MALNUTRITION IN INDIA*

P.V. SUKHATME

Gokhale Institute of Politics and Economies, Poona

1. INTRODUCTION

I deem it a great honour to be invited to deliver the first lecture in the Panse Memorial Series instituted by the Society. As you may know, Panse and I were very close friends. Panse and I worked together to found this society as also to establish and develop the Institute of Agricultural Research Statistics of the Indian Council of Agricultural Research. Panse's contribution to these developments is so large that without exaggeration he can be described as the architect of this Institute where we are meeting today. His was the pioneering work in the development of statistical methods in agriculture. It was my good fortune to have worked so closely with him and to have enjoyed his friendship. Not a month passed without he and I exchanging thoughts on some technical topics or the other. How much I miss him is, therefore, best imagined than described. I would like to take this opportunity to pay my homage to this great statistician. A nobler man I have not met in my career.

During the last years of his life, Panse and I got interested in the study of food consumption statistics. The topic fascinated both of us. It is, therefore, only proper that I should report today some of the latest results on this subject. For I know that nothing would please him better than to know that I am continuing these studies.

The particular aspect of the studies on food consumption on which I propose to speak today is malnutrition. There is a general impression that most of the malnutrition that we see in our infants and children is the result of insufficient amount of good quality protein in our diets. I want to present evidence of food consumption surveys to show that this impression is either wrong or grossly exaggerated.

2. HOW MUCH PROTEIN DOES A MAN NEED ?

An adult healthy man has about 10 kg of protein of which the majority is in muscles. The body proteins are continually broken down in their constituent amino acids and then resynthesized. In this process, part of the amino acids are derived from the diet and

*Panse Memorial Lecture delivered at New Delhi the remainder are released by break-down of protein elsewhere in the body. If there is no protein in the diet the reutilisation of the amino acids from the body protein, becomes more efficient, but never attains 100 per cent efficiency, since some amino acids are always converted into urea and excreted into urine. These constitute the obligatory losses which must be compensated by the diet if the person is not to waste away. Likewise there is an inevitable loss of protein from the gut even on a protein free diet and a small amount is lost from the skin and other roots of the body. These losses are found to add up to 0·33 mg. of protein per kg of body weight (FAO/WHO, 1971). The results of experiments on adults with egg protein show that about 0·44 g of protein on an average is needed to replace these losses. This then represents the average requirement of adult man per kg of his body weight. For a healthy active man weighing 55 kg this works out to approximately 25 g of protein as egg.

Individuals may need protein which may be below or above the suggested average. The magnitude of this individual variability is approximately 15 per cent. If m is taken to denote the average requirement of a specified age-sex group and s denotes the standard deviation of individual requirement it means that most individuals of the specified group will have a protein requirement between $m \pm 2s$. The level, $m + 2s$, represents the upper level of individual requirement and is called the recommended intake. Most individuals will have a requirement below $m + 2s$; that is to say that the probability that an individual will have a requirement exceeding $m+2s$ is very small. Likewise the probability that an individual will meet his requirement on an intake less than $m-2s$ is equally small. For a healthy active adult these limits would be 32 and 18 gms of egg protein respectively.

A similar calculation shows that a healthy child of one year old weighing 10 kg requires on average 8 g of good quality protein such as egg for maintenance and an additional protein of 2 g for growth. The latter is simply arrived thus. A healthy child puts on about 13 g of body weight a day. If we were to reckon that body weight contains 16 per cent as protein, it means that we must provide a child with approximately 2·1 g of protein as egg to meet his needs for satisfactory growth alone. Experimental evidence confirms that a diet which provides 1·25 g as egg per kilo of body weight is sufficient to maintain normal health and growth of a healthy active child and can be taken to represent the upper level of child's requirement.

