https://doi.org/10.29321/MAJ.10.A04579

# The Influence of the Quality of Irrigation Water (Channel Water *vs.* Effluent) and Method of Preparation of Rice Flour on its Nutritive Value.

By C. BALASUBRAMANIAN, B.A., B. Sc. Ag.,
*Assistant in Chemistry, Agricultural Research Institute, Coimbatore.*

**Introduction.** Rice, the staple food crop in this country, has been under cultivation from time immemorial. A large number of varieties exist to suit several soils, tracts or conditions of cultivation. The chemical composition of some of these varieties due to differences in cultural operations, and different methods of preparation of the grain for consumption has engaged the attention of Sadasivan and Srinivasan (5) and Subrahmanyam et al. (8).

The present investigation attempts to assess the differences in the net-protein values of proteins in rice flour as induced by (i) the two kinds of water used for irrigation of the crop and (ii) the difference in the preparation of rice flour, the material taken for experimentation. McCarrison (3) has done some work on "The influence of irrigation on the nutritive value of rice" and his important finding is that rice grown in puddle has a markedly lower nutritive value than the same variety raised under the rainfed conditions and this difference he partly attributes to the former containing lower amounts of water-soluble B Vitamins. Elliott (2) has proved experimentally that in the milling of a large number of grasses fodder samples and high protein-concentrates like decorticated groundnut cake, there is a loss by way of dust which is richer in nitrogen than the rest of the material.

The study of protein was undertaken to the exclusion of other constituents like fat (ether extractives), crude fibre, nitrogen—free extract and the minerals contained in ash for the simple reason that rice forms the major source of protein in the rice consumers' dietary. Apart from this, it is a well-known fact, as pointed out by Dr. A. Sreenivasan (6), that rice proteins contain all the essential amino acids and, in their general amino-acid make-up they "more nearly resemble the majority of the proteins of animal tissues, soya bean and milk than do the proteins of maize and wheat." Such being the importance of rice protein, it was felt that work on rice should be undertaken with the object of exploring all possible methods by which the nutrients, particularly protein, may be conserved in their entirety during the treatment of the grain by different processes to make it fit for human consumption. This important nutritive and economic aspect has been considered in this investigation. To this end 8 biological experiments have been conducted on albino rats. A brief account of these experiments is presented with a critical discussion of the data obtained.

**Materials and Methods.** *Materials.* There were in investigations on the utilisation of the effluent—the resultant liquid obtained during the manufacture of sludge—from the activated sludge plant erected at the Agricultural College and Research Institute, as against the ordinary channel water for irrigation. Paddy strain—G. E B. 24—was selected for the

investigation as it is the most popular and widely spread variety. The results are given in the following Tabular Statement No. I:—

**Tabular Statement No. I.**

| Year. | Channel water irrigation (lbs. per acre). | | Effluent irrigation (lbs. per acre). | | Remarks. |
|---|---|---|---|---|---|
| | Grain. | Straw. | Grain. | Straw. | |
| 1934–35 | 2,100 | 2,775 | 3,800 | 4,950 | Statistically significant. |
| 1935–36 | — | — | — | — | Young seedlings died in Effluent plots. |
| 1936–37 | 3,089 | 3,081 | 3,418 | 4,160 | Drained and flushed with Channel water. Effluent was let in only 8 weeks after transplantation. Statistically significant. |
| 1937–38 | 3,135 | 3,146 | 3,229 | 4,465 | Statistically significant. |
| 1938–39 | 3,771 | 5,115 | 3,586 | 4,896 | Nil. |
| 1939–40 | 3,465 | 5,220 | 3,729 | 6,800 | Statistically significant. |
| 1940–41 | 2,515 | 3,911 | 2,773 | 3,290 | Grain yield—Just significant. |
| 1941–42 | 2,274 | 2,008 | 2,916 | 2,595 | Statistically significant. |
| 1942–43 | — | — | — | — | Crop spoiled due to heavy rains at the time of harvest. The study was also wound up in this year. |

(N. B.—Four transplantation seedlings were got from the wet nursery which received only channel water irrigation.)

These data indicate that yields of both grain and straw from the effluent series are higher than those from the channel water series. Though the writer of this paper was not in any way connected with this irrigation experiment, he has reproduced the results, with the kind permission of the Government Agricultural Chemist, to convey an idea as to how the effluent irrigation modifies the yield of grain and straw of paddy.

