Session A Round Table Discussions

Nutritional Evaluation and Acceptance of a Novel Spun Protein Food

B. FAVRE, Rhone-Poulenc Industries, Paris, France

ABSTRACT

Spun vegetable proteins have been widely discussed in recent years, mainly for two reasons. First, they are often associated with the idea of an analog, which in our view is outdated. It is indeed illusory to want to imitate a product such as meat, which is a highly complex material and one for which the consumer has a considerable emotional attachment. Second, the actual technique of spinning is often disparaged on the supposition that its cost is prohibitive, which our experience leads us to dispute, and for the reason that its effects are antinutritional, which we will examine further in detail. "Food should nourish while pleasing the taste," said Tremolieres (1). This definition of food as needing to nourish and to please will serve as a basis for this paper. A new food must, in fact, first and foremost contain no toxic or antinutritional substances. Moreover, a food can only be considered as such in the context, and as a function of its capacity to satisfy a given nutritional need. Last, and above all, it can only be considered as a food if it is judged to be good, and acceptably priced. So we see that it would be unreasonable to separate the concept of nutrition from that of acceptability. The two notions are inextricably linked when it is a matter of creating a new food, which is what we are proposing to do.

PREPARATION OF THE PRODUCT

The important concept to be borne in mind when developing a new protein food is that vegetable proteins are not necessarily inferior to meat proteins, but they may be deficient in certain indispensable amino acids, which then become the limiting factor (2).

Porter showed as early as 1957 (3) that if 70% of proteins were provided in the food by gluten, which is known to be low in lysine, then addition of 30% of lysine-rich proteins was enough to complete the food and restore a good growth rate in rats.

Bressani (4,5) pursued the same line of thought in declining to differentiate, on the nutritional level, between animal proteins and vegetable proteins. He would take into account only the biological value resulting from the different amino acids.

It is the same approach that we have adopted in order to develop a spun vegetable protein food. It was necessary – at the outset – to choose products that were as pure as possible, and complementary both in their nutritional value and in their technological processing.

RAW MATERIALS

Raw materials were soybeans as 95% protein isolate; wheat gluten; whey proteins; egg albumen. These were processed in their final form, using the now well known technique of spinning, under conditions enabling the initial properties of the components to be retained to the maximum possible extent. In particular, only the soybean isolate was subjected to alkaline treatment, and this was done under the mildest possible time and temperature conditions. (Fig. 1).

NUTRITIONAL VALUE

Formation of "Novel" Amino Acids

It is well known that severe alkaline treatments denature, that is, alter the nature of proteins. In particular, a certain number of breakdowns occur in the interlinking disulphide bridges. This is a sought for effect in spinning, which results in the rearrangement of macromolecules. This is the purpose of collodion "maturation."

Moreover, certain amino acids can equally react together to form new molecules (6-8). It has been shown, for example, that in severe alkaline conditions N ϵ (DL-2-amino-2-carboxyethyl)-L-lysine, currently known as lysinoalanine (LAL) (9), can be formed. LAL can occur upon beta-elimination of a cystine group leading to dehydroalanine which itself condenses on the free ϵ amino group of the lysine. It has been suspected that LAL could give rise to renal lesions in rats (10). This LAL, the dosage (9) of which must be treated with caution, seems present in many foods (11). Its action, moreover, is a function of the species of animal (12) and of its degree of linking with the protein (13-14). In any event, it is always preferable to choose a process in which the alkaline treatment is sufficient to inactivate the nutritional factors in destroying the minimum of amino acids. In our case, for example, the conditions of treatment are so mild that it has not proved possible to detect the slightest trace of LAL. In conditions such as these, the nutritional value obtained remains satisfactory (15-16).

