Annals of Biochemistry
and Experimental Medicine
Vol. XX, No. 2, 1960

SUPPLEMENTARY VALUE OF THE PROTEINS OF SUNFLOWER (*HELIANTHUS ANNUS*) AND SESAME SEEDS TO GROUNDNUT AND BENGAL GRAM (*CICER ARIETINUM*) PROTEINS

P. K. TASKER, KANTHA JOSEPH, M. NARAYANA RAO, R. RAJAGOPALAN, A. N. SANKARAN AND M. SWAMINATHAN

From the Central Food Technological Research Institute, Mysore

(Received for publication, December 10, 1959)

It is now well recognized that even a partial deficiency of one or more of the essential amino-acids in the dietary proteins lowers their biological value (1). Several workers have shown that two or more proteins may mutually supplement each other's amino-acid deficiencies and their blends may possess a higher biological value than the individual components (2). The most important protein-rich foods of vegetable origin available in several underdeveloped countries for supplementing the diets of weaned infants and young children are the various pulses (legumes) *e.g.* chick pea (Bengal gram) and beans and the edible meals from oilseeds *e.g.* groundnut, soyabean, cottonseed and sesame (3, 4). Sunflower seed and coconut meals are also of importance in certain countries where they are available in large amounts (3, 4). The proteins of the above foodstuffs are partially deficient in one or more essential amino-acids as indicated below : groundnut—methionine, lysine and threonine; soyabean—methionine; cottonseed—methionine and lysine; sesame and sunflower seeds—lysine; chick pea and beans—methionine and tryptophan (2, 3, 5, 6). Some of them are, at the same time, rich sources of lysine or methionine. For example, soyabean and different legumes (pulses) are rich in lysine while sesame and sunflower are rich in methionine (2, 3, 5, 6). Hence by blending the different protein foods in suitable proportions, it may be possible to obtain a protein blend having the optimum proportions of essential amino-acids and a fairly high biological value. The present paper deals with studies on the supplementary value of the proteins of sesame and sunflower seed meals to those of groundnut, Bengal gram and their blends.

MATERIALS AND METHODS

The samples of low-fat groundnut flour, Bengal gram (*Cicer arietinum*) flour and sesame flour used in the present investigation were prepared according to the method described by Subrahmanyan *et al.* (7).

Solvent (hexane) extracted sunflower seed meal used in the present investigations was prepared as follows : Sunflower seed was crushed in a triple roller mill and the meal was passed through a 20-mesh sieve for separating the husk from the kernel. The oil present in the kernel was extracted with hexane.

The essential amino-acid composition of the samples of groundnut flour, Bengal gram flour, sesame flour and sunflower seed flour used in the present study was determined. Methionine was estimated by the method of Horn *et al.*(8), tryptophan, according to Spies (9) and histidine by the method of Macpherson (10). The other essential amino-acids were determined according to the paper chromatographic technique of Krishnamurthy and Swaminathan (11). The results are given in Table I.

TABLE I

Essential amino-acid composition of the proteins of the different protein-rich foods used in the experiment.

Amino-acid	(Calculated to 16 g. nitrogen)			
	Low-fat groundnut flour.	Sesame flour	Sunflower seed meal	Bengal gram flour
Arginine	10·6	8·5	7·8	7·5
Histidine	2·5	1·4	2·0	2·4
Lysine	3·6	2·7	4·1	6·4
Tryptophan	1·2	1·7	1·5	0·6
Phenylalanine	5·5	7·5	4·2	5·3
Methionine	1·0	3·2	3·0	1·5
Threonine	2·6	3·8	3·8	4·8
Leucine	6·4	7·4	6·5	7·8
iso-Leucine	4·6	4·6	5·6	5·9
Valine	4·8	5·0	4·6	5·1

The protein efficiency ratios (PER) of the individual proteins and protein mixtures were determined by the rat-growth method of Osborne, Mendel and Ferry (12).

