

THE WORLD FOOD PROBLEM:
IS THERE AN ENERGY OR A PROTEIN GAP?

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ABSTRACT

The problems of assessment of human nutritional requirements and the definition of human dietary allowances are discussed. These data are compared with the world food supply in terms of food energy and protein. Emphasis is given to a comparison between the protein qualities of animal and plant foodstuffs. The judgement of the adequacy of the world food supply includes a thorough consideration of the variations of nutrient requirements and of food availability. It can be shown that the food potential on earth is adequate. Most current diets offer a protein-energy ratio which is above the allowances. Nevertheless millions of people have too little food. The main problem is the uneven distribution of food availability.

INTRODUCTION

All of us are aware that there is a world food problem. In reality there are even two facets of it. Industrialised countries are confronted with overnutrition and obesity, and many inhabitants of tropical countries are suffering of lack of food. I will consider today only the problem of insufficient food availability. You might be aware that the discussion on the world food problem during the 60'ies concentrated on the protein gap; since then they have shifted to a debate on energy and protein.

Before trying to answer the question put in the title of my paper, I want to give you the information regarding the assessment of human nutritional requirements and the definition of human dietary allowances. These data indicate how much food is needed. These figures will have to be compared with the current food production and food availability in

MIFLIN, B.J., ZOSCHKE, M. Carbohydrate and Protein
Synthesis, European Communities - Commission,
Luxembourg, EUR 6043, 1978, ISBN 92-825-0631-2

order to judge whether there is a loss of energy and whether it is being gained or lost.

HEAT ENERGY AND NUTRIENT REQUIREMENTS AND METABOLISM

Heat energy is also being expended for maintenance of body support (see table). Human beings are often thought of as energy-absorbing creatures and indeed, food and energy (general terms complex mixture of vitamins, minerals and organic substances which are taken from a variety of sources) are used for repair and for maintaining the body's energy level. Substances which are valuable and which are used in the body are also being used for repair and for maintaining the body's energy level. Food and energy are also being used for repair and for maintaining the body's energy level. Substances which are valuable and which are used in the body are also being used for repair and for maintaining the body's energy level. Food and energy are also being used for repair and for maintaining the body's energy level.

Carbohydrate, fat, protein and all other nutrients are sources of energy and are interchangeable in terms of energy within wide limits. The energy available to the body is limited by the energy of the diet minus losses in urine and feces. The physiologically available energy is also limited by applying the Atwater factors (Table 1).

Table 1. Physiologically Available Energy (Atwater Factors) (from Davidson et al (1972))

1 g protein	4 kcal
1 g fat	9 kcal
1 g carbohydrate as	
polysaccharide	4.2 kcal
monosaccharide	4.1 kcal
1 g alcohol	7.1 kcal

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How much energy and protein are absorbed from food? A general energy balance study was performed by Davidson and his colleagues. They found that the energy balance of a human body is maintained by the intake of food and energy. The energy balance of a human body is maintained by the intake of food and energy. The energy balance of a human body is maintained by the intake of food and energy. The energy balance of a human body is maintained by the intake of food and energy.

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rather they depend on several factors (Table 3).

Table 2. Amino acids required to maintain N balance in adults and growth in infants under 6 months (from FAO/WHO 1973)

	Combined adult values mg/kg/day		
	Man	Woman	Infant
Histidine	-	-	28
Isoleucine	700	550	70
Leucine	1100	730	161
Lysine	800	545	103
Methionine and cysteine	1100	700	58
Phenylalanine and tyrosine	1100	700	14
Threonine	500	375	7
Tryptophan	250	168	3.5
Valine	800	622	10

The body weight, or better, body size and body composition, correlates with the amount of metabolic active cells and tissues, which determine the basal metabolic rate. Body weight is in addition a factor in considering the requirement for physical activities when the whole body or part of it has to be moved. Children are growing, with age the body weight and body composition are changing. Older people have a decreased basal metabolism. They also often have decreased physical activity, and show an increased prevalence of diseases. Men and women have different body composition. Women menstruate, they give birth to children and they are able to breastfeed them. Humans are also genetically individuals, there is the common biological variation in composition, metabolism and thus in requirement. Diseases can alter the requirement; each event of fever enhances protein metabolism. The physi-

cal activity is directly related to energy requirement. The protein requirement is comparatively independent of work load.