The requirements of protein for other age groups are similarly worked out. By way of an example, we give in Table 1 requirements (recommended intake) for selected age-sex groups (FAO/WHO, 1971). The Table also shows the average requirements for calories. It needs to be added that unlike for protein the requirements for calories are expressed as average per caput need for specified age-sex groups. Excess calorie intake is as harmful as inadequate intake which is the reason why calorie needs are expressed this way. Nevertheless variability in calorie intake is as characteristic of an individual as that in protein intake.

Expressed on energy basis Table 1 shows that if a diet has 5 per cent of its calories from good quality protein such as in egg, the

TABLE I

Recommended levels of nutrient intake for pre-school child and adult in India. (FAO/WHO, 1971, approximate only)

Age	*Weight in kg.*	*Cal/kg.*	*Total calories*	*Protein as egg g/kg*	*Total Protein as egg g*	*Protein/ Cal concentration %*
1—3	12	100	1200	1·25	15	5·0
Adult	55	46	2550	0·57	32	5·0

individual's needs for protein will be met regardless of whether the individual is a pre-school child or an adult man provided the indivi- dul eats enough to meet his energy needs. The general belief there- fore that a child needs much more protein relative to his energy needs compared to an adult is not supported by experimental evidence when protein is given as egg or milk. It nevertheless is true that dietary protein is less efficiently utilised by a child than by an adult so that relative to energy a child will undoubtedly need more dietary protein than adult. However, so long as a diet has the equivalent of 5 per cent good quality protein as most diets have, as we shall see later, we may expect a child's need to be usually met, infants excepted. Even human milk contains 5/6 per cent of calories as protein and yet is an ideal infant food.

Egg protein has a well-balanced amino acid composition and can be efficiently utilised by the body. This is not true of other foods. However, it is not very helpful to speak of the utilization of protein in individual foods since foods are usually eaten in mixtures and secondly, the utilization of protein varies according to amino acid composition of the mixtures and of other nutrients in diet. Thus, vegetable foods like wheat and pulse can be combined to give net ptotein utilisation much higher than when wheat or pulse is eaten alone. The net protein utilization (NPU) of an average Indian diet is estimated to be about 70 per cent relative to egg provided calorie needs are met. Actually, as we already stated in adults the NPU of the average diet relative to egg is higher than in children, but for simplicity in presentation we ignore this here. The egg protein itself is estimated to have net protein utilization of 90 per cent so that the average Indian diet can be assumed to have NPU of 60 per cent. This means that the cereal pulse based diet such as we eat in India will have to provide 36 g of the dietary protein to meet the requirements of an average adult and about 18 g to meet the requirements of an average child of age 1-3.

3. Overall gap (or excess)

We can now compare these figures for average requirements with what people eat. Such comparison is given in Table II. Side by side with figures for protein, we have also given figures for calories. This we have done because an overriding condition in the comparison of protein intake with requirements is that calorie needs of an individual must be met. Table II shows that the protein supply

TABLE II

Energy and protein supply compared with respective requirements
(Macro-comparison on per caput basis)

Year	*Energy in calories*			*Protein in gms*				
	Supply	*Requirement*	*% gap*	*Supply*	*Requirement*	*Recommended*	*% Supply Requirement*	*% Supply Recommended*
1963-65	2000	2200	10					
1965-67	1900	2200	15					
1970-71	2100	2200	5					
1971-	2000	2200	10	50	30	36	166	140

averages about 50 g per person per day as against an average requirement of only some 30 g based on the most recent recommendations of the *FAO/WHO*. Far from any gap the protein supply is seen to exceed the average requirement by over 60 per cent. We must conclude that unless protein intake is very very unevenly distributed it must be rare to find that protein deficiency will occur as a result of low protein intake. But protein deficiency does occur. This is confirmed by the data from surveys organised by WHO, ICMR and other bodies. As an example a study of some 5000 children under five years of age conducted with the assistance of WHO showed that some 2000 children suffered from states of protein malnutrition ranging from serious retardation in growth and extreme emaciation to other associated signs of protein deficiency like nutritional oedoma and reduced serum albumin. Data from nutrition surveys collected by State nutrition units under the guidance of ICMR during the last twenty years give much the same findings. The majority of the subjects covered in these surveys were children of school going age. Kwashiorkar was observed in 2 to 3 per cent of the cases. Other frank signs associated with states of protein malnutrition were observed in 15 per cent of the children examined, while retardation of growth was more or less universal. The incidence of protein deficiency was relatively low among children of upper income groups.

