Proteins: the Vital Nutrient

Proteins are large molecules made of amino acids joined by peptide bonds formed by carboxyl and amino groups of adjacent amino acids. Proteins in nature are mostly made up of 20 different amino acids arranged in a sequence typical of that protein. Like other large molecules, polysaccharides and nucleic acids, proteins are essential parts of all living beings and take part in all processes in their cells.

Proteins are necessary as enzymes that catalyse biochemical reactions vital to metabolism. They are also important as structural or mechanical components. They also have important roles in immune responses, cell signalling etc. Of the amino acids in proteins, some namely essential amino acids cannot be synthesised by body and hence must be obtained through food. Hence it is important that diets should have adequate amount of protein but also the quality of the protein in diet should be high.

When inadequate or poor quality proteins are consumed protein malnutrition is experienced with consequent loss of muscle mass, decreased immunity, weakening of heart and respiratory system and finally death. When infants and children experience protein malnutrition, serious added problems occur including mental retardation and growth failure. So it is essential to have adequate amount of good quality protein in the diet.

Indian scenario vs. world scenario

Around the world, millions of people do not get enough protein. Protein deficiency is a serious cause of ill health and death in developing countries. Protein-energy malnutrition affects 500 million people and kills 10 million annually. Although protein deficiency is rare in developed countries, it can affect people there who are dieting to lose weight or in older adults who may have a poor diet.

Indian diets especially in south and in rural areas are poor with respect to proteins as per the report by National Sample Survey Organisation's report on Nutritional Intake in India published in May 2007. Although national average for daily protein intake is about 57g (both urban & rural), it is far lower in states like Tamil Nadu, Andhra Pradesh, Karnataka and Orissa while the intake is much better northern states like Haryana, Uttar Pradesh, Punjab and Rajastan. The disparity is more in rural situation. The major source of protein for these southern states was pulses whereas Haryana, Punjab and Rajastan were leaders in consumption of milk and milk products.

A disturbing trend was reported that protein intake declined since 1970s when the national average for protein intake was around 62g for rural although there is a slight increase from 56g for urban. This is further aggravated by fat intake that has increased from 24g to 35.5g for rural and from 36g to 47.5g for urban population upstaging the slight increase in protein intake.

This trend is possibly because of lower pulse production affecting the pulse intake in rural areas especially in southern states. Milk production has tremendously increased over last few decades increasing the consumption in the northern states that normally consumed good amounts of milk and its products. This trend must trickle down to southern states where milk consumption is low.

Another good source of protein is soya beans. Its production has increased in India recently and in 2006 India produced 8.3 million metric tonnes of soya beans ranking fifth in the world. However, after removing the oil, the cake is mostly used for animal feed or export so there is hardly any impact on intake by common people. A small portion is used in human foods, but this avenue is increasing as many companies are making products out of soya beans, including the soya nuggets, soya flour, soya milk, soya paneer, health foods etc.

Why are proteins needed?

Growth and maintenance	Building tissue to grow, or replace worn out or damaged tissue.
Enzymes	All enzymes are protein molecules.
Hormones	Some hormones are protein-based
Antibodies	Immunoproteins, synthesized in response to invasions.
Fluid and Electrolyte balance	Proteins regulate the amount of fluids in cells, also control electrolyte balance, and keep osmotic pressure low in cells.
Acid-base balance	Proteins keep body fluid pH at desirable values
Energy	Excess amino acids can be metabolized for energy
Transportation	Proteins act as transporters, or parts of transporters
Blood clotting	Fibrin molecules interlace to provide framework for clotting

Proteins have many functions. Some proteins are utilised in building tissues for growth. They may also be used in replacing worn out or damaged tissue. As was mentioned earlier many parts of the body including muscles, skin, hair etc. are proteins and many cellular structures contain proteins. Hence, when new cells and tissues are formed as in growth of children or in repair process in healing, large amount of proteins are needed.