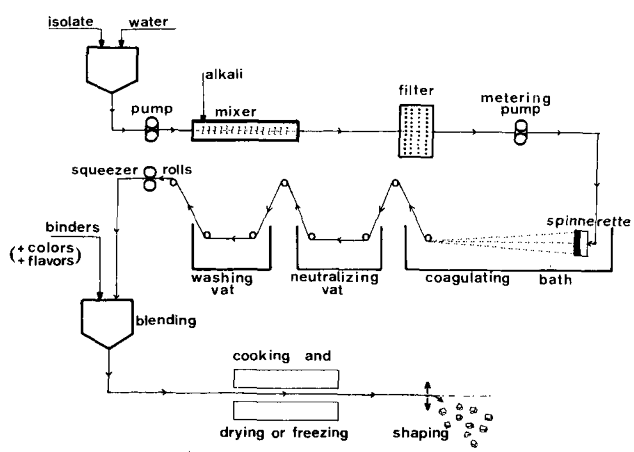

FIG. 1. Soy fiber spinning flow diagram.

TABLE I

Protein Efficiency Ratio

Protein source	PER uncorrected		PER corrected
Casein	2.96	(0.33)[a]	2.50
Soybean isolate	1.80	(0.29)	1.60
Spun soy protein	1.75	(0.28)	1.48
Spun fortified soy protein	1.79	(0.20)	1.59
Spun protein textured food = bound soybean fibers = PVF®	3.06	(0.33)	2.58

[a]( ) = Standard deviations.

TABLE II

Nitrogen Balance: Composition of the Diets

		Exp. 1[b]		Exp. 2[b]	
Total protein[a] intake	g/day	61	(100%)	60	(100%)
Protein[a] intake from test product (PVF®)	g/day	48	(78%)	29	(48%)
Protein[a] intake from meat	g/day	0	(0%)	18	(30%)
Lipids (Highly polyunsaturated fatty acids)	g/day	119		123	
Carbohydrates	g/day	417		417	
Caloric intake	kcal/day	2,983		3,015	

[a]Nx 6.25

[b]Exp. 1 without meat; exp. 2 with meat (lean beef).

TABLE III

Nitrogen Balance[a]

	PVF®		PVF® + beef	
Total N intake	9.76 –	–	9.60	–
Urine	8.12 –	0.83	7.75	0.84
Fecal	1.84 –	0.28	1.67	0.33
Absorbed	7.89 –	0.28	7.93	0.33
Retained	-0.23 –	0.97	+0.18	0.55

[a]Mean value – standard deviation (6 subjects).

Protein Nutritional Value

The spectrum in amino acids is the first element to consider when assessing the nutritional value of a protein (17). In the present instance, the equilibrium of the aminograms is obtained by judicious choice and combination of raw materials and by optimizing the technological conditions of the processing (18).

The aminograms show that soybean, whey, and gluten proteins are complementary: the soybean is, in fact, sufficiently balanced, though deficient in methionine (19-20). Gluten, on the other hand, is low in lysine and rich in sulphurated amino acids. Whey proteins richer than the soybean in lysine will compensate for the reduced amount of lysine associated with the incorporation of the gluten and will increase the proportion of sulphurated amino acids (16-21), in the same way for ovalbumin (22).

The spun vegetable protein (PVF) cubes resulting from these complementations are thus characterized by a good equilibrium of the essential amino acids.

We next determined the protein quality in vivo, according to the most simple method (23), that of the protein efficiency ratio (PER). The procedure followed, although open to argument (24), is that proposed by the AOAC (25). Calculating the PER from the composition in amino acids is not applicable here (26).

This method, recommended by the Protein Advisory Group (27), enables a comparison to be made between the suitability of various proteins and mixtures of proteins in meeting the needs for growth in rats, using casein as reference sample. Despite its defects (absence of correlation between weight gain and nitrogen retention, confusion between the maintenance and growth needs, single arbitrary protein rate), this method is still the most commonly employed.

The digestive utilization of indispensable amino acids can be determined by measurement of the fecal amino acids. Metabolic utilization can be assessed by the free amino acid content in the blood and muscle (28).

Table I shows that, with the combination of different proteins, we arrive through the complementation method at a satisfying food of the same nutritional value as the casein reference sample. It may be noted that, as this test does not provide for supplementation of free amino acid in the diet, it is possible to observe the presence, as well as the availability of the limiting amino acids of the aminogram.