To ascertain how the chemical composition of the grain, with particular reference to protein, is altered by the effluent irrigation, representative samples of grains obtained from these two differently irrigated plots were chemically analysed for their feeding values. These two samples of grain were hulled separately in a Japanese "CeCoCo" hand-operated paddy huller and the samples of rice got were floured in a power-driven mill. The rice flours, thus prepared, were taken up for chemical analysis. The results of analysis are given hereunder:—

**Tabular Statement No. II.**

Analysis of paddy for feeding values;—Rice flour is taken for analysis. (Flouring being done in a power-driven mill and samples as received were taken for analysis) Channel water *vs.* Effluent irrigation to paddy—Variety G E. B. 24.

| S. No. | Heads of Analysis. | Channel water Irrigated plot Paddy-Rice Flour. per cent. | Effluent Irrigated plot Paddy-Rice Flour. per cent. |
|---|---|---|---|
| 1. | Moisture ... ... ... | 10·28 | 10·78 |
| 2. | Ash ... ... ... | 1·47 | 1·40 |
| 3. | Ether Extractives ... ... | 2·72 | 2·59 |
| 4. | Crude Protein ... ... | 8·36 | 12·16 |
| 5. | Crude Fibre ... ... | 0 91 | 1 01 |
| 6. | Carbohydrates (by difference) ... | 76 26 | 72 06 |
| | Total ... | 100·00 | 100·00 |
| 7. | True Protein ... ... | 7·82 | 10·61 |

From the above table it will be inferred that the rice of the effluent series contains more protein than the one of the channel water series.

Suspecting some loss of nutrients, particularly of the most valued protein group, when rice is floured in a power mill, another set of samples of the respective paddies were hulled, as before, in the "CeCoCo" and the rice samples were powdered in the laboratory with an iron mortar and pestle, a method that is nearly akin to the flouring of foodstuffs with a stone grinder, in houses. The flours, thus obtained, were passed through 30 mesh sieve and the finer fractions were analysed for their respective protein contents on dry basis. The samples of rice flour, got from the flour mill and analysed already for their feeding values, were similarly sieved and as in the above samples, the materials that passed through the sieve were taken for an estimation of their protein contents on dry basis merely for the sake of comparison and confirmation of the suspicion referred to above. All these protein estimations were done in duplicate. The data gathered in this connection are given below.

**TABLE No. III**

| S. No. | Details of the samples analysed. | Protein Content on Dry Basis | |
|---|---|---|---|
| | | Channel water Irrigated Plot Paddy | Effluent Irrigated Plot Paddy. |
| | | % | % |
| 1. | Flour, obtained from the power-driven mill, is passed through 30 mesh sieve-the material that has passed through the sieve is taken for analysis. | 7·63 | 10·40 |
| 2. | Flour, prepared by using an iron mortar and pestle, is passed through 30 mesh sieve—the material that has passed through the sieve is taken for analysis | 8 05 | 11·18 |

The data contained in the above tabular statement go to confirm the suspicion and incidentally the finding of Elliott F. J. (loc. cit.) to the effect, namely, that feeding stuffs, irrespective of the level of their protein contents, really sustain a loss in their nutrients, mainly protein, during milling.

Further, to gain some additional information on these two samples of paddy, taken up for this investigation, a preliminary study was conducted with regard to their relative suitability for malt making. The weight of hundred mature grains was estimated in each of these two samples of paddy. In addition, the contents of their respective water-soluble extract and starch were determined. The data pertaining to these determinations are given in the Table No. IV:

**TABLE No. IV**

| S. No. | Details of the samples analysed. | Weight of 100 healthy and mature seeds. (Average of a number of estimations.) | Water-soluble extract (Average of two estimations) | Starch on dry basis. (Average of four estimations.) |
|---|---|---|---|---|
| | | gms. | % | % |
| 1. | Channel Water Irrigated Plot Paddy. | 1·733 | 1·129 | 74·56 |
| 2. | Effluent Irrigated Plot Paddy. | 1·652 | 1·336 | 78·32 |

The results indicate (i) that there is nothing to choose between these two samples of paddy with regard to their weights of equal volumes; (ii) that the water-soluble extract of the effluent irrigated paddy, apart from its being more brownish, is decidedly higher than that of the channel water irrigated paddy; (iii) that the effluent plot paddy contains more starch than the channel water plot paddy and (iv) that the malts prepared from these two samples of paddy are of high grade quality thereby upholding the general belief, namely, that paddy with its easily removed husk, its low protein, fat and fibre content lends itself to malting and in the making of a malt of superior quality.

The preliminary studies detailed above have shown that (i) the paddy grown under effluent irrigation is really superior to the same variety of paddy grown under channel water irrigation from the point of view of its protein content and (2) during the process of flouring in a power-driven mill rice sustains an appreciable loss in its protein fraction. To ascertain whether the superiority of (1) the effluent paddy over the channel water paddy and (2) flouring with an iron mortar and pestle over the power mill is reflected in their respective biological values, eight feeding trials were conducted, using albino rats.