If protein deficiency does then occur, and is widespread as it appears to be, it must be due to either abnormal losses such as occur during infections or low calorie intake. Unless a diet provides the energy cost of synthesizing and retaining protein, a person must lose protein. As we shall shortly see data of dietary surveys show that almost all protein deficient children suffer from calorie deficiency.

4. Micro analysis

How far do the individual diets conform to their requirements for energy, and protein for health? And what is the proportion of diets which can be considered to constitute the incidence of calorie deficiency in the population? Likewise what is the proportion of diets in which protein intake is less than the corresponding requirement? Clearly the incidence of calorie deficiency in the population is given by

$$\int_{x/y<1} f(x/y)d(x/y)$$

where x stands for the calorie intake and y the corresponding requirement and $f(x/y)$ stands for the frequency function in the population. Likewise, the proportion of diets with protein intake u less than the corresponding requirement v is given by

$$\int_{u/v<1} f(u/v)d(u/v)$$

This lecture is not the place to elaborate on the methodological aspects of evaluating these expressions. It should suffice to state that ordinarily in a healthy active population with each person meeting his exact requirements of calories and protein most people can be expected to have their calorie and protein intake per nutrition unit higher than the critical limits given by the average requirement of the nutrition unit minus twice the standard deviation of the individual requirement. For calories the critical limits can be shown to be 1900 at the psychological level and for protein 18 g. It follows that in any observed distribution the proportion of individuals with intake per nutrition unit below 1900 calories can be taken to provide an estimate of the incidence of undernutrition. Likewise the proportion of individual with intake per nutrition unit below 18 g may be taken to provide an estimate of the incidence of protein deficiency on the assumption that the utilization of protein is independent of calorie intake.

We have applied the method to the food consumption data collected by the National Sample Survey (NSS) during 1971. The results for rural and urban Maharashtra only are reproduced here (Table III) and relate to random representatives samples of 429

TABLE III

Distribution of Households by Protein Intake per Nutrition Unit in Maharashtra
(in terms of Reference Protein grams per day)

	1971 Urban %	1971 Rural %
0—5	0—	—
5—10	0 4	—
10—15	0·4	0·5
15—20	2·7	3·5
20—25	10·7	5·1
25—30	21·4	15·4
30—35	19·5	14·9
35—40	13·0	15 2
40—45	14·9	10·5
45—50	5·8	9·3
50—55	5·0	7·0
55—60	3·5	5·4
60—65	2·3	3·7
65—70	0·4	2·8
70—75		2·3
75—80		0·7
80—85		1·2
85—90		0·5
90—95		—
95—100		0·2
100 & over		0·9
	100·0	100·0
N	261	429
$\bar{u}$	35·6	41 5
S.D.	10·6	15·8
% C.V.	30	38
% Incidence	3	4

households for rural Maharashtra and 261 for urban Maharashtra. The Table is based on the food consumption data recorded by the interviewer. The recorded values of consumption of foodstuffs were converted into protein using the nutritive value of Indian foodstufls tabulated by the National Institute of Nutrition. The number of nutrition units were separately calculated for each household on the basis of age and sex of the members of the family and using FAO's scale of requirements as shown in Table 1. In converting dietary protein into 'reference' protein, animal protein was considered to have a NPU of 80 and vegetable protein a NPU of 50. No account was taken of any possible amino acid supplementation nor of the fact that NPU of dietary protein in adults relative to that in egg is much higher than in children. If anything therefore estimates of protein intake are on a conservative side. It needs to be added that Table III refers to intake of fully utilisable reference protein at the retail level, while the requirements shown in Table I refer to egg protein at the physiological level. A NPU of 0·9 was accordingly used in converting the egg protein into reference protein and an allowance of 5 to 7 per cent was added to account for the difference between the limits at the retail and physiological levels. Since the distribution in Table III relate to households and not individuals appropriate allowance was also made in calculating the critical limits. The critical limit at the retail level for reference protein appropriate for application to household distribution came to 20 g, that for calories was 2200.