Table 3. Factors influencing energy and protein requirements.

Factor	Energy	Protein
Weight	++	++
Age	++	++
Sex	+	+
Genetic constitution	+	+
Diseases	+	++
Physical activity	++	?
Climate	+	?
Ecological factors	?	+

Humans adjust metabolically to climate, in cold environments by shivering and thermogenesis, in hot zones by sweating. Finally there are ecological factors, as pollution or stress, which are able to alter metabolic functions, and thus nutrient requirements.

The nutrient requirement is an individual and changing figure. The requirement of human populations can be expressed as a distribution of individual requirements (Figure 1).

The main difference in the requirement of energy and of protein is that both inadequate and excess energy intakes are potentially harmful, but whereas insufficient protein intake is detrimental, there are no demonstrated harmful or beneficial effects of intakes well above the probable minimum protein requirement. For these reasons, the expressions of protein needs must be approached differently from that of energy requirements. The energy requirement applied to populations is the energy intake that is considered to meet the energy needs

of the average healthy person in a specific category. The safe level of protein intake is the amount of protein considered necessary to meet the physiological needs and maintain the health of nearly all persons in a specified group. This level is thus higher than the average requirement for protein (FAO/WHO 1973).

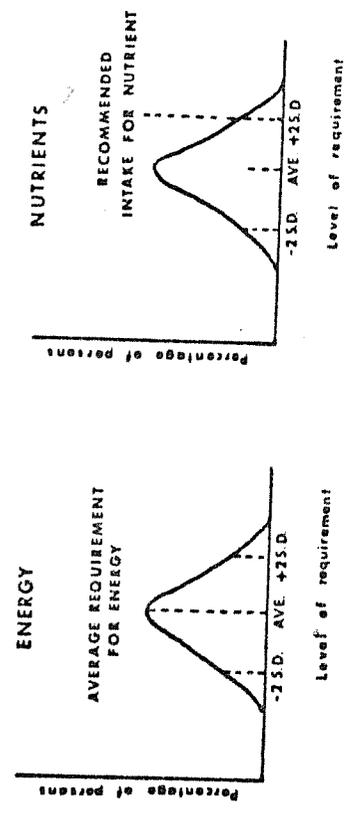


Figure 1. Comparison of average requirement for energy and recommended intake for a nutrient. It is assumed that in each case individual requirements are normally distributed about the mean (reproduced with permission from Beaton 1977).

For considering the adequacy of national food supply one has to consider the factors mentioned, and even some additional ones. Humans are eating foods and not isolated nutrients as such. As stated above, food is mostly a complex mixture of nutrients. Therefore, the intake of different nutrients and of energy are dependent on each other. Foods providing simultaneously in most cases energy and nutrients, including protein. This is indicated by the following figure, showing

the "nutrition triangle" (Figure 2).

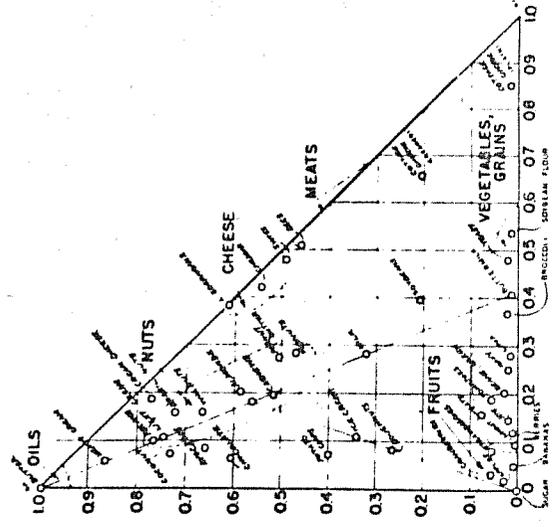


Figure 2. The nutrition triangle. The horizontal scale refers to protein, the vertical scale refers to lipid (reproduced with permission from Moon and Spencer 1976)

The horizontal scale refers to protein, n^1 is the relative mass of protein; and the vertical scale refers to fats, n^2 is the relative mass of lipids in food (Moon and Spencer 1974). Exceptions are some processed foods, like white sugar, separated fats or alcoholic spirits. These are "empty calories".

