NUTRITIONAL IMPROVEMENT OF RICE

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THE nutritive value of rice, as of all cereals, lies primarily in its high fuel value. Where, however, it constitutes a high proportion of the total diet, as in India and the East in general, consideration must be given to its content of the major nutrients such as proteins, minerals and vitamins. In assessing the nutritional qualities of rice, the feature of outstanding importance is the high concentration of essential ingredients found both in the outer coat and in the germ or embryo. The outer envelope or bran and the germ together constitute nearly one-sixth of the whole grain, the remainder being the endosperm or polished rice. Between them they contain more than half the mineral matter of the whole grain, a fourth of the proteins and practically all the fats and vitamins; they are also the fractions which are completely removed in the process of polishing.

In spite of this recognized loss in food value which rice suffers on polishing,[1-3] there is a general and widespread preference for polished rice. The reason is not far to seek when it is remembered that rice, unlike all other cereals, is predominantly consumed as cooked, whole grains and not as meal or flour. Trade demands and consumer preferences have, therefore, been determined mainly by external and physical characteristics. Polished rice has a pleasing appearance and texture, it cooks more easily and is digested better[4] than the unpolished grain and, in the raw condition, it keeps far better and can be stored for long periods or transported over long distances without appreciable deterioration. This last quality is the one which appeals to the largest section of both producers and consumers. It is also the chief reason which has militated against the introduction of any major legislation to check the wholesale replacement of unlimited rice by the milled product.

MODE OF PREPARATION OF RICE

In addition to the loss in nutritive value which rice suffers on polishing, the wasteful effects of repeated washing before cooking and of cooking in excess of water involving drainage of gruel, both of them again unique operations in the preparation of rice for food, are familiar knowledge.[5-9] Happily, some improvement has taken place in regard to the mode of cooking for, in most well regulated households, only enough water is used as would enable the rice to swell to its proper consistency. Washing losses, which are even more serious than the effects of cooking in excess water,[1] can and should be eliminated if polishing powders such as talc, chalk and glucose are avoided; their use is not being encountered in recent literature except, in a limited way, in Spain, Italy and the United States. Improvements in the cleanliness of mills and storage places are, however, essential since washing is unnecessary in case of clean, milled rice of good commercial quality, the milling in itself being a cleaning process.

SELECTION OF RICE VARIETIES

Yet another factor to be reckoned in evaluating nutritive quality in rice relates to the general favour evinced by consumers for the fine-grained, long and white varieties of rice which are often poorer in essential nutritional elements as compared to the coarse-grained and coloured varieties of rice.[10, 11] The latter also have thicker aleurone layers.[12] Improvements in rice culture have hitherto been aimed at increasing yield and other hereditary qualities such as grain size, appearance, milling and cooking properties but it should be possible to lay sufficient stress on the nutritive value of the grain as well and to encourage the grower to raise nutritionally rich varieties. As with wheat and barley,[13] manuring is another potent method of improving both the total yield and the proportion of nutritive constituents in rice.[10]

UNMILLED RICE

Any improvement in rice quality aimed or achieved through selection of right varieties or reform in mode of preparation for food can only be of minor significance compared to what may be possible through advocacy in the use of whole, unpolished rice. Repeated efforts have, therefore, been made by nutritionists and health propagandists to combat this serious shortcoming in the use of rice as a food grain. It has been suggested that the poor keeping quality of unmilled rice can be overcome by shelling the required quantity from time to time in small wooden hand-hullers or in hand or power-driven hullers which are also available. The practice of preparing rice for consumption by hand-hulling or home pounding has, however, rapidly given place to the custom of using machine-milled rice even in rural areas. The reasons for the abandonment of home pounding are many: small rice mills have been on the increase as cheap electricity became available; better roads and transportation facilities have enabled the paddy-grower to bring his paddy to a mill, thereby sparing the village folk this hard labour. Even small rice-growers are used to sell their paddy and buy machine-milled rice. Thus, home-pounded rice has become more expensive and does not meet the competition of the cheaper highly milled product.[7]

UNDERMILLING OF RICE

It has been argued that, while it may not be quite a practical proposition to ask people to go back to hand-pounded rice, even a lower degree of milling would do a great deal of good. Thus, in 1937, the League of Nations' Inter-Governmental Conference of Far Eastern Countries on Rural Hygiene met in Java and recommended the use of undermilled rice in Government institutions and its popularisation elsewhere by education and propaganda. Attention was called to the desirability of checking the spread of mechanical rice mills in rural areas and promoting the availability of undermilled rice to consumers. No new equipment is needed for its production; it can be obtained simply by less drastic scouring in the mill, either by loosening the huller blades or by avoiding the use of the pearling cone. The Earle process of milling[14] is stated to be a peeling method, the action being entirely one of rubbing rather than impact. This peeling of rice is essentially a special form of undermilling which aims to limit breakage to a minimum and to retain valuable nutrients. More or less bran can be removed depending on the peeling time.

