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Rice—an Appraisal of its Nutritive Value*

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IN reviewing the biochemical and nutritional aspects of rice, I should like to treat the subject in the form of questions and answers.

How does rice compare nutritionally with other cereals such as wheat, maize and oats ? In answering this question, no comparisons should be made with processed cereals, since the nature of processing and the response to processing would vary from cereal to cereal. The correct procedure would then be to assess the relative merits of whole grains. It is well known that cereals supply us with carbohydrates, proteins, minerals, vitamins and to some extent with fat. The characteristic deficiencies in all cereals are total absence of vitamins C and D, low riboflavin and fat and very small amounts of available calcium. Among cereals yellow maize has the highest amount of vitamin A (705 I.U. per 100g.) and brown, uncooked rice comes next with 75 I.U. per 100g. (Rose, M.S., 1949). Rice, wheat and oats cannot be regarded as significant sources of vitamin A. Approximately 13 per cent. of the daily adult requirement of riboflavin is found in brown rice and this represents the average value for other cereals. On the other hand rice and other cereals are valuable sources of carbohydrates, proteins and the vitamins thiamine and niacin. 18 lines of pureline paddy grown in Ceylon were studied by the author and Mr. G. C. N. Jayasuriya and the average values for thiamine and niacin in brown rice were 592ug and 6907ug per 100g. respectively on a moisture free basis (1951.)

A popular misconception about rice is that it has much more starch than wheat. Actual values for carbohydrate in the common cereals are given in Table I—

TABLE I

Cereal		*g. carbohydrate/100g.*
Rice, brown	..	77.2
Wheat, whole	..	75.5
Maize, whole	..	73.4
Rice, polished	..	79.4
Wheat flour, white	..	77.2

* This paper was read at the Symposium on paddy held on December 1, 1950, during the Sixth Annual Session of the Ceylon Association of Science.

Thus there exists a difference of only 1.7g. or 6.8 Calories between 100g. each of brown rice and whole wheat. Between polished rice and white wheat flour the difference is only 2.2g. equivalent to 8.8 Calories. The energy values of whole wheat and brown rice are the same, 28g. of each cereal supplying 100 Calories.

When we consider proteins, cereals display pronounced differences in their protein content, the amino-acid composition, the biological value and the physical properties of the proteins. For comparison, the average protein percentages in some cereals are given in Table II—

TABLE II

Cereal		*g. protein/100g.*
Oat meal	..	14.2
Wheat, whole	..	11.1
Maize, whole	..	10.0
Rice, brown	..	8.8 (our figures)
Rice, polished	..	7.6

The actual contribution of cereals to the total protein of the diet would depend not only on the protein content of the cereals eaten, but also on the quantity of cereals consumed daily in any form. In a recent review, W. I. M. Holman (1946) had summarised the available data on the proportion of cereals in human diets and the figures in Table III for predominantly wheat eating countries were calculated from his data —

TABLE III

Country		*g. protein from cereal*
Great Britain	..	31
U. S. America	..	25
Canada ..	..	26

In Ceylon, according to information supplied by the Director of Census and Statistics (1949), 24g. of cereal protein were consumed by an adult per day during 1948-1949. This is equivalent to 11.1 ounces of polished rice, a figure closely corresponding to the amount quoted by Cullumbine and co-workers (1949). Thus despite the differences in the protein contents of wheat and rice, Ceylonese derive daily about the same quantity of protein from rice as Canadians or Americans from wheat.