Further we have to consider that we do not eat only one

food, but rather a variety of foods. We have to consider food habits, foods have to be acceptable and palatable. Another factor to consider is the meal frequency. Higher meal frequency increases the energy requirement. It is not enough to consider the protein quantity, often expressed as crude protein (N x 6.25). This factor of 6.25 is not a constant for all foods, similar to the already mentioned Atwater factors for energy. Different foods have a different content of non-protein-nitrogen; An even more important factor is the biological quality of the proteins, which is mainly determined by the composition of essential amino acids. The biological values (BV) of a protein is measured by the ratio of retained nitrogen to absorbed nitrogen. Different proteins show different digestibility, resulting in the net protein utilization (NPU), which is biological value (BV) times digestibility.

Isolated animal protein has a superior quality compared with isolated plant proteins, since the amino acid composition of the former fits better to the amino acid requirement of human beings. But we have to consider, that we eat food mixtures, and thus protein mixtures. The different amino acid patterns of different foods are complementary to each other, as Figure 3 explains.

Good mixtures are those of cereals, which are relatively deficient in lysine, with legumes, which are relatively deficient in sulphur containing amino acids. Such types of mixtures are of similar value to animal proteins, as the results of the group of Kofranyi (1971) show (Fig.4).

Mixtures of protein decrease the minimum protein requirements. Protein requirement is dependent on the supply of energy and other nutrients, including the essential amino acids. If there is too little energy intake, then proteins are used as an energy source, and they are thus wasted for their specific metabolic function. If there is one essential amino acid available in inadequate amounts, then the protein requirement increases.

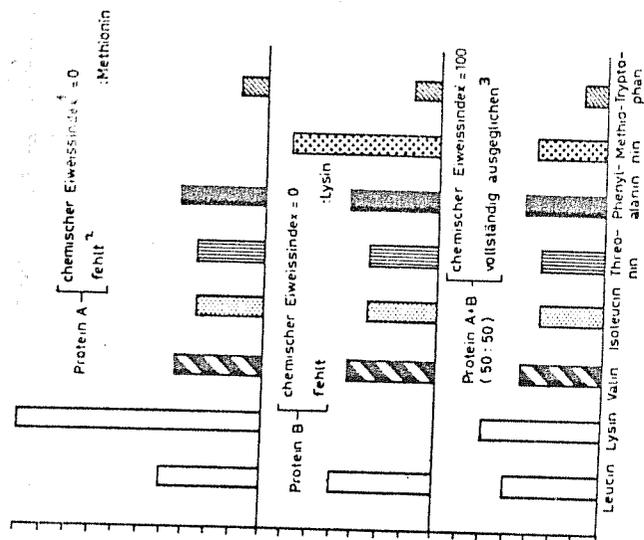


Figure 3. Principle of mutual supplementation of unbalanced proteins (reproduced with permission from Mauron 1966).

1. Chemical score, 2 missing, 3 completely balanced.

The consideration of the protein-energy-relationship is a very important aspect in the establishment of dietary recommendations. The higher the energy requirement, e.g. under heavy physical work, the lower the required protein-energy ratio. The lower the protein quality, the higher the required protein-energy ratio. The requirements of protein-energy ratios are in the range of 5-10% of the total energy intake derived from protein. When these values are compared with the

protein-energy-ratios in common food, most foods appear well above the requirement (Table 4). In other words, eating those foods in adequate amounts to ensure the fulfillment of the energy requirements, guarantees a safe level of protein intake.