To introduce undermilled rice would necessarily imply the establishment of a standard for control in degree of milling. At present there is no ready method whereby this can be done by visual inspection. A standard requiring other than the simplest laboratory test would not be satisfactory because of lack of facilities in the warehouses and because of the excessive time that would be consumed in grading rice. Several attempts have been made to define the degree of milling precisely and data exist in the literature regarding the loss in weight of the grain in relation to the loss of ash, phosphorus, thiamin, riboflavin, niacin and fat in the course of the milling process.[6,7] No correlation could, however, be worked out between the different values and the degree of milling. Even with regard to weight of bran removed, it has been observed that the per cent. nutrient losses vary from 6 to 25 times as much as the weight loss, being greatest at the stage where the rate of weight loss is least.[9] Hence, weight loss is a very insensitive index of the degree of milling in a nutritional sense and cannot be recommended as a means of control.

Furthermore, if milling is achieved by passage through a succession of hullers, as is usually the case, it is quite conceivable that all the grains entering the machine do not get equally abraded during their passage through the hullers, any difference in the beginning being only accentuated thereafter. In practice, what the miller does is to inspect visually the rice stream flowing from each huller from time to time and to adjust it for a little looser or a little tighter milling according to some stardard of colour which he endeavours to keep in mind. No doubt he acquires by training an ability to detect fine differences in degrees of whiteness but such visual standards are not susceptible of rigorous enforcement. It must, therefore, be anticipated that undermilled rice will of necessity be variable in nutritional quality.

In addition to this difficulty in adequately controlling the degree of undermilling, it is not always feasible to provide for expeditious transit of unmilled or undermilled rice from the rice-shelling mills to consumer areas and thus avoid spoilage in storage. Recent work has shown that in addition to insect infestation and onset of rancidity,[15–18] storage of rice results in loss of nutrients, being considerably more than with wheat, whether in whole grain or flour (whole or refined) form.[9,19] Storage losses would obviously be more pronounced with unmilled or undermilled rice and under tropical conditions of temperature and humidity. Hence, stability in storage presents a major problem in the rice industry and the aversion of millers to undermilled rice because of storage difficulties cannot be dismissed as mere prejudice.

The present food crisis has made it necessary, in some areas, to enforce production of undermilled rice, thereby increasing available supply of the grain; consumers have also become less meticulous in their demands because of circumstances. But for the successful development and marketing of undermilled rice as a long-term, peace-time improvement in rice quality, the foregoing problems have to be carefully considered and solved.

Parboiling of Rice

An expedient that has been much less intensively advocated than undermilling is the more widespread use of parboiled rice. The process itself is an ancient tradition and owes its prevalence and popularity presumably to the ease with which shelling and milling are facilitated by it. The grains get swollen in the process of soaking in water and steaming or boiling so that the subsequent drying operation, usually done in the sun, loosens the hulls which are thus removed readily by pounding. The observations reviewed elsewhere,[20] that there is a nutritional advantage in the parboiling of rice, was only subsequent and is still being considered as incidental. It is now generally known that parboiled rice retains, even after milling, a good proportion of its thiamin, niacin, minerals and proteins,[21,6,7] and that the nutritional merit of parboiling is due to the gelation of the starch in the endosperm with consequent imbedding of some of the bran constituents which are thus generally preserved in the kernel even after milling.[22]

Parboiled rice is customarily used in a large part of the country and, in these areas, the product is unquestionably preferred to raw rice by the people accustomed to it. The process, however, is by no means standardized.[23,24] Parboiling yields a grain of creamy to dark-brown shades and much difficulty is experienced in maintaining lightness or even uniformity of colour. There exist also flavour variations some of which are sufficiently prominent to reflect unfavourable on the universal acceptability of the rice; attempts to introduce parboiling in China under present war conditions has met with opposition on this score. The normal blandness cf cooked rice and the ease with which it can be blended with other foods make it essential that. for the successful marketing of this type of rice, it should be a product neutral in flavour. Ideally prepared parboiled rice has no objectionable flavour and, while it is desirable as well as possible, to have only a light shade of colour in the finished product, it is not always essential as, after preparation in the normal manner, parboiled rice is always practically as white as regular milled rice, the yellow cast being scarcely discernable.[6]