Animal experiments :

Weanling albino rats weighing 40-43 g. from the laboratory stock colony were allotted to the required number of groups according to the randomized block design. The different groups in the same series contained the same number of male and female animals. The compositions of the diets are given in Table II. The protein content in all the diets was maintained at 10% level on dry weight

TABLE II

Percentage compositions of experimental diets.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Low-fat groundnut flour	17·6	8·8	—	—	8·8	8·8	—	—	—	8·8	—	4·4
Bengal gram flour	—	18·4	36·8	—	—	9·2	18·4	—	—	—	18·4	9·2
Sesame meal	—	—	—	25·2	12·6	6·3	12·6	—	—	—	—	—
Sunflower meal	—	—	—	—	—	—	—	—	19·2	9·6	9·6	9·6
Skim milk powder	—	—	—	—	—	—	—	28·1	—	—	—	—
Groundnut oil	10	10	10	10	10	10	10	10	10	10	10	10
Corn starch	66·4	56·8	47·2	58·8	62·6	59·7	53·0	55·9	64·8	65·6	56·0	60·8
Salt mixture*	4	4	4	4	4	4	4	4	4	4	4	4
Vitaminized starch†	1	1	1	1	1	1	1	1	1	1	1	1
Shark liver oil	1	1	1	1	1	1	1	1	1	1	1	1

* McCollum-Davis salt mixture.

† The vitaminized starch (at 1% level) supplied the following B-group vitamins. Thiamine 0·3 mg., riboflavin 0·6 mg., niacin 0·4 mg., pyridoxine 0·4 mg., calcium pantothenate 0·6 mg., PABA 10 mg., inositol 10 mg., choline 50 mg., and folic acid 0·1 mg. per 1000 g. of the diet.

basis, the protein being derived from one or more of the foods as indicated in Tables III and IV. The diets were cooked with three times the weight of water by steaming for 5 min. and fed *ad lib.* to the rats. Records of food intake were maintained for each rat. The rats were weighed weekly. The values of PER were calculated for each rat and these were analysed by the analysis of variance technique appropriate for randomized block design. Data regarding the protein efficiency ratios of the proteins calculated for periods of 4 and 8 weeks are given in Tables III and IV.

TABLE III

Supplementary value of sesame proteins to groundnut and Bengal gram proteins.
(10 males in each group)

Diet no.	Nature of the protein rich food.	Level of protein in the diet (%)	PER (at 10% protein level) 4 weeks		PER 8 weeks	
1	Groundnut flour ..	10	1·65	±0·090 (35 d.f.)	1·47	±0·048 (35 d.f.)
2	Groundnut flour + Bengal gram ..	5, 5	1·79		1·38	
3	Bengal gram ..	10	1·51		1·27	
4	Sesame flour ..	10	1·73		1·53	
5	Groundnut flour + Sesame flour ..	5, 5	1·99		1·73	
6	Groundnut flour + Sesame flour + Bengal gram ..	5, 2·5, 2·5	2·03		1·79	
7*	Bengal gram + Sesame flour ..	5, 5	2·15	±0·10 (7 d.f.)	1·78	±0·10 (7 d.f.)
8*	Skim milk powder ..	10	2·88		2·32	

* Experiments with diets 7 and 8 were conducted separately.

TABLE IV

Supplementary value of sunflower seed proteins to groundnut and Bengal gram proteins.
(5 males and 7 females in each group)

Diet no.	Nature of the protein rich food.	Level of protein in the diet (%)	PER (at 10% protein level) 4 weeks		PER 8 weeks	
9	Sunflower meal ..	10	2·57	±0·068 (60 d.f.)	2·22	±0·055 (60 d.f.)
1	Groundnut flour ..	10	1·85		1·54	
3	Bengal gram ..	10	1·54		1·41	
10	Groundnut flour + Sunflower meal ..	5, 5	2·14		2·02	
11	Bengal gram + Sunflower meal ..	5, 5	2·24		1·95	
12	Bengal gram + Groundnut flour + Sunflower meal ..	2·5, 2·5, 5·0	2·33		2·05	
8	Skim milk powder ..	10	2·90		2·36	