Enzymes are partly or wholly proteins and there are thousands of enzymes present in cells catalysing various biochemical reactions including metabolic reactions necessary for digesting various foods and derive energy and useful materials from them as well as nuclear processes such as DNA replication, RNA synthesis etc. Enzymes accelerate these reactions enormously (as high as 10^{17}-fold in some cases) compared to those without enzymes so many reactions take place at sufficiently rapid rate even at mild conditions prevailing in body environment.

There are many proteins that act as hormones. Insulin is one example that regulates blood glucose levels. Without insulin, blood glucose will shoot up when sugars or most carbohydrates are consumed as in the case of diabetics. Insulin regulates glucose metabolism and does not allow levels in blood to go too high.

Antibodies are proteins and are extremely essential for immunity and health. Whenever we are infected by microbes our immune system produces antibodies in response to this attack that body senses as antigen. These antibodies if in sufficiently large amounts can neutralise pathogens and we are immune to the disease. Sometimes microbial attack may not give enough time for antibodies to form in large number so we fall ill but this attack prepares body's immune system so next attack can be nullified by the system which is now ready. Sometimes immunisation is done by injecting harmless antigen that readies immunity when an attack is imminent.

Proteins also act as transporters for oxygen, fat etc. These substances need to be transported through body fluids like blood which is aqueous and the solubility of these substances is low. So they combine with proteins (haemoglobin, lipoprotein etc.) so they could easily be transported through blood and taken to where they are needed.

Proteins are essential in blood clotting. Whenever there is a wound and blood flows out, the person can die of bleeding if there is no clot formation. This clot is facilitated by fibrin protein that forms interlacing network in which blood cells get caught and a clot is formed that plugs the opening through which bleeding occurs and consequently stops bleeding.

Proteins can also provide calories. When food has more protein than body needs then after using all amino acids to make the necessary proteins needed, the excess is utilised for energy purpose. Proteins have same calories as carbohydrates namely 4 kcal per gram. Proteins also helps maintain the desired environment needed such as the pH, fluid and electrolyte balance needed. Besides proteins have many other functions that make proteins as one of the most essential nutrients coming from foods.

Where are they found?

Proteins are present in all natural substances of plant, animal or microbial origin. Proteins can be synthesised by lower organisms from simple substances but animals like humans need either proteins or amino acids in food from which proteins may be synthesised in the body.

Humans obtain proteins mostly from protein rich foods including meats, eggs, grains, legumes, milk and milk products like cheese etc. Following table gives the protein contents of some of the common foods.

Dietary Sources of Protein

Food	Serving	Weight in grams	Protein grams
Chicken, roasted	6 ounces	170	42.5
Fish	6 ounces	170	41.2
Cottage cheese	1 cup	225	28.1
Cheese pizza	2 slices	128	15.4
Yogurt, low fat	8 ounces	227	11.9
Tofu	1/2 cup	126	10.1
Lentils, cooked	1/2 cup	99	9
Skim milk	1 cup	245	8.4
Split peas, cooked	1/2 cup	98	8.1
Whole milk	1 cup	244	8
Kidney beans, cooked	1/2 cup	87	7.6
Cheddar cheese	1 ounce	28	7.1
Macaroni, cooked	1 cup	140	6.8
Soymilk	1 cup	245	6.7
Egg	1 large	50	6.3
Whole wheat bread	2 slices	56	5.4
White bread	2 slices	60	4.9
Rice, cooked	1 cup	158	4.3
Baked potato	2x5 inches	156	3
Corn, cooked	1 ear	77	2.6

From: Nutritive Value of Foods, USDA

Food	g Protein/100g	Food	g Protein/100g
Bajra	11.6	Soyabean	43.2
Jowar	10.4	Almonds	20.8
Rice, milled	6.8	Cashewnuts	21.2
Whole wheat flour	12.1	Groundnut	25.3
Refined wheat flour	11	Groundnut cake	40.9
Bengal gram dal	20.8	Mackerel	18.9
Black gram (udad) dal	24	Pomfrets, white	17
Cow pea (chowli)	24.1	Prawn	19.1
Lentil	25.1	Chicken	25.9
Peas green	7.2	Mutton (lean)	21.4
Peas dry	19.7	Milk (buffalo)	4.3
Rajmah (kidney bean)	22.9	Milk (cow)	3.2

Nutritive Value of Indian Foods, Gopalan & others, 1989

Protein contents of different foods will vary with the variety of raw material and also due to the method of preparation. Milk from different species of animals or different wheat varieties will have different protein contents. Also whole wheat bread will have more protein than white bread and skimmed milk will have more protein compared to whole milk.