Rice 'Conversion' Process

In spite of the knowledge, now fairly widespread, regarding the nutritional superiority of parboiled rice and the recognition that the general health of the population subsisting on this type of rice is relatively higher than that of those who live in sections where ordinary milled rice is the staple,[5,21] there has been surprisingly little progress in process control, through technological improvements, in the production of parboiled rice. Elsewhere, however, there have been several attempts recently to modernize and improve the traditional parboiling process. The most notable among these has been the Rice Conversion Process which originated in England[25] and has been considerably developed in the United States.[26] Briefly stated, the process is as follows:

The cleaned paddy is introduced into a large vessel which is then evacuated (to 25″ or more) for a period of at least 10 minutes. Hot water (75-85° C.) to an amount about one-third greater than the weight of paddy is then introduced under a pressure of 80 to 100 lbs. per sq. inch and the rice is steeped under these conditions with recirculation of the water for a period ranging from 120 to 165 minutes. The times and temperatures required for steeping are said to depend upon the variety of rice being processed, moisture content, the length of time it has been in storage and the colour desired in the final product. The steeping water is then drained off and the steeped paddy is introduced into a large, cylindrical, rotating steam-heated vessel which is then partially evacuated and the paddy heated for a short time. At this point, dry direct steam is introduced and the paddy is heated in this manner for a few minutes. The steam is then blown off and a vacuum of 28 to 29″ applied. The product is dried under vacuum in the rotating steam-jacketted vessel until a moisture content of less than 15 per cent. is attained. Final drying is done at atmospheric pressure. The hot, dry "converted" paddy is placed in bins and cooled by passing air through it and allowing it to remain in the bins for at least 8 hours before milling in the usual way.

The process has been in commercial production at Texas since 1941. A somewhat similar process, devised by Malek[27] does not readily reveal a clear distinction from the H. R. conversion process. It has also been in operation on a plant-scale in California since recently.

Claims made for the processes are (*a*) better nutritional value due to retention of water-soluble vitamins and minerals through the milling process, (*b*) resistance to infestation because of sterilisation in process and 'case-hardening' of the grain, (*c*) higher milling yield with fewer broken grains, enabling the processing cost to be met by the reduction in the proportion of low-grade rice in the output, (*d*) storage life comparable with ordinary polished rice in spite of the higher nutritive value and (*e*) better appearance when cooked, remaining as discrete particles instead of forming into a gummy mass; this property makes processed rice preferable to ordinary rice in canning.

These claims, since substantiated,[9] are all essentially those acquired during parboiling.[28,6] Further, it is reported that the H. R. process is definitely superior to the Malek process.[29] Time and experience can alone show whether this process so highly successful in the United States where the rice industry is relatively highly mechanised and where there is no dearth of technically skilled personnel, can be made feasible in our country and, what is more important, offer distinct advantages over the indigenous methods now in use.

Artificial Enrichment of Rice

Another direction in which nutritional improvements in rice are effected has been through artificial fortification or enrichment of the cereal. Here again, the experimentation so far known has been from the United States and has not reached the stage of application to nutritional reform in rice-eating countries. The problem of enriching rice nutritionally is beset with many obstacles. It is more difficult to restore vitamins and minerals to white rice than to flour as in "national"[30] or "enriched"[31] flour because rice is rinsed before cooking. This leads to great losses when vitamin and mineral preparations are applied only to the surfaces of grains. Enrichment must, therefore, be internal if it is to be thorougly effective; in other words, the entire grain has to be impregnated with the nutrients to avoid their loss during rinsing preparatory to cooking. With undermilling or parboiling of rice, at least a portion of the nutritionally valuable factors of the grain is retained in the grain as consumed. On the other hand, it has been contended that both procedures attempt to make use of the natural nutrient content of the unmilled rice which in itself is limited and varies considerably depending upon soil, climatic, varietal and manurial factors under which the rice has been grown. Hence, it is not possible to get a rice "nutritionally well-rounded". Looking at the problem in this way, artificial enrichment of rice merits consideration provided of course it should prove to be feasible.