It will be seen that less than 5 per cent of the total number of households in rural as well as urban Maharashtra had a protein intake lower than the critical limit ; in other words less than 5 per cent can be said to have inadequate amount of protein in the diet. This proportion may be even lower since the intake in all probability has been underestimated. If we were to use an NPU of 60 in place of 50 for vegetable protein we shall find that the percentage of households that had inadequate amount of protein come to less than 2 per cent. This is about the proportion one expects in a healthy active population with each person meeting his requirements for protein. We must conclude that it is unlikely that protein deficiency occurs as a result of low protein intake.

In the preceding discussion we have assumed that diets are not limiting in calories. In actual fact, as we saw in Table II the average calorie intake is smaller than the average calorie requirement by about ten per cent so that a part of the population must go under-nourished. This is best brought out in Table IV. Rich and privileged people everywhere eat all they need and more, but the poor only what they can afford which may not always meet their needs. It is not until the income (expenditure) has reached Rs. 34 that a person is seen to meet his average calorie needs. By contrast protein needs appear to be met even in the group with income of only Rs. 13-18. Clearly when food intake is sufficient in amount to meet the energy needs the protein intake is satisfactory.

That this is so is even better seen from Table V which shows the results of bivariate analysis for Maharashtra (rural and urban)

TABLE IV

Daily per caput calories and protein supply by expenditure level, Maharashtra State, India, 1971

Expenditure in Rs./month	*11-13*	*13-18*	*18-24*	*24-34*	*34-44*	*44-54*	*>54*	*Average*
Total calories	900	1500	1530	1850	2330	2480	3180	2160
Total proteins (*g*)	27·6	43·9	45 0	55·7	69·7	74·7	94·8	64·7
Animal proteins (*g*)	1·6	3·9	4·1	5·3	7·5	8·9	12·4	7·1
No. of households	5	21	67	126	78	56	72	429

according as the diet is adequate or inadequate in calories, protein or both. The dividing lines in the Table are based at the critical limits for calories and protein. It will be seen that most of the diets which are inadequate in protein (*PD*) are also inadequate in calories ; that is they are calorie deficient (*CD*). When food intake is sufficient to meet the energy needs the protein needs are usually met. This is also evident from the values of protein calorie concentration shown in brackets in Table V. The values are seen to exceed 5 in all except one cell namely (*PD, NCD*). In less than one per cent of the cases protein deficiency is seen to occur as a result of low protein calorie concentration in the diet. We conclude that protein deficiency for the most part is the indirect result of inadequate energy in the diet.

TABLE V

Classification of households in Maharashtra according to whether the diets are deficient (D) or not (N) in calories and protein

	Urban			*Rural*		
	PD	*NPD*	*Sub-total*	*PD*	*NPD*	*Sub-total*
CD	3·4	31·8	35·2	3·5 (5·3)	29·8 (6·4)	33·3
NCD	—	64.8	64·8	0·5 (2 3)	66·2 (5·9)	66·7
Sub-total	3·4	96·6	100	4·0	96·0	100

Figures in brackets denote protein calories concentration value (NDpCal%)

But even when concentration on energy basis of protein in the diet expressed as egg equivalent is higher than 5 and the intake is above the needs of man, protein malnutrition can still occur if the food intake is not adequate to meet energy cost of synthesizing protein in the diet. This is well brought out in Table VI based on

TABLE VI

Estimated protein loss (g/day) by an adult taking a diet restricted in protein or calories, or both