How are proteins digested?

Proteins in foods when eaten start getting digested in stomach and intestine by enzymes pepsin, trypsin and chymotrypsin that convert proteins to amino acids that are absorbed by the body in the intestine. Here also there is a small difference between digestibility of different proteins. The enzymes that digest proteins are called proteases and above enzymes are naturally present in the gastrointestinal tract. Different enzymes have different affinity for various peptide bonds so when there is a mixture of enzymes the digestion or hydrolysis of proteins is more complete.

Sometimes there is difficulty in digesting proteins especially when infants, children or older people have some stomach ailment. Foods with pre-digested protein are available especially as infant food. Such foods are also useful when children have allergy to some proteins. Allergy is normally due to intact protein molecule and when this is sufficiently hydrolysed or pre-digested commonly its allergenic property is lost and it becomes safer.

There are also some enzyme supplements available that aid digestion not only of proteins but in certain formulations may also help digest carbohydrates and fats as enzymes hydrolysing these components may be incorporated.

Dietary requirements of proteins

Group	Particulars	Body wt.	Net energy	Pro-tein
		kg	Kcal/d	g/d
Man	Sedentary work		2425	
	Moderate work	60	2875	60
	Heavy work		3800	
Woman	Sedentary work		1875	
	Moderate work	50	2225	50
	Heavy work		2925	
	Pregnant woman	50	+300	+15
	Lactation			
	0-6 months	50	+550	+25
	6-12 months		+400	+18
Infants	0-6 months	5.4	108/kg	2.05/kg
	6-12 months	8.6	98/kg	1.65/kg
Children	1-3 years	12.2	1240	22
	4-6 years	19.0	1690	30
	7-9 years	26.9	1950	41
Boys	10-12 years	35.4	2190	54
Girls	10-12 years	31.5	1970	57
Boys	13-15 years	47.8	2450	70
Girls	13-15 years	46.7	2060	65
Boys	16-18 years	57.1	2640	78
Girls	16-18 years	49.9	2060	63

From: ICMR recommended dietary allowances (RDA) for Indians

As can be seen the protein requirements per kg body weight is highest among infants and young children that are actively growing and growth requires both protein and energy along with other nutrients. There is also higher requirements for pregnant and lactating women who have to support the growth of the baby. The requirements become less as the individual grows.

Protein quality

Different proteins contain different proportions of amino acids found in proteins. Some of these are called essential amino acids as these cannot be synthesised in the body from any other amino acid or other substances. Following amino acids are generally considered as essential for humans including infants and growing children and they are valine, threonine, isoleucine, methionine, phenylanine, leucine, lysine, tryptophan and histidine. Sulphur-containing amino acids methionine and homocysteine are interconvertible and cysteine can be made from homocysteine. So for convenience, sulphur-containing amino acids are considered a single pool of amino acids. Similarly, aromatic amino acid pair, phenylalanine and tyrosine are also considered together. Essential amino acids are so called not because these are more important to life than other amino acids, but because body does not synthesise them, so these must be available through diet.

Since different dietary proteins have different compositions of amino acids, especially the essential amino acids and these amino acids are needed by the body for making the desirable proteins for various functions of the body and have to be supplied only through diet; quality of each dietary protein would vary. Some will have more suitable composition than the others. Considering this, the protein quality has been evaluated.

Methods of Assessing Protein Quality

The five methods described below are the ones most often used to assess protein quality.

1. **Protein Digestibility Corrected Amino Acid Score* (PDCAAS):** The Amino Acid Score with an added digestibility component. The PDCAAS is the current accepted measure of protein quality as it closely compares to determinations done with animals. A number of nutrition experts feel this method needs further refinement and additional changes may be seen in the future.