The problems involved in the enrichment of rice are that (*i*) the rice shall be prepared in a manner which is commercially feasible and practical, (*ii*) the enriched product shall be stable to conditions of transportation, storage and household manipulation (washing and cooking) and (*iii*) the enriched product shall preferably be indistinguishable from polished rice. These objectives have been achieved by a special process* developed in the Roche Laboratories[32] in which the enrichment is performed in two steps by (*a*) producing a fortified premix, and (*b*) diluting the premix with ordinary white rice in a subsequent process.

The premix or rice concentrate consists of ordinary polished or unpolished rice to which the fortifying ingredients are added and covered by a film-forming, edible, water-insoluble coating. When the enriched rice is cooked, the coating softens and disperses so that the nutrients are readily available in the cooked rice. The premix can obtain enough amounts of the vitamins and minerals so that one half pound will enrich 100 pounds of rice to desired levels. The solvents used for coating according to the

* The author is indebted to Dr. T. J. T. Wells, Chief of the Roche Scientific Division, Volkart Brothers, India, for this personal communication.

Roche process are not objectionable from the standpoint of being explosive or highly inflammable. The coating substances have been investigated from the food angle and found to be satisfactory.

The blending of premix with white rice in the rice mills results in the final market form of enriched rice. It has been determined that the premix is homogeneously distributed throughout the finished enriched rice. Usual household washing of enriched rice prior to cooking will not remove more than 3 to 5 per cent. of the incorporated vitamins. Flavour and cooking quality are not also affected by the fortification procedure. It has been claimed that storage of the premix or of enriched rice for one year at room temperature did not affect the potency of the vitamins.

Another method of artificial enrichment, recently reported,[33] involves impregnating the rice, polished in the conventional manner, with a water solution of vitamins (thiamin, niacin and a highly soluble salt, primary sodium phosphate). The rice is dried and coated with a thin collodion membrane. The vitamins are now protected from rinsing losses but are available to the body in the cooked product since the film is removed by the hot water. The rice is prepared with a high vitamin concentration and then diluted 1 : 100 with unenriched white rice.

Artificial enrichment can obviously be effected by addition of nutrients to any desired level called for by public health considerations; further, from an economic standpoint, only 1 to 2 per cent. of the rice requires special processing. On the other hand, with any form of parboiling, the total produce has to be processed whereby it may happen that the processing and drying costs may equal to or exceed the cost of fortifying ingredients. Frequently, however, it happens that the improved milling and storage qualities of parboiled rice ensures its better saleability. Parboiling can also be extended to freshly harvested paddy which otherwise requires storage or 'curing' for some months before the rice from it becomes fit for consumption.[34]

Another factor requiring careful evaluation with enriched rice is the price for the coating ingredient which should not exceed the cost of the vitamins which it is intended to save; on the basis of available figures, it would appear that over half the cost of processing go for the protective coating; besides, the stability of the premix and of enriched rice over a wide range of storage conditions such as exist in the tropics has to be studied.

Resume

It is significant that the problems of improvement and product development in rice have received attention mostly in the United States and that during the last four years. This is no doubt a direct consequence of the advent of World War II involving the principal rice surplus areas in the East: Indo-China, Burma and Siam and the recognition by the leaders in America of the anticipated demand for rice for army and civilian feeding requirements. Admittedly, the importance of the nutritive value of rice in India surpasses any relative need in the west for control of rice quality. With the aftermath of the war and the threatened world shortage of cereals engaging the attention of the United Nations Organization, it is to be hoped that concerted efforts will be made in India towards raising the status of the rice diet. Quite apart from improvements in selection of varieties and in cooking methods, which can only be achieved by reeducation, the corrective measures discussed above are (*i*) encouragement of undermilled rice, (*ii*) extensive use of parboiled rice with reasonable technical control in production and (*iii*) artificial enrichment.

Enforcement in the production of undermilled rice is handicapped on account of the difficulty in controlling the degree of undermilling and of preventing deterioration in storage. Again, although undermilling increases nutritional quality, it does not give the colour or cooking quality required by many consumers and will not attain the equal digestibility of white rice.

There is paucity of information on the practical application of the principles of rice enrichment under tropical conditions. The large-scale synthetic production of vitamins in America and the extensive propaganda by leaders in the nutrition field towards restoration and fortification of certain foods have made the American people definitely nutrition-conscious with the result that they pay attention to enriched values and watch the labels in food packages for vitamin declarations. Conditions in this country are quite different and even if fortification were made possible through import of the necessary protective factors it would be a long time before such enriched foods become popular except when introduced compulsorily and under Government subsidy in which case economic factors are to be carefully reckoned.