But the test done with human subjects remains the decisive criterion for assessing the quality of the product (29). The nitrogen balance enables the suitability of the product studied to be recognized in maintaining the nitrogen equilibrium of an adult.

The study consist of two series: without meat and with meat. Average composition of the diets is shown in Table II. The level of protein intake is open to discussion (30). It is the result of a compromise between minimum needs and metabolic requirements. Comparison of urinary nitrogen excretion (Table III) shows a slight decrease in total nitrogen and urea nitrogen in the second series. The urea and creatine nitrogen are subject to no variations. Figures for daily excretion of creatinine represent the entire amount of urine collected.

Figures for the nitrogen balance are close to the equilibrium for the two series. The balance, slightly negative in the first series (– 0.55 g/day) becomes positive (+ 18 g/day), but the variaion is not significant, contrary to results obtained with the soy protein alone (19,31-33).

Althoff (34) had already observed that the nitrogen balance remained positive, though at a lower level than when 45 g of dehydrated TVP were introduced in a period of normal diet.

Kies (8,35,36) has compared on two levels the nitrogen intake (4 and 8 g) of beef and a product based upon extruded soybean, with and without methionine supplementation. It appeared for the soy that the methionine is the first limiting amino acid to a level of nitrogen intake of 4 g. At the level of 8 g, nitrogen retentions

TABLE IV

Acceptability Tests of Spun Protein (PVF®)
Attitudes and Behavior Analysis

	I[a]	II[b]	III[c]	
Product	Traditional	New	Analog	
Consumer Age	Adults	Adults	Children- 3 – 12	
Panel Number	645	110	300	
Serving size (g)	70	Ad libitum	100	
Attraction rate	0.82	1.00	–	–
Consumption rate	0.83	1.10	0.62	0.37
Acceptance rate	0.68	1.10	0.87	0.60

[a]I. Traditional French meat patty substituted by 30% of PVF–presented as new at the "Centre de Recherches des Carrieres" of Rhone Poulenc, Lyon – 1978.

[b]II. *Entirely vegetable salad, flavored with fish extracts presented as new at Arc et Senans during the symposium of "Intern. Assoc. of Futuribles," 1977.*

[c]III. The same salad has been given two times to the same children: first as a tuna salad, second as a new product, Saint Martin d'Héres – 1978.

become identical.

Normally, proteins provided by texturized products constitute ca. 40% of total proteins (37-39). Studies dealing with such high rates of incorporation are seldom conducted (22,40), and have not been carried out under comparative conditions of nitrogen supply.

This study has shown that the pieces of spun vegetable proteins developed have, on the one hand, been well accepted and, on the other, are able to meet the protein needs of man. The nitrogen balance corresponding to a meatless diet is near equilibrium, and the addition of 30% meat makes no significant difference to the equilibrium, nor have the subjects shown any of the gastrointestinal disorders which often appear when textured products containing flatulent glucides (41) are ingested. But the main interest in this product is shown in the lipid contribution, particularly in the unsaturated/saturated ratio of the fatty acids. It can be increased, inducing a marked diminution in the proportions of cholesterol (42-44) and of total lipids (45).

ACCEPTABILITY

It seems that the consumer is becoming increasingly receptive to a nutritional message (46). Nevertheless, no one has so far eaten, even less purchased, a product simply because of its amino acids' composition (47). So, whatever may be the nutritional value of a food, its acceptability is an essential factor to analyze. It would be enough, moreover, to consume a sufficient quantity of a food of average nutritional value to satisfy human needs (48). On the other hand, to manufacture a food that was nutritionally perfect would be useless if it were not equally attractive for purposes of consumption. It is in this context that spun vegetable proteins are interesting to consider, for their structure causes no surprise to consumers in the western world, accustomed as they are to absorbing animal meat products and, therefore, of a fibrous texture.