2. **Amino Acid Score (AAS):** A chemical technique considered fast, consistent, and inexpensive. It measures the indispensable amino acids present in a protein and compares the values with a reference protein. The protein is rated based upon the most limiting indispensable amino acid.

- Values greater than 1.0 for both the AAS and the PCDAAS are considered to indicate that the protein contains essential amino acids in excess of the human requirements. Therefore, in 1990 at a FAO/WHO meeting it was decided that proteins having values higher than 1.0 would be rounded down to 1.0. This point is under debate as experts feel that the rounding down of high quality proteins fails to reflect the ability of the protein to complement the nutritional value of a lower quality protein.

3. **Protein Efficiency Ratio (PER):** Measures the ability of a protein to support the growth of a weanling rat. It represents the ratio of weight gain to the amount of protein consumed. This method has two major concerns. First is the concern that is may not be applied to growing infants and children as the amino acid growth requirement for infants is less than those for rats. Second, the PER measures growth but not maintenance so it may be of limited use in determining the protein needs of adults.

4. **Biological Value (BV):** Measures the amount of nitrogen retained in comparison to the amount of nitrogen absorbed. The BV and the NPU methods reflect both availability and digestibility and they give an accurate appraisal of maintenance needs.

5. **Nitrogen Protein Utilization (NPU):** The ratio of the nitrogen used for tissue formation versus the amount of nitrogen digested.
From: http://www.wheyoflife.org/facts/ProteinQualityWeb.pdf

Following chart gives comparison of proteins from different sources using different methods of quality evaluation.

Protein Quality Comparison Chart

Protein Type	Protein Digestibility Corrected Amino Acid Score (PDCAAS) [1]	Amino Acid Score	Protein Efficiency Ratio (PER) [2]	Biological Value (BV)	Protein Digestibility % (PD)
Whey Protein	1.00	1.14	3.2	100	99
Whole Egg	1.00	1.21	3.8	88-100	98
Casein	1.00	1.00	2.5	80	99
Soy Protein Concentrate	1.00	.99	2.2	74	95
Beef Protein	0.92	.94	2.9	80	98
Wheat Gluten	0.25	.47	NA	54	91

Source:
[1] Protein Quality Evaluation, Report of the Joint FAO/WHO Consultation
[2] Reference Manual for U.S. Whey Products, 2nd Edition, U.S. Dairy Export Council

Proteins from Foods

Proteins are important nutrients that are obtained from daily diet. As could be seen different sources have different protein quality. There are many places in the world where people do not get enough proteins and commonly enough food to sustain. Protein deficiency causes various diseases especially among children. Protein deficiency plays a big part in kwashiorkor and severe protein and energy malnutrition causes marasmus. Protein deficiency can lead to mental retardation. Protein deficiency diseases are seen in many African and Asian countries.

Protein deficiency not associated with poverty is seen when people are crash dieting to lose weight or in older people who have poor diet. Convalescing patients also need extra protein during recovery and are prone to protein deficiency. Deficiency may also occur if people do not consume high quality protein. The essential amino acids may not be supplied adequately. One needs to consume more of lower quality protein in order to supply all the essential amino acids in sufficient quantities as does a high quality protein.

Animal proteins tend to be higher quality or complete proteins. Proteins from plant sources usually supply lower amounts of some of the essential amino acids and are called incomplete proteins. Vegetarians do not eat meat, fish, poultry and eggs. They should consume either enough of milk or soya products that would complement the essential amino acids lacking.

It must also be remembered that animal and vegetable proteins have the same effects on health. It is what comes with protein that needs to be examined. A 6-ounce (170g) broiled steak is a very good source of complete protein providing 38g. However, it also provides 44g fat (containing 16g saturated fat). The same weight of fish like salmon gives 34g protein but only 18g fat containing just 4g saturated fat. One cup (200g) of cooked lentils has 18g proteins but less than 1g fat. It also provides excellent source of fibre that is lacking in both meat and fish.

Cereals like wheat and rice are commonly deficient in lysine, while legumes and pulses have tryptophan and/or methionine as limiting amino acid. When the two are combined the quality of protein improves considerably. It is important to get enough of good quality protein in the diet along with other nutrients.

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