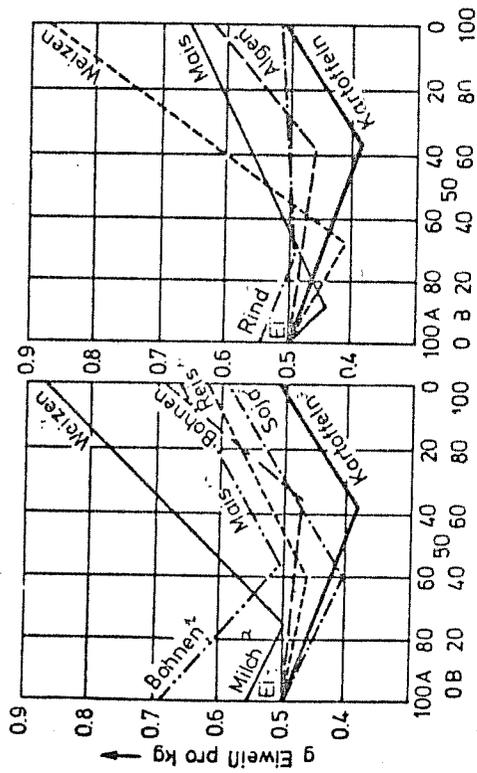


Figure 4. Minimum requirement of protein with 10 protein mixtures. Abscissa: Mixing ratio; Ordinate: daily minimum requirement/kg body weight. The diagrams are related to a human, who is in N-balance with 0.5 g egg protein/kg.
 1 beans, 2 milk, 3 egg, 4 wheat, 5 maize, 6 rice, 7 soya, 8 potatoes, 9 beef, 10 algae. (Reproduced with permission from Kofranyi 1971).

Finally in the considerations for setting up dietary recommendations other factors are involved such as, the price of foods, the economic availability of foods for different socioeconomic classes, local food production, and even political prestige. For this reason - the complexity of considered factors and the comprehensiveness of needed information -

Table 4. Apparent protein-energy-ratios in some common foods (from Beaton 1977).

Type of food	Protein as % energy
Milk, whole	22
2% skim	29
40	
Cheese, Cheddar	24
Ice cream	9
Meat, Lean	50-60
fat	18-25
Poultry	50-65
Fish	50-80
Vegetables, general	15-35
Beans, peas	15-25
Soybean	30-40
Fruits, general	2-7
Nuts, seeds	5-20
Cereals	7-15
Sugar	0
Fats	0

recommendations for different populations differ and are revised from time to time. Less changes are necessary for energy recommendations, since the average requirement has to be taken and the needed information on energy requirements is comparatively well established. Main reasons for changes in recommendations are a different population structure or changes in physical activities of the population. Table 5 shows the current official FAO/WHO energy requirement data. In contrast to the energy requirement the protein recommendations have been changed considerably in recent years, as shown by Table 6. The current values are already again under discussion, some new data indicate that the values for

Table 5. Energy requirements of children and adolescents by age periods (from FAO/WHO 1973).

Age (years)	Body weight (kg)	Energy per kg per day (kcal)	Energy per person per day (kcal)	Energy per person per day (MJ)
Children				
1	7.3	112	470	820
1-3	13.4	101	424	1 360
4-6	20.2	91	382	1 830
7-9	28.1	78	326	2 190
Male adolescents				
10-12	36.9	71	297	2 600
13-15	51.3	57	238	2 900
16-19	62.9	49	205	3 070
Female adolescents				
10-12	38.0	62	259	2 350
13-15	49.9	50	209	2 490
16-19	54.4	43	170	2 310
Adult man (moderately active)				
	65.0	46	192	3 000
Adult woman (moderately active)				
	55.0	40	167	2 200

adults might be too low (Garza et al 1977).

The normal observed protein-energy ratio of our diets is about 11%. A simple ratio based on the presented recommendations does not take into account the variability of requirements and intakes. One has to consider the variability of energy requirements and of the correlation between energy and proteins, and the variability of this ratio in freely selected diets. Therefore a probability range rather than a fixed number should be given for dietary recommendation, as it is given in Figure 5. The solid vertical line describes the

Table 6. Comparison of the suggested protein intake in successive UN Agency Reports expressed as egg or milk protein (in g/kg/day) (from Beaton 1976).

Age Group years	FAO	FAO/WHO	FAO/WHO
	1971 ¹	1965 ²	1973
1-3	1.71	1.06	1.19
4-6	1.17	0.97	1.10
7-9	1.05	0.92	0.88
10-12	1.05(M)	1.18(F)0.86	0.81
13-15	1.14	0.90	0.84
16-19	0.80	0.57	0.77
20-24	0.56	0.53	0.71
25 +	0.53	0.53	0.71
Pregnancy ⁴		+ 10 g	+ 6 g
Lactation		+ 30 g	+ 15 g

1) Mean + an "arbitrary" 50% allowance for individual variability

2) Mean + 10% for everyday stress + 20% for individual variability

3) Mean + 30% for individual variability (2 s.d.)