Numerous studies of acceptability have been carried out based on extruded soy proteins mixed with meat (38,49,50). None has been conducted, as far as we are aware, on products containing no meat. From the acceptability studies we have carried out, we have chosen three that will enable us to establish the direction of a development policy for spun vegetable proteins. None of these three studies deals with digestive acceptability, which can easily be investigated in vitro (51). Emphasis has, on the contrary, been upon the psychological and sociological factors governing acceptability.

The first study concerns traditional preparations based upon meat substituted with 30% spun vegetable proteins. The second and third studies deal with new preparations, entirely vegetable, but presented in two different contexts.

Traditional Product with Partial Substitution

In 1972, Robinson (52) showed that 71% of consumers were hostile towards the consumption of "analogs" even before trying them. Other surveys have recently revealed that, in France, 52% would favor the consumption of vegetable proteins (53) and that in the U.S.A. 33% of Americans think that the most important source of proteins for human use in the future is the soybean (Food Protein Council, October 1976). The objective, therefore, was to learn whether the consumer still rejects the idea of vegetable proteins when he is confronted with the product.

The study dealt with a typical French product called "patéde campagne" in which 30% pork was replaced by 30% spun vegetable proteins flavored with the taste of pork. We had already checked beforehand with a sensory evaluation panel that the presence of this spun protein content was undetectable as far as consumers not previously warned were concerned.

Test consumers consisted of the members of our Carrières Research Centre personnel and, on that day, there were 645 places laid in the self-service cafeteria. It was June 30, 1978, and the product was distributed free and in good measure in portions of ca. 70 g as a supplement to the menu. Guests taking part had been informed the previous evening by notices, and on the actual day by leaflets of the composition, method of manufacture, and the advantages of the product to be offered to them. Control of food left over after the meal was carried out statistically when the plates were returned, and without the guests being informed. Results, very encouraging ones, were:

- guests accepting the tasting 82%
- portions not eaten (leftovers > 60 g) 0%
- portions half eaten (leftovers > 35 g) 17%
- portions completely eaten (leftovers = 0) . . . .83% (no leftovers)

These figures enable what we call an index of attractiveness to be defined. It is assessed here at 0.82, and an index of consumption evaluated here at 0.83. The product of these two figures will be called the acceptability index, which here will be 0.68.

We have thus checked effectively that there could be a market for a traditional product containing an inexpensive protein (54) provided, though, that the latter could not be detected on the organoleptic level (55).

Completely New Product

If a market for meat "extenders" exists, and we have established that it does, we still do not think, like Duda (56), that the greatest demand will remain in this sector. It seems to us essential, in fact, to separate the notion of vegetable protein from that of meat products. As an earlier investigation showed (57), it would appear preferable to turn to new products, free from meat, and thus incapable of being compared with meat, at the same time retaining, certainly, the traditional organoleptic properties that do not frustrate consumers.

At an International Association seminar, "Futuribles," we presented, in 1977, to ARC and SENANS, an entirely vegetable dish, formulated in accordance with an original recipe and containing ca. 60% spun proteins, accompanied by vegetable hors d'oeuvres. This dish could be compared, from the organoleptic point of view, with a cold tuna fish salad. The 110 futurologists at the meeting particularly enjoyed this dish (presented as new), for the index of attractiveness was 1, and the index of consumption more than 1 (a second helping was requested).

The index of acceptability for this new food, offered to an intellectual gathering oriented towards the future, was therefore 1.1. We may also note the contradiction between this index and the result of the appreciation questionnaires filled in after the meal.

Meal

– index of attractiveness	1.0
– index of consumption	1.1
– index of acceptability	1.1

Questions

– general impression	0.48
– appearance	0.53
– consistency	0.43
– flavor	0.26

This disparity accords with the difference often noted between the findings of opinion surveys and those of behavioral studies.

Analog

When a study was made in 1978 in a very different context covering three nursery and primary schools (St Martin d'Héres, near Grenoble), the same dish was tested. The 300 children to whom the dish was offered were between 3 and 12 years old. The investigation was carried out in two phases, the first when the dish was offered instead of an entrée, without any information, the second after a session giving information (children and staff personnel).

