INVESTIGATIONS ON THE BY-PRODUCTS OF THE RICE MILLING INDUSTRY

Part I.—Minerals and Vitamins B and E in the Various Rice Fractions

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Introduction

The average annual total production of rice crop in Pakistan is placed at 8,320,000 tons out of which nearly 806,000 tons are produced in West Pakistan and approximately 7,514,000 tons in East Pakistan. In most areas of Sind, machine milling is in vogue, and during the whole process, five fractions, namely, polished rice, 'tuttar' (hulls), 'tutri' fine 'kutti' (polishings), and broken rice, are obtained in the following proportions :—

Fraction	Unparboiled Rice	Parboiled Rice
Polished rice ..	60—63%	70—75%
Tuttar (Hulls) ..	16—20%	16—20%
Tutri (Middlings) ..	1— 2%	2— 3%
Fine Kutti (Polishings)	6— 7%	2— 3%
Broken rice ..	2— 4%	Negligible

A considerable portion of the hulls are utilised as fuel in the parboiling and also for domestic cooking. Tutri and fine kutti are used chiefly as cattle feed, while broken rice is sold as such in the market for human consumption.

A much greater degree of refinement is achieved with machine milling as against hand pounding, although this increase is usually at the cost of some valuable nutrients, such as proteins, fats, minerals and some very important vitamins of the B-complex group especially thiamine. The incorporation of preliminary outmoded techniques, such as undermilling and parboiling has done much to retain the natural nutrients including B-complex vitamins of the whole grain, but, due to some disadvantages inherent in these processes, they have received only a limited acceptance. For example, the products obtained after parboiling are somewhat different from the ordinary white rice both in appearance and flavour, and are therefore less acceptable to the average consumer. A large proportion of the valuable minerals and vitamins, thus, continue to be lost in the third and the fourth fractions mentioned above. It was therefore, considered of importance to investigate the possibility of utilising these by-products of the rice milling industry as sources of vitamin 'E' B-complex vitamins, and other essential nutrients. Experiments in this connection have resulted in some very encouraging results and the preliminary findings obtained in the course of this study are presented in this paper.

Experimental

Materials and Methods.—Paddy and the other fractions were obtained through the courtesy of Mr. Mohammad Sami, proprietor of Wasi Mohammad Mohammad Sami Rice Milling Factory, Larkana (Sind).

Decalso 'Y', of the Permutit Company, London, was used as an ion exchange resin for the absorption of vitamin B_1 from the crude extract. It was activated by treating twice with hot 3% acetic acid, followed by 25% potassium chloride solution. After draining off the potassium chloride, the Decalso was once again washed with hot acetic acid, and finally with hot water till the final washed solution was free from chlorides. The activated Decalso was dried at room temperature and then used. The whole process of activation was carried out in a Buchner funnel.[1]

Weighed amounts of each fraction evenly powdered were then submitted to chemical analysis. Moisture, ash, silica, calcium and proteins were determined according to standard methods of analysis of the A.O.A.C.[2] Specific methods are described under the appropriate headings below. The results obtained for moisture, minerals, proteins and vitamin B_1 are given in Table 1, while those for the rice oil and vitamin 'E' are shown in Table 2.

Phosphorus.—Phosphorus was determined by the method of Berenblum and Chain.[3] This method is based on the ready solubility of the reducible phosphomolybdic acid in isobutyl alcohol. It consists in the reduction of phosphomolybdic acid to the blue complex by shaking the alcoholic extract with an acidified aqueous solution of stannous chloride. The intensity of the

blue colour produced was measured in a Hilger photoelectric colorimeter using filter 70 (Table 1).

Thiamine.—Thiamine was determined fluorometrically by the thiochrome method.[1] The process involves the extraction of the vitamin followed by dephosphorylation by heating first with 0.1 N hydrochloric acid in a boiling water bath and then incubating at 45°-50°C. with 6% solution of Taka Diastase (Parke Davis and Co., New York) in 2.5 M sodium acetate solution, after adjusting the *p*H to 4.5. The extracted vitamin was then purified by adsorption-elution on a column of Decalso and the fluorescent thiochrome produced after treatment with alkaline potassium ferricyanide was extracted with isobutyl alcohol, was measured on a photoflurometer.