4) Referred to last half or last two-thirds of pregnancy

average energy needs of children one to three years old. The solid curve represents the dietary protein concentration required to meet average protein needs at the specific energy intake. The broken lines describe the limits of variability (± 2 standard deviations). There are different mathematical models under discussion which could be used for prediction of protein-energy-requirements in given circumstances. An example of resulting recommendations in protein-energy-ratios

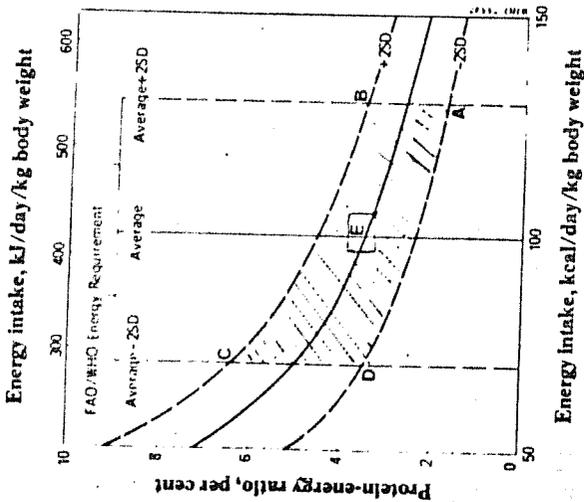


Figure 5. The relationship of protein energy ratio to energy intake (from Anon 1975).

is shown in Table 7.

I want to make some comments on the above stated changes in protein recommendations. Protein deficiency - typified in kwashiorkor - is easier to recognise and gives more dramatic results during scientific investigations in comparison with energy deficiency - typified in marasmus. Such marasmic or undernourished people, look comparatively well. They appear just a bit smaller than well-nourished people. In 1953 the

Table 7. Protein-energy ratios applicable to per-capita data.

Coefficient of variation of protein concentration (%)	Protein as % energy	
	At moderate activity levels	At low activity levels
10	5.3	6.7
15	5.8	7.3
20	6.4	8.1
25	7.5	9.5
Protein with utilisation 80% that of egg or milk		
10	6.6	8.3
15	7.2	9.1
20	8.1	10.2
25	9.4	11.8
Protein with utilisation 70% that of egg or milk		
10	7.6	9.6
15	8.2	10.3
20	9.2	11.6
25	10.7	13.5

FAO/WHO Expert Committee on Nutrition stated "protein malnutrition is the most serious and wide-spread nutritional disorder". Plenty of activities were introduced in order to combat this problem. Careful reconsideration of available information and the frustration that the set goal to close the protein gap could not be achieved influenced the establishment of the new and lower protein recommendations (McLaren 1974).

COMPARISON BETWEEN FOOD DEMAND AND FOOD AVAILABILITY

With lower dietary recommendations the arithmetic food gap, here referred to as the protein gap, is diminished or even closed at once and without any further effort.

A simple calculation will indicate the range of the world food demand. There are now 4 billion people living on the earth (Table 8).

Table 8. Estimation of world food demand

Population: 4×10^9
 Human requirement for energy:
 2,500 kcal/d 0.9×10^6 kcal/year per capita
 protein:
 70 g/d 25 kg/year p.c.
 world requirement
 3.6×10^{15} kcal/year 100×10^9 kg protein/year

Cereals contain per kg
 3,000 kcal and 100 g protein.

World food demand expressed in cereals when related to

energy: 1.2×10^9 tons

protein: 1.0×10^9 tons

Assuming each individual should have a daily ration of 2 500 kcal and 70 g proteins, which takes into consideration a lower protein quality, then one man's ration for a year is 0.9×10^6 kcal and 25 kg protein. A man eats per year foods weighing approximately 0.4-0.5 tons. When these figures are multiplied by the number of the world population, 4 billion, we reach the figures in Table 8. If these figures are compared with the world food production of 1976 (Table 9), there is no indication of a world food problem in form of undernutrition. There is in the world, on the average, enough food produced, but as almost all goods of the world so are foods not evenly distributed. A comparison of average figures does not reflect the real situation. A better comparison is the more

Table 9. The world agricultural production - 1976 (in million tons).