	Phase 1	Phase 2
– index of acceptability (interviews)	0.87	0.60
– average consumption	62	37

The results show the acceptability to have been very good in the first phase, for the dish looked like a tuna fish salad, which the children were accustomed to eating. After information had been given to the children, they experienced the feeling of having been deceived, and the index of acceptability dropped considerably, as also did the average amount consumed.

These few, very fragmentary, results show the difficulty of carrying out an acceptability test, and bring out especially strongly the all important role of the context in which the investigation is made.

Many highly standardized methods exist (58-61). If we have not made use of them, it is because they do not take into account the psychosociological context bound up with the consumer. This environment is of prime importance with textured vegetable proteins. We should not, therefore, speak of the acceptability of textured vegetable proteins but of the acceptability of a specific dish, offered in a closely defined environment.

It is only when a certain number of dishes are good enough to be attractive by themselves that we will be able to envisage a brilliant future for the protein products of which they are composed. And we believe that spun vegetable proteins will be among them.

REFERENCES

1. Tremolieres, J., and J. Claudian, Cah. Nutr. Diet. 8 11:19 (1973).
2. Juillet, M.T., Valeur Nutritiennelle Comparée des Protéines Animales et Végétales, Proceedings of the 13th World Congress -- Symposium 9, International Society for Fat Research – Sept. 1976.
3. Porter, G.G., Some Supplementary Studies with Wheat Proteins," Master's thesis, Loma Linda Univ., 1957.
4. Bressani, R., and M. Behar, 6th, Int. L. Congress of Nutrition 182, 1964.
5. Bressani, R., F. Viteri, L.G. Elias, S. de Zaghi, J. Alvarado, and A.D. Odell, J. Nutr. 93:349 (1967).
6. Besancon, P., Incidences des Traitements Technologiques sur la Valeur Nutritionnelle des Protéines d'O.éagineux, Proceedings of the 13th World Congress of Intern. Soc. for Fat Research – Symposium 9 – Sept. 1976.
7. Cheftel, C., J.L. Cuq, M. Provansal, and P. Besancon, Rev. Fr. Corps Gras 23:7 (1976).
8. C. Kies, Cereal Sci. Today 19:450 (1974).
9. Sternberg, M., C.Y. Kim, and R.A. Plunkett, J. Food Sci. 40:1168 (1975).
10. Anonymous, Nutr. Rev. 31:250 (1973).
11. Sternberg, M., C.Y. Kim and F.J. Schwende, Science 190:992 (1975).
12. O'Donovan, C.J., Food Cosmet. Toxicol. April 1976.
13. Anonymous, Nutr. Rev. 34:120 (1976).
14. de Groot, A.P., P. Slump, V.J. Feron, and L. Van Beek, J. Nutr. 106:1527 (1976).
15. Coblentz, E., J.L. Morrill, D.B. Parrish, and A.D. Dayton, J. Dairy Sci. 59:481 (1975).
16. De Rham, O., P. Van de Rovaart, E. Bujard, F. Mottu, and J. Hidalgo, Cereal Chem. 54:238 (1977).
17. Pion, R., E. Mendes Pereira, and J. Prugnaud, Deuxième Symposium International Alimentation & Travail Mai:341 (1974).
18. Anonymous, Protein Source Combinations, Food Process. 4:52 (1975).
19. Korslund, M., C. Kies, and H.M. Fox, J. Food Sci. 38:637 (1973).
20. Bookwalter, G.N., K. Warner, R.A. Anderson, G.C. Mustakas and E.L. Griffin, Ibid. 40:226 (1975).
21. Lefaivre, J., J.P. Julien, G.J. Brisson, J. Inst. Can. Sci. Technol. 8:175 (1975).
22. Turk, R.E., P.E. Cornwell, M.D. Brooks, and C.E. Butterworth, Research 63:519 (1973).
23 Hackler, L.R., Cereal Chem. 54:984 (1977).
24. Steinke, F.H., Ibid. 54:949 (1977).
25. AOAC 1970, "Official Methods of Analysis," 11th Ed., Association of Official Agricultural Chemists, Washington, DC.
26. Alsmeyer, R.H., A.E. Cunningham, and M.L. Happich, Food Technol. 7:34 (1974).
27. Protein Advisory Group, Guideline n° 6 for Preclinical Testing of Novel Sources of Protein, 4(3):17 (1974).
28. Pion, R., and E. Mendes Pereira, "Effets des Traitements Technologiques sur l'Utilisation Digestive et Métabolique des Acides Aminés de Quelques Aliments Protéiques, Ann. Nutr. Aliment. (32) (In press, 1978).
29. Bodwell, C.E., Cereal Chem. 54:958 (1977).
30. Young, V.R., W.M. Rand, and N.S. Scrimshaw, Ibid. 54:929 (1977).
31. Poullain, B., R. Bleyer, O. Picard, and G. Debry Cah. Nutr. Diet. 8:21 (1973).
32. Kies, C., and H.M. Fox J. Food Sci. 38:1211 (1973).
33. Kies, C., H.M. Fox and L. Nelson, Ibid. 40:90 (1975).
34. Althoff, J.D., Med. Klin 65:1204 (1970).
35. Kies, C., and H.M. Fox J. Food Sci. 36:841 (1971).
36. Vermury, M.K.D., C. Kies and H.M. Fox Ibid. 41:1086 (1976).
37. Poullain, B., D. Guisard, and G. Debry, Nutr. Metabol. 14:298 (1972).
38. Debry, G., B. Poullain, and R.E. Bleyer, Ann. Nutr. Aliment. 29:159 (1975).
39. Debry, G., R. Bleyer, and B. Poullain, Rev. Fr. Corps. Gras 22:611 (1975).
40. Morse, E.H., S.B. Merrow, D.E. Keyser, and R.P. Clark, Am. J. Clin. Nutr. 25:912 (1972).
41. Bleyer, R., B. Martin, L. Macleod, B. Poullain, and G. Debry, Ann. Hyg. Lang. Fr. – Med. et Nutr. 11:141 (1975).
42. Carroll, K.K., and R.M.G. Hamilton, J. Food Sci. 40:18 (1975).
43. Carroll, K.K., Nutr. Rev. 36:1 (1978).
44. Thompson, N.A., Food Cosmet. Toxicol. 16:73 (1978).