Protein (g/day)	*Calories per day*				
	900	*1600*	*2200*	*2800*	*3200*
0	45	42	40	40	40
20	30	23	21	20	20
40	30	12	−0	0	0
60	30	12	−0	0	+0

the extensive results of short term experiments on nitrogen balance in adults. It will be seen that as long as the calorie intake is limiting, but protein intake is not there is a loss of body protein. As the calorie intake is increased the loss becomes progressively smaller. It is not until the calorie intake exceeds the calorie needs for maintenance of body content of heat that protein is fully utilized. Clearly protein in the diet is partially diverted to meeting the calorie needs when the latter are not satisfied thus exposing the person to the hazard of protein malnutrition. In any assessment of the incidence of protein deficiency in the population one cannot therefore be guided by the inadequacy of protein intake alone but must also take into account adequacy of calories. People who take adequate or more than adequate protein, but who are not able to utilise them for lack of adequate energy in the diet obviously form a part of the protein deficient population.

These are the people with dietary pattern represented by the cell (*CD*, *NPD*). If we represent for brevity the different cells of the 2×2 classification as below

	Protein	
Calories	*A*	*B*
	E	*F*

then clearly B must be added to $A+E$ to give $I=\overline{A+E}+B$ for the total incidence of protein deficiency. Incidentally it is interesting to observe that excess protein over and above body needs does not leave any benefit on protein balance.

Turning to Table V we see that some 30 per cent of the households although having adequate protein in the diet are not able to utilise it fully for lack of energy. Protein in their diet is clearly diverted to meet energy needs, thereby exposing the individuals to the hazard of protein malnutrition. Adding this proportion to protein deficient diets we get for the total incidence a value made up as follows :

$$I_{rural} = A+E+B$$
$$= 3{\cdot}5+0{\cdot}5+29{\cdot}8$$
$$= 33{\cdot}8$$

and

$$I_{urban} = 3{\cdot}4+31{\cdot}8$$
$$= 35{\cdot}2$$

We conclude that a third of the households are protein deficient of which almost all (over 97 per cent) are protein deficient by virtue of their being short of calorie supply. The role of low calorie intake in the causation of protein deficiency is thus much more pronounced than can be assessed when protein intake is compared with the corresponding requirements. In fact the entire protein deficiency in the urban areas appears to be the indirect result of low calorie intake. We have examined data from several other states. They all conform that what our diets lack is not protein but energy to avoid the body katabolise the protein people actually do eat.

As long as the energy intake is below the level for maintenance the body will tend to use even its own tissues to meet calorie needs. Supplementing such diets with protein to prevent protein malnutrition would therefore appear wasteful. To do so would amount to a costly and inefficient method of improving diets to meet the total energy and protein needs. It follows that the policies and plans to combat protein malnutrition, which take as a first reference point for attack the existing inequalities in protein consumption, must clearly give way to policies and plans to combat inequalities in the quantity of diet. Since the quantity of the diet is primarily determined by the level of income these policies and programmes must aim at eliminating inequalities in the income itself. At least it should enable the poor to have a minimum income which is sufficient for them to afford a cereal/pulse based diet adequate to meet their energy needs.

5. Protein Malnutrition in Children

Two arguments against these data have been presented. First, they relate to households and not to individuals. Secondly, although a household may have enough protein when it has enough food this does not necessarily mean that the pre-school child would get enough protein. Despite the fact that the pre-school child represents a group of prime interest data on the food intake of young children are scanty. However, Gopalan and his co-workers at the National

Institute of Nutrition have studied several thousand children of pre-school age in the rural areas in the South India. Table VII gives data

TABLE VII

Incidence of protein-calorie decficieny in pre-school children in South India

Age (1-5 years)	*PD*	*NPD*	
CD	18	63	81
NCD	1	18	19
	19	81	100

CD, calorie-deficient ; NCD, not calorie-deficient ;
PD, protein-deficient ; NPD, not protein-deficient.