*Method.* The Mitchell's Nitrogen-balance method was adopted. The technique as recommended by Mitchell (4) was followed with slight alterations. In the place of Nitrogen-free diet, egg-diet at a low protein level of about 2% was fed to the experimental rats. The composition of the diets fed to the experimental rats is indicated below:—

I. *Egg-protein diet in the place of Nitrogen-free diet :-*

| | |
|---|---|
| Salt Mixture (Steenbock and Nelson) | 4% |
| Starch —Sufficient to make | 100% |
| Egg powder—Sufficient to give about | 2% protein level to the diet. |
| Sugar | 10% |
| Agar Agar | 1% |
| Fat (Coconut oil + Oil contained in the egg powder added to the diet) | 10% |

II. *Test Diets.* The test diets were kept at about 5% Protein level. The composition of each test diet is briefly indicated below:—

| | Channel water Paddy-Diet. | Effluent Paddy-Diet. |
|---|---|---|
| Salt Mixture (Steenbock and Nelson) | 4% | 4% |
| Starch —Sufficient to make | 100% in both the cases. | |
| Rice Flour—Sufficient to give | 5% protein level to the diets. | |
| Agar Agar | 1% | 1% |
| Sugar—That can be possibly added, not exceeding | 10% limit. | |
| Fat (Coconut oil) | 10% | 10% |

As usual, the diets were got ready for experiment after complete cooking, drying, powdering and finally testing them for their individual protein contents on dry basis. The daily rations to the animals were weighed according to the consumption of individual animal and given in the form of a paste to avoid waste. The weight of the food actually consumed was

determined. Besides, four to five drops of De John's Cod Liver Oil and 50 m. gms. of Marmite dissolved in 1 c. c. of sugar water were given to each rat during the experimental period as a source of vitamins A and D and $B_1$ Complex respectively.

Six pairs of littermates of approximately equal weights were chosen for the experiment. To each animal a separate metabolism cage was allotted. Every experiment, whether it be with low egg-protein diet or 5% rice protein diet, was preceded by a preliminary period of three days and ended after 5 days in the case of low egg-protein diet, which had been assigned the place of nitrogen-free diet, and after seven days in the case of test diets, which in this investigation, happened to be rice protein diets at about 5% protein level. A resting period of three to four days was always allowed between one experimental period and another, when the test animals were kept on stock diets consisting of milk, vegetables like cabbage (*Brassica oleracea* var. *Capitata*), Carrot (*Daucus Carota*), etc, soaked and sprouted Gram (*Cicer arictinum*) and cooked rice and dhall. The animals were weighed both at the beginning and at the end of each balance experiment.

The daily excretion of urine of each animal was collected separately in beakers containing about 3 c. c. of 10% Sulphuric acid and a few drops of Carbolic acid solution. At 9 A. M. on each day the daily collections of urine samples were washed with distilled water and finally with about 5% Sulphuric acid solution. The washings were made upto 250·0 c. c. and preserved in bottles, numbered previously. Aliquots of these urine samples, generally 250·0 c. c., were taken for nitrogen estimation. The fecal matter voided daily was collected and preserved in small wide-mouthed numbered bottles containing a mixture of 95% Alcohol and 10% Sulphuric acid. The entire fecal collection was taken for the estimation of nitrogen by the Kjeldahl method; but, for distillation an aliquot of the made up digested material was taken.

**Experiment and discussion of the results.** With the four samples of rice flour got ready as detailed above four diets were prepared, all at about 5% protein level. With these four diets eight biological experiments were conducted with the definite object of finding out the difference in the biological values of rice proteins due to (i) differential irrigational treatments and (ii) method of preparation of rice flour. Details regarding the method adopted for this investigation have been already given in a brief manner. Need for brevity accounts for the ommission to present the entire data collected during these experiments. Hence, they have been summarised and presented in Table V.

The following main conclusions can be drawn from the data given above: (i) In spite of the fact, that the channel water irrigated paddy shows superiority over the effluent irrigated paddy in respect of digestibility coefficient and that there is not much to choose between them as regards biological value, that is the percentage of the digested material available for assimilation by the system of the rat, the latter is superior to the former

TABLE V

**Section A.**

Paddy Grains Hulled in "CeCoCo" Machine—Rice floured in power-driven flour mill—Flour passing through 30 mesh sieve.

| S. No. | Details of group feeding. | Protein content of rice flour on dry basis. | | Digestibility coefficient. | | Biological value. | | Net-protein value. | | Average net-protein value. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | C | E | C | E | C | E | C | E | |
| | | % | % | % | % | % | % | % | % | % |
| 1. | First Group of Six Rats—Average | 7·63 | 10·40 | 91·82 | 87·41 | 91·85 | 88·78 | 6·43 | 8·07 | C=6·39 |
| 2. | Second Group of Six Rats—Average | 7·63 | 10·40 | 94·77 | 92·54 | 87·65 | 88·37 | 6·34 | 8·50 | E=8·29 |