45. Favre, B., B. Poullain, and R. Bleyer, Ann. Nutr. Aliment. (32) 1978 (à paraître).
46. Bloom, G.F., Food Eng. 46(5):100 (1974).
47. Bombal, J., Rev. Med. Vet. 125:269 (1974).
48. Davis, C.B.E., Austr. Food Manuf. 1:22 (1975).
49. Bleyer, R., B. Poullain, and G. Debry, Ann. Hyg. Lang. Fr. – Med. et Nutr. 10:81 (1974).
50. Gounelle, H., and M. Astier-Dumas, Ann. Hyg. Lang. Fr. – Med. Nutr. 6 4:97 (1970).
51. Maga, J.A., K. Lorenz, and O. Onayemi, J. Food Sci. 38(1):173 (1973).
52. Robinson, R.F., Food. Technol. 26(5):59 (1972).
53. Birck, J.F., F. Gautier, B. Poullain, and D. Sartori, Facteurs Psychologiques et Sociologiques de L'Acceptabilité des Aliments non Conventionanels Action Concertée DGRST – Pub. Décembre 1977.
54. Anton, J.J., Chem. Technol. 6:90 (1976).
55. Schutz, H.G., Cereal Sci. Today 19:453 (1974).
56. Duda, Z., Vegetable Protein Meat Extenders and Analogs, FAO, Rome, 1974.
57. Farmer, M., Food Prod. Dev. 8:26 (1974).
58. Depledt, F., Courr. Norm. 217:108 (1971).
59. Kramer, A., J. Sci. Food Agric. 24:1407 (1973).
60. Moskswitz, H.R., J. Food Sci. 36:677 (1971).
61. Noble, A.C., Food Technol. 12:56 (1975).