typical of those reported by him. It will be seen that nearly 80 per cent of children had diets deficient in calories ; by comparison the percentage of children with diets deficient in protein is only about 20. What is of interest is that there is only 1 per cent children with diets adequate in calories but deficient in protein. The results reported in Table V are thus in complete accord with those of Gopalan although the influence of low calorie intake in causing protein deficiency appears to be even more predominant in his survey than in the data reported by us. The high incidence of calorie deficiency was probably due to the preponderance of the poor children in the community which he surveyed. This is no way detracts from the value of information the survey provides for assessing the relative importance of low calorie and low protien intake in causing protein malnutrition and hence in developing measures to combat it. Our conclusions are thus quite the opposite of those of Scrimshaw and his co-workers in U.S.A. who have thought that protein is the primary limiting factor responsible for protein malnutrition and whose findings primarily form the basis of the United Nations thinking.

The proof of the pudding lies in eating it. It is therefore of interest to determine whether a food supplement in amounts needed to overcome calorie deficient can help avert protein deficiency. Field studies reported by the National Institute of Nutrition indeed show that children receiving such supplements had higher gains in height and weight compared to children who had not received the supplement. The food supplement had the following composition :

Wheat flour	23 g.
Sugar	35 g.
Fat	10 g.

providing approximately 310 calories and 3 grams of protein. The gains in all age groups were statistically significant and confirm that calories were the primary deficiencies in the dietaries of pre-school children of the poor socio-economic class.

6. Nutrition and Infection

It does not follow that supplements alone were effective in raising the height and weight of children. The relatively larger attention which the children in the experimental group received in the course of the year could have brought with it unconscious attention to hygiene and health, thereby influencing the results. It needs to be added that while protein deficiency is undoubtedly associated with inadequate diet, it is also associated with other factors, particularly infections. In consequence, intervention at any single level whether of food or control of infection is unlikely to be effective. This is well brought out in the studies in 3 villages in Gautamala by Scrimshaw and his associates summarised in Table VIII. In one

Table VIII

Nutrition and Infection Field Study (1959-64)

	Control village	*Sanitation village*	*Feeding village*
Respiratory diseases, cases 100/years	56	127	73
Acute diarrheal diseases, cases 100/years	129	241	124
Nutritional State			
% Normal	14·8	14·4	17·3
% first degree	37·6	34·9	54·5
% second degree	42·4	46·7	27·3
% third degree	5·0	4·1	0·9
Death rate/100 Age 1-4	5·2	3·4	2·4

Source : Taken from Scrimshaw et al. Arch. Environ. Health 19(1969).

village minimal improvements in environmental sanitation and provision of medical care were made ; in another village a complete food supplement was made available 6 days a week to children under the age of 5 years and to pregnant and nursing women. The control village received no intervention. Data were collected over a 5-year period. The findings given in Table VIII show that food supplement was apparently accompanied by increase in height and weight and did reduce the amount of several malnutrition, but not as much as might have been expected. In particular the amount of first degree of malnutrition was not greatly affected. Sanitation alone was not effective either. However, as in NIN studies the results raise the possibility that nutrition programme in the experimental village brought with it increased though unconscious attention to matter of health and hygiene thereby making the programme more effective than it would be if increased food supply alone had been available.

7. Protein Value of Diets

That inadequate energy rather than the low content of utilizable protein is the principal factor accounting for the major part of protein malnutrition can also be inferred from the protein value of diets. These values are calculated from the index known as NDpCal% which measures the utilizable protein in the diet expressed as a percent of calories. The assumptions implicit in predicting NPU and NDpCal% are still the subject of controversy but there is agreement that they do not seriously detract from the value of the concept or from its use in predicting the protein value of diets with a degree of accuracy adequate for practical purposes. Table IX shows that the

TABLE IX

NDpCal% of different foods and food mixtures
(Mixtures providing 2200 calories)

	Rice	*Wheat*	*Maize*
Staple alone	4·9	5·7	4·8
Staple+30 g legume	6·2	7·0	6·3
Staple+60 g legume	6·7	8·3	6·5
Staple+30 g skim milk powder	7·1	8·0	7 0
Staple+45 g legume +15 g skin milk powder	6·8	8·8	6·9

