protein sources and habitual physical activity (**Table 2**). The following example illustrates how the ratio was calculated for a 25-year-old, non-pregnant, non-lactating woman:

Weight: 50 kg, BMR: 1231 kcal (5.15 MJ)/d
Protein recommendation: 0.75 g/kg/d x 50 = 37.5 g/d
Protein energy: 37.5 g x 4 kcal (16.7 kJ)/g protein = 150 kcal (626 kJ) protein energy/d

Correction for protein digestibility
High digestibility (95%): 150/0.95 = 158 kcal (659 kJ)
Low digestibility (80%): 150/0.80 = 187.5 kcal (782 kJ)

Energy requirement
Sedentary: 1.5 x BMR = 1850 kcal (7.725 MJ)
Active: 1.9 x BMR = 2337 kcal (9.785 MJ)

Correction for reduced energy availability (add 5% energy)
Sedentary: 1937 kcal (8.11 MJ)
Active: 2453 kcal (10.27 MJ)

P/E ratio for:

Active woman, higher quality diet:	158/2337 = 6.7%
Active woman, lower quality diet:	187.5/2453 = 7.6%
Sedentary woman, higher quality diet:	158/1850 = 8.5%
Sedentary woman, lower quality diet:	187.5/1937 = 9.6%

3. Recommended P/E ratios

The most important application of a P/E ratio is to evaluate if a diet has a proportion of dietary proteins that may prevent the occurrence of protein deficiency. To suggest P/E ratios that may be universally applied to diets of heterogeneous populations of different geographic and socioeconomic backgrounds, it is better to overestimate the proportion of protein that the diet should have, than to risk suggesting a P/E ratio that may be too low for some populations. Consequently, the highest set of values shown in **Table 2** should be used. These correspond to sedentary individuals with diets based on vegetable foods that resemble mixed diets eaten by most people in developing countries. Protein digestibility of such diets is of the order of 80% relative to animal proteins, and about 5% of its energy is lost through feces due to the high fiber content.

For populations who consume diets with a higher content of animal proteins and refined, processed cereals, the values in the third column of **Table 2**, corresponding to sedentary individuals with a diet of higher quality, can be used.

Table 2. P/E ratios suggested for diets of population groups with different dietary protein sources and habitual occupations

Age and Sex	Very active		Sedentary	
	Dietary quality**		Dietary quality**	
	higher	lower	higher	lower
Children				
6–9 months		***	6.9	7.7
9–12 months		***	6.2	7.0
2–3 years		***	4.8	5.4
5 years		***	4.8	5.4
7 years, boys	5.8	6.6	7.3	8.2
Adults				
non-elderly men	6.0	6.8	8.0	9.0
non-elderly women	6.7	7.6	8.5	9.6
pregnant	7.3	8.2	9.3	10.6
lactating < 6 mo	8.2	9.3	9.9	11.2
lactating > 6 mo	7.5	8.4	9.0	10.2
elderly men	8.5	9.6	10.3	11.6
elderly women	8.6	9.7	10.4	11.7

* Daily energy requirements calculated according to Table 1.

** Lower dietary quality: 80% protein digestibility and 95% energy availability (children 6–9 months: 90% protein digestibility and 100% energy availability). Higher dietary quality: 95% protein digestibility (6–9 months: 100%) and 100% energy availability.

*** Energy requirements for children under 7 years based on mean intakes, according to the FAO/WHO/UNU 1985 Report. No differences made for activity level.

Table 3. Safe lower limit suggested for P/E ratios of diets consumed by the general population or in institutions that cater to specific age groups

	Any diet	High protein digestibility
Family diet (general population)	12%	10%
Families without pregnant or lactating women and elderly persons	10%	9%
Nurseries	8%	7%
Preschool child-care centers	6%	5%
Nursing homes for the elderly	12%	10%

To simplify further the recommendations, Table 3 shows the P/E ratios suggested for the family diet and for institutions that cater to some specific groups. The highest values in the corresponding columns of Table 2 were used for the family diet in order to suggest a ratio that would be adequate for all family members.

4. Food sources of energy and proteins

In recognition of the role of diet in health maintenance and disease prevention, comments on the sources of dietary energy and protein are appropriate. The Panel concurred with recommendations made by the WHO Study Group on Diet, Nutrition, and the Prevention of Chronic Diseases (1990), in order to improve dietary quality without increasing the risk of developing diet-related chronic diseases.

Fats should provide between 15 and 30% of total dietary energy, and not more than one third of them should be saturated fatty acids. Carbohydrates should provide between 60 and 75% of dietary energy. Free, refined sugars should be limited to a maximum of 10% of total energy, except when they are the only inexpensive source available to increase the energy content of bulky diets with a very low energy density (BENGOA *et al.*, 1989).

Vegetable diets have relatively low protein digestibilities and may be deficient in one or more indispensable amino acid. Animal proteins will improve the digestibility and amino acid score of those diets. They will also enhance the absorption and bioavailability of other dietary components, such as inorganic iron. In addition, most aminal protein foods provide significant amounts of various micronutrients, such as highly digestible heme iron, zinc, iodine, retinol and Vitamin B_{12}.

On the other hand, many sources of animal proteins, such as pork, beef, full-fat milk and egg yolk, contain relatively large amounts of saturated fatty acids and cholesterol, which may increase the risk of developing diet-related chronic diseases. Therefore, it is the consensus of the Panel that animal proteins should be limited to a maximum of between 30 and 50% of total dietary proteins.

In conclusion, when a P/E ratio is recommended, the intake of a mixed diet with predominance of vegetable protein sources, a certain proportion of animal proteins, low in saturated fats and rich in complex carbohydrates, should be advocated. Its energy density must also be considered, since some vegetable diets can have such a low density that their bulk will not allow satisfying the energy requirements of young children and the elderly, even though their P/E ratio may be adequate.

References

BENGOA, J.M., TORUN, B., BEHAR, M., SCRIMSHAW, N.S. (Eds.): Metas nutricionales y guias de alimentacion para America Latina, Bases para su desarrollo. Arch. Latinoam. Nutr., *38*, 373–428, 1988. English version: Nutritional goals for health in Latin America. Food Nutr. Bull., *11* (1), 4–20 (1989).

FAO/WHO/UNU: Energy and Protein Requirements. WHO Technical Report Series No. 724. World Health Organization, Geneva, 1985.

WHO: Diet, Nutrition and the Prevention of Chronic Diseases. WHO Technical Report Series No. 797. World Health Organization, Geneva, 1990.