Effect of Composition and Processing on the Nutritive Value of Some Leguminous Seeds

R. PION, E. MENOLES-PEREIRA, and **J. PRUGNAUD,** I.N.R.A. – *Laboratoire d' Etude du Métabolisme Azoté, THEIX 63110, Beaumont, France*

ABSTRACT

Leguminous seeds are potential protein sources with variable nutritive value because of their amino acid pattern. Their nutritive value may be affected by some nonprotein components: tannins, poorly digestible carbohydrates and antinutritional factors. Some deleterious effects may be avoided by different technological processes developed to eliminate or inactivate the indesirable compounds. Unfortunately, the processes may themselves result in a decrease of the nutritive value of the proteins by making their amino acids unavailable to the animal organism. We studied some of these effects in field beans, soybeans, lupines and peas, using digestibility and growth trials with rats. The samples were used as sole proteins in balanced diets and supplemented with synthetic amino acids to meet the requirements. The significance of differences in apparent digestibilities was estimated from the amino acid composition on the feces using two calculation procedures described previously. These techniques were developed to assess the relative part of the undigestible food and of the intestinal bacteria in the feces. The growth of the animals was compared to a control group eating a fish meal diet. The free amino acids in blood and muscle were estimated in order to emphasize some amino acid unavailability.

INTRODUCTION

We previously reported some experiments with rats related to the nutritive value of some raw and processed seeds, as well as protein concentrates and isolates, and textured proteins (1-3). We summarize in the present paper results obtained with leguminous seeds, with and without processing. We use as the main criteria interpretation of the amino acid composition of the feces and the blood and muscle free amino acid contents (4,5).

MATERIALS AND METHODS

The samples under study were soybean commercial products (isolate, concentrate, textured protein) differing by their nitrogen contents, whole horse beans, peas and lupines either raw or cooked, hulled horse beans with or without heat treatment, extruded high protein horse bean flour.

The animals were male weanling S.P.F. rats of the Sprague-Dawley strain, 21 days old, housed in individual cages. The temperature (22 C) and relative humidity (60%) were controlled. They received during a six day period a commercial standard diet, and were divided into experimental groups of 5 rats in the balance trials and of 10 rats in the growth experiments. In all the experiments, the animals were fed the experimental diets during seven days before the beginning of the experiments.

The samples were used as sole protein source in semiliquid diets supplemented with synthetic amino acids in order to meet the amino acid requirements. The diets were approximately isonitrogenous and made isoenergetic with wheat starch and peanut oil. A standard vitamin and trace mineral mixture (6) was added. The minerals (Na, K, P, Mg, Ca) lacking in the samples were added. In the digestibility experiments, the feces were collected during five days. In the growth experiments, the compositions of the diets were corrected for nitrogen digestibility. The diets made from high protein foodstuffs had a high wheat starch content, and the others contained important amounts of the samples own carbohydrates. Food intake was measured daily during the 10 day experimental period, and body weights were meausred three times each week. At the end of the experiments, the animals were killed between 9 and 10 a.m.

TABLE I

Digestion of Some Soybean Samples

Sample	Textured	Concentrate	Isolate
Sample crude protein % dry matter	55.7	69.7	91.7
Dietary crude protein % dry matter	14.25	14.0	12.85
Apparent digestibility			
– sample nitrogen	84	79.9	90.4
– diet organic matter	92.8	90.2	94.5
ARD			
– feces/bacteria	13.9	14.4	15.0
– feces/food	25.2	26.5	24.8
Regression coefficients			
a (food)	0.15[a]	0.15	0.29[a]
b (bacteria)	1.0	1.0[a]	0.80[a]
K	-0.81	-0.82	-0.46
R^2	0.96[a]	0.95[a]	0.95[a]

[a]$P < 0.01$.