NDpCal% of cereal-pulse based diets, such as eaten in rural India, has a value larger than 5. As we saw already, this is adequate to satisfy protein needs, provided the diet is taken in a quantity adequate to meet the calorie needs. Very young infants need a higher proportion of protein and a higher NDpCal%. This is usually provided in the form of breast milk ; if the mother's diet is adequate this will be sufficient for the first 3-6 months of life. After this, however, solid supplements of calories and proteins are essential. If these are starchy foods providing calories, but little protein then there is a risk that the NDpCal% of the mixed diet may fall below that needed for adequate growth, and the child may become prone to develop protien deficiency.

Incidence of primary protein deficiency can thus be expected in areas where the staple food is either a starchy root, like tapioca, cassava or plantain. Where, however, as in most parts of India, the staple food is a cereal, rice, wheat, jowar (sorghum), bajra (millet) etc. subjected to normal processing and accompanied by minimal amounts of pulses and vegetables, the protein value of the diet of the population will be greater than an *NDpCal*% 5. The requirements for both protein and calories will be met at this level provided total supplies are adequate. When the amount of legumes in the diet are negligible and the diet is mostly rice or maize, the *NDpCal*% may fall slightly below 5. Such a diet can still meet the requirements provided sufficient cereal is consumed to meet the average calorie requirements. The danger does not lie in its 'low protein value. for a child fed in this way can be healthy and active. However, any depression of food intake occasioned by infection, by marginal deficiency of mineral or vitamins or by economic factors would result in a calorie intake less than the minimum requirement and would thus expose the child to the risk of protein deficiency. This need not however be interpreted to mean that a child's needs for protein should be met from protein-rich foods to prevent protein malnutrition. It means that children are more demanding than adults in their requirements and it is easier to meet these requirements with good foods like eggs and milk if one can afford them. These are questions largely of nutrition education, and need special attention in the nutrition programme.

8. Relevance and role of protein-rich food

Considerable attention that is being focused on the protein problem arises from the possible link between low protein consumption and kwashiorkor. The importance of ensuring a smooth transition from breast feeding to an adequate solid diet is therefore evident. Weaning foods will undoubtedly help. It is not clear, however, why such weaning foods need to be protein-rich and why so great an emphasis is placed on the production of protein-rich infant foods in the country. No more than 5-6 per cent of the calories in breast milk are derived from protein and yet it is known to be an ideal infant food. If breast milk fails to meet the nutritional requirements of the infant after the first 6-8 months it is not because its protein content is low but because it is just not available in adequate amounts to satisfy the appetite of a growing infant. On present evidence, therefore, and in the existing state of knowledge, the utilizable protein in the cereal-pulse diet should be more than adequate to meet infants' needs. Care will need to be exercised however to ensure that it is given in an appropriate form which enables the infant to consume sufficient quantities to meet his energy needs.

It is probable that even if a cereal-pulse based diet has enough and more utilizable protein to meet a child's needs, the bulk involved in meeting the energy needs may be too much for the child to take. Thus, whereas a one year old child requiring 1,000 calories can meet its needs with about 1.5 litres of milk containing roughly 180 grams of solids in milk, the volume of cooked grains of rice or idli can be as high as 0.75 kg, the equivalent of 0.25 kg, of dried cereals and pulses. Many studies in India and abroad have been made to see if a child can be successfully weaned and meet his daily energy needs on cooked meals of different dilutions. Thus, the studies at the National Institute of Nutrition and those by Foman and Nicol indicate that a child has little difficulty in consuming the needed quantity of a traditional diet of grain if it is given in an appropriate form and provided the diet is evenly spaced during the day. The latter is not much of a restriction since a toddler rarely eats all at one sitting, moving away the moment he gets satisfaction of his appetite. When, however, a diet is monotonous and the protein content is only marginally adequate as when starchy roots are used along with grain, a child may turn away without taking enough to meet its needs. Actually, the criticism of bulk would apply equally to cereals fortified with amino acids. Thus, while fortification with lysine may improve the utilizable protein in bread it will hardly increase its energy content so that the bulk needed to meet the energy needs, even with fortified grains would be the same. Clearly, what a child of 1 to 3 needs most is a supplement of a concentrated source of calories which can also bring vitamins and minerals along with it, such as milk or eggs. If protein rich weaning foods are advocated it would not be because of their high quality protein alone. In addition they would contain a concentrated source of calories, such as oil or sugar which would reduce the volume of the meal and could also provide vitamins and minerals. Protein foods which do not bring adequate calories to synthesize protein in the diet clearly cannot be expected to make any significant contribution to the solution of the problem of protein malnutrition.