Product	World	Industrialised countries	Developing countries
Cereals	1 478	487	435
Starchy roots, tubers	538	72	175
Legumes	51	3	25
Vegetables	312	93	104
Fruits	260	99	129
Sugar	85	25	42
Meat	122	59	23
Milk	431	209	87
Eggs	24	11	4
World population	100%	20%	48%

(FAO, Monthly Bulletin 1977)

difficult one, when the distributions of food requirements and of food availability are compared (Figure 6). Food is not distributed equally, there are geographic differences, seasonal distributions, bad harvests, differences due to different food habits and customs. Rural and urban populations differ also in their food availability, and the well-to-do have more food than the poor. The uneven distribution was indicated already in Table 9 and a further impression of the bias in the consumption of produced foods is given by the comparison of the usage of cereals as food and feed in the different regions of the world (Figure 7).

The Brazilian nutritionist Dutra de Oliveira calculated, that the pets living in USA and Great Britain - numbering 25 million dogs and 35 million cats - consume 8% of the human food energy intake and 22% of the human protein intake. All

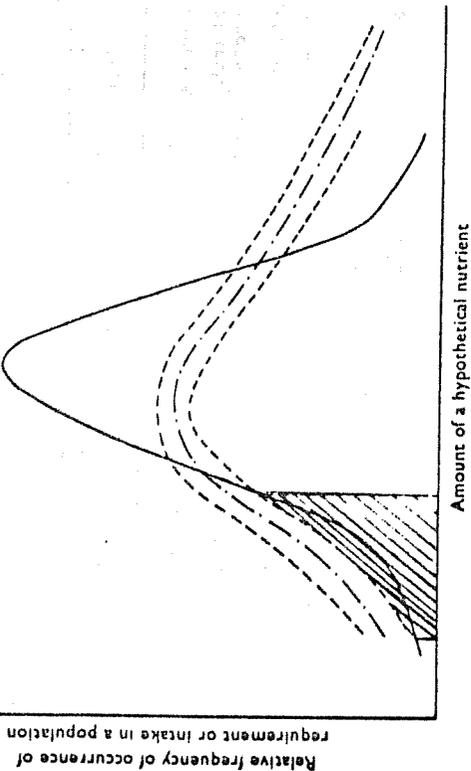


Figure 6. Distribution of the daily requirement for a hypothetical nutrient in a population (—) and the distribution of the mean daily intake of the same nutrient (---) with limits of experimental errors (----): proportion of population whose daily intake is certainly less than their requirement (reproduced with permission from Chan Chin Yuk et al 1975 and modified according to a personal communication from the authors).

animals in the world consume foods sufficient to feed 15 billions of people (Dutra de Oliveira 1974).

All the forementioned figures indicate that the food potential of earth is adequate to supply all humans with enough food now and in the near future. Despite that nutritional studies show that millions of people, especially in developing countries, are suffering from undernutrition. Their number ranges between 450 millions, a figure given by FAO, and one billion, a recent estimate published by the World Bank. The figures of the world Bank are based chiefly on calculations using income distribution as a main factor. The huge

WORLD CEREAL CONSUMPTION,
AS FOOD AND FEED

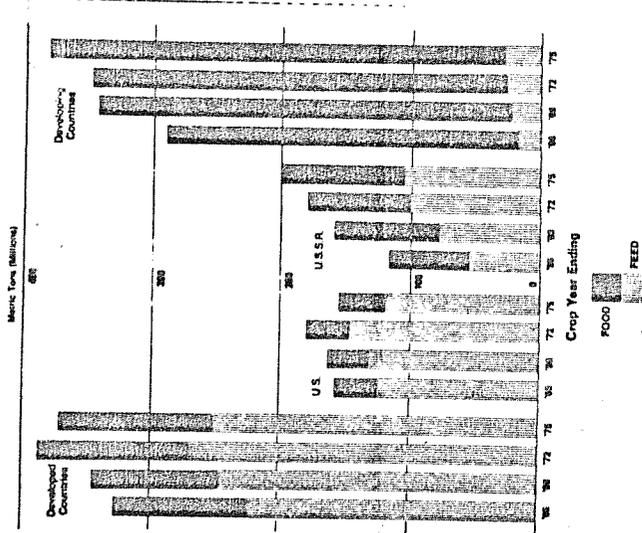


Figure 7. World cereal consumption, as food and feed (reproduced from Rockefeller Foundation 1975).

figure of 1 billion humans with inadequate food availability emerged despite according to their calculation there is in the world a total food gap of only 4% of the world's annual cereal production (Reutlinger et al 1976). The food availability, and so the food problem, is closely related to underdevelopment and poverty. Table 10 shows the correlation between income and food availability for countries in Latin America. But I could have chosen examples from other developing countries, all would show similar correlations. When we ask now again,

Table 10. Calorie availability and income distribution within populations of Latin America.