The widespread utilization of parboiled rice undoubtedly offers advantages but it becomes absolutely necessary to effect technological improvements and product control before parboiling can be expected to yield an ideal product which combines in it the pleasing appearance and keeping quality of polished rice with the superior nutritive value of unpolished rice.

It is indeed difficult to prescribe the final answer. But, whether it be undermilling, parboiling or fortification, there is no denying the fact that whatever can be done for the nutritional improvement of rice will be well justified by enormous benefits through diminished malnutrition. For better nutritional welfare and widespread dietary improvement, it is the staple food that has to be improved in quality. It is only then that the lower income groups whose total diet contain the largest proportion of cereal foods and who are, therefore, in greatest danger from nutritional deficiencies, get the best advantage.

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A HOME-MADE INFRA-RED SPECTROMETER

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WHILE great advances have been made of recent years in the technique of infra-red spectroscopy, little work is being done on the behaviour of crystals in this interesting region of the spectrum. Infra-red investigations of crystals should provide us with fundamental knowledge about the dynamics of the atoms composing them and are essential for a proper understanding of the nature of the solid state of matter. Great interest centres round the infra-red spectrum of diamond in particular, since this is the simplest of cubic crystals. Fortunately, the most interesting region in the infra-red spectrum of diamond lies in the near infra-red and is capable of being explored with a rocksalt-prism spectrometer. Two years ago the investigation of the infra-red spectrum of diamond was undertaken by the writer at the suggestion of Sir C. V. Raman. Since there was no infra-red spectrometer available in this laboratory, it was necessary to set up an instrument for this research. With the home-made instrument which has resulted, it has been possible to establish some important facts about the infra-red spectrum of diamond. A description of the construction of the instrument, which may be of interest, is given below.

As a source of continuous infra-red radiation a globar is used. Though the widely used Nernst filament has got a higher operating temperature and consequently higher infra-red radiancy, the globar, in virtue of its large heat capacity, serves as a very steady source. The ¼″ thick 6″ long globar element now being used is mounted inside a water-cooled iron jacket cut with a slit 1″ by ¼″ in the centre for the exit of radiation.

The arrangement of the optical parts of the spectrometer is indicated in Fig. 1 (not to scale), which is self-explanatory. The spherical glass mirrors M_2 and M_4 which are of 10″ focal length and 3½″ diameter were obtained

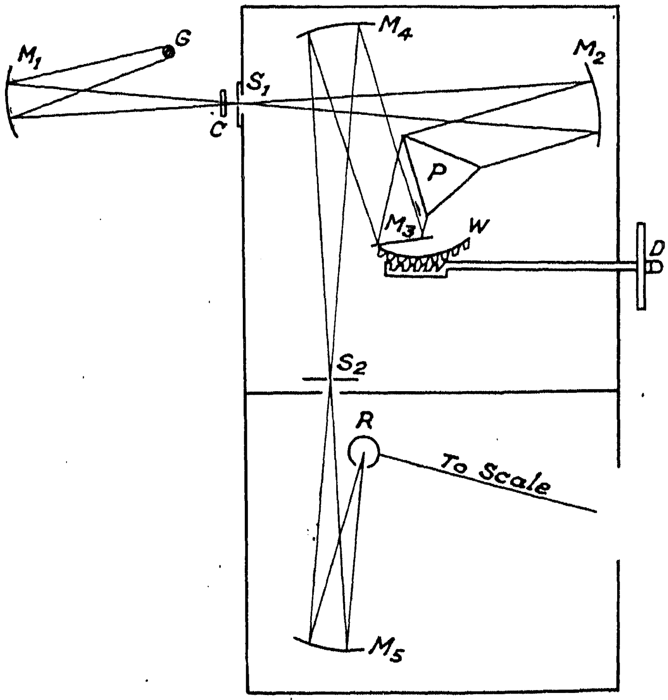

FIG. 1.—*Arrangement of the Home-Made Spectrometer.* G.—Globar; M_1 and M_5—Focussing mirrors; C—Crystal under investigation; S_1—Entrance slit; M_2 and M_4—Spectrometer mirrors; P—Rocksalt prism; M_3—Plane mirror; W—Worm wheel; D—Graduated drum; S_2—Exit slit; R—Radiomicrometer.