The biological qualities of cereal proteins differ widely, partly due to differences in digestibility and partly due to the amino acid composition of the proteins. Mitchell and Block (1946) have collected most of the available data on the biological values of protein in adult human nutrition and the following figures in Table IV have been taken from their article—

TABLE IV

Source of protein		*Biological value*
Egg, whole	..	100
Rice, white	..	88
Wheat, whole	..	70
Wheat flour, white	..	41
Oats, rolled	..	87

In drawing conclusions from these figures, it should be remembered that (*a*) these results were obtained in different laboratories, and (*b*) experimental procedures have not been sufficiently standardised in human experiments to permit significant comparisons. With these reservations, rice proteins appear to be superior to wheat proteins. Another way of assessing the biological values of proteins has been suggested by Mitchell and Block (1946), and is termed 'the chemical score' method by these authors. Table V gives the chemical scores of some familiar foodstuffs—

TABLE V

Source of protein	*Chemical score*
Egg, whole ..	100
Milk	68
Oats, rolled ..	46
Rice, white ..	44
Wheat, whole ..	37
Wheat flour, white ..	28

This method of assessment again points to the superiority of rice protein to wheat protein—a comforting thought to rice-eating countries. Thus the higher biological value of rice protein counterbalances the slight differences in cereal protein consumed daily as shown in Table III.

A pertinent question arises out of the above considerations. Accepting the figure of 24g. rice protein as the daily consumption by a Ceylonese adult, does this amount meet the most important function of any food protein, namely the adequate supply of the eight essential amino acids listed in Table VI ? Dr. William C. Rose (1949) has worked out the daily adult requirements with regard to these amino acids and his figures are compared in Table VI with what 24g. of rice protein would supply—

TABLE VI

Essential amino acids	*Rose's estimate of adult human daily needs, mgs.*	*mgs/100g white rice ($N=1.22$)*	*11.1 oz.* polished rice contain*	*Column 4 as % of Column 2*
Tryptophane	250	99	313	125
Phenyl alanine	1,100	509	1,607	146
Lysine	800	243	767	96
Threonine	500	311	982	196
Methionine	1,100	258	815	74
Leucine	1,100	684	2,160	196
Valine	800	479	1,513	189
Isoleucine	700	403	1,272	182

* 11.1 oz. polished rice contain 24g. protein.

The last two columns in Table VI indicate, in different ways, to what extent the amount of rice we consume daily would supply the essential amino acids. One cannot escape the conclusion that even polished or white rice, consumed in quantities prevailing in Ceylon (11.1 oz.), can more than meet the adult minimum requirements of essential amino acids, with the exception of methionine and lysine which, however, are supplied to an appreciable degree.

How does rice compare with other cereals with regard to vitamins? Table VII gives the average figures for three cereals with respect to vitamins whose importance to human nutrition is well established—

TABLE VII

Cereal	Vitamin A I.U./100g.	Thiamine*	Riboflavin*	Niacin*
Rice, brown	75	527	140	6,146
Wheat, whole	—	320–770	100–120	5,300
Maize, whole	705	230–740	130–150	790–6,210

(Burkholder et al, 1944)

* Values expressed as microgrammes per 100g.

Here again rice compares very favourably with other cereals, but the treatment to which rice is subjected before consumption is the main factor in the loss of its vitamins. This brings one to the subject of processing rice and its influence on the nutritive properties of rice.

It is common knowledge that in processing rice an appreciable amount of invaluable vitamins and other constituents is lost for human consumption. Thus when brown rice is milled to polished rice, M. C. Kik (1945) found serious losses as given in Table VIII:

TABLE VIII

Percentage losses on milling

76% thiamine
57% riboflavin
63% niacin
10% protein
85% fat
70% minerals

One of the effective methods of preventing such considerable loss of nutrients is our traditional method of parboiling rice. A modern development of the parboiling process is known as 'rice conversion' process, originated by Erich Huzenlaub and practised on a commercial scale in U. S. A. by a firm, Harwell and Mars of Houston. The product is called 'converted rice'. In this process, paddy, free from dirt, stones, chaff, &c., is introduced into a large vessel, which is then evacuated and hot water (75–80°C) subsequently introduced. The paddy is steeped in this hot water under a pressure of 80–100 lb. per sq. inch, for two to two and a half hours, the time and temperature of steeping depending on the variety used. The water is drained off and the paddy is introduced into a large, cylindrical, rotating, steamheated vessel. This is partially evacuated and steam introduced, and after a time, the paddy is dried in vacuo in this vessel itself to a moisture content of 15 per cent. The paddy is finally dried at atmospheric pressure and milled. A yellow coloured 'converted rice' is thus obtained. In a recent study of this ' converted rice ' (Jacobs, 1944), the losses by milling were reported to be much less. Table IX gives a comparison of vitamin losses sustained by converted rice and raw rice by milling—