Income level	Percent of		kcal p.c./d
	Total population	Total income	
Very low	20	2.5	1 700-1 850
Low	30	11.4	2 100-2 300
Medium	30	25.1	2 500-2 600
High	15	31.1	3 000-3 200
Very high	5	29.9	4 100-4 700
Total	100	100.0	2 400

(CEPAL 1975) p.c. = per capita, d = day

whether there is a world food energy gap or a protein gap, and take the above mentioned facts into consideration, the question seems to be an idle one, but still I will try to give an answer. There is both; under certain conditions and for certain populations there will be a protein gap, for others there will be an energy gap. Only careful analyses of given situations will indicate the scope and kind of the existing problem. Overall it seems to me that the energy problem is the more important one. A comparison of the protein-energy-ratios which humans need with those of current diets, demonstrates that for most people there will be enough protein when the energy requirement is fulfilled or, in other words, when there is enough food. This is especially valid for adults, but may be not for some groups at-risk, which have a higher requirement, such as infants, pre-school-children and pregnant and lactating women.

The main world food problem is the energy problem and the uneven distribution of food availability, but this does not at all mean the protein problem can be neglected.

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DISCUSSION FOLLOWING THE TALK

KÖLE: Are the Kofranyi estimates of N equilibrium, which are very low for some of the mixtures based on realistic levels or are especially high amounts used?

OLTERSDORF: No, this was under a quite normal condition. Of course, this has to be in order to have a good experiment. If you want to test only nitrogen you have to be sure that there is only one factor that you test. The main point of the experiment to be discussed is, is it varied only for minimum requirement or is it varied as well for this normal level because there is no linear relationship between nutrient balance and nutrient intake. With higher nitrogen intake, the utilisation of nitrogen becomes more uneconomical to express it in simple terms.

SCHÖN: A couple of years ago I visited Prof. Kofranyi, and as far as I remember, this experiment was done with equilibrium amounts of energy. I would like to ask you if this enhancement effect is so dramatic as demonstrated by Kofranyi?

OLTERSDORF: I have never heard of a nutritionist saying it is not reproducible. The main discussion is really that should we test protein quality on minimum requirements because this is an unrealistic condition. The realistic condition is that there is a higher requirement for protein (e.g. stress) or there is a higher protein intake. The nutritionists are discussing better applicable conditions, which really means the optimal requirement. There are hundreds of experiments on food mixtures, remember names like 'Incaparim' or 'Supramine' - vegetable mixtures which showed a superior value than their simple ingredients. There is no doubt that the apparently dramatic changes or improvements in protein quality by mixtures are valid.

PROTEIN-ENERGY-INTERRELATIONSHIPS

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ABSTRACT

The significance of protein energy interrelationships is discussed in respect of non-ruminant and ruminant animals. For pigs an equation is given for calculation of protein utilisation from body weight of the animals and protein energy ratio in a feed with normal amino acid composition. A general system for description of protein energy interrelationships is proposed which permits consideration of the protein synthesis capacity (growth potential) of the animal as a function of feed composition, age, sex and racial properties of the animal. From this system a ration value (RW) is derived, which is defined as the amount of protein energy (MJ) stored and/or used for basal N-turnover, produced from a unit of feedstuff. Calculation of this ration value can be based on N-balance experiments or simply on blood urea measurements.

INTRODUCTION

Protein and energy are the most important factors in human diets and in rations for animals. Feedstuffs and foods supplying energy and protein make up 90 to 95% in a diet. The requirements in protein and energy should be known with relatively high precision, since not only deficiencies but also surpluses have negative effects on health and/or performance, whereas most other nutrients can be given in surplus whenever contents of the feedstuffs or requirements are not exactly known.