**Section B.**

Paddy Grains Hulled in "CeCoCo" Machine—Rice floured with iron mortar and pestle—whole flour passed through 30 mesh sieve.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | First Group of Six Rats—Average | 8·05 | 11·18 | 97·01 | 92·58 | 89·00 | 86·69 | 6·95 | 8·97 | C=6·77 |
| 2. | Second Group of Six Rats—Average | 8·05 | 11·18 | 96·95 | 94·58 | 84·44 | 86·27 | 6·59 | 9·12 | E=9·05 |

N. B. { C = Paddy from the Channel water irrigated plots.
E = Paddy from the Effluent irrigated plots.

from the point of view of net protein value, which is now accepted as the criterion for judging the food value of protein constituent, irrespective of the nature of processing after hulling. In the calculation of this value, as per the following formula, it will be observed that the protein content of the foodstuff on dry basis is taken into consideration and it is this factor that tilts the value in favour of effluent irrigated paddy.

*Formula for the calculation of net-protein value:—*

$$\text{Net Protein Value} = \frac{\left\{\begin{matrix}\text{Digestible Protein} \\ \text{in the feeding stuff}\end{matrix}\right\}^{*} \times \left\{\begin{matrix}\text{Biological value of} \\ \text{the feeding stuff}\end{matrix}\right\}}{100}$$

* Digestible protein in the feeding stuff = Protein content in the feeding stuff on dry basis × Digestibility co-efficient of the feeding stuff.

Net-protein value is always expressed as the percentage of the feeding stuff.

(ii) The consistent difference noted in the data of the two sections A and B of the Table No. V, given above, goes to show the loss sustained by protein when rice is floured in a power-driven mill. As the major portion of protein is mainly present in the bran layer which is lost during milling in a power mill, it is assumed that fat, mineral matter and vitamin $B_1$ Complex, which are associated with the valuable bran layer, are also irrevocably lost, and (iii) The chemical analysis—*vide* tabular statements No II—of these two samples of paddy grown under differential irrigational treatments has shown that the effluent paddy is superior to the channel water paddy in respect of protein content, though in the matter of other ingredients it ranks

below it. This inference is in conformity with the main finding of the biological assay of these two samples of paddy.

**Summary and Conclusions.** (i) Effluent is better than channel water for irrigating paddy—G. E. B: 24—from the point of view of yield of both grain and straw.

(ii) The effluent paddy is superior to the channel water paddy in its protein content.

(iii) Considered from the point of view of net-protein value effluent paddy is to be preferred to the channel water paddy.

(iv) Flouring in a power-driven mill results in the loss of valuable protein, which is present chiefly in the bran layer.

and (v) It is inferred that concurrently with the loss of protein other essential nutrients like fats, important minerals and vitamin $B_1$ Complex, associated with the bran layer, are also los

**Recommendations.** 1. Water containing more of plant nutrients than the ordinary river, or channel water is to be preferred to the latter for the irrigation of crops, notably for paddy. In case it affects the seedlings adversely, it must either be diluted with, or entirely replaced by, the water from the usual source of irrigation. The fact, namely, that quality of water allowed for irrigation has got a noticeable effect on the nutritive value of the grain, should always be borne in mind by a practical and successful cultivator.

2. The time honoured practice of flouring the foodstuffs, like cereals and pulses, at home with a hand-operated stone grinder must always be encouraged as thereby no nutrient, particularly, the protein, is lost.

**Acknowledgment.** The investigations embodied in this paper were carried out under the able guidance of Sri Rao Bahadur P. Venkataramiah, the then Government Agricultural Chemist, to whom the writer of this paper offers his grateful thanks. Further, the author wishes to thank adequately Sri H. Shiva Rao, the Government Agricultural Chemist, for his help in preparing this paper.

## Literature Cited.

1. Arthur H. Smith—*Ann. Rev. Biochem.*, 1932, 1, 330.
2. Elliott F. J.—Analyst, 1934, 59, 606—609.
3. Mc Carrison R.—*J. Med. Res.*, 1927–28, XV, 915—920.
4. Mitchell H. H.—*J. Biol. Chem.*, 1923–24, 58, 873—903.
5. Sadasivan V. and Sreenivasan A.—*Ind. Jour. Agric. Sci.*, 1938, 8 (Part II), 807—818.
6. Sreenivasan A.—The Scholar, June 1938, 460—465.
7. Steenbock H. and Nelson E. M.—*J. Biol. Chem.*, 1923, 56, 362.
8. Subrahmanyam V. et. al.—*Ind. Jour. Agric., Sci.* 1938, 8 (Part II), 459—486.