TABLE IX

Material	*Percentage losses in vitamins by milling*		
	Thiamine	*Riboflavin*	*Niacin*
Raw rice	76	57	63
Converted rice	8	29	22

This is certainly a very great step in conserving the vitamins in rice. It is even claimed that ' converted rice ' keeps well during storage and is fairly resistant to action of weevils. To give an idea of how much valuable nutrients is lost in ' bran ', the average composition of bran is given in Table X—

TABLE X

Constituents	*per 100g. bran*
Carbohydrates	41.8 g
Proteins	12.5 g
Fat	14.4 g
Ash	9.9 g
Thiamine	2,500 microgrammes
Riboflavin	268 do.
Niacin	32,000 do.

An interesting line to pursue is the recovery of these valuable constituents from bran in a form acceptable to human consumption.

The traditional method of washing rice before cooking results in a further loss of vitamins, but parboiled or converted rice stands up very well to this treatment. Losses by washing are presented in Table XI—

TABLE XI

Material	*Percentage losses in vitamins by washing (Kik, 1945)*		
	Thiamine	*Riboflavin*	*Niacin*
Rice, brown	21	8	13
Rice, polished	43	26	23
Rice, parboiled	7	12	10

Does paddy or rice lose much vitamin during storage ? The most appreciable loss is in thiamine. In Table XII figures are given for materials stored at 84°F—(Kik, 1945)—

TABLE XII

Material	*Percentage loss in thiamine during storage at 84°F for 3, 9 & 30 months*		
	3 months	*9 months*	*30 months*
Paddy	5	8	20
Rice, polished	7	13	29

It is interesting to record the work of Barton-Wright (1944) on barley grains found in the tomb of King Tutankhamen (1350 B.C.). He found no thiamine at all, but found significant amounts of riboflavin and niacin. Losses during storage at 84°F for 30 months in riboflavin and niacin were not appreciable (c. f. Table XIII), (Kik, 1945)—

TABLE XIII

	Percentage loss of vitamins during storage for 30 months at 84°F	
	Riboflavin	*Niacin*
Paddy	6	4
Rice, polished	4	4

In this brief survey an attempt has been made to bring out the salient biochemical and nutritional aspects of rice. The nutritional properties of rice compare favourably with other cereals and even surpass them in some respects such as digestibility and biological value of its proteins. No doubt its nutritional properties could be enhanced by (*a*) attempting to increase the protein content and (*b*) conservation of its constituents by parboiling or the more effective large-scale ' rice conversion ' process.

REFERENCES

Barton-Wright, E. C. and others (1944). Nature, 153, 288.

Burkholder, R. P. and others (1944). Yale J. Biol. Med. 16,659.

Cullumbine, H. and others (1949). Ceylon J. Med. Science, 6,259.

Director of Census and Statistics (1949). F.A.O. April number, p. 236.

Holman, W. I. M. (1946). Nutr. Abstracts and Reviews, 15,402.

Hoover, A. A. and Jayasuriya, G. C. N. (1951). Tropical Agriculturist, p. 9, Vol. CVII. No. 1 (1951).

Jacob, M. B. (1944). The Chemistry and Technology of Food and Food Products. New York, Vol. 1, 644.

Kik, M. C. and Williams, R. R. (1945). Bulletin Nat. Res. Council, Washington. No. 112.

Mitchell H. H. and Block, R. J. (1946). Nutr. Abstracts and Reviews, 16,271.

Rose, W. C. (1949). Federation Proceedings, 8, 546 and Nutr. Reviews, 8, 118, 1950.

Rose, M. S. (1949). Rose's Foundations of Nutrition, 4th edition, New York.