Fat from Rice Fractions.—Each fraction was well powdered and its oil was extracted with ether in a Soxhlet apparatus. The ether extract was dried with anhydrous sodium sulphate and filtered in a tared flask. The solvent was distilled off, the last traces being removed in vacuo, and the oil was recovered and weighed (Table 2).

Determination of Vitamin 'E'.—Rice oil was first of all treated according to the method of Parker and McFarlane,[4] which consists in shaking the petroleum ether solution of the oil with 85% sulphuric acid. In this way quinones and other unsaturated substances were made water soluble and removed. Vitamin E was then determined colorimetrically by the ferric chloride—$\alpha\,\alpha'$ dipyridyl method of Emmerie and Engel.[5] The red colour produced was measured in a Hilger photoelectric colorimeter using filter 52. A standard curve was prepared for different concentrations of the vitamin by using α-tocopherol (Merck). (Table 2).

TABLE 1.—SHOWING THE ANALYSIS OF UNPARBOILED PADDY AND ITS FRACTIONS*.

	Moisture %	Ash %	Silica %	Calcium (CaO) %	Phosphorous (P_2O_5) %	Protein %	Nitrogen free extract † %	Fibre %	Vit. B_1 (thiamin) µg/gm
Paddy ..	12.30	6.62	2.80	0.13	0.62	6.03	62.75	10.20	3.3
Hulls ..	10.10	20.83	16.40	0.32	0.31	2.77	24.75	39.85	0.4
Tutri ..	11.05	22.64	13.50	0.21	—	3.78	—	—	2.5
Fine Kutti ..	8.76	14.30	9.1	0.38	2.68	12.84	33.37	20.05	14.0
Polished rice ..	13.06	0.90	0.11	0.05	0.45	6.62	78.32	3.40	0.6

* The percentage of fat in various fractions is given in Table 2.

† Calculated by difference.

TABLE 2.—SHOWING THE ANALYSIS OF OIL FROM UNPARBOILED PADDY AND ITS FRACTIONS.

	Oil %	Acidity as oleic acid %	Iodine value	Refractive index at 40°C.	Saponification value	Vitamin E mg./100 g.
Paddy	2.1	6.1	82.9	1.4680	186.6	110
Hulls	1.7	9.3	—	1.4635	—	—
Tutri	5.7	25.4	80.5	1.4630	185.4	140
Fine Kutti	10.68	28.7	82.2	1.4660	188.3	162

Higher values of vitamin E were, however, recorded if oil was not previously treated according to the method of Parker and McFarlane, and this treatment became particularly indispensible in the case of oil extracted from rice fractions stored for a year or more. The change in acidity of stored oil, noted by the authors has also been recorded by other workers.[6,7]

Discussion

From Table I it is clear that out of all the fractions obtained as by-products of the rice milling industry, fine kutti is the richest in vitamin B_1 and other nutrients. The hulls, as expected, are very rich in silica and this is responsible for their utilisation in the glass manufacturing industry in Italy. The hulls have also been used for the production of activated carbon, water proof boards and a host of other products.[8] Further, the use of the hull ash as an insulating agent (due to the cellular structure of the silica) holds considerable promise.[9] Values from 6 to 10% of mineral matter, and 13 to 30 ug/mg of thiamine [10] have been reported in the literature. The abnormally high proportion of ash and comparatively low vitamin B_1 content noted by present authors in fine kutti is probably due to the contamination of this fraction with the hulls during the hand sifting of the fraction.

Rice oil needs special consideration. Table 2 shows that 10 to 12% of the oil, containing 0.1-0.2% of vitamin E, could be easily extracted from fine kutti. Because of the presence of vitamin E, which acts as an antioxidant, this oil can be stored over long periods without developing rancidity. It has also been reported that after purification rice oil can become a nutritionally valuable and acceptable edible oil.[12]

A large increase in acidity was observed in the oil extracted from the stored rice fractions, the acidity shooting upto about 80% in six months. Other workers have also noticed such an increase in the acidity of the rice oil on storage,[11] and it is reported to be due to the splitting of the fat by the lipases.

Rice oil being a very potent source of vitamin E, can be exploited for the production of vitamin E concentrate, which can be usefully employed as an antioxidant in food technology. Further work in this direction is in progress.

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