all these disabilities it is not surprising that the standard of medical practice is low, and scientific or rational medicine has not been practised.

The immediate implementation of a progressive plan like the one put forward by the Bhore Committee will enable us to draw abreast of recent knowledge and to introduce in our country up-to-date teaching and research, and what is best in the health administration of advanced countries.

Trained personnel is the most important single factor for provision of adequate medical relief on rational lines. We need at least ten times the number we have, and it will take 30 to 40 years to train this number. It is imperative, therefore, that we make the most of what we have. The present retiring age in services is 55 years, when most of the incumbents are yet fit to carry on efficiently for many more years. They should be made to work as long as possible and, if necessary, their sphere of work should be changed to suit their physical capacity. When we come to highly specialised workers, such as research workers, of whom we have a still less adequate number, it would be foolish to retire them, as is the usual practice, when they are most valuable for training and directing other workers and organising new institutions.

The Role of Indigenous Medicine

There are many people who consider that while a comprehensive and rational system of public health is being evolved, use should be made of Indigenous Medicine. Indigenous system—good, bad or indifferent—still caters for the needs of the major portion of the population particularly in rural areas. They, therefore, consider that it cannot be excluded altogether from the field, and urge that it be used to the best advantage while the process of evolution of a perfect system of rationalisation of medicine is being worked out. During this transition period, they also hope that Indigenous Medicine will overhaul itself and becomes an integral part of the permanent system evolved.

For the rationalisation of medical practice in India two important points suggest themselves. Firstly, the practice of medicine be so regulated by the exponents of modern and of the indigenous systems that the fullest possible use can be made of the facilities available for diagnosis, treatment and prevention of disease. The second point is that a synthesis of indigenous and modern systems of medicine be attempted so as to promote the utilisation of the knowledge from all available sources for the interpretation of health and disease. Both extension and acceleration are possible through a partial synthesis of the two systems in the elementary stage of our teaching. The present course of study in the indigenous medicine should be suitably curtailed on one side and enlarged on the other. The net effect of this suggestion will be twofold. It will shorten considerably the period of study, and thus will lead to the training of a much larger number of qualified practitioners. And secondly, while giving the students a sufficient background of scientific knowledge with regard to the diagnosis, treatment and prevention of disease, it will make them at the same time conscious of their own limitations and of the necessity to appeal to higher practice in difficult cases. There are about a hundred thousand practitioners of indigenous medicine in India, many of whom could be quickly fitted for this purpose after suitable training. The services of such practitioners will be of particular value in the rural areas, which are now almost beyond the reach of modern medicine. Rural medical relief will be considerably facilitated if some further steps are taken to standardise medical practice by prescribing uniform scales of drugs and medical appliances for institutions, their production in bulk and distribution under the auspices of the State. If all practitioners are properly registered, and practice by non-registered practitioners prohibited, a reasonable standard of competence could be secured.

N. N. De.

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TECHNOLOGY OF RICE*

THE number of named varieties of rice is said to exceed two thousand. Hundreds of varieties are cultivated. There exist between these varieties marked differences in quality as revealed by consumers' preferences. Attempts have been made to correlate quality in rice with certain chemical and physico-chemical properties of the cereal, but rarely with success. Extensive investigations were carried out at the Central College, Bangalore, to correlate varietal differences in physical properties with the quality of rice. A study of sorption and desorption of water by rice grains showed that, in general, superior varieties of rice lose water more readily during dehydration, and take up water at a faster rate during hydration, than varieties of poorer quality. This showed greater permeability of the grain to moisture in superior varieties. Other physical properties did not exhibit any useful correlation with quality.

The observation on sorption led to an extensive investigation of the swelling of rice grains when cooked. Correlation between absorption of water and cooking quality furnished a convenient method of expressing it in quantitative terms by "Swelling Numbers". This simple method of determining cooking quality has been in use at the Central College for over ten years and has been found to give highly reproducible results.

Important conclusions arrived at from these experiments were: (*a*) Rice from freshly harvested paddy (which is notorious for its poor cooking quality) gives a very low swelling number, (*b*) storage or proper heat treatment improves the cooking quality of freshly harvested paddy, (*c*) overcuring adversely affects

* Abstract of Presidential Address delivered by Dr. B Sanjiva Rao to the Chemistry Section of the Indian Science Congress, in January 1948, at Patna.

the quality and (*d*) parboiled rice swells less than raw rice when cooked under the same conditions.

It is obvious that any process that cuts short the curing process will be of economic importance.

The unsuitability of rice from fresh paddy as food seems to be due to at least two causes. One is its poor swelling quality when cooked. Cooked rice that has swollen presents a large internal surface at which the digestive enzymes can be adsorbed and can act efficiently. Another reason for the poor quality of rice from fresh paddy seems to be the poor permeability of the envelope surrounding the starch granules.

