Studies of Protein Reserves

The Relation Between Protein Intake and Resistance to Protein Deprivation

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IN A recent publication[1] protein reserves have been defined as "a moiety beyond current needs which may be called upon to meet situations of privation or stress." The concept that ingestion of protein beyond current needs can build up a useful reserve has played an important part in dietetics. It is one of the chief reasons advanced for giving a surfeit beyond minimal adequate requirements—for providing a "margin of safety."

The term "protein reserves" has been used, improperly we believe, to describe the nitrogenous portion of the healthy body which is lost in states of dietary privation when the body is obliged to live on its own tissues. In a sense the normal body can be regarded as a reserve—a "tissue reserve" rather than a protein reserve, however—for its liquidation provides many nutrients besides protein and the nitrogen lost under these circumstances includes a variety of nonprotein components.

There is no question as to the value of protein in the area of protein malnutrition; by definition additional protein is required to maintain health. The value of a protein intake beyond an adequate minimum—the ability of such a surfeit intake to build a protein reserve that would protect against stress—has, however, been seriously questioned. Experiments which we have reported elsewhere[2] failed to demonstrate the existence of such a reserve. Growing rats were fed at two levels of protein: an "adequate" diet containing 27 per cent casein and a "surfeit" diet containing 64 per cent casein. Analysis of the fat-free bodies of these animals showed no differences in nitrogen content, and a number of stresses applied to these animals, including the stress of protein deprivation, failed to reveal any benefit from the additional protein ingested. No evidence of a protein reserve could then be found. Presumably the body had maintained its constancy of nitrogen composition in the face of an elevated protein intake by the well known mechanism of increasing the protein turnover rate.[3–5]

The conclusion drawn from these studies as to the nonexistence of useful stores of protein laid down by a diet above the "minimum adequate" may be criticized on the grounds that the 27 per cent casein diet actually provided more than the minimum adequate intake of protein. This raises the question as to how the adequate minimum should be defined. The 27 per cent casein diet had been selected because such a level has been found to induce maximal weight gain in the growing rat.[6,7] Other criteria of adequacy, however, can be applied. The present experiments were undertaken to ascertain the minimal level of protein intake which would support optimum resistance to the stress of protein deprivation.

EXPERIMENTAL

Pathogen-free rats weighing approximately 100 gm. were obtained from the Charles River Farms, and were divided into six groups of twelve rats each. The rats were caged individually and offered food *ad libitum*. Six different diets were employed to give protein concentrations of 5, 10, 15, 20, 25 and 45 per cent. The protein used was vitamin-free casein ob-

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TABLE I
Composition of Diets

Content	Diet						
	A	B	C	D	E	F	G
Protein	5	10	15	20	25	45	0
Corn oil	8	8	8	8	8	8	8
Sucrose	81	76	71	66	61	41	86
Vitamin mixture*	2	2	2	2	2	2	2
Salt mixture*	4	4	4	4	4	4	4

* Purchased from Nutritional Biochemical Corporation.

tained from Nutritional Biochemical Corporation. The composition of the diets is shown in Table I. The animals were maintained on the six experimental diets for a period of forty-five days and were then shifted to the protein-free diet in which carbohydrate was substituted for the dietary protein. Observations were made on the survival and on the weights of the animals which were recorded twice weekly.

RESULTS

Composite weight curves of the six groups of experimental animals are shown in Figure 1. Survival data and maximal weight attained are plotted against the protein intake in Figure 2. It is clear that maximum weight gain rises progressively with increase in dietary protein up to the 20 to 25 per cent intake. Survival to protein deprivation is notably impaired in the groups fed only 5 and 10 per cent protein, but when 15 per cent or more protein is given the results are comparable. The good resistance to stress in the group fed 15 per cent protein is to be contrasted to their weight which was 15 to 20 per cent less than that of the groups fed larger amounts of protein.

COMMENT

The observations presented support our previous findings[1, 2] that high protein diets fail to provide protein stores that are useful in combating the stress of protein deprivation. Furthermore, they show that the protein intake of the rat may be decreased to as low as 15 per cent of the diet without encountering any evidence of impaired resistance to subsequent protein deprivation. At the 5 and 10 per cent levels, however, impaired resistance to such stress is evident. As judged by this criterion the "minimum adequate" protein intake of the growing rat appears to be 15 per cent, intakes below this being in the range of protein malnutrition. Intakes above this figure may be regarded as surfeit as judged by this same criterion. A greater weight gain

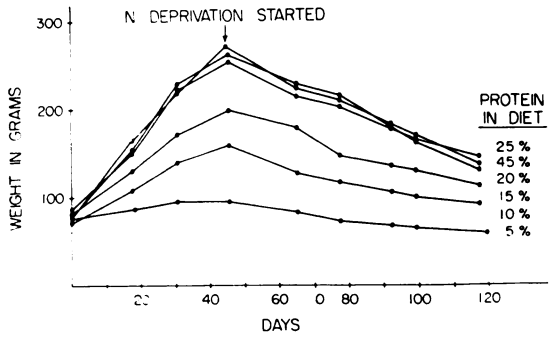

FIG. 1. Effect of nitrogen deprivation on weight curve as influenced by prior protein intake.

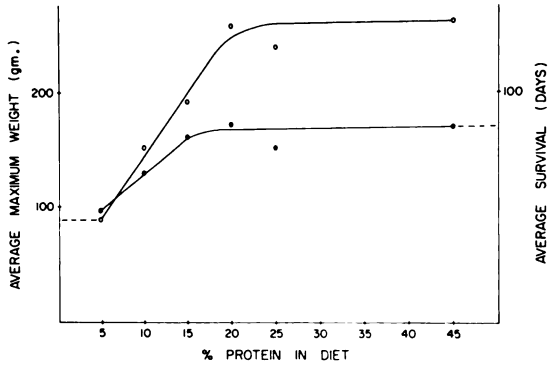

FIG. 2. The influence of protein intake on weight gain (O) and on survival under nitrogen deprivation (●).

TABLE II
Effects of Nitrogen Deprivation on Survival and Weight as Influenced by Prior Protein Intake

Data	Protein Intake					
	5%	10%	15%	20%	25%	45%
Average survival (days)	50	68	83	89	79	87
Average maximum weight (gm.)	94	159	198	263	245	272
Average survival / Average maximum weight	0.53	0.43	0.43	0.34	0.32	0.31

can be obtained in the growing rat by increasing the protein intake beyond 15 per cent, but this greater weight gain carries with it no corresponding benefit from the point of view of resistance to subsequent protein deprivation. The last line of Table II indicates the relation between maximum weight and survival on protein deprivation. There is no significant difference on the higher protein intakes, but with the lower intakes survival in terms of body weight is increased from 0.31 to 0.34 day per gm. to 0.53 day per gm. It is possible that decreased turnover rates at the lower levels of intake were responsible for this difference.

SUMMARY

Protein stores are best defined as increments of body protein induced by intakes above the "minimum adequate" which can be called upon to meet situations of privation and stress.

Observations on growing rats indicate that, according to the definition, useful protein stores cannot be demonstrated by the use of diets containing more than 15 per cent protein. Intakes below this figure must be regarded as the range of protein malnutrition. A surfeit intake above this figure will increase weight gain, but fails to improve resistance to the stress of protein deprivation.

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