Results and Discussion

The results (Tables III and IV) show that the proteins of sesame supplemented those of groundnut and Bengal gram and their blends to a significant extent. The PER of the proteins of groundnut, Bengal gram and sesame were in the range of 1·27 to 1·53. The proteins of sesame supplemented to a significant extent those of groundnut, Bengal gram and their blends. The proteins of a blend of groundnut, Bengal gram and sesame had almost the same PER (1·79) as that (1·78) of a blend of Bengal gram and sesame. The PER of sunflower seed protein (2·22) was higher than those of the proteins of groundnut, Bengal gram and sesame. Sunflower seed proteins supplemented those of groundnut, Bengal gram and their blends to a significant extent.

The results obtained in the present and previous studies (7, 13, 14) are of considerable importance to many underdeveloped countries where protein malnutrition is widely prevalent. They have shown the possibility of obtaining protein blends of high nutritive value by mixing different protein-rich foods in suitable proportions.

Summary

1. The protein efficiency ratios of the proteins of edible flours from groundnut, sesame and sunflower seed and of Bengal gram and their blends have been determined at 10% level.

2. The proteins of sunflower seed possessed a higher PER than those of groundnut, Bengal gram and sesame.

3. Both sesame and sunflower seed proteins supplemented to a significant extent those of groundnut, Bengal gram and their blends.

Acknowledgment

We are thankful to Miss K. Indiramma for help in the statistical analysis of the results and to Dr. V. Subrahmanyan, Director of the Institute, for his kind interest in the work.

REFERENCES

1. Mitchell, H. H. and Block, R. J. (1946-47), *Nutr. Abs. & Rev.*, **16** : 249.
2. Dean, R. F. A. *Plant protein in child feeding*. Med. Res. Council. Spe. Report Series 279. Her Majesty's Stationery Office, London, 1953.
3. Kuppuswamy, S., Sreenivasan, M. and Subrahmanyan, V. (1958), *Protein in Foods*, I. C. M. R., Spe. Rep. Ser. No. **33**.
4. Autret, M. and Van Veen, A. G. (1955), *Amer. J. Clin. Nutr.*, **3** : 234.
5. Riesen, W. H., Clandinun, D. R., Elvehjem, C. A. and Cravens, W. W. (1947), *J. Biol. Chem.*, **167** : 143.
6. Vijayaraghavan, P. K. and Srinivasan, P. R. (1952), *J. Nutr.*, **51** : 261.
7. Subrahmanyan, V., Rama Rao, G., Kuppuswamy, S., Narayana Rao, M. and Swaminathan, M. (1957), *Food Science*, **6** : 84.
8. Horn, M. J., Jones, D. B. and Blums, A. E. (1946), *J. Biol. Chem.*, **166** : 313.
9. Spies, J. R. (1950), *Analyt. Chem.*, **22** : 1447.
10. Macpherson, H. T. (1942), *Biochem. J.*, **36** : 59.
11. Krishnamurthy, K. and Swaminathan, M. (1955), *Analyt. Chem.*, **27** : 1936.
12. Osborne, T. B., Mendel, L. B. and Ferry, E. L. (1919), *J. Biol. Chem.*, **37** : 223.
13. Krishnamurthy, K., Tasker, P. K., Indira, K., Rajgopalan, R., Swaminathan, M. and Subrahmanyan, V. (1958), *Ann. Biochem. Exptl. Med.*, **18** : 175.
14. Krishnamurthy, K., Ramakrishnan, T. N., Ganapathy, S. N., Rajagopalan, R., Swaminathan, M., Sankaran, A. V. and Subrahmanyan, V. (1959), *Ann. Biochem. Exptl. Med.* **19** : 139.