The swelling of starches has received considerable attention in recent years. It is generally recognised that the starch granules enlarge by tangential expansion and not by development of internal, radially directed pressure. Swelling is influenced by the following factors: (1) original size of granule; (2) relative percentages of amylose and amylopectin; (3) extent of crystallisation of starch and the nature of the crystallites in the granules; and (4) whether the structure of the granule has been previously influenced by chemical or physical treatment. Some of these factors are of particular importance with reference to processes for curing rice. Hydrogen bonding seems to play a part in the swelling of starch. Cations have been found to have a marked effect on the swelling.

It should be noted that all these investigations on the swelling of starch have been carried out with granules that have been detached from their natural setting in the raw material. We are concerned, however, with the overall swelling of the rice grain in its cooked state as served at the table.

The principal material that binds the starch granules into a rigid structure seems to be the protein in rice. It is well known that proteins form complexes with carbohydrates. The latter also form complexes with fats, phosphoric acid and silicic acid. Sjostrom pictures the granules in the rice grain enclosed in honeycomb-like structures of gluten, and states that in the aggregates the granules are held together by the gluten particles. Protein (about 1 per cent. of the grain) seems to be the binding material in the production of a coherent structure from small glycogen units. The framework of the rice grain is, under certain circumstances, rather a delicate structure. In processes for the curing of rice, this has to be constantly borne in mind.

It has already been pointed out that one of the facors affecting the swelling of starch granules is the relative proportion of amylose and amylopectin, which constitute two distinct fractions of starch. Investigations were carried out at Central College to find out how far varietal differences in amylose-amylopectin ratios would affect the swelling numbers of the different varieties of rice. It was found that there was a close correlation between the amylose content of a rice and its swelling number. The question arises if the amylose-amylopectin ratio of a rice can be altered by appropriate treatment and the cooking quality of the rice thus improved. It was, however, found that heat treatment of paddy by methods like parboiling did not affect the amylose-amylopectin ratio. Haworth has suggested a scheme for the synthesis and breakdown of amylopectin and amylose by the P. and Q. enzymes of potato. P. enzyme under appropriate conditions acts on amylopectin to yield amylose. Much more knowledge of the action of the enzyme, however, will have to be obtained before we can hope to alter the quality of a rice by enzymatic action.

In starch there is a strong tendency for the formation of "Interlocked macromolecules". The formation of cross-linkages in the macromolecules reduces swelling capacity. We may look upon rice as a colloidal system which has limited swelling capacity owing to the presence of cross-linkages.

Rice in fresh paddy is in a large measure in the hydrogel condition. As the rice ages, there is elimination of water due to syneresis. As syneresis proceeds, cross-linkages are formed, and there is greater rigidity in structure until, ultimately, on adequate storage, we are able to husk the rice without undue damage. It may be noted that in the rice grain there are capillary spaces, as in silica gel. Employing a special technique, M. R. A. Rao actually measured the volume of air entrapped in rice capillaries. The work of Subba Rao showed that some of the cavities in rice were of molecular dimensions. The hysteresis loops in rice disappeared on successive sorption and desorption of water vapour, but not of carbon tetrachloride vapour, by the rice. When rice grains undergo a series of sorptions and desorptions, there is considerable gain in the elasticity of the walls leading to the final disappearance of the hysteresis loop.

Parboiled Rice

The fact that rigidity in structure in the rice grain can be attained by the application of wet heat and the consequent development of cross-linkages, is of great practical importance and is the basis of several methods of curing rice. One of the oldest of such methods, practised in India, is the parboiling of paddy. The out-turn of parboiled rice is usually 6 to 10 per cent. more than that of ordinary milled rice and the process conserves the water-soluble vitamins of the B group, the proteins and the mineral matter in rice. When rice has been properly parboiled, the keeping quality of the rice also improves, partly because the vitamins in the cured rice are not readily available to the weevils. Another important advantage of parboiling is that when parboiled rice is washed, prior to its cooking (and rice invariably is washed before it is cooked), the loss of thiamin is about 8 per cent. only, while raw milled rice loses 60 per cent.

It must be mentioned, however, that the process as practised by the trade in India is far from perfect and is in great need of standardisation and quality control. The need for reform in parboiling has also been emphasised by the Rice Study Group of the FAO.

The chief defects of improperly parboiled rice seem to be: (1) objectionable odour, (2) uninviting taste, and (3) toughness of the cooked grain. The first two undesirable features can be eliminated to a large extent, by reducing the period of soaking of paddy and by employing hot water for soaking. This aspect of the problem has been investigated at the Central

College, and we recommend that rice be soaked for two to three hours at 70° C.

Another essentially needed improvement is the frequent determination of moisture in paddy that is being dried. In American factories, where paddy is cured by certain improved methods of parboiling, moisture determinations are carried out every 15 to 30 minutes on cured paddy that is being dried. It should be noted that the extent of moisture in rice profoundly affects its storage.