In common tables the requirements in protein and energy are given separately, in spite of the well known fact, that there are interactions between these two factors. These interactions can easily be demonstrated in nitrogen balance experiments, which show increasing efficiencies of protein utili-

is a point that Prof. Menke was making. In almost any live-stock feeding situation it will be a mixed ration which the animal is presented with and to some extent especially with cattle and perhaps especially in the U.K., we can manipulate grass and cereals quite effectively in terms of what is fed to an animal to achieve a desired level of protein. One imagines that a similar practice could exist in other parts of Europe, for example with maize and lucerne so that what I am really saying is that my objective would be for a total yield of nutrients because I do not think it is realistic for the animal feeding expert to expect the geneticist to produce a single type of plant which will be a complete feed.

MIFLIN: Is not the problem how much imported soybean meal the E.E.C. has to pay for and how much of this can be replaced by internal sources?

CONNELL: No, that is where the flaw is. I cannot speak for all the European countries but as far as the U.K. is concerned almost 60% of the imported protein is in fact used in ruminant feeding.

MIFLIN: This is soybean meal.

CONNELL: Yes, the normal imports are soya and ground nut. I can let you have the figures later.

MIFLIN: This does not matter so much but this negates your argument that you can make do with grass for ruminants. You cannot argue that you can manipulate the grass to produce the protein and then say the majority of the protein is brought into the country for ruminants.

CONNELL: Well, there is a winter feeding period and a summer feeding period. In the summer there is probably too much protein in the grass for the lactating animal and the growing animal. It is cheap though. If it were not cheap you would start adding barley to achieve your protein content that you are looking for. In the winter by improving the quality of conserved forages and then adding barley to the situation you would not need so very much in the way of imported proteins. That might be the situation but that is not the position at the moment. We are getting away from breeding, but mixed feeds, I am sure, will account for a lot of the systems varying from country to country as local conditions will dictate.

MIFLIN: All you are saying actually is the alternative source to increased protein intake from cereals as a substitute for soya is to use conserved grass.

CONNELL: Yes, that is what I was saying.

OLTERSODORF: Plant breeders and plant producers should include into the references and the aims of their work, the following consideration. There are two different usages for plants. Partly they are used as feedstuff for animals, and partly they are used for human consumption directly. Both sectors are in a kind of competition with each other. The aims of plant breeders and plant producers differ and are depending on which sector of usage they are devoting their efforts. The re-

quired standards for feedstuffs and human foodstuffs differ in quantity and quality. The different sources of plants and their different possible usages should be compared carefully and completely, in order to use the world resources in the most economic way, and to avoid as far as possible irrational and luxurious consumption of potential human foods as feed. A very good example for such systematic and rational consideration of food production is given by Giles and Hobday (Reference: K.W. Giles, S.M. Hobday. Improving Plant Proteins for Human Needs. World Review of Nutrition and Dietetics, 25, 217-248. Karger, Basel 1976).

GILLOI: In the protein programme, some scientists are working on peas. In terms of human nutrition, this seems a very good idea. In wheat, on the other hand, we can serve both animal and human needs by increasing protein content and improving its nutritive value. It seems to me that such an objective would be compatible with all explicitly stated aspects of our general requirements and expectations of future research in this area. This could be a good conclusion for the meeting. It would find support in the idea of Mr. Connell that we are neglecting very interesting material to feed our animals, and we are feeding these animals with very sophisticated material which could be used for human feeding. There is also, I should say, an important philosophical problem which is concerned with long range human food requirements. It is not easy to formulate a general conclusion in which we can demonstrate an awareness of a human food problem, but maybe we could say something on this. Do not forget that we are entering a very big energy crisis, and in the future perhaps more and more people will consume a greater proportion of plant protein in their diet. We must be careful to show that we are aware of the problem, and that we are not neglecting this aspect of future needs.

MIFLIN: The majority of agricultural production in the world, whether in the U.S., Europe or elsewhere, is in cereals, so I think we should concentrate on cereal problems. The other point which you have made, confirmed by Dr. Oltersdorf, is that although you can determine what animals eat, you cannot tell humans what to eat. As people become more prosperous, they will eat more meat from monogastric and ruminant animals, and despite what one might like to do in solving world food problems, I still think that perhaps the politicians will be interested in what people say about what happens in the E.E.C. and that the best way to make an impact is to concentrate on the crops that people are growing, and that is the cereals.

MESDAG: What do you think about traditional means of protein production; do you think we are giving enough consideration to the problem? Have we considered other methods and possibilities for producing protein?

GILLOI: You are thinking in terms of single cell protein production?

MESDAG: Yes, artificial sources.