Why then, one may ask, India in common with other developing countries is being urged to produce protein-rich foods and to distribute those through special feeding programmes when there is so little justification to back these efforts ? The answer must be traced to the recent breakthrough in food technology. The last decade witnessed phenomenal developments in creating new protein foods at a cost which is claimed to be marginally higher than the cost of the primary product and much lower than that of animal protein products. There is therefore a genuine feeling that it must be possible to use these advances in technology for the benefit of the poor without their having to wait for the time when animal products will be available at a cost within their reach. While appreciating this, the fact remains that inadequate quantities of food and not proteins per *se* is the primary problem in the dietary of the poor. To add protein or upgrade its quality would merely provide a costly source of calories to make up the calorie deficit.

In criticizing the current policy of promoting lysinefortified bread and similar products it is not for a moment suggested that the products are not tasty or good products, but they have nothing in them by way of protein value that cannot be obtained from other locally available protein sources. It is also invideous to compare the cost per unit of protein in the new products with that in animal products in an effort to show how amino acid fortified bread is more eeonomic. Actually, the animal products, and milk in particular, have a lot more to offer by way of nutrition than lysine-fortified bread. Yet India, is being successfully persuaded to expand the production of semi-conventional protein in the name of commitment to combat malnutrition. In fact, this effort amounts to little more than adding to the dietary variety and caters more to the needs of those who already have enough or more than enough to eat, thereby leaving the protein problem largely unsolved. As Hegsted observes: "It is a case where enthusiasts and entrepreneurs have combined to make it a *fait accompli* even before we have data to evaluate the relative costs of other procedures or effectiveness."

9. Concluding Remarks

Why one may ask have earlier U.N. studies reached different conclusions? The main reason is that by examining the diets simultaneously for the two variates the inter-relationship between protein and calories had now been taken into account. The other reason briefly, can be traced to the difference in interpretation placed on the meaning of requirement in the study of intake distributions. I conclude by quoting from a recent article by the late Sir Norman Wright:

"I well remember the occasion, when that distinguished statistician Sir Arthur Bowley, noting that the mean level of calories consumed by the British population in the Spartan period of the early post-war years coincided almost exactly with the accepted calorie requirements concluded (to the consternation of officials in the Ministry concerned) that some 50 per cent of the population must be undernourished. His argument was that if intake x, and requirement y are each normally distributed with the same mean, then the difference can be considered to be normally distributed around zero with a given standard deviation. It followed that the probability of y exceeding x or that a person is undernourished is 1/2."

In reproducing the quotation above, it is not my intention to criticize the late Sir Arthur Bowley for a pronouncement which he may have made, but which to the best of my knowledge he never published. There is nothing surprising either if the officials of the Ministry concerned were taken aback by his assessment. The suggestion that half the people of U.K. were either losing body weight, or were forced to reduce their physical activity for want of adequate food, or both, would always have serious policy implications which no Government would accept without having factual data to support it. This was fifty years ago. The fact of the matter is that the concept of requirement had not been fully developed at that time, and certainly not to the stage which could permit assessment of the type we are asked to make to-day for the developing countries. The point of quoting Bowley's assessment is to suggest that apparently we are confronted to-day with much the same argument that he then put forward, though in a new form and under more sophisticated mathematical formulation. Further comment is hardly necessary.