A defect of parboiled rice which has been partly responsible for its rather limited popularity, is that parboiled rice when cooked yields a tougher product than that given by raw polished rice. "Tenderness testers" are now being used in food technology in America, to express quantitatively the tenderness of foods. We find that the swelling number (S.N.) can be used as a rough index of the tenderness of the cooked rice. Parboiled rices have S.N. ranging from 240 to 250, while raw polished rices of good cooking quality have swelling numbers ranging from 300 to 320. Parboiled rice, therefore, appears to be an overcured product. By reducing the duration and the temperature of gelatinization of starch, it is practicable to obtain a parboiled rice having a higher swelling number, but the grain will be less hard and there will be a greater loss in milling, due to breakage. We have, therefore, to fix an optimum for the swelling number, taking into account the preference of certain consumers for softness in cooked rice, as also the gain in head rice that is secured by greater gelatinization of the starch.

In recent years, several attempts have been made to modernize the parboiling process, and rice is now cured in America on a large-scale by two patented processes—"Rice Conversion Process" and "Malek Process". These are fundamentally akin to the parboiling process used in India for ages. The swelling numbers of several samples of American converted rice were determined at the Central College, and found to be even smaller than those of parboiled rices of India. Consumers' tests on converted rice were carried out in India recently, on a fairly large scale, under the auspices of the Ministry of Food. It was generally felt that converted rice, on cooking did not yield a sufficiently soft product acceptable to consumers in India, accustomed to raw, polished rice.

Calcured Rice

In an endeavour to obtain a form of cured rice that has the appearance of raw, polished rice. as also its cooking quality, while having. at the same time all the desirable features of parboiled rice, a modified process of curing rice has been developed at the Central College. In this process, the paddy is soaked for 2 hours in a dilute solution (0·2 molar) of calcium chloride at 70° C., the pH of which is adjusted to 4·5. The solution is drained off, and the gelatinization of the starch is effected by heating the paddy with steam to a temperature of 98° C. The paddy is then dried and husked. In this process, the gelatinization of starch is carried out to a very moderate extent. the necessary rigidity in structure of the grain being secured by the employment of calcium ion to modify the colloidal properties of starch and of the protein. When rice is soaked in calcium chloride solution, there is an exchange of cations, the potassium in the rice partially goes into solution and is replaced by calcium. The colloidal properties of starch also are modified by calcium ion.

In the calcuring process, the gelatinisation of starch is so adjusted that there is no appreciable fall in the swelling number of the rice. Calcured rice, when cooked, is soft unlike other forms of cured rice. Each cooked grain, however, retains its individuality. The cooked rice has no objectionable flavour. The calcium content of calcured rice is about five times that of ordinary, raw polished rice. There is thus some nutritional improvement owing to higher calcium content.

The thiamin content of calcured rice is on an average 2·3 micrograms per gram of the cereal. The thiamin value can no doubt be increased by soaking for a longer period but this would adversely affect the appearance of the calcured rice. The loss in thiamin on washing calcured rice is 4 to 5 per cent. as compared with the 8 per cent. loss sustained by parboiled rice and 60 per cent. by raw polished rice. Calcured rice is also much less susceptible to insect attack than parboiled rice or raw rice. It is not, however, clear yet how the calcium modifies the rice to make it less susceptible to insect attack.

Dielectric heating for drying cured paddy, though scccessful, is not economically practicable. This has been found to be very advantageous in the gelatinisation of the starch because of the greater uniformity in heating and of the greater fixation of thiamin in the endosperm. In small-scale experiments, 2·7 μg of thiamin per gram of rice were fixed, while ordinary heat treatment under identical conditions yielded calcured rice having 2·3 μg of thiamin per gram.

The question may now be considered: What is the best form in which rice can be supplied to the consumer? The Rice Study Group of the FAO has recommended that "a large percentage of the rice supply should be parboiled, since such rice keeps in good condition for longer periods"; and that "the consumption of parboiled rice or rice treated by similar methods and having higher nutritive value should be encouraged by governments, since such rice has distinct advantages over lightly milled or hand-pounded rice". In India nearly 60 per cent. of the rice consumed seems to be in the parboiled form, but parboiled rice is not at all popular in several Asian countries. No doubt, many people accustomed to raw rice have, during the present shortage of this cereal, changed over to parboiled rice. But it is debatable how far the changeover is of a lasting character.

Williams advocates mixing with raw polished rice. prior to its cooking, a small quantity of specially treated rice, very rich in vitamins. Until India is in a position to manufacture the synthetic vitamins used in fortification of rice. this method of rectifying the nutritional defects of raw polished rice is scarcely to be commended. The proper solution seems to be a process which renders parboiled rice more attractive in appearance and in flavour.

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